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REMARKS ON THE WORKING CONDITIONS IN THE REGION OF THE POLISH POLAR HORNSUND STATION

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Abstract: The Polish Polar Station in Hornsund is a scientific base of great importance. In 2020, students of Gdynia Maritime University were able to visit the station and prepare photographic documentation of its surroundings. This article includes historical basics compared with the latest research concerning the flora, fauna, meteorology and studies on the Hansbreen glacier. research programme conducted on the station and climate changes in the Spitsbergen and perspective for the future fate of the Svalbard Archipelago.

Keywords: Arctic, Svalbard, Polish Polar Station in Hornsund, Climate, Climate Change, Research, Glacier, Flora, Fauna.

1. INTRODUCTION

Since 1970, Gdynia Maritime University (Maritime School of Higher Education in Gdynia at the time) has been supporting the Polish presence in the Svalbard Archipelago. S/T "Jan Turlejski" participated in 15 excursions to the Arctic with supplies and to transport polar expeditions crews in the period 1970–1980.

Since 2000, this role has been taken over by the newly built M/V "Horyzont II". Throughout this time, the vessel has been serving a role in training cadets of Gdynia Maritime University and transporting the supplies and crew of the Polar Station in the Arctic.

At the beginning of June 2020, a group of students from the Department of Navigation of Gdynia Maritime University, members of the NKBP "SeaQuest" science club, had the opportunity to participate in a cruise to Spitsbergen.

Apart from RADAR and ECDIS studies, they sailed the polar waters, saw glaciers and polar bears, visited the northernmost town in the world (Longyearbyen) and sailed with scientists from the Polish Academy of Sciences.

The main purpose of the cruise was to transport a group of scientists and crew of the 43rd Polar Expedition to the Polish Polar Station in Hornsund from the Polish

Academy of Sciences along with the equipment and cargo that was necessary for the functioning of the Station.

During their stay in the Hornsund Fjord, the students prepared vast photographic documentation of the landscapes, glaciers and flora and fauna of the fjord, which was the secondary purpose of their journey. Apart from this, the students were able to learn from the scientists and listen to their lectures about the Arctic, meteorology, oceanography and constant climate changes happening in the polar regions.

2. POLISH POLAR STATION IN HORNSUND

The Stanisław Siedlecki Polish Polar Station in Hornsund (Fig. 1) was launched in 1957 as a foreign post of the Institute of Geophysics of the Polish Academy of Sciences and is located on the shore of Isbjørnhamna Bay in the Hornsund Fjord (77° 00,0'N 015°33,0'E). It is located in the southern part of the Norwegian island of Spitsbergen, which belongs to the Svalbard Archipelago (Fig. 2) [https://hornsund.igf.edu.pl/o-stacji/].

Spitsbergen is surrounded by the polar waters of the Arctic Ocean to the north, the Barents Sea in the south-east and the Greenland Sea in the south-west. The Hornsund Fjord is approximately 35 km long and approximately 14.5 km wide at its mouth to the Greenland Sea. The coastline of Hornsund is diversified, with multiple bays and glaciated valleys [Wawrzyniak and Osuch 2020].

The Hansbreen glacier, located in close proximity to the station (about 2 km), flows into the Isbjørnhamna Bay. The glacier ends with an ice cliff of 20–40 m in height. In the period of time when the bay isn't covered with sea ice, the glacier calves into growlers and ice debris that later drift into Hornsund Fjord and open waters by sea currents and tidal currents. During the summer, the process of calving is highly intensive.

The fjord waters are very often covered with high concentrations of ice and sometimes compact floating ice (Fig. 3) [Marsz and Styszyńska 2007].

Fig. 1. Polish Polar Station in Hornsund (1)

Photo: Adam Winnicki.

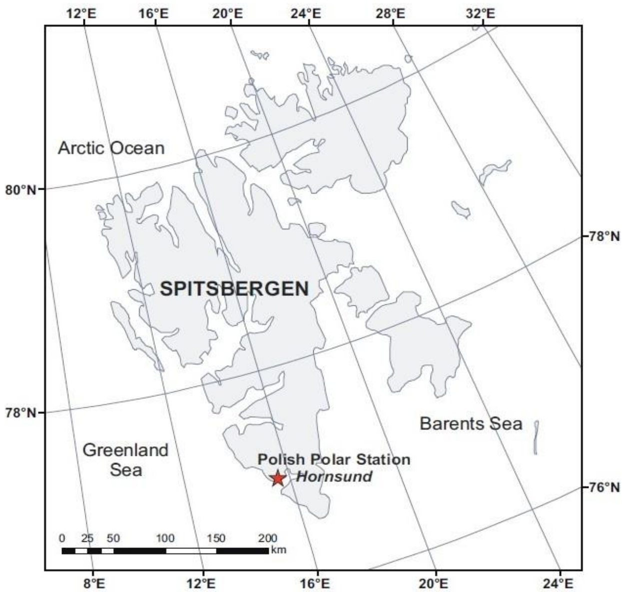

Fig. 2. Polish Polar Station in Hornsund (2)

Source: [Osuch and Wawrzyniak 2016].

Fig. 3. Floating ice after calving of Hansbreen

Photo: Adam Winnicki.

The year 1978 was the first of all-year studies conducted according to WMO standards by the Institute of Geophysics of the Polish Academy of Sciences, and since then, it has been the northernmost permanent Polish scientific site. Basic meteorological parameters are measured and observed systematically via a 24-hour system. It has become a modern interdisciplinary scientific platform that carries out research projects aimed at better understanding the functioning of the Arctic nature and the changes it undergoes [Wawrzyniak and Osuch 2020].

Since 2001, most of the traditional instruments have been replaced with the modern, automated weather station Vaisala QLC-50 logger. The sensors of the system are installed on a meteorological mast situated 160 m south-west of the main station building [Wawrzyniak and Osuch 2020].

Apart from meteorological studies, a broad scope of research is conducted at the station. Traditional research programmes like meteorology, seismology and earth magnetism were gradually supplemented with observations and measurements of ionospheric, glaciological and environmental research, atmospheric physics and optics [https://hornsund.igf.edu.pl/about-the-station/scope-of-research/].

3. CLIMATE

The most important climate-creating factor is the presence of solar radiation that depends on the geographical latitude, which defines the height of the culmination of the Sun and its substantial seasonal variability. At a latitude of 77°N, the duration of the day is subject to considerable changes. The solar operation at the stated latitude lasts 261 days. April 24 is the beginning of the polar day, which lasts until August 18 (117 days). On June 22, the sun reaches its highest point above the horizon. Afterwards, the days become shorter very quickly. From October 31 to February 11, the sun is located below the horizon, which means that the polar nights last for 104 days [Marsz and Styszyńska 2007].

Very little solar radiation and atmospheric together with ocean circulations have a major impact on the climatic conditions and heat transfer in the region [Osuch and Wawrzyniak 2016]. Apart from this, the presence of solar radiation is modified by the degree of cloudiness and type of clouds occurring in the region. Due to localisation and the island character of the region, the constant flow of ocean air masses influence the cloudiness, humidity and other weather parameters significantly, which are factors creating the climate. The circulation of the atmosphere over Spitsbergen is very diversified and influenced by the processes happening over the North Atlantic [Marsz and Styszyńska 2007]. In the winter, the main factor influencing the air temperature is the atmospheric circulation, while in the summer, solar radiation plays a major role in climate creation.

It is important to state that weather factors vary significantly locally and regionally due to the influence of elements, such as the presence of sea ice and its distribution, the presence of glaciers, orography of the terrain and location near the seashore [Wawrzyniak and Osuch 2020]. The change of air temperature from day to day in Hornsund Fjord is significant, especially in the winter season. This is due to the high variability of baric systems which regulate the flow of cold or warm air masses [Araźny 2000]. The inter-annual variability of the presence of sea ice extending into the sea areas east and west of Spitsbergen shows clear connections with the air temperature variability in Hornsund Fjord [Marsz and Styszyńska 2007].

Climate change in the Arctic implies a global warming trend, but the warming in the far north is much faster than in lower geographical latitudes.

The characteristics of Earth's climate zones are primarily determined by astronomical factors, but there are differences in the mechanisms that cause local warming trends and determine their scale [Wawrzyniak and Osuch 2020].

According to studies by Przybylak [2007], the trend of the air temperature in the European Arctic, particularly in the Svalbard Archipelago, indicates a 2.6°C increase in the mean annual temperature over the last 100 years, approx. three times higher than the estimated global warming for this period of time (0.8°C). The cause of the difference in warming rates is very complex and still not well understood [Wawrzyniak and Osuch 2016].

The variability of air temperatures and rapid on-going changes in temperature and changing distribution of precipitation affect many aspects of both the biotic and abiotic components of the Arctic's ecosystems, which are susceptible to changes [Wawrzyniak and Osuch 2016].

4. FLORA AND FAUNA

During the short polar summer, all flowering plants, fungi, algae, bryophytes and lichens develop their life cycle. The coastal strip, mountain slopes facing the sea and some valleys are covered by a low-growing tundra. There are no trees or shrubs here, and dwarf polar willows are in the form of shrubs not exceeding a few centimetres in height.

Fig. 4. Rock lichens and colourful flowers

Photo: Hubert Żywiec.

Due to the limited number of insects, flowering plants are wind-pollinated, which is favoured by frequent and strong winds, which also carry seeds and spores over long distances. Rock lichens and mosses create colourful spots on the stones, while in places where soil has formed, colourful carpets of flowers and mosses appear in summer. Dense clusters of vegetation appear on the slopes, where the birds that provide fertiliser nest (Fig. 4).

Hornsund is also well-known for its large colonies of birds. Many of the bird species spend most of their time by the sea, but they breed on land. They usually come here for the breeding season, raise their offspring and fly south before winter (only the rock ptarmigan remains for the winter). There are 109 species of birds in

Spitsbergen, 15 of which are regularly hatched here. Others hatch sporadically or arrive by accident.

Little Auks (Alle Alle) are most associated with Horsund. Hundreds of thousands of them breed here. Most of Svalbard's Little Auks breed either here or in the northwest of Spitsbergen. Little Auks breed under large boulders, which means that the nest itself can't be seen.

Besides Alle Alle, there are many more such birds, such as Kittiwake, Brünnich's Guillemot or Fulmar, which nest in colonies on steep rock walls. Skuas and Purple Sandpiper, which live on the flat tundra, can also be found. Unfortunately, they are more endangered by predators (Arctic foxes); therefore, they nest one at a time and use defensive tactics – they pull the aggressor away from the nest, pretending to be sick or scare aggressors away with aerial attacks. The largest avian predator is the Pale Seagull, which hunts fish, as well as Little Auks, stealing their eggs and chicks from the nests. The birds are under protection, and their breeding places have been established as bird sanctuaries, access to which is prohibited during the breeding season.

In the waters of Spitsbergen, more than 30 fish species live, though most of them at greater depths. The most important and most numerous is the polar cod, which constitutes the main prey of seals and fish-eating birds of the Arctic. Laminaria thickets are the habitat of three species of small fish from the Cottidae family (popularly known as sculpins), while under stones in the tidal zone, eelpouts hold onto stones with their belly suction cups. In spring, the fjords are visited by 2 m-long Greenland sharks, but these are rarely seen as they occur at great depths.

Along with birds and fish, other species of animals can be found. The most numerous marine mammals in Hornsund are the fish-eating Ringed Seals, the reproduction of which depends on the presence of a permanent winter ice cover with snow. In the years when there is less ice in the fjord, they cannot find breeding sites and move elsewhere. Bearded, Common, Gray, Hooded and Greenland Seals can also be observed.

It is also possible to see walruses and white (beluga) whales. Occasionally, three species of dolphins appear, as well as minke whales, killer whales and cachalots.

The polar bear, which is the largest predator on Earth, can also be found in the coastal zone or in the open sea, where it hunts for seals, being its main food source.

There are not many other land mammals, besides reindeer and Arctic foxes. The Spitsbergen Rhine is stocky and has short legs. They are whitish with grey and beige spots and white in winter. They live up to 20 years. Both males and females have antlers that they lose in early winter, and they grow new ones in spring (Fig. 5).

Fig. 5. Reindeer near Hornsund Station

Photo: Hubert Żywiec.

In contrast to the reindeer, the most common colouration of the Arctic fox is brown-grey in summer and snow-white in winter, although black foxes are also found throughout the year. They feed on birds (especially their chicks), eggs, fish and carrion and live for 12–14 years.

The lowest level of the fauna of Hornsund consists of some 600 species and is dominated by crustaceans, polychaetas and molluscs. The benthos biomass ranges from 10 g in bays near glaciers to 200 g of wet weight per 1 m^2 in the outside part of the fjord. In shallow waters, Laminaria thickets can reach many kg/m^2. Of the Spitsbergen fjords on the west coast of the island, Hornsund has the greatest proportion of Arctic fauna, particularly in its outside part. The high seas are dominated by migratory thermophilous Atlantic species.

5. RESEARCH

Polish Polar Station is the main research centre in the region. The year is divided into two seasons - summer and winter. Summer begins in June when the University's ship M/V "Horyzont II" brings the next Polar Expedition crew, which consists of summer and winter seasoners. The first are the cook, mechanics, technicians, etc. They stay at the station for approx. 3 months before the "Horyzont II" arrives a second time to take them back home. After the winter starts, the winter seasoners are left alone for the next 9 months until the following June. There are 9 people who stay at the Station for the the year – the Commander of the Expedition, three meteorologists, a geologist, a computer specialist and three technicians. There is a lot of work every day for each of them.

Systematic, whole-day measurements and observations of basic meteorological parameters are conducted according to WMO standards. Three meteorologists work at the station in a 24/48 hour system fulfilling a meteorological telegram called SYNOP (or FM-12 by WHO). FM-12 telegrams contain basic meteorological parameters, such as wind speed and direction, air and water temperature, air pressure, pressure change and humidity, which are collected automatically, but parameters such as cloud coverage and cloud types require human observation. Up-to-date SYNOP meteorological telegrams are sent at 0 h, 3 h, 6 h, 9 h, 12 h, 15 h, 18 h, 21 h UTC and are transferred by radio through the Bjornoya meteorological station. SYNOP telegrams are collected from stations all over the world at almost the same time, and they provide the groundwork for meteorological prognosis for weather around the world [https://hornsund.igf.edu.pl/hornsund.old/meteo.html].

The second most significant area of research is geomagnetism. The area of Spitsbergen has the Earth's highest variation in its magnetic field. Magnetic observations are carried out by measuring apparatus located in non-magnetic pavilions. Each magnetism observatory consists of at least two buildings: a recording pavilion and absolute measurement pavilion.

The devices of the geomagnetic observatory record three magnetic field components (horizontal X and Y and vertical Z) every second. Afterwards, the measurements are calculated into final data, and once a year, they are published in geomagnetic yearbooks by the international data centre outside the Hornsund Station [https://hornsund.igf.edu.pl/hornsund.old/magneto.html].

Seismology is another area of research. The main task of the seismology laboratory in Hornsund Fjord to constantly record local earthquakes of tectonic or glacial origin and local tectonic shocks. The station is part of an international network of seismological observatories. The local seismic net consists of ten short-period seismometers located 600 to 1100 m from the station. Three spatial components of vibration are measured at two posts (orientation north-south, east-west and vertical), others measure only the vertical component. Signals from the posts are transferred by cable to the station, where automatic digital registration is performed. After preliminary processing, the archived data is sent to the Institute of Geophysics for further processing and analysis. Annually, during the period of increased activity of glaciers (during the spring and summer), additional measurements of vibrations connected with the dynamics and activity of Hansbreen are conducted. Registration is done by portable devices deployed directly on the surface of the glacier [https://hornsund.igf.edu.pl/hornsund.old/sejsmo.html].

6. HANSBREEN GLACIER

Hansbreen is one of the best-researched glaciers at Svalbard. It has been selected as one of four glacial masses at Svalbard to be studied concerning climate effects. Year-round observations, measurements and experiments conducted on the glacier include mapping of its surface topography and radio-echo sounding of its ice thickness, and the subglacial bed topography can be provided thanks to the proximity of the Polish Polar Station.

Hansbreen is located in southern Spitsbergen (Svalbard) and flows from mountains to the north and terminates in Isbjørnahamna Bay to the south. It is a medium-sized glacier, the estimated surface area of which is circa 56 m^2 with a 4 km-wide tongue and a 1.5 km-wide active calving front. The ice divide to the north between Hansbreen and Vrangpeisbreen is well-defined and is located at about 490 m a.s.l. [Budzik et al. 2012]. The eastern boundary between Hansbreen and its neighbouring glacier Paierlbreen is more difficult to define due to the transfusion of ice from the accumulation field to Kvitungisen (a tributary of Paierlbreen) through a glacial breach. Due to the surge of Paierlbreen in the 1990s, the glacier surface topography in the area was altered. Thus, the location of the ice divide has changed over time, and different surface areas have been reported for Hansbreen in different publications [Budzik et al. 2012].

Fig. 6. Hansbreen Ice Cliff

Photo: Hubert Żywiec.

The Hansbreen system consists of the main trunk glacier and smaller adjacent glaciers. It is surrounded by four glaciers to the west – Staszelisen, Deileggbreen, Tuvbreen and Fuglebreen – and by three small circular glaciers to the east, though nowadays they are separated from Hansbreen by ice-cord frontal moraines that merge with the lateral moraines of Hansbreen. All the mentioned glaciers provide meltwater into the Hansbreen drainage system.

The glacier valley is limited by the Sofiekammen ridge to the east, the highest elevation of which is Wienertinden at 924 m a.s.l., and a mountain chain on the western side, with the highest point being the northern peak of Slyngfjellet (788 m a.s.l.). There are two passes connecting Hansbreen with Werenskioldbreen to the west – Kosibapasset and Bergkardet. Their elevation is below 500 m. a.s.l. The eastern mountain ridge has a mean altitude of c. 700 m a.s.l. and a relative elevation of approx. 500 m above the glacier's surface, excluding lower elevation passes. It forms an orographic barrier to air masses advecting from the east. Therefore, a distinct foehn effect can be observed during easterly winds. The mountain range bounding Hansbreen on the western side is generally 150–200 m lower than that on the eastern side (especially in the southern part), and it is dissected by tributary valleys [Budzik et al. 2012].

Fig. 7. Waterfall at the Hansbreen Ice Cliff

Photo: Hubert Żywiec.

7. CONCLUSIONS

The Polish Polar Station in Hornsund is a scientific base of great importance which helps scientists research and understand processes that occur not only in the far north but also globally. Conditions within the Arctic Circle are extremely hard, so humanity knows little of what is happening up there, which is why research in the Svalbard Archipelago is so important.

During their stay at the Hornsund base, members of the NKBP "SeaQuest" science club learned a lot about the Arctic and opened their minds concerning on-going climate change, which was occuring before their eyes. This only increased their appetite to seek new opportunities to study.

The science club is now planning another excursion to the Hornsund Fjord, during which they may conduct their own research on sea ice, glacier ice and, most importantly, conduct a series of dives in the polar waters. Diving in such waters creates new possibilities due to the clearness and high visibility.

The students are mostly interested in diving to wrecks located in Hornsund Fjord to establish their precise position and to prepare accurate photographic documentation.

Fig. 8. Students of Gdynia Maritime University in Hornsund Fjord in June 2020

Photo: Hubert Żywiec.

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