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EDITORIAL

Preface—biodiversity of Icelandic waters

Karin Meißner[1] · Saskia Brix[1] · Kenneth M. Halanych[2] · Anna M. Jażdżewska[3]

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This special issue focuses on the biodiversity of Icelandic waters and on the outcome of the IceAGE (Icelandic Animals: Genetics and Ecology) project. It presents international efforts to deepen our understanding of deep-water ecosystems and biodiversity patterns found in the region. The IceAGE project is a successor of BIOFAR and BIOICE studies that explored the biodiversity found on the continental shelves around the Faroe Islands and Iceland, respectively. In contrast, IceAGE is exploring the diversity of animals that live on the deep continental slope and in abyssal waters around Iceland. Information on the development of the IceAGE project, the geologic setting, and other scientific background is provided in detail in Brix et al. (2014a). Although the project encompasses basic questions about deep-sea biodiversity and correlation between genetic, morphological, and environmental patterns, several larger issues are central to the project. Namely, deep waters around Iceland include boreal, subarctic, and Arctic zones that hold discrete bodies of water. This allows for comparative studies of deep-sea ecosystems. How much variation exists between basins in the deep sea? Is there gene flow between deep-sea basins? Do we see the same patterns in the deep sea and the continental shelf?

Importantly, the IceAGE project and its predecessors, BIOFAR and BIOICE, offer unprecedented baseline data for two major societal issues facing current and future generations. One is the impact of climate change on the deep sea. The northern Atlantic region around Iceland has long been known to be a critical region for regulation of the global thermohaline circulation. Recent reports have shown that human-mediated global climate change is already producing measurable changes in the circulation patterns in this region (Jochumsen et al. 2016). One of these largest changes concerns the formation of cold deep water (Lohmann and Gerdes 1998; Meehl et al. 2007; Winton 1997). With the loss of Arctic sea ice deep-water formation has slowed, presumably impacting the flow and chemistry moving along the study region. The second societal issue is deep-sea mining. There has been growing international interest in deep-sea resource extraction and mining operations are about to begin in some areas (Halfar and Fujita 2007; Mengerink et al. 2014; Nagender Nath and Sharma 2000). These operations, in particular, are targeting mid-ocean ridges and other geothermally active areas. The ridges around Iceland include such areas, e.g., the Reykjanes Ridge with hydrothermal vent sites. The extent of damage and loss of ecosystem services caused by mining activities cannot be adequately evaluated without baseline data.

This special issue embedded in a topical collection of articles presents international efforts to collect and analyze biodiversity from the region that can enhance our understanding of deep-water ecosystems around Iceland. From the beginning in 2011, the IceAGE project relied on an international group of scientists who pursued the pre-determined objectives. One of the main tasks was the geo- and time-referenced collection of marine invertebrates together with information on environmental parameters from different habitats around Iceland. In contrast to earlier projects, sampling was extended to deep waters north and south of Iceland, and specimens were no longer exclusively fixed in formalin but also in 96% ethanol. This allowed the use of a larger range of methods, as for example molecular methods (Riehl et al. 2014) in addition to various classical methods.

This article is part of the Topical Collection on Biodiversity of Icelandic Waters by Karin Meißner, Saskia Brix, Ken M. Halanych and Anna Jazdzewska.

✉ Karin Meißner
karin.meissner@senckenberg.de

[1] Forschungsinstitut Senckenberg, Deutsches Zentrum für Marine Biodiversitätsforschung, Biozentrum Grindel, Martin–Luther–King–Platz 3, 20146 Hamburg, Germany

[2] Molette Biology Laboratory for Environmental and Climate Change Studies, Department of Biological Sciences, Auburn University, Auburn, AL 36849, USA

[3] Department of Invertebrate Zoology and Hydrobiology, Faculty of Biology and Environmental Protection, University of Lodz, Banacha 12/16 St., 90-237 Lodz, Poland

An interim assessment of achievements from the IceAGE project to date includes collection of specimens from altogether more than 350 stations in water depths between 117 and 2780 m during two expeditions (Fig. 1). Cruise IceAGE1 (M85/3) with R/V *Meteor* took place in September 2011 (https://www.tib.eu/de/suchen/id/awi%3Adoi~10.2312%252Fcr_m85_3/) and the cruise IceAGE2 (POS456) (http://www.geomar.de/fileadmin/content/zentrum/ze/fs/Poseidon_Berichte_2013_PDF/POS456_Brix.pdf) with R/V *Poseidon* in August 2013. Various gears for the collection of benthic fauna were used and accompanied by the measurement of abiotic parameters of near-bottom water by means of a conductivity-temperature-depth sensor (CTD). A map indicating the location of sampling stations for different gears is provided by Ostmann et al. 2014 and Meißner et al. 2014 (also see Fig. 1). These two publications also inform about sediments and habitat features based on the analyses of sediment samples and visual assessment of recordings by a digital underwater video camcorder and still camera. This information is supplemented by the description of the hydrography in the nearby area. Sorting revealed that the samples contained several hundred thousands of marine invertebrates spanning the diversity of animal life. Under supervision of the German Centre of Marine Biodiversity Research (DZMB Hamburg, Germany; see also Brandt et al. 2017) and the Icelandic cooperation partner (University of Iceland, Sandgerði sorting centre, Iceland), samples have been sorted into taxonomic groups down to family level (e.g., Annelida, Isopoda, Amphipoda). This has provided specialists access to their groups of interest and provided material to publish on diverse topics spanning several taxa. Several resulting publications were compiled in the first IceAGE special issue published by *Polish Polar Research* in 2014. It included many descriptions of newly discovered species combined with taxonomic and biodiversity studies (Jóźwiak 2014; Mikkelsen and Todt 2014; Parapar et al. 2014; Schnurr and Malyutina 2014; Todt and Kocot 2014; Yasuhara et al. 2014), studies combining taxonomy and phylogeny using morphological and molecular tools (Błażewicz-Paszkowycz et al. 2014; Khodami et al. 2014), phylogeographic studies on selected taxa (Brix et al. 2014b; Jennings and Etter 2014), and a publication with a modeling approach providing a GIS layer on sediment characteristics (Ostmann et al. 2014).

A special issue solely dedicated to Amphipoda and published in *ZooKeys* is another outcome from the IceAGE project. It presents a collection of new species descriptions (Krapp-Schickel 2018; Peart et al. 2018; Tandberg and Vader 2018), information about the distribution patterns of

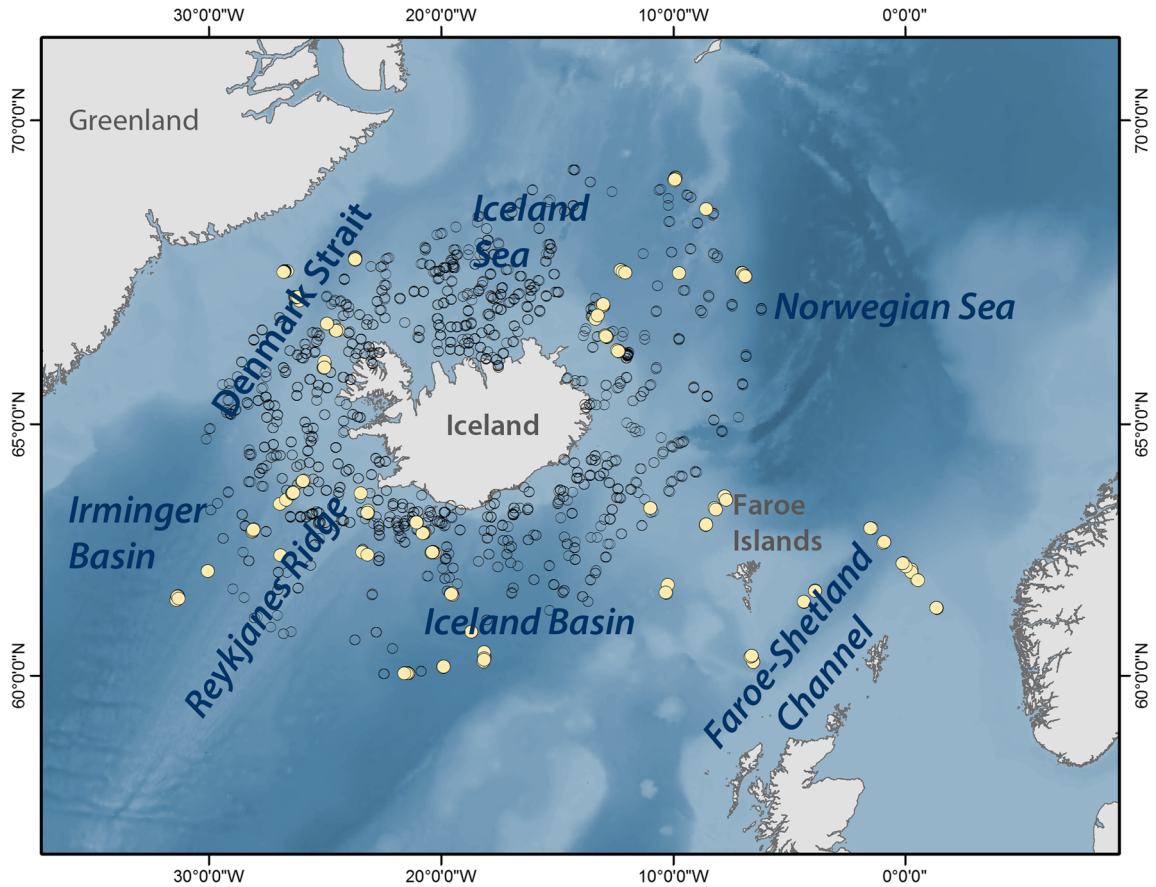

Fig. 1 IceAGE study area with stations from both the IceAGE (yellow circle) and BIOICE (empty circle) projects

amphipod families (Brix et al. 2018), and results of combining morphological and molecular approaches in studies of chosen taxa (Jażdżewska et al. 2018; Lörz et al. 2018).

The present topical collection continues these works. While the first special issue in *Polish Polar Research* was focused on BIOICE and IceAGE material, the second collection here presented as topical collection "Biodiversity of Icelandic waters" is a variety of papers studying organisms in Icelandic waters in the North Atlantic, but also includes contributions from adjacent Nordic regions related to the IceAGE themes. Ostmann and Martinez investigate meiofauna density and diversity north and south of the Greenland-Iceland-Scotland (GIS) Ridge. A modeling approach was used to assess the magnitude of compositional change along environmental gradients. Food supply, water depth, oxygen in bottom water, and bottom roughness are determined as most important environmental variables affecting meiofauna distribution. Dealing with polychaetes, Bogantes et al. study the genus *Laonice* (Spionidae, Annelida) using both morphology and COI gene data to confirm the presence of not less than seven lineages in waters around Iceland, including species known to science and at least one new. Moreover, a preliminary phylogeny for *Laonice* is provided. Parapar et al. tested the sufficiency of micro-computed tomography for studying the gross internal and external anatomy of the polychaete species *Cossura pygodactylata* and explored advantages and disadvantages of this method compared to classical histology. The study of the ostracod genus *Cytheropteron* resulted in the identification of the GIS Ridge as a barrier for species distribution (Jöst et al.). Species assemblages associated with different depths were also recognized. The distribution pattern of Isopoda around Iceland allowed distinguishing assemblages associated with depth and geographic locality both at family and species levels (Brix et al.). Combining morphological data, molecular data, and species distribution models, Schnurr et al. reveal species complexes in the munnopsid genus *Eurycope* (Isopoda, Asellota) and support the theory of the GIS Ridge as a potential barrier. Jennings et al. detect three genetically distinct groups in the desmosomatid genus *Oecidiobranchus* (Isopoda, Asellota), discussing potential new species of high morphological similarity and hidden in the previously described ones. For Tanaidacea, new genera and new species of Tanaidomorpha are described in three publications (Jakiel et al.; Jóźwiak 2014; Segadilha et al.) as well as presenting distribution data of pseudotannaids in the North Atlantic including descriptions of new species (Jakiel et al.). Two publications are dealing with selected amphipod families and also include the descriptions of new species. An integrative taxonomy approach for Oedicerotidae from the Arctic hydrothermal vent Loki's castle is provided (Tandberg et al.). The first finding of the Sicafodiidae, a family previously known from the southern hemisphere only, is reported for waters south of Iceland (Jimenez and Coleman).

The IceAGE project is an ongoing project. Looking ahead what is going to happen in the next few years, we can report about two upcoming expeditions. The first expedition is planned for summer 2018 with RV Maria *Sybilla Merian* (MSM75 "Reykjanes Ridge hydrothermal vent activity"), and the second will most likely start in summer 2019 as "IceAGE3," following the same sampling design as previous expeditions including revisited stations. The IceAGE project is somewhat unique in that we have been able to undertake a series of biodiversity surveys in the same general regions. Such efforts are critical for establishing the baseline data and providing long-term observations that help society understand its impact on deep-sea ecosystems.

The guest editors
Karin Meißner, Saskia Brix, Kenneth M. Halanych, Anna Jażdżewska

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