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Population dynamics of benthic foraminifera in the intertidal mudflat of Northern Germany

Simon Masche

Tese para obtenção do Grau de Mestre em Biologia Marinha

Trabalho efetuado sob a orientação de:

(Alfred Wegener Institute):

Prof. Dr. Jelle Bijma

Dr. Markus Raitzsch

(Universidade do Algarve):

Dr. Isabel Mendes

2012

Section Marine Biogeosciences

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ABSTRACT

The population dynamics of benthic foraminifera from the intertidal mudflat near Dorum-Neufeld in Northern Germany was examined. The study covered the period from September 2011 – July 2012. Biweekly, sediment samples were taken from four spatially distributed sites covering an area of approximately 100,000 m^2 in the mudflat. Three benthic species are known to dominate the foraminifer population in the study area: *Ammonia aomoriensis* (Asano, 1951)*, Haynesina germanica* (Ehrenberg, 1840) and *Elphidium williamsoni* (Haynes, 1973). The aim of this study is to obtain a long-term overview of the population dynamics of the three species and to gain information on the reproduction period for each species, thus providing constrains for optimizing sampling strategies for laboratory cultures. Coexistence and competition for resources among the three dominant foraminifer species in the benthic realm is analyzed.

The very high abundance of living foraminifers in the mudflat in May and June with a maximum in May for both *A. aomoriensis* and *H. germanica* is observed. The fact that the higher abundance, starting in March and declining in June, is observed at all four sampling locations substantiates this finding. The population dynamics in the intertidal mud flats of Dorum-Neufeld has not been systematically analyzed before and now confirms assumptions previously derived from observations in laboratory stock cultures.

In contrast, *E. williamsoni* has a completely different lifecycle than *A. aomoriensis* and *H. germanica* with higher reproduction in colder months between September and March. It is present throughout the year and distributed patchier in all stations.

The most appropriate time for sampling foraminifers for culture experiments is between May and June for *A. aomoriensis* and *H. germanica* and from September until March for *E. williamsoni*.

The abundance of *E. williamsoni* does not show a peak during May and June like *A. aomoriensis* and *H. germanica*, but exhibits the highest abundance during winter

months. This means that either *E. williamsoni* competes with *A. aomoriensis* and *H. germanica* or that a colder climate favors the reproduction of *E. williamsoni*. In contrast, the similar abundance peak of *A. aomoriensis* and *H. germanica* suggests that these species coexist without competing with each other, maybe due to the use of different food sources.

Haynesina germanica and *E. williamsoni* are both cleptoplasts, they are able to use diatom chloroplasts for photosynthesis. This adaptation might grant these two species an ecological niche alongside *A. aomoriensis* in the intertidal mudflat ecosystem.

The sediments from Dorum that exclusively consist out of muddy, non-cohesive silt to fine sand plays a role in the relatively high Foraminifer densities, but very low species richness.

In this study, regarding to temperature reconstruction with the help of fossil Foraminifera, the calculated average temperature is ~10° C higher, than the measured average temperature which shows that population dynamics have a significant influence on possible temperature reconstructions with proxy signals (e. g. Mg/Ca).

Keywords: benthic foraminifera, *Ammonia aomoriensis, Haynesina germanica, Elphidium williamsoni,* population dynamics

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RESUMO

A presente tese de Mestrado examinará a dinâmica populacional de foraminíferos bentónicos, numa zona intertidal lodosa, próxima de Dorum-Neufeld, no norte da Alemanha.

Os foraminíferos bentónicos são Protistas comuns, que habitam quase todos os ambientes bentónicos. Apesar da sua distribuição ubíqua são biologicamente versáteis. A sua distribuição e abundância são influenciadas por parâmetros físicos, químicos e biológicos, o que os transforma em excelentes ferramentas para interpretações ecológicas e ambientais. Possuem ainda um potencial de preservação excelente no registo fóssil, podendo fornecer informações credíveis para compreender as alterações em ambientes marinhos, ocorridos no passado histórico e geológico.

O estudo da dinâmica populacional preenche a lacuna entre as características individuais de um organismo na população e a dinâmica da população como um todo. Esta ciência tem a função investigar as alterações ocorridas nas populações em termos de tamanho e composição etária, a curto e longo prazo, fornecendo deste modo bases para futuros estudos.

O objetivo desta investigação é a obtenção a médio-termo, da dinâmica populacional de três espécies de foraminíferos bentónicos. Pretende-se ainda obter informações sobre o período reprodutivo de cada espécie, no sentido de restringir os períodos ideais de amostragem, de modo a proceder à colheita de espécimes para cultura em laboratório. Serão ainda analisadas, a coexistência e competição entre as três espécies de foraminíferos bentónicos dominantes neste ambiente.

A amostragem para a realização deste estudo decorreu entre Setembro de 2011 e Julho de 2012. Bimensalmente, amostras de sedimento superficiais foram colhidas em quatro locais, espacialmente distribuídos na planície lodosa próxima de Dorum-Neufeld, cobrindo uma área aproximada de 100.000 m^2. Serão analisadas três espécies de

foraminíferos bentónicos, que são já conhecidas por dominar a população na área de estudo, nomeadamente: *Ammonia aomoriensis*, *Haynesina germanica* e *Elphidium williamsoni*.

Os valores de abundância mais significativos de foraminíferos vivos, na planície lodosa, ocorreram entre Maio e Junho, para as espécies *A. aomoriensis* e *H. germanica*. Este resultado mostra sem ambiguidade, que estas espécies apresentam o seu período de maior reprodução durante estes dois meses. Este resultado é ainda reforçado pelo aumento de abundância destas espécies, que se inicia em Março e diminui em Junho, em todos os locais de amostragem.

As maiores abundâncias de foraminíferos observadas em Maio e Junho podem estar relacionadas com o aumento de alimento disponível, nomeadamente forte aumento de fitoplâncton durante a primavera ou aumento das descargas de água-doce. Deve notar-se, contudo, que a classe de tamanho inferior, entre 90-125 μm (considerada a fração juvenil dos foraminíferos), possui o seu pico reprodutivo em Maio em todas as estações, e após este período a sua abundância decresce, ao passo que na classe de tamanho seguinte (125-250 μm) o maior pico de abundância se prolonga por mais tempo. Em alguns casos, o pico de abundância da classe de tamanho 125-250 μm começa logo após o pico de abundância dos juvenis. Estes dois eventos estão possivelmente relacionados com o crescimento dos juvenis, que são posteriormente adicionados à fração de tamanho maior (125-250 μm). Em culturas de laboratório das espécies de *A. aomoriensis* e *H. germanica* realizadas no Instituto Alfred Wegener (Alemanha), o conhecimento prático demonstrou que os foraminíferos juvenis conseguem num dia construir uma nova câmara da sua carapaça. Esta informação pode permitir determinar o momento exato de maior reprodução, através do cálculo do número de câmaras existentes num foraminífero juvenil, por exemplo, um foraminífero com 10 câmaras era um juvenil à 10-20 dias atrás.

Elphidium williamsoni possui um ciclo de vida completamente diferente das espécies *A. aomoriensis* e da *H. germanica*. Esta espécie apresentou as maiores abundâncias nos

meses mais frios, entre Setembro e Março, no entanto, ocorreu durante todo o ano, apresentando variações de abundância em todas as estações analisadas.

O melhor período do ano para amostragem de foraminíferos para cultura em laboratório é entre Maio e Junho para as espécies *A. aomoriensis* e *H. germanica*, e entre Setembro e Março para a espécie *E. williamsoni*.

Em termos de competição e coexistência, *E. williamsoni* não apresenta aumento significativo de abundância durante os meses de Maio e Junho, como se verificou para as espécies *A. aomoriensis* e *H. germanica*. Isto poderá indicar que *E. williamsoni* compete diretamente com *A. aomoriensis* e *H. germanica* ou que o clima mais frio favorece a sua reprodução. Por outro lado, os picos de abundância similares apresentados por *A. aomoriensis* e *H. germanica* sugerem que estas espécies coexistem no mesmo ambiente não havendo competição entre elas, talvez devido ao uso de diferentes tipos de alimento.

A influência do tamanho dos grãos de sedimento na densidade e na diversidade das associações de foraminíferos continua a ser controverso. Tipicamente, num ambiente com correntes fortes os sedimentos são mais grosseiros, enquanto correntes mais fracas permitem a sedimentação de material mais fino. Uma grande amplitude da maré em zonas de planície lodosa pode também ser considerada um importante fator limitante, devido à energia variável que controla a sedimentação, resultando na deposição de sedimentos finos em cima de sedimentos mais grosseiros. O que está de acordo com os sedimentos superficiais da planície lodosa de Dorum, que é composta por sedimentos lodosos não coesivos a areia fina. Baseado nas observações de densidade e diversidade das associações de foraminíferos bentónicos, pode ser assumido que substratos grosseiros (silte + argila <12-13%) favorecem o estabelecimento dos foraminíferos epifaunais. Outros estudos, no entanto, revelam que quer a densidade quer a riqueza específica estão claramente relacionados com o tamanho dos grãos de sedimento: quanto maior for o grão, menor a densidade e a riqueza especifica e vice-versa. Os resultados obtidos neste estudo revelaram ser diferentes. A densidade de foraminíferos

bentónicos é relativamente elevada, mas a riqueza específica é muito baixa. Apenas três espécies de foraminíferos bentónicos ocorrem na planície lodosa de Dorum. Isto poderá estar relacionado com as severas condições físicas de hidrodinâmica que apenas permitem a sobrevivência e desenvolvimento de espécies muito tolerantes.

Isto poderá explicar a existência de *H. germanica* num ambiente fisicamente controlado como a planície lodosa de Dorum, onde existe uma elevada turbulência hidrodinâmica. Outra explicação poderá estar relacionada com o facto de a *H. germanica* e o *E. williamsoni* serem cleptoplásticos, isto é, são capazes de usar cloroplastos de diatomáceas para fazer fotossíntese. Esta adaptação poderá conceder a estas duas espécies um nicho ecológico em paralelo com a *A. aomoriensis* no ecossistema da planície lodosa.

Quando são efetuadas reconstruções de temperatura com base em foraminíferos fósseis (ex. Mg/Ca), a dinâmica de populações poderá ter uma influência significativa nos valores obtidos. O sinal do registo geoquímico é obtido, normalmente, a partir do registo químico total, que representa a média de crescimento de numerosos indivíduos durante diferentes períodos, isto sob a influência de diferentes condições ambientais. No entanto, o registo obtido é um sinal médio que não tem em conta as variações sazonais de abundância. Quando são investigados foraminíferos fósseis, para a maior parte das espécies, não é conhecido o seu pico de abundância durante o ano.

Neste estudo, o cálculo da temperatura média (23.4ºC) é aproximadamente 10ºC superior ao valor de temperatura média registado para esta área, que é de 13.4ºC. O que vem demonstrar que é importante conhecer as variações populacionais dos foraminíferos, de modo a melhorar e compreender os indicadores (*proxies*) geoquímicos, assim como a sua fiabilidade e limitação.

A dinâmica populacional na planície lodosa de Dorum-Neufeld nunca tinha sido analisada de uma forma sistemática, confirmando com este estudo os pressupostos anteriormente assumidos com base em observações realizadas em cultura de laboratório.

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Palavras-chave: Foraminíferos bentónicos, *Ammonia aomoriensis, Haynesina germanica, Elphidium williamsoni,* dinâmica de populações

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GENERAL INTRODUCTION

Benthic foraminifera are common marine protozoa inhabiting almost all benthic environments. Formerly, benthic foraminifera were considered to occupy only the sediment surface and the top centimeters of the sediment, but later they were found also to inhabit deeper sediment layers (Jorissen, 1999). Benthic foraminifera are capable of vertical migration (Severin and Erskian, 1981; Moodly et al., 1998). The upper layers of sediment are usually well oxygenated, thus vertical migration is an excellent adaptation to escape temporary environmental changes such as severe anoxia, since the sediment surface is the last microhabitat to turn chemically hostile and the first to be re-oxygenated (Duijnstee et al., 2003). Under conditions of experimental bottom-water anoxia, typical shallow living foraminiferal taxa reside almost exclusively in the top 5 mm of the sediment, whereas they live deeper in the sediment (and reach a density maximum between 5 and 10mm) when the bottom-water is oxygenated (Duijnstee et al., 2003).

Despite their ubiquity in the marine realm (e.g. Murray, 1991), their biological versatility (e.g. Lipps, 1983), and their importance in the carbon cycle (e.g. Gooday et al., 1992; Graf, 1992; Moodley et al., 1998), modern benthic foraminifera have been seriously neglected by biologists. This lack of attention is compensated for by their popularity among paleontologists. The calcareous and agglutinated tests that foraminifera produce have a high potential to fossilize such that they are very abundant in old marine sediments. Some are found in deposits dating back to Cambrian times (e.g. Culver, 1991).

The calcareous tests of foraminifera are susceptible to dissolution in calcite undersaturated waters due to decreasing water pH (ocean acidification), which makes them an important group to study the effects of ocean acidification. During the Paleocene-Eocene, ~ 2000 x 10^9 metric tons of carbon were rapidly released in form of methane, which lowered the ocean pH and led to an increase in ocean temperature.

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During the Paleocene-Eocene thermal maximum (PETM), sea surface temperature rose by 5°C in the tropics and as much as 9°C at high latitudes (Zachos et al., 2005), which contributed to the mass extinction of benthic foraminifera at the P-E boundary.

Because of their excellent preservation potential, fossil foraminiferal shells are used for paleoenvironmental reconstructions in the marine realm (e.g. Duijnstee et al., 2003). For instance, paleoecological transfer functions are empirically derived equations for quantitatively estimating past atmospheric or oceanic conditions. The relationships represented in these functions are based on the spatial correlations between modern climate data and Foraminifera (assemblages and shape diversity), which are used as calibration sets (Sachs et al., 1977). Paleoenvironmental reconstructions also use geochemical composition of tests and include, among others, the Mg/Ca ratio as a recorder of bottom-water temperature (e.g. Martin et al., 2002), B/Ca as a proxy for the calcite saturation state (e.g. Yu and Elderfield, 2007), the boron isotopic composition as a pH proxy (e.g. Hönisch et al., 2008), and the stable isotopes of oxygen and carbon that are used to reconstruct past changes in sea level, temperature, carbon cycle and marine productivity (e.g. Zachos et al., 2001).

However the exact calcification mechanisms and secondary factors influencing the minor and trace metal incorporation into shell calcite are largely unknown. Another source of uncertainty when developing or applying proxies using shells from sediments is the lack of knowledge about foraminiferal population dynamics. The recorded geochemical signal is usually derived from bulk chemistry, which displays an average of numerous individuals grown at different times and thus under different environmental conditions. Consequently, the record is an averaged signal that obliterates seasonal changes in abundance. For this reason, it is important to gain knowledge about foraminiferal population variations to improve our understanding of geochemical proxies as well as their reliability and limitation.

The study of population dynamics bridges the gap between the characteristics of individual organisms in a population and the dynamics of the total population as a

whole. Individuals in biological populations differ with regard to their physical and behavioral characteristics and therefore in the way they interact with their environment (Cushing, 1998). The science of population dynamics has the task to investigate the short and long term changes in size and age composition of populations, thus providing a baseline for future studies such as to investigate the impact of Ocean Acidification on foraminiferal population structure.

Three benthic species, which will be examined in this study, have been identified to be the only calcareous foraminifers that populate in the intertidal mudflat of Dorum-Neufeld: *Elphidium williamsoni* (Haynes, 1973), *Ammonia aomoriensis* (Asano, 1951) and *Haynesina germanica* (Ehrenberg, 1840). The foraminifer sampling is carried out approximately biweekly, and the obtained time series data cover the period from September 2011 to July 2012. The present study is limited to this period, but the study will be extended beyond the deadline of this Master thesis to finally span approximately 1 ½ years (November 2011 – July 2013).

Shallow-water species such as *A. aomoriensis* are also often used for culturing studies because most deep-sea foraminifers are unable to survive under laboratory conditions, which is probably due to the pressure differences between natural habitat and laboratory. At the Alfred Wegener Institute for Polar and Marine Research (AWI) these shallow-water species are taken from the intertidal mudflat near Dorum-Neufeld in northern Germany. However, to date it has never been systematically investigated when the highest population densities occur in this area, and foraminifera for culturing were more or less randomly sampled.

Goals:

● Provide information on the population structure of each of the benthic species and investigate the potential influence on the mean geochemical proxy-signal (e.g. Mg/Ca)

● Provide information on the timing of reproduction of foraminifera in the intertidal mudflat. The number of juveniles is expected to give an idea of the optimum time for reproduction.

● The factors that influence foraminiferal abundance changes are still unknown and need to be explored; this study will provide some ideas concerning this matter. In addition, coexistence and competition among the three dominant foraminifer species in the benthic realm will be analyzed.

● Baseline for future studies to investigate the impact of ocean acidification on foraminiferal population structure.

Ocean Acidification

Over the last century, human activities have significantly influenced the biogeochemical cycles of carbon and nutrient elements with profound environmental impacts on local to global scales (IPCC, 2007). Since the industrial revolution surface ocean pH decreased by 0.1 units and model projections show that this decrease can reach 0.3 to 0.4 units in 2100 (IPCC scenario B2, 2007).

Carbon is the fourth most abundant element in the Universe. Most of it is stored in rocks, about 65,500 billion metric tons. The rest resides in the ocean, atmosphere, plants, soil, and fossil fuels. The carbon cycle represents the flows between each reservoir, which is divided into slow and fast components. A carbon increase puts carbon gases into the atmosphere resulting in warmer temperatures on Earth. The carbon cycle maintains a balance that prevents all of Earth's carbon from entering the atmosphere or from being stored entirely in rocks, thus it acts as a planet's thermostat. Human disturbances such as burning fossils and deforestation change the global carbon cycle. By clearing forests, the ability of the plants to store carbon, as they grow, vanishes and in agriculture, woods are often replaced by plats which store less carbon.

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With deforestation soil is exposed that vents carbon into the atmosphere. Since the beginning of the Industrial Revolution, when humans first started burning fossil fuels, carbon dioxide concentrations in the atmosphere have risen from about 280 parts per million to 387 parts per million, a 39 percent increase. As for now, land plants and the ocean have taken up about 55 percent of the extra carbon that humans have put into the atmosphere while about 45 percent has stayed in the atmosphere (Riebeek, 2011). The main reason of this surface ocean pH decrease is the increase of anthropogenic carbon dioxide (CO_2) in the atmosphere. The carbon dioxide data from Mauna Loa (volcano on Hawaii in the Pacific Ocean), which constitute the longest record of direct measurements of atmospheric CO_2, show a steady increase of atmospheric CO_2 from 1960 to 2010 (Tans, NOAA/ESRL). Since the partial pressure of CO_2 in the surface ocean tends to equilibrate with the atmosphere, the carbon uptake by the oceans increases with increasing atmospheric CO_2. In seawater, carbon is present in three forms (CO_2, HCO_3^- and CO_3^{2-}) (Fig. 1B), the relative proportions of which determine the pH (Zeebe and Wolf-Gladrow, 2001) (Fig. 1A). Hence, the more CO_2 is released by human beings, the more is absorbed by the ocean, which leads to a reduced surface ocean pH, also known as ocean acidification, yet the ocean remains alkaline.

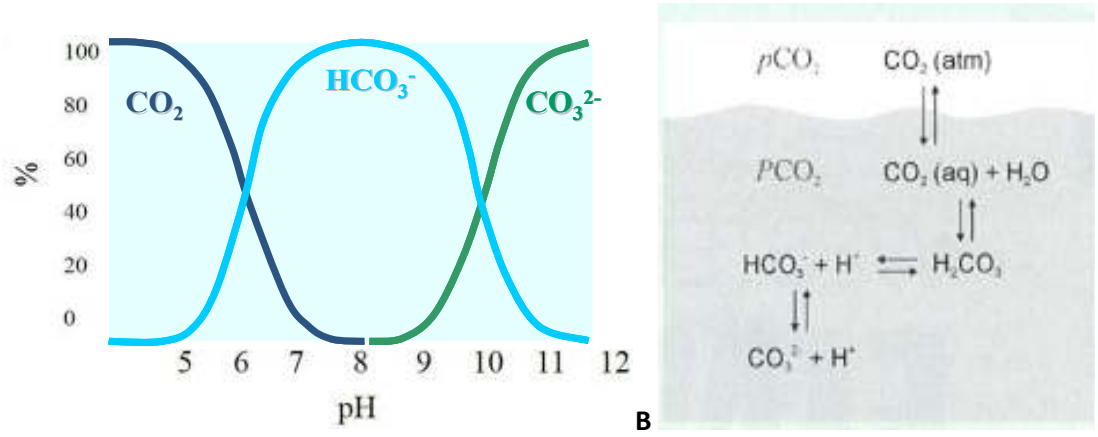

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Figure 1: A. Bjerrum plot for inorganic carbon species (Zeebe and Wolf-Gladrow, 2001). B. Carbonate chemistry (Bijma and Burhop, 2010).

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The increase of CO_2 due to human activity has contributed to growing concerns about climate change consequences (Gruber and Sarmiento, 2002) and perturbation of ocean chemistry (Doney, 2006).

Population dynamic studies serve as a baseline study for the effects of ocean acidification. Ocean acidification is a major threat for marine organisms, although the response is highly species-specific. Some organisms show no response or even higher growth rates (some marine algae) while others, especially corals and pteropods, which are carbonate producers, whose skeletons and shells are made up of the more soluble form of calcium carbonate – aragonite, are highly sensitive to ocean acidification. As a result, the shells end up being thinner and more fragile. For example, sea grass shows increased photosynthetic rates and higher reproduction rates in acidified water (Fabry et al., 2008). On the other hand, corals are more sensitive in a way that calcification rates may vary substantially in response to changes in pH and aragonite saturation state (McNeil et al., 2004). The effect of elevated atmospheric CO_2 on marine calcification is more diverse than previously thought. That is why further species-specific and multispecies studies with multiple stress factors have to be carried out.

Relating to the timing of reproduction of benthic foraminifers, biological consequences of ocean acidification suggest that calcification and metabolic processes are compromised in acidified seawater. Calcifying organisms can increase the rates of many of their biological processes, such as their metabolism and the ability to calcify to compensate for increased seawater acidity (Wood et al., 2008).

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Study area

The Wadden Sea stretches along the European continental coastline from Den Helder in the Netherlands to Esbjerk in Denmark with a length of 450 km and 20 km in width. In Germany it covers an area of 500.000 ha. The term "Wadden Sea" stands for the area from the dike towards the sea within a 10 meter depth contour line.

The Wadden Sea at the North Sea coast is the largest continuous Wadden Sea on Earth and a world heritage site, where millions of migratory birds take refuge. The Wadden Sea National Park in Schleswig-Holstein is with an area of 285.000 ha, the largest National Park in middle Europe. My study area is located in the intertidal mudflat near Dorum-Neufeld, Northern Germany (N 53° 44', E 08° 30').

The Wadden Sea is an open system where water exchange with the North Sea occurs through tidal inlets. The quality of water, sediment and marine habitats is to a large degree influenced by processes occurring in the North Sea and vice versa.

Especially the intertidal estuarine mudflat with its organic substances offers a splendid amphibian biotope. The upper centimeters of the sediment habitats many algae, bivalves, snails, worms and crustaceans. At 30 cm depth, no oxygen is present and forms blackish colored sediment due to composition processes.

Organisms living in tidal flat ecosystems have to tolerate extreme environmental gradients in salinity, incident light, oxygen availability and temperature. Nevertheless, this type of landscape exhibits high rates of primary production (Loebl et al., 2007).

These high rates are not only supported by the presence of well-adapted phytoplankton and microorganism consortia, but also by enhanced nutrient availability due to rapid organic matter (OM) remineralization. In intertidal areas, aerobic and anaerobic OM degradation processes are fuelled by filtration of suspended particles and dissolved OM from the water column within permeable sediments (Beck and Brumsack, 2012).

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Continuous supply of organic substrate supports enhanced microbial activity, and ultimately the release of metabolic products such as nutrients and methane (CH_4) to the pore waters. Tidal pumping induces advective flushing of permeable sediments and the transport of remineralization products to the open water column, where they can once again support primary production (Beck and Brumsack, 2012).

Intertidal mudflats are favored habitats for benthic foraminifera. They are, non-vegetated, soft sediment habitats, found between mean high-water and mean low-water spring tide datums (Dyer et al. 2000) and are generally located in estuaries and other low energy marine environments. Intertidal mudflats underlie drastic changes in soil composition due to seasonal and tidal changes. Although tidal flats comprise only about 7% of total coastal shelf areas (Stutz and Pilkey 2002), they are highly productive components of shelf ecosystems responsible for recycling organic matter and nutrients from both terrestrial and marine sources and are areas of high primary and secondary productivity (Black et al., 1998). Large amounts of sediment and organic matter are transported and deposited in intertidal mudflats, thus resulting in a high food supply for microorganisms, finfish, shellfish and migrating birds.

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MATERIALS AND METHODS

Sampling sites and sample collection

Nine spatially distant sampling sites were selected in the intertidal mudflat near Dorum-Neufeld. They were arranged in three rows. Within each row, three sampling sites are located approximately 100 meters away from each other, ranging from close to the shore towards 300 m off shore (Fig. 2). The sampling sites 1-3 and 8-9 are located close to tidal flat channels, while site 7 is located in a salt grass patch. Sites 4-6 are in the midst of the sampling area.

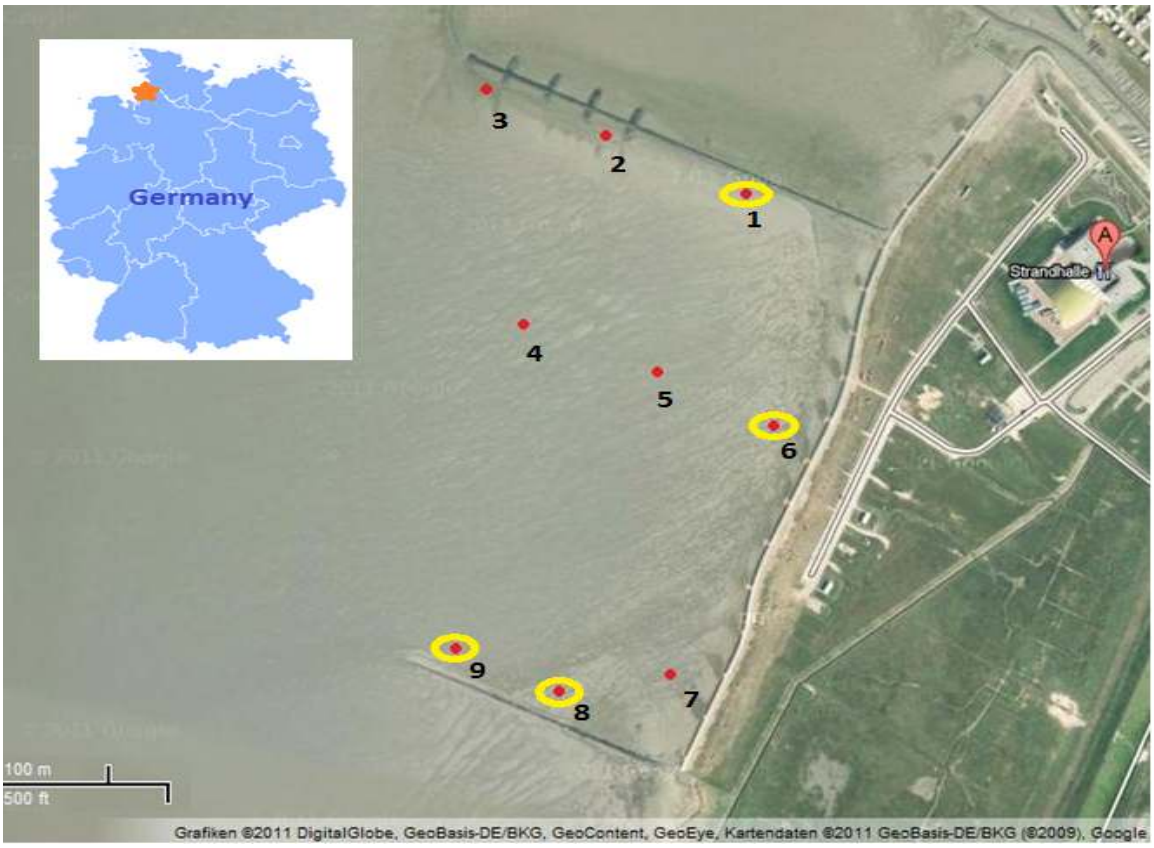

Figure 2: Sampling locations (sites 1-9) in the intertidal mudflat near Dorum-Neufeld, Northern Germany (N 53° 44', E 08° 30'). Stations 1, 6, 8 and 9 (yellow mark) were continuously sampled. Stations 2, 3, 4, 5, 7 only during September - December 2011.

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Starting in September 2011 until July 2012, sediment was collected biweekly from the sediment surface of the intertidal mudflat near Dorum-Neufeld at low tide (Fig. 3). Stations 1, 6, 8 and 9 were continuously sampled. Stations 2, 3, 4, 5, 7 only during September - December 2011. From each sampling site, the upper ~0.5 to 1 cm of the sediment was collected from a 30 cm x 30 cm frame, filled into plastic jars, and subsequently covered with sea water to avoid desiccation (Fig. 3 and 4). Temperature and salinity were measured in a tidal flat channel along with sample collection. In the laboratory, the sediment was resuspended for homogenization and subsamples (20 ml, ±1 ml) were put into centrifuge tubes containing 70% ethanol and Rose Bengal (1g/l) (for further details see Diz, et al., 2009), and stored at 4°C until further processing. Rose Bengal was used to distinguish between (recently) living and dead individuals as it adheres to proteins and produces a red coloration (Murray and Bowser, 2000) when the organism are alive. To obtain the exact number of foraminifers, which were counted from the varying amounts of sediment, the data was normalized by dividing the number of counted foraminifers through the respective sediment amount.

Figure 3: Sampling at Site 1 during low tide, close to a tidal flat channel.

Figure 4: Surface sediment collection (~0.5 to 1 cm).

After the first three months of sampling (September through December 2011), I excluded some of the nine sampling sites (Fig. 5) to focus on the most productive sampling sites.

Station 1, 6, 8 and 9 showed the highest abundance of species throughout the first three sampling month, which was the criterion for sorting out the sampling sites. The second main criterion is to keep sampling sites with a high abundance of *A. aomoriensis*, because this species is the primary target species used in culture experiments at the AWI and is therefore of special importance for further investigation.

Sampling station 1 shows a high abundance of *A. aomoriensis* in all three sampling months and has also a high abundance of the other two species. Station 6 is another sampling station with relatively high number of *A. aomoriensis*, especially in the months of November and December. Station 8 has a relatively high occurrence of *A. aomoriensis* compared to stations 3, 4, 5 and 7.

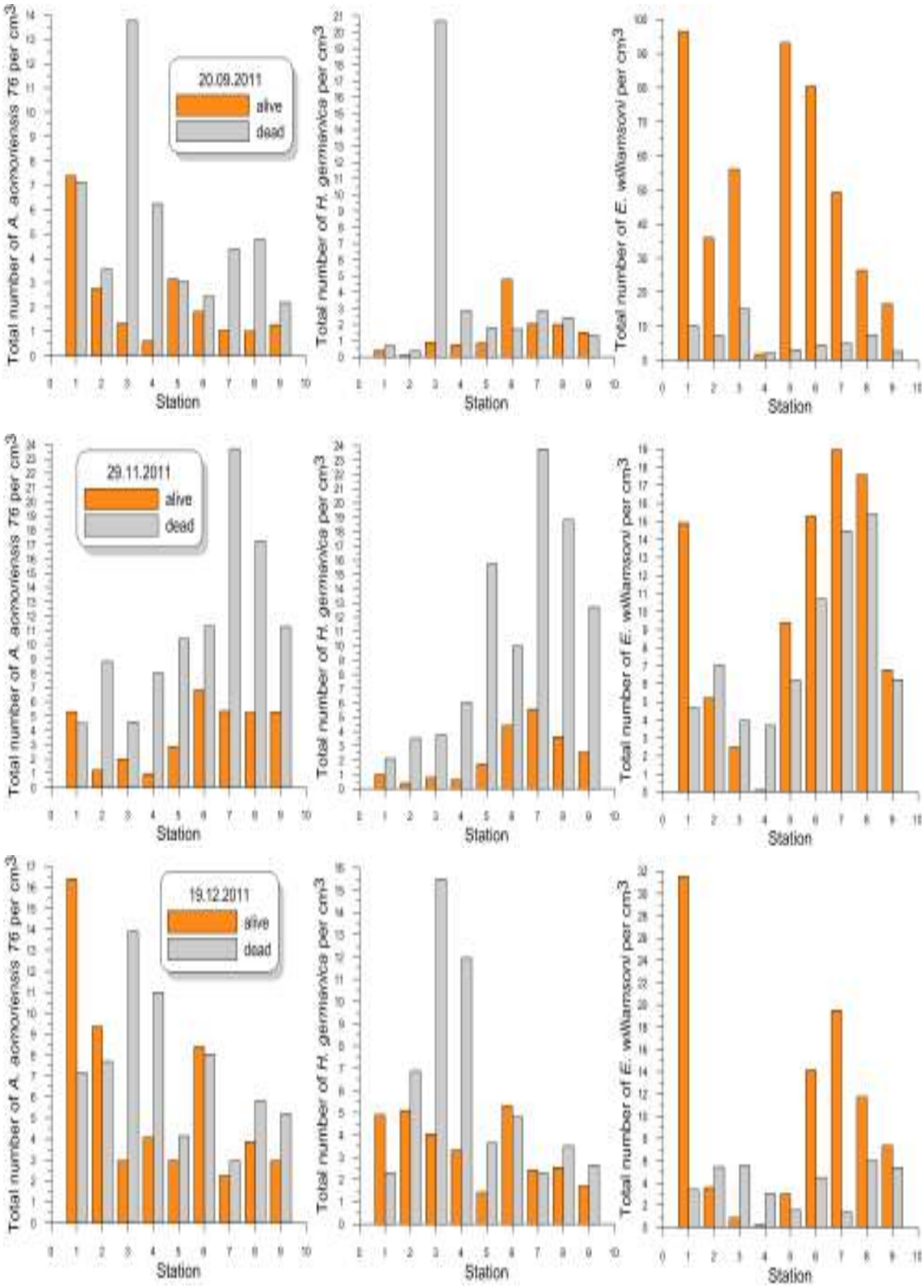

Figure 5: Total number per cm^3 of living and dead *A. aomoriensis*, *H. germanica* and *E. williamsoni.*

Stations 2, 3, 4, 5, and 7 were excluded because they had the lowest abundance of foraminifers and are therefore less attractive for further investigation. The number of dead individuals was not considered for site selection.

From January 2012 samples were only taken from stations 1, 6, 8 and 9 and these were taken into account in the results.

Sample preparation

In the laboratory, the subsamples were fixed in Alcohol and Rose Bengal stained. After 24 hours, they were washed and wet-sieved over 63 µm and 1.6 mm sieves to remove macrofauna and sediment smaller than 63 µm (silt and clay < 63 µm) and excess Rose Bengal and ethanol (Fig. 6). The washed sediment samples are then oven dried (60°C) and filled in glass jars for subsequent heavy liquid separation with Sodium Polytungstate.

Figure 6: Removing macrofauna, silt, clay and excess Rose Bengal.

In order to separate the foraminifera (stained and unstained) in the samples from the remaining sediment we use a heavy liquid separation technique with Sodium Polytungstate (Munstermann and Kersthold, 1996). Sodium Polytungstate [Na_6 (H_2 W_{12} O_{40})] is a high-density agent, which is non-toxic, ecologically safe and recoverable, so that it can be re-used. To obtain the best results in separating foraminifers, we adjusted to a density of 2.45 g/ml, by adding distilled water to the solution. The exact density of 2.45 g/ml, which worked best for separating foraminifers, was eventually obtained by trial and error.

We verified the efficiency of the separation. After density centrifugation no foraminifera were found in the remaining sand fraction and all foraminifera were kept in the supernatant.

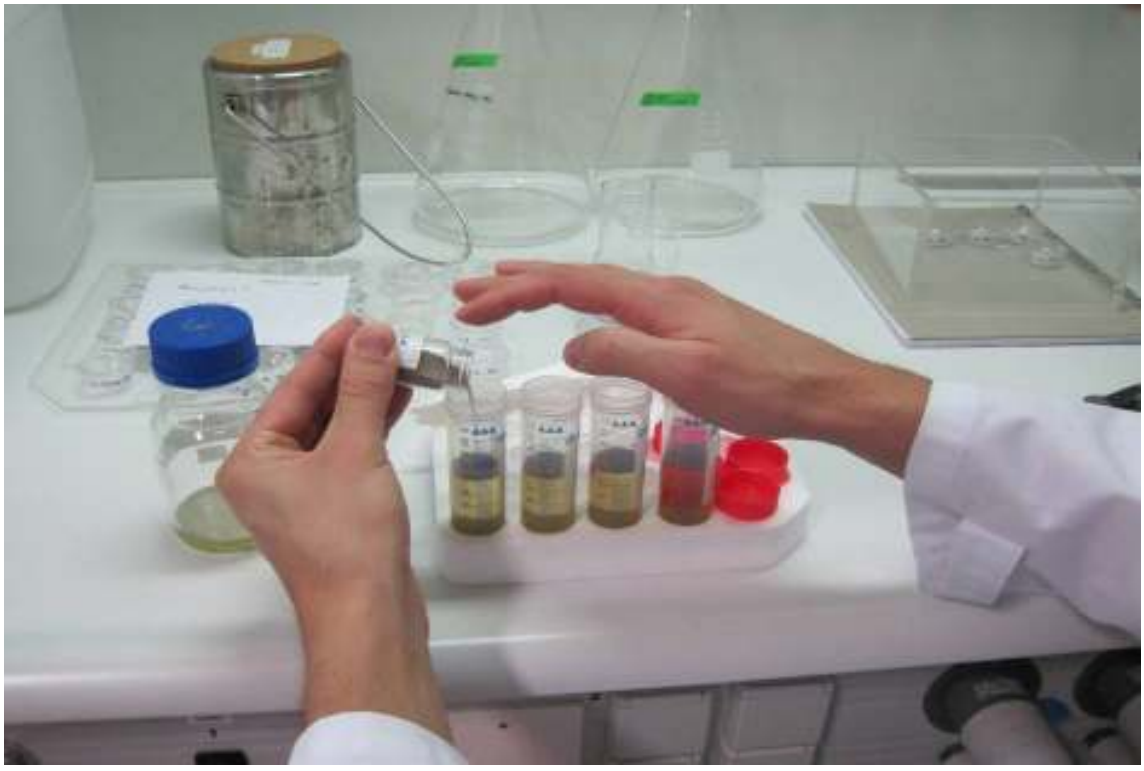

Figure 7: Sediment samples mixed with Sodium Polytungstate.

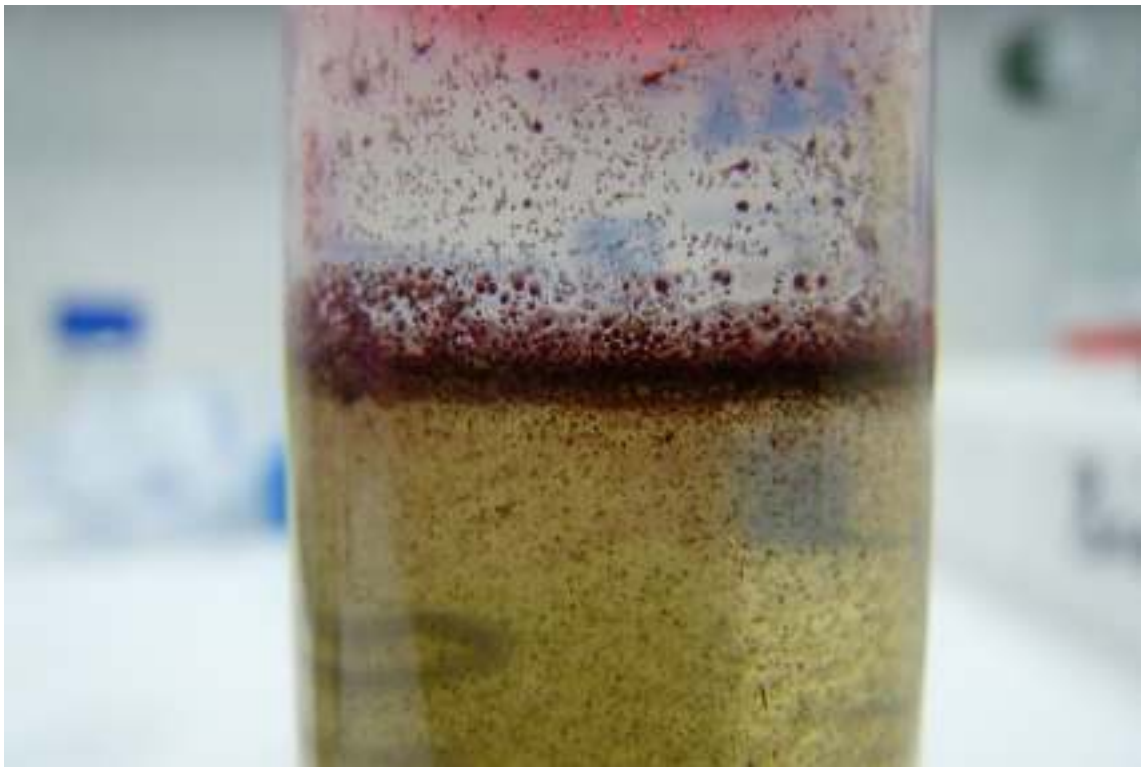

Figure 8: Stained foraminifers floating on top of the Sodium Polytungstate solution.

For separation, each sediment sample (20 cm^3) was equally divided into four centrifuge tubes containing Sodium Polytungstate (Fig. 7). After mixing and centrifuging for 10 minutes at 2000 rpm, the foraminifers were decanted from the upper layer of the solution (Fig. 8) over a filter to collect the Sodium Polytungstate. The remaining Sodium Polytungstate in the tube and bottom sediment was also filtered for recycling. The filter containing the foraminifers (stained and unstained) and sediment remains was thoroughly washed with MilliQ water to remove any remaining Sodium Polytungstate from the shells. Subsequently, the sample was air-dried and filled into vials for further processing.

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Speciation

Before counting and classification, the foraminifers were dry-sieved over 90, 125, 250 and 355 µm sieves to separate different size classes and to remove remaining sediment.

The foraminifers of each size class were identified and total numbers of dead or alive specimens were counted. Counting was done using a binocular (Zeiss, steREO, Discovery, V12) and picking trays. We identified three benthic species that are present in the intertidal flat of Dorum, which will be examined in this study: *E. williamsoni, A. aomoriensis* and *H. germanica*. No other species, except the three mentioned above, were observed.

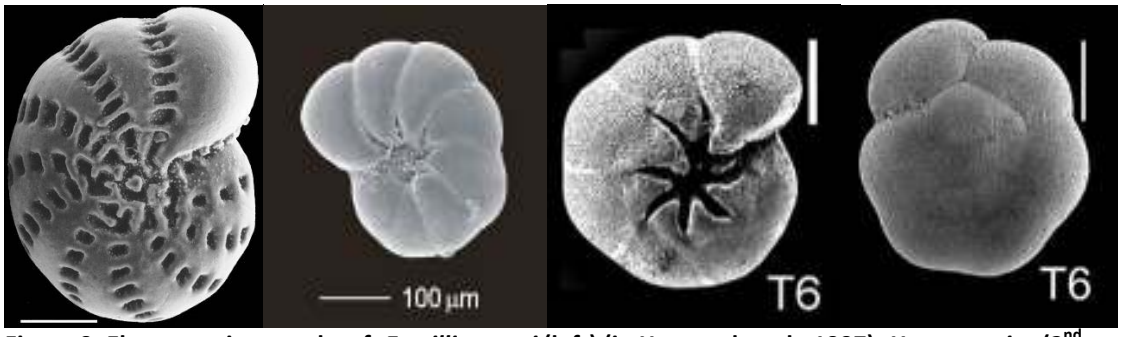

Figure 9: Electron micrographs of: *E. williamsoni* (left) (in Hayward et al., 1997), *H. germanica* (2nd from left) (in Banner and Culver, 1978), and *A. aomoriensis T6* (umbilical view, 2nd from right and spiral view, right) (in Hayward et al., 2004). Scale bar is 100 µm.

Figure 10: Live shots of: *E. williamsoni* (left) (in Austin, 2001), *H. germanica* (middle) (in Goldstein, 2006), and *A. aomoriensis T6* (right) (in Dissard et al., 2010). Scale bar is 100 µm if not labeled.

In the literature, the *Ammonia* species that is present in Northern Germany's mudflats is often referred to as *Ammonia tepida* (Cushman, 1926). Morphological distinction of molecular types in *Ammonia* revealed though, that the species near Dorum, Neufeld is the molecular subtype (T6) of *A. aomoriensis*. This specific molecular subtype is characterized by a commonly elongate folium, pointed, with weak, imperforate, secondary calcite; often with one or more small umbilical bosses; radial sutures perpendicular to spiral suture on spiral side (Fig. 9 and 10) (Hayward et al., 2004). *Ammonia* species are free epibenthic or endobenthic in fine sediments. "Foraminifera are recorded as feeding primarily upon bacteria, small diatoms, and nannoplankton. Thus their food items are usually below 50 μm and commonly below 25 μm in size" (Lipps, 1970).

Haynesina germanica and *E. williamsoni* are both cleptoplasts, they are able to use diatom chloroplasts for photosynthesis (see Fig 10 for green color of chloroplasts in *H. germanica*). "Kleptoplastidy is the ability of heterotrophic organisms to preserve chloroplasts of algal preys they eat and partially digest. As the sequestered chloroplasts stay functional for months, the "host" becomes photosynthetically active"(Pillet et al., 2010).

Characterizing kleptoplastidy is of major importance for understanding endosymbiosis and the emergence of photosynthesis among eukaryotes. Most of the hypotheses assume that the acquisition of chloroplasts by the host cell was carried through a predator-prey relationship between a heterotrophic eukaryotic cell feeding on algae (Keeling, 2004).

Haynesina germanica mainly bears chloroplasts of pennate diatoms (see Fig 11). The majority of kleptochloroplasts found in *E. williamsoni* belong to diatoms from clades C (*Cymatosirales*) and D (pennate diatoms) with almost the same ratio. In comparison to other foraminifers, chloroplasts sequestered by *Haynesina* and *Elphidium* originated exclusively from diatoms (Pillet et al., 2010).

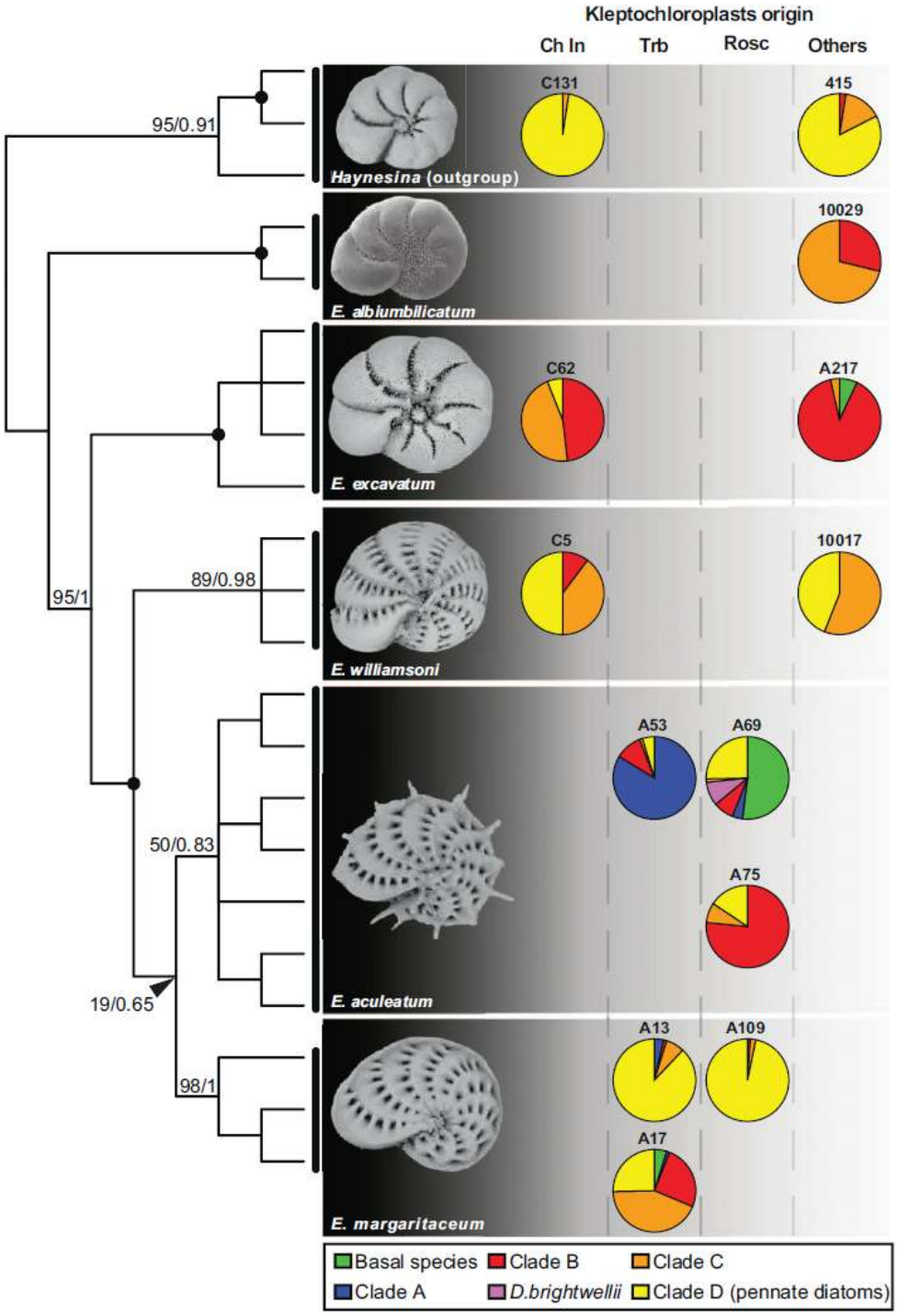

Figure 11: Elphidiids rDNA phylogeny and content of kleptochloroplasts per individual per species (Pillet et al., 2010). Each pie represents a single individual; they are shown by morphospecies horizontally and by sampling location vertically, Chezzetcook Inlet (Ch In), Trebeurden (Trb), Roscoff (Rosc) and others.

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Haynesina germanica has been widely described as a conspicuous inhabitant of shallow-water settings along European coastlines, the Mediterranean Sea, the Gulf of Mexico and Canada (e.g. Calvo-Marcilese and Langer, 2010, see references therein). It is a mid-latitudinal, temperate and euryhaline species that favors shallow-water muddy and phytal environments of salt-marshes, intertidal habitats with salinities that generally range between 1 and 30, and optimal temperatures between 12 and 22 ºC (Banner and Culver, 1978; Hottinger et al., 2001). Armynot du Châtelet et al. (2004) have also shown that *H. germanica* is a successful pioneer species in polluted estuarine environments and in zones that are rich in organic matter (see also Gebhardt, 2009).

Elphidium williamsoni was originally described from beach sands off Dunkerque, France. Tests *of E. williamsoni* exhibit numerous papillae of different sizes in the umbilical area. They are surrounded by thickened extensions of the chamber walls pointing into the umbilicus (Fig. 9). The sutural bridges are generally indistinct. The test of *E. williamsoni* is slightly compressed with a width * 10/diameter ratio of 4–5 (Lutze, 1965).

Classification and Phylogeny

When it comes to foraminiferal classification and phylogenic trees, foraminifera are primarily classified based on the composition and morphology of their test. Three basic wall compositions are known, organic, agglutinated and secreted calcium carbonate.

Agglutinated forms, for example the *Textulariina*, are composed of randomly accumulated grains or grains selected on the basis of specific gravity, form or size; where some forms arrange particular grains in specific parts of the test.

Foraminifera that secrete tests are again subdivided into three major groups, microgranular (i.e. *Fusulinina*), porcelaneous (i.e. *Miliolina*) and hyaline (i.e. *Globigerinina*) (Fig 12).

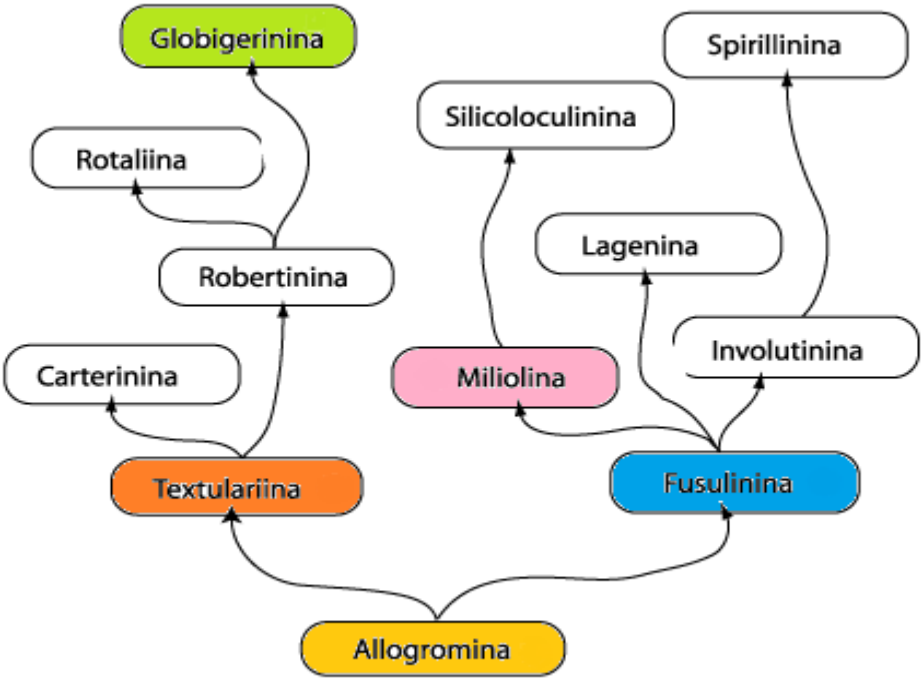

Figure 12: Foraminiferal suborders and phylogeny. Redrawn from Tappan and Loeblich (1988).

Microgranular walled forms are composed of equidimensional subspherical grains of crystalline calcite. Porcelaneous forms have a wall composed of thin inner and outer veneers enclosing a thick middle layer of crystal laths; they are imperforate and made from high magnesium calcite. The hyaline foraminifera add a new lamella to the entire test each time a new chamber is formed (Olney, 2002).

The *Spirillinina* have a test constructed of an optically single crystal of calcite, the Suborder *Silicoloculinina* has a test composed of silica. The Suborder *Involutina* have a two chambered test composed of aragonite. The *Robertinina* also have a test composed of aragonite and the Suborder *Carterina* is believed to secrete spicules of calcite which are then weakly cemented together to form the test (Olney, 2002).

Elphidium williamsoni, *A. aomoriensis* and *H. germanica* all belong to the Order *Rotaliida*, whose tests are typically enrolled or may be encrusted with proliferated chambers (Pawlowski et al., 2003).

Reproduction

Of roughly 4000 living species of foraminifera the life cycles of only about 20 are well-known. There is a large variety of reproductive, growth and feeding strategies, yet the alternation of sexual and asexual generations is frequent throughout the group and this characteristic separates the foraminifera from other members of the *Granuloreticulosea*. Asexually produced haploid generations commonly form a large proloculus (initial chamber) and are therefore termed *megalospheric*. Sexually produced diploid generations have a tendency to produce a smaller proloculus and are therefore termed *microspheric*. Importantly, in terms of preservation in the fossil record, many foraminiferal tests are either partially dissolved or partially disintegrated during the reproductive process (Olney, 2002).

The diploid zygote growths to a diploid, microspheric agamont, which forms young haploid foraminifera via meiosis (see Fig. 13). The young foraminifers can either grow to a haploid, megalospheric gamont or form a schizont, which is able to reproduce asexually. The megalospheric gamont produces gametes via mitosis which subsequently turn into diploid zygotes.

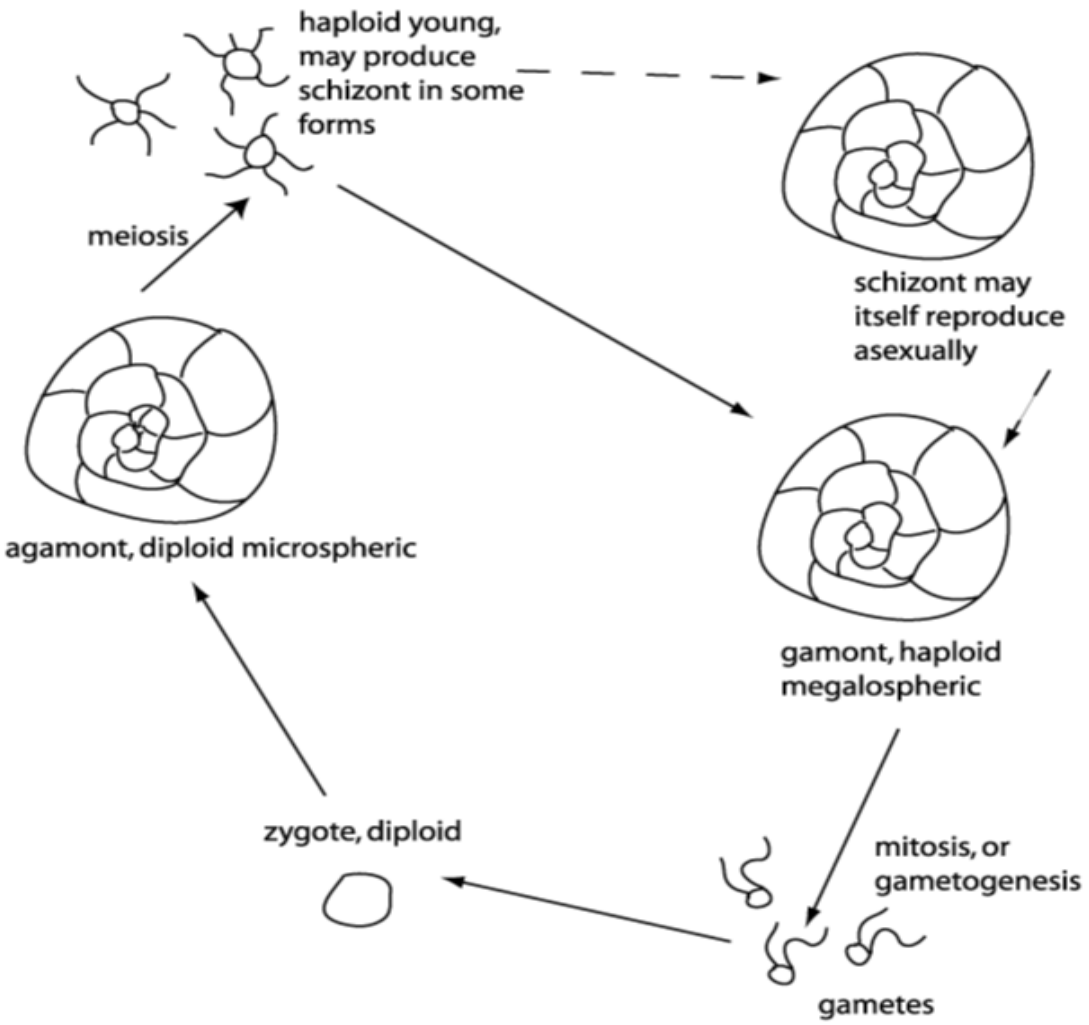

Figure 13: Generalized foraminifera life cycle. Redrawn from Goldstein (1999).

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Residual calculations

The absolute numbers from the respective species are calculated from the size fraction data. Subsequently the relative abundance ($0 < x < 1$) is calculated. The residual values ($-1 < x < 1$) are then determined from the mean abundance. Finally, the percentage (%) deviation from of the standard residual values was calculated (see Figures 22-24 and supplemental data).

$$\frac{\text{residual value}}{\text{mean relative abundance} \times 100} = \text{percentage deviation of mean relative abundance}$$

The residual graphs allow a different way of representing the data and show the percentage change compared to the mean value as a function of grain size and time (Figs. 22-24).

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Mg/Ca temperature calculation

Calculating the mean temperature from *Ammonia aomoriensis*, using a theoretical Mg/Ca calibration for *Cibicidoides* spp. of Elderfield et al. 2006. The calculated temperature is 23, 4° C.

month	Temp	number of A.a.	percentage of A.a. to total number
Sep	19	2	0,692041522
Oct	12	4	1,384083045
Nov	4	6	2,076124567
Dec	4	4	1,384083045
Jan	1	3	1,038062284
Feb	4	2	0,692041522
Mar	10	3	1,038062284
Apr	12	15	5,190311419
May	20	50	17,30103806
Jun	22	70	24,22145329
Jul	25	60	20,76124567
Aug	28	70	24,22145329
	13,41666667	289	
	measured average T	total number	

theoretical Mg/Ca using calibration for *Cibicidoides spp.* of Elderfield et al. 2006
7,276423648
3,36907924
1,397436497
1,397436497
1,004650263
1,397436497
2,703749422
3,36907924
8,122512149
10,12127338
14,0783687
19,58256216

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contribution of monthly Mg/Ca to annual Mg/Ca	
0,050355873	
0,046630855	
0,029012522	
0,019341682	
0,010428895	
0,009670841	
0,028066603	
0,174865704	
1,405278919	
2,451519505	
2,922844712	
4,743181145	
11,89119726	23,46508105
annual Mg/Ca	calculated average T

Formula for temperature calculation with Mg/Ca:

$$\frac{Mg(mmol)}{Ca(mol)} = 0.9 \times EXP(0.11 \times T)$$

RESULTS

Total abundance of foraminifers

Ammonia aomoriensis and H. germanica:

Analysis of the total numbers of living specimens (Figs. 14-17), reveals a peak starting in May through June at all sampling stations for *A. aomoriensis* and *H. germanica*. The abundance in this time period for *A. aomoriensis* and *H. germanica* ranges from 60 to 90 individuals/cm^3, whereas during the rest of the sampling period it rarely exceeds 20 individuals/cm^3. In fact, from November to March the total numbers of living *A. aomoriensis* and *H. germanica* predominantly remains below 5 individuals/cm^3.

The number of living individuals, start to increase in March with its maximum in May and June can be observed for *A. aomoriensis* and *H. germanica* at all four stations (Fig. 14-17).

In contrast, living specimens of *E. williamsoni* show no peak during May and June, but have various peaks which are not uniform at all sampling stations.

Considering the total amount of dead foraminifers at sampling station 1, there is a significant peak for both *A. aomoriensis* and *H. germanica* in February with an average of 30 dead individuals/cm^3. There is also a slight increase from April to July ranging from 1 to 7 dead individuals/cm^3, which is present at all sampling stations.

Examining station 6 for the total amount of dead foraminifers, the quantity does not exceed 13 dead individuals/cm^3 for all three species at any time, except *E. williamsoni* in May and June with 17 and 20 dead individuals/cm^3, respectively (Fig. 15).

Sampling station 8 has one peak in November with 19 dead individuals/cm^3 for *A. aomoriensis* and *H. germanica.*

Similarly to station 8, sampling station 9 has one peak in November with 12 dead individuals/cm^3 for *A. aomoriensis* and *H. germanica.*

***Elphidium williamsoni*:**

At station 1, *E. williamsoni* exhibits two high peaks with 96 individuals/cm^3 on September 20th and 90 individuals/cm^3 on January 16th. This species also shows several smaller peaks throughout the year ranging from 20 to 40 individuals/cm^3 (Fig. 14).

At sampling station 6, there is only one high peak with 80 individuals/cm^3 on September 20th. From November to July, the total number of living specimen is between 10-20 individuals/cm^3.

At sampling station 8, the highest abundance of *E. williamsoni* is also in September with 26 individuals/cm^3. There are several smaller peaks in January, March, April and June, but none of them exceeds 20 individuals/cm^3 (Fig. 16).

At sampling site 9, the total amount of living *E. williamsoni* does not exceed the 20 individuals/cm^3 mark, the highest amounts can be registered in September, February, March and June, each with 16, 15, 18 and 17 individuals/cm^3 (Fig. 17).

Considering the total amount of dead foraminifers at sampling station 1, *E. williamsoni* has a single peak in June with 38 dead individuals/cm^3 (Fig. 14).

In sampling station 8, *E. williamsoni* has a peak in June with 20 individuals/cm^3 and a second peak in November with 15 dead individuals/cm^3 (Fig. 16).

In sampling station 9, *E. williamsoni* has a peak in June with 14 dead individuals/cm^3 and a second peak in November with 15 dead individuals/cm^3 (Fig. 17).

Size fractions

The four sampling sites can be divided into close-to-shore (station 6), mid-shore (station 1, 8) and off-shore sampling sites (station 9) (Fig. 2). Regardless of the location and distance to the shore, all four sites show a major peak from May through June for *A. aomoriensis* and *H. germanica.*

At sampling station 1 (mid-shore) *A. aomoriensis* and *H. germanica* have their highest abundance in the 125-250 µm size class with 47 individuals/cm^3 in May and June. In the smallest size class with 90-125 µm there is also a rise from April to May and a decline afterwards until July.

The abundance in the biggest size class (>350 µm) is very small to zero. *E. williamsoni* is the most frequent species in this size class with an average of less than 1 individual/cm^3.

Elphidium williamsoni has several high peaks in the 125-250 µm size class with more than 50 individuals/cm^3 in September and January and three smaller peaks with roughly 20 individuals/cm^3 in December, March and June (Fig. 18).

In the 250-350 µm size class, there are three peaks, the highest in January with 36 individuals/cm^3, the second highest in March with 29 individuals/cm^3 and the lowest in April with 21 individuals/cm^3.

The abundances at sampling station 6 (close to shore) are similar to station 1 (mid-shore), except that the peak in the smallest size class with 90-125 µm is smaller in May with 26 individuals/cm^3, compared to ~40 individuals/cm^3 at station 1. There is only

one peak of *E. williamsoni* in September with more than 50 individuals/cm^3 instead of several peaks as in station 1.

Station 8, which is another mid-shore sampling site (such as station 1), shows similar patterns as station 1, but has lower total numbers (Figs. 18 and 20). Compared to station 1, *E. williamsoni* shows no high peaks at station 8, but is more equally abundant with 10 individuals/cm^3 on average, which is not the case in station 1 (Fig. 18).

The off-shore station 9 is similar to the other three stations, which are spatially different. *Ammonia aomoriensis* and *H. germanica* have their highest abundance in the 125-250 µm size class with 30 and 40 individuals/cm^3, respectively, in May and June. In the smallest size class with 90-125 µm, there is also a rise which begins in April with a maximum in May and a decline afterwards until July.

Elphidium williamsoni displays medium peaks in September with 15 individuals/cm^3 in the 125-250 µm size class and in March with 14 individuals/cm^3 in the 250-350 µm size class (Fig. 21).

Temporal variation of foraminifers

Ammonia aomoriensis and *H. germanica* have their highest total abundance in spring and summer, throughout all four sampling sites, whereas in autumn and winter until the end of March low abundance predominates. A clear increase in both species can be observed with its maximum in May and June (Fig. 14-17).

Elphidium williamsoni does not show such an increase, but reaches peaks in total abundance throughout the rest of the season; it has two high peaks with 96 individuals/cm^3 in September and 90 individuals/cm^3 in January. *Elphidium williamsoni* is generally more abundant in autumn and winter than *A. aomoriensis* and *H. germanica*, especially at station 1 (Fig. 14).

Regarding seasonal differences in size classes, the smallest size fraction of 90-125 µm for *A. aomoriensis* and *H. germanica* tends to increase not as much as the 125-250 µm size class and also tends to decrease in June, whereas the larger size class with 125-250 µm is more abundant during this month.

For example, at station 8 (Fig. 20), the maximum peak in the smallest size class for *A. aomoriensis* and *H. germanica* is at 34 individuals/cm^3 in May, which is almost identical to the peak in the larger size class above (125-250 µm). In the next sampling period in June, the abundance decreases in the smallest size class (90-125 µm) down to 23 individuals/cm^3, whereas in the larger size class (125-250 µm) a clear increase up to 38 individuals/cm^3 is observed.

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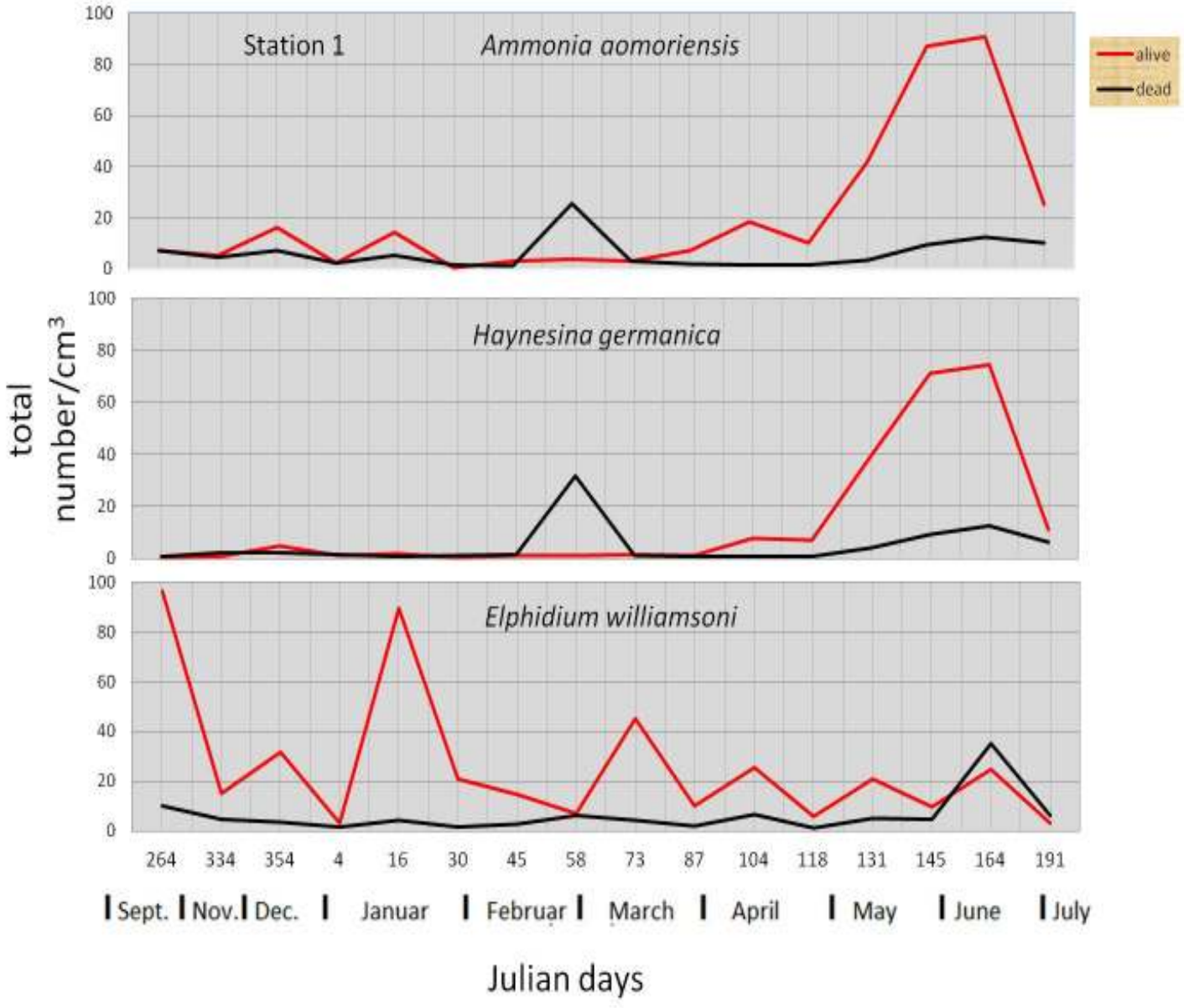

Figure 14: Total numbers of individual foraminifers per cm^3 for each species from September to July at Station 1. Living and dead foraminifers are shown in red and black, respectively.

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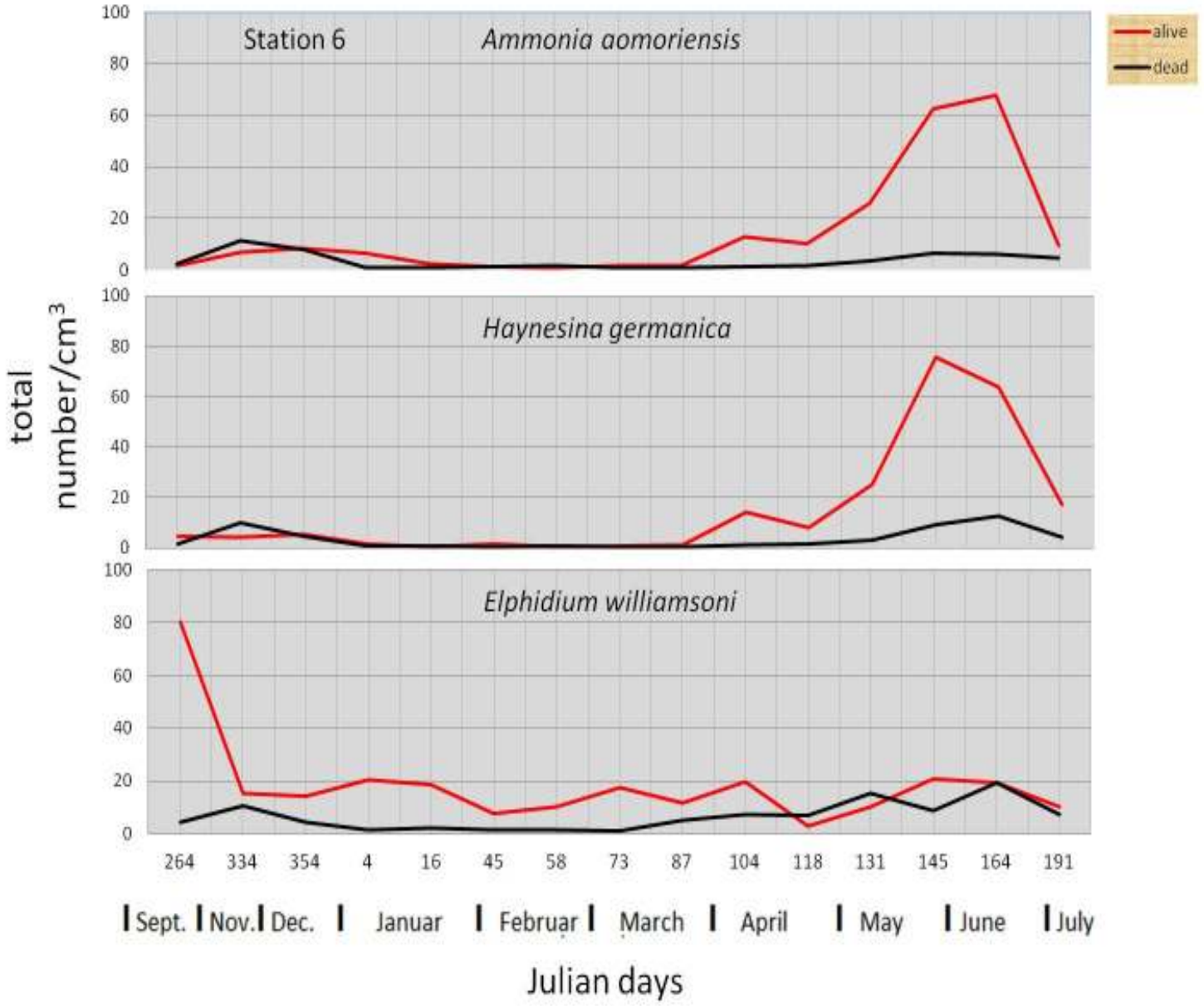

Figure 15: Total numbers of individual foraminifers per cm^3 for each species from September to July at Station 6. Living and dead foraminifers are shown in red and black, respectively.

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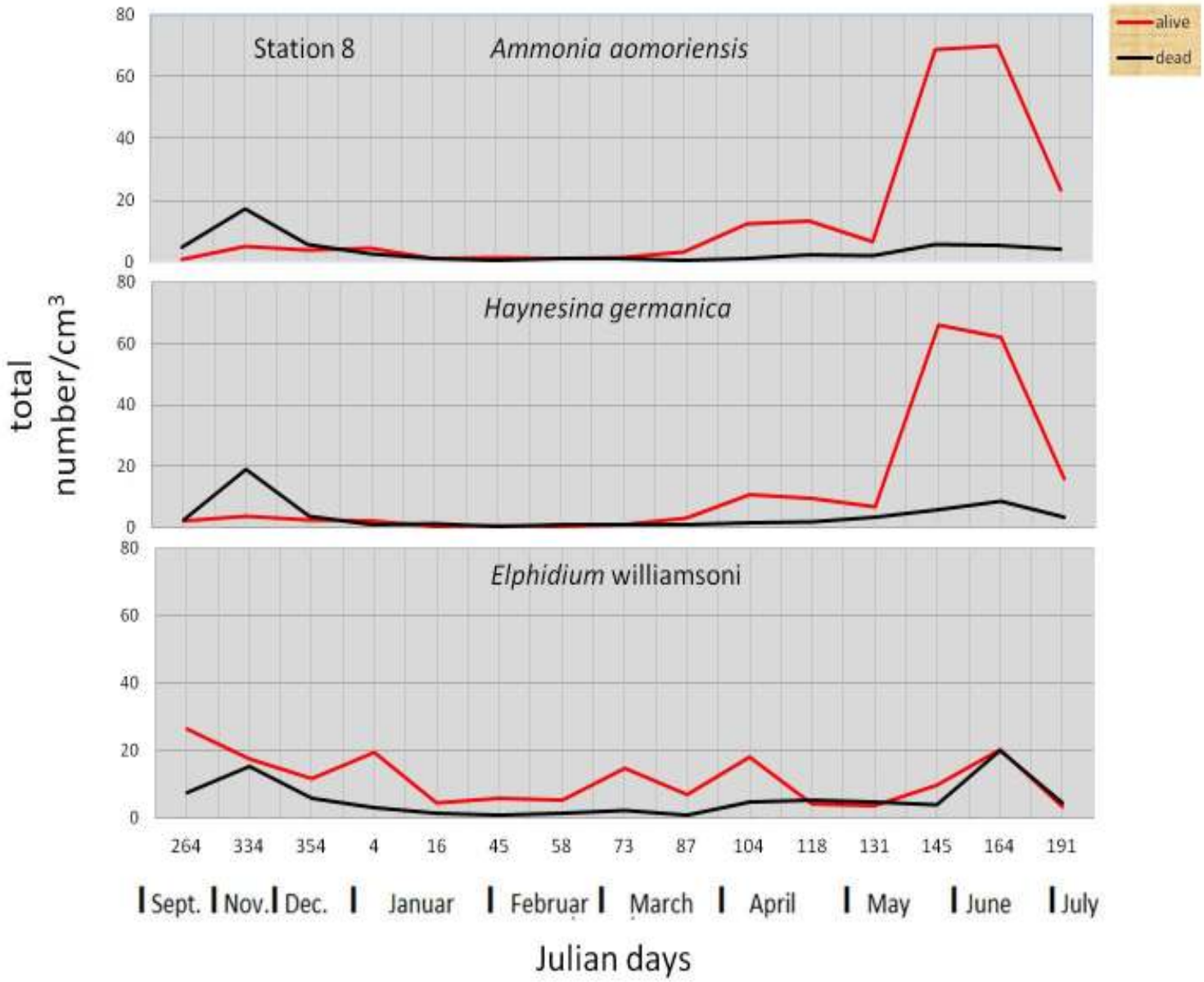

Figure 16: Total numbers of individual foraminifers per cm^3 for each species from September to July at Station 8. Living and dead foraminifers are shown in red and black, respectively.

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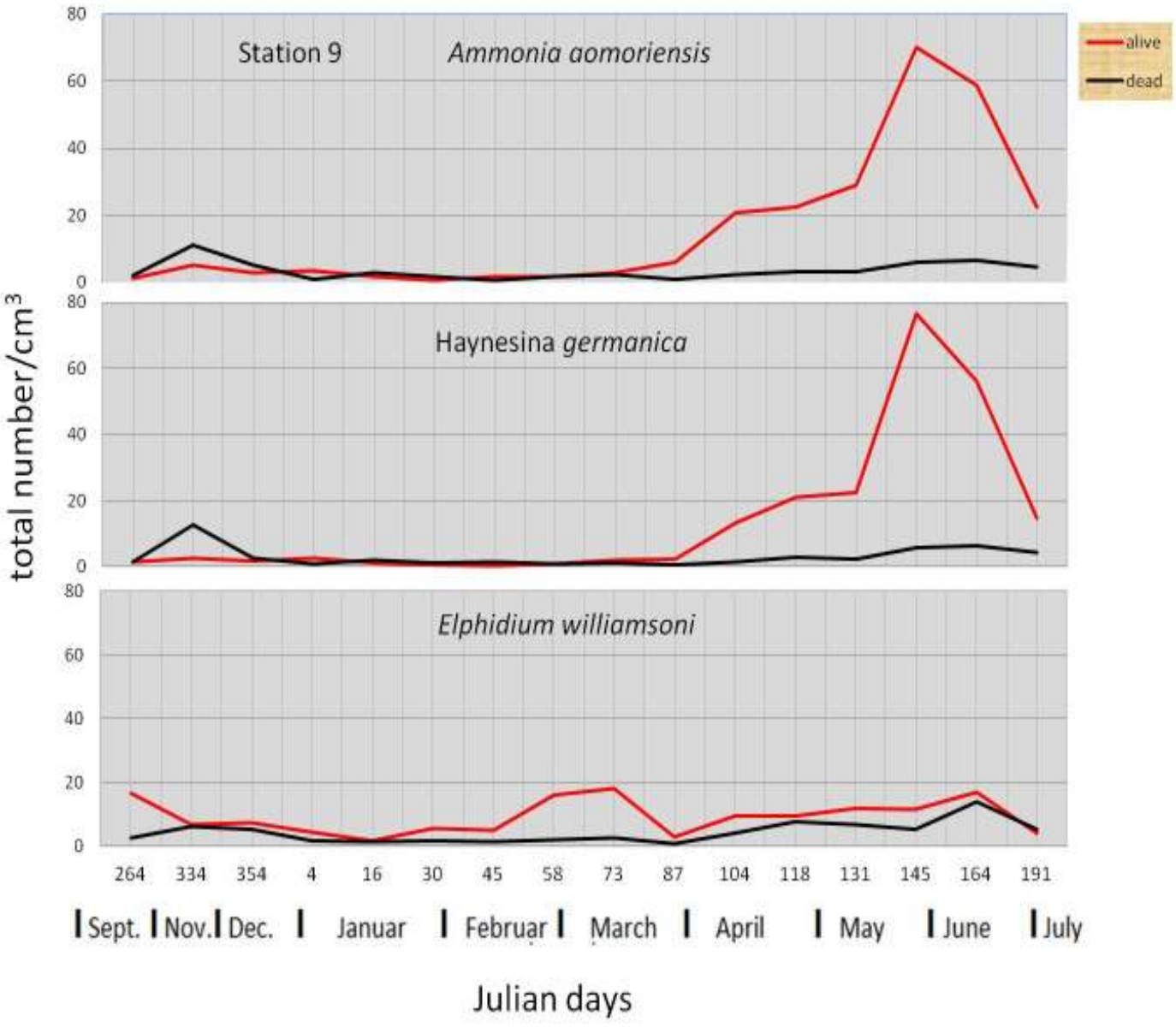

Figure 17: Total numbers of individual foraminifers per cm^3 for each species from September to July at Station 9. Living and dead foraminifers are shown in red and black, respectively.

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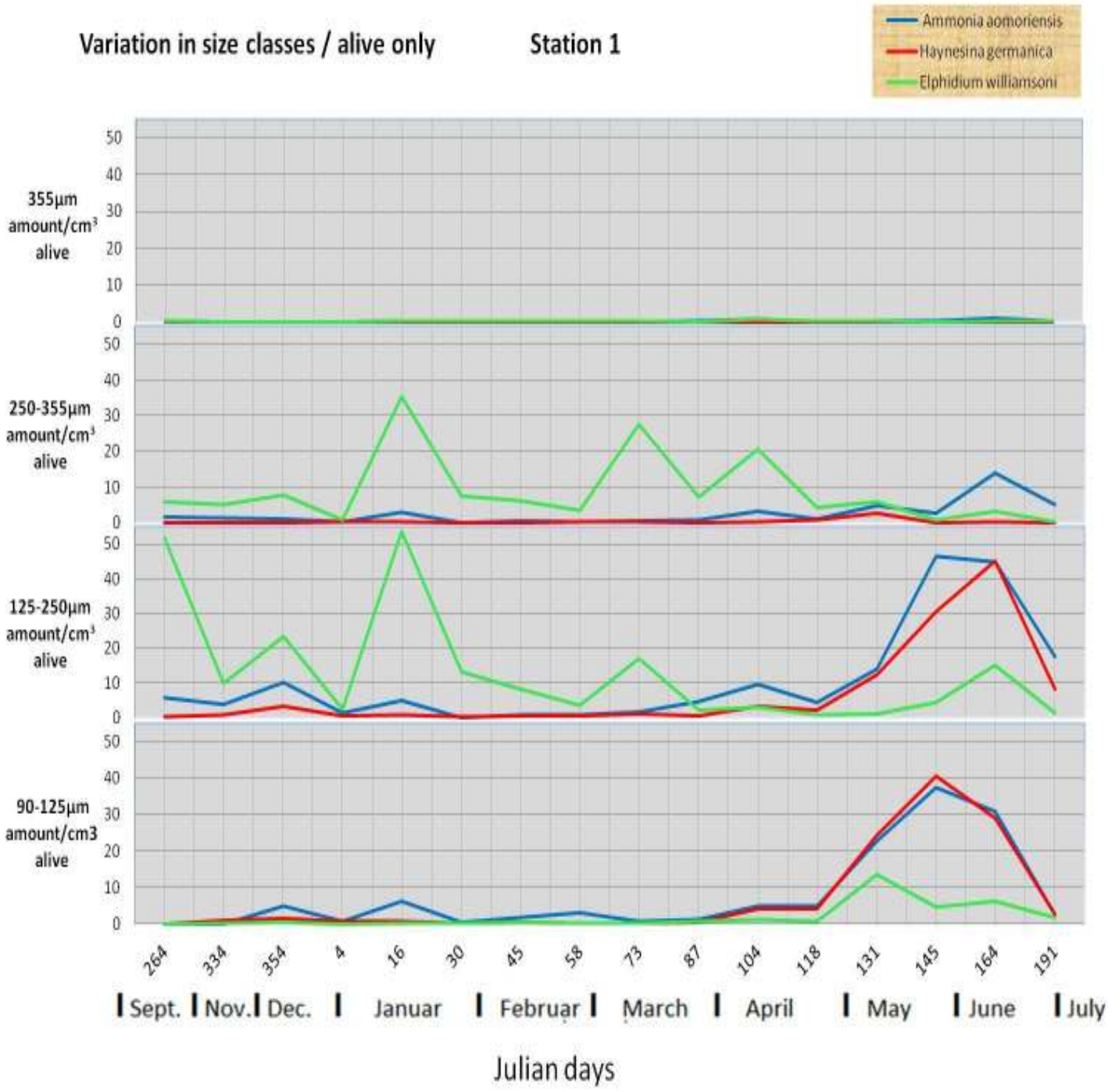

Figure 18: Foraminifer abundance in four different size classes from station 1. Only living individuals are shown.

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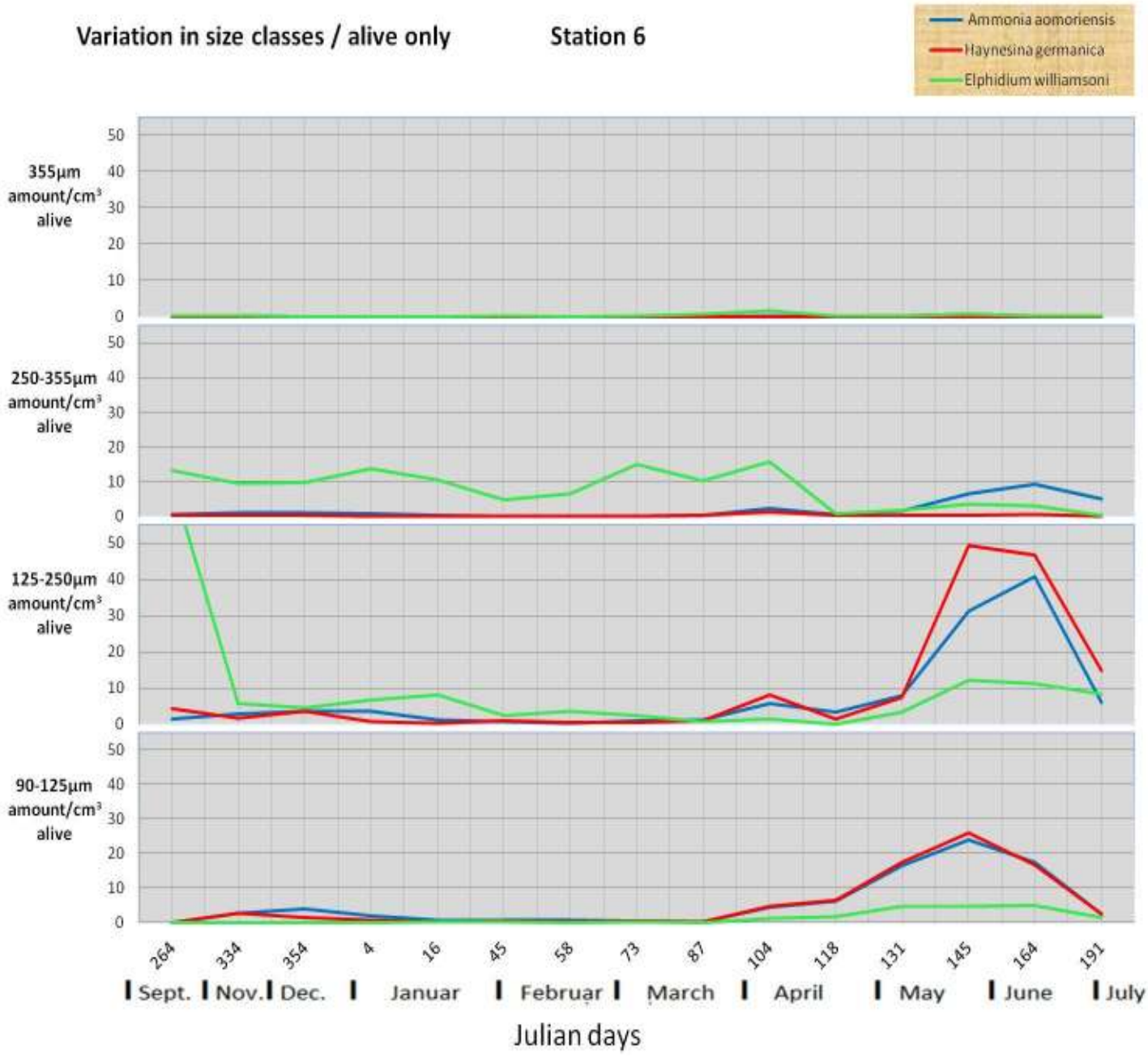

Figure 19: Foraminifer abundance in four different size classes from station 6. Only living individuals are shown.

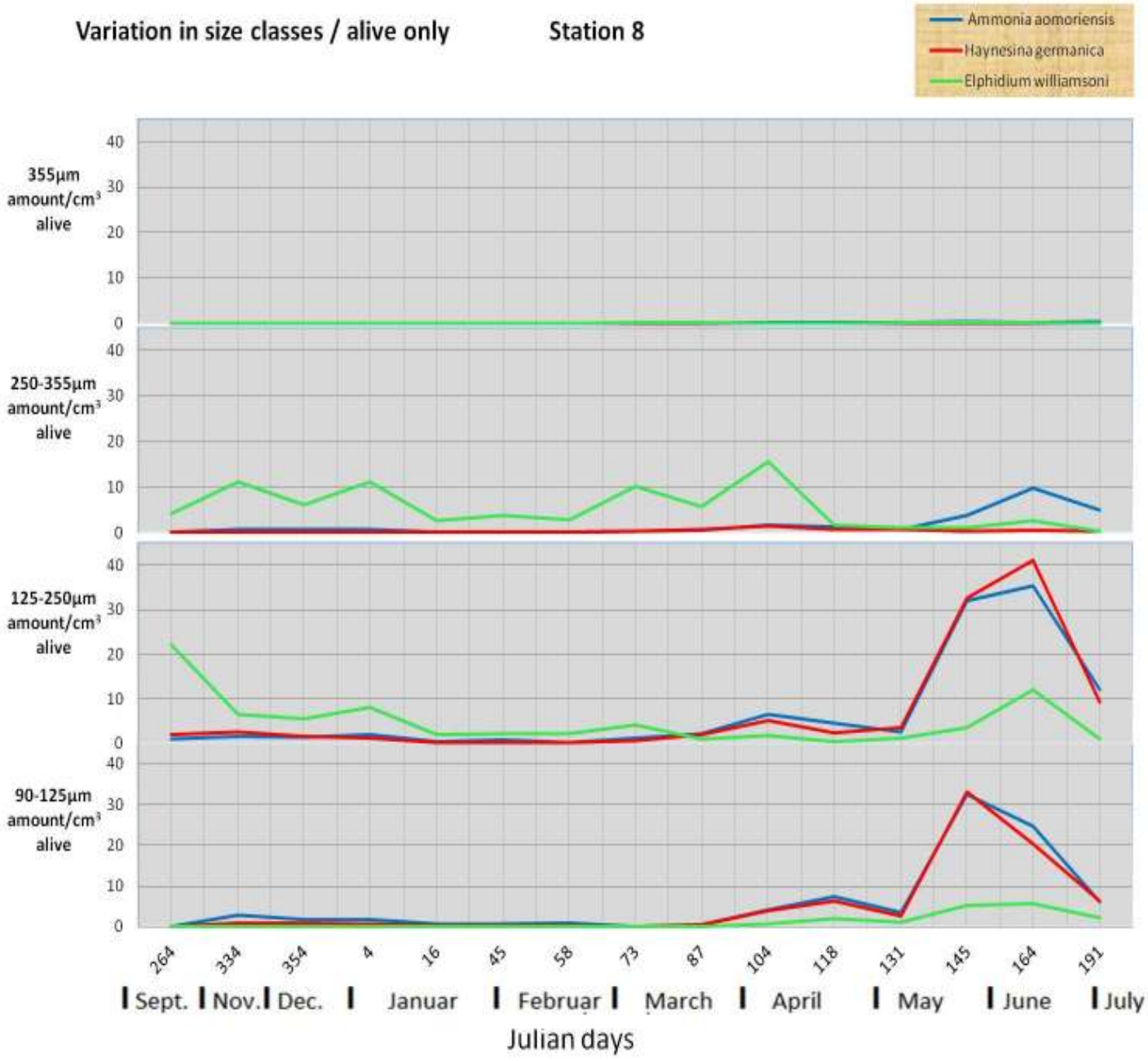

Figure 20: Foraminifer abundance in four different size classes from station 8. Only living individuals are shown.

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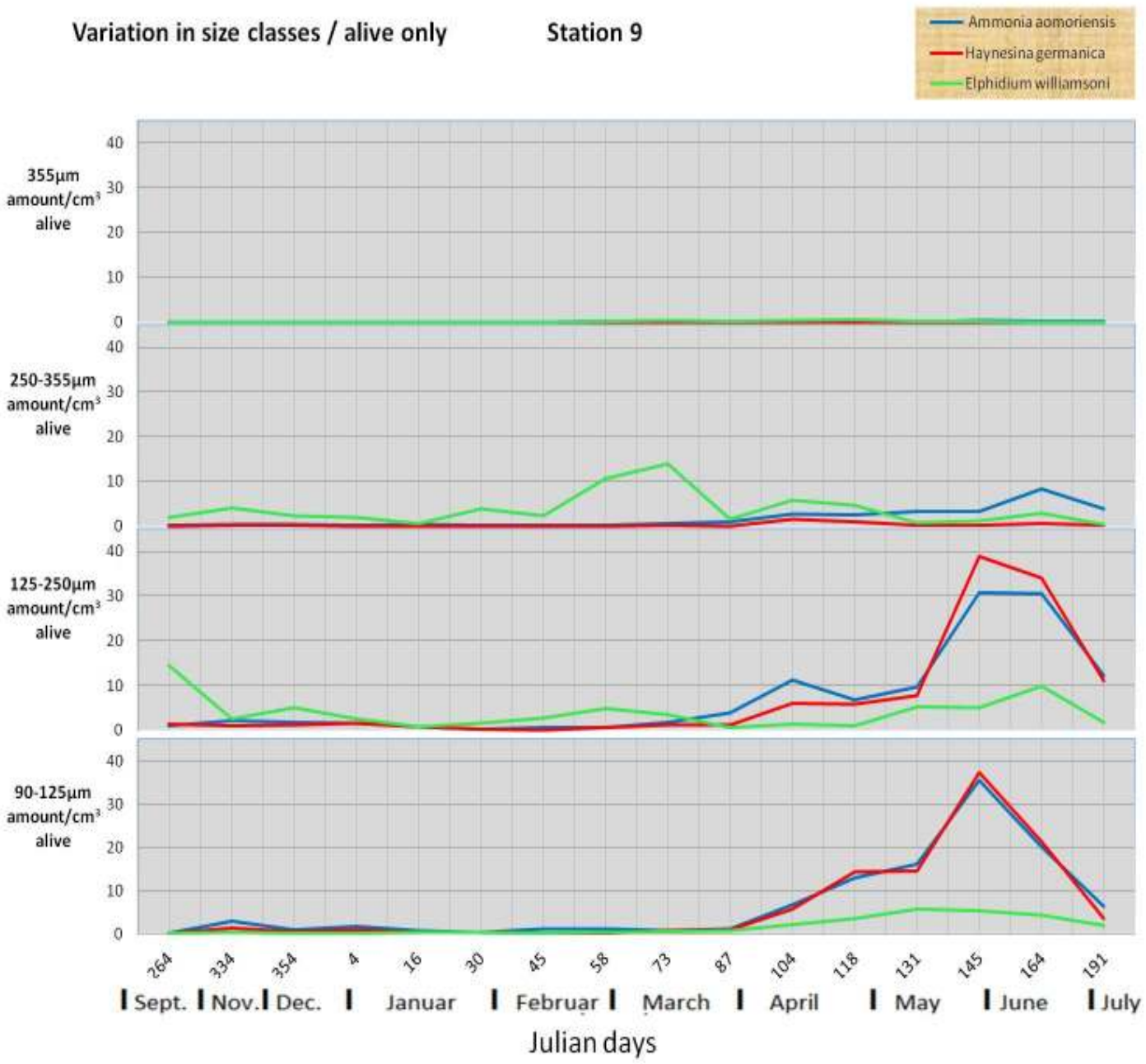

Figure 21: Foraminifer abundance in four different size classes from station 9. Only living individuals are shown.

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Residuals

The residuals for *A. aomoriensis*, *H. germanica* and *E. williamsoni* are diagrammed in size class, sampling day and the percentage deviation from the mean relative abundance (Figs. 22-24).

The residuals of *A. aomoriensis* show the maximum deviation in size class 125-250 µm, 250-355 µm and ≥355 µm at sampling day 267 (12.06.12) with over 450% higher than the mean relative abundance (represented with 0%). The highest deviation in size class 90-125 µm is at sampling day 248 (24.05.12) with over 450% higher than the mean relative abundance. From sampling day 1 to 234 (20.09.11 - 10.05.12) the deviation is below the mean abundance through all size classes.

The residuals of *H. germanica* show their maximum deviation in size class 125-250 µm at sampling day 267 (12.06.12) with over 500% higher than the mean relative abundance (see Figure 23). The highest deviation of the 90-125 µm size fraction is similar to *A. aomoriensis* with over 450% higher than the mean relative abundance at sampling day 248 (24.05.12). In size class 250-355 µm, the highest deviation is between day 200 (06.04.12) and 240 (16.05.12) with 300-350% over the mean abundance. From sampling day 1 (20.09.11) to 200 (06.04.12) the deviation is below the mean abundance through all size classes. No data were recorded for size fraction ≥355 µm because no foraminifera were collected in this size class for *H. germanica.*

The residuals of *E. williamsoni* show the maximum deviation in size classes 90-125 µm, 125-250 µm and ≥355 µm at different time periods. The size class of 90-125 µm has its highest residual value around sampling day 230 (06.05.12) – 280 (25.06.12) with 200-350% over the relative mean abundance. The size class of 125-250 µm has its highest residual value around day 1 (20.09.11) – 30 (20.10.11) with the average of 400% over the mean abundance. It is the only size class that has high residuals in the early

sampling period. The size class of ≥355 µm has its highest residual value around the days of 200 (06.04.12) – 220 (26.04.12) with 450%. Size class 250- 355 µm shows its highest deviation at day 180 (17.03.12) with 150% over the mean abundance (Fig. 24).

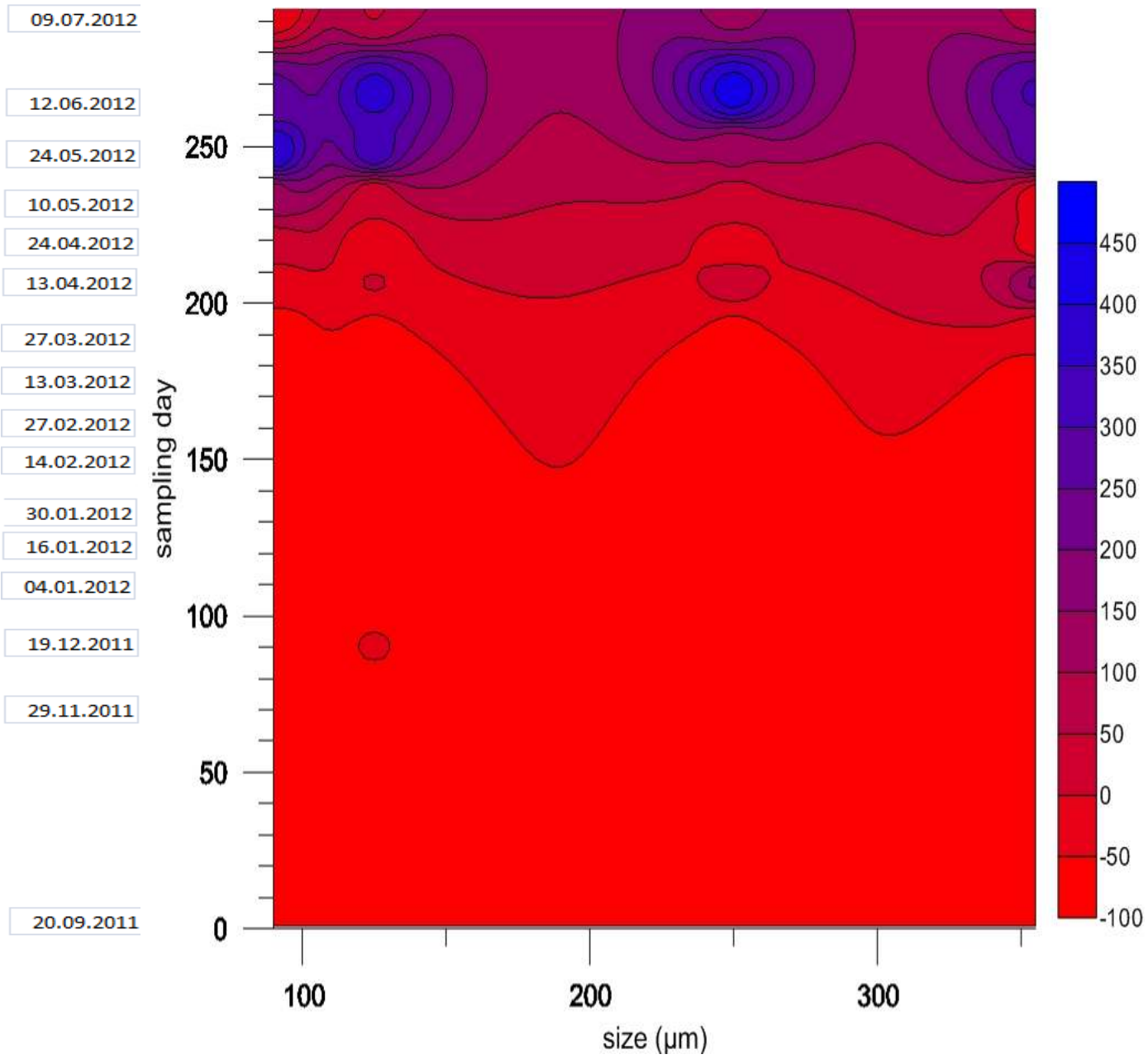

Figure 22: Residuals of *A. aomoriensis*. Left side shows all sampling dates and sampling day. Right side bar shows percentage deviation from the mean relative abundance.

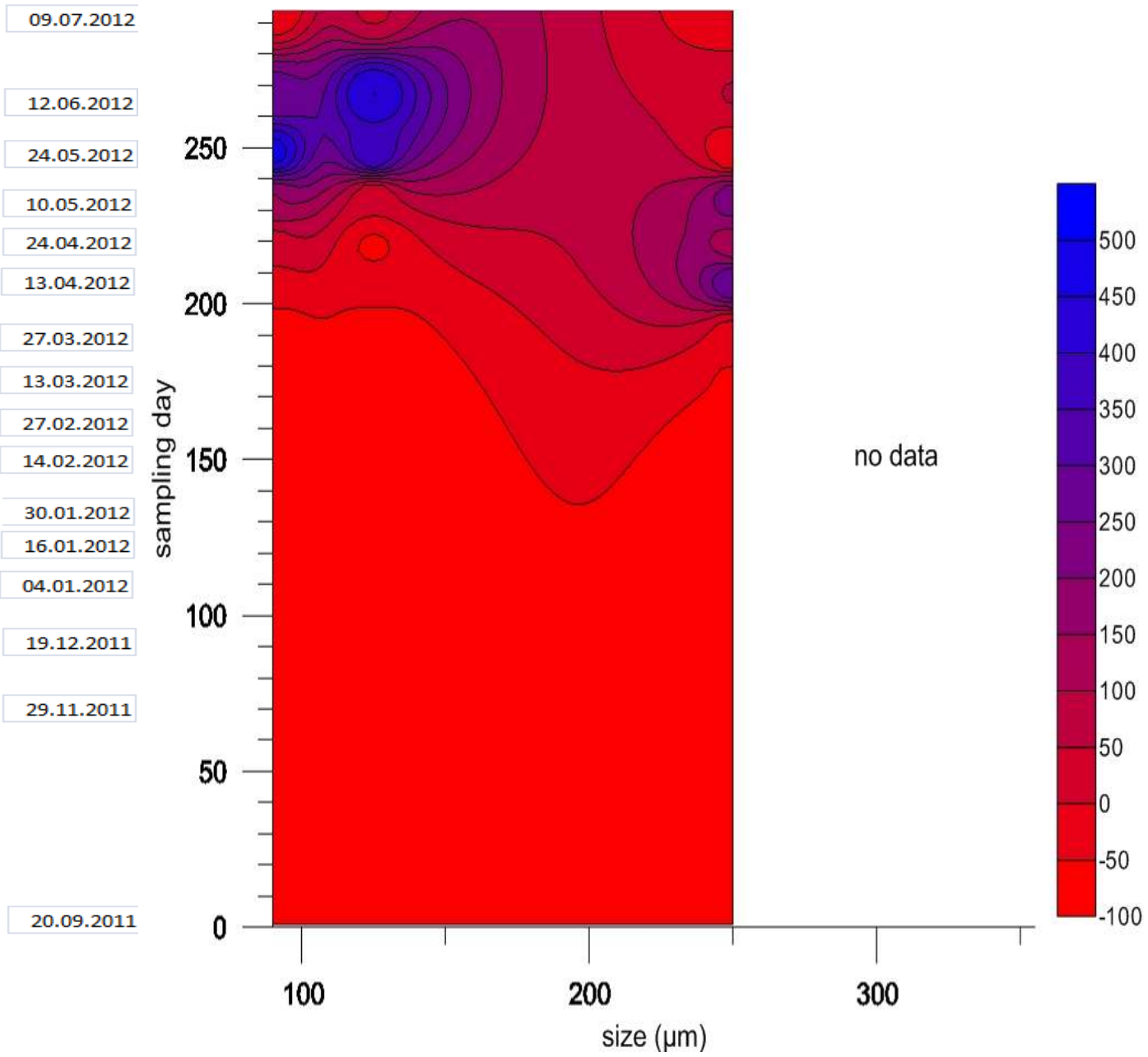

Figure 23: Residuals of *H. germanica*. Left side shows all sampling dates and sampling day. Right side bar shows percentage deviation from the mean relative abundance.

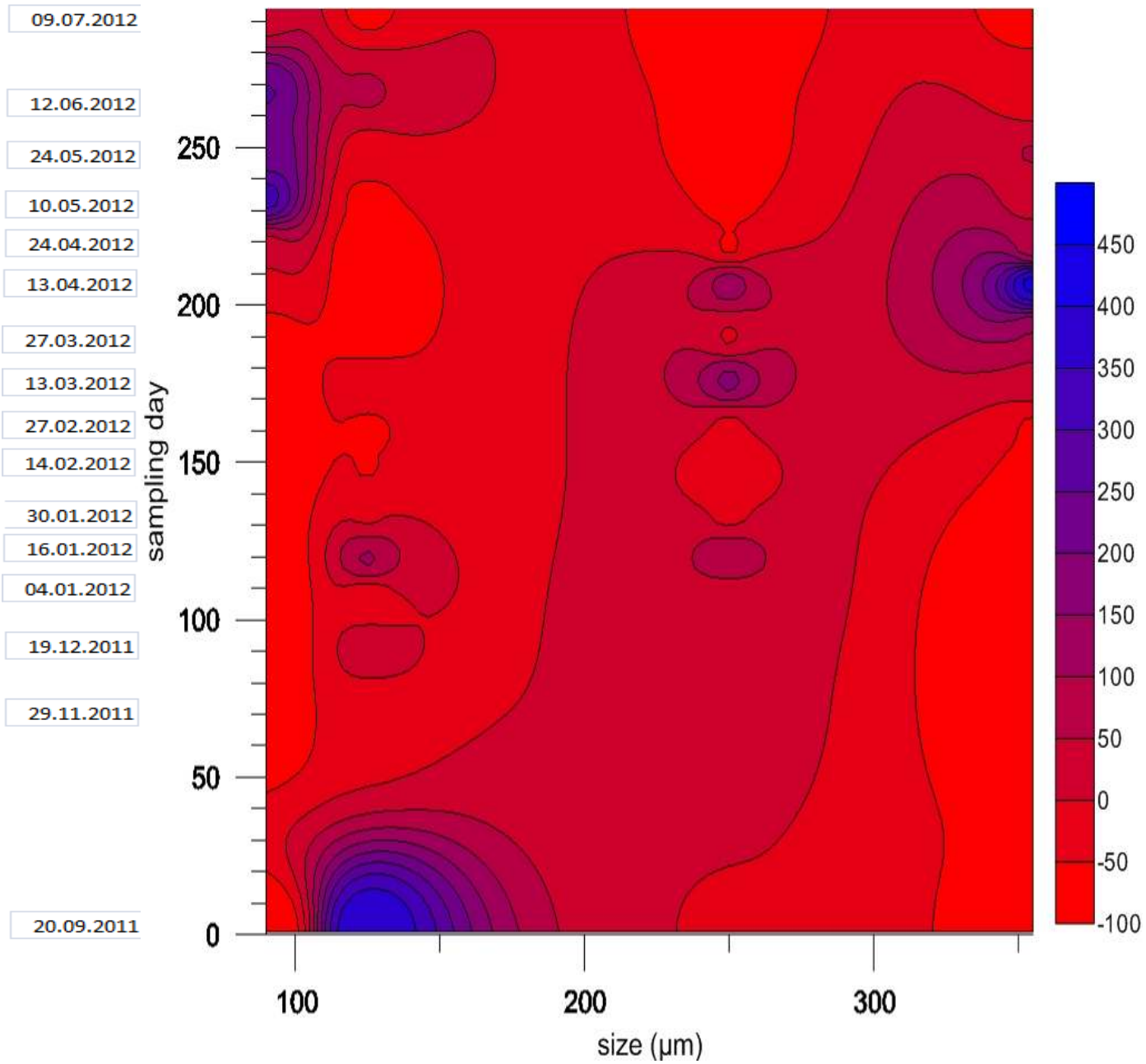

Figure 24: Residuals of *E. williamsoni*. Left side shows all sampling dates and sampling day. Right side bar shows percentage deviation from the mean relative abundance.

DISCUSSION

The results provide an overview of the population dynamics of the three dominant foraminifer species; with an 11-month examination period from September 20th to July 9th, this study gives a rich and detailed look of the annual distribution and abundance of the foraminifers coexisting in the intertidal mudflat near Dorum-Neufeld in North Germany.

The high abundance of living foraminifers in the mudflat in May and June with its maximum in May for both *A. aomoriensis* and *H. germanica* can be clearly seen in the results (Figs. 10-17) and shows that the time of highest reproduction is within these two months. The fact that this peak, starting in spring and declining in summer can be observed at all four sampling locations substantiates this finding. Before this study this information was not systematically analyzed and confirms now assumptions previously derived from observations in laboratory stock cultures. The high abundance of foraminifers in May and June could be related to more food sources, such as spring blooms or the increase of fresh water discharges. It should be noted, however, that the smallest size class with 90-125 µm (considered to be the juvenile fraction of foraminifers) has its highest peak of reproduction in May at all sampling stations (Figs. 18-21) and after this period the amount decreases, whereas in the size class above (125-250 µm), the high peak lasts longer. In some cases (Figs. 20 and 21) the peak from the 125-250 µm size class begins soon after the juvenile peak of abundance. These two events are possibly caused by the growing juveniles that add to the 125-250 µm size class later on. In laboratory cultures of *A. aomoriensis* and *H. germanica* at the AWI, practical knowledge shows that a growing juvenile foraminifer builds approximately one new chamber per day in the early life phase. This knowledge could enable the determination of the exact time of highest reproduction via back calculation of the existing chambers of growing juvenile foraminifers. For example a foraminifer with 10 existing chambers, was juvenile 10 - 20 days before.

When considering the dead specimens of *A. aomoriensis* and *H. germanica* during this high reproduction period, no considerable increase can be observed. This suggests that a higher input of sediment at this time can be excluded, because otherwise the amount of dead foraminifers/cm^3 would also be higher. This is not the case, so the higher abundance must be related to higher reproduction occurring at these sampling stations (Figs. 14-17). Another possibility, regarding the low number of dead specimens throughout the study could be test dissolution as a taphonomic process caused by low water pH.

The high peaks of living specimens of *H. germanica* and *A. aomoriensis* in May and June come along with a low abundance of dead foraminifers during this period. This fact lets the question arise where the dead assemblages have gone? Intertidal mudflats are known for their high productivities. The top sediment layer goes through the guts of deposit feeding organisms, such as the lugworm *Arenicula marina.* This large marine worm habitats the coasts of Europe and can be detected by its highly coiled casts of sand. *Arenicula marina* lies in its burrow with its head at the base of the head shaft, swallowing and digesting sediment, which makes the column of sand drop slightly. It is possible that the dead foraminifer shells dissolve in the guts of the lugworm, which would explain the low abundance of dead foraminifers. Another and probably more reasonable explanation might be that the dead shells are transported away by the currents, because they are not attached to the sediment anymore with the absence of pseudopodia.

Elphidium williamsoni has a completely different life cycle than *A. aomoriensis* and *H. germanica* with higher reproduction in colder months such as September, January and March (Fig. 14), but it is also present throughout the year and not equally distributed at all stations (Figs. 14-17). *Elphidium williamsoni* does not show a clear peak during May and June like *A. aomoriensis* and *H. germanica*, suggesting that either *E. williamsoni* competes with *A. aomoriensis* and *H. germanica* or that a colder climate favors the reproduction of this species. *Elphidium williamsoni* abundance related to high peaks is

not equally distributed at stations 8 and 9 (Figs. 16 and 13), so there it cannot be clearly concluded whether competition between the species, living conditions or both are the dominant factors. The similar reproduction peak of *A. aomoriensis* and *H. germanica* suggest that these species coexist and maybe do not share the same food sources, because *H. germanica* is a cleptoplast and *A. aomoriensis* is not.

Only a few studies included foraminifera in assessing the benthic community structure in the North Sea, despite their high abundances and ecological importance (de Nooijer et al., 2008). However, a comparison of foraminifer densities determined in this study with foraminifer densities obtained from the continental shelf of the northern Gulf of Cadiz shows the following: For the northern Gulf of Cadiz continental shelf, Mendes et al. (2012) showed that the highest value (1173 specimens/10 cm^3) was obtained in the area off the Tinto-Odiel mouth, in muddy sediments at 27.5 m water depth. In contrast, the lowest value (14 specimens/10 cm^3) in the same area was found at 87 m depth, also in muddy sediments. Population density averaged 225 specimens/10 cm^3 in the study area. For comparison, the highest value found in this study is about 800-900 specimens/10 cm^3 and averaged density is about 210 specimens/10 cm^3. Hence, the highest and average foraminifer densities are comparable between this study and the one by Mendes (2012).

Both studies also demonstrate that the number of foraminifers is highly variable in shallow waters within a relatively small area (Fig. 5), potentially depending on a complex set of physical, chemical, and biological parameters that control the spatial and temporal distribution of foraminifer abundances. These may include temperature, salinity, water depth, sediment type, oxygen concentration, food availability, water currents, and interactions with other organisms (e.g., Loubere and Fariduddin, 1999; Murray, 2006).

Interestingly, temperature and salinity that was measured each sampling day in a tidal flat channel (Fig. 25) changed contemporaneously and in the same direction as the abundance of *A. aomoriensis* and *H. germanica* (Figs. 14-17). More precisely, the total

numbers of living *A. aomoriensis and H. germanica* increased approximately 7 times (from roughly 10 to 70 individuals/cm^3) between April and June, when temperature and salinity increased from 13 to 28°C and from 22 to 34 psu, respectively (Fig. 25). This suggests that both species favor warmer temperatures and/or higher salinity for reproduction. However, it is known from stock sediments in the AWI culture lab that reproduction of these species takes place at approximately the same time, putting into question this hypothesis, because the stock sediments are isolated from variations of external influences, such as temperature, salinity or light/dark cycles. However, based on the dataset of this study, it is not possible to exclude these factors as triggers for foraminiferal reproduction, but there are more potential factors that may have a control on the spatial and temporal distribution of the foraminifer population.

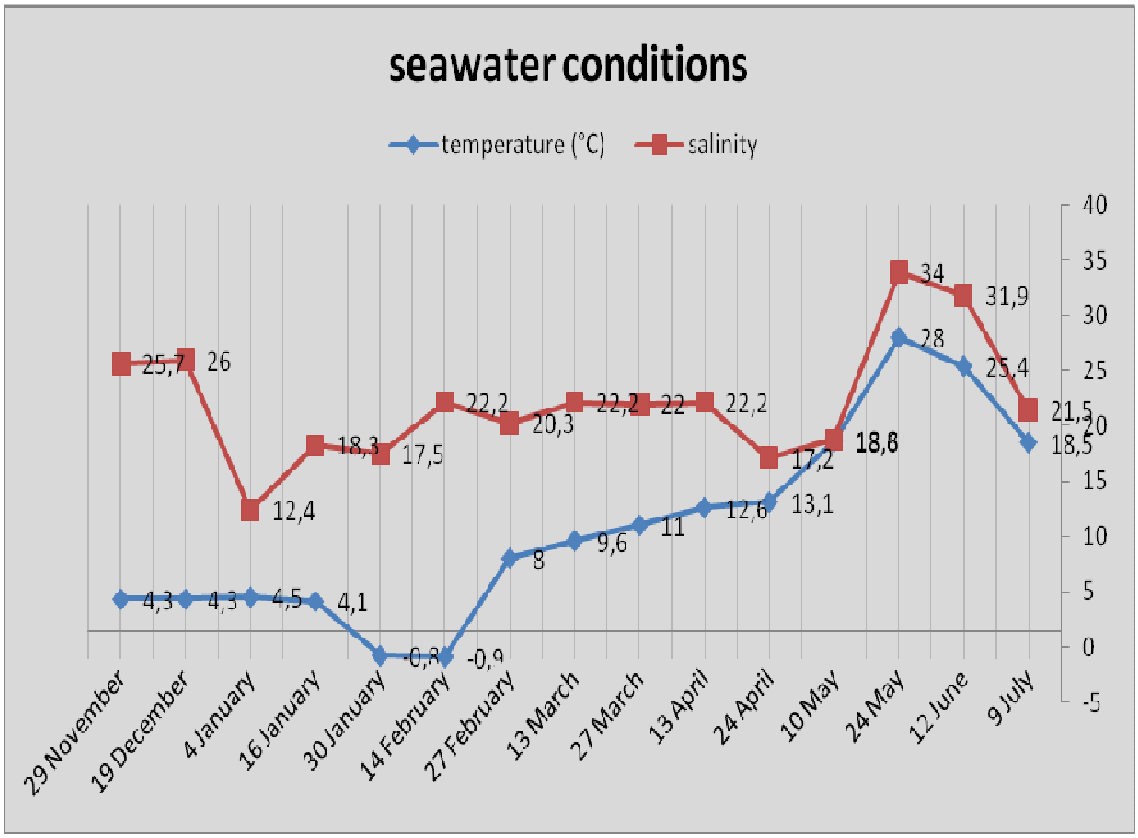

Figure 25: Measured temperature and salinity over the sampling period.

For instance, the effects of sediment grain-size on foraminiferal density and diversity are still a matter of debate. Generally, in an environment with strong currents, the grain size is coarse due to removal of finer sediments (winnowing), whereas weak currents allow fine grains to settle. Strong tidal elevation in an intertidal mudflat may also be an important limiting parameter, owing to the variable energy that controls sediment sorting, resulting in fine grains laying on top of the coarse grains (upward fining) (e.g., Horton and Murray, 2007). This is in broad agreement with the mudflat surface sediments from Dorum that exclusively consist of muddy non-cohesive silt to fine sand. Based on the observations of faunal density and diversity, Diz et al. (2004) suggest that very coarse substrates (silt + clay < 12–13%) provide a favorable settlement for epibenthic foraminifera, with attached forms that dominate the living assemblage. Moreover, large particles characterizing shelly sands apparently provide both shelter and attachment, and constitute a stable substrate for epifaunal feeding (Murray, 1986). In contrast, other studies reveal that benthic foraminifera favor a high proportion of fine particles (e.g., Debenay et al., 2001). Similarly, the study by Armynot du Châtelet et al. (2009) showed that both density and species richness are clearly linked to sediment grain-size: the coarser the grain-size is, the lower the density and species richness are and vice versa.

The results from this study show a somewhat different picture. Foraminifer densities are relatively high, but species richness is very low. Why do only three foraminifer species inhabit the intertidal mudflat near Dorum? The water depth is low to non-existent at low tide, leaving the foraminifers exposed to a relatively dry environment for several hours. It might be that the harsh physical conditions of hydrodynamic turbulences only allow highly tolerant species to survive. According to Alve (1995), the colonization pattern of the tidal marsh is biologically controlled whereas the mudflat must be physically controlled. The physical control on test construction is mainly hydrodynamic and consequently of sediment dynamic origin. It allows only highly tolerant species like *H. germanica* to survive and develop (Cearreta, 1988; Debenay et al., 2000). This could explain the existence of *H. germanica* in a physically controlled environment such as

the mudflat of Dorum, where high hydrodynamic turbulence exists. Another explanation is that *H. germanica* and *E. williamsoni* are both cleptoplasts, they are able to use diatom chloroplasts for photosynthesis (see Fig. 11 for detailed information). This adaptation might grant these two species an ecological niche alongside *A. aomoriensis* in the intertidal mudflat ecosystem.

The organic matter content of mudflat sediments of Dorum-Neufeld is very high, and may enable as an important food source for the high densities of these three species. A few studies indicate that organic waste seems to favor both diversity and density of the foraminiferal populations (Debenay et al., 2001). By contrast, other authors observe a decrease of density, specific richness and/or diversity index when the OM content increases (Schafer et al., 1995). Food availability in form of nutrients, driven by tidal circulation, may also promote enhanced primary production. Except for species that feed on live food or have endosymbionts, labile organic matter and the bacteria feeding on it are primary food sources for benthic foraminiferal assemblages (e.g., Murray, 2006).

Another important factor for the survival and therefore the distribution of benthic foraminifers is the availability of sufficient oxygen. Dissolved oxygen and organic carbon flux are generally considered to be the main factors controlling the depth distribution of benthic foraminifera in sediments (van der Zwaan et al., 1999), particularly in deep waters where there tends to be minimal spatial and temporal variability (Murray, 2001). In the intertidal mudflat of Dorum-Neufeld, the oxygenation is higher than in the deep see, due to the constant mixing of surface water with oxygen and the energy of the currents that oxygenates the sediment. On the other hand, the intertidal mudflat sediments are characterized by higher sedimentation rates and a very high organic matter content of the sediments due to high primary production, resulting in relatively high oxygen consumption within the sediment surface layer (occasionally within 1-2 cm sediment depth). Consequently, sediments below this horizon are black due to low oxygen, hampering the foraminifera to inhabit deeper sediment layers.

Apart from the above mentioned factors that might have a control on the spatial and temporal distribution of foraminifers, also river discharge and suspended particulate matter contribute towards a high density of living benthic foraminifera, as observed around the Guadiana and Guadalquivir Rivers mouths (Mendes et al., 2012). Spatial and seasonal variability may be biologically induced (Alve and Murray, 2001) and responds to predation (Buzas, 1982), reproduction mode (Stouff et al., 1999), sources and distribution pattern of food particles (Alve and Murray, 2001) and species interactions (Hayward et al., 1996).

Regarding temperature reconstruction with the help of fossil Foraminifera, population dynamics have a significant influence on possible temperature reconstructions with proxy signals (e. g. Mg/Ca). In this study, the calculated average temperature is ~10° C higher, than the measured average temperature (see Mg/Ca temperature calculation in materials and methods). The measured mean temperature from this study is 13, 4° C. When calculating the mean temperature, using a theoretical Mg/Ca calibration for *Cibicidoides* spp. of Elderfield et al. 2006, the temperature is 23, 4° C.

The reason for this is that *A. aomoriensis* population abundance is higher during the summer in addition to the higher temperature and Mg/Ca in the tests. In this case, when taking all the tests out of a sediment core that covers a one year span, the summer population would be more abundant than the winter population. When measuring the Mg/Ca from all tests out of this deposit, consequently the Mg/Ca would be relatively high. The Mg/Ca measurement would result in a higher annual average temperature as the "true" annual mean actually is. The influence of foraminifer population dynamic on the interpretation of an Mg/Ca proxy is significant, especially when the population is not equally distributed throughout the year.

When investigating fossil Foraminifera, for most benthic foraminifera, it is not known, where the abundance peaks lie during the year, therefore it is important to carry out population dynamic studies to fill the knowledge gap and avoid errors in paleothermometry.

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GLOSSARY

› secondary calcite / lamellar wall: test-wall built of layers of calcite or aragonite formed at consecutive instars and covering exposed surfaces of previously formed test. Most lamellar genera are bilamellar and some primarily multilamellar.

› folium: in spiral lamellar foraminifera the mostly triangular in outline and often texturally differentiated portion of the lateral chamber wall.

› bosses: round and raised knob-like inflational structure in axial position.

› suture: line of adherence of chamber wall(s) to previously formed test.

› spiral side: that side of the test in trochospiral forms which comprises the proloculus or towards which the proloculus is displaced.

› umbilical side: in trochospiral tests the side opposite to the spiral one.

› epibenthic: living upon or in the bottom of the continental shelf or littoral zone of the ocean.

›endobenthic: refers to meiofaunal-sized organisms that move within the sediments.

›papillae: papilla (plural: papillae); hemispherical to subconical inflational protuberance of the outer lamella.

›gamont: specimen producing gametes in the process of reproduction irrespective of its involvment in meiosis (diploid gamonts) or not (haploid gamonts). Foraminiferal gamonts, produced by asexual reproduction, are megalospheric

›agamont: specimen grown from the zygote, producing either gamonts or schizonts in an asexual process involving apogamous nuclear divisions and/or meiosis. Foraminiferal agamonts, produced by a sexual reproduction, are microspheric.

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›schizont: apogamic offspring of an agamont reproducing either by again apogamous nuclear divisions and cytotomy or undergoing meiosis. Foraminiferal schizonts, produced by asexual reproduction, are megalospheric.

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SUPPLEMENTAL MATERIAL

Excel table with original data:

Table 1. Number of *A. aomoriensis* per cm^3 sediment for different size classes

	A. aomoriensis (standardized)							
Date/Station	90-125µm		125-250 µm		250-355µm		>355µm	
20.09.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	N/A	N/A	5,85	5,85	1,50	1,23	0,04	0,04
2	0,00	0,00	1,91	2,15	0,85	1,39	0,00	0,00
3	0,00	0,00	0,79	9,27	0,52	4,39	0,03	0,09
4	0,00	0,00	0,52	5,84	0,08	0,40	0,00	0,00
5	0,00	0,00	2,43	2,57	0,71	0,46	0,00	0,00
6	0,00	0,00	1,33	1,07	0,47	1,37	0,00	0,00
7	0,00	0,00	0,71	2,45	0,32	1,94	0,00	0,00
8	0,00	0,00	0,94	3,63	0,06	1,16	0,00	0,00
9	0,00	0,00	1,04	1,92	0,23	0,27	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
29.11.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	N/A	N/A	3,92	3,86	1,39	0,58	0,00	0,03
2	N/A	N/A	0,77	6,31	0,43	2,49	0,00	0,00
3	0,65	1,43	0,92	2,19	0,41	0,89	0,00	0,08
4	0,47	1,37	0,43	6,03	0,07	0,60	0,00	0,00
5	1,22	4,44	1,28	4,91	0,38	1,03	0,00	0,00
6	2,69	1,94	2,94	8,13	1,09	1,22	0,09	0,00
7	2,93	9,47	2,07	11,93	0,33	2,30	0,00	0,00
8	2,87	4,33	1,67	11,27	0,70	1,60	0,00	0,03
9	2,80	1,87	2,13	9,00	0,33	0,37	0,00	0,00

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	90-125µm		125-250 µm		250-355µm		355µm	
19.12.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	5,00	1,80	10,30	5,10	1,10	0,25	0,00	0,00
2	3,40	1,60	5,40	4,95	0,50	1,15	0,05	0,00
3	1,40	1,80	1,40	9,20	0,15	2,90	0,00	0,00
4	2,80	2,60	1,10	8,10	0,15	0,30	0,00	0,00
5	0,73	1,09	1,91	2,73	0,32	0,32	0,00	0,00
6	4,00	3,60	3,50	3,70	0,90	0,75	0,00	0,00
7	0,95	1,90	0,95	0,67	0,29	0,38	0,05	0,00
8	1,82	0,91	1,36	3,91	0,68	1,00	0,00	0,00
9	0,80	1,80	1,70	2,70	0,45	0,70	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
04.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,80	0,60	1,45	1,55	0,20	0,15	0,00	0,00
6	2,00	0,50	3,65	0,40	0,75	0,20	0,00	0,00
8	1,85	0,75	2,00	0,85	0,60	1,15	0,00	0,00
9	1,71	0,00	1,57	1,00	0,19	0,05	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
16.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	6,16	0,88	5,04	3,76	3,04	0,56	0,08	0,16
6	0,75	0,25	1,21	0,79	0,29	0,04	0,00	0,00
8	0,67	0,33	0,42	0,63	0,13	0,21	0,00	0,00
9	0,77	0,32	0,77	2,41	0,32	0,14	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
30.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,48	0,29	0,05	0,90	0,05	0,48	0,00	0,00
9	0,38	0,05	0,24	0,86	0,14	0,95	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
14.02.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	1,65	0,41	0,88	0,65	0,53	0,35	0,00	0,00
6	0,75	0,25	0,65	0,55	0,05	0,65	0,00	0,00
8	0,75	0,17	0,75	0,21	0,13	0,38	0,00	0,00
9	1,15	0,40	0,55	0,15	0,15	0,15	0,00	0,00

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	90-125µm		125-250 µm		250-355µm		355µm	
27.02.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	3,00	0,62	0,71	19,57	0,33	5,43	0,00	0,05
6	0,74	0,59	0,30	0,78	0,04	0,19	0,00	0,04
8	0,93	0,33	0,19	0,67	0,11	0,41	0,00	0,00
9	1,00	0,29	0,57	0,95	0,19	0,67	0,10	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
13.03.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,84	0,65	1,68	1,23	0,48	1,16	0,00	0,06
6	0,43	0,18	1,07	0,54	0,00	0,39	0,00	0,00
8	0,16	0,10	1,13	0,90	0,26	0,32	0,00	0,00
9	0,67	0,38	1,81	1,43	0,48	0,48	0,05	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
27.03.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	1,29	0,50	4,79	1,17	0,92	0,46	0,17	0,00
6	0,15	0,11	1,26	0,41	0,37	0,30	0,00	0,04
8	0,58	0,08	2,21	0,33	0,54	0,17	0,04	0,00
9	1,17	0,21	3,83	0,54	0,92	0,08	0,08	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
13.04.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	4,90	0,30	9,75	1,05	3,15	0,35	0,55	0,00
6	4,48	0,26	5,83	0,52	2,30	0,39	0,17	0,13
8	4,20	0,28	6,52	0,72	1,64	0,28	0,08	0,00
9	6,60	0,44	11,32	1,72	2,72	0,12	0,20	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
24.04.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	4,79	0,46	4,46	0,96	1,17	0,33	0,00	0,00
6	6,20	0,36	3,40	1,32	0,60	0,16	0,00	0,00
8	7,33	0,50	4,67	1,71	1,21	0,25	0,08	0,00
9	12,96	1,58	6,88	1,00	2,46	0,46	0,21	0,04

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	90-125µm		125-250 µm		250-355µm		355µm	
10.05.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	22,86	2,29	14,11	1,07	4,93	0,21	0,18	0,00
6	16,40	0,88	7,80	2,32	1,52	0,44	0,04	0,00
8	3,44	0,32	2,68	1,36	0,56	0,36	0,08	0,00
9	16,00	0,48	9,64	2,20	3,36	0,40	0,00	0,04
	90-125µm		125-250 µm		250-355µm		355µm	
24.05.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	37,50	2,50	46,50	6,56	2,75	0,47	0,22	0,03
6	23,91	2,17	31,30	3,91	6,48	0,48	0,65	0,00
8	32,58	2,19	31,94	2,74	3,84	0,74	0,26	0,03
9	35,52	2,79	30,86	2,52	3,31	0,76	0,38	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
12.06.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	30,95	2,14	44,76	9,05	13,95	1,24	1,00	0,05
6	17,50	1,25	40,83	3,33	9,29	1,58	0,21	0,00
8	24,62	1,73	35,38	2,69	9,77	1,00	0,23	0,00
9	20,00	1,52	30,52	3,79	8,21	1,34	0,14	0,03
	90-125µm		125-250 µm		250-355µm		355µm	
09.07.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	2,67	0,23	17,67	7,00	4,97	2,93	0,07	0,00
6	2,60	0,16	6,00	3,20	0,80	1,36	0,04	0,04
8	6,06	0,24	12,12	2,73	4,94	1,15	0,33	0,15
9	6,21	0,28	12,24	3,28	3,79	1,03	0,17	0,03

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Table 2. Number of *H. germanica* per cm^3 sediment for different size classes

	Haynesina germanica (standardized)							
Date/Station	90-125µm		125-250µm		250-355µm		>355µm	
20.09.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	N/A	N/A	0,35	0,62	0,04	0,08	0,00	0,00
2	0,00	0,00	0,09	0,24	0,03	0,12	0,00	0,00
3	0,00	0,00	0,85	20,36	0,06	0,33	0,00	0,00
4	0,00	0,00	0,76	2,56	0,00	0,28	0,00	0,00
5	0,00	0,00	0,86	1,71	0,00	0,07	0,00	0,00
6	0,00	0,00	4,40	1,53	0,37	0,17	0,00	0,00
7	0,00	0,00	2,00	2,58	0,03	0,26	0,00	0,00
8	0,00	0,00	1,94	2,25	0,06	0,16	0,00	0,00
9	0,00	0,00	1,46	1,23	0,04	0,08	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
29.11.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	N/A	N/A	0,92	2,00	0,06	0,11	0,00	0,00
2	N/A	N/A	0,34	3,20	0,03	0,31	0,00	0,00
3	0,27	1,03	0,49	2,51	0,00	0,19	0,00	0,03
4	0,37	2,13	0,23	3,87	0,00	0,03	0,00	0,00
5	0,88	10,19	0,78	5,13	0,06	0,41	0,00	0,00
6	2,63	5,75	1,63	3,94	0,16	0,28	0,00	0,00
7	2,73	10,80	2,60	12,53	0,23	0,33	0,00	0,10
8	0,87	7,33	2,67	11,27	0,10	0,20	0,00	0,00
9	1,33	5,47	1,00	7,07	0,20	0,17	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
19.12.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	1,40	2,20	3,40	0,10	0,10	0,00	0,00	0,00
2	2,20	2,40	2,80	3,90	0,10	0,55	0,00	0,00
3	1,60	1,80	2,30	12,10	0,15	1,60	0,00	0,00
4	2,00	2,20	1,30	9,40	0,00	0,35	0,00	0,00
5	0,18	0,91	1,18	2,73	0,05	0,00	0,00	0,00
6	1,60	2,20	3,50	2,50	0,20	0,10	0,00	0,00
7	1,14	1,71	1,14	0,48	0,14	0,10	0,00	0,00
8	0,91	1,27	1,64	2,18	0,00	0,05	0,00	0,00
9	0,40	1,00	1,20	1,60	0,10	0,05	0,00	0,00

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	90-125µm		125-250 µm		250-355µm		355µm	
04.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,60	0,60	0,55	0,75	0,15	0,15	0,00	0,00
6	0,80	0,30	0,75	0,50	0,10	0,15	0,00	0,00
8	0,75	0,55	1,30	0,25	0,10	0,20	0,00	0,00
9	0,95	0,00	1,67	0,86	0,05	0,00	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
16.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,72	0,24	0,88	0,48	0,20	0,12	0,00	0,00
6	0,21	0,29	0,17	0,33	0,13	0,04	0,00	0,00
8	0,17	0,38	0,21	0,63	0,04	0,04	0,00	0,00
9	0,36	0,45	0,77	1,45	0,00	0,14	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
30.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,19	0,43	0,14	0,71	0,00	0,14	0,00	0,00
9	0,24	0,33	0,29	0,62	0,00	0,10	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
14.02.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,41	0,53	0,53	1,06	0,06	0,12	0,00	0,00
6	0,40	0,10	1,05	0,25	0,00	0,20	0,00	0,00
8	0,33	0,13	0,13	0,13	0,00	0,00	0,00	0,00
9	0,10	0,25	0,10	0,90	0,00	0,10	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
27.02.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,24	0,38	0,52	31,10	0,38	0,24	0,00	0,00
6	0,19	0,41	0,41	0,56	0,00	0,04	0,00	0,00
8	0,22	0,30	0,15	0,41	0,00	0,04	0,00	0,00
9	0,14	0,19	0,62	0,38	0,00	0,10	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
13.03.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,19	0,13	1,03	0,71	0,16	0,23	0,00	0,00
6	0,36	0,29	0,39	0,29	0,00	0,07	0,00	0,00

8	0,13	0,13	0,58	0,42	0,23	0,19	0,00	0,00
9	0,76	0,52	1,19	0,52	0,14	0,19	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
27.03.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,58	0,33	0,63	0,33	0,00	0,13	0,00	0,00
6	0,11	0,07	1,04	0,22	0,15	0,11	0,00	0,00
8	0,50	0,17	2,04	0,38	0,63	0,25	0,00	0,00
9	0,92	0,25	1,25	0,13	0,08	0,04	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
13.04.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	4,25	0,35	3,25	0,45	0,40	0,15	0,05	0,00
6	4,78	0,13	8,17	0,91	1,35	0,22	0,00	0,00
8	3,92	0,36	5,24	0,68	1,44	0,32	0,00	0,00
9	5,72	0,28	5,96	1,16	1,52	0,08	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
24.04.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	4,08	0,33	2,08	0,33	0,71	0,25	0,00	0,00
6	6,48	0,36	1,52	1,28	0,24	0,16	0,00	0,00
8	6,38	0,33	2,42	1,00	0,71	0,33	0,00	0,00
9	14,29	1,42	5,79	1,21	1,00	0,21	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
10.05.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	24,29	1,71	12,50	2,29	2,75	0,14	0,00	0,00
6	17,60	0,96	7,48	1,92	0,28	0,44	0,00	0,00
8	2,64	0,24	3,52	2,52	0,60	0,44	0,00	0,00
9	14,40	0,40	7,68	1,68	0,24	0,12	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
24.05.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	40,63	2,50	30,63	5,94	0,00	0,84	0,00	0,00
6	26,09	2,61	49,30	6,09	0,13	0,65	0,00	0,00
8	33,23	1,42	32,58	3,94	0,19	0,32	0,00	0,00
9	37,24	1,66	38,97	3,97	0,28	0,17	0,00	0,00

	90-125µm		125-250 µm		250-355µm		355µm	
12.06.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	29,05	2,38	45,24	8,57	0,19	1,67	0,00	0,00
6	16,67	1,92	46,67	10,42	0,58	0,38	0,00	0,00
8	20,38	2,12	41,15	5,77	0,38	0,58	0,00	0,00
9	21,21	1,59	34,14	4,48	0,62	0,34	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
09.07.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	2,50	0,30	8,33	5,67	0,13	0,27	0,00	0,00
6	2,40	0,12	14,80	3,80	0,08	0,52	0,00	0,00
8	6,36	0,21	9,39	2,73	0,24	0,45	0,00	0,00
9	3,45	0,28	11,03	3,62	0,17	0,34	0,00	0,00

Table 3. Number of *E. williamsoni* per cm^3 sediment for different size classes

	Elphidium williamsoni (standardized)							
Date/Station	90-125µm		125-250µm		250-355µm		>355µm	
20.09.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	N/A	N/A	90,62	8,31	5,85	1,85	0,04	0,04
2	0,00	0,00	33,18	5,91	2,73	1,30	0,03	0,06
3	0,00	0,00	52,42	10,61	3,67	4,30	0,00	0,12
4	0,00	0,00	1,80	2,04	0,00	0,08	0,04	0,00
5	0,00	0,00	87,93	2,29	5,11	0,79	0,04	0,00
6	0,00	0,00	66,93	2,87	13,30	1,63	0,13	0,00
7	0,00	0,00	45,16	3,10	4,10	1,81	0,00	0,03
8	0,00	0,00	22,25	2,50	4,16	4,84	0,00	0,06
9	0,00	0,00	14,54	2,23	2,00	0,38	0,00	0,00

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	90-125µm		125-250 µm		250-355µm		355µm	
29.11.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	N/A	N/A	9,83	3,81	5,08	0,78	0,00	0,08
2	N/A	N/A	3,91	4,46	1,29	2,57	0,00	0,00
3	0,19	0,51	1,19	1,62	1,08	1,73	0,03	0,08
4	0,00	0,33	0,07	2,50	0,03	0,80	0,00	0,03
5	0,00	0,69	5,91	4,31	3,50	1,19	0,00	0,00
6	0,00	1,81	5,75	6,56	9,47	2,25	0,06	0,06
7	0,00	1,33	10,60	10,13	8,37	2,87	0,00	0,13
8	0,00	1,60	6,47	7,80	11,07	5,87	0,03	0,13
9	0,27	1,47	2,53	4,00	3,97	0,70	0,00	0,07
	90-125µm		125-250 µm		250-355µm		355µm	
19.12.2011	alive	dead	alive	dead	alive	dead	alive	dead
1	0,40	0,40	23,40	2,50	7,75	0,50	0,00	0,00
2	0,00	0,20	2,60	3,45	1,00	1,80	0,00	0,00
3	0,00	0,10	0,70	1,80	0,15	3,50	0,00	0,15
4	0,00	0,20	0,20	2,40	0,05	0,45	0,00	0,00
5	0,00	0,18	1,73	1,18	1,27	0,18	0,00	0,00
6	0,00	0,60	4,50	3,10	9,65	0,80	0,00	0,00
7	0,00	0,19	10,95	0,86	8,57	0,33	0,00	0,00
8	0,00	0,18	5,64	3,91	6,09	1,86	0,00	0,05
9	0,00	0,40	5,10	4,10	2,25	0,90	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
04.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,00	0,00	2,60	1,35	0,70	0,25	0,00	0,00
6	0,00	0,30	6,60	0,55	13,65	0,55	0,00	0,00
8	0,15	0,25	8,20	1,80	11,05	1,00	0,00	0,05
9	0,00	0,38	2,52	0,57	1,95	0,67	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
16.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,24	0,16	53,76	1,72	35,28	2,20	0,08	0,16
6	0,17	0,29	8,00	1,50	10,42	0,29	0,00	0,00
8	0,13	0,17	1,96	0,79	2,50	0,42	0,00	0,00
9	0,23	0,23	0,86	0,73	0,55	0,50	0,00	0,00

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	90-125µm		125-250 µm		250-355µm		355µm	
30.01.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,19	0,33	13,14	0,71	7,43	0,52	0,05	0,00
9	0,19	0,19	1,57	1,00	3,76	0,71	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
14.02.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,35	0,47	8,12	1,59	6,18	0,76	0,12	0,00
6	0,15	0,05	2,50	0,65	4,85	0,75	0,10	0,00
8	0,04	0,21	2,13	0,29	3,83	0,46	0,00	0,00
9	0,10	0,15	2,70	0,55	2,25	0,75	0,00	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
27.02.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,14	0,24	3,57	4,00	3,43	1,90	0,05	0,05
6	0,04	0,33	3,48	1,07	6,48	0,15	0,00	0,00
8	0,15	0,33	2,30	0,59	2,85	0,37	0,00	0,00
9	0,29	0,48	4,90	0,86	10,57	0,67	0,19	0,00
	90-125µm		125-250 µm		250-355µm		355µm	
13.03.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,32	0,26	17,10	2,71	27,52	1,26	0,16	0,10
6	0,11	0,18	2,39	0,43	15,00	0,43	0,14	0,00
8	0,16	0,10	4,26	1,06	10,19	0,94	0,10	0,06
9	0,52	0,24	3,48	1,19	13,81	1,05	0,29	0,10
	90-125µm		125-250 µm		250-355µm		355µm	
27.03.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,67	0,33	2,21	0,75	7,13	0,75	0,00	0,00
6	0,07	0,11	0,74	0,30	10,22	4,48	0,70	0,11
8	0,13	0,08	1,04	0,04	5,71	0,83	0,13	0,00
9	0,63	0,21	0,63	0,25	1,46	0,50	0,21	0,04

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	90-125µm		125-250 µm		250-355µm		355µm	
13.04.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	1,15	0,15	2,95	0,50	20,60	5,95	0,80	0,00
6	1,13	0,17	1,48	0,22	15,57	6,09	1,52	0,61
8	0,72	0,20	1,80	0,16	15,52	4,44	0,04	0,04
9	2,12	0,32	1,36	0,08	5,80	3,84	0,36	0,04

	90-125µm		125-250 µm		250-355µm		355µm	
24.04.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	0,67	0,13	0,83	0,29	4,17	0,88	0,25	0,00
6	1,72	0,28	0,08	0,28	0,84	5,64	0,16	0,56
8	2,00	0,46	0,50	0,58	1,63	4,29	0,00	0,08
9	3,50	1,08	1,04	0,25	4,54	6,29	0,46	0,13

	90-125µm		125-250 µm		250-355µm		355µm	
10.05.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	13,57	1,71	1,14	1,39	5,89	2,07	0,21	0,00
6	4,80	0,32	3,44	2,88	1,84	10,64	0,24	1,36
8	1,20	0,16	1,20	1,68	1,00	2,76	0,12	0,24
9	5,60	0,24	5,24	1,32	0,84	5,16	0,08	0,20

	90-125µm		125-250 µm		250-355µm		355µm	
24.05.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	4,69	0,94	4,38	0,94	0,75	3,00	0,00	0,03
6	4,78	0,43	12,17	1,96	3,43	6,13	0,52	0,22
8	5,16	0,26	3,55	1,03	0,97	2,74	0,10	0,03
9	5,31	0,48	5,03	1,48	1,14	3,21	0,17	0,07

	90-125µm		125-250 µm		250-355µm		355µm	
12.06.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	6,19	0,71	15,24	8,10	3,29	25,29	0,19	0,95
6	5,00	0,58	11,25	7,92	3,00	10,63	0,04	0,25
8	5,58	0,69	12,12	6,35	2,62	12,69	0,12	0,31
9	4,31	0,52	9,83	6,72	2,93	6,72	0,00	0,10

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	90-125µm		125-250 µm		250-355µm		355µm	
09.07.2012	alive	dead	alive	dead	alive	dead	alive	dead
1	1,50	0,17	1,50	2,17	0,30	3,70	0,03	0,03
6	1,60	0,12	8,40	3,32	0,20	3,76	0,04	0,16
8	2,12	0,24	1,06	2,12	0,18	2,00	0,03	0,18
9	1,90	0,10	1,83	2,24	0,31	2,93	0,03	0,10

Excel table with Residual data:

Residual data of *A. aomoriensis*:

date	Julian day	sampling day	size fraction	individuals in size fraction	relative abundance	residuals	residuals%
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	0	**0**	**-0,01612903**	-100
19.12.2011	40896	91	90	5	**0,01246685**	**-0,00366218**	-22,7055166
04.01.2012	40912	107	90	0,8	**0,0019947**	**-0,01413434**	-87,6328827
16.01.2012	40924	119	90	6,16	**0,01535916**	**-0,00076987**	-4,77319648
30.01.2012	40938	133	90	0,47619048	**0,00118732**	**-0,01494171**	-92,6386206
14.02.2012	40953	148	90	1,64705882	**0,00410673**	**-0,0120223**	-74,5382878
27.02.2012	40966	161	90	3	**0,00748011**	**-0,00864892**	-53,62331
13.03.2012	40981	176	90	0,83870968	**0,00209121**	**-0,01403782**	-87,0344738
27.03.2012	40995	190	90	1,29166667	**0,0032206**	**-0,01290843**	-80,0322585

13.04.2012	41012	207	90	4,9	**0,01221752**	**-0,00391152**	-24,2514063
24.04.2012	41023	218	90	4,79166667	**0,0119474**	**-0,00418163**	-25,9261201
10.05.2012	41039	234	90	22,8571429	**0,05699132**	**0,04086229**	253,34621
24.05.2012	41053	248	90	37,5	**0,09350139**	**0,07737236**	479,708625
12.06.2012	41072	267	90	30,952381	**0,07717575**	**0,06104672**	378,489659
09.07.2012	41099	294	90	2,66666667	**0,00664899**	**-0,00948004**	-58,7762755
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	2,6875	**0,00670093**	**-0,0094281**	-58,4542152
19.12.2011	40896	91	90	4	**0,00997348**	**-0,00615555**	-38,1644133
04.01.2012	40912	107	90	2	**0,00498674**	**-0,01114229**	-69,0822066
16.01.2012	40924	119	90	0,75	**0,00187003**	**-0,014259**	-88,4058275
14.02.2012	40953	148	90	0,75	**0,00187003**	**-0,014259**	-88,4058275
27.02.2012	40966	161	90	0,74074074	**0,00184694**	**-0,01428209**	-88,5489654
13.03.2012	40981	176	90	0,42857143	**0,00106859**	**-0,01506044**	-93,3747586
27.03.2012	40995	190	90	0,14814815	**0,00036939**	**-0,01575964**	-97,7097931
13.04.2012	41012	207	90	4,47826087	**0,01116596**	**-0,00496307**	-30,7710279
24.04.2012	41023	218	90	6,2	**0,0154589**	**-0,00067014**	-4,15484061
10.05.2012	41039	234	90	16,4	**0,04089128**	**0,02476224**	153,525905
24.05.2012	41053	248	90	23,9130435	**0,05962408**	**0,04349504**	269,669268
12.06.2012	41072	267	90	17,5	**0,04363398**	**0,02750495**	170,530692
09.07.2012	41099	294	90	2,6	**0,00648276**	**-0,00964627**	-59,8068686
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	2,86666667	**0,00714766**	**-0,00898137**	-55,6844962
19.12.2011	40896	91	90	1,81818182	**0,0045334**	**-**	-

						0,01159563	71,8929151
04.01.2012	40912	107	90	1,85	**0,00461274**	**-0,0115163**	-71,4010412
16.01.2012	40924	119	90	0,66666667	**0,00166225**	**-0,01446679**	-89,6940689
14.02.2012	40953	148	90	0,75	**0,00187003**	**-0,014259**	-88,4058275
27.02.2012	40966	161	90	0,92592593	**0,00230868**	**-0,01382036**	-85,6862068
13.03.2012	40981	176	90	0,16129032	**0,00040216**	**-0,01572688**	-97,5066296
27.03.2012	40995	190	90	0,58333333	**0,00145447**	**-0,01467457**	-90,9823103
13.04.2012	41012	207	90	4,2	**0,01047216**	**-0,00565688**	-35,072634
24.04.2012	41023	218	90	7,33333333	**0,01828472**	**0,00215568**	13,3652423
10.05.2012	41039	234	90	3,44	**0,00857719**	**-0,00755184**	-46,8213954
24.05.2012	41053	248	90	32,5806452	**0,08123562**	**0,06510659**	403,660827
12.06.2012	41072	267	90	24,6153846	**0,06137527**	**0,04524624**	280,526687
09.07.2012	41099	294	90	6,06060606	**0,01511134**	**-0,0010177**	-6,30971712
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	2,8	**0,00698144**	**-0,0091476**	-56,7150893
19.12.2011	40896	91	90	0,8	**0,0019947**	**-0,01413434**	-87,6328827
04.01.2012	40912	107	90	1,71428571	**0,00427435**	**-0,01185468**	-73,4990343
16.01.2012	40924	119	90	0,77272727	**0,0019267**	**-0,01420234**	-88,0544889
30.01.2012	40938	133	90	0,38095238	**0,00094986**	**-0,01517918**	-94,1108965
14.02.2012	40953	148	90	1,15	**0,00286738**	**-0,01326166**	-82,2222688
27.02.2012	40966	161	90	1	**0,00249337**	**-0,01363566**	-84,5411033
13.03.2012	40981	176	90	0,66666667	**0,00166225**	**-0,01446679**	-89,6940689
27.03.2012	40995	190	90	1,16666667	**0,00290893**	**-0,0132201**	-81,9646205

13.04.2012	41012	207	90	6,6	**0,01645624**	**0,00032721**	2,02871806
24.04.2012	41023	218	90	12,9583333	**0,03230993**	**0,01618089**	100,321536
10.05.2012	41039	234	90	16	**0,03989393**	**0,02376489**	147,342347
24.05.2012	41053	248	90	35,5172414	**0,08855764**	**0,07242861**	449,057365
12.06.2012	41072	267	90	20	**0,04986741**	**0,03373838**	209,177934
09.07.2012	41099	294	90	6,20689655	**0,01547609**	**-0,00065294**	-4,04822753
				401,063551	**0,01612903**		
20.09.2011	40806	1	125	5,84615385	**0,01163138**	**-0,00449765**	-27,88545
29.11.2011	40876	71	125	3,91666667	**0,00779251**	**-0,00833652**	-51,6864144
19.12.2011	40896	91	125	10,3	**0,02049265**	**0,00436362**	27,0544505
04.01.2012	40912	107	125	1,45	**0,00288489**	**-0,01324414**	-82,1136939
16.01.2012	40924	119	125	5,04	**0,01002747**	**-0,00610156**	-37,8296669
30.01.2012	40938	133	125	0,04761905	**9,4742E-05**	**-0,01603429**	-99,4126008
14.02.2012	40953	148	125	0,88235294	**0,00175551**	**-0,01437352**	-89,115838
27.02.2012	40966	161	125	0,71428571	**0,00142113**	**-0,01470791**	-91,1890118
13.03.2012	40981	176	125	1,67741935	**0,00333736**	**-0,01279168**	-79,3083889
27.03.2012	40995	190	125	4,79166667	**0,00953339**	**-0,00659564**	-40,8929538
13.04.2012	41012	207	125	9,75	**0,01939839**	**0,00326935**	20,2699896
24.04.2012	41023	218	125	4,45833333	**0,0088702**	**-0,00725883**	-45,0047484
10.05.2012	41039	234	125	14,1071429	**0,02806726**	**0,01193823**	74,0170179
24.05.2012	41053	248	125	46,5	**0,09251538**	**0,07638634**	473,595335
12.06.2012	41072	267	125	44,7619048	**0,0890573**	**0,07292827**	452,155263
09.07.2012	41099	294	125	17,6666667	**0,03514921**	**0,01902018**	117,925109
20.09.2011	40806	1	125	1,33333333	**0,00265277**	**-0,01347626**	-83,5528219
29.11.2011	40876	71	125	2,9375	**0,00584439**	**-0,01028465**	-63,7648108
19.12.2011	40896	91	125	3,5	**0,00696352**	**-0,00916551**	-56,8261576

04.01.2012	40912	107	125	3,65	**0,00726196**	**-0,00886707**	-54,9758501
16.01.2012	40924	119	125	1,20833333	**0,00240407**	**-0,01372496**	-85,0947449
14.02.2012	40953	148	125	0,65	**0,00129323**	**-0,01483581**	-91,9820007
27.02.2012	40966	161	125	0,2962963	**0,0005895**	**-0,01553953**	-96,3450715
13.03.2012	40981	176	125	1,07142857	**0,00213169**	**-0,01399734**	-86,7835176
27.03.2012	40995	190	125	1,25925926	**0,00250539**	**-0,01362364**	-84,4665541
13.04.2012	41012	207	125	5,82608696	**0,01159145**	**-0,00453758**	-28,1329828
24.04.2012	41023	218	125	3,4	**0,00676457**	**-0,00936447**	-58,0596959
10.05.2012	41039	234	125	7,8	**0,01551871**	**-0,00061032**	-3,78400835
24.05.2012	41053	248	125	31,3043478	**0,06228244**	**0,04615341**	286,151137
12.06.2012	41072	267	125	40,8333333	**0,0812411**	**0,06511207**	403,694828
09.07.2012	41099	294	125	6	**0,01193747**	**-0,00419156**	-25,9876987
20.09.2011	40806	1	125	0,9375	**0,00186523**	**-0,0142638**	-88,4355779
29.11.2011	40876	71	125	1,66666667	**0,00331596**	**-0,01281307**	-79,4410274
19.12.2011	40896	91	125	1,36363636	**0,00271306**	**-0,01341597**	-83,1790224
04.01.2012	40912	107	125	2	**0,00397916**	**-0,01214988**	-75,3292329
16.01.2012	40924	119	125	0,41666667	**0,00082899**	**-0,01530004**	-94,8602569
14.02.2012	40953	148	125	0,75	**0,00149218**	**-0,01463685**	-90,7484623
27.02.2012	40966	161	125	0,18518519	**0,00036844**	**-0,01576059**	-97,7156697
13.03.2012	40981	176	125	1,12903226	**0,0022463**	**-0,01388273**	-86,0729541
27.03.2012	40995	190	125	2,20833333	**0,00439365**	**-0,01173538**	-72,7593613
13.04.2012	41012	207	125	6,52	**0,01297205**	**-0,00315698**	-19,5732993
24.04.2012	41023	218	125	4,66666667	**0,0092847**	**-**	-

						0,00684433	42,4348768
10.05.2012	41039	234	125	2,68	**0,00533207**	**-0,01079696**	-66,9411721
24.05.2012	41053	248	125	31,9354839	**0,06353814**	**0,0474091**	293,936442
12.06.2012	41072	267	125	35,3846154	**0,07040045**	**0,05427142**	336,482802
09.07.2012	41099	294	125	12,1212121	**0,0241161**	**0,00798706**	49,5198006
20.09.2011	40806	1	125	1,03846154	**0,0020661**	**-0,01406293**	-87,1901786
29.11.2011	40876	71	125	2,13333333	**0,00424443**	**-0,0118846**	-73,6845151
19.12.2011	40896	91	125	1,7	**0,00338228**	**-0,01274675**	-79,029848
04.01.2012	40912	107	125	1,57142857	**0,00312648**	**-0,01300255**	-80,6158259
16.01.2012	40924	119	125	0,77272727	**0,0015374**	**-0,01459163**	-90,4681127
30.01.2012	40938	133	125	0,23809524	**0,00047371**	**-0,01565532**	-97,0630039
14.02.2012	40953	148	125	0,55	**0,00109427**	**-0,01503476**	-93,2155391
27.02.2012	40966	161	125	0,57142857	**0,0011369**	**-0,01499213**	-92,9512094
13.03.2012	40981	176	125	1,80952381	**0,00360019**	**-0,01252884**	-77,6788298
27.03.2012	40995	190	125	3,83333333	**0,00762672**	**-0,00850232**	-52,7143631
13.04.2012	41012	207	125	11,32	**0,02252202**	**0,00639299**	39,6365417
24.04.2012	41023	218	125	6,875	**0,01367835**	**-0,00245068**	-15,1942381
10.05.2012	41039	234	125	9,64	**0,01917953**	**0,0030505**	18,9130974
24.05.2012	41053	248	125	30,862069	**0,06140249**	**0,04527346**	280,695458
12.06.2012	41072	267	125	30,5172414	**0,06071643**	**0,0445874**	276,441877
09.07.2012	41099	294	125	12,2413793	**0,02435518**	**0,00822615**	51,0021089
			125	**502,619151**	**0,01612903**		
20.09.2011	40806	1	250	1,5	**0,01229962**	**-0,00382951**	-23,7427978
29.11.2011	40876	71	250	1,38888889	**0,01138854**	**-0,00474059**	-29,3914795
19.12.2011	40896	91	250	1,1	**0,00901972**	**-0,0071094**	-44,0780517

04.01.2012	40912	107	250	0,2	**0,00163995**	**-0,01448917**	-89,832373
16.01.2012	40924	119	250	3,04	**0,02492723**	**0,0087981**	54,5479297
30.01.2012	40938	133	250	0,04761905	**0,00039046**	**-0,01573866**	-97,5791364
14.02.2012	40953	148	250	0,52941176	**0,00434104**	**-0,01178808**	-73,0856934
27.02.2012	40966	161	250	0,33333333	**0,00273325**	**-0,01339588**	-83,0539551
13.03.2012	40981	176	250	0,48387097	**0,00396762**	**-0,01216151**	-75,4009025
27.03.2012	40995	190	250	0,91666667	**0,00751643**	**-0,00861269**	-53,3983765
13.04.2012	41012	207	250	3,15	**0,0258292**	**0,00970008**	60,1401246
24.04.2012	41023	218	250	1,16666667	**0,00956637**	**-0,00656275**	-40,6888428
10.05.2012	41039	234	250	4,92857143	**0,04041303**	**0,02428391**	150,559379
24.05.2012	41053	248	250	2,75	**0,0225493**	**0,00642018**	39,8048706
12.06.2012	41072	267	250	13,952381	**0,11440598**	**0,09827685**	609,313023
09.07.2012	41099	294	250	4,96666667	**0,0407254**	**0,02459628**	152,496069
20.09.2011	40806	1	250	0,46666667	**0,00382655**	**-0,01230258**	-76,2755371
29.11.2011	40876	71	250	1,09375	**0,00896847**	**-0,00716065**	-44,3957901
19.12.2011	40896	91	250	0,9	**0,00737977**	**-0,00874935**	-54,2456787
04.01.2012	40912	107	250	0,75	**0,00614981**	**-0,00997931**	-61,8713989
16.01.2012	40924	119	250	0,29166667	**0,00239159**	**-0,01373753**	-85,1722107
14.02.2012	40953	148	250	0,05	**0,00040999**	**-0,01571914**	-97,4580933
27.02.2012	40966	161	250	0,03703704	**0,00030369**	**-0,01582543**	-98,1171061
13.03.2012	40981	176	250	0	**0**	**-0,01612912**	-100
27.03.2012	40995	190	250	0,37037037	**0,00303694**	**-0,01309218**	-81,1710612
13.04.2012	41012	207	250	2,30434783	**0,01889507**	**0,00276594**	17,1487454
24.04.2012	41023	218	250	0,6	**0,00491985**	**-0,01120928**	-69,4971191
10.05.2012	41039	234	250	1,52	**0,01246361**	**-**	-

						0,00366551	22,7260351
24.05.2012	41053	248	250	6,47826087	**0,05312009**	**0,03699097**	229,342699
12.06.2012	41072	267	250	9,29166667	**0,0761893**	**0,06006018**	372,371002
09.07.2012	41099	294	250	4,93939394	**0,04050177**	**0,02437265**	151,109575
20.09.2011	40806	1	250	0,0625	**0,00051248**	**-0,01561664**	-96,8226166
29.11.2011	40876	71	250	0,7	**0,00573982**	**-0,0103893**	-64,4133057
19.12.2011	40896	91	250	0,68181818	**0,00559074**	**-0,01053839**	-65,3376354
04.01.2012	40912	107	250	0,6	**0,00491985**	**-0,01120928**	-69,4971191
16.01.2012	40924	119	250	0,125	**0,00102497**	**-0,01510416**	-93,6452332
14.02.2012	40953	148	250	0,125	**0,00102497**	**-0,01510416**	-93,6452332
27.02.2012	40966	161	250	0,11111111	**0,00091108**	**-0,01521804**	-94,3513184
13.03.2012	40981	176	250	0,25806452	**0,00211606**	**-0,01401306**	-86,8804813
27.03.2012	40995	190	250	0,54166667	**0,00444153**	**-0,0116876**	-72,462677
13.04.2012	41012	207	250	1,64	**0,01344758**	**-0,00268154**	-16,625459
24.04.2012	41023	218	250	1,20833333	**0,00990803**	**-0,0062211**	-38,5705871
10.05.2012	41039	234	250	0,56	**0,00459186**	**-0,01153727**	-71,5306445
24.05.2012	41053	248	250	3,83870968	**0,03147644**	**0,01534732**	95,15284
12.06.2012	41072	267	250	9,76923077	**0,08010521**	**0,06397609**	396,649471
09.07.2012	41099	294	250	4,93939394	**0,04050177**	**0,02437265**	151,109575
20.09.2011	40806	1	250	0,23076923	**0,00189225**	**-0,01423687**	-88,2681227
29.11.2011	40876	71	250	0,33333333	**0,00273325**	**-0,01339588**	-83,0539551
19.12.2011	40896	91	250	0,45	**0,00368989**	**-0,01243924**	-77,1228393
04.01.2012	40912	107	250	0,19047619	**0,00156186**	**-0,01456727**	-90,3165458
16.01.2012	40924	119	250	0,31818182	**0,00260901**	**-0,01352011**	-83,8242298
30.01.2012	40938	133	250	0,14285714	**0,00117139**	**-**	-

						0,01495773	92,7374093
14.02.2012	40953	148	250	0,15	**0,00122996**	**-0,01489916**	-92,3742798
27.02.2012	40966	161	250	0,19047619	**0,00156186**	**-0,01456727**	-90,3165458
13.03.2012	40981	176	250	0,47619048	**0,00390464**	**-0,01222448**	-75,7913644
27.03.2012	40995	190	250	0,91666667	**0,00751643**	**-0,00861269**	-53,3983765
13.04.2012	41012	207	250	2,72	**0,02230331**	**0,00617418**	38,2797266
24.04.2012	41023	218	250	2,45833333	**0,02015771**	**0,00402858**	24,9770813
10.05.2012	41039	234	250	3,36	**0,02755115**	**0,01142202**	70,8161329
24.05.2012	41053	248	250	3,31034483	**0,02714399**	**0,01101486**	68,2917565
12.06.2012	41072	267	250	8,20689655	**0,06729447**	**0,05116534**	317,223313
09.07.2012	41099	294	250	3,79310345	**0,03110248**	**0,01497336**	92,8343043
			250	**121,955694**	**0,01612912**		
20.09.2011	40806	1	355	0,03846154	**0,0063632**	**-0,00976586**	-60,5482205
29.11.2011	40876	71	355	0	**0**	**-0,01612906**	-100
19.12.2011	40896	91	355	0	**0**	**-0,01612906**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612906**	-100
16.01.2012	40924	119	355	0,08	**0,01323546**	**-0,0028936**	-17,9402986
30.01.2012	40938	133	355	0	**0**	**-0,01612906**	-100
14.02.2012	40953	148	355	0	**0**	**-0,01612906**	-100
27.02.2012	40966	161	355	0	**0**	**-0,01612906**	-100
13.03.2012	40981	176	355	0	**0**	**-0,01612906**	-100
27.03.2012	40995	190	355	0,16666667	**0,02757387**	**0,01144481**	70,9577113
13.04.2012	41012	207	355	0,55	**0,09099377**	**0,07486471**	464,160447
24.04.2012	41023	218	355	0	**0**	**-0,01612906**	-100
10.05.2012	41039	234	355	0,17857143	**0,02954343**	**0,01341437**	83,1689764
24.05.2012	41053	248	355	0,21875	**0,0361907**	**0,02006164**	124,381996
12.06.2012	41072	267	355	1	**0,16544321**	**0,14931416**	925,746268

09.07.2012	41099	294	355	0,17241379	**0,02852469**	**0,01239563**	76,8528048
20.09.2011	40806	1	355	0	**0**	**-0,01612906**	-100
29.11.2011	40876	71	355	0,09375	**0,0155103**	**-0,00061876**	-3,83628738
19.12.2011	40896	91	355	0	**0**	**-0,01612906**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612906**	-100
16.01.2012	40924	119	355	0	**0**	**-0,01612906**	-100
14.02.2012	40953	148	355	0	**0**	**-0,01612906**	-100
27.02.2012	40966	161	355	0	**0**	**-0,01612906**	-100
13.03.2012	40981	176	355	0	**0**	**-0,01612906**	-100
27.03.2012	40995	190	355	0	**0**	**-0,01612906**	-100
13.04.2012	41012	207	355	0,17391304	**0,02877273**	**0,01264367**	78,3906553
24.04.2012	41023	218	355	0	**0**	**-0,01612906**	-100
10.05.2012	41039	234	355	0,04	**0,00661773**	**-0,00951133**	-58,9701493
24.05.2012	41053	248	355	0,65217391	**0,10789775**	**0,09176869**	568,964957
12.06.2012	41072	267	355	0,20833333	**0,03446734**	**0,01833828**	113,697139
09.07.2012	41099	294	355	0,04	**0,00661773**	**-0,00951133**	-58,9701493
20.09.2011	40806	1	355	0	**0**	**-0,01612906**	-100
29.11.2011	40876	71	355	0	**0**	**-0,01612906**	-100
19.12.2011	40896	91	355	0	**0**	**-0,01612906**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612906**	-100
16.01.2012	40924	119	355	0	**0**	**-0,01612906**	-100
14.02.2012	40953	148	355	0	**0**	**-0,01612906**	-100
27.02.2012	40966	161	355	0	**0**	**-**	-100

						0,01612906	
13.03.2012	40981	176	355	0	**0**	**-0,01612906**	-100
27.03.2012	40995	190	355	0,04166667	**0,00689347**	**-0,00923559**	-57,2605722
13.04.2012	41012	207	355	0,08	**0,01323546**	**-0,0028936**	-17,9402986
24.04.2012	41023	218	355	0,08333333	**0,01378693**	**-0,00234212**	-14,5211443
10.05.2012	41039	234	355	0,08	**0,01323546**	**-0,0028936**	-17,9402986
24.05.2012	41053	248	355	0,25806452	**0,04269502**	**0,02656596**	164,708714
12.06.2012	41072	267	355	0,23076923	**0,0381792**	**0,02205014**	136,710677
09.07.2012	41099	294	355	0,33333333	**0,05514774**	**0,03901868**	241,915423
20.09.2011	40806	1	355	0	**0**	**-0,01612906**	-100
29.11.2011	40876	71	355	0	**0**	**-0,01612906**	-100
19.12.2011	40896	91	355	0	**0**	**-0,01612906**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612906**	-100
16.01.2012	40924	119	355	0	**0**	**-0,01612906**	-100
30.01.2012	40938	133	355	0	**0**	**-0,01612906**	-100
14.02.2012	40953	148	355	0	**0**	**-0,01612906**	-100
27.02.2012	40966	161	355	0,0952381	**0,0157565**	**-0,00037256**	-2,30987925
13.03.2012	40981	176	355	0,04761905	**0,00787825**	**-0,00825081**	-51,1549396
27.03.2012	40995	190	355	0,08333333	**0,01378693**	**-0,00234212**	-14,5211443
13.04.2012	41012	207	355	0,2	**0,03308864**	**0,01695958**	105,149254
24.04.2012	41023	218	355	0,20833333	**0,03446734**	**0,01833828**	113,697139
10.05.2012	41039	234	355	0	**0**	**-0,01612906**	-100
24.05.2012	41053	248	355	0,37931034	**0,06275432**	**0,04662526**	289,076171
12.06.2012	41072	267	355	0,13793103	**0,02281975**	**0,0066907**	41,4822439
09.07.2012	41099	294	355	0,17241379	**0,02852469**	**0,01239563**	76,8528048
			355	**6,04437978**	**0,01612906**		

Section Marine Biogeosciences

Alfred Wegener Institute for Polar and Marine Research

Am Handelshafen 12, 27570 Bremerhaven

Germany

Residual data of *H. germanica:*

date	Julian day	sampling day	size fraction	individuals in size fraction	relative abundance	residuals	residuals%
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	1	**0,00271197**	**-0,01341706**	-83,1857591
19.12.2011	40896	91	90	1,4	**0,00379676**	**-0,01233227**	-76,4600627
04.01.2012	40912	107	90	0,6	**0,00162718**	**-0,01450185**	-89,9114554
16.01.2012	40924	119	90	0,72	**0,00195262**	**-0,01417641**	-87,8937465
30.01.2012	40938	133	90	0,19047619	**0,00051657**	**-0,01561247**	-96,7972874
14.02.2012	40953	148	90	0,41176471	**0,0011167**	**-0,01501234**	-93,076489
27.02.2012	40966	161	90	0,23809524	**0,00064571**	**-0,01548333**	-95,9966093
13.03.2012	40981	176	90	0,19354839	**0,0005249**	**-0,01560414**	-96,7456308
27.03.2012	40995	190	90	0,58333333	**0,00158199**	**-0,01454705**	-90,1916928
13.04.2012	41012	207	90	4,25	**0,01152589**	**-0,00460314**	-28,5394761
24.04.2012	41023	218	90	4,08333333	**0,0110739**	**-0,00505514**	-31,3418496
10.05.2012	41039	234	90	24,2857143	**0,06586224**	**0,04973321**	308,345851
24.05.2012	41053	248	90	40,625	**0,11017397**	**0,09404494**	583,078537
12.06.2012	41072	267	90	29,047619	**0,07877641**	**0,06264737**	388,413665
09.07.2012	41099	294	90	2,5	**0,00677994**	**-0,0093491**	-57,9643977
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	2,625	**0,00711893**	**-0,0090101**	-55,8626176
19.12.2011	40896	91	90	1,6	**0,00433916**	**-**	-

						0,01178987	73,0972145
04.01.2012	40912	107	90	0,8	**0,00216958**	**-0,01395945**	-86,5486073
16.01.2012	40924	119	90	0,20833333	**0,00056499**	**-0,01556404**	-96,4970331
14.02.2012	40953	148	90	0,4	**0,00108479**	**-0,01504424**	-93,2743036
27.02.2012	40966	161	90	0,18518519	**0,00050222**	**-0,01562682**	-96,8862517
13.03.2012	40981	176	90	0,35714286	**0,00096856**	**-0,01516047**	-93,994914
27.03.2012	40995	190	90	0,11111111	**0,00030133**	**-0,0158277**	-98,131751
13.04.2012	41012	207	90	4,7826087	**0,01297031**	**-0,00315872**	-19,5840652
24.04.2012	41023	218	90	6,48	**0,0175736**	**0,00144456**	8,95628116
10.05.2012	41039	234	90	17,6	**0,04773076**	**0,03160172**	195,93064
24.05.2012	41053	248	90	26,0869565	**0,07074717**	**0,05461813**	338,632372
12.06.2012	41072	267	90	16,6666667	**0,04519958**	**0,02907054**	180,237349
09.07.2012	41099	294	90	2,4	**0,00650874**	**-0,0096203**	-59,6458218
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	0,86666667	**0,00235038**	**-0,01377866**	-85,4276579
19.12.2011	40896	91	90	0,90909091	**0,00246543**	**-0,0136636**	-84,7143264
04.01.2012	40912	107	90	0,75	**0,00203398**	**-0,01409505**	-87,3893193
16.01.2012	40924	119	90	0,16666667	**0,000452**	**-0,01567704**	-97,1976265
14.02.2012	40953	148	90	0,33333333	**0,00090399**	**-0,01522504**	-94,395253
27.02.2012	40966	161	90	0,22222222	**0,00060266**	**-0,01552637**	-96,263502
13.03.2012	40981	176	90	0,12903226	**0,00034993**	**-0,0157791**	-97,8304205
27.03.2012	40995	190	90	0,5	**0,00135599**	**-0,01477305**	-91,5928795
13.04.2012	41012	207	90	3,92	**0,01063094**	**-0,00549809**	-34,0881756
24.04.2012	41023	218	90	6,375	**0,01728884**	**0,0011598**	7,19078587

10.05.2012	41039	234	90	2,64	**0,00715961**	**-0,00896942**	-55,610404
24.05.2012	41053	248	90	33,2258065	**0,09010755**	**0,07397851**	458,666714
12.06.2012	41072	267	90	20,3846154	**0,05528256**	**0,03915353**	242,751834
09.07.2012	41099	294	90	6,36363636	**0,01725802**	**0,00112899**	6,99971495
20.09.2011	40806	1	90	0	**0**	**-0,01612903**	-100
29.11.2011	40876	71	90	1,33333333	**0,00361597**	**-0,01251307**	-77,5810121
19.12.2011	40896	91	90	0,4	**0,00108479**	**-0,01504424**	-93,2743036
04.01.2012	40912	107	90	0,95238095	**0,00258283**	**-0,0135462**	-83,9864372
16.01.2012	40924	119	90	0,36363636	**0,00098617**	**-0,01514286**	-93,8857306
30.01.2012	40938	133	90	0,23809524	**0,00064571**	**-0,01548333**	-95,9966093
14.02.2012	40953	148	90	0,1	**0,0002712**	**-0,01585784**	-98,3185759
27.02.2012	40966	161	90	0,14285714	**0,00038742**	**-0,01574161**	-97,5979656
13.03.2012	40981	176	90	0,76190476	**0,00206627**	**-0,01406277**	-87,1891498
27.03.2012	40995	190	90	0,91666667	**0,00248598**	**-0,01364306**	-84,5869458
13.04.2012	41012	207	90	5,72	**0,0155125**	**-0,00061654**	-3,82254194
24.04.2012	41023	218	90	14,2916667	**0,03875864**	**0,0226296**	140,303526
10.05.2012	41039	234	90	14,4	**0,03905244**	**0,0229234**	142,125069
24.05.2012	41053	248	90	37,2413793	**0,10099768**	**0,08486864**	526,185524
12.06.2012	41072	267	90	21,2068966	**0,05751257**	**0,04138353**	256,577868
09.07.2012	41099	294	90	3,44827586	**0,00935164**	**-0,0067774**	-42,0198589
			90	**368,735052**	**0,01612903**		
20.09.2011	40806	1	125	0,34615385	**0,000736**	**-0,01539303**	-95,4367736
29.11.2011	40876	71	125	0,91666667	**0,00194905**	**-0,01417998**	-87,9159004
19.12.2011	40896	91	125	3,4	**0,0072292**	**-0,00889983**	-55,1789762

04.01.2012	40912	107	125	0,55	**0,00116943**	**-0,0149596**	-92,7495403
16.01.2012	40924	119	125	0,88	**0,00187109**	**-0,01425795**	-88,3992644
30.01.2012	40938	133	125	0,14285714	**0,00030375**	**-0,01582528**	-98,1167637
14.02.2012	40953	148	125	0,52941176	**0,00112565**	**-0,01500338**	-93,0209478
27.02.2012	40966	161	125	0,52380952	**0,00111374**	**-0,01501529**	-93,0948002
13.03.2012	40981	176	125	1,03225806	**0,00219482**	**-0,01393421**	-86,392099
27.03.2012	40995	190	125	0,625	**0,0013289**	**-0,01480014**	-91,7608412
13.04.2012	41012	207	125	3,25	**0,00691026**	**-0,00921877**	-57,1563743
24.04.2012	41023	218	125	2,08333333	**0,00442966**	**-0,01169938**	-72,5361374
10.05.2012	41039	234	125	12,5	**0,02657793**	**0,0104489**	64,7831759
24.05.2012	41053	248	125	30,625	**0,06511593**	**0,0489869**	303,718781
12.06.2012	41072	267	125	45,2380952	**0,0961868**	**0,08005777**	496,35816
09.07.2012	41099	294	125	8,33333333	**0,01771862**	**0,00158959**	9,85545058
20.09.2011	40806	1	125	4,4	**0,00935543**	**-0,0067736**	-41,9963221
29.11.2011	40876	71	125	1,625	**0,00345513**	**-0,0126739**	-78,5781871
19.12.2011	40896	91	125	3,5	**0,00744182**	**-0,00868721**	-53,8607108
04.01.2012	40912	107	125	0,75	**0,00159468**	**-0,01453436**	-90,1130094
16.01.2012	40924	119	125	0,16666667	**0,00035437**	**-0,01577466**	-97,802891
14.02.2012	40953	148	125	1,05	**0,00223255**	**-0,01389649**	-86,1582132
27.02.2012	40966	161	125	0,40740741	**0,00086624**	**-0,01526279**	-94,6292891
13.03.2012	40981	176	125	0,39285714	**0,00083531**	**-0,01529373**	-94,8211002
27.03.2012	40995	190	125	1,03703704	**0,00220498**	**-0,01392405**	-86,3290995
13.04.2012	41012	207	125	8,17391304	**0,01737966**	**0,00125062**	7,75386805
24.04.2012	41023	218	125	1,52	**0,00323188**	**-**	-

						0,01289716	79,9623658
10.05.2012	41039	234	125	7,48	**0,01590423**	**-0,0002248**	-1,39374756
24.05.2012	41053	248	125	49,3043478	**0,10483261**	**0,08870358**	549,962162
12.06.2012	41072	267	125	46,6666667	**0,09922428**	**0,08309525**	515,190523
09.07.2012	41099	294	125	14,8	**0,03146827**	**0,01533924**	95,1032802
20.09.2011	40806	1	125	1,9375	**0,00411958**	**-0,01200945**	-74,4586077
29.11.2011	40876	71	125	2,66666667	**0,00566996**	**-0,01045907**	-64,8462558
19.12.2011	40896	91	125	1,63636364	**0,00347929**	**-0,01264974**	-78,4283842
04.01.2012	40912	107	125	1,3	**0,0027641**	**-0,01336493**	-82,8625497
16.01.2012	40924	119	125	0,20833333	**0,00044297**	**-0,01568607**	-97,2536137
14.02.2012	40953	148	125	0,125	**0,00026578**	**-0,01586325**	-98,3521682
27.02.2012	40966	161	125	0,14814815	**0,000315**	**-0,01581403**	-98,0470142
13.03.2012	40981	176	125	0,58064516	**0,00123459**	**-0,01489444**	-92,3455557
27.03.2012	40995	190	125	2,04166667	**0,00434106**	**-0,01178797**	-73,0854146
13.04.2012	41012	207	125	5,24	**0,01114147**	**-0,00498756**	-30,9228927
24.04.2012	41023	218	125	2,41666667	**0,0051384**	**-0,01099063**	-68,1419193
10.05.2012	41039	234	125	3,52	**0,00748435**	**-0,00864469**	-53,5970577
24.05.2012	41053	248	125	32,5806452	**0,06927409**	**0,05314506**	329,499375
12.06.2012	41072	267	125	41,1538462	**0,08750273**	**0,0713737**	442,516917
09.07.2012	41099	294	125	9,39393939	**0,01997372**	**0,00384469**	23,8370534
20.09.2011	40806	1	125	1,46153846	**0,00310757**	**-0,01302146**	-80,7330441
29.11.2011	40876	71	125	1	**0,00212623**	**-0,0140028**	-86,8173459
19.12.2011	40896	91	125	1,2	**0,00255148**	**-0,01357755**	-84,1808151

04.01.2012	40912	107	125	1,66666667	**0,00354372**	**-0,01258531**	-78,0289099
16.01.2012	40924	119	125	0,77272727	**0,001643**	**-0,01448603**	-89,8134037
30.01.2012	40938	133	125	0,28571429	**0,0006075**	**-0,01552154**	-96,2335274
14.02.2012	40953	148	125	0,1	**0,00021262**	**-0,01591641**	-98,6817346
27.02.2012	40966	161	125	0,61904762	**0,00131624**	**-0,01481279**	-91,8393094
13.03.2012	40981	176	125	1,19047619	**0,00253123**	**-0,0135978**	-84,3063642
27.03.2012	40995	190	125	1,25	**0,00265779**	**-0,01347124**	-83,5216824
13.04.2012	41012	207	125	5,96	**0,01267236**	**-0,00345667**	-21,4313817
24.04.2012	41023	218	125	5,79166667	**0,01231444**	**-0,00381459**	-23,6504618
10.05.2012	41039	234	125	7,68	**0,01632948**	**0,00020045**	1,24278325
24.05.2012	41053	248	125	38,9655172	**0,08284983**	**0,0667208**	413,668934
12.06.2012	41072	267	125	34,137931	**0,07258525**	**0,05645622**	350,028535
09.07.2012	41099	294	125	11,0344828	**0,0234619**	**0,00733287**	45,463769
			125	**470,315004**	**0,01612903**		
20.09.2011	40806	1	250	0,03846154	**0,00210748**	**-0,01402157**	-86,933626
29.11.2011	40876	71	250	0,05555556	**0,00304414**	**-0,01308491**	-81,1263486
19.12.2011	40896	91	250	0,1	**0,00547945**	**-0,01064959**	-66,0274275
04.01.2012	40912	107	250	0,15	**0,00821918**	**-0,00790987**	-49,0411413
16.01.2012	40924	119	250	0,2	**0,0109589**	**-0,00517014**	-32,054855
30.01.2012	40938	133	250	0	**0**	**-0,01612905**	-100
14.02.2012	40953	148	250	0,05882353	**0,00322321**	**-0,01290584**	-80,0161338
27.02.2012	40966	161	250	0,38095238	**0,0208741**	**0,00474506**	29,4193238
13.03.2012	40981	176	250	0,16129032	**0,00883783**	**-0,00729122**	-45,2055282
27.03.2012	40995	190	250	0	**0**	**-**	-100

						0,01612905	
13.04.2012	41012	207	250	0,4	**0,02191781**	**0,00578876**	35,89029
24.04.2012	41023	218	250	0,70833333	**0,03881279**	**0,02268374**	140,639055
10.05.2012	41039	234	250	2,75	**0,15068493**	**0,13455588**	834,245744
24.05.2012	41053	248	250	0	**0**	**-0,01612905**	-100
12.06.2012	41072	267	250	0,19047619	**0,01043705**	**-0,005692**	-35,2903381
09.07.2012	41099	294	250	0,13333333	**0,00730594**	**-0,00882311**	-54,7032367
20.09.2011	40806	1	250	0,36666667	**0,02009132**	**0,00396228**	24,5660992
29.11.2011	40876	71	250	0,15625	**0,00856164**	**-0,0075674**	-46,9178555
19.12.2011	40896	91	250	0,2	**0,0109589**	**-0,00517014**	-32,054855
04.01.2012	40912	107	250	0,1	**0,00547945**	**-0,01064959**	-66,0274275
16.01.2012	40924	119	250	0,125	**0,00684932**	**-0,00927973**	-57,5342844
14.02.2012	40953	148	250	0	**0**	**-0,01612905**	-100
27.02.2012	40966	161	250	0	**0**	**-0,01612905**	-100
13.03.2012	40981	176	250	0	**0**	**-0,01612905**	-100
27.03.2012	40995	190	250	0,14814815	**0,00811771**	**-0,00801134**	-49,670263
13.04.2012	41012	207	250	1,34782609	**0,07385348**	**0,05772444**	357,891195
24.04.2012	41023	218	250	0,24	**0,01315068**	**-0,00297836**	-18,465826
10.05.2012	41039	234	250	0,28	**0,01534247**	**-0,00078658**	-4,87679701
24.05.2012	41053	248	250	0,13043478	**0,00714711**	**-0,00898194**	-55,6879489
12.06.2012	41072	267	250	0,58333333	**0,03196347**	**0,01583442**	98,1733396
09.07.2012	41099	294	250	0,08	**0,00438356**	**-0,01174548**	-72,821942
20.09.2011	40806	1	250	0,0625	**0,00342466**	**-0,01270439**	-78,7671422
29.11.2011	40876	71	250	0,1	**0,00547945**	**-**	-

						0,01064959	66,0274275
19.12.2011	40896	91	250	0	**0**	**-0,01612905**	-100
04.01.2012	40912	107	250	0,1	**0,00547945**	**-0,01064959**	-66,0274275
16.01.2012	40924	119	250	0,04166667	**0,00228311**	**-0,01384594**	-85,8447615
14.02.2012	40953	148	250	0	**0**	**-0,01612905**	-100
27.02.2012	40966	161	250	0	**0**	**-0,01612905**	-100
13.03.2012	40981	176	250	0,22580645	**0,01237296**	**-0,00375609**	-23,2877395
27.03.2012	40995	190	250	0,625	**0,03424658**	**0,01811753**	112,328578
13.04.2012	41012	207	250	1,44	**0,07890411**	**0,06277506**	389,205044
24.04.2012	41023	218	250	0,70833333	**0,03881279**	**0,02268374**	140,639055
10.05.2012	41039	234	250	0,6	**0,03287671**	**0,01674767**	103,835435
24.05.2012	41053	248	250	0,19354839	**0,01060539**	**-0,00552366**	-34,2466339
12.06.2012	41072	267	250	0,38461538	**0,02107482**	**0,00494577**	30,6637404
09.07.2012	41099	294	250	0,24242424	**0,01328352**	**-0,00284553**	-17,6422485
20.09.2011	40806	1	250	0,03846154	**0,00210748**	**-0,01402157**	-86,933626
29.11.2011	40876	71	250	0,2	**0,0109589**	**-0,00517014**	-32,054855
19.12.2011	40896	91	250	0,1	**0,00547945**	**-0,01064959**	-66,0274275
04.01.2012	40912	107	250	0,04761905	**0,00260926**	**-0,01351978**	-83,8225845
16.01.2012	40924	119	250	0	**0**	**-0,01612905**	-100
30.01.2012	40938	133	250	0	**0**	**-0,01612905**	-100
14.02.2012	40953	148	250	0	**0**	**-0,01612905**	-100
27.02.2012	40966	161	250	0	**0**	**-0,01612905**	-100
13.03.2012	40981	176	250	0,14285714	**0,00782779**	**-0,00830126**	-51,4677536
27.03.2012	40995	190	250	0,08333333	**0,00456621**	**-**	-

						0,01156284	71,6895229
13.04.2012	41012	207	250	1,52	**0,08328767**	**0,06715862**	416,383102
24.04.2012	41023	218	250	1	**0,05479452**	**0,03866547**	239,725725
10.05.2012	41039	234	250	0,24	**0,01315068**	**-0,00297836**	-18,465826
24.05.2012	41053	248	250	0,27586207	**0,01511573**	**-0,00101332**	-6,28255863
12.06.2012	41072	267	250	0,62068966	**0,03401039**	**0,01788135**	110,864243
09.07.2012	41099	294	250	0,17241379	**0,00944733**	**-0,00668172**	-41,4265991
			250	**18,2500162**	**0,01612905**		

Residual data of *E. williamsoni:*

date	Julian day	sampling day	size fraction	individuals in size fraction	relative abundance	residuals	residuals %
20.09.2011	40806	1	90	0	**0**	**-0,01612904**	-100
29.11.2011	40876	71	90	0,2	**0,00215673**	**-0,0139723**	-86,628251
19.12.2011	40896	91	90	0,4	**0,00431347**	**-0,01181557**	-73,256502
04.01.2012	40912	107	90	0	**0**	**-0,01612904**	-100
16.01.2012	40924	119	90	0,24	**0,00258808**	**-0,01354095**	-83,9539012
30.01.2012	40938	133	90	0,19047619	**0,00205403**	**-0,014075**	-87,265001
14.02.2012	40953	148	90	0,35294118	**0,003806**	**-0,01232303**	-76,4027959
27.02.2012	40966	161	90	0,14285714	**0,00154052**	**-0,01458851**	-90,4487507
13.03.2012	40981	176	90	0,32258065	**0,0034786**	**-0,01265043**	-78,4326629
27.03.2012	40995	190	90	0,66666667	**0,00718911**	**-0,00893992**	-55,4275033
13.04.2012	41012	207	90	1,15	**0,01240122**	**-0,00372781**	-23,1124433
24.04.2012	41023	218	90	0,66666667	**0,00718911**	**-0,00893992**	-55,4275033

10.05.2012	41039	234	90	13,5714286	**0,14634982**	**0,13022078**	807,368682
24.05.2012	41053	248	90	4,6875	**0,05054846**	**0,03441942**	213,400367
12.06.2012	41072	267	90	6,19047619	**0,06675606**	**0,05062702**	313,887469
09.07.2012	41099	294	90	1,89655172	**0,02045179**	**0,00432275**	26,8010681
20.09.2011	40806	1	90	0	**0**	**-0,01612904**	-100
29.11.2011	40876	71	90	0	**0**	**-0,01612904**	-100
19.12.2011	40896	91	90	0	**0**	**-0,01612904**	-100
04.01.2012	40912	107	90	0	**0**	**-0,01612904**	-100
16.01.2012	40924	119	90	0,16666667	**0,00179728**	**-0,01433176**	-88,8568758
14.02.2012	40953	148	90	0,15	**0,00161755**	**-0,01451149**	-89,9711883
27.02.2012	40966	161	90	0,03703704	**0,0003994**	**-0,01572964**	-97,5237502
13.03.2012	40981	176	90	0,10714286	**0,00115539**	**-0,01497364**	-92,836563
27.03.2012	40995	190	90	0,07407407	**0,00079879**	**-0,01533025**	-95,0475004
13.04.2012	41012	207	90	1,13043478	**0,01219024**	**-0,0039388**	-24,4205491
24.04.2012	41023	218	90	1,72	**0,01854791**	**0,00241888**	14,9970414
10.05.2012	41039	234	90	4,8	**0,05176162**	**0,03563258**	220,921976
24.05.2012	41053	248	90	4,7826087	**0,05157408**	**0,03544504**	219,759215
12.06.2012	41072	267	90	5	**0,05391835**	**0,03778932**	234,293725
09.07.2012	41099	294	90	1,6	**0,01725387**	**0,00112484**	6,973992
20.09.2011	40806	1	90	0	**0**	**-0,01612904**	-100
29.11.2011	40876	71	90	0	**0**	**-0,01612904**	-100
19.12.2011	40896	91	90	0	**0**	**-0,01612904**	-100
04.01.2012	40912	107	90	0,15	**0,00161755**	**-0,01451149**	-89,9711883
16.01.2012	40924	119	90	0,125	**0,00134796**	**-0,01478108**	-91,6426569

14.02.2012	40953	148	90	0,04166667	**0,00044932**	**-0,01567972**	-97,214219
27.02.2012	40966	161	90	0,14814815	**0,00159758**	**-0,01453145**	-90,0950007
13.03.2012	40981	176	90	0,16129032	**0,0017393**	**-0,01438973**	-89,2163315
27.03.2012	40995	190	90	0,125	**0,00134796**	**-0,01478108**	-91,6426569
13.04.2012	41012	207	90	0,72	**0,00776424**	**-0,00836479**	-51,8617036
24.04.2012	41023	218	90	2	**0,02156734**	**0,00543831**	33,71749
10.05.2012	41039	234	90	1,2	**0,01294041**	**-0,00318863**	-19,769506
24.05.2012	41053	248	90	5,16129032	**0,05565766**	**0,03952862**	245,077394
12.06.2012	41072	267	90	5,57692308	**0,0601397**	**0,04401067**	272,866078
09.07.2012	41099	294	90	2,12121212	**0,02287445**	**0,00674542**	41,8215803
20.09.2011	40806	1	90	0	**0**	**-0,01612904**	-100
29.11.2011	40876	71	90	0,26666667	**0,00287565**	**-0,01325339**	-82,1710013
19.12.2011	40896	91	90	0	**0**	**-0,01612904**	-100
04.01.2012	40912	107	90	0	**0**	**-0,01612904**	-100
16.01.2012	40924	119	90	0,22727273	**0,00245083**	**-0,0136782**	-84,8048307
30.01.2012	40938	133	90	0,19047619	**0,00205403**	**-0,014075**	-87,265001
14.02.2012	40953	148	90	0,1	**0,00107837**	**-0,01505067**	-93,3141255
27.02.2012	40966	161	90	0,28571429	**0,00308105**	**-0,01304799**	-80,8975014
13.03.2012	40981	176	90	0,52380952	**0,00564859**	**-0,01048045**	-64,9787526
27.03.2012	40995	190	90	0,625	**0,00673979**	**-0,00938924**	-58,2132844
13.04.2012	41012	207	90	2,12	**0,02286138**	**0,00673235**	41,7405394
24.04.2012	41023	218	90	3,5	**0,03774285**	**0,02161381**	134,005607
10.05.2012	41039	234	90	5,6	**0,06038856**	**0,04425952**	274,408972
24.05.2012	41053	248	90	5,31034483	**0,05726501**	**0,04113598**	255,042991
12.06.2012	41072	267	90	4,31034483	**0,04648134**	**0,0303523**	188,184246

09.07.2012	41099	294	90	1,89655172	**0,02045179**	**0,00432275**	26,8010681
			90	**92,7328205**	**0,01612904**		
20.09.2011	40806	1	125	51,8	**0,10638429**	**0,09025523**	559,581297
29.11.2011	40876	71	125	9,83333333	**0,02019522**	**0,00406615**	25,2100919
19.12.2011	40896	91	125	23,4	**0,04805777**	**0,0319287**	197,957575
04.01.2012	40912	107	125	2,6	**0,00533975**	**-0,01078931**	-66,8936028
16.01.2012	40924	119	125	53,76	**0,11040964**	**0,09428058**	584,538428
30.01.2012	40938	133	125	13,1428571	**0,02699215**	**0,01086309**	67,3510187
14.02.2012	40953	148	125	8,11764706	**0,01667162**	**0,00054256**	3,36386446
27.02.2012	40966	161	125	3,57142857	**0,00733482**	**-0,00879424**	-54,5241797
13.03.2012	40981	176	125	17,0967742	**0,03511251**	**0,01898345**	117,697153
27.03.2012	40995	190	125	2,20833333	**0,00453537**	**-0,0115937**	-71,8807845
13.04.2012	41012	207	125	2,95	**0,00605856**	**-0,0100705**	-62,4369724
24.04.2012	41023	218	125	0,83333333	**0,00171146**	**-0,01441761**	-89,3889753
10.05.2012	41039	234	125	1,14285714	**0,00234714**	**-0,01378192**	-85,4477375
24.05.2012	41053	248	125	4,375	**0,00898516**	**-0,0071439**	-44,2921201
12.06.2012	41072	267	125	15,2380952	**0,03129525**	**0,01516619**	94,0301666
09.07.2012	41099	294	125	1,5	**0,00308063**	**-0,01304844**	-80,9001555
20.09.2011	40806	1	125	66,9333333	**0,13746438**	**0,12133532**	752,277507
29.11.2011	40876	71	125	5,75	**0,01180907**	**-0,00432**	-26,7839293
19.12.2011	40896	91	125	4,5	**0,00924188**	**-0,00688719**	-42,7004664
04.01.2012	40912	107	125	6,6	**0,01355476**	**-0,00257431**	-15,9606841
16.01.2012	40924	119	125	8	**0,01643001**	**0,00030094**	1,86583744
14.02.2012	40953	148	125	2,5	**0,00513438**	**-0,01099469**	-68,1669258
27.02.2012	40966	161	125	3,48148148	**0,0071501**	**-0,00897897**	-55,6694967
13.03.2012	40981	176	125	2,39285714	**0,00491433**	**-0,01121473**	-69,5312004

27.03.2012	40995	190	125	0,74074074	**0,0015213**	**-0,01460777**	-90,567978
13.04.2012	41012	207	125	1,47826087	**0,00303598**	**-0,01309308**	-81,1769648
24.04.2012	41023	218	125	0,08	**0,0001643**	**-0,01596476**	-98,9813416
10.05.2012	41039	234	125	3,44	**0,0070649**	**-0,00906416**	-56,1976899
24.05.2012	41053	248	125	12,173913	**0,02500218**	**0,00887312**	55,0132309
12.06.2012	41072	267	125	11,25	**0,0231047**	**0,00697563**	43,2488339
09.07.2012	41099	294	125	8,4	**0,01725151**	**0,00112244**	6,95912931
20.09.2011	40806	1	125	22,25	**0,04569595**	**0,02956689**	183,31436
29.11.2011	40876	71	125	6,46666667	**0,01328092**	**-0,00284814**	-17,6584481
19.12.2011	40896	91	125	5,63636364	**0,01157569**	**-0,00455338**	-28,2308873
04.01.2012	40912	107	125	8,2	**0,01684076**	**0,00071169**	4,41248338
16.01.2012	40924	119	125	1,95833333	**0,00402193**	**-0,01210714**	-75,0640919
14.02.2012	40953	148	125	2,125	**0,00436422**	**-0,01176484**	-72,9418869
27.02.2012	40966	161	125	2,2962963	**0,00471602**	**-0,01141304**	-70,7607318
13.03.2012	40981	176	125	4,25806452	**0,008745**	**-0,00738406**	-45,7810865
27.03.2012	40995	190	125	1,04166667	**0,00213932**	**-0,01398974**	-86,7362191
13.04.2012	41012	207	125	1,8	**0,00369675**	**-0,01243231**	-77,0801866
24.04.2012	41023	218	125	0,5	**0,00102688**	**-0,01510219**	-93,6333852
10.05.2012	41039	234	125	1,2	**0,0024645**	**-0,01366456**	-84,7201244
24.05.2012	41053	248	125	3,5483871	**0,0072875**	**-0,00884156**	-54,8175721
12.06.2012	41072	267	125	12,1153846	**0,02488198**	**0,00875292**	54,267975
09.07.2012	41099	294	125	1,06060606	**0,00217822**	**-0,01395084**	-86,4950594
20.09.2011	40806	1	125	14,5384615	**0,02985838**	**0,01372931**	85,12157

29.11.2011	40876	71	125	2,53333333	**0,00520284**	**-0,01092623**	-67,7424848
19.12.2011	40896	91	125	5,1	**0,01047413**	**-0,00565494**	-35,0605286
04.01.2012	40912	107	125	2,52380952	**0,00518328**	**-0,01094579**	-67,8637537
16.01.2012	40924	119	125	0,86363636	**0,00177369**	**-0,01435537**	-89,0031198
30.01.2012	40938	133	125	1,57142857	**0,00322732**	**-0,01290174**	-79,9906391
14.02.2012	40953	148	125	2,7	**0,00554513**	**-0,01058394**	-65,6202799
27.02.2012	40966	161	125	4,9047619	**0,01007316**	**-0,00605591**	-37,5465401
13.03.2012	40981	176	125	3,47619048	**0,00713923**	**-0,00898984**	-55,7368683
27.03.2012	40995	190	125	0,625	**0,00128359**	**-0,01484547**	-92,0417314
13.04.2012	41012	207	125	1,36	**0,0027931**	**-0,01333596**	-82,6828076
24.04.2012	41023	218	125	1,04166667	**0,00213932**	**-0,01398974**	-86,7362191
10.05.2012	41039	234	125	5,24	**0,01076165**	**-0,00536741**	-33,2778765
24.05.2012	41053	248	125	5,03448276	**0,01033957**	**-0,00578949**	-35,8947747
12.06.2012	41072	267	125	9,82758621	**0,02018341**	**0,00405435**	25,1369124
09.07.2012	41099	294	125	1,82758621	**0,00375341**	**-0,01237566**	-76,7289251
			125	**486,914958**	**0,01612906**		
20.09.2011	40806	1	250	5,84615385	**0,01473563**	**-0,00139341**	-8,63913244
29.11.2011	40876	71	250	5,08333333	**0,01281289**	**-0,00331615**	-20,5601228
19.12.2011	40896	91	250	7,75	**0,0195344**	**0,00340536**	21,1132553
04.01.2012	40912	107	250	0,7	**0,0017644**	**-0,01436464**	-89,0607382
16.01.2012	40924	119	250	35,28	**0,08892563**	**0,0727966**	451,338793
30.01.2012	40938	133	250	7,42857143	**0,01872422**	**0,00259518**	16,0901249
14.02.2012	40953	148	250	6,17647059	**0,01556821**	**-0,00056082**	-3,477102

27.02.2012	40966	161	250	3,42857143	**0,00864195**	**-0,00748709**	-46,4199423
13.03.2012	40981	176	250	27,516129	**0,06935627**	**0,05322723**	330,008769
27.03.2012	40995	190	250	7,125	**0,01795905**	**0,00183001**	11,3460573
13.04.2012	41012	207	250	20,6	**0,0519237**	**0,03579466**	221,926846
24.04.2012	41023	218	250	4,16666667	**0,01050237**	**-0,00562667**	-34,8853466
10.05.2012	41039	234	250	5,89285714	**0,01485335**	**-0,00127569**	-7,90927589
24.05.2012	41053	248	250	0,75	**0,00189043**	**-0,01423861**	-88,2793624
12.06.2012	41072	267	250	3,28571429	**0,00828187**	**-0,00784717**	-48,6524447
09.07.2012	41099	294	250	0,3	**0,00075617**	**-0,01537287**	-95,311745
20.09.2011	40806	1	250	13,3	**0,03352355**	**0,01739452**	107,845974
29.11.2011	40876	71	250	9,46875	**0,02386663**	**0,00773759**	47,9730499
19.12.2011	40896	91	250	9,65	**0,02432348**	**0,00819444**	50,8055373
04.01.2012	40912	107	250	13,65	**0,03440575**	**0,01827671**	113,315605
16.01.2012	40924	119	250	10,4166667	**0,02625591**	**0,01012688**	62,7866335
14.02.2012	40953	148	250	4,85	**0,01222475**	**-0,00390428**	-24,2065434
27.02.2012	40966	161	250	6,48148148	**0,01633701**	**0,00020798**	1,28946086
13.03.2012	40981	176	250	15	**0,03780852**	**0,02167948**	134,412752
27.03.2012	40995	190	250	10,2222222	**0,0257658**	**0,00963677**	59,7479497
13.04.2012	41012	207	250	15,5652174	**0,03923319**	**0,02310415**	143,245697
24.04.2012	41023	218	250	0,84	**0,00211728**	**-0,01401176**	-86,8728859
10.05.2012	41039	234	250	1,84	**0,00463784**	**-0,01149119**	-71,2453691
24.05.2012	41053	248	250	3,43478261	**0,0086576**	**-0,00747143**	-46,322877
12.06.2012	41072	267	250	3	**0,0075617**	**-0,00856733**	-53,1174495
09.07.2012	41099	294	250	0,2	**0,00050411**	**-0,01562492**	-96,8744966
20.09.2011	40806	1	250	4,15625	**0,01047611**	**-0,00565293**	-35,0481332
29.11.2011	40876	71	250	11,0666667	**0,02789428**	**0,01176525**	72,9445195

19.12.2011	40896	91	250	6,09090909	**0,01535255**	**-0,00077649**	-4,81421574
04.01.2012	40912	107	250	11,05	**0,02785227**	**0,01172324**	72,6840609
16.01.2012	40924	119	250	2,5	**0,00630142**	**-0,00982762**	-60,931208
14.02.2012	40953	148	250	3,83333333	**0,00966218**	**-0,00646686**	-40,0945189
27.02.2012	40966	161	250	2,85185185	**0,00718829**	**-0,00894075**	-55,4326372
13.03.2012	40981	176	250	10,1935484	**0,02569353**	**0,00956449**	59,2998489
27.03.2012	40995	190	250	5,70833333	**0,01438824**	**-0,00174079**	-10,7929248
13.04.2012	41012	207	250	15,52	**0,03911921**	**0,02299018**	142,539061
24.04.2012	41023	218	250	1,625	**0,00409592**	**-0,01203311**	-74,6052852
10.05.2012	41039	234	250	1	**0,00252057**	**-0,01360847**	-84,3724832
24.05.2012	41053	248	250	0,96774194	**0,00243926**	**-0,01368978**	-84,8765966
12.06.2012	41072	267	250	2,61538462	**0,00659225**	**-0,00953678**	-59,1280329
09.07.2012	41099	294	250	0,18181818	**0,00045829**	**-0,01567075**	-97,1586333
20.09.2011	40806	1	250	2	**0,00504114**	**-0,0110879**	-68,7449664
29.11.2011	40876	71	250	3,96666667	**0,00999825**	**-0,00613078**	-38,01085
19.12.2011	40896	91	250	2,25	**0,00567128**	**-0,01045776**	-64,8380872
04.01.2012	40912	107	250	1,95238095	**0,00492111**	**-0,01120793**	-69,4891338
16.01.2012	40924	119	250	0,54545455	**0,00137486**	**-0,01475418**	-91,4758999
30.01.2012	40938	133	250	3,76190476	**0,00948214**	**-0,0066469**	-41,2107701
14.02.2012	40953	148	250	2,25	**0,00567128**	**-0,01045776**	-64,8380872
27.02.2012	40966	161	250	10,5714286	**0,026646**	**0,01051697**	65,2051778
13.03.2012	40981	176	250	13,8095238	**0,03480784**	**0,01867881**	115,808566
27.03.2012	40995	190	250	1,45833333	**0,00367583**	**-0,01245321**	-77,2098713

13.04.2012	41012	207	250	5,8	**0,01461929**	**-0,00150974**	-9,36040245
24.04.2012	41023	218	250	4,54166667	**0,01144758**	**-0,00468146**	-29,0250278
10.05.2012	41039	234	250	0,84	**0,00211728**	**-0,01401176**	-86,8728859
24.05.2012	41053	248	250	1,13793103	**0,00286823**	**-0,0132608**	-82,2169636
12.06.2012	41072	267	250	2,93103448	**0,00738787**	**-0,00874116**	-54,1952093
09.07.2012	41099	294	250	0,31034483	**0,00078225**	**-0,01534679**	-95,150081
			250	**396,736095**	**0,01612904**		
20.09.2011	40806	1	355	0,03846154	**0,0047501**	**-0,01137945**	-70,5503459
29.11.2011	40876	71	355	0	**0**	**-0,01612955**	-100
19.12.2011	40896	91	355	0	**0**	**-0,01612955**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612955**	-100
16.01.2012	40924	119	355	0,08	**0,0098802**	**-0,00624935**	-38,7447194
30.01.2012	40938	133	355	0,04761905	**0,00588107**	**-0,01024848**	-63,5385235
14.02.2012	40953	148	355	0,11764706	**0,01452971**	**-0,00159984**	-9,91870501
27.02.2012	40966	161	355	0,04761905	**0,00588107**	**-0,01024848**	-63,5385235
13.03.2012	40981	176	355	0,16129032	**0,01991976**	**0,00379021**	23,4985496
27.03.2012	40995	190	355	0	**0**	**-0,01612955**	-100
13.04.2012	41012	207	355	0,8	**0,09880203**	**0,08267247**	512,552806
24.04.2012	41023	218	355	0,25	**0,03087563**	**0,01474608**	91,4227519
10.05.2012	41039	234	355	0,21428571	**0,02646483**	**0,01033528**	64,0766445
24.05.2012	41053	248	355	0	**0**	**-0,01612955**	-100
12.06.2012	41072	267	355	0,19047619	**0,02352429**	**0,00739474**	45,8459062
09.07.2012	41099	294	355	0,03333333	**0,00411675**	**-0,0120128**	-74,4769664
20.09.2011	40806	1	355	0,13333333	**0,016467**	**0,00033745**	2,09213433

29.11.2011	40876	71	355	0,0625	**0,00771891**	**-0,00841064**	-52,144312
19.12.2011	40896	91	355	0	**0**	**-0,01612955**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612955**	-100
16.01.2012	40924	119	355	0	**0**	**-0,01612955**	-100
14.02.2012	40953	148	355	0,1	**0,01235025**	**-0,0037793**	-23,4308993
27.02.2012	40966	161	355	0	**0**	**-0,01612955**	-100
13.03.2012	40981	176	355	0,14285714	**0,01764322**	**0,00151367**	9,38442963
27.03.2012	40995	190	355	0,7037037	**0,08690919**	**0,07077964**	438,819598
13.04.2012	41012	207	355	1,52173913	**0,18793864**	**0,17180908**	1065,18197
24.04.2012	41023	218	355	0,16	**0,01976041**	**0,00363085**	22,5105612
10.05.2012	41039	234	355	0,24	**0,02964061**	**0,01351106**	83,7658418
24.05.2012	41053	248	355	0,52173913	**0,0644361**	**0,04830655**	299,49096
12.06.2012	41072	267	355	0,04166667	**0,00514594**	**-0,01098361**	-68,096208
09.07.2012	41099	294	355	0,04166667	**0,00514594**	**-0,01098361**	-68,096208
20.09.2011	40806	1	355	0	**0**	**-0,01612955**	-100
29.11.2011	40876	71	355	0,03333333	**0,00411675**	**-0,0120128**	-74,4769664
19.12.2011	40896	91	355	0	**0**	**-0,01612955**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612955**	-100
16.01.2012	40924	119	355	0	**0**	**-0,01612955**	-100
14.02.2012	40953	148	355	0	**0**	**-0,01612955**	-100
27.02.2012	40966	161	355	0	**0**	**-0,01612955**	-100
13.03.2012	40981	176	355	0,09677419	**0,01195186**	**-0,00417769**	-25,9008702
27.03.2012	40995	190	355	0,125	**0,01543782**	**-0,00069174**	-4,28862407
13.04.2012	41012	207	355	0,04	**0,0049401**	**-**	-

						0,01118945	69,3723597
24.04.2012	41023	218	355	0	**0**	**-0,01612955**	-100
10.05.2012	41039	234	355	0,12	**0,0148203**	**-0,00130925**	-8,11707911
24.05.2012	41053	248	355	0,09677419	**0,01195186**	**-0,00417769**	-25,9008702
12.06.2012	41072	267	355	0,11538462	**0,01425029**	**-0,00187926**	-11,6510376
09.07.2012	41099	294	355	0,03030303	**0,0037425**	**-0,01238705**	-76,7972422
20.09.2011	40806	1	355	0	**0**	**-0,01612955**	-100
29.11.2011	40876	71	355	0	**0**	**-0,01612955**	-100
19.12.2011	40896	91	355	0	**0**	**-0,01612955**	-100
04.01.2012	40912	107	355	0	**0**	**-0,01612955**	-100
16.01.2012	40924	119	355	0	**0**	**-0,01612955**	-100
30.01.2012	40938	133	355	0	**0**	**-0,01612955**	-100
14.02.2012	40953	148	355	0	**0**	**-0,01612955**	-100
27.02.2012	40966	161	355	0,19047619	**0,02352429**	**0,00739474**	45,8459062
13.03.2012	40981	176	355	0,28571429	**0,03528644**	**0,01915689**	118,768859
27.03.2012	40995	190	355	0,20833333	**0,02572969**	**0,00960014**	59,5189599
13.04.2012	41012	207	355	0,36	**0,04446091**	**0,02833136**	175,648763
24.04.2012	41023	218	355	0,45833333	**0,05660533**	**0,04047577**	250,941712
10.05.2012	41039	234	355	0,08	**0,0098802**	**-0,00624935**	-38,7447194
24.05.2012	41053	248	355	0,17241379	**0,02129354**	**0,00516399**	32,0156909
12.06.2012	41072	267	355	0	**0**	**-0,01612955**	-100
09.07.2012	41099	294	355	0,03448276	**0,00425871**	**-0,01187084**	-73,5968618
			355	**8,09726109**	**0,01612955**		

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