BAZOOCA

BAltic ZOOplankton CAscades

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1. CONCEPT, OBJECTIVES AND EXPECTED OUTCOME OF THE PROJECT

The alien ctenophore *Mnemiopsis leidyi*, notorious for wrecking havoc on the Black Sea (Kideys 2002), was recently introduced to the Baltic, where it thrives (Kube *et al.* 2007). As an enclosed brackish water system where many organisms live close to their tolerance thresholds the Baltic is very sensitive to such disturbances. We aim to test the overall hypothesis that *Mnemiopsis* in the Baltic causes cascading effects throughout the pelagic food web, from gelatinous and top predators to microbes. Using field studies, experiments and modelling we will address the set of research aims (organized as Work Packages, **WP1-6**) outlined in Fig. 1. We will consider **WP1-6** within the natural spatial (Baltic proper, Bothnian Sea, Bothnian Bay) environmental (oxygen, temperature, salinity, light, N, P) gradients in the Baltic.

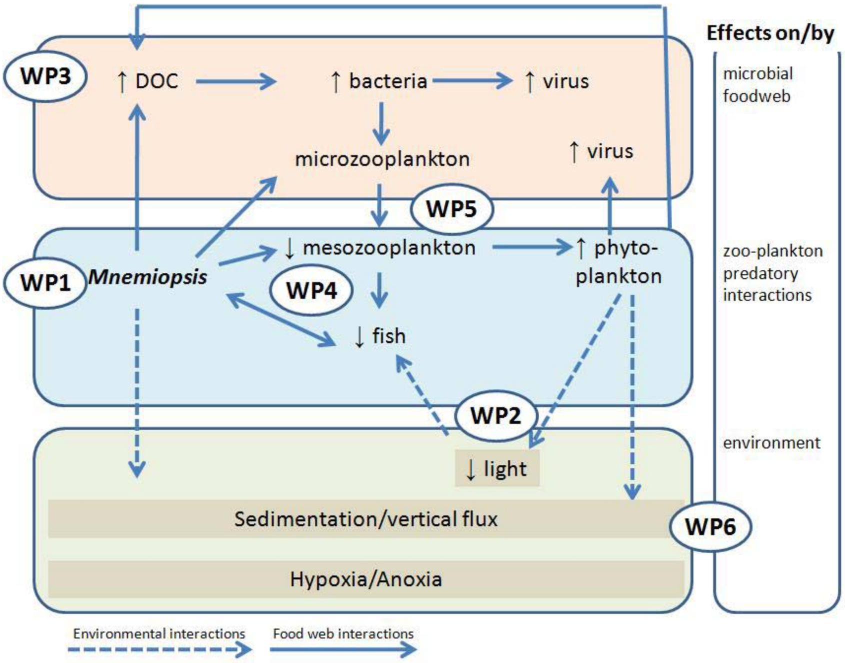

Figure 1. Hypothetical effects of *Mnemiopsis* on the pelagic ecosystem and the major aims (WP1-6) to be addressed. The large blue arrows indicate the direction of hypothesised effects (and not energy flow), while small vertical black arrows indicate increase or decrease.

WP1. Population dynamics and distribution of *Mnemiopsis*.
WP2. Effects on and by the light environment. Changes in optical properties may affect the competitive relationship between visually feeding fish and tactile zooplanktivores like *Mnemiopsis*.
WP3. Production of dissolved organic carbon (DOC) by *Mnemiopsis* and its impact on the microbial loop.
WP4. Predatory and competitive interactions involving *Mnemiopsis.* We will quantify feeding rates of *Mnemiopsis* on fish (cod) eggs and larvae, mesozooplankton and microzooplankton, and measure assimilation of carbon in *Mnemiopsis*.
WP5. Cascading effects on phyto-, micro- and mesozooplankton abundance and composition.
WP6. Synthesis of negative effects of invasion on socio-economical and environmental issues, such as fisheries, eutrophication, clogging of industrial sites and biodiversity.

During extensive monitoring in the Baltic we will employ a range of simultaneous standard measurements of abundance and production rates for virio, bacterio- (**WP3**), different size groups of phyto- and zooplankton (**WP3-5**) and jelly plankton (**WP1**), as well as physical and chemical parameters (light, oxygen, temperature, salinity, nutrients) (**WP2**). Predatory interactions and cascading effects will be studied experimentally (**WP3-5**). We will also apply novel molecular methods, isotope tracer techniques, water sampling devices, video profiling, automatized video and particle tracking analyses, and modelling in assessing **WP1-6**.

Understanding food web effects and potential cascades is crucial given the overall stress from contemporary environmental challenges, e.g. eutrophication, increased maritime activities, and climate change. We expect significant scientific outcomes of the project, in terms of 20-30 scientific papers and 3 PhD theses. The results will be useful for both scientists and policy makers. The current regime shift towards more jellyfish is unprecedented in the Baltic. Its effects on this specific ecosystem cannot be forecasted solely on the basis of lessons from other ecosystems.

2. STATE OF THE ART

Recent dramatic changes in the Baltic ecosystem include altered pelagic food webs. Over-fishing and eutrophication are suggested as ultimate causes for this, but the mechanisms remain elusive (cf Aksnes 2007). Management efforts, such as reduced discharges of nutrients and removal of intermediate trophic levels, all aim at restoring the pelagic food web in favour of a healthy Baltic. To this end, we need thorough knowledge of the pelagic ecosystem, in particular a mechanistic understanding of the trophic interactions and particle dynamics in the water. Our current view of Baltic food web dynamics does not include jellyfish top predators. To accommodate this gap in knowledge, we have gathered the best competence available to address the changes imposed by the invading ctenophore *Mnemiopsis*. We have chosen *Mnemiopsis* as our model organism due to it's proven potential to elicit ecosystem responses and since it currenlty occurs in significant numbers throughout our study area (Lehtiniemi *et al.* 2007). However, the results from the project are relevant and can be generalized also for other gelatinous predators in the Baltic. In the unlikely event that *Mnemiopsis* abundances in the Baltic should unexpectedly decrease, most of the planned experiments can still be carried out using established components of the Baltic gelatinous fauna (e.g. *Aurelia aurita, Pleurobrachia pileus* and several hydromedusae).

First records of *Mnemiopsis* in northern European waters came from near Kiel in the autumn 2006 (Javidpour *et al.* 2006). Shortly after that it was observed in the North Sea (Boersma *et al.* 2007; Faasse & Bayha 2006) and Skagerrak (Hansson 2006). It overwintered in the southern Baltic (Kube *et al.* 2007) and swiftly spread to almost the entire Baltic in 2007 (Lehtiniemi *et al.* 2007). *Mnemiopsis* is native to estuaries along the Atlantic coast of North and South America (Burrell & van Engel 1976), and ranks among the world's most detrimental invasive species (The invasive species specialist group of the World Conservation Union). In the 1980s, *Mnemiopsis* was introduced via ballast water into the Black Sea (Travis 1993). Population densities boomed, and *Mnemiopsis* expanded into the Caspian Sea (Bilio & Niermann 2004). It has been suggested that *Mnemiopsis* caused a collapse of economically important fish stocks (Purcell *et al.* 2001). However, recent research rather indicates that overfishing (Daskalov *et al.* 2007) and water clarity changes (Aksnes 2007) were likely significant drivers for the collapse. Most studies on *Mnemiopsis* are from the Ponto-Caspian region and American waters where potential prey and predators differ from those in the Baltic. We thus cannot predict the responses in the Baltic based solely on existing knowledge. In the light of the considerable stress from contemporary environmental challenges in the region, it is crucial to study how *Mnemiopsis* adapts to and develops in the Baltic, and what its cascading ecosystem effects will be. Assessment of potential ecocatastrophes associated with the establishment of *Mnemiopsis* in the Baltic requires fundamental estimates of population growth and predation effects on the pelagic community. *Mnemiopsis* certainly has the potential to alter biodiversity in the Baltic through its predatory and competitive interactions with fish larvae and zooplankton, all the way down to microbes. There is concern that direct predation by *Mnemiopsis* on cod eggs and larvae may be significant since the depth distributions of *Mnemiopsis* and spawning cod overlap (Haslob *et al.* 2007, Huwer *et al.* 2008). This relation will be examined in the proposed project.

Few time series exist where jellyfish, lower levels of the food web and physical forcing factors have been monitored synchronically. This has constrained quantitative understanding of drivers of jellyplankton dynamics, and constitutes a bottleneck in marine ecological process studies. The knowledge resulting from BAZOOCA will improve our ability to predict changes and succession in pelagic ecosystems, in the Baltic and globally.

3. INNOVATION AND NEW APPROACHES

We will take a multidisciplinary approach using field studies, experiments and models to study the ecosystem effects of *Mnemiopsis* on the Baltic pelagic ecosystem. We will carry out a spatial monitoring survey over two years, where *Mnemiopsis* will be studied synchronically with environmental and biological parameters relevant for other trophic levels (**WP1**). Distributional patterns will be analysed according to the hypothesis that optical properties affect the competitive relationship between tactile and visual predators (Eiane *et al.* 1999, Sørnes *et al.* 2007, Aksnes 2007) (**WP2**). DOC production by *Mnemiopsis* and its role for bacterial production and community composition will be assessed experimentally (Hansson & Norrman 1995, Titelman *et al.* 2006) and in the field (Riemann *et al.* 2006). Molecular analyses include state-of-the-art methods such as PCR, denaturing gradient gel electrophoresis, cloning, sequencing and CARD-FISH (fluorescent *in situ* hybridization with catalyzed reporter deposition) (**WP3**). Microbial colonization and enzymatic activity related to living and dead jellyfishes will be investigated (**WP3-4**). Clearance rate and prey selection of *Mnemiopsis* on micro- and mesozooplankton, and fish eggs and larvae will be measured experimentally (Møller *et al.* in prep. Titelman & Hansson 2006) and in the field (Hansson *et al.* 2005) (**WP4**). Stomach contents analysis (Møller *et al.* in prep) and novel DNA-based methods (Blankenship & Yayanos 2005, Riemann *et al.* in prep) will be used to determine prey composition and mucus and bolus production (Sørnes & Aksnes 2004) will be assessed. The assimilation efficiency of *Mnemiopsis* will be measured with isotope tracer techniques; modified from techniques applied for copepods (Thor *et al.* 2006). Contemporary close-up video analysis and mechanistic models will be used to assess predatory encounters (Hansson & Kiørboe 2006). Finally, we will use video profilers (Tiselius 1998), and novel water sampling devices (Kiørboe 2007) to study the predation process *in situ* (**WP4**). Mesocosm experiments (cf. Granéli & Turner 2002, Pitt *et al.* 2007) will be conducted to study the cascading effects of *Mnemiopsis* on the plankton community (**WP5**).

4. THEMES AND KEY RESEARCH ISSUES OF THE BONUS-169 SCIENCE PLAN ADDRESSED. RELEVANCE FOR THE MANAGEMENT OF THE BALTIC SEA – RELATION TO THEMES 1 AND 7

The current project aims to enhance our understanding and predictive power of the Baltic ecosystem's response to the human-induced invasion by the alien ctenophore *Mnemiopsis*. The project partners include seven universities and governmental research institutes in four

Nordic countries. We apply a multidisciplinary approach to address the effect of *Mnemiopsis* on all levels of the Baltic pelagic food web from light, DOC and microbes to top predators. Our research has implications for significant environmental health issues such as eutrophication, hypoxia, sustainable fisheries and biodiversity. We predict that abundant *Mnemiopsis* may have tremendous negative socio-economic consequences.

Linking science and policy (Theme 1) and integrating ecosystem and society (Theme 7): Understanding the dynamics of *Mnemiopsis* and its effect on the Baltic ecosystem is essential for developing integrated ecosystem based management strategies for fisheries and preserving productivity and biodiversity of the sea. Results on the effects of the *Mnemiopsis* invasion and its ecosystem consequences will be passed on to scientists, legislators, policy makers and the public through scientific and popular papers, reports and talks. We also expect to disseminate results through public media. Our previous jellyfish projects (e.g. EUROGEL) received massive media coverage throughout Europe. This will surely increase the understanding and awareness of environmental issues and provide scientific and political support for better management. Through synthesis of the expected negative consequences of the invasion on socio-economical and environmental issues, e.g. fisheries, eutrophication, clogging of industrial sites and biodiversity, we provide decision making tools. An internet portal will be established to inform the public and media about the project and its progress. A forum for asking questions about *Mnemiopsis* and jellyfish ecology in general will be available.

Climate change and geophysical forcing (Theme 2): We will examine how the optical environment varies with temperature, salinity and oxygen conditions in the Baltic, and especially target the effect of light as a physical forcer on the competitive interactions between *Mnemiopsis* and fish.

Combating eutrophication (Theme 3): The invading *Mnemiopsis* may benefit from eutrophication, because increased turbidity provides a competitive benefit for tactile over visual predators. We will also study cascading effects of *Mnemiopsis* predation on zooplankton for increased algal blooms.

Achieving Sustainable Fisheries (Theme 4): Detailed knowledge of the pelagic food web interactions is essential for predicting fish production. Abundant *Mnemiopsis* may dramatically alter the energy flow in the Baltic pelagic food web (Fig. 1). Direct predation on fish eggs and larvae may reduce the recruitment success of pelagic spawners such as cod and sprat, and planktivorous fish may experience significant competition for food. In addition, cascade effects can deteriorate the light and oxygen environment and thus habitat profitability for fish. Understanding these changes is a prerequisite for informed decisions regarding sustainable fisheries management.

Protecting Biodiversity (Theme 5): *Mnemiopsis* will likely impact both composition and diversity of the Baltic pelagic community through predation and competition as well as through catalyzing significant changes in the physical light and oxygen environment. Our results will contribute to understanding cascading effects of introduced species in general.

Relevance for the management of the Baltic Sea: It is crucial to enhance our understanding and predictive power of the Baltic ecosystem's response to the invasion by the alien *Mnemiopsis*. This invasion by a gelatinous predator is unprecedented in the Baltic, and *Mnemiopsis* has already proven its potential for contributing to ecocatastrophes in the Ponto-Caspian region (Kideys 2002). The effect of this introduction will likely exacerbate the existing human-induced challenges in the Baltic such as eutrophication, overfishing, climate change and invasive species. Globally increased jellyfish outbreaks during the past decades have raised concerns that eutrophication (Aksnes 2007) and overfishing may facilitate regime shifts from a fish-dominated to a jellyfish-dominated trophic structure (Mills 2001). Jellyfish are tolerant to hypoxia (Purcell *et al.* 2001; Rutherford & Thuesen 2005) and do not rely on vision for predation making them likely to gain a competitive advantage over fish in oxygen depleted or visually constrained waters (Sørnes & Aksnes 2004, Aksnes 2007). Such conditions abound in the Baltic. By controlling zooplankton jellyfish can indirectly cause phytoplankton blooms and increased sedimentation (Stibor *et al.* 2004). Superimposed on eutrophication jellyfish may thus further deteriorate both oxygen and light conditions. This implies a vicious circle of worsening conditions for fish populations already challenged by excessive fishing pressure. Combined with the more direct negative effects that abundant jellyfish can have on fish populations due to feeding on eggs and larvae and competing for zooplankton prey, the resulting negative socio-economic consequences for fisheries and dependant industries may be significant. In addition, the environmental degradation due to shifting light regimes is worrying. Direct and cascading effects may potentially alter pelagic interactions all the way down to microbes (Hansson & Norrman 1995, Stibor *et al.* 2004, Riemann *et al.* 2006, Titelman *et al.* 2006), and may thus have severe consequences for the ecological balance in the Baltic. In addition, mass occurrences of jellyfish have implications for human well-being through deterioration of recreational use and coastal industries. The knowledge acquired by the proposed project will provide fundamental insights for policy making and prudent management of the Baltic ecosystem.

5. CONTRIBUTION IN PRODUCING DELIVERABLES DESCRIBED IN THE BONUS-169 SCIENCE PLAN

The proposed project contributes to several deliverables within all of the principal areas of programme focus as defined in the BONUS-169 Science Plan (pp 10-11, Table 1).

Linking science and policy: BAZOOCA will study the potentially grave effects of the recent invasion by the gelatinous predator *Mnemiopsis* on the entire pelagic ecosystem of the Baltic, from microbes to top predators and physical environmental parameters. The ultimate aim of the project is to synthesize results in a holistic manner that improves our understanding of the functioning of the Baltic pelagic food web and the currently relatively poorly understood role of gelatinous zooplankton within it, as well as to consider the wider repercussions of the invasion on the Baltic ecosystem as a whole. The resulting novel scientific knowledge will be highly relevant for policy making and prudent management of the Baltic resources. In addition to making science of the highest quality, emphasis within BAZOOCA will be on effective dissemination and exchange of research results and conclusions. In addition to the production of publications and presentations aimed at the scientific community, results will be transferred to various stakeholders as well as the general public through talks, popular articles, reports, internet content and media exposure (see section *6. Dissemination plan*). In this way we hope to increase public awareness on the problem of invasive species and *Mnemiopsis*, as well as to communicate our results to a maximum number of potential user groups.

Large scale ecosystem threats and changes including responses and mitigation: Spreading of detrimental invasive species is a prime example of the negative large scale environmental threats resulting from increased human encroachment on the Baltic system. The current regime shift towards a higher predominance of jellyplankton is unprecedented in the Baltic, and it is crucial that we understand its consequences for the functioning of the pelagic food web. It is likely that the introduction will both be exacerbated by and exacerbate already existing challenges of anthropogenic origin in the Baltic, including eutrophication, overfishing, climate change and invasive species, and may thus result in significant socio-economic consequences (see Section 4, *Relevance for the management of the Baltic Sea*). BAZOOCA will bring together the expertise of scientists working with different ecosystem components to study the effects of the invasion. The project will utilize a combination of tried and tested as well as novel, state of the art methods including field observations, experiments and modelling in order to monitor and predict the impacts of the invasion in the Baltic Sea and its sub-regions.

Strengthening collaboration and use of common resources: The project is transnational and includes collaboration between seven institutes in three Baltic states (Sweden, Denmark, Finland) as well as in Norway. This strong pan-Baltic dimension is essential for the success of BAZOOCA, as it will allow us to extend the geographic range of our study to encompass a large part of the Baltic ecosystem and its local variability, thus enabling us to overcome some of the limitations inherent in local investigations. It will also facilitate the efficient utilization and sharing of existing state of the art marine research infrastructures and expertise within the Baltic area, as well as promote intensified networking, dissemination, communication and information flow at an international level and between various research institutions. We will use existing national databases to spread the data and contribute to other investigations of the Baltic food web. The project will also incorporate training of Baltic area researchers by integrating scientists in the MSc, PhD, post-doctoral and assistant/associate professor stages of their careers and providing them with opportunities for international collaboration and exchange (see section *10. Researcher exchange and training*).

6. DISSEMINATION PLAN

We expect that the project will generate 20-30 scientific papers (or 1-3 per task) in high impact scientific journals, as well as 3 PhD theses. Results will also be presented yearly at scientific meetings by students and scientists. Popularized talks and informal university seminars will be given during stays of visiting scientists. Results will also be used in university course work. In addition, results will be disseminated to the general public in popular scientific articles, talks, and in reports to the research council. Finally, an internet site will be established to inform the public and media about BAZOOCA and its progress. A forum for asking questions about *Mnemiopsis* and jellyfish ecology will be available on the web site. We envision large public interest in our results; our previous projects on jellyfish ecology have attracted massive coverage in news papers, TV, and radio. As much as possible we will also submit data to national databases.

7. PARTICIPANTS AND MANAGEMENT OF THE PROJECT

The research involves collaboration between seven academic and governmental research institutes in four countries. The contribution of people to specific project aims is summarized in the *Research Plan* (section 11) and the *Gantt chart* (section 12).

SWEDEN Göteborg University (GU). P Tiselius (Prof., 49, PhD 1990) will be the project coordinator. PT's leadership experience includes department chair (Marine Ecology 2000-2003) and head of several large research projects. PT has published on a wide range of zooplankton topics, **LF Möller** (Post Doc, 34, PhD 2006) specializes in jellyplankton physiology and ecosystem effects and **J Titelman** (Assist. Prof., 35, PhD 2002) focuses on behavioural strategies of zooplankton ranging from protists to jellyfish. A project secretary (NN) will be employed. His/her duties will include maintaining the webpage.

Kalmar University (KU). L Riemann (Assoc. Prof., 36, PhD 2002) and **Å Hagström** (Prof., 61, PhD 1980) are experienced with analyses of bacterioplankton activity and community dynamics. This includes microbiological and molecular analyses of bottom-up and top-down (especially viral lysis) effects on bacterial abundance, activity and composition. Recently molecular methods have been applied to identify prey items for fish larvae.

Swedish meteorological institute (SMHI). LJ Hansson's (Researcher, 43, PhD 1998) work incl. aspects of jellyfish ecology incl. release of DOC, feeding behaviour and physiology.

Umeå University (UmU). U Båmstedt (Prof. 61, PhD 1979) has published extensively on copepods and jellyfish ecology and physiology. Present work focuses on food web interactions in the Baltic.

DENMARK National Institute of Aquatic Resources, Technical University of Denmark (DTU). T Kiørboe's (Prof., 56, PhD 1982) work includes topics such as small scale turbulence, marine snow formation and colonization, copepod physiology and behaviour. TK ranks amongst the top 0.5% most cited scientists (i.e. ISI highly cited).

FINLAND University of Helsinki (UHEL). **J Kuparinen** (Prof. 56, PhD 1986) specializes in Baltic phytoplankton ecology. **A Hosia** (Post Doc, 32, PhD 2007) specializes in field ecology and taxonomy of jellyplankton.

NORWAY University of Bergen (UiB). **DL Aksnes** (Prof., 51, PhD 1986) is an experienced modeller, with many papers on the effects of optical properties for the competitive abilities of jellyfish and fish, fish foraging models, and integrative life history models.

The team competence excels in all relevant aspects (experimental-, field-, and modelling-work, supervision, administration, leadership). The group is gender, age and career stage balanced. In addition to the 3 PhD students and 2 post docs applied for (see section 10, *Researcher exchange and training*), the institutes host additional post docs, MSc and PhD students working on related topics. Spin-off MSc projects are expected. The group is well-connected through many past and present projects.

8. BUDGET

The budget includes funding of 3 PhD students (NN) at GU, KU and DTU, and 2 post docs (AH, LFM), all for 3 years, and 5-9 months of salaries for LR, ÅH (KU), JT (GU), LJH (SMHI) and JK (UHEL). PT (GU) will receive 20% salary for 3 years for coordination. We also apply for a part time project secretary (30%, 3 years NN) and technical support (27 months, NN) at GU. Other salaries are funded from other sources. Ship time costs are of two sorts, one for the extra cost of joining existing monitoring cruises and another for exclusive use of research vessels dedicated to the project. Funding for ship time is included in budgets of GU, SMHI and UmU, but will be transferred between institutes if necessary.

Costs for advanced molecular methods are supported at KU (WP3-5) but will be used also by UHEL. Consumables are relatively large since our research requires specialized equipment and analysis. Travel costs related to joint meetings, workshops and research cruises are included. We expect a strong collaborative character in the project and that the three PhD students will interact closely. Other costs are for arranging meetings and networking activities, costs related to research cruises and expenses for visiting scientists.

9. SIGNIFICANT FACILITIES AND LARGE EQUIPMENT

BAZOOCA will utilize a broad range of infrastructures in and around the Baltic Sea to fulfil its goals. The advantageous combination of research institutes, academia and the wide range of expertise is clearly only possible on an international level within the Baltic region. The spatial distribution of institutes from the most northern to the most southern parts of the Baltic is strategic, and allows for a large spatial coverage, and offers possibilities to test hypotheses of cascading effects under very different environmental constraints within the Baltic. Through the institutes we have access to a wide range of research vessels and place on already scheduled research cruises, as well as significant infrastructures. The Swedish, Danish and Finnish fisheries and environmental institutes involved pursue several yearly transects in the Baltic focussing on levels ranging from physic-chemical properties and environmental monitoring to fisheries. Intensive process cruises will be conducted with RV *Skagerak* (GU, 38 m, 12 scientists). Monitoring of the pelagic community will be carried out in connection with scheduled national monitoring cruises with RV *Argos* (Fishery Board of Sweden, 61 m, 12 scientists), *KBV 005* (Swedish Coast Guard, 46 m, 10 scientists), RV *Dana* (DTU, 78 m, 14 scientists) and RV *Aranda* (Finnish Institute of Marine Research, 59 m, 25 scientists).

Mesocosm experiments will be carried out at KU and Tvärminne Zoological Station (UHEL), both of which have excellent large scale mesocosm infrastructures. KU has fully equipped laboratories for microbial and molecular work. Many experiments will be carried out at Kristineberg Marine Research Station (GU), which hosts dedicated thermoconstant rooms, a well equipped plankton laboratory and convenient access to live animals of all sorts. Culturing facilities are excellent and experiments and observations of living organisms can be done year around. The hydrodynamic and mechanistic observations of jelly fish behaviour and predation will be conducted at Department of Marine Ecology and Aquaculture (DTU), where state of the art video equipment is in place and large volume culturing systems allow supply of prey for observing interactions with jellyfishes. UmU has excellent facilities for routine water sampling parameters, such as DOC and nutrient analyses.

We will also benefit from supporting data from national databases collected within the various national sampling programs (e.g. SMHI). In addition, analysis and smaller experiments will be conducted at all participating institutes. Throughout the consortia, the academic environment is excellent with large international networks, in which young scientists and PhD students can enjoy a highly stimulating intellectual climate. The well balanced mix of academic and governmental research institutes also offers possibilities. While universities have access to large student bodies, the environmental and fisheries institutes are directly linked to policy makers and other stake holders allowing for the use of various public information channels.

10. RESEARCHER EXCHANGE AND TRAINING

The transnational network allows for integrating various scientific approaches, and will provide data for modellers and access to theoretical approaches for field specialists. Most of the tasks, including cruises and workshops, involve research collaboration between several institutes and researchers at all career stages. These are outlined in the *Gantt chart* (section 12).

Interaction between participants in the consortia will be formally ensured through 4 planned meetings, in addition to workshops and cruises, and informal research visits. The project starts with a Kick off meeting and ends with a mini-symposium, both at Kristineberg, GU. Two additional yearly meetings are scheduled for January 2009 and 2010 when results and future plans will be discussed, and joint manuscripts planned.

A vital part of BAZOOCA consists of PhD students and Post Docs. The three PhD students will be employed from the beginning of the project, and will be tightly connected through participation in research cruises and workshops. They will focus mainly on the following topics indicated by suggested thesis titles (main tasks and affiliation in parentheses):

- *Effects of the light environment on the competition between jellyfish and fish in the Baltic Sea* (WP2.1-2.3, WP4.1) (GU).
- *Predation by jellyfish on plankton, including cod larvae and eggs: a hydrodynamic and mechanistic analysis* (WP1, WP4.4-4.5) (DTU)
- *Direct and indirect effects of the ctenophore Mnemiopsis on activity and community composition of marine bacterioplankton* (WP3, 5) (KU)

Our previous experience in large European networks (e.g. KEYCOP, EUROGEL, BASICS) is that students and post docs fare very well from such collaboration; apart from scientific gains, early networking with fellow students and experienced researchers often proves vital for their continued careers. The 2 full time post-docs will provide stability and excellence of the research. The post docs will focus largely on WP4-6, and will be responsible for organizing workshops and process important tasks after cruises and workshops. BAZOOCA offers ample opportunities for international exchange and student collaboration with more experienced scientists with a wide range of expertise. The team is well experienced with supervising students (>40 PhD and >30 Post docs). We will also include new MSc students in our activities.

Scientists and student will be encouraged to give open seminars during collaborative research stays and project meetings. In addition, we hope to apply for funding (from e.g. Nordic Marine Academy) to organize an international PhD course on ”Cascading effects of gelatinous zooplankton”.

11. DETAILED RESEARCH PLAN

The detailed research plan is divided up into Work Packages (WP) and Tasks (numbers). The participant responsible for the WP is indicated in the heading in bold underlined font, and other involved partners in normal font). Collaboration and main responsibilities of WPs and tasks as well as milestones for the progress of the project are detailed in the *Gantt chart* (section 12).

WP1: Population dynamics and distribution of *Mnemiopsis* and other jellyfish

GU, SMHI, UHEL, DTU, UmU, UiB

1.1 Monitoring
1.2 Process cruises

Many environmental parameters in the Baltic Sea are continuously being monitored in agreement with e.g. the Helsinki Commission (HELCOM). However, no quantitative monitoring of large gelatinous plankton is covered by HELCOM guidelines.

1.1 We plan to sample gelatinous zooplankton within regular monitoring cruises. The project will thus benefit from access to the logistics of open sea expeditions and to supportive environmental data generated within the regular monitoring programs (e.g. physical, chemical and biological data). The field sampling will yield data on distribution and abundance of *Mnemiopsis* over a relatively large scale (Fig. 2).

We aim at collecting data on abundance and size distribution of large gelatinous zooplankton by approximately monthly sampling for jellyfish from spring to autumn at 6 stations (5 times 2009, 5 times 2010) on board the ship *Argos* that is used for Swedish national monitoring. Complementary sampling will be done with the Finnish ship *Aranda* and the Swedish Coast Guard ship *KBV 005* in summer and on 2 cruises with the Danish ship *Dana* in March and October. The combined data will contribute information about the spatial and temporal changes of gelatinous zooplankton in the Baltic (Fig. 2). The abundance data collected within WP1 will support WP2 and WP4.

1.2 We plan 2 dedicated process cruises, outlined as transects between the coast and the open sea. Suggested location for transect sampling is between the Bornholm Basin and the southern Swedish coast (Fig. 2). These cruises will be targeted towards research topics outlined in WP2-5 and planned as two 36 h anchor stations along with 4 transect stations. The main objective is to determine the predation effect *in situ*, and the consequences of the *Mnemiopsis* population for the microbial food web. *Mnemiopsis* and other jellyfish will be sampled for experiments on board and the vertical distribution determined by video and multi-nets. Samples for potential prey, including fish larvae and eggs, will be taken and the co-occurrence with jellyfish determined. The *in situ* feeding rate of *Mnemiopsis* will be quantified from gut contents and used to estimate the predation pressure on various prey. Because the diel signal will likely be important 36 h stations are necessary. Observations on predator prey interactions will be made using the Sea corer (Kiørboe 2007).

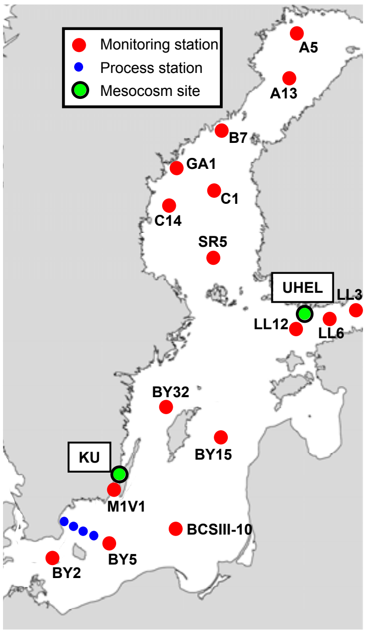

Figure. 2. Monitoring stations, location of process studies transect and mesocosm sites at KU and UHEL. The stations BY2, BY5, BCSIII, BY15, BY32 and MIVI will be sampled by *Argos*, LL3, LL6, LL12 and SR5 by *Aranda*, C1, C14, GA1, B7, A13 and A5 by *KBV 005*. *Dana* will sample a grid of stations in the BY5 area. The process studies transect is only a suggested location based on a strong gradient in *Mnemiopsis* abundance found by Huwer *et al.* (2008). Detailed positioning will depend on actual *Mnemiopsis* distribution

Participants Each monitoring cruise will require the participation of 1-2 PhD students (GU/DTU). The process cruises will host 12 scientists**,** which will include all PhD students and post-docs and additional scientists according to tasks performed.

WP2: Effects on and by the light environment

<u>GU</u>, UiB

2.1 Sampling
2.2 Analyses and modelling of fish and jellyfish abundance as a function of light environment
2.3 Cascade effects on the light environment

A recent review of all the fish stocks in the Black Sea suggests that environmental destruction (climate change, and decreased light due to eutrophication) may have contributed to decreased fish stocks, and allowed *Mnemiopsis* to establish so rapidly (Aksnes 2007, see also Daskalov *et al.* 2007). This suggests that a changing light regime (Sanden & Håkansson 1996) might be one key to understand dynamics in the Baltic. In contrast to fish, *Mnemiopsis* does not use vision to detect prey, but light is still important for competitive interactions with fish as a poor light environment is likely to favour tactile predators like jellyfish over visual fish predators (Sørnes *et al.* 2007, Aksnes *et al.* 2004, Aksnes 2007, Eiane *et al.* 1999, Sørnes & Aksnes 2004). In WP2 we will examine how light and optical properties vary along the transect relative to variables such as salinity, oxygen and chl*a*, which might be valuable proxies for light attenuation (Højerslev *et al.* 1996, Sørnes & Aksnes 2006, Morel 1988). We will target the potential effect of light on the competitive relationship between *Mnemiopsis*, other jellyfish, fish, and their common zooplankton prey.

2.1 Sampling for light environment will be conducted in conjunction with the monitoring (1.1), and the 2 process cruises (1.2). We hypothesize that the abundance of zooplankton prey and the habitat profitability for *Mnemiopsis* are affected by the light regime of the water column. This is expected to change along transects. The light regime will be characterized by measurements of light profiles *in situ* and spectral absorbance from water samples from relevant depths. Oxygen, salinity, temperature and chl *a* will also be sampled. Data from this task will feed directly into 2.2.

2.2 Initial data analyses will concentrate on distribution differences of *Mnemiopsis*, other jellyfish, and acoustical assessment of fish and their zooplankton prey (WP1) as a function of the light environment along the transect. We envision an analysis of fish abundance versus water clarity similar to the ones that have been conducted for the Black Sea (Aksnes 2007) and Norwegian coastal waters (Aksnes *et al.* 2004, Sørnes & Aksnes 2006). Here we plan to utilize published data on water clarity (Sanden & Håkansson 1996), and supply these with additional data on historical Secchi depth observations in the Baltic Sea, fish landings data (all from the ICES data base) and available Baltic Sea fish abundance data. Potential effects of changes in optical properties for fish and jellyfish in the Baltic will be examined in collaboration with related projects at UiB.

2.3 Potential effects on the light environment by increasing jellyfish abundances will be targeted experimentally in the mesocosm experiments (WP3.2-3.3, WP5.1). Light and spectral absorbance will be measured directly, and related to the experimental treatments.

Participants: The WP involves scientists at GU and UiB**.** One PhD student will work on 2.1-2.3. The student will be enrolled at GU, but will also work closely with UiB. He/she will also take active part in experiments within WP4. The anticipated thesis title is:

Effects of the light environment on the competition between jellyfish and fish in the Baltic Sea.

WP3: Effects of *Mnemiopsis* on dynamics of dissolved organic carbon, microbial activity, and community composition

KU, UHEL, GU, UmU

3.1 Microbial abundance and activity in situ
3.2 Cascades and molecular microbial ecology
3.3 DOC and nutrient dynamics

Reports on the impact of jellyfish on lower trophic levels are few, despite the possibility of both direct substrate generation (Hansson & Norrman 1995) and potential indirect cascading effects in pelagic food webs affecting trophic levels down to microbes. For instance, Stibor *et al.* (2004) found that jellyfish consistently reduced copepod biomass while the net effect on algal biomass depended on initial cell size, and their susceptibility to copepod grazing. Altered phytoplankton size distribution likely influences the release of dissolved organic carbon (DOC) from algal cells (Bjørnsen 1988), which affects bacterial growth. Jellyfish biomass may also stimulate bacterial growth directly through release of nutrients (Nemazie *et al.* 1993) and bio-available DOC (Hansson & Norrman 1995, Riemann *et al.* 2006, Titelman *et al.* 2006). Finally, microbial colonization and degradation of gelatinous tissue (Titelman *et al.* 2006) may also support a release of DOC. Hence, by modifying carbon and nutrient conditions *Mnemiopsis* may influence bacterial biomass, activity and community composition in the Baltic Sea. This will affect the phenotypic profile of the bacterioplankton assemblage (Martinez *et al.* 1996). In turn, this influences the turnover of principal nutrients and, thereby, the ecological balance and productivity of the Baltic Sea. These potentially dramatic effects have, however, not been examined for *Mnemiopsis in situ* or experimentally.

3.1 The full microbial food web (i.e. nutrients, DOC and particulate organic matter, chl *a*, abundance of heterotrophic flagellates, bacteria and viruses) will be sampled during all cruises (WP1.1-1.2). In addition, bacterial production and ectoenzymatic activities will be determined during the process cruises (WP1.2).

3.2 A mesocosm workshop will be organised to intensely study microbial responses to the presence and activity of *Mnemiopsis*. This will be examined in triplicate mesocosms (~1000 L, 2-3 weeks duration) with/without *Mnemiopsis* (two concentrations) using water from the southern Baltic proper. Food web cascades and microbial dynamics will be monitored: nutrients, DOC and particulate organic matter, chl *a*, phytoplankton concentration and identity, abundance of heterotrophic flagellates, bacteria and viruses, bacterial production and ectoenzymatic activities, viral (whole genome profiling) and bacterial community composition (denaturing gradient gel electrophoresis, cloning, sequencing, 454 pyrosequencing, fluorescent *in situ* hybridization with catalyzed reporter deposition). The workshop will be organized by KU taking advantage of local mesocosm facilities. Emphasis will be on dynamics of DOC and the microbial loop in response to *Mnemiopsis*.

3.3 We hypothesize that *Mnemiopsis* feeding activity regulates zooplankton and phytoplankton biomass and community composition, affecting dynamics of nutrients and DOC, which in turn has pronounced effects on bacterio- and virioplankton activity and community composition. DOC and nutrient dynamics in the mesocosms will be studied with the aim to reveal direct/indirect links to *Mnemiopsis* activities.

Through the combined expertise of participating partners (KU, UmU, GU, UHEL) a comprehensive description of cascading food web responses will be obtained. WP3 is linked to experiments on direct DOC release by *Mnemiopsis* and bacterial degradation of *Mnemiopsis* (WP4.3) and is tightly integrated with WP5, which is more focused on effects on zoo-/phytoplankton and include larger volume mesocosms. Integration of results from WP3 and WP5 will allow for comparison of effects of different size-classes of *Mnemiopsis* across the Baltic salinity gradient. Sizes ranges from mainly juveniles in the Gulf of Finland (Lehtiniemi *et al.* 2007) to larger specimens in the southern Baltic proper (Huwer *et al.* 2008).

Participants: The mesocosm experiment will be organised by KU and all PhD students will join as well as AH (UHEL). Further microbial work within 3.1-3.3 will be carried out by the PhD student at KU. She/he will produce a thesis with a preliminary title:

Direct and indirect effects of the ctenophore Mnemiopsis on activity and community composition of marine bacterioplankton.

WP4: Predatory and competitive interactions involving *Mnemiopsis*

<u>GU</u>, DTU, UmU, KU

4.1 Feeding rates
4.2 Assimilation efficiency
4.3 Carbon budgets
4.4 Feeding mechanisms
4.5 In situ observations

Despite evidence for high predation impact by jellyfish on both fish and zooplankton, little is known about their role in the carbon flow in marine ecosystems. Because jellyfish may contribute substantially to the planktonic biomass (e.g. Graham *et al.* 2001), the fate of carbon and nutrients bound in these populations is of interest. A complete understanding of the energy flux through the food web requires detailed knowledge of feeding behaviour, predation rates and metabolism of key organisms. Also, it is important to understand how different factors, such as individual size, food availability and temperature, which are fluctuating in the field, affect energetic and behavioural parameters (Møller & Riisgård 2007). By applying the budgets and rates obtained in the laboratory to *in situ* abundance, size and growth (WP1) both direct and indirect effects of jellyfish predation will be evaluated.

4.1 Feeding (clearance rates and ingestion) will be quantified in controlled laboratory experiments. These results will be supplemented with data on *in situ* gut contents of *Mnemiopsis* obtained using microscopy (Møller *et al.* in prep) or DNA-based identification of prey items (Blankenship & Yayanos 2005, Riemann *et al.* in prep). Due to the distributional overlap between *Mnemiopsis* and cod we will conduct targeted experiments to determine feeding rates on cod eggs and larvae (Titelman & Hansson 2006). Rates obtained within 4.1 will be used in 4.2-4.4. The effect of light on feeding success of jellyfish *vis-à-vis* fish will be evaluated in experiments with light gradients and various prey (Sørnes & Aksnes 2004).

4.2 Energy budgets can be used to evaluate how much of the prey carbon that is channelled into the jellyfish and how much is excreted. A critical factor in such calculations is the assimilation efficiency (AE) by the animal in question. AE is typically assumed to be 85-90% in jellyfish (e.g. Olesen *et al.* 1994, Uye & Shimauchi 2005), based solely on a few measurements on siphonophores (Purcell 1983). However, in contrast Stibor & Tokle (2003) reported AE as low as 10-30% in the hydromedusae *Sarsia gemmerifa* suggesting that AE may be highly variable in gelatinous plankton. AE of *Mnemiopsis* will be measured directly with isotope tracer techniques modified from those applied to copepods (Thor *et al.* 2007) and hydromedusae (Stibor & Tokle 2003). Metabolism is strongly dependent on prey type (Møller & Thor in prep) and therefore AE will be assessed using single- and multi-species prey.

4.3 Fast growth and high reproduction is characteristic of *Mnemiopsis* and the extent to which this is realised in the field is vital to the development of the population. Growth will be measured experimentally on various wild or cultured prey (Møller & Riisgård 2007). Experiments will be conducted in conjunction with 4.1. DOC excretion (Hansson & Norrman 1995), respiration and ammonium excretion (Møller & Thor in prep) will be measured at the end of the incubations making it possible to construct carbon budgets.

DOC release will be related to individual size, temperature, feeding and growth on different prey types. Microbial colonization and degradation of *Mnemiopsis* tissue will be conducted in junction with WP3, largely as in Hansson & Norrman (1995) and Titelman *et al.* (2006). Through a combination of results from 4.1-4.3, we will be able to predict the growth of *Mnemiopsis* in the field under variable food conditions.

4.4 Detailed studies on the hydrodynamic interaction between *Mnemiopsis* and their prey will be conducted. The flow field surrounding a foraging *Mnemiopsis*, with estimation of deformation rates relevant to escape responses of prey, will be quantified. A combination of Particle Image Velocimetry (Stamhuis & Videler 1995) and rheoscopic flakes will be used to quantify velocity gradients. These can be used to predict (i) prey encounter rate and (ii) attack success of various prey. Common prey types such as copepods and cladocerans will be observed. Cladocerans, which at times dominate the prey field, are expected to react differently than copepods to attacking *Mnemiopsis*. Observations of capture of cod larvae will be made and clearance rates estimated from the hydrodynamic analysis. These data will be compared to gut contents *in situ* (4.1).

4.5 *In situ* observations of prey encounters may be obtained during periods of high abundance. The *in situ* video camera (Tiselius 1998) will be used to locate *Mnemiopsis* and the newly developed Sea corer (Kiørboe 2007) deployed to enclose a large volume of water for video observation on the ship. This task will be performed during the process cruises (WP1:2).

Participants: This workpackage involves several partners, and has a significant student component (2 PhD students and one post doc). The PhD student enrolled at GU and also involved in WP2 (see p. 11) will work on 4.1 together with scientists at GU, KU and UmU. The GU Post Doc (LFM) will be responsible for 4.2-4.3. The second PhD student will be enrolled at DTU and will focus his/her thesis work on 4.4-4.5. He/she will produce a thesis tentatively called:

Predation by jellyfish on plankton, including cod larvae and eggs: a hydrodynamic and mechanistic analysis

WP5: Cascading effects on the plankton community

UHEL, KU, GU, UmU

5.1 Cascade experiments
5.2 Cascades in the field

Mnemiopsis and other jellyfish can impact the plankton community through direct predation as well as by triggering top-down (Lindahl & Hernroth 1983, Verity & Smetacek 1996, Schneider & Behrends 1998, Kideys 2002) or bottom-up processes (Hansson & Norrman 1995, Riemann *et al.* 2006, Titelman *et al.* 2006) . We hypothesize that cascading effects propagating down the classic food chain and the microbial loop will cause changes in the abundance and species composition of planktonic organisms all the way to phytoplankton and microbes.

5.1 Effects of *Mnemiopsis* will be studied in a 2-3 week mesocosm workshop at the Tvärminne zoological station (UHEL). To facilitate comparison of results, a set-up similar to that used in the WP3 mesocosm experiment (KU) will be applied, i.e. triplicate mesocosms without and with 2 different concentrations of *Mnemiopsis.* In contrast to the WP3 experiment, priority will be given to studying the cascading effects on zoo- and phytoplankton. However, KU partners will also participate and generate data on the microbial components. Changes in the abundance and composition of phytoplankton, heterotrophic flagellates, microzooplankton and mesozooplankton will be examined, chl*a*, DOC and nutrient levels will be recorded, and changes in algal and bacterial productivity studied with isotope methods. Microbial and molecular analyses will be as outlined for WP3, but less intensive. Shorter, smaller scale microcosm studies with juvenile individuals will be conducted during cruises as well as on land in temperature regulated aquaria rooms.

5.2 Data on the *Mnemiopsis* population and planktonic community composition in the field will be used to evaluate the cascading effect *in situ*. In addition to the parameters in WP3.1 (nutrients, DOC and particulate organic matter, chl *a*, abundance of heterotrophic flagellates, bacteria and viruses), phytoplankton, microzooplankton and mesozooplankton will be sampled during the cruises.

Data from the meso- and microcosm experiments together with the field monitoring (WP1) of the plankton community will allow us to picture actual community level changes caused by *Mnemiopsis.* WP5 is closely related to WP3, which deals with the detailed consequences of the *Mnemiopsis* invasion at the microbial community level, as well as to WP4, which will help elucidate the causative influences behind our observations. Together, these subcomponents will allow us to compare the effects of *Mnemiopsis* across the Baltic salinity gradient. As a large proportion of northern Baltic *Mnemiopsis* are larvae or small individuals (Lehtiniemi *et al.* 2007), we hypothesize a locally significant predatory impact on microplankton (Sullivan & Gifford 2004, 2007). In southern Baltic proper, where the average size of the ctenophores is larger (Huwer *et al.* 2008), they may prey more on the mesozooplankton component.

Participants: The Post Doc AH (UHEL) will be responsible for 5.1 and collaborate with PhD students as well as senior scientists from GU and KU for the mesocosms (5.2). UHEL will be responsible for integrating the field data.

WP6: Synthesis of negative effects by jellyfish in the Baltic

GU, All partners

6.1 Changing light environments
6.2 Bottom-up and top-down effects on the food web
6.3 Effects on fisheries and eutrophication

In WP6 we attempt to bring together the results from all the previous components (WP1-5) in order to gain a more comprehensive understanding on the adverse effects of abundant gelatinous predators on the Baltic ecosystem. We hypothesize that abundant *Mnemiopsis* will exacerbate the impact of several of the existing human-induced challenges in the Baltic, e.g. eutrophication and overfishing. Negative effects of abundant gelatinous predators on socio-economical and environmental issues such as fisheries, eutrophication, clogging of industrial sites and biodiversity will be considered. The resulting conclusions will provide support for policy making and ecosystem management.

All tasks (6.1-6.3) will also address the effects of the varying environmental conditions (e.g. gradients in salinity and light conditions) across the spatial range encompassed by the study (Fig. 2) in modifying the response to *Mnemiopsis.* While the tasks are here presented separately, there is a significant amount of overlap in them. For example, the light environment, competitive interactions between jellyplankton and fish, and impact on fish stocks are all intricately linked.

6.1 Light is potentially an important physical factor in defining the outcome of the competitive interactions between tactile gelatinous predators and the visually foraging fish (Eiane *et al.* 1997, 1999, Sørnes & Aksnes 2004). Environmental degradation, including decreased light due to eutrophication, may have been a contributing factor in the decrease of fish stocks and the rapid invasion by *Mnemiopsis* in the Black Sea (Aksnes 2007, cf Knowler 2007). We hypothesize that by impacting the dynamics of the pelagic food webs, e.g. through cascading effects promoting algal blooms, *Mnemiopsis* may alter and deteriorate the Baltic light environment. Results regarding light environment (WP2), as well as observed bottom-up or top-down effects likely to impact on the light conditions (WP3, WP5) will be used to analyze changes to the light environment and their potential consequences.

6.2 The bottom-up and top-down processes driven by abundant *Mnemiopsis* have the potential to alter diversity and dynamics of various groups of organisms in the pelagic community. The direct and cascading effects altering the pelagic interactions may thus have consequences for the ecological balance in the Baltic. In this task, we will bring together results from monitoring activity (WP1), effects on the microbial community and DOC (WP3), predatory and competitive interactions (WP4) and cascading effects on phyto- and zooplankton (WP5). Potential links and causative relationships between the subcomponents within the pelagic food web will be analysed. The ultimate goal is to explain the functioning of the Baltic pelagic food web in the presence of gelatinous top predators. The resulting knowledge will improve our ability to predict changes and succession in pelagic ecosystems, in the Baltic and globally.

6.3 Globally increased jellyfish outbreaks during the past decades have raised concerns that eutrophication (Aksnes 2007) and overfishing may facilitate regime shifts from a fish-dominated to a jellyfish-dominated trophic structure (Mills 2001). Changes in the light environment (6.1) and the food web dynamics (6.2) will obviously impact fish. Recently, an intense, targeted fishery on the most important zooplanktonivorous fish, sprat (*Sprattus sprattus*), has been suggested as a mean to restore the stocks of larger cod (Swedish Board of Fisheries, report Försök med skarpsillsutfiskning, 2008-03-31). Since the diet of *Mnemiopsis* and other jellyfishes largely overlaps that of sprat, this strategy may in fact stimulate population growth of jellyfishes. Clearly, BAZOOCA will contribute key knowledge in this area. Results from all work packages as well as tasks 6.1 and 6.2 will be employed to predict the effect abundant gelatinous predators will have on fish through changes in light conditions (WP2) and food web dynamics (WP3, WP5), as well as competition for food and predation (WP4).

The invading *Mnemiopsis* may benefit from the increased turbidity resulting from eutrophication. However, they may also exacerbate the effects of eutrophication, e.g. by contributing to the formation of harmful algal blooms (HABs) or promoting increased sedimentation. Superimposed on eutrophication jellyfish may thus further deteriorate both oxygen and light conditions. Based on the data from monitoring (WP1) and conclusions regarding food web dynamics (WP3-5, 6.1-6.2) the potential consequences of the invasion with respect to eutrophication and the occurrence of HABs will also be considered.

Participants All participants will contriute to WP6. The yearly project meetings in 2009 and 2010 are instrumental in the data assimilation and synthesis along the project. The meetings will provide opportunities for discussion and collation of results, as well as for planning of joint synthesis papers.

12. GANTT CHART (SEE PAGE 20)

13. PLAN OF SUBMITTING DATA

Data management within the project will be fully transparent and all primary data shared among the participants. We will use national databases to disseminate our data through established information channels. Through our web page we hope to spread popularised data to the public and keep media updated on our progress.

14. ETHICAL ISSUES

The project strengthens the net-working and recruitment of women to natural sciences in the Nordic countries. It involves several early career female researchers (AH, LFM, JT). In addition, women and minorities will be encouraged to apply for the advertised PhD and technical positions. All employment procedures will adhere to current laws preventing discrimination based on age, gender, race, and religion.

All experiments with live animals will be conducted according to national (i.e. the country in which the experiments are conducted) and European regulative, with the necessary permits. Also, results will be published in scientific journals requiring those standards.

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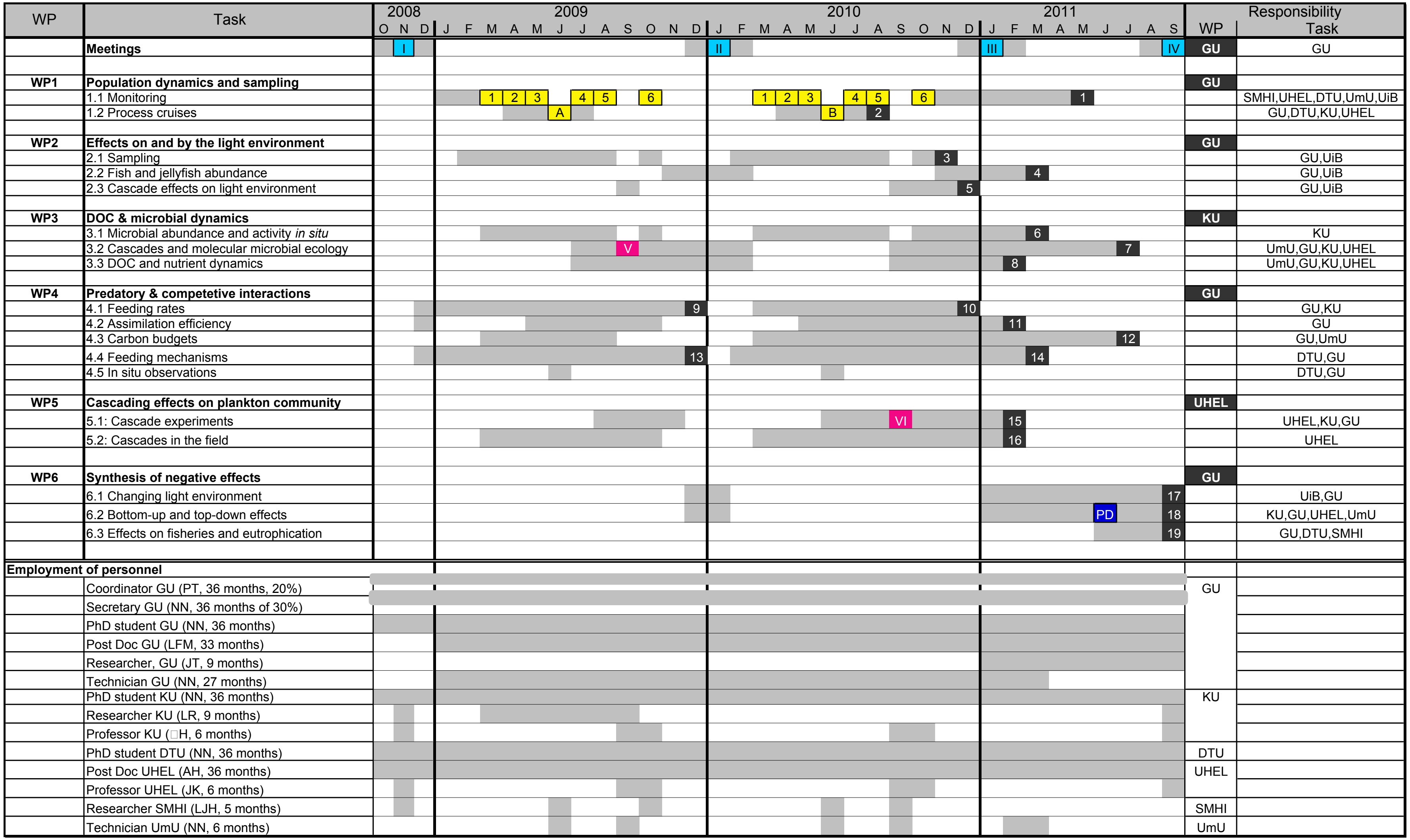
12. GANTT CHART



WP	Task	Responsibility WP	Responsibility Task
	Meetings	**GU**	GU
WP1	**Population dynamics and sampling**	**GU**	
	1.1 Monitoring		SMHI,UHEL,DTU,UmU,UiB
	1.2 Process cruises		GU,DTU,KU,UHEL
WP2	**Effects on and by the light environment**	**GU**	
	2.1 Sampling		GU,UiB
	2.2 Fish and jellyfish abundance		GU,UiB
	2.3 Cascade effects on light environment		GU,UiB
WP3	**DOC & microbial dynamics**	**KU**	
	3.1 Microbial abundance and activity *in situ*		KU
	3.2 Cascades and molecular microbial ecology		UmU,GU,KU,UHEL
	3.3 DOC and nutrient dynamics		UmU,GU,KU,UHEL
WP4	**Predatory & competetive interactions**	**GU**	
	4.1 Feeding rates		GU,KU
	4.2 Assimilation efficiency		GU
	4.3 Carbon budgets		GU,UmU
	4.4 Feeding mechanisms		DTU,GU
	4.5 In situ observations		DTU,GU
WP5	**Cascading effects on plankton community**	**UHEL**	
	5.1: Cascade experiments		UHEL,KU,GU
	5.2: Cascades in the field		UHEL
WP6	**Synthesis of negative effects**	**GU**	
	6.1 Changing light environment		UiB,GU
	6.2 Bottom-up and top-down effects		KU,GU,UHEL,UmU
	6.3 Effects on fisheries and eutrophication		GU,DTU,SMHI
Employment of personnel			
	Coordinator GU (PT, 36 months, 20%)	GU	
	Secretary GU (NN, 36 months of 30%)		
	PhD student GU (NN, 36 months)		
	Post Doc GU (LFM, 33 months)		
	Researcher, GU (JT, 9 months)		
	Technician GU (NN, 27 months)		
	PhD student KU (NN, 36 months)	KU	
	Researcher KU (LR, 9 months)		
	Professor KU (□H, 6 months)		
	PhD student DTU (NN, 36 months)	DTU	
	Post Doc UHEL (AH, 36 months)	UHEL	
	Professor UHEL (JK, 6 months)		
	Researcher SMHI (LJH, 5 months)	SMHI	
	Technician UmU (NN, 6 months)	UmU	

Meetings	
I	Kick off
II	2009 meeting
III	2010 meeting
IV	Final symposium

Process cruises	
A	Skagerak
B	Skagerak

Monitoring cruises	
1	Dana
2	Argos
3	Argos, Aranda, KBV005
4	Argos, KBV005
5	Argos, Aranda, KBV005
6	Dana

Mesocosm workshops	
V	Mesocosm workshop, KU
VI	Mesocosm workshop, UHEL

PhD course	
PD	Cascading effects of gelatinous zooplankton

Milestones	
1	Abundance of zooplankton and other parameters from monitoring sampling analysed
2	Process cruises finished
3	Data on optical properties and light analysed and ready
4	Analysis of interaction between jellyfish and fish ready
5	Cascading effects on light in mesocosms analysed
6	Overview of bacterial/viral abundance and bacterial production *in situ*.
7	Completed analyses of food web cascading effects on the microbial loop
8	Overview of direct and indirect effects of *Mnemiopsis* on DOC dynamics
9	Feeding rates of *Mnemiopsis* on typical prey determined
11	Assimilation efficiency of Mnemiopsis and other jelly fishes determined
12	Understanding of the role of jelly fishes for the carbon flow of the Baltic
13	Flow fields and hydrodynamic disturbances of *Mnemiopsis* determined
14	Mechanistic understanding of the predation on typical prey and cod egg and larvae achieved
15	Cascading effects on phyto/zooplankton from mesocosms determined
16	Cascading effects on phyto/zooplankton in the field determined
17	Final understanding of light and optical effects
18	Final understanding of cascading effects of *Mnemiopsis*
19	Holistic overview of major ecosystem effects of *Mnemiopsis*