



First BONUS BIO-C3 periodic report, 01.01.2014 – 31.12.2014

Grant agreement number: call2012-107

Project acronym: BIO-C3

Project title: Biodiversity changes – causes, consequences and management implications

Period covered: from January 1st 2014 to December 31st 2014

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Overview

All scientific work in BIO-C3 is currently advancing in line with the project document of work, and we expect to meet the official schedule of deliverables. Work packages (WP) 1 to 4 are running, whereas WP5 - which requires input from WP1 to 4 and officially starts in project month 14 – will embark in 2015. The key focus in the reporting period was the creation of a solid data and sample foundation and the establishment of cultures required for the experiments, analyses and models to come. However, although the first scientific project deliverable is only due in project month 20, scientific results and output are starting to accumulate, and have been used to inform stakeholders and the public at numerous occasions.

One WP overarching benefit of BIO-C3 is increasingly becoming reality: the improved coordination of large-scale scientific activities in the Baltic Sea. This includes the coordination of the temporal and thematic coverage of research cruises of the consortium in the Baltic (9 in total in 2014), and the initiation of new collaborative activities (e.g., sampling initiatives of invasive combjelly *Mnemiopsis leidyi*, invasive round goby *Neogobius melanostomus*; assembly, data harmonization and collaborative use of long-term data series on meso-zooplankton (Section “Other relevant information, page 31).

In terms of the management structure (WP6), the establishment and maintenance of the BIO-C3 website, including internal pages used for document sharing, and of BIO-C3 mailing lists now provides the foundation for efficient communication in the years to come. An example is the review task in WP1.1, relying on contributions of all partners, that has benefited from discussions on the project mailing list. The BIO-C3 2015 meeting, scheduled for July 1-3 in Kiel, and the BIO-C3/BAMBI/INSPIRE Summer school “*The Baltic Sea: a model for the global future ocean?*” July 5-11 in Glücksburg, Germany, will be used to strengthen collaborative links further, and will place specific focus on the integration of new scientific information from WP1-3 into modelling and synthesis tasks in WP 3-5.

2014 has also seen the establishment off close interactions between BIO-C3 and the thematically related BONUS projects BAMBI and INSPIRE. This includes collaborations on sampling and research, as well as the planning for the 2015 joint summer school and the joint theme session “*From genes to ecosystems: spatial heterogeneity and temporal dynamics of the Baltic Sea*” at the 2015 ICES Annual Science Conference.

In the following, the scientific activities and progress in each of the project WPs is summarized (Scientific report, pages 5-31). This is followed by the summary of BIO-C3 output and statistics for 2014 (Performance statistics report, pages 32-44).

I. Scientific report

1. Scientific results during the reporting period (by work package)

WP1 – Genetic adaptation and ecophysiology

Lead: Dorte Bekkevold, P2 DTU Aqua

Overview:

WP 1, “Genetic adaptation and eco-physiology”, investigates physiological tolerances and adaptive variation of key Baltic Sea species. The goal is to provide a general understanding of principal determinants of the distribution of species and populations, which ultimately determine the functional diversity and resilience of Baltic Sea ecosystems in response to environmental drivers. WP1 output will feed into WP2, 3 and 4, and is therefore crucial for the incorporation of evolutionary processes into future projections of the Baltic Sea. Work in all three tasks in this WP is going according to plan.

Task 1.1: Environmental conditions, eco-physiology and species distribution

Lead: Axel Temming, P3 UHH, participation of Partners P1-8 and P11.

Deliverable 1.1: *Review of environmental factors influencing distributions of selected Baltic species. (Month 20)*

Milestone 1.1: *Preliminary overview on how environmental factors determine key species distribution. (Month 12)*

Work is on-going, according to plan. Responsible persons for the respective species and functional groups were assigned, and participants have collectively completed an overview (meta-data) table, tabulating which species, populations, environmental factors (hereunder hydrological conditions), spatial distributions, etc., are to be treated with respect to environmental tolerances and preferences. This table is currently used for the internal exchange between work packages and will be finalized according to the deliverable schedule. The end product of this effort will be a focus at the BIO-C3 meeting in July 2015, in order to ensure that the resulting data are transferred efficiently into WP2, 3 and 4.

In addition to extensive literature reviews, partners have contributed with a number of datasets that were previously not accessible in this form to the scientific community, e.g., the analysis of existing long-term data series and data extraction from existing databases. Key work-lines include:

- The analysis of ICES survey data from Baltic International Trawl Survey (BITS) for cod and flatfish has started, with the aim to provide actual distribution maps. The next step is to combine fishing data with hydrographical data to trace physiological barriers. The merging of catch data and hydrographical data is complicated due to the

fact that these datasets are stored in different data bases at the ICES platform. However, work is progressing according to plan and a data synthesis is underway.

- Information on the spatial distribution of the key benthic invertebrate species in the NE Baltic Sea was collated into a geo-referenced GIS database, and then related to available data on abiotic drivers potentially affecting the spatial range of the species. Calculations of environmental tolerance and preference are pending to the decision of species and environmental proxies to be included into the final analyses.
- Spatio-temporal distribution of goby larvae was identified in Pärnu Bay (Estonia). *Pomatoschistus minutus* strongly dominated whereas *P. microps* and *Gobius niger* occurred relatively sporadically. Distribution of the non-native cladoceran *Evadne anonyx* has been studied in relation to temperature and salinity in the Gulf of Riga and Pärnu Bay since shortly after its first detection in 2000. The abundance of the species has remained low, seldom exceeding 100 individuals m⁻³ with both salinity and water temperature affecting the spatial distribution and population abundance. The species was found to occur only sporadically at salinities below ca. 6 PSU.
- Historical phytoplankton datasets were compiled to investigate the distribution of planktonic species. Baltic Sea wide phytoplankton distribution and dynamics are analyzed. Ichthyoplankton, zooplankton and environmental data from the ongoing time series in the Kiel Fjord and the adjacent Kiel Canal from the period 2007-2013 were analyzed for relationships between temperature and fish larvae abundance. Temperature played a significant role in determining the abundance of Gobideae and Clupeidae (Webers, 2014, BSc thesis¹).
- Benthic samples were collected and analysed in order to update the distribution model of *Marenzelleria* spp.. The presence of *Marenzelleria viridis* within the Lithuanian coastal zone was confirmed by metabarcoding of eDNA samples. Historical data on the species distribution within the area was compiled. The analyses of environmental factors affecting species distribution are on-going.

Task 1.2.: Physiological tolerance, preference and phenotypic plasticity

Lead: Catriona Clemmesen, P1 GEOMAR, participation of partners P2-P8.

Deliverable 1.2: *Documentation of key drivers and physiological tolerance limits for selected resident and invasive species. (Month 26)*

Milestone 1.2: *Assessment of physiological tolerance completed. (Month 22)*

Work is on-going, according to plan. Specifically, the evaluation of physiological tolerance, preference and phenotypic plasticity in relation to environmental factors has started for a range of different species. Specific lines of work are listed in the following:

¹Webers, F. (2014) Occurrence of fish larvae in the Kiel Canal and the Kiel Fjord in relation to water temperature (Bachelor thesis), Christian-Albrechts-Universität Kiel, Kiel, Germany, 42 pp.

- Herring (*Sprattus sprattus*) larvae were experimentally exposed to increased temperature crossed with different CO₂ concentrations to simulate the effect of ocean acidification scenarios. Gene expression analysis was performed on 32 candidate genes related to acid-base regulation, heat stress regulation, immune system response and metabolism. Results indicated two types of responses. As a response to exposure to different lower pH levels a hermetic, dose dependent response was identified, while gene expression analyses in a crossed pH-temperature treatment indicated phenotypic buffering (Listmann 2014, M.Sc thesis²).
- A series of experiments investigating functional feeding responses in different size classes of sprat was conducted at a wide range of temperatures. These data will be combined in a subsequent step with field data on plankton densities to estimate the environmental limits within which successful feeding and growth is possible.
- An experiment on the early life stages of cod (*Gadus morhua*) was performed to assess the trans-generational effects of ocean acidification on larval cod growth and mortality. Adult cod were incubated in either 380ppm or 1200ppm CO₂ for three weeks prior to spawning. Eggs were then collected and transplanted to incubators with the same or opposite treatment as the parents. The eggs were incubated for 14 days and the larvae later reared until 36 days post hatching. Additionally, eggs from un-incubated parents were hatched and reared in different CO₂ environment. Data analysis is on-going. A follow up experiment with longer parental incubation time and focusing on epigenetic analyses is under development.
- During the April 2014 RV ALKOR cruise, >1150 individual egg buoyancies of cod (*Gadus morhua*), flounder (*Platichthys flesus*), dab (*Limanda limanda*), sprat (*Sprattus sprattus*) and four-bearded rockling (*Rhinonemus cimbricus*) were determined using combinations of plankton net hauls and artificial strip spawning of individuals caught in fisheries hauls. In total 27 egg batches were successfully fertilized and measured in gradient columns. Of these, 20 were flounder egg batches (Bornholm Basin, N=4; Gdansk Deep, N=2; Gotland Basin; N=14), 5 cod egg batches (Arkona Basin, N=2; Bornholm Basin, N=2; Gdansk Deep, N=1), and 2 dab egg batches (both from Kiel Bight). To our knowledge, we have determined for the first time the egg buoyancy development from fertilization to first hatch for dab. Next steps are to compare the recent results with data from past years and similar, planned experiments in 2015. This will be particularly interesting due to the large inflow of higher saline water into the Baltic Sea in December 2014, representing strongly different environmental conditions compared to the stagnation years before.
- A workshop on round goby was held on 4-5 September 2014 in Copenhagen, jointly organized by BIO-C3 and the NORDEN project "*Round goby – need for collaborative science and management in Nordic and Baltic countries*". The aim was to facilitate information exchange between scientists and stakeholders as well as initiating new research and discussing management issues related to this invasive species in the Baltic Sea. An outcome of the workshop was the preparation of a manuscript identifying issues and actions to be considered prior to implementing post-invasion

²Listmann, L. (2014) Gene expression analysis in Atlantic herring (*Clupea harengus*) in response to temperature and CO₂ (Master thesis), Christian-Albrechts-Universität Kiel, Kiel, Germany, 52 pp.

management of the round goby (*Neogobius melanostomus*)³. In connection with the workshop, a round goby tissue sampling program was initiated (Appendix 1), to facilitate analyses of invasion genetics under Task 1.3.. This effort has already resulted in an extensive round goby tissue sample set, preserved in ethanol for genetic analyses. The sampling will continue in the future, in order to be able to include temporal variation in the analysis. Several collections were taken in connection with other BIO-C3 activities; e.g. TI-OF sampled round gobies in Greifswald Bay, Germany, for the study of trophic interactions with the resident faunal community.

- Round gobies were caught with hand-lines in the Trave estuary, Germany, and maintained at 16 psu and 12°C in aquarium facilities. Repeated spawning was observed and subsequently triggered systematically by means of specific habitat structures and combination of small groups of male and female individuals. In preliminary trials the egg development was studied under these relatively high salinities and found to be significantly longer than reported in the literature for lower salinities. However, hatching was successful and a number of larvae were raised to 2 cm juveniles.
- In relation to hydrography effects of goby distribution, a hand-line survey was established along the German coast of the Mecklenburg Bight and Kiel Bight. We found a distribution 'hot spot' in the Trave estuary and in parts of the Kiel Fjord, and lower concentrations along the coastline between these two regions. North of Kiel Fjord abundances declined rapidly. Generally in regions with low abundance of round goby the abundance of black goby was higher. From all samples otoliths were collected to allow the comparison of growth in the different regions. These data will be analyzed in the framework of a bachelor thesis at the University of Hamburg.
- To test whether salinity may act as a barrier for natural dispersal of juvenile and adult round goby, experiments on salinity tolerance and preference are currently being performed. The aim is to implement an aerobic scope model and evaluate osmoregulation and growth capacity, all as a function of salinity.
- External drivers and local environmental conditions contributing to the spatial distribution of the round goby in the Baltic Sea were modelled. Based on the collected distribution data, an updated map on the species distribution and its invasion progress in the Baltic Sea was produced.
- The copepod *Eurytemora affinis* was sampled along the latitudinal gradient of the Baltic Sea, and laboratory cultures were established to test their physiological tolerance. Populations from the following sites were successfully established: Bothnian Bay (North), Gulf of Riga (East), Askö (West), and Öland/Kalmar (South). Experiments with three *E. affinis* populations were conducted to test the response to changing salinity and temperature, as well as morphological differences, with

³Ojaveer H, Lehtiniemi M, Christoffersen M, Clink S, Florin A-B, Galil BS, Gruszka P, Puntila R & Behrens J ' Risk-averse: post-invasion management of the round goby *Neogobius melanostomus* in the Baltic Sea', under review in *Management of Biological Invasions*'.

development time of individual stages and egg production measured as response variables.

- The copepods *Temora longicornis* and *Acartia bifilosa* were isolated from the Kattegat and Baltic Proper. Laboratory cultures were established to test the physiological tolerance of these species. Due to contamination problems with heterotrophic dinoflagellates one culture of *Temora longicornis* from the Baltic Proper was lost and needs to be re-established in spring 2015. Experiments on instantaneous and long-term salinity tolerances with regard to reproductive success and offspring survival were conducted as planned to identify the critical limits and underlying mechanisms of salinity adjustments. These data are required to plan and interpret upcoming common garden experiments. The experiments will be continued in 2015 together with common garden experiments under Task 1.3.
- Two field surveys were conducted in 2014, representing 17 locations along a salinity gradient from the Nemunas river mouth to the Curonian lagoon to the western edge of the Lithuanian EEZ. Zooplankton and phytoplankton samples were collected within vertically stratified water columns above and below the halocline. Meso- and microzooplankton species composition and distribution along those gradients is currently being analyzed.
- Zooplankton biodiversity within the Lithuanian coastal zone was assessed from samples collected in 2013, applying novel molecular techniques (meta-barcoding). The results were compared to the data obtained with traditional monitoring methods. The results of the study are submitted for publication. Information of NIS distribution is being updated in the AquaNIS database (incorporating the results of the current studies from BIO-C3).
- A tissue sampling protocol was developed for the invasive comb jelly *Mnemiopsis leidyi* (Appendix 1). Collections were initiated and will continue in 2015. The genetic analysis of these samples is in preparation.

Task 1.3.: Adaptive evolution of resident versus invasive species

Lead: Thorsten Reusch, P1 GEOMAR, participation of partners P2-5, P7, P11.

Deliverable 1.3: *Report on adaptive evolution linking trait and functional genetic variance for selected species.* (Month 32)

Milestone 1.3: *Assessment of functional diversity and potential for adaptations completed.* (Month 22)

The analysis of genetic adaptations and adaptive potential in response to different environmental drivers in a range of focal species is on-going, according to plan. This includes the establishment of sample collections and cultures needed for further analyses. Where sample collections (e.g., from long-term data series) were available from the onset of the

project, laboratory analyses are now underway. Specific lines of work are detailed in the following:

- Genetic analyses of cod (*Gadus morhua*) in the Baltic Sea:

A first line of work focuses on cod in Arkona Basin (ICES subdivision SD24). In preparation for genetic time series analyses, an inventory of available time series was carried out and an extensive contemporary baseline dataset has been assembled. The latter consists of hundreds of adult and juvenile samples distributed both spatially (within SD24) and temporally (collected throughout the year). These samples will provide important reference material for the interpretation of historical patterns of population distributions and potential changes. The inventory of available historical material from SD24, in particular otoliths that have been collected through monitoring programmes, will be catalogued to ensure that historical analyses will target geographically and temporally relevant samples.

A second line of work focuses on time series of cod genetic diversity in response to environmental drivers and changes in stock structure in the Bornholm Basin (ICES SD25). This study integrates datasets on oceanographic parameters, cod biology and neutral and selected genetic markers. The assembly of the individual datasets needed for this integrative analysis was completed. In particular, genetic datasets (microsatellite and SNP data) of archived Bornholm Basin cod samples spanning the years 1992 – 2011, probabilistic maturation reaction norms, and time series of environmental condition and cod stock structure for the same period were collated. Data analysis is currently running and is going according to plan.

- Selection experiments with two populations of the copepod *Eurytemora affinis* in response to changing salinity were conducted to determine whether thermal performance could evolve within selected populations. Samples were preserved in order to test the genetic variation between *E. affinis* populations. The design for further selection experiments under changing salinity and temperature with *E. affinis* populations was planned. Common-garden studies are under planning for different populations of *Temora* and *Acartia* to determine local tolerance and adaptation potential.
- Tissue samples of round goby (*Neogobius melanostomus*) from sites spanning the area of distribution in the Baltic Sea and from different timepoints have been collected by collaboration of a large number of participants. This sample set will be used to conduct a study addressing phylogeography, invasion paths and dynamics in this invasive species. The collections were initiated in collaboration with a large number of partners from both BIO-C3 and the NORDEN round goby network.
- Together with DTU-Aqua and the IOW (Leibniz Institute for Baltic Sea Research Warnemünde), the TI-OF conducted a two week cruise in the Bornholm Basin and Gdansk Deep. The objective of the first week was to record the abundance and distribution of fish species in the Bornholm Sea and Gdansk Deep, focusing on the abundance, vertical and horizontal distribution and feeding ecology of herring, sprat and cod. Data on hydrography were recorded in parallel. The objective of the second

week was to determine the density and abundance of phytoplankton, zooplankton, ichthyoplankton and gelatinous plankton in the Bornholm Sea in order to analyze their dependence on local hydrographic features in the area, including seawater salinity, temperature and oxygen saturation. The plankton samples were transferred to DTU and IOW for further analyses, while remaining samples acquired during the hydroacoustic survey were analyzed at TI-OF. The survey will be repeated in 2015 and a MSc study will be initiated in April 2015 to analyze the data gathered during several successive years with a particular focus on the question, what effect the massive inflow of North Sea water into the central Baltic sea (December 2014) has on the local fish community.

- A tissue sampling protocol was developed for the invasive comb jelly *Mnemiopsis leidyi* (Appendix 1), and a sampling initiative was started and will continue in 2015. The genetic analysis of these samples is in preparation.

WP2 – Food webs under changing biodiversity

Lead: Axel Temming, P3 UHH

Overview:

Biodiversity influences food web structure, ecosystem functioning, and stability. Recently, changes in community composition on nearly all trophic levels, including planktonic and benthic foodwebs and fishes were described in the Baltic Sea, but the underlying processes by which these changes impact coastal and pelagic systems are only partly understood. WP 2 investigates the consequences of changing biodiversity including non-indigenous species on Baltic food web configurations, transfer of energy and essential compounds, and productivity of the system using a combination of existing information, field work, experiments, and modelling, and considering different trophic levels, functional groups and habitats. The work in all three tasks of this WP has started as planned, and no major problems are anticipated.

Task 2.1: Bottom up control

Lead: Monika Winder, P4 SU, participation of P1, P2, P3, P5, P9, P11.

Deliverable 2.1: *Report on effects of changing drivers on pelagic and benthic species composition and production. (Month 24)*

Milestone 2.1: *Analysis of bottom up control mechanisms under impact of various drivers done. (Month 16)*

This task investigates how shifts in benthic and pelagic species composition at the base of the food web, as well as temporal and spatial mismatch among interlinked trophic levels (e.g., zooplankton/fish larvae) influence energy and nutrient flow and overall productivity. All work to date is going according to plan, with specific progress described below:

- Cruises with RV Alkor were conducted in April and May 2014 to continue time series that investigate bottom up effects and spatio-temporal match/mismatch among interlinked trophic components of the food web. Analysis of the phenology and nutritional condition of larval cod is ongoing. (P1)
- Regarding the creation of coherent seasonal time series to identify the phenological variability of plankton in the pelagic food web, hydrographical measurements and diverse sampling for phyto-, microzoo-, mesozooplankton and fish larvae were conducted on 10 cruises to the Bornholm Sea in 2014. The analysis of samples progresses as scheduled in the research plan. Existing data-sets from the years 2011-2013 relevant to estimate the inter-annual variability of controlling bottom up mechanisms were identified, but require the analysis of complementary samples. Analysis of distribution and abundance of *Mnemiopsis leidyi* is ongoing in collaboration with P1 and IOW, and collection of samples for genetic analyses from several cruises in the Baltic and North Sea to analyse invasion pathways has been performed. (P2)
- Previous studies published by P2 on the Baltic Sea imbalance in essential lipids available in the food web, in particular arachidonic acid (ARA) and docosahexaenoic acid (DHA) are followed-up to elucidate effects on clupeid and cod nutritional and reproductive status. A concept and plan for sampling and analyses was prepared in July 2014 with contributions from P3 in particular regarding zooplankton. Results will be compared with similar data from years with different conditions obtained in 2003-4 and 2007-8. Sampling of benthos, zooplankton, clupeids and cod was conducted during the Baltic International Trawl Surveys (BITS) in November 2014 and lipid, fatty acid and histological analyses are ongoing. Baltic female and male cod larger than 15 cm were systematically sampled including: morphometric data, gonads and liver for fatty acid analysis, and histological samples for maturity stages and size classes. This sampling program will be continued throughout 2015. In addition, cod larvae and zooplankton have been sampled and will be analysed to interlink plankton prevalence and cod larval condition and growth in collaboration with P1. Samples for analysis were selected, and laboratory work has been initiated. (P2)
- Furthermore, for cod as a key species in the Baltic Sea ecosystem, population dynamics are being analyzed to investigate the extreme changes in survival, growth and nutritional status. Danish data on cod size, condition and maturation are analyzed using a detailed 20 year data series initiated in 1995 supplemented by new data. The sampling of cod during the BITS surveys in November 2014 also included visual maturity staging of cod and sampling for histological verification conducted in a joint effort with the EU financed sampling program. Histological verification of maturity determination in SD25 as well as preliminary analysis of the data series will be available at the ICES Benchmark workshop on Baltic cod stocks (WKBALTCOD) in March 2015. (P2)
- A data base on Baltic cod stomachs has been developed in the frame of an EU financed tender, including >100 000 stomachs so far not included in the ICES database. The specifications for the tender do not foresee detailed information on catch position. In order to develop the database for the analysis of potential feeding hot spots, a sub-set of the database (ca. 30 000 stomachs) was prepared to include

precise positional information. Once identified, feeding hotspots will then be compared with observed cod conditional indices and distribution of cod eggs to identify the potential role of feeding hot spots in egg production in a spatially explicit context.

- Work to compare the linkage of cod to the benthic or pelagic food web with special emphasis on the supply of arachidonic acid (ARA) is ongoing. Liver, muscle and gonads of Baltic female cod were sampled during the RV Alkor cruise in August 2014, covering all abundant maturity stages and size classes. These samples will be interpreted with regard to lipid quality markers. In addition, in order to trace ARA through the food web and compare the influence of the pelagic and benthic production, various potential prey organisms, such as benthic macro- and mega-fauna as well as sprat and herring were sampled. The biochemical analyses are ongoing as planned. These data will be compared with samples to be collected in 2015 from regions where a strong overlap between cod and round goby is expected. A first set of feeding experiments with Baltic cod comparing the influence of pelagic and benthic prey on fatty acid composition and condition was performed. These will be followed by more experiments in 2015 according to the work plan. (P3)
- Phytoplankton laboratory cultures were established and sampled for a quantitative comparison of key food quality parameters (fatty acid, amino acids) using various species across four major phytoplankton groups. Laboratory experiments were conducted to test the transfer of essential compounds (fatty acid, amino acids) to copepods, cladocerans and rotifers using a high- and low-quality alga as food source in combination with compound-specific stable isotopes. Data are currently being analyzed and summarized in a manuscript. (P4)
- In addition, compound-specific stable isotope of carbon amino acids was used to estimate resource use of a key zooplankton species (*Acartia* spp.) in the Northern Baltic Proper over the season. Therefore, zooplankton seston samples were collected for stable isotope analysis and combined with phytoplankton counts from the monitoring program. This study is being finalized. (P4)
- Laboratory experiments were conducted to investigate whether microzooplankton maintains homeostasis. Therefore, the food source (phytoplankton) was grown under different nutrient concentrations of nitrogen and phosphorus (different food quality) and fed to dinoflagellates, ciliates and rotifers. Stoichiometric ratios (C:P, C:N, N:P) of prey and consumers were measured after six days of feeding on the respective food, as well as cell size and growth rates. The results are published in the Journal of Plankton Research. (P4)
- Data compilation for analyses of trophic interactions between zooplankton and fish larvae, based on samples collected from the Baltic Proper in the past, is ongoing. (P5)
- Analysis of fine-scale monitoring data on herring *Clupea harengus membras* larvae and their environment was started in a coastal habitat in the Gulf of Riga during 2004-2013. The key habitat characteristics to be included in the analysis are water temperature and abundance of the main herring larvae prey, the copepod *Eurytemora*

affinis. This study will shed light on the factors influencing the abundance of various size groups of larval herring. (P6)

- Daily growth rate and instantaneous mortality of larvae of the two dominating marine fish species in the Gulf of Riga, herring and gobies *Pomatoschistus* spp., were investigated at two coastal stations to assess the spatial variability and drivers of fish larvae growth. It was concluded that despite of abundant food, shallow coastal areas might act as a 'predation trap' for fish larvae when temperatures are high, due to high metabolic requirements of vertebrate predators. A resulting manuscript is under revision. (P6)
- Two high-resolution coupled bio-geochemical and ecological models were set-up for the Gulf of Riga and Pommeranian Bay pilot areas. The bio-geochemical models will provide hindcasts of hydrodynamic and water quality parameters, including dissolved nutrients covering the period 1970 to present. The ecological models will provide time series of growth of rooted vegetation, macrophytes, *Mytilus* and *Macoma*. Based on these hindcasts energetic models are being established which describe the predation pressure and survival of predators feeding on vegetation and bivalves. These predators will be round goby, cyprinids (as a group), long-tailed duck, velvet scoter, common scoter and mute swan. Trends in the survival of predators will be analysed for different depth strata from the lagoons to the coast and from the coast to the slopes of the Bornholm and East Gotland Basin. The calibration of the ecological model on *Macoma* as well as the predator models are delayed, but we expect to finalise these within the mile stone deadlines. (P9)
- Together with DTU-Aqua and the IOW the TI-OF conducted a 2 week cruise in the Bornholm Basin and Gdansk Deep to (1) observe the abundance and distribution of fish species in the Bornholm Sea and Gdansk Deep, and to (2) determine the density and abundance of phytoplankton, zooplankton, ichthyoplankton and gelatinous plankton in the Bornholm Sea in order to analyse their dependence on local hydrographic features in the area. The plankton samples were transferred to DTU and IOW for further analyses, while remaining samples acquired during the hydroacoustic survey were analysed at TI-OF. The survey will be continued in 2015 and a MSc study will be initiated in April 2015 to analyse the data gathered during several successive years with a particular focus on the question, what effect the massive inflow of North Sea water into the central Baltic sea (December 2014) will have on the local fish community. (P11)

Task 2.2: Top down control

Lead: Olle Hjerne, P4 SU, participation of P1, P2, P3, P5, P11.

Deliverable 2.2: *Report on effects of changing predation pressure on benthic and pelagic species. (Month 26)*

Milestone 2.2: *End of analysis of consequences for biodiversity of changing selective predation (top-down control). (Month 12)*

This task aims at understanding consequences of changing selective predation pressures on biodiversity in the Baltic Sea, using a combination of historical data series, monitoring data, new field studies and laboratory analyses, and modelling. Progress has been made on all of these aspects, including the collection of data needed to assess effects of different predators, and the implementation of several models to assess top-down control. Work is progressing according to plan, with details on specific lines of work summarized below:

- Stable isotope analysis of cod (*Gadus morhua*), herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) samples from the Western Baltic, Arkona Basin, Bornholm Basin, Gdansk Deep and Gotland Basin collected during the May 2012 and April 2014 cruises with RV Alkor was completed. This work has so far resulted in a Bachelor thesis (Mohm 2014⁴), available via the BIO-C3 website. Additional statistical analyses focusing on ontogenetic shifts, general feeding ecology of the three species, and spatial differences between basins is ongoing. Discussion of the resulting dataset with P2 and P3 in the context of existing stomach content data for the same species, and subsequent publication of results is planned for 2015. (P1)
- (1) *Cascading top-down effects by cod*: The latest data in the ICES cod stomach content database stemmed from 1993. Since then, the Baltic has changed markedly. Abundance and spatial distribution of cod and its major fish prey, herring and sprat have changed. Furthermore, due to the occurrence of extended hypoxic areas on the sea-bed, the availability of benthic food may also have changed dramatically. In an EU funded stomach tender, more than 100 000 stomachs have been added to the existing database of 49 476 stomachs. In BIO-C3, the stomach data have so far been transformed to give frequency of occurrence of the different major prey species *Saduria entomon*, sprat and herring by ICES statistical rectangle and month/year. The data cover the whole Eastern Baltic Sea and the time period 1964-2014. (P2)
- (2) *Cod top-down control on Saduria*: Data on *Saduria* in the cod diet were isolated from the cod stomach content database. The data include observed number and weight of *Saduria* individuals in cod stomachs, and can be transformed back to ingested mass of *Saduria*, in different periods and regions.
- A cruise with RV ALKOR was conducted in August 2014. Sprat abundance and diet, and zooplankton abundance were investigated. New stomach samples of sprat were collected in three main basins: Arkona and Bornholm Basin and Gdansk Deep. The trend of decreasing sprat abundances in the Bornholm Basin in summer has further established. Sprat were most abundant in the Arkona Basin, and almost absent in the more eastern Bornholm Basin. Zooplankton abundance was measured with net samples and the Video Plankton Recorder. Additional work was conducted to improve and complete the existing databases containing stomach content data and zooplankton abundance. (P3)
- Multivariate autoregressive (MAR) models were used on historical phytoplankton and environmental time series (28 and 20 yrs, respectively) at one coastal and open sea

⁴Mohm, C. (2014) Feeding ecology of Baltic cod assessed by stable isotope analysis (Bachelor thesis), Christian-Albrechts-Universität Kiel, Kiel, Germany, 42 pp.

station in the Northern Baltic Proper to investigate drivers of phytoplankton annual and seasonal dynamics and community interactions and differences between sites. This study is in review. (P4)

- A preliminary mesocosm experiment was conducted to investigate the effect of temperature on food web interactions, feedbacks, and potential adaptations of zooplankton. For this purpose, a transplacement experiment with the plankton community inside and outside the heated Forsmark experimental area was used. Samples are being analyzed and used for planning of an upcoming experiment. (P4)
- Historical data of benthic species composition and abundance as well as cod abundance and consumption were compiled from the Bornholm basin to investigate the role of cod top-down control on benthos. Data are being quality checked and analyzed. (P4)
- A study was conducted to estimate the magnitude and uncertainty of seal prey consumption using bioenergetics modeling, population and diet data. The consumption of seal was compared to fish catches to assess potential resource competition between seals and fisheries. The results are in review. (P4)
- The review of information on potential impacts of fish larvae on zooplankton in the Vistula Lagoon (Poland) was initialized. (P5)
- The role of microzooplankton on algal community structure and the food web effects of allochthonous matter via bacteria were reviewed based on experimental and monitoring data. All available Baltic Sea monitoring data (both published and unpublished) on allochthonous matter inputs and its cycling in the pelagial system has been assembled into a quality checked data file, and carbon budget calculations based on these data were completed. This information will be included on the common BIO-C3 website. The experimental microzooplankton grazing data from the Lithuanian coast is at manuscript stage. The grazing rates and food web effects can be applied to microzooplankton communities in the Baltic Sea. (P7, P8)
- TI-OF extended its small-fish monitoring on a herring spawning bed within Greifswald Bay, one of the most important spawning grounds of the spring-spawning herring of the Western Baltic Sea. Whereas monitoring was previously restricted to the herring spawning season in spring, it now covers the seasonal changes in the faunal community throughout the year. Beach seine sampling has been conducted monthly since spring 2014 and analysis of these samples is in progress. A preliminary result is the observation of an increasing abundance of round goby in the shallow parts of an important spawning bed within Greifswald Bay (below 2 m water depth), which coincides with the decrease of formerly dominant fish species (e.g., threespine stickleback *Gasterosteus aculeatus*). The increase in abundance appears to be still in progress. Field sampling and the analyses of existing samples and data from earlier investigations and surveys will continue to further examine the expansion of round goby within Greifswald Bay. (P11)

- Existing data and samples on the effects of stickleback predation on the survival of herring eggs within Greifswald Bay were analyzed. For example, earlier published results of field experiments (predator exclusion experiments) conducted with artificially spawned substrates (Kotterba et al., 2014) were now confirmed by analysing data from additional experiments that used naturally spawned substrates within the spawning area. Both experiment types show a relatively high predation effect of the small fish community on herring eggs during particular periods of the spawning event in spring. A manuscript for a peer reviewed publication is in preparation. (P11)
- To examine the spatio-temporal overlap between herring spawn and its predators, weekly herring egg samples were taken on fixed transects located in different depths with a Van-Veen-Grab, and the small fish community in shallow water was sampled with a beach seine net. Preliminary results show significant differences in spawning behaviour, egg mortality and predator abundances for the years covered so far in the analyses (2012-2014). This study will be continued in 2015. Previously sampled stomachs of dominant predators are currently being analysed. The results will be implemented into models to extrapolate the predation effect on herring spawn for the different years. (P11)

Task 2.3: Changes in food web function and diversity due to non-indigenous species

Lead: P7 SYKE, participation of partners P2, P3, P5, P6, P8, P11.

Deliverable 2.3: *Report assessing the effects of key NIS on ecosystem functioning.* (Month 38)

Milestone 2.3: *Drift models to establish spread of non-indigenous species established.* (Month 30)

This task focuses on direct and indirect food-web effects of increasing abundance and expanding ranges of invasive non-indigenous species (NIS), as well as habitat engineering through these effects on native populations. Work to date is going according to plan, and progress is described in more detail below:

- The invasive ctenophore *Mnemiopsis leidyi* was sighted in northern Europe, including the Baltic Sea up to the south-western Polish coastline from 2005 to 2010. Probably due to cold winter conditions in 2010-2013, *M. leidyi* disappeared from large regions, such as the Baltic Sea, while maintaining its presence in the North Sea. Limfjorden, connecting the North Sea with the Baltic Sea, suffers from severe eutrophication but hosts a yearly *M. leidyi* population, with two orders of magnitude higher abundances than normally observed in northern Europe. We are currently investigating the hypothesis that Limfjorden acts as source region for invasive species, sustaining populations in lower reproductive regions or seeding populations after local extinctions, by use of a meteorologically driven hydrodynamic drift model combined with field observations and molecular analyses of *M. leidyi* from different regions of the extended Baltic Sea area. Preliminary analyses of this work in progress show that

particles released from Limfjorden are partly transported towards the SW Baltic and may reach the central Baltic Sea. Further, we were able to validate our drift model with field observations during the research cruises in the southern and central Baltic Sea in 2014, and collected molecular samples to follow the re-invasion of *M. leidy* into the SW Baltic during 2014, thus showing the potential importance of pockets maintaining high abundances of invasive species for re-invasion dynamics. Achieving good environmental status of such areas can be a key to mitigate invasion impacts, especially in the Baltic Sea. (P1, P2)

- *M. leidy* was re-sighted in the SW Baltic Sea up to the Bornholm Basin in 2014, and a manuscript on this observation is in preparation (P1, P2). In addition, a review paper about the range expansion of *M. leidy* in Europe - which includes the Baltic Sea, is in preparation. (P1, P2).
- A hand line survey to determine round goby presence and abundances was established along the German coast of the Mecklenburg and Kiel Bight. We found distribution hot spots in the Trave estuary and in parts of the Kiel Fjord, and lower concentrations along the coastline between these two regions. North of Kiel Fjord abundances declined rapidly. Generally, in regions with low abundance of round goby, the abundance of black goby was higher. Stomach samples were taken from both species to investigate the potential competition. Otoliths were sampled for growth studies. A separate sampling initiative was started to collect cod samples from shallow regions of the Western Baltic. The idea is to study the role of round goby in the diet of established species. Sampling was tested from commercial and scientific gill nets (cooperation with BONUS INSPIRE) as well from hand lines. The diet studies of cod are supplemented with an analysis of the prey quality, measured also as fatty acid composition. Problems were encountered with regard to catching sufficient numbers of juvenile cod, both for stomach sampling and in particular for experimental purposes. (P3)
- A workshop on round goby was organized in collaboration with Norden at DTU Aqua, in Copenhagen from 4-5 September 2014. This has resulted in the better coordination of the round goby research in the Baltic Sea, including factors responsible for the spread and feeding ecology of this species. Round goby distribution data have been collected over the Baltic Sea, and a manuscript is under preparation. Round goby and prey sample collection around the Baltic Sea was initiated and will continue in the future. P2, P6, P7
- The AquaNIS database was updated with invasion event information for alien species in the Baltic Sea. A manuscript concerning the alien species in the Baltic Sea based on AquaNIS data is in preparation. Furthermore, a paper discussing the monitoring needs concerning alien species was written (Lehtiniemi et al 2015)⁵. (P6, P7)

⁵M. Lehtiniemi, H. Ojaveer, M. David, B. Galil, S. Gollasch, C. McKenzie, D. Minchin, A. Occhipinti-Ambrogi, S. Olenin, J. Pederson 2015: Dose of truth—Monitoring marine non-indigenous species to serve legislative requirements. Marine Policy. Volume 54:26–35.

- Work in the reporting period resulted in a description of the invasion history of *Evadne anonyx* in the Gulf of Riga (Kalaus and Ojaveer 2014)⁶, an evaluation of the ecosystem impacts of the widespread NIS (Ojaveer and Kotta 2014)⁷, and the experimental evaluation of the habitat occupancy of the non-native Harris mud crab (Nurkse et al 2015)⁸ (P6)
- Data for the adjustment of empirical models of *Marenzelleria* distribution are currently being compiled. Information on non-indigenous species is being updated in AquaNIS database. Round goby diet analysis was initiated, using previously collected material, applying gut content and stable isotopes analyses. A publication on the primary results is in preparation. New samples for the assessment of round goby impact on the food web were collected, and literature analysis to assess round goby impacts on the food web and biodiversity have been performed. (P8)
- In a pilot study in November 2013, we tested the utilization of a 2 m beam trawl to estimate the round goby abundance in Greifswald Bay, Germany, with RV Clupea (draft 4 m), in preparation for the standardized monitoring of goby abundances in the future. (P11)
- In November 2014, the beam trawling with RV Clupea was repeated but only single individuals of round goby could be detected at depths > 4 m. However, many round gobies were found in shallower regions of the Bay (less than 2 meters water depth) using a beam trawl applied from a smaller research boat. Two MSc studies were initiated in autumn 2014 focussing on habitat-dependent abundance, length distribution and feeding behaviour of round goby within Greifswald Bay and adjacent waters. Preliminary results suggest a strong habitat-dependent spatial distribution of the gobies and a feeding behaviour that is in good accordance with published earlier studies from other areas. (P11)
- During periods with higher sea surface temperatures (SSTs) (>7°C), the distribution of round goby within Greifswald Bay appeared to be rather related to the habitat complexity (gobies were most abundant in the highly structured, SAV-rich littoral) than to water depth (the maximum depth within Greifswald Bay is approximately 13 metres). However, during the final beach seine sampling in mid of December 2014 (about 1 °C sea surface water temperature), no round goby could be observed in the shallow areas indicating a retreat of the gobies towards deeper but less structured (no SAV) areas of the bay. The investigation of habitat-dependent spatial distribution of round gobies will be continued, with a particular focus on seasonal migration patterns and potential overlap with spring spawning herring in Greifswald Bay (P11)

⁶Kalaus, M. and Ojaveer, H. 2014: Over one decade of invasion: the non-indigenous cladoceran *Evadne anonyx* G.O. Sars, 1897 in a low-salinity environment. *Aquat Invasions* 9:499-506.

⁷Ojaveer, H. and Kotta, J. 2014. Ecosystem impacts of the widespread non-indigenous species in the Baltic Sea: literature survey evidences major limitations in knowledge. *Hydrobiologia*. DOI 10.1007/s10750-014-2080-5.

⁸Nurkse, K.; Kotta, J.; Orav-Kotta, H.; Pärnoja, M.; Kuprijanov, I. 2015. Laboratory experiment on the habitat occupancy of the crab *Rhithropanopeus harrisii* (Gould) in an invaded ecosystem: The north-eastern Baltic Sea. *Estuarine Coastal and Shelf Science*, 154, 152–157. doi:10.1016/j.ecss.2014.12.046.

- Further work on the invasive round goby will entail a cooperation with the University of Rostock (Dr. H. Winkler), to assess the importance of this species as food for higher trophic levels. This aspect is essential for stock assessment activities targeting the piscine predators in the study area. Goby predators (pikeperch, perch) caught unintentionally during gill net investigations within the study area were already transferred to the University of Rostock and will be incorporated into an on-going MSc-thesis on the relevance of round goby as prey for these predators. (P11)
- BIO-C3 research activities within Greifswald Bay will be coordinated with BONUS INSPIRE activities in the same area to improve the cost-performance ratio for both projects. Consequently, multi-mesh-size gill net transect sampling and beach seine sampling conducted within the INSPIRE network will be used to gain more information on the depth distribution of round goby within the Pomeranian Bight.

WP3: Natural and anthropogenic drivers of biodiversity

Lead: Helén Andersson, P12 SMHI

Overview:

WP3 is concerned with the examination of historical and contemporary data and development of models for future scenarios of the spatio-temporal variation of drivers. The ultimate goal is to thus improve the understanding of environmental change in the Baltic Sea ecosystem. A highlight from the first reporting period has been the completion of comprehensive work to produce a report focusing on drivers of biodiversity in the Baltic Sea. This review includes the definition of different drivers, and the selection and evaluation of the most important ones among them. It is an important stepping stone for other WP3 tasks and will also feed into the modelling work of WP2 and WP4. All work in WP3 is progressing without any major deviations from the original work plan. The WP does not have any milestones or deliverables during the first reporting year.

Task 3.1: Dynamics of drivers including socio-economy (Month 1-24)

Lead: Daniel Oesterwind, P11 TI-OF, participation of P1, P2, P6, P8, P9.

Deliverable 3.1: *Report on patterns and dynamic of drivers of biodiversity (species, communities, habitats) across Baltic Sea ecosystems in space and time including socio-economy. (Month 24)*

Milestone 3.1: *Meta-database on drivers affecting biodiversity completed. (Month 16)*

This task entails a comprehensive review of drivers of biodiversity in the Baltic Sea, including the assessment of their spatial heterogeneity. Specific progress to date includes:

- The first step of the work has been focused on the definitions of a driver (in form of a manuscript) and to produce a table with different drivers without any geographical limits.
- The second step of the task was to find out which drivers are the most important in the Baltic Sea. Widely accessible databases have been exploited and relevant information compiled from literature (incl. socio-economy).
- In terms of none-native species two accepted papers (Kalaus and Ojaveer 2014, Ojaveer and Kotta 2014) were provided.
- Effect of the invasive habitat engineer species *D. polymorpha* on biodiversity and its possible implications for environmental status assessments was analyzed within a desktop study (BQI assessment exercise for the Curonian Lagoon,) and published in Zaiko and Daunys (2015).
- A manuscript which identifies, summarizes and evaluates relevant drivers on biodiversity in the Baltic is also in preparation. To ensure that the whole expertise of the consortium and all countries are involved, the draft versions will be forwarded within the group in the first quarter of 2015.

Task 3.2 Driver interactions (Month 1-30)

Lead: Jonne Kotta, P6 UT-EMI, participation of P1, P2, P9, P12.

Deliverable 3.2: *Report on the nature and types of driver interactions including their potential future. (Month 30)*

Milestone 3.2: *Framework for evaluating dynamics of habitats under driver forcing established (Month 22)*

This task investigates a set of key interactions of selected natural and anthropogenic drivers in space and time. Model runs of different drivers relevant to the key species-functions-communities of BIO/C3 project will be made in order to provide both spatial and temporal variability of selected drivers and their interactions. Progress during the reporting period includes:

- A review of data and reports in order to summarize data on shipping, fishing effort and introduction of non-indigenous species (NIS). This has resulted in a summary of the most important evidence-based information on the ecological roles and impacts of the most widespread NIS. In addition, the major knowledge gaps related to interactions between NIS and the abiotic and biotic environment were identified. These results were published in a synthesis papers (Ojaveer and Kotta 2014).
- Data on environmental drivers and their future in the Gulf of Riga pilot area have also been collated. The activity involved the creation of a geodatabase, consisting of water temperature, salinity and current velocity from of a 3D model in a resolution relevant

to the potential biological study organisms. Based on the RCP4.5 climate scenario, future projections of temperature, salinity and current velocity were established. The key organisms for the spatial predictive modelling analyses in the Gulf of Riga pilot area were identified and include benthic invertebrates, benthic macrophytes, and invasive species. Based on the compiled datasets and initial modelling of physical environment, the current range and future distribution of higher orders were modelled (Kotta et al, 2014).

- Two high-resolution bio-geochemical models have been set-up for the Gulf of Riga and Pommeranian Bay pilot areas. These models will provide hindcasts of water temperature and the dispersal of dissolved nutrients covering the period 1970 to present. Based on the hindcasts combined trends in water temperature and nutrient loadings will be analysed for different depth strata and water masses from the lagoons to the coast and from the coast to the slopes of the Bornholm and East Gotland Basin.
- Understanding the impact of deep water dynamics on the physical and biogeochemical environment in the Baltic Sea is important for the exploration of sensitive areas where eutrophication and pollution emanating from the deep waters may disturb habitats and biodiversity. For this purpose a study was conducted on the renewal and fate of the East Gotland Deep water and accumulated pools of phosphorus, using a coupled high-resolution 3-dimensional physical model (Eilola et al. 2014). This tracer study investigated whether specific regions with regular uplifting of deep water exist, and whether there are regions where a possible addition of excess phosphorus to the spring primary production is to be expected. In order to investigate the internal supply of phosphorus from the sediment further, a new approach to model the oxygen dependent benthic phosphate fluxes was taken (Almroth-Rosell et al. 2015). This study revealed that the sum of deposition of organic and inorganic phosphorus on oxic sediments is at all depth levels larger than the release of phosphorus from the sediment. For anoxic bottoms the opposite is seen; the release of total phosphorus during the investigated period is larger than the deposition of phosphorus.
- Statistical analyses to investigate the impact of nutrient concentrations on secondary production (i.e. fish) were initiated. There is ample evidence of negative impacts to the environment associated with eutrophication, whereas relatively little empirical evidence is available on the possible link between nutrient enrichment and enhanced fish production. The sharp multi-fold increase in nutrient concentrations from the 1950s to the 1980s in the Baltic Sea allows investigating related impacts on fish production based on empirical evidence. The analyses are facilitated by reconstructed historical stock dynamics (incl. growth, recruitment production) of sprat, supplemented by nutrient concentrations from a 3D coupled physical-biogeochemical ocean model. The analyses can provide insights to whether reduced fish production can be expected resulting from reduction in nutrient concentrations.
- Possible candidates of pelagic Baltic Sea key species for habitat modelling were identified. Habitat modelling of early life stages of cod, flounder and the clupeid copepode *Pseudocalanus* sp. as well as investigation of the frequency and

magnitude of deep-water inflow events from the western Baltic Sea and the North Sea is ongoing. The resulting data (1970-2013) have been compiled and are now available as a comprehensive database. Additional hydrodynamic model runs were performed simulating different eutrophication and temperature scenarios to identify possible interactions between these drivers. Furthermore the pH environment within the main basins of the Baltic Sea from ICES measurements is under investigation. Methods to analyze seasonal variations and the historical development of pH-related physiological stressors to inhabitants of the Baltic Sea are under development. Additionally, the shift detecting method of shiftogram panels was implemented for the pH time series and has also been used for resulting habitat time series derived from hydrodynamic model data to identify possible common shifts in the Baltic Sea ecosystem.

Task 3.3: Connectivity (Month 6-30)

Lead: Flemming Hansen, P9 DHI, participation of P1, P6, P10, P11, P13.

Deliverable 3.3: *Report on the importance of connectivity as a driver of biodiversity (populations, species, communities, habitats).* **(Month 30)**

Milestone 3.3: *Set of models to evaluate importance of connectivity ready.* **(Month 28)**

In this task analyses of the connectivity patterns and processes in shallow coastal and offshore areas are performed for selected species, and the effects of predicted changes in environmental forcing on transport and connectivity within coastal meta-populations will be explored. Dispersal will be analyzed and habitat maps will be combined with fine-scaled hydrodynamic models in order to set up a spatial population distribution model, where population dispersal dynamics is simulated under different scenarios of habitat destruction, fragmentation and restoration. During the reporting period, the following work has taken place:

- A literature review was conducted in order to compile information about dispersal traits of focus species. These dispersal traits are essential in the trajectory simulations of dispersal and connectivity. At the regional scale (e.g. the entire Baltic Sea), previous trajectory analyses were organized into connectivity matrices for later analyses of dispersal barriers and multi-generational connectivity.
- At the local scale, in order to develop dispersal models, bottom topography, sediment and wave exposure was modeled in the Gulf of Riga pilot area, and all available biological data relevant to these dispersal models were compiled into a geo-referenced database. Spatial predictive modeling of the key benthic macrophyte, invertebrate and fish species in the Gulf of Riga was also initiated and key environmental proxies that are likely affecting the ranges of distribution of the key benthic organisms identified. A concept was developed to use a hydrodynamic and ecosystem model for linkage to predicted biomasses of *Macoma baltica* and *Mytilus edule* (spawning population), phytoplankton concentration (food), temperature, salinity and hydrodynamics with larval dispersal behavior (vertical migration, mortality,

pelagic larval duration, settling success etc.). Dispersal modeling and connectivity analyses for target species at the local scale will be carried out in 2015.

- To study the transport and connectivity between the shallow coastal areas and offshore areas, the herring migration was used as an example. Existing data on adult herring and the results of weekly gill net fishing on herring (March to May), and an intensive ichthyoplankton sampling in the study area Greifswald Bay are currently being analyzed. In the framework of analyzing mortality causes of herring larvae, no significant effects of larvae predators were detected. This might be due to the temporal mismatch between herring larvae and the gelatinous plankton (e.g. *Aurelia aurita* or comb jellies) within the bay and the extensive offer of alternative prey for other predators (e.g. threespine sticklebacks) during the herring larvae season. Therefore, we conclude that the spawning-related net import is mainly determined by the herring egg mortality and to larval mortality unrelated to predation (e.g. first-feeding bottleneck).
- Long-term drift model runs are used in this task in order to investigate connectivity patterns of Baltic key species in relation to oceanographic circulation, different initial spatial distribution patterns and specific biological traits. In cooperation with colleagues from BONUS INSPIRE, hydrodynamic drift modeling was used to test whether the environmental conditions in the different spawning grounds are i) suitable for spawning, ii) suitable for fish egg survival and iii) to estimate the population connectivity of the egg stage between the different spawning grounds. The main conclusion was that a combination of topographic features and egg buoyancy could appear as a barrier for most of the egg size classes and potentially limit the transport of eggs between basins. Further, the hypothesis that Limfjorden acts as seeding area for invasive species, sustaining populations in lower reproductive regions was tested. A hydrodynamic drift model showed that particles released from the Limfjorden region are partly transported towards the SW Baltic and may also reach the central Baltic Sea. Combining drift model results with field observations of *M. leidyi* from different regions, we followed its invasion into the SW Baltic. We also explored whether passive larval drift can shape the genetic and morphological architecture of Baltic *Mytilus* populations. Genetic analyses showed that the vast majority of Baltic specimens are hybrid genotypes and also support the existence of a zone of major genetic transition in an area West of Rügen island. Genetic data were compared with larval drift patterns yielding evidence that *Mytilus* larvae disperse over short distances along coastlines (not across offshore areas) in a stepping stone manner. This rejects the hypothesis that long distance dispersal promotes massive interspecific hybridization.
- A meeting was arranged with the Swedish Agency for Marine and Water Management to inform about work within BIO-C3, in particular the importance of connectivity and relevance for selection of new marine protected areas (MPA). A report was published about connectivity and coherence of MPAs in the Kattegat-Skagerrak area (Moksnes et al. 2014).

Task 3.4 Dynamics of habitats in space and time under driver forcing (Month 12-36)

Lead: Helén Andersson, P12 SMHI, participation of P2, P6, P9, P11

Deliverable 3.4: *Report on dynamics of benthic and pelagic habitats in space and time under different driver forcing, including identification of vulnerable habitats. (Month 36)*

In accordance with the work schedule in the BIO-C3 Document of Work, this task has not started yet.

References (Note: all of these references are official BIO-C3 contributions, also see Section II.8. and II.13.):

Almroth-Rosell, E., Eilola, K., Kuznetsov, I., Hall, P. O., and Meier, H. M., 2015. A new approach to model oxygen dependent benthic phosphate fluxes in the Baltic Sea. *Journal of Marine Systems*, 144, 127-141, <http://dx.doi.org/10.1016/j.jmarsys.2014.11.007>.

Eilola, K., E. Almroth Rosell, and H. E. M. Meier, 2014: Impact of saltwater inflows on phosphorus cycling and eutrophication in the Baltic Sea. A 3D model study. *Tellus A*, 66, 23985, <http://dx.doi.org/10.3402/tellusa.v66.23985>

Ojaveer, H. & Kotta, J. (2014): Ecosystem impacts of the widespread non-indigenous species in the Baltic Sea: literature survey evidences major limitations in knowledge. *Hydrobiologia*, doi: 10.1007/s10750-014-2080-5

Kalaus M. & Ojaveer, H., (2014): Over one decade of invasion: the non-indigenous cladoceran *Evadne anonyx* G.O. Sars, 1897 in a low-salinity environment. *Aquatic Invasions*, 9, 499-506, doi: <http://dx.doi.org/10.3391/ai.2014.9.4.08>

Kotta, J.; Möller, T.; Orav-Kotta, H.; Pärnoja, M. 2014. Realized niche width of a brackish water submerged aquatic vegetation under current environmental conditions and projected influences of climate change. *Marine Environmental Research*, 102, 88–101.

Moksnes et al. 2014. Larval connectivity ecological coherence of marine protected areas (MPAs) in the Kattegat-Skagerrak region. Swedish Agency for Marine and Water Management Report No 2014:2.

Zaiko A., Daunys D. 2015. Invasive ecosystem engineers and biotic indices: giving a wrong impression of water quality improvement? *Ecological Indicators* 52: 292-299.

WP4 – Impacts of changing biodiversity on ecosystem functioning

Lead: Brian MacKenzie, P2 DTU Aqua

Co-Lead: Erik Bonsdorff, P13 AAU

Overview:

This work package draws on large amounts of data in various national and international repositories. These data need to be assembled and compiled in ways that facilitate later analysis and modeling. Since the official start of the WP in project month 8, most of the activity has occurred in sub-task 4.1 and focused on identifying where the data are located, contacting the relevant colleagues and institutes, and starting data assembly and compilation. Partner activities are detailed below. The work is due to be completed during Year 3, so progress will continue in the coming years.

Task 4.1: Retrospective analyses of biodiversity and ecosystem functioning

Lead: Erik Bonsdorff, P13 AAU, participation of P2, P4, P5, P6, P7, P8.

Deliverable 4.1: *Report summarizing statistical analyses of (i) how biodiversity indicators (species, communities, traits) respond to past abiotic variables and (ii) relationships between biodiversity and ecosystem functioning in the Baltic Sea. (Month 32)*

Milestone 4.1: *Data identified and compiled, preliminary models parameterized, initial results available. (Month 26)*

This task will conduct statistical analyses of the spatio-temporal variation of biodiversity indicators and selected species with major functional roles in Baltic Sea food webs (e.g., species with strong interactions with other species; species that modify habitats). The activities to date have mainly focused on the compilation of datasets necessary for the analyses to follow in the coming project years. Progress in the reporting period includes:

- Compilation of datasets of benthic species composition, including *Saduria entomon*, was initiated via contact with key institutes and colleagues around the Baltic Sea. Presence of *Saduria* in cod stomachs (WP 2.2) will be eventually compared with the abundance and distribution in the sea and environmental variables. Work is being done in collaboration within a wider analysis of benthic biodiversity conducted by P13. (P2)
- Historical phytoplankton and environmental data were compiled from two stations in the Northern Baltic Proper (one coastal and one offshore) to investigate drivers of timing, species composition and magnitude of spring phytoplankton blooms over the last 20 yrs. A resulting manuscript is currently in preparation. (P4)
- Data compilation for statistical analyses of spatio-temporal variation of biodiversity indicators was initialized for zooplankton, macrozoobenthos, and fish. (P5)

- Zooplankton and abiotic environment data were assembled into a common database and harmonization of data entries was carried out. Secondly, pelagic fish stomach data have been assembled. Data analysis will start in 2015 (P6).
- Data compilation for the adjustment of empirical models on *Marenzelleria* distribution has started. Information on non-indigenous species is currently being updated in the AquaNIS database. Round goby diet analysis was initiated using previously collected material, applying gut content and stable isotopes analyses. A publication on the primary results is in preparation. New samples for the assessment of round goby impact on the food web were collected in 2014. Literature analysis on round goby impacts on the food web and biodiversity were carried out. Finally, analysis of a long-term collection of underwater videos was initiated to assess the changes in mussel abundances and distribution. (P8)
- Compilation of input data for a study on past changes in functional trait diversity across taxonomic groups (fish, benthos, plankton) in the coastal areas of the Baltic Sea was initiated. (P13)

Task 4.2 Dynamics of populations, traits and ecosystems

Lead: Stefan Neuenfeldt, P2 DTU Aqua, participation of P1, P5, P4, P9, P10, P13.

Deliverable 4.2: *Report summarizing food web responses and interactions to changes in biodiversity and community species /trait composition. (Month 38)*

Milestone 4.2: *Model outputs of how biodiversity may respond to future scenarios of multiple drivers. (Month 32)*

This task will synthesize and scale the process knowledge generated in WPs 1-3 using (i) existing population and ecosystem models and (ii) food web models developed in Task 2.1. As such, most activity in the task will commence later on in the project. First steps taken during the reporting period include:

- Historical phytoplankton data (28 and 20 yrs) at one coastal and open sea station in the Northern Baltic Proper were assembled. Multivariate autoregressive (MAR) models were then used to investigate phytoplankton community interactions. (P4)
- Zooplankton and abiotic environment data were assembled into a common database and data entries were harmonized. Secondly, analysis of pelagic fish stomach data was started. (P6)

Task 4.3 Projection of impacts of changed drivers on future biodiversity

Lead: Monika Winder, P4 SU, participation of P2, P5, P6, P7, P8, P9, P12, P13

Deliverable 4.3: *Report summarizing scenarios of future change of biodiversity and ecosystem functioning of the Baltic Sea under combinations of drivers. (Month 40)*

This task will investigate how distributions and abundances of species and populations important for food web functioning, as well as entire species assemblages in the Baltic Sea might change under different scenarios of anticipated changes of major drivers. Only one partner has started work on the task to date:

- Assembly and statistical analyses of changes in a time series of the fish species composition of the fish community in the inner Danish waters (Belt Sea, Øresund, Kattegat). An existing dataset was updated to include data from 2013. Analyses have been conducted to identify new immigrating species, temporal changes in species richness and to relate changes in species richness to temperatures. A peer-reviewed manuscript on the analyses is in preparation. (P2)

WP5 – Indicators and tools for adaptive management

Lead: Piotr Margonski, P5 NMFRI

Note: This work package starts only in Month 14 of the project. Accordingly, while meetings and discussions between WP5 personnel took place in 2014 to concretize the future work plan, scientific work within the three WP tasks has not yet started.

WP6 – Project management and dissemination

Lead: Thorsten Reusch, P1 GEOMAR

Task 6.1 Dissemination and communication strategy (lead: P1; participants: P2-13)

Deliverable 6.1: *Homepage and leaflet produced and publicised. (Month 8)*

Milestone 6.2: *Communication and dissemination strategy developed. (Month 14)*

During the reporting period, we have developed and implemented the BIO-C3 dissemination and communication strategy (Milestone 6.2). This includes the BIO-C3 website (www.bio-c3.eu), consisting of public pages as well as an internal section used for document exchanges in the consortium, and contribution of BIO-C3 content to the BONUS website (www.bonusportal.org). A project flyer was also produced and distributed (Appendix 2). These products jointly constituted BIO-C3 Deliverable 6.1, submitted to BONUS and approved in 2014. Moreover, BIO-C3 mailing lists (“All project personnel”, “Young scientists”, “Steering committee”, “Work package and Task leaders”) were established and are increasingly used for discussion and scientific coordination within the project. We have made significant efforts to present BIO-C3 results at international and national conferences,

produce peer-reviewed and popular publications, be available for interviews, and use project output and BIO-C3 personnel expertise to inform stakeholders and support informed management decisions (see Statistics report). We have also established tight collaborations with the thematically linked BONUS projects BAMBI and INSPIRE. This includes joint sampling efforts already conducted and planned for the project duration, and the joint planning of the 2015 BIO-C3/BAMBI/INSPIRE summer school “*The Baltic Sea: a model for the global future ocean?*” and the theme session “*From genes to ecosystems: spatial heterogeneity and temporal dynamics of the Baltic Sea*” at the 2015 ICES Annual Science Conference (see Statistics report, Section “Other contributions”).

Task 6.2 Project organisation and milestone-trend analysis (lead: P1; participants: P2-13)

Milestone 6.1: *Kick-off meeting executed. (Month 4)*

Milestone 6.3: *Annual project meetings (Month 18)*

Project organisation has been advanced both via large-scale meetings and smaller scale exchanges between coordinators and WPs/Tasks, and within and between WPs. The kick off meeting of BIO-C3 took place from March 3-4 2014 in Copenhagen, with participation of BIO-C3 scientists, advisory board, and representatives of several national funding agencies, and included a meeting of the steering committee and the advisory board (Milestone 6.1). The second bi-annual steering committee meeting took place via video conference on September 5 2014. The first annual meeting of BIO-C3 is planned for July 1-3 2015, and will include the meeting of the advisory board. Invitations will go out shortly. BIO-C3 is currently advancing in line with the original time-line, and we expect to meet all milestones and deliverables.

Task 6.3 Financial administration and reporting to the Commission (lead: P1; participants: P2-13)

Deliverable 6.2: *First periodic report to the BONUS Secretariat, including reporting to meta database. (Month 14)*

The administration of the project coordinator GEOMAR has facilitated the distribution of funds to participants, and the relevant financial information for all participants for the first reporting period are submitted with this report. The steering committee has agreed to enforce the submission of data underlying publications resulting from BIO-C3 to public databases for all partner institutes, and this was communicated to the consortium at several occasions. Data and metadata on first cruises and experiments are available via the GEOMAR data portal (<https://www.bio-c3.eu/de/osis>). The present report constitutes Deliverable 6.2.

2. Promoting an effective science-policy interface to ensure optimal take up of research results (performance statistics 1-4)

From the onset, BIO-C3 has made strong efforts to pass on the expertise of project personnel, and to use the first output resulting from BIO-C3, to inform stakeholders and policy makers in the Baltic realm and beyond. This includes contributions to the implementation of the MSFD, and the design of the Ballast Water Management Convention and EU marine fisheries research priorities (Statistic 1), as well as advice to national policy makers and stakeholders (Statistic 2). The strength of the BIO-C3 consortium and the role that project participants play in the science-policy interface is reflected in the membership and participation in a total of **100** committees or working groups in 2014, including those of ICES, HELCOM, EC, MSFD, UN, and OSPAR (Statistic 3). Finally, BIO-C3 participants have already organized two stakeholder events with a total of 65 participants in 2014. These activities will continue and are expected to increase, as scientific output from BIO-C3 grows (Statistic 4). All of these activities combined ensure that new results from BIO-C3 during the reporting period have become visible to stakeholders and policy makers, and can be applied in informed decision-making benefiting the Baltic region.

3. Collaboration with research programmes and the science communities in other European sea basins and on an international level (performance statistic 5)

BIO-C3 scientists have collaborated with a range of different research programmes and individual scientists from beyond the Baltic region, including most European countries, the US, and global networks, and focusing on seas including the North Sea, Atlantic, Mediterranean and the US Great Lakes. These exchanges are highly relevant for the project, since scientifically and for management purposes, they serve to place the Baltic Sea results in a larger context. Pan-Baltic approaches will benefit for example the research foci on bio-invasions, environmental/global change, and connectivity, amongst others. We consequently expect pan-regional comparative or integrative output/publications in addition to the products focusing more strongly on the Baltic Sea per se over the lifetime of the project (Statistic 5).

4. Progress in comparison with the original research and financial plan and the schedule of deliverables.

Scientifically, BIO-C3 is going according to plan, and we expect to meet the schedule of deliverables.

Regarding the financial plan, only 67% of the resources initially budgeted for the first project period were used. This was explained by the discrepancy between the actual project kick-off on March 1st 2014 and the official start date January 1st 2014, due to delays in signing the project Consortium Agreement. This resulted in the onset of work, the hiring of PhDs and postdocs, and purchases and other expenses only after March 1st. Most partners therefore used less resources in the categories “personnel” and “other direct costs” than originally budgeted for the 1st project period. Where applicable, minor budget request changes to use these resources within the same budget category but later in the project were submitted. Note that all deliverable and milestone deadlines and the project end were also pushed back by two months to account for the delayed project start in the final BIO-C3 DOW in agreement with the BONUS secretariat.

5. Amendments to the description of work and schedule of deliverables

There have been no changes to the original description of work. Deliverable 2.1 was postponed by four months from month 20 to month 24. This was approved by BONUS. We do not expect any negative consequences or delays for other lines of work or work packages from this change.

6. Other relevant information

BIO-C3 has offered the unique opportunity to strengthen collaborations and to improve coordination of sampling and research initiatives in the Baltic region. This will have clear benefits for the scientific output of the project and beyond. Initiatives include:

- **The improved coordination of research cruises in Baltic region:**
The timing of research cruises by project partners has been adjusted to avoid previous overlaps in survey coverage, and regular exchange of survey staff between the institutes has been initiated. During 2014, five institutes (DTU Aqua, GEOMAR, NMFRI, UHH-IHF and TI-OF) have contributed to a total of 9 research cruises to the BIO-C3 focus area in the Bornholm Basin, achieving an almost monthly survey coverage from March to November, with the exception of the period September-October. Furthermore, collaboration with the IOW, Germany, has enabled additional sampling during periods not covered by the aforementioned cruises. During 2015, an even broader coverage is anticipated, including additional BIO-C3 dedicated survey time on cruises conducted by UHH-IHF as well as an additional, dedicated BIO-C3 cruise in September organized by DTU Aqua.
- **A large-scale sampling and research initiative of meso-zooplankton**, for which data harmonization was partly funded by BIO-C3 and BONUS INSPIRE (<http://kodu.ut.ee/~riina82/index.html>)
- **A large-scale sampling and research initiative on the invasive round goby *Neogobius melanostomus*** in the context of BIO-C3 WP1, and circulated within the BIO-C3 consortium and among institutes and researchers around the Baltic Sea (Appendix 1).
- **A large-scale sampling initiative of the invasive combjelly *Mnemiopsis leidyi*** in the context of BIO-C3 WP1, also circulated within the BIO-C3 consortium and among institutes and researchers around the Baltic Sea (Appendix 1).
- **Internal coordination of benthos sampling requirements**, existing benthos samples and data, and future benthos sampling efforts.

II. Report on performance statistics

1. Number of times the project has contributed significantly to the development and implementation of 'fit-to-purpose' regulations, policies and management practices (3 in total)

P02 - DTU Aqua:

- Köster, F.W. et al. 2014: Marine fisheries science priorities for H2020; EFARO's perspective. 24rd Meeting of Directors of Fisheries and Aquaculture Research Organisations (EFARO) of the EU, Ancona, 13.-15.5.2014.

P06 – UT-EMI:

- Contribution to the national process of MSFD (D1, D2, D3, D4 and D6) to propose monitoring schemes and start to develop program of measures. The activity has taken place throughout the year and will continue in 2015.
- Contribution to the Ballast Water Management Convention (harmonizing the procedure for exemptions, advising national government in various other related issues). This activity will continue in 2015.

2. Number of suggestions for designing, implementing and evaluating the efficacy of relevant public policies and governance (3 in total)

P02 - DTU:

- Storr-Paulsen, R & Huwer, B. 2014: Efficiency of MPA's as fisheries management tool in the Baltic MPAs in the Baltic. Brief to Ministry of Food, Agriculture and Fisheries.
- Storr-Paulsen, R & Eero, M. 2014: ICES Advice on Baltic Fish Stocks. Information to the Baltic Sea Advisory Council. Information to Danish Fishing Industry.

P10 - UGOT:

- UGOT arranged a meeting (Oct 14, 2014) with the Swedish Agency for Marine and Water Management to inform about work within BIO-C3, in particular the importance of connectivity and relevance for selection of new marine protected areas (MPA), and published a technical report for the Swedish Agency for Marine and Water Management about connectivity and coherence of MPAs in the Kattegat-Skagerrak area (Moksnes et al. 2014. Larval connectivity ecological coherence of marine protected areas (MPAs) in the Kattegat-Skagerrak region. Swedish Agency for Marine and Water Management Report No 2014:2).

3. Number of times the scientists working in the project have served as members or observers in stakeholder committees (99 in total)

See Appendix 3 for the list of all WG and stakeholder committee memberships and observer functions of BIO-C3 personnel in 2014.

4. Number of international, national and regional stakeholder events organized by the project (2 in total)

Co-organized by partners P02-DTU-Aqua, P06-UT-EMI, P07-SYKE:

- Workshop „Round goby – need for collaborative science and management in Nordic and Baltic countries“, held on 4-5 September 2014 at DTU-Aqua Charlottenlund, Denmark. The workshop was co-funded by BIO-C3 and NORDEN. Scientists from all Baltic countries were invited and attended. The key-note lecture was given by Dr. D. Heath, Canada. In addition to scientists, various stakeholder representatives participated, including: Baltic Sea RAC, ICES, the Danish Ministry of Environment, GEMBA Seafood Consulting, Ministry of Food, Agriculture and Fisheries of Denmark, Swedish Agency for Marine and Water Management. Number of participants: 55.

P06 - UT-EMI:

- Stakeholder communication meeting at the Estonian Ministry of Environment (10 November 2014) to relay the concluding results of the EU FP7 project VECTORS and the initial results of non-native species research obtained in the BONUS BIO-C3 project. Attended by ~10 people from the Estonian Ministry of Environment and the Ministry of Agriculture.

5. Number of joint events/co-operation activities/partnerships of the project with non-Baltic research actors & other European marine basins. (14 in total)

P01 – GEOMAR:

- Cooperation activities: (C. Clemmesen /F. Mittermayer) participation in a joint project at the national Cod Breeding center of NOFIMA Tromsø, Norway from middle of March to end of May 2014 to evaluate the effect of future climate stressors on the survival and growth of cod larvae from the Barent Sea area.
- Joint event: (C. Jaspers) participation in the 3 day ICES/CIESM Joint Workshop on *Mnemiopsis* Science (JWMS) including the production of an ICES expert group report. Report of the Joint CIESM/ICES Workshop on *Mnemiopsis* Science (JWMS), 18-20 September 2014, La Coruna, Spain. ICES CM 2014/SSGHIE:14. 80pp.
- Joint event: (C. Jaspers) organization of the special theme session “*Gelatinous zooplankton on a global perspective: interactions with fisheries and consequences for social-economics*” at the ICES annual science conference in La Coruna, Spain, September 2014, in co-operation with ICES and PICES colleagues from Spain and the United States.
- Cooperation activity: (C. Jaspers) Coordination of the special issue on *Interactions of gelatinous zooplankton within marine food webs* for Journal of Plankton Research (manuscript submissions by 15th of December 2014).

P04 – SU:

- Collaboration with Carol Lee, University of Madison, USA, was established to investigate evolutionary adaption of the copepod *Eurytemora affinis*.

P06 – UT-EMI and P05 – NMFRI:

- Organization and contribution of large-scale datasets to the BONUS BIO-C3/INSPIRE Baltic Sea mesozooplankton study (<http://kodu.ut.ee/~riina82/policy.html>)

P06 – UT-EMI:

- Partnership with several European, South and North America, Australia and New Zealand scientists in fields of coastal marine ecology and marine bioinvasion to address major issues concerning ecosystem functioning (e.g., modeling species distribution patterns, relationships between community structure and functioning) and marine bioinvasions globally (e.g., on monitoring requirements, information availability and classification criteria, climate impacts, various management issues, evaluation of ecosystem impacts): Bella Galil (National Institute of Oceanography, Israel), Chad Hewitt and Marnie Campbell (School of Science, University of Waikato, Hamilton, New Zealand), James Carlton (Maritime Studies Program, Williams College-Mystic Seaport, USA), Marta Coll (Institut de Recherche pour le Développement, France), Elizabeth Cook (Scottish Marine Institute, Oban, UK), Anna Occhipinti-Ambrogi and Agnese Marchini (University of Pavia, Italy), Cynthia McKenzie (Northwest Atlantic Fisheries Centre, Canada), Alison MacDiarmid and Tasman Crowe (National Institute of Water and Atmospheric Research, New Zealand).
- Partnership with various North Sea scientists to address the importance of climate impact on marine biodiversity and related MSFD descriptors. A set of joint publications is envisioned. Simon P.R. Greenstreet (Marine Scotland–Science, Marine Laboratory, UK), Sasa Raicevich (Istituto Superiore per la Protezione e la Ricerca Ambientale, Italy), Nikolaus Probst (Johann Heinrich von Thünen-Institute, Institute of Sea Fisheries, Germany).
- Partnership within the global research network ‘Oceans Past Initiative’ (OPI, www.oceanspast.net) and the EU COST Action ‘Oceans Past Platform’ (OPP).

P08 – KUCORPI:

- Collaboration on several different lines of work with the DEVOTES project:
 - KUCORPI has performed two studies on non-indigenous species in co-operation with researchers from University of Oviedo. The studies were aimed at updating information on NIS distribution within Lithuanian coastal zone applying molecular techniques. Specific molecular primers for detection of newly spreading bivalve *Rangia cuneata* were designed; metabarcoding approach was tested for NIS detection from integrated zooplankton samples. The results were presented at international scientific conferences and two corresponding manuscripts were submitted for publication.
 - In collaboration with DEVOTES, the keystone species and processes were identified and reviewed for the Baltic Sea. Public report was circulated among the

BIO-C3 partners and is available online (<http://www.devotes-project.eu/wp-content/uploads/2014/07/DEVOTES-D6-1-Keystones.pdf>).

- The performance of the Benthic Quality Index being tested within the Lithuanian coastal waters. A paper on effect of invasive ecosystem engineers on index specificity was published in Ecological Indicators - Zaiko A., Daunys D. 2015. Invasive ecosystem engineers and biotic indices: giving a wrong impression of water quality improvement? Ecological Indicators 52: 292-299.

P10 – UGOT:

- Close collaboration with researchers along the Skagerrak and North Sea coasts, e.g., in connectivity analyses and protection strategies of cod. Collaborating partners include Department of Aquatic Resources at the Swedish University of Agricultural Sciences, DTU AQUA (Technical University of Denmark) and Institute of Marine Research (Norway), DHI and University of East Anglia (UK).

P13 – AAU:

- Collaboration within the Nordic Center of Excellence NorMER (NordForsk/Norden).

6. Number of persons and working days spent by foreign scientists on research vessels participating in the cruises arranged by the project. (3 persons, 40 working days in total)

P01 – GEOMAR:

- 1 person for 16 working days: Dr. Anders Nissling, Uppsala University, Sweden, participated in the entire 16 day cruise with RV Alkor organized by GEOMAR in April the context of BIO-C3.

P03 – UHAM-IHF:

- 1 person for 12 working days: Dr. Bastian Huwer, DTU Aqua, participated in the RV Alkor cruise August in 2014 organized by IHF in the context of BIO-C3.

P05 – NMFRI:

- 1 person for 12 working days: Dr. Bastian Huwer, DTU Aqua, participated in the RV Baltica cruise in June organized by NMFRI in the context of BIO-C3.

7. Number of persons and working days spent by foreign scientists using other major research facilities involved in the project. (1 person, 52 working days in total)

P01 – GEOMAR:

- 1 person, 52 days: Dr. Davis Costalga from the Nelson Mandela University in Port Elizabeth, South Africa was a guest in Kiel from November 1st to December 22nd 2014 working on biochemical indicators and fish otolith microstructure analyses together

with Catriona Clemmesen to compare responses of clupeid fish larvae to environmental forcing.

Note regarding the following Statistics 8. – 13.: All BIO-C3 output (interviews, reports, popular and peer-reviewed publications) is continuously updated on the BIO-C3 website: <https://www.bio-c3.eu/publications>

8. Number of peer-reviewed publications arising from the project research with authors from, at least, two different participating states (3 in total)

Note: Peer-reviewed publications with authors from a single state listed under 13..

P02–DTU-Aqua :

- Huwer B., Hinrichsen H.-H., Böttcher U., Voss R., Köster F.W. 2014. Characteristics of juvenile survivors reveal spatio-temporal differences in early life stage survival of Baltic cod. *Marine Ecology Progress Series* 511: 165-180.

P06 – UT-EMI:

- Lehtiniemi, M., Ojaveer, H., David, M., Galil, B., Gollasch, S., McKenzie, C., Minchin, D., Occhipinti-Ambrogi, A., Olenin, S. & Pederson, J. 2015. Dose of truth — Monitoring marine non-indigenous species to serve legislative requirements *Marine Policy*, 64, 26–35

P13 – AAU:

- Törnroos A, Bonsdorff E, Bremner J, Blomqvist M, Josefson AB, Garcia C, Warzocha J (2014) Marine benthic ecological functioning over decreasing taxonomic richness. *Journal of Sea Research* in press

9. Number of entries to existing openly accessible common databases, storing original data from the entire Baltic Sea system or larger geographical area. (7 in total)

P01 – GEOMAR:

- Biological information from Alkor cruise AL435 in April 2014. Available at the GEOMAR data portal. <https://portal.geomar.de/metadata/cruise/show/325599>
- Hydrographical data from Alkor cruise AL435 in April 2014 was added to the Oceanographic data base of the ICES council. Available to the public through the ICES webpage, <http://ocean.ices.dk/HydChem/HydChem.aspx?plot=yes>
- Biological information from Alkor cruise AL437 in Mai 2014. Available at the GEOMAR data portal. <https://portal.geomar.de/metadata/leg/show/325776>
- Hydrographical data from Alkor cruise AL437 in Mai 2014 was added to the Oceanographic data base of the ICES council. Available to the public through the ICES webpage, <http://ocean.ices.dk/HydChem/HydChem.aspx?plot=yes>

P02 – DTU:

- Hydrography and single fish data on cod growth and nutrition from March and November surveys 2014 in the central Baltic Sea submitted to ICES regional database (i.e., 2 entries in total for DTU)

P06 – UT-EMI:

- Multiple entries throughout the year to 'Information system of aquatic alien and cryptogenic species in Europe' (AquaNIS; <http://www.corpi.ku.lt/databases/index.php/aquanis>) to update the Baltic non-native species invasion events (first record by country, source region, pathway/vector responsible, species status, population status). Information of the invasion events module of the Baltic Sea is freely accessible.

10. Number of popular science papers produced by the project. (4 in total)

P01 – GEOMAR:

- Petereit, C. und Hoch, C. (2014) Die Bestandsgröße des Ostsee-Herbst-Herings ist unbekannt. Fisch & Fang, 2014 (11). p. 59.

P02 – DTU:

- Storr-Paulsen M., Huwer B. (2014) Havforskningsskibet DANA er netop vendt hjem fra Østersøen. Fiskeri Tidende, November 22, 2014, p.9

P10 – UGTO:

- Popular article about the role of connectivity in marine protection (EXTRAKT No 1, 2014, The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning).

P13 – AAU:

- Debate article on the functional properties of the Baltic Sea in relation to environmental change (E. Bonsdorff & A. Norkko); daily newspaper Hufvudstadsbladet, August 2014.

11. Number of interviews to media given by the members of the project's consortium. (12 in total)

P01 – GEOMAR:

- Dierking, J. and Reusch, T. 2014. NDR report "Der Ostsee geht die Luft aus" (Declining Oxygen in the Baltic Sea). April 15 2014. (Interviews for television report)
- Jaspers, C. (2014) Das unbekannte Wasserwesen. Kieler Nachrichten , 31.07.2014 (Interview for newspaper article)
- Jaspers, C. (2014) Quallen trüben den Badespaß. Kieler Nachrichten, 31.07.2014 (Interview for newspaper article)
- Nestler, R., Behrens, J. und Jaspers, C. (2014) Das Meer von morgen. Der Tagesspiegel, 21.06.2014 (Interviews for newspaper article)

- Petereit, C. (2014) Forschung soll Fischbestand sichern NDR Schleswig-Holstein Magazin, 12.02.2014 (Interview for television report)

P02 – DTU:

- Interview to TV2 Bornholm by M. Storr-Paulsen & B. Huwer during, Rønne about results of Q4 BITS cruise on status of cod and return of *Mnemiopsis* in the Eastern Baltic. November 2014.
- Interview to DR Sjælland by Jane Behrens on round goby – in relation to the workshop described in 4. September 2014.
- Interview with Jyllandsposten by Jane Behrens on round goby – in relation to the workshop described in 4. September 2014

P07 – SYKE:

- Puntila, R., Non-indigenous species in Gulf of Bothnia, Raahen Seutu (interview with Finnish local newspaper in the city of Raahen), 14.10.2014;
- Puntila, R., Where to report on observations of non-indigenous species, Raahen Seutu (interview with Finnish local newspaper in the city of Raahen), 17.10.2014

P13 – AAU

- Bonsdorff, E.; Interview for Radio Vega Åboland (Finland), June 2014
- Bonsdorff, E.; Interview for the daily newspaper Åbo Underrättelser, June 2014

12. Number of multi-media products and TV episodes produced by the project with dissemination purpose.

None until now.

13. Number of other international, national and regional communication, dissemination and public outreach initiatives to disseminate the project's research results.

P01 – GEOMAR:

Presentations of project results:

- Dierking, J., B. v. Dewitz, L. Elsbernd, S. Bracamonte, H. Schulz, R. Voss, K. Hüsey, R. Froese, H.-H. Hinrichsen, T. Reusch. 2014. Baltic cod genetic diversity predicted by stock structure and oxygen situation – a new indicator for ecosystem based management? Invited presentation, ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB), Kiel, Germany, February 10-14.
- Dierking, J., B. v. Dewitz, L. Elsbernd, S. Bracamonte, H. Schulz, R. Voss, K. Hüsey, C. Petereit, R. Froese, H.-H. Hinrichsen, T. Reusch. 2014. Effects of climate change on Baltic Sea fish stocks. Presentation to a visiting delegation of the European Parliament Committee on Fisheries. GEOMAR Kiel, Germany, March 25.

- Dierking, J. 2014. Unraveling ecological, genetic, and economic consequences of ecosystem regime shifts. Excellence Cluster The Future Ocean Symposium, Kiel, Germany, May 5.
- Dierking, J., B. v. Dewitz, L. Elsbernd, S. Bracamonte, H. Schulz, R. Voss, K. Hüßy, C. Petereit, R. Froese, H.-H. Hinrichsen, T. Reusch. 2014. Windows to the past: otolith records help unravel long-term changes in Baltic cod genetic composition and ecology. Invited presentation, weekly seminar of the Institute for Hydrobiology and Fisheries Science (IHF), Hamburg, Germany, July 4.
- Reusch, T. 2014 Experimental evolution meets marine phytoplankton.SMBE (Society for Molecular Biology & Evolution), satellite meeting. Kiel, Germany, April 23.
- Reusch, T. 2014 Introduction to the BIO-C3 – Causes, Consequences and Management Implications project. BONUS projects Kick-off meeting, Riga, Latvia, Aug 26-27.
- Reusch, T. 2014 Simultaneous adaptation of key phytoplankton species to ocean acidification and warming. University of Lausanne (invited talk), September 18.
- Petereit, C. 2014. Wie das Schweben von Fischeiern die Verteilung bestimmt: Dorsch- und Plattfischbestände in der westlichen Ostsee. Maasholm wissenschaftliche Vorträge im NEZ, Maasholm, Germany, July 22 (Invited presentation, in German).
- Petereit, C., Hinrichsen, H. H., Köster, F. W., Haslob, H., Voss, R., Kraus, G. und Clemmesen-Bockelmann, C. 2014. They are different: Methods of non-genetic population separation of Baltic Sea fish. National Institute of Aquatic Resources (DTU-Aqua), Silkeborg, Denmark, August 28 (invited presentation).

Publications (not peer reviewed):

- Petereit, C., Gill, D., Puebla, O. 2015. "Glasfische" der Ostsee - Was sind es wirklich? Fischerblatt, 2015-1:8-10 (in German)

Blog entries:

- Nicolai, M. 2014. Eine Seefahrt. die ist... 11.02.2014, Oceannavigator BLOG, <http://www.oceanblogs.org/oceannavigator/2014/02/16/eine-seefahrt-die-ist/> (In German)

P02 – DTU:

Presentations of project results:

- Köster, F.W. 2014: Sustainable seafood production from competitive European fisheries. EU presidency conference: Research and Innovation to foster the

Competitiveness of the European Agri-Food and Seafood sectors, Athens 10.-11.3. 2014.

P04 – SU:

Presentations of project results:

- Griffiths et al.. Phytoplankton community interactions and environmental sensitivity in coastal and offshore habitats. Joint Aquatic Sciences Meeting, Portland, OR, USA. May 2014
- Griffiths et al.. Phytoplankton community interactions and environmental sensitivity in coastal and offshore habitats. SLU-Öregrund, Sweden, December 2014

Publications (peer-reviewed):

- Golz A.L., Burian A., Winder M. 2015. Stoichiometric regulation increases from unicellular to multicellular zooplankton. *Journal of Plankton Research*. DOI: 10.1093/plankt/fbu109

P06 – UT-EMI:

Presentations of project results:

- Arula, T., Ojaveer, H. and Simm, M. 2014. Small-scale dynamics of vital rates of herring *Clupea harengus membras* and goby *Pomatoschistus* spp. larvae in a shallow temperate bay. EU FP7 project VECTORS Final Meeting in La Grande Motte (France) in 17-21 November 2014. Poster presentation.
- Kalas, M. and Ojaveer, H. 2014. Over one decade of invasion: the non-indigenous cladoceran *Evadne anonyx* G.O. Sars, 1897 in a low-salinity environment. EU FP7 project VECTORS Final Meeting in La Grande Motte (France) in 17-21 November 2014. Poster presentation.
- Nurkse, K., Kotta, J., Ojaveer, H. and Orav-Kotta, H. 2014. Food consumption and dietary preference of the round goby (*Neogobius melanostomus*) under experimental conditions. BIO-C3 and NORDEN financed workshop on 'Round goby – need for collaborative science and management in Nordic and Baltic countries', held on 4th -5th September 2014 in DTU-Aqua Charlottenlund, Denmark. Oral presentation.
- Kotta, J., Ojaveer, H., Puntila, R. and Nurkse, K. 2014. Distribution of the invasive round goby *Neogobius melanostomus* in a brackish water ecosystem: relative contribution of natural and anthropogenic drivers. BIO-C3 and NORDEN financed workshop on 'Round goby – need for collaborative science and management in Nordic and Baltic countries', held on 4th -5th September 2014 in DTU-Aqua Charlottenlund, Denmark. Oral presentation.

Publications (peer-reviewed):

- Kalas, M. and Ojaveer, H. 2014. Over one decade of invasion: the non-indigenous cladoceran *Evadne anonyx* G.O. Sars, 1897 in a low-salinity environment. *Aquatic Invasions* 9:499-506.

- Kotta, J., Möller, T., Orav-Kotta, H., Pärnoja, M. 2014. Realized niche width of a brackish water submerged aquatic vegetation under current environmental conditions and projected influences of climate change. *Marine Environmental Research* 102:88-101.
- Nurkse, K., Kotta, J., Orav-Kotta, H., Pärnoja, M., Kuprijanov, I. 2015. Laboratory analysis of the habitat occupancy of the crab *Rhithropanopeus harrisii* (Gould) in an invaded ecosystem: The north-eastern Baltic Sea. *Estuarine, Coastal and Shelf Science* 154: 152-157.
- Ojaveer, H. and Kotta, J. 2014. Ecosystem impacts of the widespread non-indigenous species in the Baltic Sea: literature survey evidences major limitations in knowledge. DOI 10.1007/s10750-014-2080-5.

P08 – KUCORPI:

Presentations of project results:

- 2014 -Mares Conference Marine Ecosystems Health and Conservation, Nov 17-21, Olhao, Portugal, - 2 oral presentations “Metabarcoding approach in biodiversity and biosecurity surveys: a pilot study from the Baltic Sea”; “eDNA and species-specific primer for early detection. A case study on the bivalve *Rangia cuneata*, currently spreading in Europe”.
- 2014 -New Zealand Marine Science Society Conference, Aug 12-15, Nelson, New Zealand, – oral presentation “Metabarcoding approach in biodiversity and biosecurity surveys: a pilot study from the Baltic Sea”.
- 2014 - Lithuanian national conference "Marine science and technology 2014", Apr 23-25, Klaipeda, Lithuania– poster presentation "New Generation molecular techniques in the Baltic Sea research or every sea drop has its own "barcode".
- 2014 – Mar 6, seminar at Klaipeda University “Presentation of BIO-C3 project: Biodiversity changes – causes, consequences and management implications”.

Publications (peer-reviewed):

- Zaiko A., Daunys D. 2015. Invasive ecosystem engineers and biotic indices: giving a wrong impression of water quality improvement? *Ecological Indicators* 52: 292-299.

P09 – DHI:

Presentations of project results:

- Henrik Skov 2014. Decadal changes in the boundaries of concentrations of marine birds – consequences for marine protected areas. Presentation at “Littoral 2014”, 24-25/9 2014, Lithuania.

P10 – UGOT:

Presentations of project results:

- Communication with the County Administrative Board in Västra Götaland, Sweden.

P11 – TI-OF:

Presentations of project results:

- Kotterba, P. 2014. Kaviar fürs Fisch-Volk – der Stichling ist ein unterschätzter Räuber! Talk. 'Rostock's Eleven' Science Communication workshop, 11 – 13 June, Rostock, Germany. (Award for best presentation)
- Kotterba, P., Hammer, C., Kühn, C., and Polte, P. 2014. The effect of predation of threespine stickleback (*Gasterosteus aculeatus*) on the eggs of Atlantic herring (*Clupea harengus*) in a Baltic spawning site. Talk. 38th Annual Larval Fish Conference, 17-21 August, Quebec, Canada.
- Kotterba, P.: Atlantic herring *Clupea harengus* within the estuarine food web of a southern Baltic Sea lagoon. Talk. Zoological Seminar of the University of Rostock, 17 October 2014, Rostock, Germany.
- Polte, P., Kotterba, P., Moll, D., v. Nordheim, L. 2014. Stressors of early herring (*Clupea harengus*) life history in Greifswald Bay. Talk. Seminar for Hydrobiology and Fishery Science, 21 November, Hamburg, Germany.
- Winkler, H., Oesterwind, D. 2014: Die Erfolgsgeschichte der Schwarzmundgrundel (*Neogobius melanostomus*) in der Ostsee” on the Baltic Day in Rostock 23rd May, Poster, Rostock, Germany

P12 – SMHI:

Presentations of project results:

- Eilola, K., Impact of saltwater inflows on phosphorus cycling and eutrophication in the Baltic Sea. 14 Dec 2014, Seminar at Gothenburg University, Oceanographic department.

Publications (peer-reviewed):

- Almroth-Rosell, E., Eilola, K., Kuznetsov, I., Hall, P. O., and Meier, H. M., 2015. A new approach to model oxygen dependent benthic phosphate fluxes in the Baltic Sea. Journal of Marine Systems, 144, 127-141, <http://dx.doi.org/10.1016/j.jmarsys.2014.11.007>.
- Eilola, K., E. Almroth Rosell, and H. E. M. Meier, 2014: Impact of saltwater inflows on phosphorus cycling and eutrophication in the Baltic Sea. A 3D model study. Tellus A, 66, 23985, <http://dx.doi.org/10.3402/tellusa.v66.23985>.

P13 – AAU:

Presentations of project results:

- Bonsdorff, E. 2014. Key-note speech at the HELCOM40-anniversary conference, Helsinki, March.
- Bonsdorff, E. 2014. Invited Discussion-comment at the BDF Baltic Sea Day, Turku, June.
- Törnroos, A.; 6 blog-entries on the BONUS-blogs.

14. Number of post graduate courses organized by the project and persons participating.

None as of yet, but planning for the BIO-C3/BAMBI/INSPIRE Summer school (scheduled for the week 5-11 July 2015) took place in 2014. The announcement and call for registration to go out in early March 2015.

15. Number of mobility activities (persons, visit days) from the project to the other BONUS projects. (8 persons in total)

P01 – GEOMAR:

- Participation Thorsten Reusch in BONUS BAMBI Kick-off meeting 19-21 Feb 2014, Tjärnö, Sweden

P03 – IHF:

- 4 persons one day coordination with INSPIRE

P06 – UT-EMI:

- Participation in BONUS BAMBI and INSPIRE meetings and initiation of joint activities (Baltic Sea zooplankton study, ICES 2015 science conference Theme Session proposal).

P13 – AAU:

- Collaboration with BONUS-COCOA (PhD student Marie Järnstöm, COCOA, and post-doc Anna Törnroos, BIO-C3) on traits, with PI Erik Bonsdorf involved in both projects.

P10 – UGOT:

- Per Jonsson and Hanna Corell (post.doc) visited Turku University within the Bonus-BAMBI project for one week in September 2014.

16. Number of PhD students and the number of post-docs funded by the project as well as the number of doctoral thesis defended. (9 PhD students and 10 postdocs in total)

P01 – GEOMAR: 2 PhD students: Burkhard von Dewitz, Felix Mittermayer; 2 postdocs (both partly funded): Cornelia Jaspers and Jan Dierking, scientific coordination of BIO-C3

P02 – DTU: 2 PhD students: Anette Maria Christensen (shared with IOW Warnemünde), Laurene Pécuchet

P03 – IHF: 2 PhD students: Jan Niemax, Rini Brachvogel

P04 – SU: 1 PhD student, Konrad Karlsson

P08 – KUCORPI: 1 PhD student: Arturas Skabeikis; 5 postdocs: Alba Ardura, Evelina Griniene, Aurelija Samuiloviene, Diana Vaiciute, Andrius Siaulys (all partly funded)

P07 – SYKE: 1 PhD student: Riika PUntila (University of Helsinki)

P11 – TI-OF: 1 Postdoc: Paul Kotterba

P12 – SMHI: 1 Postdoc Elin Almroth Rosell (partly funded in 2014)

P13 – AAU: 1 Postdoc: Anna Törnroos

17. Table of distribution of the project's research staff involved

Age	PhD students		Post-docs		Assistants and eq		Associate prof. and eq		Professors and eq	
	F	M	F	M	F	M	F	M	F	M
<= 24	0	1	0	0	1	0	0	0	0	0
25 - 49	6	7	11	5	4	3	6	12	1	4
50 - 64	0	0	0	0	0	1	3	5	0	7
> 65	0	0	0	0	0	0	0	0	0	0

18. List of other significant in kind, free of charge research infrastructures

None at this time.

19. List of other than infrastructure in kind contributions the project has received.

Contributions are summarized in the EPSS system.

20. Other contributions

During 2014, preparations for two major activities that will take place in 2015 were carried out: the BIO-C3/BAMBI/INSPIRE summer school “*The Baltic Sea: a model for the global future ocean?*” for PhDs and postdocs from these three BONUS projects and some external participants will take place from July 5-11 2015 (relevant for statistic 14.); secondly, BIO-C3/BAMBI/INSPIRE will convene the theme session “*From genes to ecosystems: spatial heterogeneity and temporal dynamics of the Baltic Sea*” at the 2015 ICES Science conference in Copenhagen (relevant for Statistic 5.).

Appendix 1: Sampling initiatives distributed via the BIO-C3 network in 2014

1. Round goby *Neogobius melanostomus* (exert from the original sampling call)



BIO-C3 WP1 - Genetic adaptation and eco-physiology – Round goby study

Dorte Bekkevold, Henn Ojaveer, Cornelia Jaspers, Jane Behrens

It is of interest to understand how non-indigenous species adapt and become established in newly invaded marine ecosystems, and potentially becoming invasive. Knowledge of dispersal routes and rates is vital for accurate predictions of future population distributions and dynamics, along with assessment of the extent to which range expansion is associated with genetic adaptation to novel biotic (e.g. parasites, predators, food-webs) and abiotic factors such as ambient oxygen, temperature and salinity. The non-indigenous round goby *Neogobius melanostomus* is nowadays found across the whole Baltic Sea. Following its initial introduction likely via ballast water ~25 years ago, the current hypothesis is that expansion in this region is mediated both through natural range expansion and repeated introductions through shipping.

A means to determine invasive species' demographic dynamics is to use genetic marker analysis to compare genetic variation among local populations, and to use genetic modelling to determine founding sources and expansion routes

2. Combjelly *Mnemiopsis leidyi* (exert from the original sampling call)



DNA Sampling of *Mnemiopsis leidyi* for genotyping of populations

BIO-C3 WP1 - Genetic adaptation and eco-physiology

Cornelia Jaspers^{1,2}, Dorte Bekkevold¹, Thorsten Reusch²*

¹DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Denmark

²Helmholtz Centre for Ocean Research, GEOMAR, Kiel, Germany*corresponding *author: coja@aqu.dtu.dk

It is of interest to understand how non-indigenous species adapt and become established in newly invaded marine ecosystems, and potentially becoming invasive. Knowledge of dispersal routes and rates are vital for accurate predictions of future population distributions and dynamics, along with assessment of the extent to which range expansion is associated with genetic adaptation to novel biotic (e.g. parasites, predators, food-webs) and abiotic factors such as ambient oxygen, temperature and salinity. The non-indigenous comb jelly *Mnemiopsis leidyi* is nowadays found across large areas of Northern Europe, and was widely distributed in the SW and central Baltic Sea. Following its initial introduction likely via ballast water ~10 years ago, the current hypothesis is that expansion in this region is mediated both through natural range expansion and repeated introductions through shipping.

A means to determine invasive species' demographic dynamics is to use genetic marker analysis to

Appendix 2: BIO-C3 Flyer and website

1. Front page of the BIO-C3 flyer distributed at numerous occasions in 2014

BIO-C3 SCIENCE

Goal
To investigate the dynamics of biodiversity in the Baltic Sea, their causes and the consequences for the function of food webs. This includes implications for biodiversity management policies.

Background
Baltic biodiversity is historically dynamic responding to various drivers. Species diversity is generally low and contains many recent immigrants and glacial relict species because of low salinity and relatively young age of the Baltic. Nevertheless, Baltic food webs sustain many goods and services valued by society. With global change, distributional and compositional changes of benthic and pelagic communities are occurring and/or projected, raising concern about consequences for this system.

The Science
Using projections of abiotic/biotic drivers (climate change, eutrophication, species invasions, fisheries), BIO-C3 will assess how biodiversity responds in time and space. We will investigate the potential and genetic basis for colonisation, acclimation and adaptation of species and populations to extreme conditions in the Baltic Sea, and how compositional and adaptive changes of Baltic biodiversity affect ecosystem functions. Results will feed into impact assessments that guide management policies including improved operationalization of status indicators, and guidelines for MPAs.

BIO-C3 CONTACT

BIOC3@geomar.de
www.bio-c3.eu

Thorsten Reusch - COORDINATOR
Fritz Köster - CO-COORDINATOR
Cornelia Jaspers - SCIENTIFIC COORDINATOR
Jan Dierking - SCIENTIFIC COORDINATOR

COORDINATED BY

GEOMAR
Helmholtz Centre for Ocean Research Kiel

Technical University of Denmark
DTU Aqua
Institut for Akvatiske Ressourcer

BIO-C3 FUNDING

InnovationsFonden
Research Council of Lithuania
ACADEMY OF FINLAND
The National Centre for Research and Development
Federal Ministry of Education and Research
The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
Eesti Teadusagentuur
Estonian Research Council

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Biodiversity changes - causes, consequences and management implications

GEOMAR
DTU
BONUS
EUROPEAN UNION

2. Start page of the public website of BIO-C3 (www.bio-c3.eu)

BIO-C3
Biodiversity changes - causes, consequences and management implications

SIGN IN

HOME PROJECT PEOPLE AND CONTACTS PROJECT OUTPUT OSIS IMAGE GALLERY LINKS

Biodiversity changes - causes, consequences and management implications BIO-C3

The importance of biodiversity for ecosystems at land has long been acknowledged. In contrast, its role for marine ecosystems has gained less research attention. The overarching aim of BIO-C3 is to address biodiversity changes, its causes, consequences and possible management implications for the Baltic Sea. BIO-C3, which is a BONUS - Science for a better future of the Baltic Seas region - project, equally funded by national and European means, has a life time of 3.5 years and a total budget of 3.7 Mio EUR. Scientists from seven European countries and 13 different partner institutes are involved. Project coordination is the responsibility of the Helmholtz Centre for Ocean Research Kiel, GEOMAR in Germany, assisted by DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Charlottenlund.

Why is Biodiversity of importance?

There are no exact data; however, an estimated 130 animal and plant species go extinct every day. In 1992 the United Nations tried countering this process with the "Biodiversity Convention". It labeled biodiversity as worthy of preservation - at land as well as at sea. Biological variety should not only be preserved for ethical reasons: It also fulfils key functions in the ecosystem. At sea this includes healthy and fertile fish stocks, clear water without algal bloom but also the absorption of nutrients from agriculture.

Biodiversity and BIO-C3

BIO-C3 Activities

10 February 2015: BONUS BIO-C3, BAMB and INSPIRE are convening the joint theme session: "From genes to ecosystems: spatial heterogeneity and temporal dynamics of the Baltic Sea" at the ICES Annual Science Conference 2015. Submit your abstract before April 30th!

January 2015: The Baltic Sea zooplankton dataset - a large scale long-term dataset comprised of contributions of several institutes - has been assembled and harmonized, partly funded by BONUS BIO-C3 and INSPIRE. See how to get involved!

Download project [flyer](#) and [poster](#)!
Follow the BIO-C3 [blogs](#)!

Appendix 3: BIO-C3 scientist memberships and participations in stakeholder committees in 2014 (n = 99, detailed information below)

Last name	First name	Affiliation	Working group (ICES, HELCOM, OSPAR etc.)
Clemmesen-Bockelmann	Catriona	GEOMAR	ICES WGRP (Working Group on Recruitment Processes)
Dewitz	Burkhard	GEOMAR	DEMO (DEMOstration exercise for Integrated Ecosystem Assessment and Advice of Baltic Sea fish stocks)
Dewitz	Burkhard	GEOMAR	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
Dierking	Jan	GEOMAR	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
Hinrichsen	Hans-Harald	GEOMAR	DEMO (DEMOstration exercise for Integrated Ecosystem Assessment and Advice of Baltic Sea fish stocks)
Hinrichsen	Hans-Harald	GEOMAR	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
Petereit	Christoph	GEOMAR	ICES WGBAST
Petereit	Christoph	GEOMAR	ICES WKTRUTTA
Andersen	Ken Haste	DTU Aqua	ICES WGEVO
Andersen	Ken Haste	DTU Aqua	ICES WGIPEM
Andersen	Ken Haste	DTU Aqua	ICES WGSAM
Andersen	Ken Haste	DTU Aqua	ICES WKLIFE
Behrens	Jane	DTU Aqua	ICES WKSIBCA
Bekkevold	Dorte	DTU Aqua	ICES WGAGFM
Bekkevold	Dorte	DTU Aqua	ICES WGIMT
Eero	Margit	DTU Aqua	ICES SGSPATIAL
Eero	Margit	DTU Aqua	ICES WGBFAS
Eero	Margit	DTU Aqua	ICES WGHIST
Eero	Margit	DTU Aqua	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
Eero	Margit	DTU Aqua	ICES WKD3R
Eero	Margit	DTU Aqua	ICES WKSIBCA
Hemmer Hansen	Jakob	DTU Aqua	ICES WGAGFM
Huwer	Bastian	DTU Aqua	ICES WGALES
Huwer	Bastian	DTU Aqua	ICES WGBIFS
Huwer	Bastian	DTU Aqua	ICES WKIDCLUP
Jaspers	Cornelia	DTU Aqua	ICES JWMS (Joint workshop on Mnemiopsis science)
Köster	Fritz	DTU Aqua	ICES Bureau

Last name	First name	Affiliation	Working group (ICES, HELCOM, OSPAR etc.)
Köster	Fritz	DTU Aqua	ICES Council
Köster	Fritz	DTU Aqua	ICES WGRFE
Köster	Fritz	DTU Aqua	ICES WKSIBCA
Lindegren	Martin	DTU Aqua	ICES WGCAMEDA
Lindegren	Martin	DTU Aqua	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
MacKenzie	Brian	DTU Aqua	ICES SCCIME (Strategic Initiative on Climate Change Effects on Marine Ecosystems)
MacKenzie	Brian	DTU Aqua	ICES WGHIST
MacKenzie	Brian	DTU Aqua	ICES WGRFE
Neuenfeldt	Stefan	DTU Aqua	ICES SGSPATIIL
Neuenfeldt	Stefan	DTU Aqua	ICES WGBFAS
Neuenfeldt	Stefan	DTU Aqua	ICES WGBIODIV
Neuenfeldt	Stefan	DTU Aqua	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
Neuenfeldt	Stefan	DTU Aqua	ICES WGIPEM
Neuenfeldt	Stefan	DTU Aqua	ICES WGSAM
Neuenfeldt	Stefan	DTU Aqua	ICES WKBREF
Neuenfeldt	Stefan	DTU Aqua	ICES WKSIBC
Tomkiewicz	Jonna	DTU Aqua	ICES WKMSGAD
Temming	Axel	UHAM-IHF	ICES WGCRAN
Luzeńczyk	Anna	NMFRI	ICES WGBFAS (Baltic Fisheries Assessment Working Group)
Margonski	Piotr	NMFRI	ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea
Margonski	Piotr	NMFRI	ICES WGZE (Working Group on Zooplankton Ecology)
Radtke	Krzysztof	NMFRI	ICES WGBFAS (Baltic Fisheries Assessment Working Group)
Radtke	Krzysztof	NMFRI	ICES WGBIFS (Baltic International Fish Survey Working Group)
Radtke	Krzysztof	NMFRI	ICES WGRFS (Working Group on Recreational Fisheries Surveys)
Warzocha	Jan	NMFRI	ICES BEWG (Benthos Ecology Working Group)
Kalaus	Marilyn	UT-EMI	ICES WGITMO (Working Group on Introductions and Transfers of Marine Organisms, member)
Kalaus	Marilyn	UT-EMI	ICES WGZE (Working Group on Zooplankton Ecology, member)
Ojaveer	Henn	UT-EMI	Global network on Oceans Past Initiative (OPP, executive director)
Ojaveer	Henn	UT-EMI	ICES SCICOM Steering Group on Ecosystem Pressures and Impacts (SGEPI, chair, since 01.01.2015)

Last name	First name	Affiliation	Working group (ICES, HELCOM, OSPAR etc.)
Ojaveer	Henn	UT-EMI	ICES Science Committee (SCICOM, member)
Ojaveer	Henn	UT-EMI	ICES Strategic Initiative on Biodiversity Advice and Science (SIBAS, co-chair, until 31.12.2014)
Ojaveer	Henn	UT-EMI	ICES WGBOSV (Working Group on Ballast and Other Ship Vectors, member)
Ojaveer	Henn	UT-EMI	ICES WGIAB (Working Group on Integrated Assessments of the Baltic Sea, member)
Ojaveer	Henn	UT-EMI	ICES WGITMO (Working Group on Introductions and Transfers of Marine Organisms, chair)
Ojaveer	Henn	UT-EMI	Serving as management board member of EU JPI Oceans
Ojaveer	Henn	UT-EMI	UN Regular Process for Global Reporting and Assessment of the State of the Marine Environment (nominated expert)
Orav-Kotta	Helen	UT-EMI	BMB member
Kuosa	Harri	SYKE	HELCOM CORESET II
Lehtiniemi	Maiju	SYKE	HELCOM MONAS
Lehtiniemi	Maiju	SYKE	HELCOM CORESET II
Lehtiniemi	Maiju	SYKE	HELCOM MORE
Lehtiniemi	Maiju	SYKE	HELCOM/OSPAR TG Ballast
Lehtiniemi	Maiju	SYKE	ICES/IOC/IMO WGBOSV (Working Group on Ballast and Other Ship Vectors)
Lehtiniemi	Maiju	SYKE	ICES WGITMO (Working Group on Introductions and Transfers of Marine Organisms)
Lehtiniemi	Maiju	SYKE	ICES WGZE (Working Group on Zooplankton Ecology, member)
Skov	Henrik	DHI	HELCOM Habitat
Skov	Henrik	DHI	ICES Seabird Ecology
Jonsson	Per	UGOT	OSPAR process extending MPA network
Döring	Ralf	TI-SF	EC/STECF participation in 2 plenary and 4 working group meetings (one as chair)
Döring	Ralf	TI-SF	EC/STECF participation in 2 plenary and 4 working group meetings (one as chair)
Döring	Ralf	TI-SF	EC/STECF participation in 2 plenary and 4 working group meetings (one as chair)
Döring	Ralf	TI-SF	EC/STECF participation in 2 plenary and 4 working group meetings (one as chair)
Döring	Ralf	TI-SF	EC/STECF participation in 2 plenary and 4 working group meetings (one as chair)
Döring	Ralf	TI-SF	EC/STECF participation in 2 plenary and 4 working group meetings (one as chair)
Döring	Ralf	TI-SF	ICES SGIMM (Study Group on Integration of Economics, Stock Assessment and Fisheries Management)
Oesterwind	Daniel	TI-OF	ICES ADGBYC (Advice drafting Group on bycatch of cetaceans and other protected species)
Rau	Andrea	TI-OF	EU DG ENV & DG MARE: Workshop on "Marine Environment and Fisheries" (ex-D3+ workshop)
Rau	Andrea	TI-OF	MSFD Fach AG Fisch und Fischerei

Last name	First name	Affiliation	Working group (ICES, HELCOM, OSPAR etc.)
Rau	Andrea	TI-OF	MSFD ErBeM
Rau	Andrea	TI-OF	ICES SGSPATIAL (Study group on Spatial Analyses for the Baltic Sea)
Rau	Andrea	TI-OF	ICES WGECO (Working Group on the Ecosystem Effects of Fishing Activities)
Rau	Andrea	TI-OF	ICES WKD3R (Workshop to draft recommendations for the assessment of Descriptor D3)
Rau	Andrea	TI-OF	ICES WKGMSFD-D3 (Workshop on guidance for the review of MSFD Decision Descriptor 3 - commercial fish and shellfish)
Rau	Andrea	TI-OF	ICES/HELCOM WGIAB (Working Group on Integrated Assessments of the Baltic Sea)
Stepputtis	Daniel	TI-OF	ICES WGELECTRA
Stepputtis	Daniel	TI-OF	ICES WGFTFB
Stepputtis	Daniel	TI-OF	North Sea Advisory Council
Andersson	Helén	SMHI	ICES WGIPEM (Working Group on Integrated Physical-biogeochemical and Ecosystem Modelling)
Andersson	Helén	SMHI	OSPAR ICG-EMO
Kuznetsov	Ivan	SMHI	OSPAR ICG-EMO
Meier	Markus	SMHI	Baltic Earth (chair)
Meier	Markus	SMHI	OSPAR ICG-EMO