Haustráðstefna
Autumn Conference
Jarðfræðafélags Íslands 2024

Icelandic Shores and Beyond:
Current Research and Perspectives

Abstract volume

In Askja

Náttúrufræðahúsi Háskóla Íslands

4. october 2024

Jarðfræðafélag Íslands

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Editors:

Þorsteinn Sæmundsson, Angel Ruiz-Angulo & Anett Blischke

Sponsors and collaborators

Program Autumn conference JFÍ, 4. Oktober 2024

08:30 – 09:00	Registration
Convener:	**Þorsteinn Sæmundsson**
09:00 – 09:05	Opening
	Þorsteinn Sæmundsson
09:05 – 09:15	Welcome note
	Jón Atli Benediktsson, Rector of the University of Iceland
09:15 – 09:30	Geological Mapping Offshore Iceland: Past, Present and Future
	Anett Blischke
09:30 – 09:45	Hydrography and ocean currents around Iceland – observation programs of Hafrannsóknastofnun
	Andreas Macrander
09:45 – 10:00	Charting coastal waters around Iceland
	Árni Vésteinsson
10:00 – 10:15	Overview University of Iceland
	Angel Ruiz-Angulo
10:15 – 11:00	**Coffee break**
Convener:	**Angel Ruiz-Angulo**
Invited talk	
11:00 – 11:30	MAREANO - the Norwegian seabed mapping programme
	Lilja Rún Bjarnadóttir
11:30 – 11:45	Seabed Extraction in Iceland
	Tinna Jónsdóttir
11:45 – 12:00	The origin and impact of ocean variability on climate in Iceland
	Steingrímur Jónsson
12:00 – 12:15	Seafloor mapping: Iceland's EEZ and Collaborative Seafloor Exploration
	Davíð Þór Óðinsson (Julian Burgos)
12:15 – 13:00	**Lunch**
Convener:	**Steingrímur Jónsson**
Invited talk	
13:00 – 13:30	Marine Tectonics from SWOT Altimetry: Global Abyssal Hills
	David Sandwell

13:30 – 13:45 The Tjörnes Transform, N-Iceland: Assessing post-glacial tectonic activity on offshore fault systems with high-resolution seismic data

Bryndís Brandsdóttir

13:45 – 14:00 Deep structural mapping, fault geometries, and stratigraphic framework of the Skjálfandi Bay area

Anett Blischke

14:00 – 14:15 IODP Leg 197: the volcanic successions at Detroit, Nintoku and Koko shield volcanos on the Hawaiian-Emperor Seamount chain

Þorvaldur Þórðarsson

14:15 – 14:30 Bathymetry - experiences from Vegagerðin

Gunnar Orri Gröndal

14:30 – 14:45 "Marine Habitat Mapping in Iceland: progress and challenges"

Julian Burgos

14:45 – 15:15 Coffee break

Convener: Anett Blischke

15:15 – 15:30 Glacial fingerprints on the Iceland shelf

Ívar Örn Benediktsson

15:30 – 15:45 Revisiting fjörumórinn in Faxaflói: refining Iceland´s Early Holocene low-stand

Wesley R. Farnsworth

15:45 – 16:00 Skrítið vatn (weird water): Observations of Complex Seawater Density Inversions in an Icelandic Fjord

Audria Dennen

16:00 – 16:15 Exploring Offshore Geothermal Fields around Iceland

Árni Hjartarson (Bjarni Richter)

16:15 – 16:30 Sea level rise around Iceland and risk of future flooding

Halldór Björnsson

16:30 – 16:45 Surges along the south coast of Iceland due to Katla eruptions

Jón Elvar Wallevik (Halldór Björnsson)

16:45 – 17:00 Bathymetry and Bottom Boundary Current Interactions South of Iceland: Key to Sustaining Benthic Ecosystems

Angel Ruiz-Angulo

17:00 Concluding notes: *Mr. Guðlaugur Þór Þórðarsson,*

Minister of the Environment, Energy and Climate

Refreshments

Posters

Fracture zones and rift systems of eastern Iceland: Tectonic and geodynamic links to extinct rifts on the Iceland-Faroe Ridge and Iceland Plateau

Anett Blischke, Bryndís Brandsdóttir, Jeffrey A. Karson & Ögmundur Erlendsson

Distribution and Diversity of Benthic Invertebrate Species in Icelandic Waters: a comprehensive database referenced with a zoological collection.

Guðmundur Guðmundsson

Ostracoda from Hvalfjörður: diversity, distribution and biomonitoring experiment

Sarah Schmickal, Hafrún Birta Hafliðadóttir, Íris Mýrdal Kristindóttir, Hildur Magnúsdóttir & Steffen Mischke

Geothermal utilization in the coastal area of Hjalteyri, central North Iceland

Sigurveig Árnadóttir, Bjarni Gautason, Erlendur Bogason, Finnbogi Óskarsson, Hjalti Steinn Gunnarsson, Sif Guðjónsdóttir & Sverrir Óskar Elefsen

Marine Heat Waves (MHW) around Iceland

Rakel M. E. Óttarsdóttir, A. Ruiz-Angulo & Simon Van Gennip

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Ögmundur Erlendsson Anett Blischke, Davíð Þ. Óðinsson & Sigvaldi Thordarson

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Exploring Offshore Geothermal Fields around Iceland

Árni Hjartarson[1], Ögmundur Erlendsson[1], Gylfi Páll Hersir[1], Bjarni Richter[1], Geir Hagalínsson[2] & Davíð Þór Óðinsson[3]

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The Icelandic waters hold numerous geothermal fields, both low and high temperatures. Still, none of them are harnessed (Fig. 1). Majority of the known low-temperature sites (< 100°C at 1 km depth) are hot springs found in the tidal zone all around Iceland. In recent years, geothermal sites have been discovered farther out at sea. The best-known are the Ystavík and Arnarnes vents in Eyjafjörður, N-Iceland, where rows of geothermal chimneys are connected to active fissures and faults. All these low-temperature vents are issuing more or less fresh water. Several offshore high-temperature areas have also been discovered and are related to the rift zones and volcanic activity of the Reykjanes Ridge, Kolbeinsey Ridge and the Tjörnes Fracture Zone, such as: (1) The Kolbeinsey geothermal field, at around 100 m depth, 100 km off the north shore, near the islet of Kolbeinsey; (2) The Grímsey geothermal vent field, at 400 m depth east of Grímsey island; (3) The Eldey geothermal field, at 80-120 m depth, 12 km SW of Reykjanes; and (4) The Steinahóll geothermal field, at 160-300 m depth near the insular shelf break, some 120 km SW of Reykjanes. The high-temperature fields are all issuing hot brine. Because of the water pressure, the seafloor's boiling temperature is high. In the case of the Grímsey vent field, it is 250°C, similar to the core temperature of many onshore high-temperature systems. Some areas are inferred geothermal fields because of indirect indications of geothermal activity, such as gas bubbles on the sea floor, geothermal altered material in the core section, and geothermal precipitates recovered from trawls and melted nylon trawls. Further mapping and exploration of the oceanic floor around Iceland in the coming years will undoubtedly lead to the discovery of unknown geothermal fields. Using offshore geothermal energy might be possible in the future, and the first steps have already been taken in that direction.

Charting coastal waters around Iceland

Árni Þór Vésteinsson & Sigríður Ragna Sverrisdóttir

Icelandic Coast Guard, Hydrographic and Maritime Safety Department

The presentation focuses on two topics. The first part is a brief overview of hydrographic surveying of coastal waters around Iceland past 100 years. The second part is an overview of the Icelandic Coast Guard's (ICG) part in mapping the seabed of the Icelandic Exclusive Economic Zone (IS EEZ) project from 2018 (Kortlagning hafsbotnsins). The ICG focuses on home waters.

The presentation and separate posters give examples of interesting geological features that become visible when multibeam surveying is carried out in shallow waters.

Deep structural mapping, fault geometries, and stratigraphic framework of the Skjálfandi Bay area

Anett Blischke[1,2], Bryndís Brandsdóttir[2], Jeffrey A. Karson[3] & Robert S. Detrick[4]

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We present ongoing work concerning the offshore segment of the 75-80 km long, WNW-trending, right-lateral Húsavík-Flatey Fault System (HFF) within the Tjörnes Fracture Zone (TFZ), one of the most active seismic zones in Iceland. The TFZ is a complex transform zone comprising normal, strike-slip, and oblique-slip faults, linking the Northern Volcanic Zone (NVZ) on land and the offshore Grímsey Oblique Rift (GOR) with the Eyjafjarðaráll graben and Kolbeinsey Ridge (KR) to the west. Seismic activity has illuminated faults that have moved in recent decades, outlining the youngest / present-day active segments of the HFF but not older structures and fault segments. A multi-channel seismic reflection survey in the TFZ in 2001 provided a unique insight into the stratigraphic and structural features within the Skjálfandi Bay area. The high-resolution 2D-MCS portable multichannel seismic acquisition system imaged sediment structures to 500-700 m depth with a 2-5 m vertical resolution. The LDEO-owned system used a 600-m long streamer with 193 hydrophones in 48 groups at a 12.5 m group interval. The onboard processed data, available as high-resolution images, was fitted into the 3D seismic interpretation system PETREL and referenced to available multibeam data for subsurface interpretations, correlated to the onshore geological strata and fault systems, and 3D data modelling. The Húsavík-Flatey fault is divided into several active and inactive segments that can be traced across Skjálfandi Bay, offshore the Flateyjardalur Peninsula and into the southern part of the Eyjafjarðaráll Graben, with vertical offset increasing westward. The offshore HFF segments can be traced to onshore stratigraphy and fault zone outcrops. The Tjörnes beds can be correlated into the eastern Skjálfandi Bay in separate NW dipping fault blocks along near-vertical strike-slip fault systems with both compressional features, such as restraining bend structures or compressional positive flower structures or pop-up structures, and extensional fault systems with normal faulting or small-scale step-over basin formation that connect with the N-S striking obliquely opening half-graben basin. The basin seabed is dotted with pockmarks which align along the N-S faults and connecting faults between strike-slip segments. The deep stratigraphic section indicates several unconformities that show a good correlation to the pre-glacial strata of the Flateyjardalur, Húsavík, and Tjörnes areas. The 3D tectonic map illuminates the complex sub-surface structures of half-graben formation linked to transform crustal movements along the HFF, between the Eyjafjarðaráll Graben and Northern Volcanic Zone.

Fracture zones and rift systems of eastern Iceland: Tectonic and geodynamic links to extinct rifts on the Iceland-Faroe Ridge and Iceland Plateau

Anett Blischke[1,2], Bryndís Brandsdóttir[2], Jeffrey A. Karson[3] & Ögmundur Erlendsson[4]

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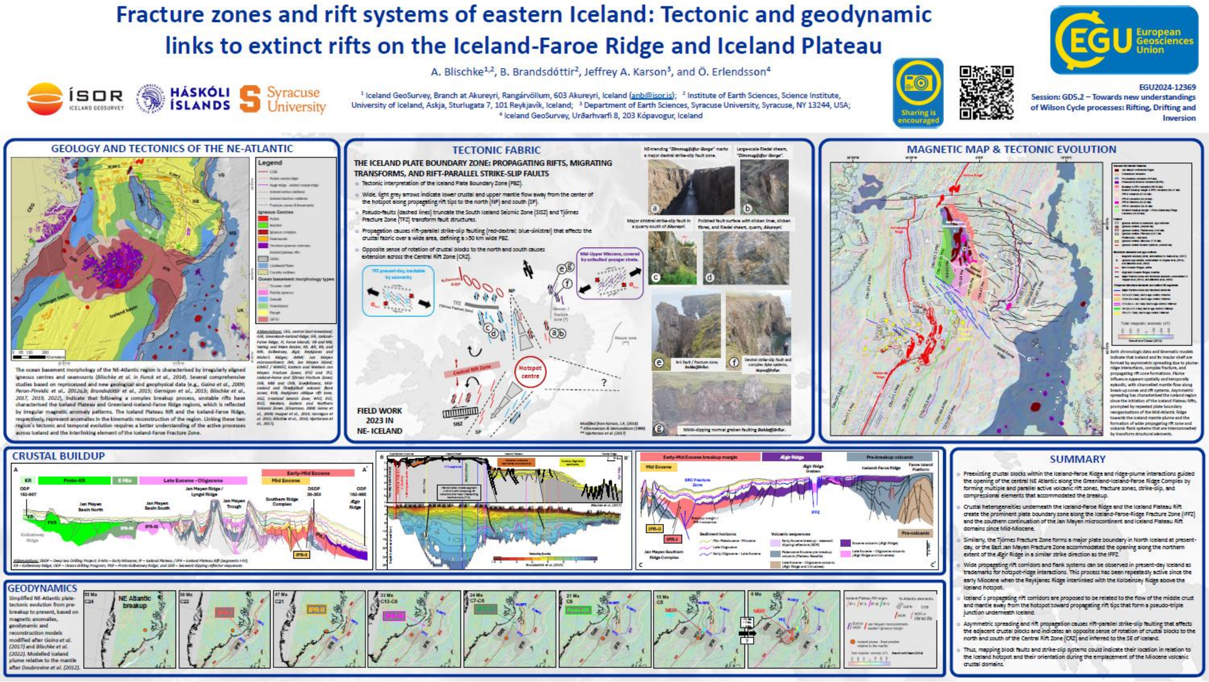
[3]Department of Earth Sciences, Syracuse University, USA

[4]Iceland GeoSurvey, Kópavogur, Iceland

We presented our ongoing work at the European Geosciences Union (*EGU2024-12369*) concerning the offshore domain northeast and east of Iceland in connection with onshore structural mapping, as to continue the work from North-Atlantic Geoscience Tectonostratigraphic Atlas (NAGTEC) project and the mapping of the Jan Mayen microcontinent and Iceland Plateau region a comprehensive study of re-processed and new geological and geophysical data is needed to establish a detailed kinematic model of the NE-Atlantic region, linking the tectonic evolution of Iceland to the offshore Iceland Plateau Rifts, the Iceland-Faroe Ridge, and the Iceland-Faroe Fracture Zone regions. Acquisition of new tectonic and structural data from extinct rift zones on land is required to further our understanding of offshore rift systems. Kinematic models indicate that Northeast Iceland and its insular shelf formed by asymmetric spreading similar to the Iceland Plateau Rift under the influence of the Iceland mantle plume. These processes created multiple volcanic rift zones, fracture zones, and strike-slip elements that accommodated the breakup and formation of crustal domains north of Iceland, such as the Iceland-Faroe Fracture Zone (IFFZ), and along the Iceland-Faroe Ridge. Recent structural mapping within the Tröllaskagi-Flateyjarskagi region and the Tjörnes Fracture Zone have revealed stress-field variations within an overall right-lateral obliquely opening rift zone that includes N-S to NNE-SSW striking left lateral strike-slip fault systems, also referred to as block fault systems that serves as an analogue case. This corresponds to changes and rotations in dyke strike directions adjacent to the Dalvík lineament of the Húsavík-Flatey Fault system since Mid-Miocene. To map out structural evidence and geometries for old and abandoned propagating rift systems onshore NE Iceland, we conducted preliminary fieldwork in the Vopnafjörður region, which we aim to continue within the next three years. Our goal is to delineate abandoned rift segments within NE Iceland and model the evolution of individual rift systems with time, to determine if younger rifts cut through or have discordant trends with respect to older rift structures. We plan to assess, how onshore Miocene rift systems (~15-6 Ma) align to older Miocene systems offshore and whether the IFFZ is a pseudo-fault that developed gradually during rift propagation or a prominent feature along the NE insular margin of Iceland, within a segmented Tertiary transform zone system. Our multidisciplinary approach will thus further our understanding of the dynamics of rift zone development and transfer in proximity to the Iceland mantle plume.



Poster: https://zenodo.org/records/10970387

Geological Mapping Offshore Iceland: Past, Present and Future

Anett Blischke[1,2], Ögmundur Erlendsson[3], Steinunn Hauksdóttir[3], Freysteinn Sigmundsson[2], Sigvaldi Thordarson[3] & Bryndís Brandsdóttir[2]

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Geological mapping offshore Iceland has the potential to significantly advance our understanding of Iceland´s geology and the North Atlantic region as a whole. This research is not only crucial for the seabed habitat mapping or climate studies but also for the sub-sea formation and structures, such as the region´s crustal, tectonic setting and geodynamic evolution, volcanic systems and their formation, geothermal activities, coastal or deep-sea sedimentary processes, submarine erosional processes, resource mapping, and many more. Since Iceland straddles the Northeast-Atlantic Ridge, where the Eurasian and North American plates diverge, our offshore geological mapping significantly contributes to large-scale regional mapping projects, e.g., NAGTEC, EMODnet Geology, IODP, etc. It involves several methods, including seismic surveys (refraction and reflection), bathymetry (multibeam and backscatter), sediment sampling, geophysical surveying (gravity, magnetic or resistivity surveys), or remote sensing methods for geodynamic modelling. Understanding seafloor geology at various scales is essential for responsibly utilising natural resources, such as building materials, rare earth metals, geothermal energy, or carbon capture storage (CCS). Furthermore, geological risk assessments are required to plan infrastructure for coastal communities, assessing seafloor stability and erosion due to sea level and geodynamic changes. Achieving this requires close collaboration among earth scientists, institutes, agencies, and government bodies. Knowing where all the data is located and available is crucial for such collaboration projects and has been building up during the last decades in Iceland for a highly specialized knowledge base concerning acquiring and interpretation of marine research data. Governmental projects have been conducted since the 1970´s for projects and consultancy to the authorities of Iceland regarding resource evaluation and decision-making toward geothermal site exploration, nearshore subsea slides hazards, infrastructure placement queries, database overviews as a whole for seafloor and subseafloor data across Iceland´s insular shelf outside 200 nautical miles, or Iceland´s exist of hydrocarbon exploration. Monitoring of geoscientific research campaigns and participation in research projects such as offshore geological mapping can only be achieved by good collaborations that share acquisition and research costs. Since 2000, Iceland has participated in the Law of the Sea framework for Iceland´s economic area and within international waters, defining the outer limits of the continental shelf in accordance with article 76 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS). This work demands rigorous scientific data analysis, with various offshore datasets, including multibeam, geophysical, geological, and geochemical data, being collected and analysed by government agencies, research institutes, or academic scientists. These efforts have revealed that large areas around Iceland remain unexplored, requiring decades of further study. Well-coordinated collaborative projects are crucial in advancing the geoscientific understanding of Iceland's seafloor and crustal structure.

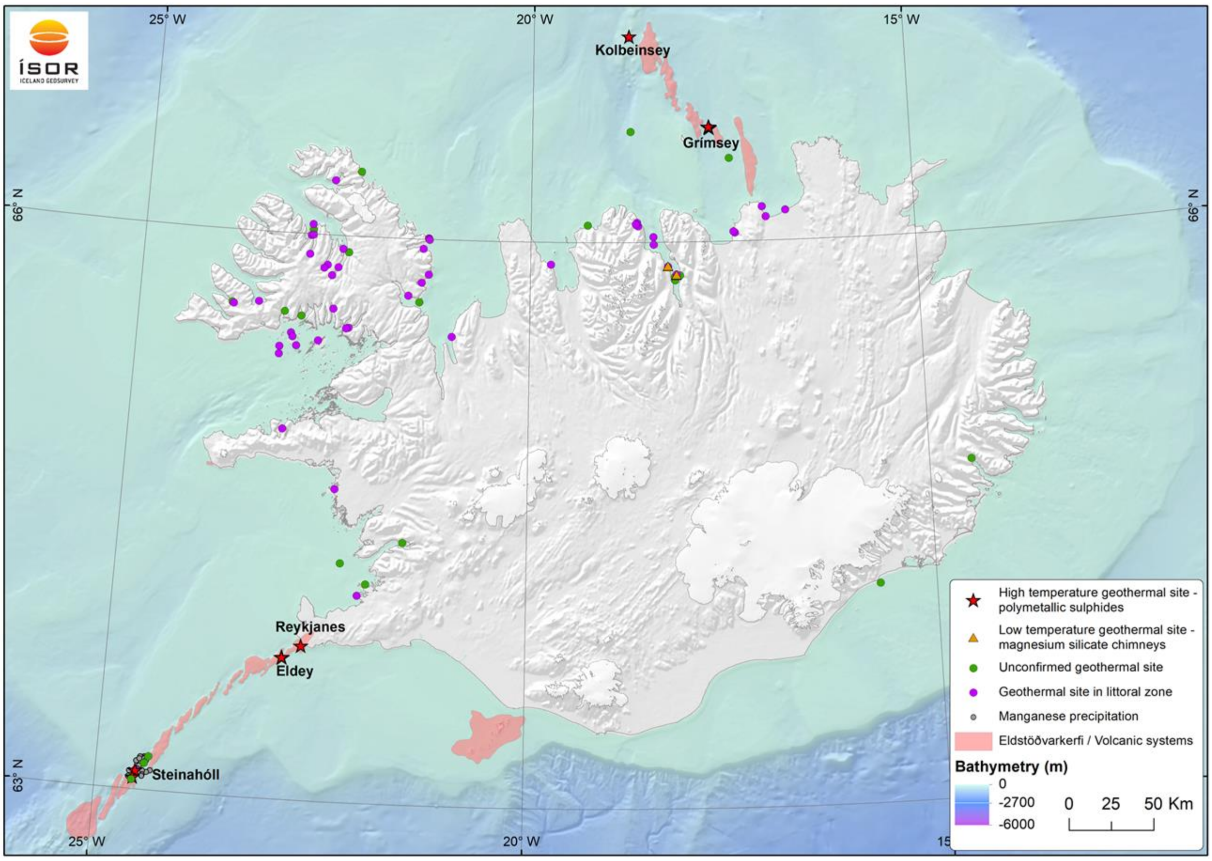

Figure 1. *Geothermal sites within Icelandic water. Based on Benjamínsson (1988) and Hjartarson et al. (2018, 2020).*

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The Tjörnes Transform, N-Iceland: Assessing post-glacial tectonic activity on offshore fault systems with high-resolution seismic data

Bryndís Brandsdóttir[1], Anett Blischke[1,2], Gunnar Guðmundsson[3], Kristín Jónsdóttir[3], Jeffrey A. Karson[4], Robert S. Detrick[5] & Neal W. Driscoll[6]

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The Tjörnes Fracture Zone (TFZ), northern Iceland is a complex transform made up of normal, strike-slip, and oblique-slip faults, linking the Northern Volcanic Zone (NVZ) on land with the Kolbeinsey Ridge (KR) to the west. Overall, the TFZ is roughly 150 km long (E-W) by 50-75 km wide (N-S), incorporating three major N-S trending extensional basins, Eyjafjarðaráll (EB), Skjálfandadjúp-Skjálfandi and Öxarfjörður. The EB is the magma-starved southward extension of the KR wheres the Grímsey oblique rift is the northwards extension of the NVZ. Rifting is most pronounced within these N-S striking, 200-700m deep, 65 km long, and 25-30 km wide rift basins, characterized by complex half-graben tectonics. The western margin of the EB consists of a complex system of near-vertical faulting with hanging wall tilting east towards the center of the basin whereas the eastern margin has near-vertical faults with up to 30 m vertical displacement and minor tilt. The WNW-trending, right-lateral Húsavík-Flatey Fault System (HFFS) can be traced offshore for 75-80 km, in multibeam, CHIRP and multichannel reflection seismic data, from the southern EB, eastward across the Skjálfandi Bay, into the NVZ. The inferred offshore pattern of WNW-ESE strike-slip faults and NE-SW basin-bounding faults matches onshore tectonics from adjacent areas of the Tjörnes and Flateyjarskagi Peninsulas. Paleoearthquake records derived from high-resolution CHIRP seismic reflection profiles indicate vertical displacement of up to 15 m along the eastern HFFS, near the town of Húsavík, during five regional earthquake sequences, in the last ~10,000 years. A vertical displacement of up to 45 m is observed along the western HFFS in EB. The most recent destructive earthquakes along the HFFS occurred in 1755, 1867, 1872 and 1884. Present TFZ seismicity consists of frequent earthquake swarms, lasting days or weeks with a maximum earthquake magnitude exceeding five. Four normal M>5 events in 2012 and 2013 within the southern EB triggered activity along the western HFFS, whereas an M5.7 strike-slip event within the western HFFS in June 2020, triggered rifting within the southern EB, culminating in a M6 event. This activity was followed by three M>4 events in Sept. 2020 within the western Skjálfandi Bay. The current seismic activity reflects the complicated interplay between rifting and strike-slip faulting along the divergent plate boundary.

Marine Habitat Mapping in Iceland: progress and challenges

Julian Burgos[1]

[1]Hafrannsóknastofnun (Marine and Freshwater Research Institute)

Habitat maps are essential tools for the conservation and management of marine resources. In Iceland, full coverage benthic habitats maps are based on the use of predictive models that combine in-situ observations, usually from underwater cameras, with an array of environmental predictors. There is currently need to expand mapping efforts, partially to respond to commitments under the Kunming-Montreal Global Biodiversity Framework. To achieve this, a number of challenges need to be addressed. These include: 1) the scaling-up of situ observations, for example through the use of low-cost cameras, eDNA, and AI tools, 2) the improvement of predictive layers, including marine sediments, 3) the development of a habitat classification system, and 4) the prioritization and coordination of mapping activities.

Seafloor mapping: Iceland’s EEZ and Collaborative Seafloor Exploration

Davíð Þór Óðinsson[1]

[1]Hafrannsóknastofnun (Marine and Freshwater Research Institute)

The Seabed Mapping Project was initiated by the Marine Research Institute in 2000, focusing initially on mapping fishing grounds and vulnerable marine environments. In 2017, the newly formed Marine and Freshwater Research Institute received funding to expand the project’s scope to map the entire seafloor within Iceland's Exclusive Economic Zone (EEZ) (Figure 1). This expansion included upgrading the Kongsberg EM 300 multibeam echosounder (MBES) to the Kongsberg EM 302, offering enhanced resolution and increased coverage with 432 beams. The project also expanded its mapping capabilities with the addition of the Kongsberg TOPAS PS18 sub-bottom profiler, allowing for detailed imaging of subsurface layers and providing valuable insights into geological formations. These technologies enable the production of high-resolution maps of the seafloor’s structure and composition.

Table 1. Breakdown of the seabed mapping effort since 2000

Full coverage measurements (MFRI)			
Year	Total	1000km²/yr	Ratio
2000 - 2016	94	-	12.5%
2000 - 2017	117	23	15.5%
2000 - 2018	172	55	22.8%
2000 - 2019	218	46	28.9%
2000 - 2020	266	48	35.3%
2000 - 2021	305	39	40.5%
2000 - 2022	334	28	44.3%
2000 - 2023	347	13	46.0%
2000 - 2024	369	22	48.9%

Full coverage measurements* (MFRI, LHG, SHOM)			
Year	Total	1000km²/yr	Ratio
2000 - 2024	400	-	53.0%

* Based on available data

The data collected by the Seabed Mapping Project is crucial for sustainable marine resource management. It supports a wide range of applications, including but not limited to marine infrastructure development, geological mapping, conservation efforts, fisheries management, offshore mining opportunities, disaster preparedness, and navigation safety. The data is provided in the form of georeferenced images and compressed text files, making it available for multifaceted purposes. Between 2000 and 2024, the collective multibeam efforts of the Seabed Mapping Project and other institutes have successfully mapped roughly 400,000 km² of the seafloor, covering nearly 53% of Iceland’s EEZ (Table 1).

The ENIGMAS Project (Enhancing Nordic Geological Mapping of the Seabed) aims to improve the compatibility of seabed classification systems across Iceland, Norway, Denmark, and the Faroe Islands. The project focuses on harmonizing methods for classifying seabed features and substrates, while also exploring semi-automatic methods for seafloor mapping. By harmonizing classification systems, ENIGMAS supports more effective management of shared marine resources, benefiting areas such as fisheries, offshore development, and marine conservation.

These two projects demonstrate their effectiveness through complementary contributions to seabed mapping and classification. The Seabed Mapping Project provides detailed multibeam bathymetric data, backscatter, and sub-bottom profiles, essential for understanding the seafloor's structure. This high-resolution data, along with similar data provided by other ENIGMAS partners, forms the foundation for harmonizing seabed classification systems across borders. By combining the detailed mapping capabilities of the Seabed Mapping Project with the harmonization efforts of ENIGMAS, both projects contribute to improved cross-border collaboration, better marine resource management, and more informed decision-making in fields like fisheries, offshore development, and conservation.

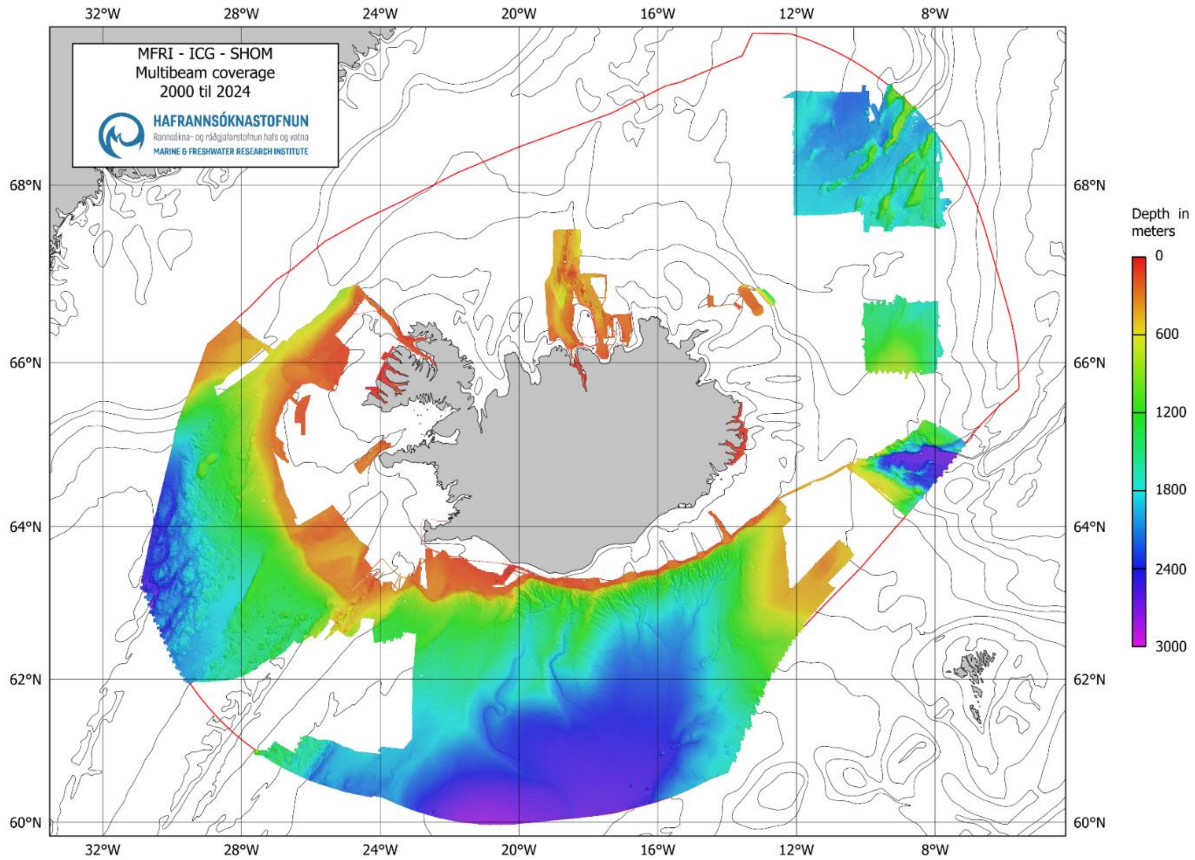

Figure 1. Multibeam coverage since 2000. Based on data available from continuous multibeam surveys conducted by MFRI, ICG and SHOM.

Skrítið vatn (weird water): Observations of Complex Seawater Density Inversions in an Icelandic Fjord

A. Dennen[1], A. Ruiz-Angulo[1] & A. Macrander[2]

[1]Institute of Earth Sciences, University of Iceland

[2]Marine and Freshwater Research Institute

We present the observations and analysis of newly discovered seawater density inversions located in Ísafjarðardjúp; a major fjord located in the Westfjords region of Iceland. This discovery was initially made in 2022 during a *conductivity-temperature-depth* (CTD) survey of hydrothermal vent fields. The site was revisited in July 2023 to 1) Verify that the original discovery was real, 2) Conduct a density inversion-focused CTD survey, and 3) Deploy a mooring equipped with four high resolution MicroCAT instruments to capture a continuous time series of water column hydrography. Our CTD survey results showed that the density inversion could be observed from 13-17 meters deep during an ebb tide, with the strongest inversion signal appearing in the right-hand fjord channel along the Hveravík-Borgarey shelf-slope interface. Time series analysis revealed that density inversion events episodically occur, for several days at a time, and are primarily tied to changes in salinity. Those inversions are responsible for generating unstable vertical density profiles, which can be characterized by Brunt–Väisälä frequency (N^2 [s^{-2}]), Spice, and the Turner Angle. Our results showed that inversion-specific water parcels were highly resistant to vertical oscillation and displayed diffuse convective mixing, salt fingering, and statically unstable overturning. Variable magnitudes of overturn within the water column could be observed during inversion events which appeared to be influenced by seasonally driven stratification. Furthermore, as these unique hydrodynamic structures influence fjord circulation, they also likely influence the distribution and concentration of biologically important nutrients and phytoplankton.

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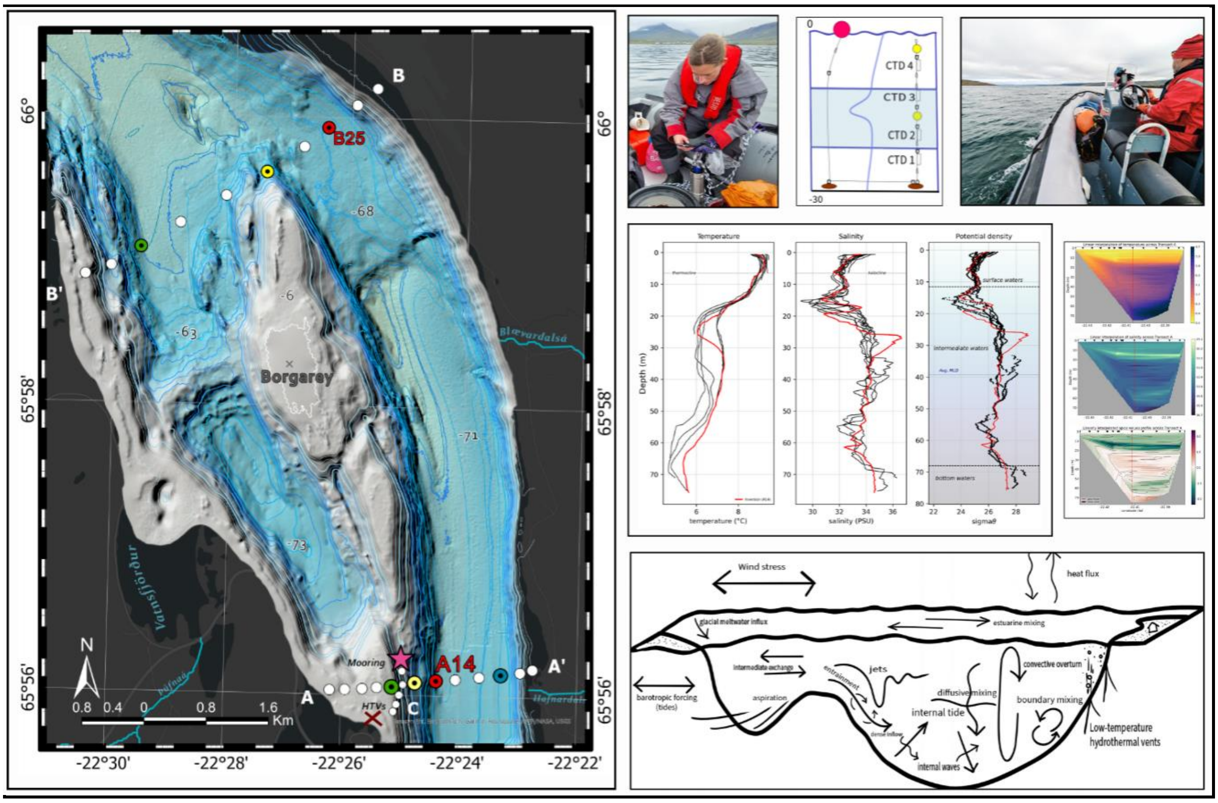

Left: Bathymetric map of the study area showing each CTD station sampled (*white*), focus stations (*green*, *yellow*, *red*, *blue)*, the mooring location (*star*) and location of shallow water hydrothermal vents near Hveravík (X). **Right, top:** Image of Audria using the CTD; Mooring schema showing which MicroCATs aimed to capture the density inversion (*blue line*); Image of mooring deployment. **Right, middle:** CTD transect depth profiles of temperature (°C), salinity (PSU), and density (sigma**θ**) where red represents the primary inversion profile; and linear interpolations of temperature, salinity, and Spice (τ). **Right, bottom:** Illustrated representation of fjord hydrodynamics at play in Ísafjarðardjúp.

Revisiting *fjörumórinn* in Faxaflói: refining Iceland´s Early Holocene low-stand

Wesley R. Farnsworth[1,2], Ka Yan (Hilary) Kwok[1] & Ívar Örn Benediktsson[1]

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[2]Globe Institute, University of Copenhagen, Øster Voldgade 5-7 Copenhagen, Denmark.

The thin, dynamic crust of Iceland is particularly sensitive to the loading and unloading of the land by glaciers and ice sheets. Determining the pattern and rate of postglacial sea level change in Iceland is critical for constraining models of deglaciation, ice sheet behaviour, and palaeoclimate. Despite decades of work, relative sea level (RSL) histories remain poorly resolved due to patchy coverage, poorly constrained sea level index points, chronological uncertainties and minimal data from the shallow marine enviroment. While many of these records can be improved with enhanced geochronological precision today, the largest unknown relates to the sea level low-stands during the deglaciation. This project will compile and quality assess existing data as well as further investigate submerged peat to improve our understanding of relative sea level low-stands. The database will be supplemented with new geochronological (tephra and radiocarbon) data from submerged coastal peatlands located in west Iceland, specifically the classic site of Seltjörn, Grótta (-4.2 m beneath hightide; Þorarinsson 1956). These findings contribute to our understanding of the deglaciation of the Icelandic Ice Sheet and the Early Holocene sea level low-stand.

Þórarinsson, S. 1956: *Mórinn i Seltjörn* [English summary: The submerged peat in Seltjörn]. Náttúrufrædingurinn 26, 179-193.

Bathymetry - experiences from Vegagerðin

Gunnar Orri Gröndal[1]

[1]Vegagerðin – Icelandic Road and Coastal Administration

Vegagerðin has quite a long record of conducting bathymetric surveys in relation with mainly harbour construction projects in Iceland. In the process we have built up experiences, which will be discussed in the presentation.

Bathymetry refers to the measurement of the height (depth) and shape of the seabed. The aim of these measurements is mapmaking and construction monitoring.

Vegagerðin uses multibeam echo-sounding equipment in most of her surveys. In some cases single beam equipment is used to survey flat and sandy areas with slowly varying depth and bed composition.

A modern sonar system consists of

- Carrier phase GNSS positioning system, which is usually with built-in RTK function
- Motion sensors (Inertial Measurement Unit), which measures rotation on three axes, and accelerometer, which records heave (change in (vertical) position)
- Multibeam echo sounder. Single beam echo sounder in a few cases.
- Sonar Interface Unit (SIU), which processes raw data from sensors
- PC or laptop to operate the sonar system, process data into meaningful information, monitor progress and store results
- Computer screen to display progress for surveyor and skipper / captain of survey vessel

It is necessary to have a suitable vessel in order to be able to conduct good surveys. Vegagerðin has made good results in conducting bathymetry surveys in quite challenging conditions. Our methods make use of the possibility to mount our equipment onto different vessels depending on the conditions. Notably Vegagerðin can carry out bathymetric surveys in Landeyjahöfn using three vessels (Geisli, Lóðsinn, Herjólfur) in widely varying conditions.

Planning of a survey starts by looking at the survey area, what are the general conditions and does an existing survey exist. What are the requirements for the result. What are the weather conditions and how is the tide. What is the condition of the benchmarks.

From the information about conditions survey lines are drawn and swath widths and overlap is considered. Our equipment has the ability to use until 160 deg wide swaths (80 deg. to each side of the survey vessel), but the quality of the outermost transects is usually poor, except in conditions with high rising or even vertical constructs. 120-130 deg. swaths are recommended.

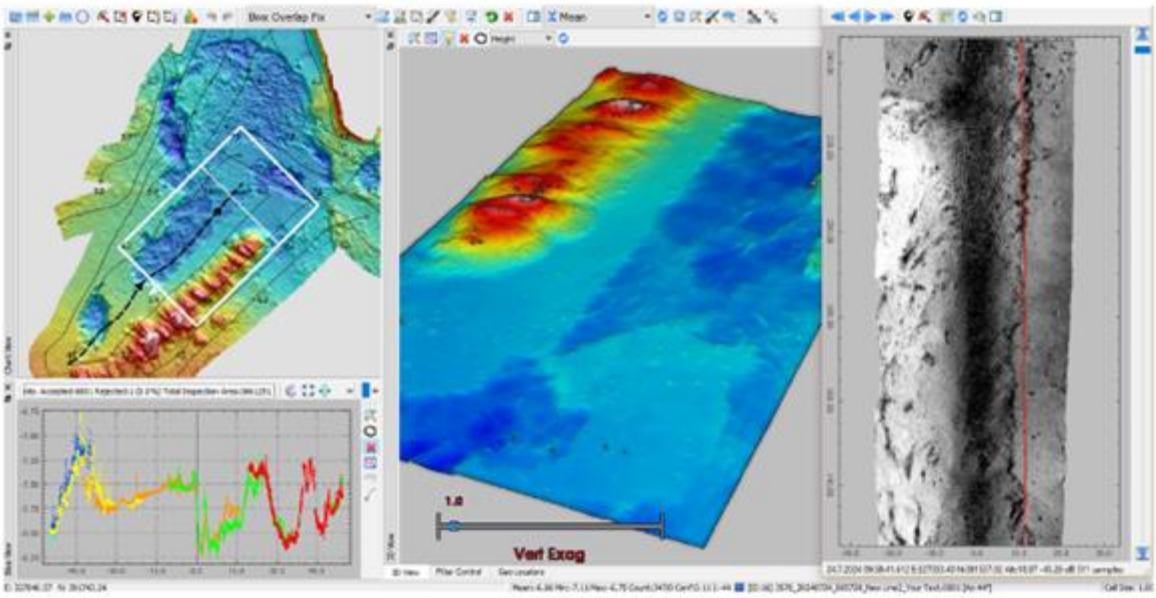

Figure 1 shows the result of a typical bathymetric survey on a construction site (Njarðvík). The illustration to the upper left gives an overview which shows survey tracks lines and the bed elevation. An escavator has dug up material, which has been dumped and piled into a new breakwater. The lower illustration to the right shows a section into the point cloud with points from individual tracks coloured differently. The middle illustration shows a part of the 3d terrain model. The illustration to the right is a side scan sonar image from the thick trackline to the left, where scratch marks from the escavator bucket can be clearly identified.

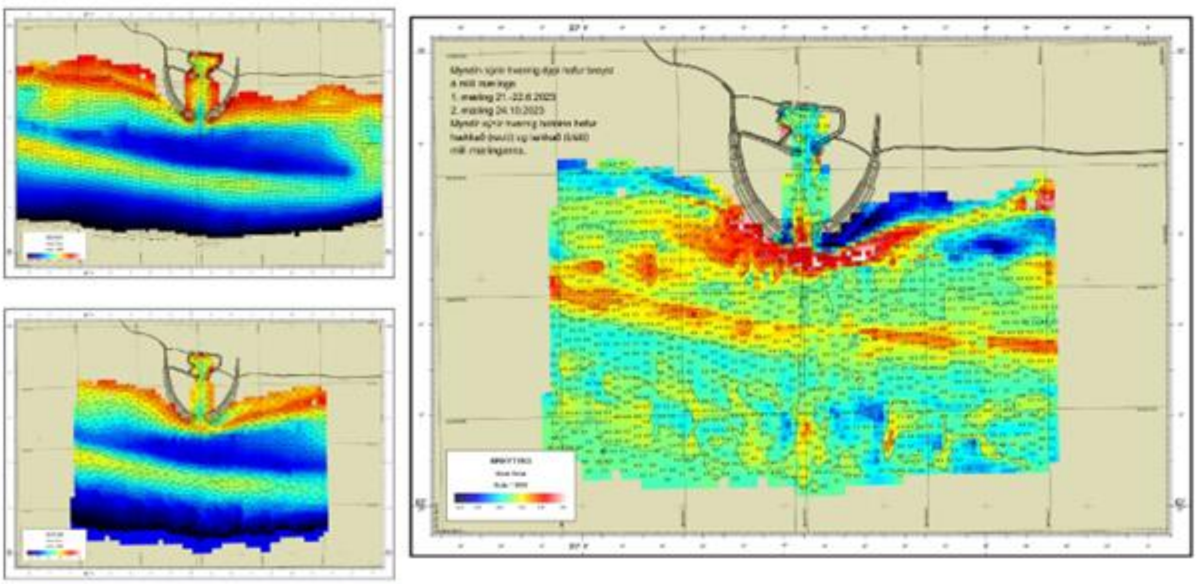

Figure 2 shows how the bed in front of the harbour mouth at Landeyjahöfn changed in Autumn 2023. The upper left illustration is the 20x20m gridded map produced in June 2023. The lower left illustration is the map produced in October 2023. The right illustration is the difference grid between these two maps. It shows quite clearly how sand from the beach to the East has been mobilised and spread infront of and to the West of Landeyjahöfn. The red area is about 1km long and 100m wide and contains 100-200 thous. m^3.

Distribution and Diversity of Benthic Invertebrate Species in Icelandic Waters: a comprehensive database referenced with a zoological collection.

Guðmundur Guðmundsson[1]

[1]Icelandic Institute of Nature Research

Distribution of benthic species in Icelandic waters is largely controlled by the cold northern seas of the Arctic and the temperate waters of the North Atlantic. This division is part of the larger biogeographic boundary between the northern Arctic and the southern Boreal regions. Detailed knowledge of distributions of Recent shell bearing species has significance for the interpretation of past environmental conditions, e.g. in fossil bearing Pliocene-Pleistocene strata. The Icelandic Benthos Database (IBD) holds information on over 7 million museum specimens and 151,000 occurrence records of 3,506 benthic invertebrate marine species found within the 200-mile Exclusive Economic Zone of Iceland (EEZ). The area spans a depth range of 20–3000 m, with annual mean bottom water temperature ranging from -1°C to over +9°C. The IBD is compiled and maintained by the Marine and Freshwater Research Institute and The Icelandic Institute of Nature Research. The BIOICE dataset is largest, based 1,390 zoological samples collected at 579 sampling stations that were and distributed according to a randomly stratified sampling plan within the EEZ. The BIOICE dataset serves as a reference control of distribution records of studies from smaller sub-areas within the EEZ and numerous literature records, also recorded in IBD. All species names and current taxonomical classification reflects the standardized nomenclature of WoRMS (The World Register of Marine Species). The objective is to gain a comprehensive overview of taxonomic diversity and distribution of all benthic invertebrate species in Icelandic waters. The IBD offers a unique oversight and research opportunities on the rich biodiversity patterns in Icelandic waters.

Sea level rise around Iceland and risk of future flooding

Halldór Björnssson[1], Guðfinna Aðalgeirsdóttir[2], Berglind Pétursdóttir[2], Guðrún Elín Jóhannsdóttir[1] & Angel Ruiz-Angulo[1].

[1]Icelandic Met Office

[2]University of Iceland

As global sea level rises, Iceland is in an interesting position in that the mass loss of the Greenland Icesheet will have a fingerprint that actually leads to sea level drop in Iceland. However other factors such as thermal expansion and mass loss in Antarctica will lead to sea level rise around Iceland. Furthermore, glacial mass loss in Iceland and vertical land motion will also affect the regional pattern of sea level change. These factors have different uncertainties associated with them, which makes projections for sea level rise in Iceland more challenging than in many other places.

This presentation will discuss two separate projects that to estimate the future sea level rise in Iceland. We will also discuss methods to estimate storm surges and the influence that changing sea level will have on those.

Glacial fingerprints on the Iceland shelf

Ívar Örn Benediktsson[1]

[1]Jarðvísindastofnun Háskólans - Institute of Earth Sciences, University of Iceland

The shelf around Iceland bears obvious fingerprints of glacial action from the present coast to the shelf edge (Figure 1). This includes deep troughs, moraine ridges, and streamlined subglacial bedforms (drumlins and flutings). For a long time, glacial striae and other landforms on the points of peninsulas and on the island of Grímsey were the main indicators of ice extent beyond the present coast and onto the shelf. In 1975, a conspicuous end moraine was described far off the Breiðafjörður Bay as the first glacial landform mapped on the Iceland shelf. Since then, various data have shed light on the glacial history and geomorphology of the Iceland shelf, allowing for hypothetical outlining of the extent and dynamics of the former Iceland Ice Sheet (IIS). However, solid understanding of the ice-sheet configuration and retreat dynamics at different times is hampered by fragmented high-resolution seafloor mapping and limited chronological data. Based on the existing geomorphological data, conceptual and numerical models place the ice-sheet margin at the shelf edge during maximum glaciation(s) with ice drainage via several ice streams located in troughs. Sediment cores on the western and northern shelf suggest that the Last Glacial Maximum extent of the Iceland Ice Sheet occurred before c. 21-28 ka BP and that the ice-sheet had retreated to the mid-shelf between 18 and 16 ka BP. No sediment cores exist from the northeastern, eastern, and southern shelf that could constrain the chronology of this part of the ice sheet. It therefore remains unverified if ice-sheet extent and dynamics were synchronous across the Iceland shelf. Future efforts should aim at testing the hypothesized extent and dynamics of the Iceland Ice Sheet with high-resolution mapping and dating of key glacial landforms in order to better constrain the evolution of the Iceland Ice Sheet in time and space and provide important inputs for numerical ice-sheet models.

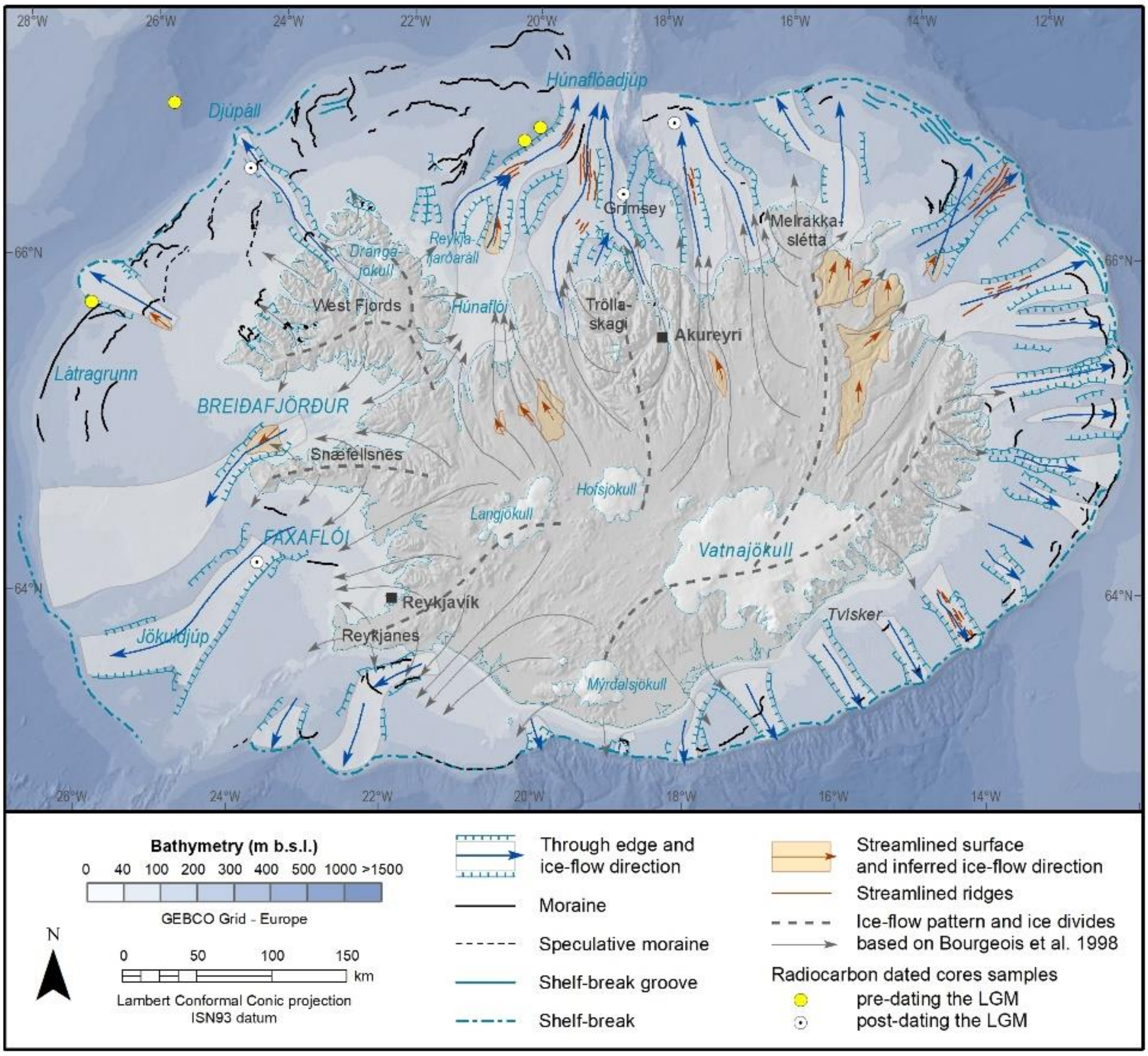

Figure 1. Overview of the geomorphological imprint of the IIS on the shelf. From Benediktsson et al. 2022, European Glacial Landforms (https://doi.org/10.1016/B978-0-12-823498-3.00055-8).

Surges along the south coast of Iceland due to Katla eruptions

Jón Elvar Wallevik[1], Halldór Björnsson[1], Angel Ruiz Angulo[2] & Magnús Tumi Guðmundssson[2]

[1]Icelandic Met Office

[2]University of Iceland

The floods associated with Katla eruptions are known to cause massive floods, especially along the Mýrdalssandur coast. Most studies so far have focused on the jökulhlaups, - the meltwater pulses from the Mýrdalsjökull glacier to the sea, but the possibility of coastal waves and flooding has received less attention. Historic sources mention several cases of flooding along the coast, especially during the Katla eruption in 1721. These were reported along the coast from Mýrdalur as far as Vestmannaeyjar and Grindavík.

There are two ways a glacial surge can initiate a coastal surge. The first one is from the flood water wave from the jökulhlaup impacting the ocean, the second one is from a submarine landslide. Offshore Mýrdalssandur the continental shelf is close to the coastline, and density currents from the jökulhlaup likely to reach the shelf break and may trigger a submarine landslide. While this mechanism is speculative, its effect needs to be studied and compared with the consequences of a more direct impact.

This study will discuss a sequence of model calculation experiments that examines the impact of a large jökulhlaup impacting the ocean, and also the consequences of a large submarine landsslide occuring simultaneously. The results show a impressive surges spreading from the source regions. The surge associated with the landsslide mostly spreads into the deep ocean, but part of it may be trapped on the shelf. This is a work in progress, but the results so far indicate that in Vík the wave height maximum amplitudes exceed 1 m but are close to an order of magnitude lower in Vestmannaeyjar further from the source. While the direct impact has a larger effect, the magnitude of added flooding due to a submarine landsslide is sensitive to the length of the time interval of the landslide.

MAREANO – the Norwegian seabed mapping programme

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In a world facing increasingly shifting climate and a declining ecodiversity, there is an ever growing demand for scientific information on marine environments. Despite being one of our greatest resources, the oceans are surprisingly underexplored.

The Norwegian offshore seabed mapping programme MAREANO started in 2005 with an annual budget of 5 million NOK (nearly 440 000 EUR) in popular fishing grounds off northern Norway. It has since developed into a large programme with a budget of 162 million NOK (around 14.2 million EUR) in 2024. So far, MAREANO, through a collaborative effort across the three executive partner institutions, has conducted multi-disciplinary, multi-purpose ecosystem-based seabed mapping of 300 000 km^2 in Norwegian waters.

Most of the mapping hitherto has focused on continental shelf areas in the Barents Sea, Norwegian Sea and North Sea. In 2019 MAREANO acquired multibeam bathymetry and sediment profiles from several areas far offshore in Subarctic and Arctic parts of the Norwegian Sea ranging in depth from a few tens of m to almost 6000 m. In 2025 MAREANO plans to continue with more detailed mapping in selected areas on and to the side of the Mid-Atlantic ridge in the Norwegian Sea, covering both areas defined as *Especially Valuable and Vulnerable areas* and recommended nominated blocks within the region opened for seabed mineral activities. The mapping will include geological and biological sampling, as well as sampling for pollution studies. Other ongoing activities include mapping in the North Sea, with a special focus on *Especially Valuable and Vulnerable areas*, and on open areas/potential new areas under consideration for the offshore wind industry respectively.

MAREANO has a large product portfolio that includes geological and biological maps, data and modelling results. The products also include results from studies of pollution and human impact. Furthermore, MAREANO continually develops programme methods, including testing new technology that can improve and/or effectivise acquisition, processing and dissemination of results to users, while also adhering to Q-FAIR principles. MAREANO data and results are an important contribution to the scientific knowledge fundament for the Norwegian ocean management plans, and are used by management agencies, industry, NGO's, the scientific community and the public.

Hydrography and ocean currents around Iceland – observation programs of Hafrannsóknastofnun

Andreas Macrander[1]

[1]Hafrannsóknastofnun (Marine and Freshwater Research Institute), Hafnarfjörður, Iceland

Hafrannsóknastofnun (MFRI) is the primary instute in Iceland on marine research. The institute has its headquarters in Hafnarfjörður and branch offices at several places in the country. Two research vessels are operated by the MFRI, serving fisheries and environmental research in North Atlantic waters. While a key responsibility of the MFRI is the assessment of fish stocks and advice to the government on sustainable exploitation of living resources, the institute also carries out seafloor and benthic habitat mapping (see separate talk by Julian Burgos), and an extensive environmental monitoring program (this talk).

The ocean around Iceland is characterized by the interplay of warm, saline Atlantic Water from the south, and cold, fresh waters of polar origin from the north. Variable amounts of Atlantic Water enter the Iceland Sea by the North Iceland Irminger Current. In addition, dense waters formed in the Iceland Sea, flow along the north Iceland shelf edge and leave the Nordic Seas as overflows via Denmark Strait and across the Iceland-Faroe-Scotland ridge, forming the deep limb of the Atlantic Meridional Overturning circulation.

The hydrographic conditions are monitored by the MFRI in the ástand sjávar project, where more than 70 repeat CTD stations on sections around the country are taken on a regular basis. The surveys are conducted 3 – 4 times per year since 1970; some data date back to the 1950s. Along with temperature and salinity profiles, water samples are taken for nutrients, oxygen, and other parameters. In particular, ocean acification is monitored on three key stations since the 1980s, constituting some of the longest timeseries of CO2 in the ocean.

The Denmark Strait Overflow is monitored with two current meter moorings at the sill since 1996, in cooperation with the University of Hamburg. The variable inflow of Atlantic Water to the Iceland Sea is observed by two current meter moorings on Hornbanki.

In addition to open-ocean oceanography, MFRI measures hydrographic conditions and water exchange in Icelandic fjords. While many of these are rather open and with rapid water renewal all year round, some fjords have shallow sills and deep basins, where oxygen is depleted during summer and fall seasons. These fjords are particularly sensitive to organic loading from aquaculture, and the observations serve as a base for carrying capacity assessments. The environmental impact of aquaculture is being monitored by extensive sampling, including multicorer and box corer sampling of the seafloor, and biodiversity assessment of benthic fauna.

Further research is done in cooperation with universities and other partners, both within Iceland and international.

Marine Heat Waves (MHW) around Iceland

Rakel M. E. Óttarsdóttir[1], A. Ruiz-Angulo[1] & Simon Van Gennip[2]

[1]Institute of Earth Sciences, University of Iceland

[2]Mercator-Océan International (MOI)

There is no dispute about the anthropogenically induced changes in the ocean and atmosphere temperatures. The greenhouse emissions produce an excess of energy accumulated in the atmosphere, which is then slowly taken up by the ocean and advected to different regions. The Sea Surface Temperature (SST) has shown over the last decade a remarkable increase, particularly in the North Atlantic. When this excess of ocean temperature above the average value lasts for longer than 5 consecutive days is defined as Marine Heat Wave (MHW). The opposite, an abnormally lower ocean temperature than the seasonal average is called Marine Cold Spell (MCS). The ocean, unlike the atmosphere, takes longer times to warm up and/or cool down; thus, warmer oceans take longer time to release their excess heat into the nearby coastal cities, where MHW can increase the heat index, which is a metric of how the temperature feels by the human body. Conversely, the Marine Cold Spells (MCS) would impact the cold sensation in the cities adjacent to the ocean.

We present a composite analysis of the past MHWs and MCSs for selected coastal regions around Iceland. The methodology is based on standard analysis similar to the one used on the Copernicus MHW bulletin reports. The analysis presented here is based Copernicus Marine Service datasets for the variable SST: OSTIA (1983-today), which provides observational satellite based-data, and GLORYS12 (1993-today), which is global circulation model with reanalysis with 10 days forecast. The two different datasets provide us a comparison between the reanalysis model and the satellite-based measurements. The results shown here are currently the base for a forecast system for MHW currently under development. Our analysis focused on identifying and characterizing MHWs and MCSs around Iceland in two different approaches. First, we divided the ocean around Iceland into 18 zones and used their average SST to detect heat waves within those regions, which are also divided by shelf only and deep ocean. Second, we chose rectangular areas around Iceland for the most important coastal towns; for example: around Akureyri and Reykjavík, for a more regional analysis (Figure 1). We generated plots for the zones and rectangles that provide information on MHWs and MCSs, including metrics like duration and maximum intensity. We also looked at the data by decade for comparison. These plots have shown an ongoing transition from a colder anomalies towards warmer anomalies, i.e., an increase in MHWs and mostly a decrease in MCSs. However, there also appears to be a resurgence of MCSs in recent years for some zones. This finding is interesting and requires further investigation, particularly to observe how this evolves in the coming years. Finally, our goal is to develop an automated system capable of forecasting marine heatwaves (MHWs) or marine cold spells (MCSs), and also evaluating the model's performance against observational data. MHWs have significant implications for fisheries, coastal activities, and marine ecosystems. This study was partially funded by the Reykjavik Energy Research Fund (VOR) 2023 and greatly benefited from collaboration with Copernicus Marine Services.

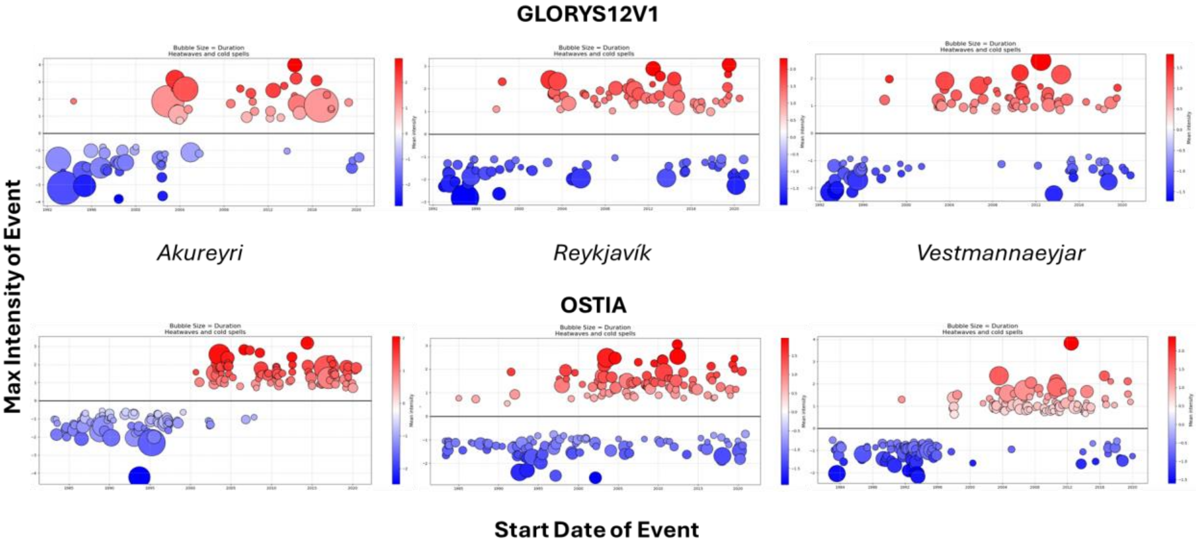

Figure 1. Composite of occurrence and intensity MHW and MCS for Akureyri, Reykjavík and Vestmannaeyjar. The upper panel shows the results from GLORYS12 (1993-2022) and the lower panel corresponds to the satellite derived OSTIA dataset (1983-2022).

University of Iceland participation in Ocean Sciences

Angel Ruiz-Angulo[1]

[1]Institute of Earth Sciences, University of Iceland

The University of Iceland is without a doubt *“the greatest house of studies”* in Iceland. In general, Universities contribute to society by advancing education, learning, and research at the highest levels. These tasks seem simple but the often unseen participants and infrastructure behind them are complex. Ocean Sciences is not an exemption to this complexity. Iceland is located in one of the most exciting places for Ocean studies; for instance, two of the main branches of the Atlantic Meridional Ocean Circulation (AMOC), which is currently on the spot as a tipping point, flow around us. Besides the large number of yearly surveys carried by the Icelandic Marine and Freshwater Research Institute there are more than 60 expeditions per year. There is a global interest around Iceland and we need to join efforts both internally at the national leval and with international institutions to collect and share not only data but knowledge. Universities participate as places for the free pursuit of knowledge, creative thinking, innovation, and the education of future generations; it is our mandate to be curious about the processes that are shaping the current changes, for example: climate change effects in the Ocean. Following the ideas in the handbook of new employees: *“Knowledge creation at the University helps our society address a wide range of challenges, including climate change, natural hazards, rapid technological advancements, and a variety of threats to human health and wellbeing.”*

This talk will provide an overview at the Geoscience Society of Iceland Autumn conference, which this year focuses on research in the sea and coastal areas around Iceland and the continental shelf. This presentation will cover the general (physical-processes-biased) characteristics of the ocean surrounding Iceland along with several case studies we have been working on since I took on the role of Oceanographer at the University of Iceland. These examples span multiple temporal and spatial scales and involve the collaboration of various institutions. We hope this talk will inspire more organizations to join in on some of the ideas we are presenting. We do have a lot of ocean around us and we should keep in mind the established principles of the Ocean Decade: “the science we need for the ocean we want”.

Bathymetry and Bottom Boundary Current Interactions South of Iceland: Key to Sustaining Benthic Ecosystems

A. Ruiz-Angulo[1], C. de Marez[1], M. Le Corre[2,3] & J. Gula[3,4]

[1]Institute of Earth Sciences, University of Iceland.

[2]Service Hydrographique et Océanographique de la Marine (SHOM), Brest, France.

[3]Laboratoire d'Océanographie Physique et Spatiale (LOPS), University of Brest, CNRS, IRD, Ifremer, IUEM, Brest, France.

[4]Institut Universitaire de France (IUF), Paris, France.

The Bottom Boundary Current south of Iceland has a particular signature and it is often referred to as the Iceland-Scotland Overflow Water (ISOW). The ISOW originates from dense, cold water that overflows from the Greenland and Iceland seas into the Atlantic Ocean. The ISOW carries cold, oxygenated, and nutrient-rich water from the Nordic Seas into the deep North Atlantic. These conditions provide an ideal habitat for cold-water corals, which thrive at depths where the ISOW flows, typically between 200 and 2,000 meters. Remarkably, the path of this current closely correlates with the locations of cold-water corals.

Recent studies have revealed the structure of this bottom boundary current. It follows closely the bottom bathymetry over a smooth path along the Iceland-Faroe Ridge (IFR), turning southwest at the corner of Stokesness. After this turn, the topography changes dramatically, with multiple submarine canyons and hills setting the flow into a different regime. This abrupt topographic shift brings significant benefits, as it facilitates the vertical transfer of momentum and tracers, including nutrients. This process not only transports nutrient-rich waters to the upper layers of the water column but also replaces nutrient-depleted water masses from those layers.

Understanding this process is crucial for interpreting ongoing changes in ocean hydrography, including the noticeable temperature variations observed in recent decades. The ISOW is a vital component of North Atlantic oceanography, influencing marine ecosystems through nutrient transport and playing a key role in global climate systems.

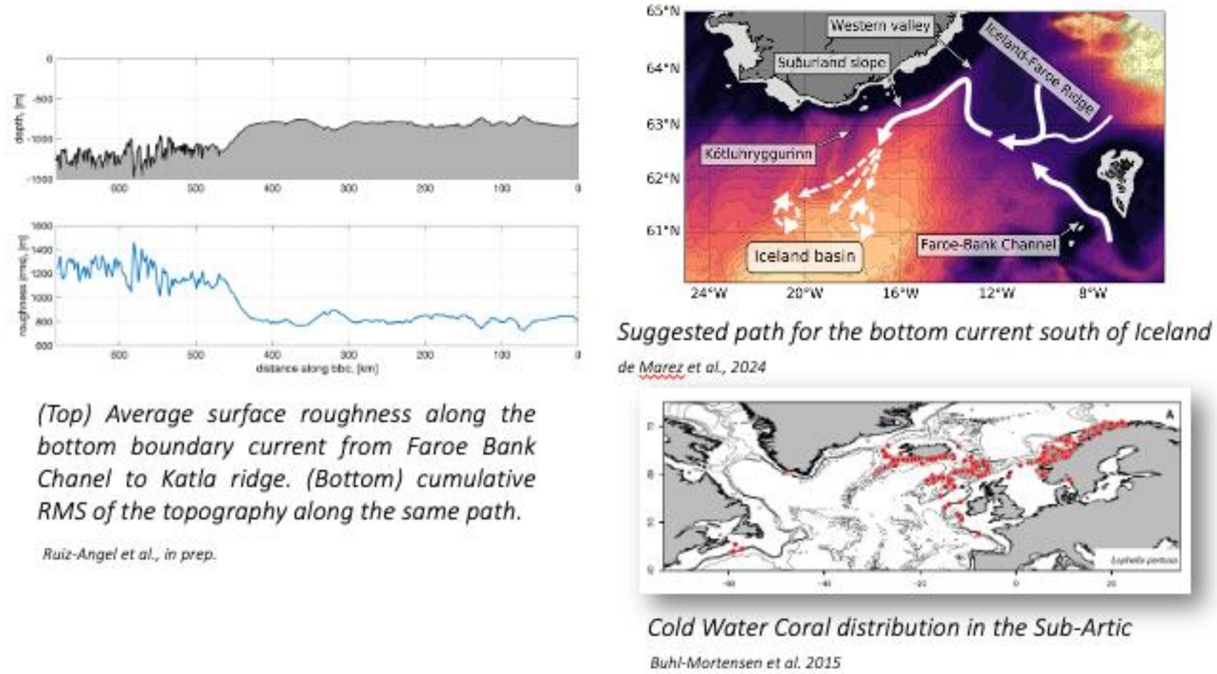

Figure 1. (Left) Bottom bathymetry profile along the Bottom Boundary Current south of Iceland zero referenced at the Faroe-Bank Channel towards the Katla Ridge and the resulting cumulative RMS showing the great difference from smooth to rough. Right-top: Suggested contributions and pathways of the BBC originating the ISOW; Right-bottom: Cold Water Corals spatial distribution around the area of interest.

Ostracoda from Hvalfjörður: diversity, distribution and biomonitoring experiment

Sarah Schmickal[1], Hafrún Birta Hafliðadóttir[2], Íris Mýrdal Kristindóttir[3], Hildur Magnúsdóttir[4] & Steffen Mischke[2]

[1]Universität Heidelberg, Institut für Geowissenschaften, Germany

[2]University of Iceland, Institute of Earth Sciences

[3]Running Tide

[4]Marine and Freshwater Research Institute, Environmental Division

Ostracods are micro-crustaceans characterized by bivalved carapaces. The calcareous ostracod valves, often well-preserved in marine sediments, are invaluable in reconstructing paleoenvironmental and paleoclimatic conditions. Consequently, a comprehensive understanding of the distribution of both recent and fossil ostracod species is essential for accurate paleoenvironmental reconstructions, and also for monitoring human impacts such as pollution and consequences of global warming. In Iceland, research on ostracods is rare. To establish knowledge on the distribution of shallow marine ostracods in coastal waters of Iceland, we studied the diversity and distribution of modern ostracods in Hvalfjörður (Iceland) – a fjord located approximately 30 km northeast of Reykjavik. Over the course of one year, 27 samples were collected with three primary objectives: (1) to identify the species inhabiting the study area, (2) to map their distribution regarding depth and location within the fjord, and (3) to monitor their response to environmental changes in their immediate surroundings caused by deploying 500 kg of lime-coated wood chips as part of a research initiative by *Running Tide*.

The ostracod carapaces (animals collected alive) and valves from the sediment samples collected in Hvalfjörður fjord represent 17 taxa belonging to nine families. The most abundant species are *Elofsonella concinna*, *Sarsicytheridea bradii* (Fig. 1), *Acanthocythereis dunelmensis* and *Robertsonites tuberculatus*. The total concentration of ostracods (including both carapaces and valves) peaks at a water depth between 14 and 44 meters, with a notable decrease around the 30-meters mark. The number of disarticulated valves consistently exceeded the number of recorded carapaces.

The biomonitoring experiment with the deployment of lime-coated wood chips at Location 1 in June 2023 did not provide evidence for significant impacts on the local ostracod population in comparison to the ostracod fauna at the unaffected control site at Location 2 with similar water depth (ca. 30 m) over the period from the deployment of the wood chips until the end of the experiment in April 2024.

The established knowledge on the diversity and distribution of ostracods in Hvalfjörður will serve as important reference to assess the state of the benthic ecosystem in the fjord in the future and to identify future biodiversity changes as consequences of global warming.

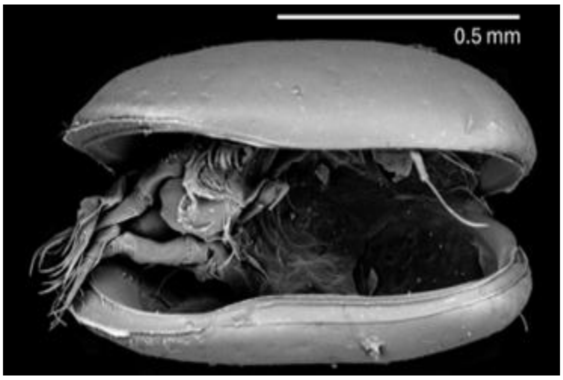

Figure 1 Ventral view on a specimen of one of the most abundant ostracod species in Hvalfjörður, *Sarsicytheridea bradii*

Geothermal utilization in the coastal area of Hjalteyri, central North Iceland

Sigurveig Árnadóttir[1], Bjarni Gautason[2], Erlendur Bogason[3], Finnbogi Óskarsson[4], Hjalti Steinn Gunnarsson[1], Sif Guðjónsdóttir[5] & Sverrir Óskar Elefsen[5]

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Hjalteyri is a small village on the western shore of Eyjafjörður in central North Iceland, about 20 km north of the region's largest town, Akureyri, and tens of km west of the active plate boundary. While no geothermal surface manifestations exist in the area, a thermal anomaly was discovered in 1998 when a shallow well was drilled to obtain sediment-filtered seawater for flatfish-farming practices. Geothermal prospecting consequently commenced in the vicinity of Hjalteyri in 1999 and the first production well (HJ-19) was drilled in 2002, resulting in one of Iceland's most productive low-temperature geothermal wells. Since then, two additional production wells have been drilled in Hjalteyri from the same drillpad, only ~400 m from the sea. At this time, geothermal prospecting had been challenging in the town of Grenivík by the eastern shore of Eyjafjörður, with quite obscure results, and after the successful drilling of HJ-19, an idea emerged to install a submarine pipe to carry geothermal water across the fjord. To explore this option and seek a practical route for the pipe by mapping the seafloor, a multibeam survey was carried out in Eyjafjörður in 2004 by Icelandic Coast Guard's vessel Baldur. The survey resulted in the discovery of hydrothermal vents on the shelf north of Hjalteyri. The vents are aligned on a ~750 m line with a N-S/NNE-SSW trend which is transected perpendicularly by a shorter line of vents. The vents were named Arnarnesstrýtur and declared as protected natural monuments in 2007.

In 2017, the assigned keeper and inspector of the hydrothermal vents noted some alterations in the structures and in October 2020, temperature of the upwelling geothermal water had dropped from ~80°C to ~30°C, enforcing previous concerns that exploitation in Hjalteyri was affecting geothermal activity in the vents. By the end of 2021, increased chlorine content was measured in quality control samples from the production wells in Hjalteyri, indicating minor inflow of seawater into the geothermal system. Consequently, Norðurorka made an agreement with Strýtan Dive Center and Cowi to continuously monitor temperature and electrical conductivity of geothermal upflow from the vents. These data confirm that temperature from the vents decreases during winter, when production in Hjalteyri is at maximum, and increases during summer, when production is at minimum. Since first noted in 2021, chlorine content has continued to increase in the production wells.

The urgency of decreasing the production from Hjalteyri is obvious. To enable this, Norðurorka has launched a major campaign urging and educating the community on responsible uses and activated an extensive effort in geothermal exploration with the aim of obtaining geothermal water from other areas. The effort includes multiplex local research in Hjalteyri with the objective of understanding the system's nature and response to production, closer examination of other presently utilized systems with the aim of increasing production, and regional exploration in the Eyjafjörður region seeking new and previously unknown geothermal systems.

The origin and impact of ocean variability on climate in Iceland

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Iceland enjoys a much warmer climate than the average for its latitude. A major reason for this is the Irminger Current south of Iceland, that carries Atlantic water that is relatively warm and has high salinity to the south coast of Iceland. It usually extends clockwise to the shelf north of Iceland where it is called the North Icelandic Irminger Current. Also, the atmosphere brings heat polewards over Iceland. There is a large heat flux from the ocean to the atmosphere and the air temperature therefore depends to a high degree on the ocean temperature. The area is characterized by high variability due to the presence of water masses with very different properties and varying distributions. As well, there are variations in properties within the different water masses. This variability influences the ocean ecosystems in the area in various ways. Regular seasonal measurements of temperature and salinity in the ocean around Iceland started in 1971 at standard stations. They show clearly multi-decadal as well as shorter term variability. The data show clear rise in temperature starting after 1995 and continuing until today although the data show a minor cooling in recent years although it is not nearly as cold as during the cold period before 1996. The warming after 1995 was accompanied by higher salinity and this indicates that the warming was not due to climate change but rather was mainly caused by advection of warmer and saltier water from the south. Thus, this warming was probably a part of the natural variability in the ocean around Iceland and illustrates the changes in the properties of the water masses advected towards Iceland. The other ocean current that has a major influence on the climate around Iceland is the East Greenland Current that transports cold and fresh (low salinity) Polar water through Fram Strait and southwards along the east coast of Greenland towards Denmark Strait. Variations in this flow can lead to drastic changes in the climate around Iceland. This happened during the so-called ice years from 1965-1971 when sea ice sometimes covered the shelf north and even east of Iceland. We therefore must follow closely what happens along the path of those currents that have large impacts on the oceanic climate and ecosystems around Iceland as well as the climate on land.

IODP Leg 197: the volcanic successions at Detroit, Nintoku and Koko shield volcanos on the Hawaiian-Emperor Seamount chain

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The Hawaiian-Emperor Seamount chain represents an age-progressive and hotspot-generated volcanic lineament that provides ~ 80 Myr record of magmatism and volcanism associated with the Hawaiian mantle plume. During the IODP Leg 197 the basement of three seamounts, namely the Detroit (~75 Ma; Sites 1203 and 1204), Nintoku (~56 M; site 1205), and Koko (~49 Ma; site 1206) seamounts were drilled to test the hypothesis of southward motion of the Hawaiian hotspot (Fig. 1). Concurrently, information on the ages and nature of the volcanic successions that make up these extinct Hawaiian hotspot shield volcanoes was obtained and is reported on here.

At Detroit Seamount site 1203 the basement was encountered at 462 mbsf and the volcanic succession was cored to depth of ~457-m (56.5% core recovery). It consists of 18 basalt lava units, representing at least 14 eruption units [i.e., lava flow fields] comprised of aphyric to plagioclase-olivine-phyric tholeiite and alkali basalt lavas, 14 volcaniclastic interbeds, and occasional biogenetic sediments. Three lava flow types are identified within the succession, pillow lava, compound and simple pahoehoe. Five lava units are "Simple" pahoehoe represents five, 2-10 m thick, inflated lava, while the remaining 13 units are compound pahoehoe (7) and pillow lava (6). The compound pahoehoe dominates the lower part of the succession while the pillow lava is confined to the upper part. This implies a change from subaerial to submarine setting for the lava emplacement with time, most likely driven by gradual regional subsidence of this part of the volcanic flank (Fig. 2).

At Detroit Seamount site 1204 the basement was encountered at ~816 mbsf and the volcanic succession was cored to depth of ~880 m (52% core recovery). The following lithofacies are identified at site 1204: compound pahoehoe (Unit 3) resting on calcareous sediment (Unit 4), which in turn caps >8-m-thick pahoehoe sheet lobe (Units 2) on lapilli breccia and a thin pahoehoe (Unit 1) mixed with carbonate sand. This facies association and the pahoehoe nature of these alkalic lavas implies origin at subaerial vents and an emplaced in a nearshore environment (Fig. 2).

At Nintoku Seamount site 1205 the basement was encountered at ~43 mbsf and a subaerial volcanic succession was cored to depth of ~ 283-m (52% core recovery). The 1205 succession is divided into 25 lava units intercalated with soil or sandstone. The lava units are primarily simple aphyric to plagioclase/olivine phyric alkalic lava flows that commonly feature oxidized flow tops that are capped by soil horizons. This implies subaerial emplacement for this succession during the post-shield stage of the Nintoku shield volcano (Fig. 2).

At Koko Seamount site 1206 the basement was encountered at ~57 mbsf and the volcanic succession was cored to depth of ~ 278-m (56.5% core recovery). The 1206 succession is comprised of 10, commonly olivine-phyric, tholeiitic pāhoehoe and ā‘ā lava flow fields, where five are underlain by distinct horizon of hyaloclastite breccia (i.e., flow-foot breccia) that is sometimes intercalated with sandstone. This implies subaerial venting and a near-shore emplacement for these lava flow fields during the main shield stage of the Koko shield volcano (Fig. 2).

Also, as will be demonstrated in the presentation, these results are underpinned by measurements of sulfur concentration in glasses from these volcanic formations. We also show that the Leg 197 Emperor Seamount Chain paleomagnetic and radiometric age data define an age-progressive paleolatitude history, indicating formation during times of the rapid motion (>40 mm per year) of the Hawaiian plume in the Late Cretaceous – Early Tertiary (i.e., 81 to 47 Ma).

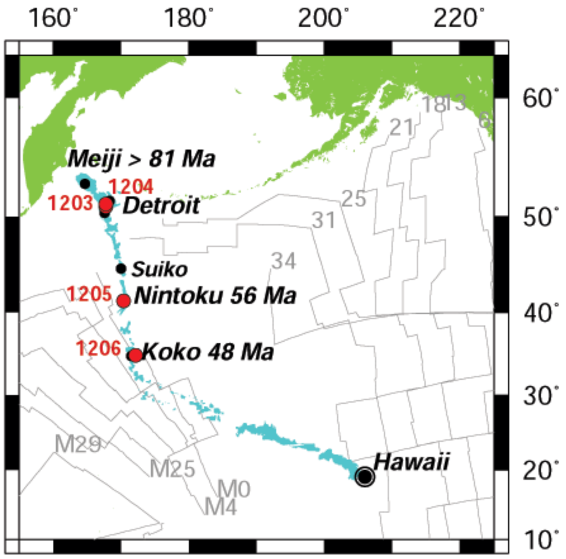

Figure 1. Hawaiian-Emperor chain shown with ODP Leg 197 sites and marine magnetic-anomaly identifications (e.g., Tarduno et al 2003).

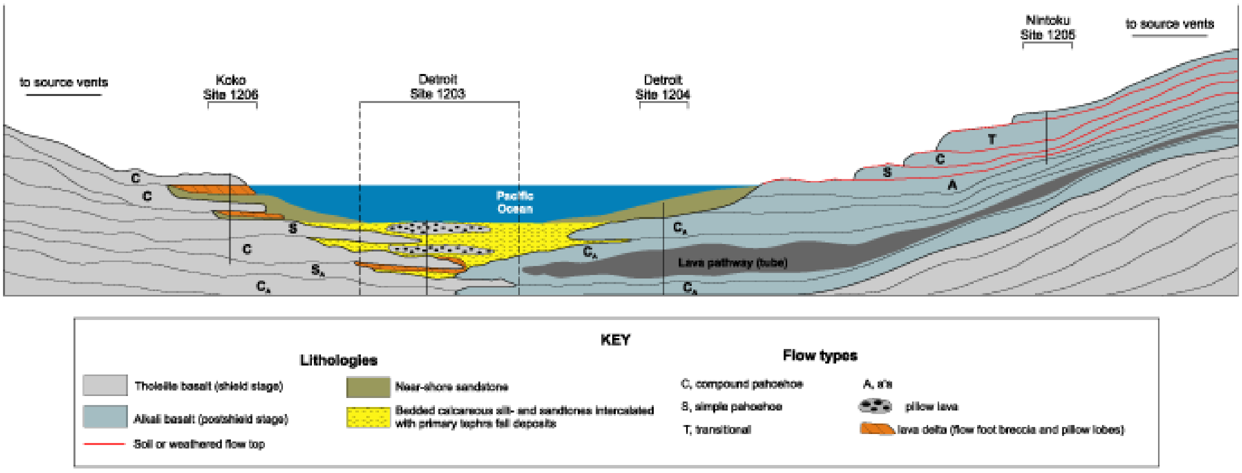

Figure 2. Schematic drawing showing the inferred volcanic environments for the volcanic successions drilled at Detroit (sites 1203 and 1204), Nintoku (site 1205) and Koko (site 1206) during IODP Leg 197. The lower part of the succession at Detroit site 1203 and the complete succession at Detroit site 1204 erupted and were emplaced subaerially, but subsequently submerged via post-eruption subsidence. The upper part of the succession at Detroit site 1203 was emplaced into low-energy, shallow-marine environment. The Nintoku site 1205 succession was erupted and emplaced subaerially, while Koko site 1206 succession was produced by subaerial eruption producing lavas emplaced into water in a near shore environment.

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Seabed Extraction in Iceland

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Seabed extraction, mainly of construction material, around Iceland has gained prominence in recent years, driven by both domestic needs and increasing international demand for geological resources. Iceland's seabed holds valuable materials such as sand, gravel, shell deposits, which have historically been used primarily for local construction. However, rising interest from European markets has intensified the pressure to scale up extraction for export, raising concerns about the sustainability and regulation of these activities.

The legal framework governing seabed extraction in Iceland is primarily defined by Law No. 73/1990 on the Exploration and Utilization of Resources on the Seabed, which establishes the Icelandic state's ownership of all seabed resources within its territorial waters and exclusive economic zone (EEZ). While the law provides a foundation for managing these resources, it lacks specific provisions to address the increasing demand and complexity of large-scale extraction activities.

The National Energy Authority (Orkustofnun) plays a crucial role in regulating seabed extraction through its responsibility for issuing licenses. Orkustofnun oversees the licensing process, ensuring that extraction projects comply with legal requirements and assessing their potential impacts. However, there are growing concerns that the current licensing framework is not robust enough to manage the increasing demand, particularly for large-scale exports. The licensing procedures lack detailed criteria for monitoring, long-term sustainability considerations, and protection for sensitive marine ecosystems.

As demand for seabed materials increases, the fragile legal framework raises concerns about our ability to balance increasing demand with environmental protection. The need for updated legislation and stricter regulatory controls is becoming increasingly urgent to prevent unsustainable exploitation of seabed resources and safeguard Iceland's marine ecosystems for future generations.

Marine Tectonics from SWOT Altimetry: Global Abyssal Hills

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The global seafloor represents one of the last unexplored frontiers within our inner solar system. To date, only 25% of it has been surveyed by ships using multibeam echo sounders, which provide spatial resolutions of approximately 200-400 m (Mayer et al., 2018). The remaining 75% has been indirectly mapped using gravity measurements from satellite altimeters, which offer a coarser spatial resolution of 12-16 km full wavelength (Sandwell et al., 2021). This paper investigates the use of the Surface Water and Ocean Topography (SWOT; Fu et al., 2024) wide-swath radar altimetry system to narrow this resolution gap. By analyzing one year of SWOT ocean data, we derived a global gravity field with a spatial resolution approaching 6 km. This improved gravity map enables detailed characterization of global abyssal hills, identification of thousands of small seamounts, submarine canyons, and extinct spreading ridges. For instance, the well-mapped V-shaped gravity signatures of abyssal hills along the Reykjanes Ridge reveal 3-8 Ma magmatic pulses from the Iceland hot spot (e.g., Parnell-Turner et al., 2017). The high-resolution gravity data from SWOT now reveals abyssal hill fabric on the flanks of all intermediate and fast-spreading ridges, often showing a characteristic spacing of 10-20 km. Notably, the most surprising result is that individual hills frequently extend along entire ridge segments (100-300 km), suggesting synchronous spreading pulses over large areas. Along the Southeast Indian Ridge, these pulses exhibit a characteristic timescale of 0.3-0.7 Ma, which is 10 times shorter than those along the Reykjanes Ridge.

Evidence of volcanism and former rift axis within the southern extent of the Iceland-Faroe Ridge

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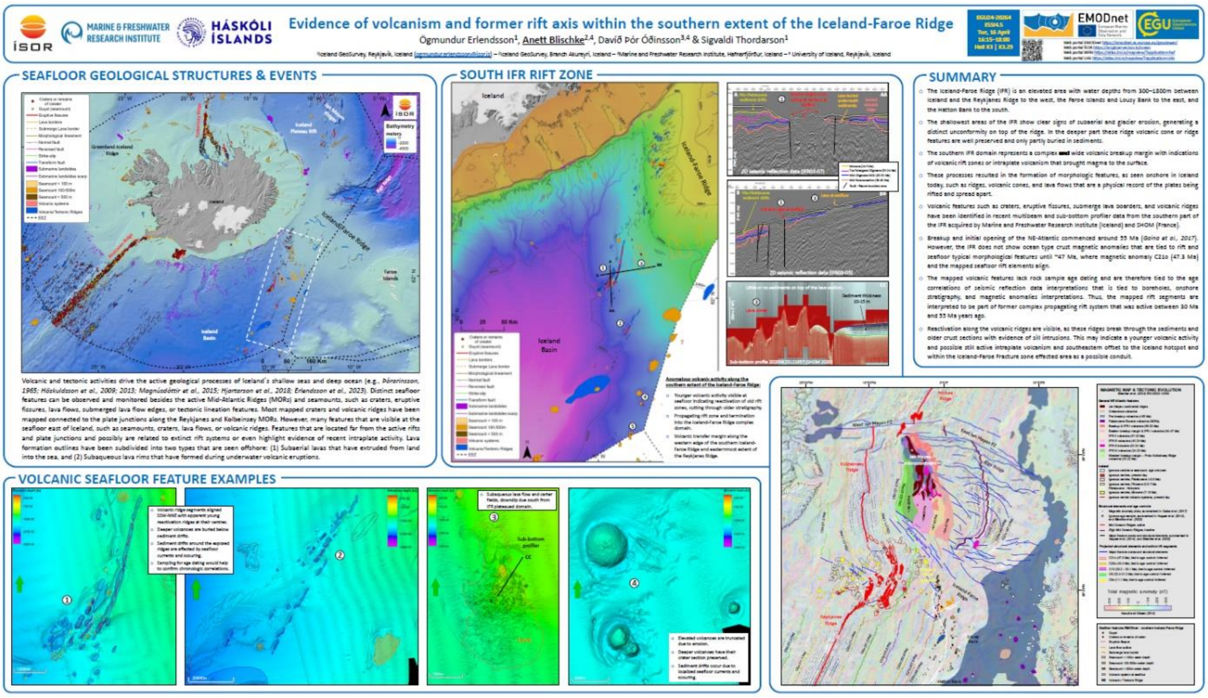
We presented our ongoing work at the European Geosciences Union (*EGU2024-20264*) concerning the offshore domain of southeast Iceland in connection with the Iceland-Faroe Ridge (IFR) as an elevated area between Iceland, the Faroe Islands, and the Hatton Bank with water depths from 300–1800 m. It is believed that the Iceland hotspot is responsible for the formation of the IFR. During the opening of the Northeast Atlantic, the Reykjanes mid-ocean ridge formed by interlinking with the Iceland hotspot. These processes created a complex and wide volcanic breakup margin of volcanic rift zones or intraplate volcanism that brought magma to the surface. These processes resulted in the formation of morphologic features, as seen onshore in Iceland today, such as ridges, volcanic cones, and lava flows that are a physical record of the plates being rifted and spread apart. Therefore, the IFR has been in development since the opening of the NE-Atlantic (<55 Ma), standing out as a prominent feature on bathymetric and geophysical datasets. Volcanic features such as craters, eruptive fissures, submerged lava boarders, and volcanic ridges have been identified on the ridge in recent multibeam and sub-bottom profiler data from the southern part of the Iceland-Faroe Ridge acquired by Marine and Freshwater Research Institute (Iceland) and SHOM (France). With northeast-southwest trending structures, the most preserved features lie at around 1500-2000 m water depth in the southern slopes of the Iceland-Faroe Ridge. There is also evidence of volcanism in shallower depths of the IFR. However, these features are not as well preserved and have been affected by subaerial erosions and glacier erosional processes during the last ice age. These volcanic features are considered to be a part of former rift axes that were probably active 30-55 Ma years ago compared to the age correlations of the surrounding oceanic floor. In the deeper part, these ridge volcanic cones or ridge features are well preserved and only partly buried in sediments. They are not age-dated but appear to be younger in formation time than the surrounding oceanic floor (30-55 Ma), where volcanic ridges appear to break through the sediments and older crust with evidence of sill intrusions seen on sub-bottom profiler seismic reflection data. This may indicate younger volcanic activity and possibly still active intraplate volcanic zones that can only be confirmed by sampling, age and petrophysical analysis.



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