The Polarquest2018 Arctic expedition
A geographical report

Gianluca Casagrande

Geografia a libero accesso
Collana a cura di Claudio Cerreti

Volumi pubblicati

1. Elena dell'Agnese e Massimiliano Tabusi (a cura di), *La musica come geografia: suoni, luoghi, territori*
2. Margherita Ciervo, *Il disseccamento degli ulivi in Puglia. Evidenze, contraddizioni, anomalie, scenari. Un punto di vista geografico*
3. Gianluca Casagrande, *The Polarquest2018 Arctic expedition. A geographical report*

The Polarquest2018 Arctic expedition
A geographical report

Gianluca Casagrande

Certificazione scientifica
Questo volume è stato sottoposto a un processo di referaggio a cura di esperti anonimi, che si desidera ringraziare per il loro determinante apporto.

Via della Navicella, 12 – 00184 Roma

www.societageografica.it

ISBN 978-88-85445-06-2

In copertina

Fotografia di Michael Struik

In loving memory of Prof. Cristina Gemo La Greca (1948-2019),
geographer, mentor and friend

Nota bene: Unless otherwise specified, all topographical data in this book are indicated according to information made available by the Norsk Polarinstitutt, through the TopoSvalbard WebGIS platform (*www.toposvalbard.npolar.no*). All the last access to the different mentioned web sites can be dated to September 2020. All the photos can be dated to the expedition time-frame (July 22nd - August 24th, 2018). The source of data for Section 3 (*Chronographical report*) is S/Y NANUQ logbook (Gallinelli, 2018b). Data cited from this source are only marked with the page number. All time indications in this chapter are UTC.

CLAUDIO CERRETI

PREFACE

This book is the third in the «Geografia a libero accesso» series, that the Italian Geographical Society has created to host its digital publications. The purpose of the editorial initiative is to make works by the Society's members easier to access and circulate, so that results from studies and research activities may be freely disseminated. We hope that our fellows and the wide audience in the Web will appreciate this effort.

Gianluca Casagrande's book further extends the accessibility beyond the Italian-speaking context: a necessary choice, since it has an international endeavor as its topic and will have international readers as a significant share of its audience.

The work features – on an extrinsic level – several «new» elements; yet, in many ways, it is a sort of «translation» in present-day terms of a kind of scientific literature that must be considered – in our field – a classic. Not by chance, among the Italian Geographical Society's publications, it has several and historic precedents: the genre we are referring to is the journey report. In the following pages, the reader will find an extensive account of the geographical aspects of the Arctic research and communication expedition «Polarquest2018», in which the author participated as onboard scientist, also as a representative of the Society.

As any other good journey report, this one too begins by presenting the scientific rationale of the expedition in its geographical context, clearly stating the reasons for the presence of a geographer in the crew. Then comes the account, derived from the expedition logbook and from other texts written during the operations. Several scientific activities – full-blown research work and methodological tests – are then presented and discussed, putting forth some relevant results of surveys and visits conducted in various «points of interests» of the Svalbard Islands.

The book could not obviously summarize the complexity of a highly multidisciplinary international expedition, so rich in experimental characters, hosting several different and independent – both epistemologically and organizationally – research programmes. Such complexity was further developed in the multiple thematic connections among the different subjects covered in the various public communication and cultural dissemination products and events that stemmed from Polarquest2018.

Multiple elements of interest for today's geography are pointed to, or hinted to, in this writing. First of all, the increasing interest for the exploitation of Arctic spaces and resources – and the Svalbard archipelago is, due to its position and well-developed infrastructures and services, one of the primary elements of this interest.

The peculiar environmental, geographical and political features of Svalbard are therefore central in a global discourse and the book either considers or touches various aspects of this matter: environmental protection, definition and management of cultural heritage, policies and regulations regarding access and protection of territorial assets.

In the second part, focusing on the «subject-specific reports», the more experimental and methodological component of the expedition is presented. In a solid connection to the idea – a traditional one among Italian geographers – that «geography must be done on foot», the author and his colleagues conducted a series of observations in the attempt of producing rather original geographical and cartographical data, especially if one takes into accounts the innovative techniques used for their acquisition.

The result is a set of methodological proposals, which meet, in several cases, lines of development in our field: familiarization of researchers with specific types of instruments; application of low-cost and open-access tools, towards an always good «democratization» of research capabilities; a potentially strategic connection with citizen science and, finally, the creation of conceptual frameworks to foster positive cooperations between geographers and professionals in other fields.

In the book the reader can find a rather complete – though with no ambition of exhaustivity – presentation of the developed activities. After all, it is a work in progress. Nevertheless, we should acknowledge the author to have offered ideas and information that are useful from several points of view. First, the book gives an original contribution to the knowledge of a specific phase in the life of relevant places and environments of the Svalbard Islands, an area which is going through a deep transformation. This is a main duty for a geographer, especially when the object of observation are places which may still be legitimately considered as «remote». Moreover, as it was previously stated, the book suggests interesting methodological perspectives: a central one, proposed by the author by jointly considering several different components of the expedition, is the reference to an «innovative research paradigm», based on the integration of low-cost, high environmental and operational sustainability, with a focus on simplicity and effectiveness. This vision, well developed in «Polarquest2018», may prove useful both in scientific work and in environmental protection as well.

We would like to conclude these comments by recalling an author's remark at the end of his complex work. With its participation in Polarquest2018, the Italian Geographical Society marked also an important return: its first official return to the Arctic as an operational component of a field-work-based expedition – exactly ninety years after the polar mission of airship «ITALIA». The latter took place in 1928 under the aegis of the Society, and from the ITALIA's expedition, not by chance, Polarquest2018 widely and programmatically drew inspiration.

In both journeys – regardless of the different scales, complexity levels and ages – the Society aimed to re-affirm, to the best of its ability, its own cultural vocation: to study our planet and to spread knowledge about it.

GIANLUCA CASAGRANDE

INTRODUCTION

Fig. 1 – *The journey of S/Y NANUQ from Ísafjörður, Iceland to Tromsø, Norway*
Source: map by E. Falqui (2019, modified)

Between July 22nd and September 4th 2018, an international Arctic research and communication expedition called «Polarquest2018» was conducted on board the eco-sustainable sail-yacht NANUQ[1]. The 17.8-meter sailboat cruised for a total of 3,564 nautical miles[2] most of which north of the Arctic Circle (including two transfers and one operation leg). The crew, consisting generally of ten members, carried out a series of activities and observations in the framework of three research programmes.

The expedition was organized by Association *Polarquest2018* (Switzerland) in partnership with Association *Acapela* and with scientific, technical and cultural entities from France, Switzerland, Italy and Norway[3]. Funding was provided by institutional and private sponsors.

(1) Nanuq is the name of the polar bear in the Inuit language.

(2) 1 NM = 1.852 km. In this book, nautical miles are used in describing maritime travel, while measures in all geographic descriptions are expressed in the metric system.

(3) Scientific partners: Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi, Italy's National Research Council (CNR), CNR-ISMAR Lerici, Ticass, Geographic Research and Application Laboratory (GRE-

Year 2018 marked the 90th anniversary of the Arctic flights of airship ITALIA (1928), hence commemorations and ceremonies took place during the expedition. Such events saw the presence and/or the endorsement of a delegation of descendants of the airship's crew.

The expedition's journey (fig. 1) began at the Icelandic port of Ísafjörður on July 22nd, for the so called «leg 13»[4]. The boat reached Greenland and the Svalbard islands, arriving in the main town of the latter, Longyearbyen, on August 2nd. The second leg of the journey («leg 14») started from there on August 4th. After circumnavigating the two main islands of the archipelago, Spitsbergen and Nordaustlandet, NANUQ returned to Longyearbyen on August 23rd. The last phase of the journey – a transfer trip with limited crew and equipment – began in the evening of the 24th, as the boat departed Svalbard bound to continental Norway. The expedition ended on September 4th, with arrival in Tromsø. NANUQ was later moved to a smaller port for wintering.

During Polarquest2018, on August 13th, NANUQ reached the northernmost point of her navigation, stopping in proximity of a large area of floating ice, not far from the extreme edge of the Arctic pack, at 82°07'N, 25°25'E. The point was less than 900 km from the North Pole. In that area, a sampling of microplastics and a measurement of cosmic rays were carried out. In both cases, innovative and important data in the respective fields were recorded. A full discussion of those topics along with the related scientific programmes, however, is beyond the scope of this writing.

What is more relevant to this work is the set of conceptual and operational developments of the expedition, along with the geographical observations which were conducted.

The project was highly interdisciplinary in nature. It consisted in navigating an experimental, environment-friendly floating laboratory through an Oceanic route, beyond the Arctic Circle and around Svalbard. During this travel, many activities involved scientific research, communication and story-telling. The research programmes were thematically different and required non trivial scientific and technical work by skilled onboard scientists and operators. Programme «PolarquEEEst» was dedicated to measuring cosmic rays at high latitudes; programme «Microplastics» consisted in performing a series of water samplings along the route in order to evaluate the presence of this particular type of pollution; programme «AURORA» called for the use of small commercial drones for mapping areas of interest. Data collected during these activities were processed, after the expedition, by different institutional workgroups. Communication

---

AL) – European University of Rome, CRS4, Italian Geographical Society, CERN. Gold Sponsors: ElysiaCapital, GlobalGiving, Loterie Romande, Foundation H. Dudley Wright, NORBIT SUBSEA. Technical Sponsors: B&G, Survitec, Allianz, Advanced Tracking, Hamilton, Drift & Noise, FlyToDiscover, EWOL, Greementimport, WeatherDock, Drone Capture Systems, Spade, Svalbard Islands, Informasistemi. Ship's store Sponsors: «Marramiero», «Barilla», «Eli Prosciutti», «Oleificio Andreassi», «Rodolfi», «Caseificio Sociale Il Battistero».

(4) It was the 13th Arctic journey of S/Y NANUQ after her launching in 2014 (*igloo.sailworks.net/boat_e.htm*).

and story-telling – i.e. the other component of the expedition – aimed to presenting the visited areas and environments, as well as the activities and ceremonial aspects.

From a scientific point of view, Polarquest2018 tested innovative methodologies for research in the Arctic by the use of sustainable, low-environmental impact, citizen-science-level technologies and procedures. The challenge was actually to obtain valuable and full-blown scientific results according to academically recognized quality standards, obviously after appropriate scaling and application to the specific context and operational rationale. Several examples demonstrated this philosophy. One could cite, for instance, the highly innovative POLA-1 Cosmic-Ray detector, designed and built by major scientific institutions in Italy with high-profile laboratory components: the device included, nevertheless, design options for use onboard a typical tourist-class sail-yacht. The detector hardware even included consumer-level individual components and underwent final assembly at CERN in by high school students. Another example could be the drones flown during the expedition. Though somewhat inadequate from a technical point of view, these off-the-shelf systems proved effective, allowing to acquire all the expected data and even more.

While the expedition *per se* involved skilled personnel and scientific institutions, much field and lab activities were actually conducted by citizen-science-level protocols, and the obtained results, presented in this work as elsewhere, suggest that the operational approach is valid and easily repeatable.

More accessible and affordable technologies and methods allow to overcome, at least for some useful scientific purposes, the existence of an objective financial and organizational divide, separating high-profile institutions from small and low-budget workgroups. Yet, the latters' activity could provide valuable information about certain phenomena in a critical area such as the Arctic. The same information might be harder to comprehend by the sporadic use of cutting-edge research equipment and processes. So much, for the moment, about the research side.

Speaking now about communications, it is out of question that public awareness about environmental problems is crucial to achieve more environmental-friendly policies and social attitudes. Along with traditional mass media, the Web and social networks are now main vectors for story-telling about science and exploration. Each channel has its own features and implies specific methods for conveying contents. Polarquest2018, as other comparable endeavors in the Arctic during the same period, made wide use of traditional media (TV, radio, newspapers and publications) along with innovative ones (websites, Twitter, Facebook, Instagram…). In the various contexts, it notified a growing audience of its own activity and experience in real-time or quasi-real-time. The peculiar nature of the expedition has confronted the project leadership with dealing with different objects, aspects and ways to communicate. The challenge was twofold: on the one hand, there was a need for effectiveness, by faster and more pervasive communication. On the other hand, there was the complex task of conveying engaging but at the same time accurate accounts of what was being done.

In the overall expedition scenario, in summary, there were actually two sides and each one had its own, specific, approach. On one side, scientific research followed its standard, recognized paths; on the other side, communication focused on emotion and story-telling, occasionally with some degree of «poetical license» for the sake of effectiveness. Each side of the expedition should be evaluated in the respective professional field and a complete assessment of the Polarquest2018 experience would be out of the scope of this report.

However, in the author's opinion, many of the results obtained by Polarquest2018 are relevant and useful to foster knowledge and public awareness about the Arctic and its environmental issues. For a better understanding of its contributions, the project should be considered, specifically, in terms of the acquired data, in terms of methodological indications and in terms of communication impacts: all aspects of the experience are valuable for those – authorities and citizens – dedicated to monitoring and managing environmental and anthropic phenomena, in a fragile geographical context such as the lands of the «Great North».

September 27th, 2020

Part I

Expedition Overview

1. *Geographical context*

1.1 *An Arctic space*

The Svalbard and Jan Mayen archipelago is a group of islands located in the Arctic Ocean between Long. 10° E and 35° E, and Lat. 74° N and 81° N. Its overall surface is 61,022 km^2, it includes two larger islands, i.e. Spitsbergen (37,814 km^2) (Eeg-Henriksen and Sjømæling 2016, p. 4) and Nordaustlandet (14,443 km^2). Other major islands are Edgeøya (5,030 km^2) and Barentsøya (1,330 km^2) (Stange, 2012, p. 15) (fig. 2).

In the second semester of year 2018, when Polarquest2018 visited Svalbard, the total population was 2,787 inhabitants, out of which: 2,310 were in Longyearbyen and Ny-Ålesund (1,586 Norwegian residents and 724 not resident in mainland Norway), 467 in Barentsburg/Pyramiden and 10 in Hornsund (Statistics Norway, 2020a).

Total population density is therefore about 0.045 inhabitants/km^2, a very low value indicating an essentially uninhabited region, even more if one takes into account that most of the inhabitants are concentrated around Isfjorden, in Western Spitsbergen.

Fig. 2 – *The Svalbard archipelago*

Source: *www.toposvalbard.npolar.no* (modified)

Morphologically, much of Svalbard is mountainous. The maximum altitude is at the summit of Newtontoppen (1,712 m a.s.l.[5]), but sharp profiles and skylines are a common sight in the area (fig. 3). About 43% of the total surface of the archipelago is below 300 m a.s.l (Rein Bore et al., 2012, p. 4) and several islands, islets and rocks are pretty flat and low (fig. 4).

Fig. 3 – *Mount Bautaen (487 m a.s.l.)[6] is a most evident example of Svalbard's «jagged peaks», earning the archipelago its ancient name of «Spitsbergen»/«Spitzbergen», variously meaning «pointed/steep mountains»*

Source: ph. by G. Casagrande (2018)

(5) A.s.l.: above sea level.

(6) Position: 76°58'N, 16°23'E.

Fig. 4 – *Storøya*[7]*, off the icy coast of Nordaustlandet is flat and mostly covered with ice, even in summer. It exemplifies well the orography of many small islands of Svalbard*
Source: ph. by G. Casagrande (2018)

Given the high latitude of the archipelago, daylight follows the typical astronomical patterns of the polar region (fig. 5). In Longyearbyen, Svalbard's main settlement, the sun never sets between April 20th and August 22nd. «Polar night», i.e. 24 hour/day darkness is between November 11th and January 30th. Average annual temperatures (-16°C in winter and +6°C in summer in the period 1961-1990) and precipitations (200-400 mm), in general, are typical of the Arctic region, although Svalbard is reached by the Gulf Stream and therefore features a milder climate (warmer and more humid) than other locations at the same latitude (Ruman et al., 2012, p. 575). Average temperatures appear to be increasing in recent years (Eeg-Henriksen and Sjømæling, 2016, p. 5). Seasonal temperature increase begins in early March and reaches the maximum in July, with a major variation in May (Salvatori et al., 2005, p. 2). A 2020-published study led by the Norwegian Meteorological Institute considered temperature variation trends in Svalbard based on historical series from 1898 to 2018, stating that:

(7) Position: 80°05'N, 28°04'E.

«The most pronounced changes in the 120-year record occur during the last three decades. […] During the entire time span of the series, the western Spitsbergen climate has gone through stepwise changes, alternating between cold and warm regimes; 1899-1929 was cold, 1930-1961 warm, 1962-1998 cold and 1999-2018 warm. The latest cold regime was 1.0°C warmer than the first cold one, and the latest warm regime was 1.7°C warmer than the previous warm one. For the whole series the linear trend for annual means amounts to 0.32°C/decade, which is about 3.5 times the increase of the global mean temperature for the same period. Since 1991, the rate of warming at Svalbard Airport is 1.7°C/decade, which is more than twice the Arctic average (0.8°C/decade, north of 66°N) and about seven times the global average for the same period» [Nordli et al., 2020, p. 1].

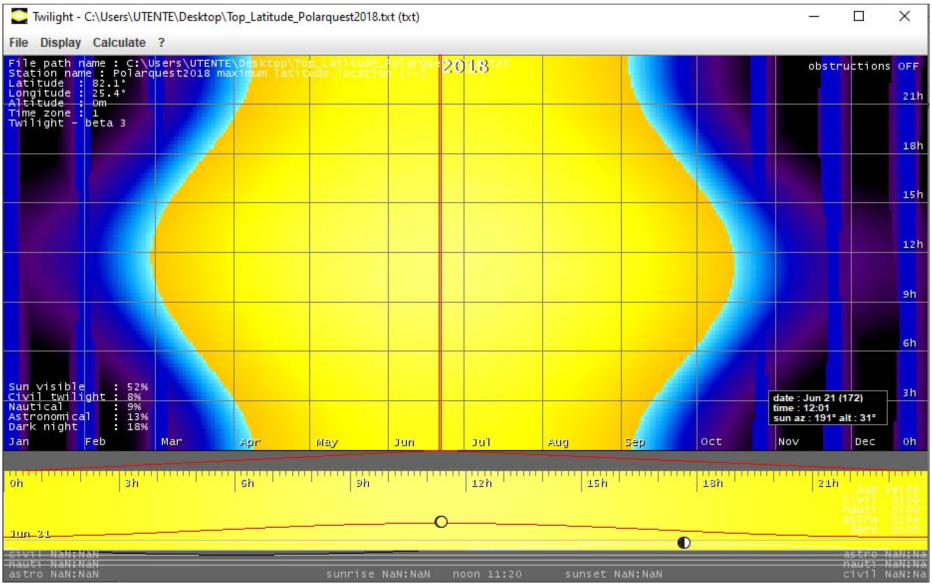


Fig. 5 – *Yearly daylight diagram at the northernmost location reached by Polarquest2018 (82°07'N, 25°25'E), as visualized by the* Twilight *application*

Source: *Twilight* by P. Gallinelli (*http://www.sailworks.net/igloo/app_twilight_e.htm*)

About 60% of land surface in Svalbard is covered with glaciers and ice (Elvevold et al., 2007, p. 27; Ruman et al., 2012, p. 574), with the two largest glaciers being Austfonna (8,492 km^2) and Olav V Land (4,150 km^2). «Tidewater glaciers are the dominant glacial systems existing, and [their] cliffed fronts constitute up to 25% (900 out of 3,587 km) of the archipelago total shoreline length» (Strzelecki et al., 2020, p. 1326). However, glaciers in Svalbard are overall retreating and shrinking (Eeg-Henriksen and Sjømæling, 2016, p. 5; Kohler et al., 2007, pp. 4-5). Fürst et al. (2019, p. 7) cites other studies (i.e. Hagen et al., 1993 and Martín-Español et al., 2015), estimating, respectively, a total ice volume in Svalbard to be 6,988 km^3 in 1993, and 6,746 km^3 in 2015.

> «Typically, the glaciers move with moderate velocities, not exceeding 1 m per year (in water equivalent) for ice flow and 10 m per year for surface velocity at ELA. However, rapid movements occur as well, particularly during surge episodes […]. Surges tend to repeat in cycles, which in Svalbard last between several decades and several hundreds of years. Earlier in the Quaternary, the whole Svalbard was covered with an ice sheet. Once it melted, isostatic movements lifted the land, leaving raised beaches next to the shores. […] Even nowadays the mass balance of Svalbard glaciers is negative, so the percentage covered by ice diminishes. Particularly intense ablation is experienced by tide-water glaciers, where additional ablation process is calving. Along with glaciers, ice-cored moraines melt and reshape» [Ruman et al., 2012, p. 574].

Besides its own wide ice-covered surface, the archipelago is relatively close to the Arctic pack, and its islands and coasts are seasonally subject to be surrounded or blocked by pack ice.

Summer 2018 presented the Polarquest2018 expedition, along with residents and tourists, with particularly evident deglaciation conditions both on land and sea. Corresponding time periods for years 2016, 2017 and 2019 indicated a different situation in terms of coverage (fig. 6). While the permanent ice-cover of the archipelago appears to be decreasing, letting new land to appear, the morphology of entire Svalbard, including mountains, valleys and seafloors along the coasts appear to be deeply shaped by millennia of ice presence and motions (*ibidem*):

> «Svalbard is a geologically diversified area, consisting of rocks formed as early as in the Precambrian, as well as Tertiary and Quaternary sediments. Western and north-eastern part of the archipelago is built of rocks called "The Basement", formed before Silurian. These rocks underwent multiple metamorphosis, folding and faulting episodes. The oldest rocks found in the area, dated using zircon minerals, are 3200 million years old. The southern part is generally formed by post-Devonian strata, with Tertiary rocks located in the middle of the area (Central Tertiary Basin, with almost horizontal rock layers). Devonian rocks show only in the middle north of Spitsbergen […]. Tertiary strata contain coal seams» [*ibidem*, pp. 573-574].

The archipelago features three major groups of geologic formations (fig. 7): a Precambrian-Silurian basement consisting prevailingly in igneous and metamorphic rocks; an area of unaltered sedimentary rocks, dating back to the late Paleozoic to Cenozoic, and, finally, areas of unconsolidated Quaternary superficial deposits, including moraines, fluvial and beach deposits, talus and scree (Elvevold et al., 2007, p. 8). Large coal seams are present in Spitsbergen; coal reserves originated in the Tertiary have been intensively worked in the mining settlements of Longyearbyen, Grumantbyen, Barentsburg, Sveagruva and Ny-Ålesund (*ibidem*, p. 31). Most soil in the archipelago, besides the periglacial areas, for a total of about 25.000 km^2 (Humlum et al., 2003, p. 199) is permafrost – between 1 and 500 meters in depth (*ibidem*, p. 191; Ruman et al., 2012, p. 574) and about 1 to 2 meters of it thaw in the summer (Wawrzyniak, 2016, p. 220), although in recent years, the general trend towards deglaciation reduces the frozen surfaces on large areas and, by reducing their total albedo, it causes a greater absorption of solar energy in the soil, and therefore a larger proportion of permafrost to thaw. This process releases more methane and carbon dioxide in the atmosphere on a seasonal basis and, as it is the case in many other regions of the Arctic, it causes concern about possible climate and environmental perturbations.

Another historically famous mining site (Pyramiden) was active in an area of Carboniferous formations in Billefjorden (Elvevold et al., 2007, p. 15).

Svalbard feature a typical Arctic tundra vegetation for about 6-7% of its land area, with no trees and very low and small plants, fungi, lichens and musks.

> «The environment and proliferation of the species are characterised by large variations in temperature, a short grow season, little availability of nutrients, wind exposure and soil movements caused by frost. Nevertheless, a total of 178 natural species of vascular plants, 380-390 species of moss, 708 species of lichen and more than 750 species of fungus have been registered as of 2015» [Eeg-Henriksen and Sjømæling, 2016, p. 6].

«Vegetation starts to bloom in lower temperatures than in temperate latitudes: 0°C is the beginning of vegetation period […] and 2.5°C is enough for flowers to blossom and produce seeds» (Ruman et al., 2012, p. 575). While Arctic ecosystems in general show variations that can be related to climate change, there is evidence that at least some vegetation ecosystems in Svalbard show minor or at least not evident change even after relatively long periods of time, probably due to the inherent stability of plant species, the remoteness of the habitats – limiting the establishment of alien species – and their capability to resist climate-induced changes of the environmental contexts (Prach et al., 2010, p. 638; citing also Parmesan, 2006). Nevertheless, in spite of its biological robustness, typical Arctic tundra vegetation requires long time for development. This, particularly, is a major frailty aspect, when put under intense human presence and activity.

Wildlife of Svalbard includes many species of marine and land-based animals, as well as birds, most of which are now protected or subject to limited and thoroughly regulated harvesting.

As far as birds are concerned, 212 species were documented in Svalbard in 2015, 28 of which are habitual nesting birds. The most common terrestrial birds in Svalbard are the rock ptarmigan and the snow bunting (Norwegian Polar Institute, 2020a; Stange, 2012, pp. 148-169).

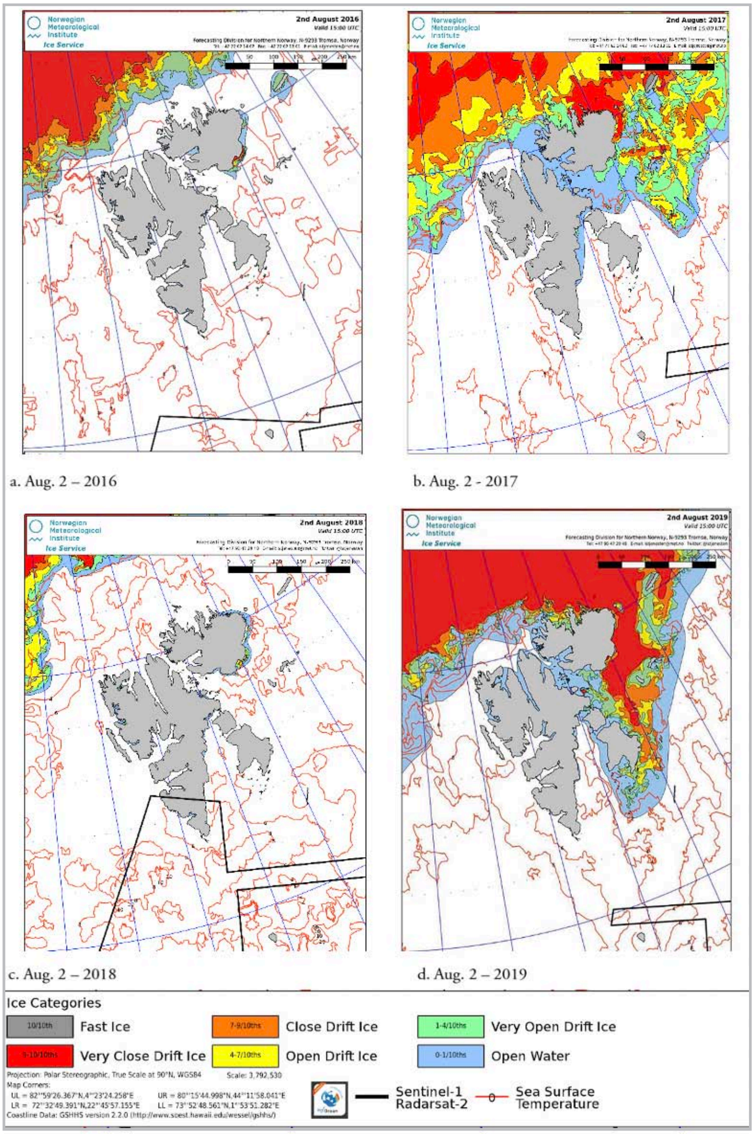


Fig. 6 – *Ice charts published by the Norwegian Meteorological Institute for the same date in years 2016, 2017, 2018 and 2019. As NANUQ was planned to navigate in «open water», «very open drift ice», «open drift ice», up to a maximum of «close drift ice», the circumnavigation of Svalbard would have been deemed possible only in 2016 and 2018, with the latter being the mostly deglaciated year in the series*

Source: *https://cryo.met.no* (modified)

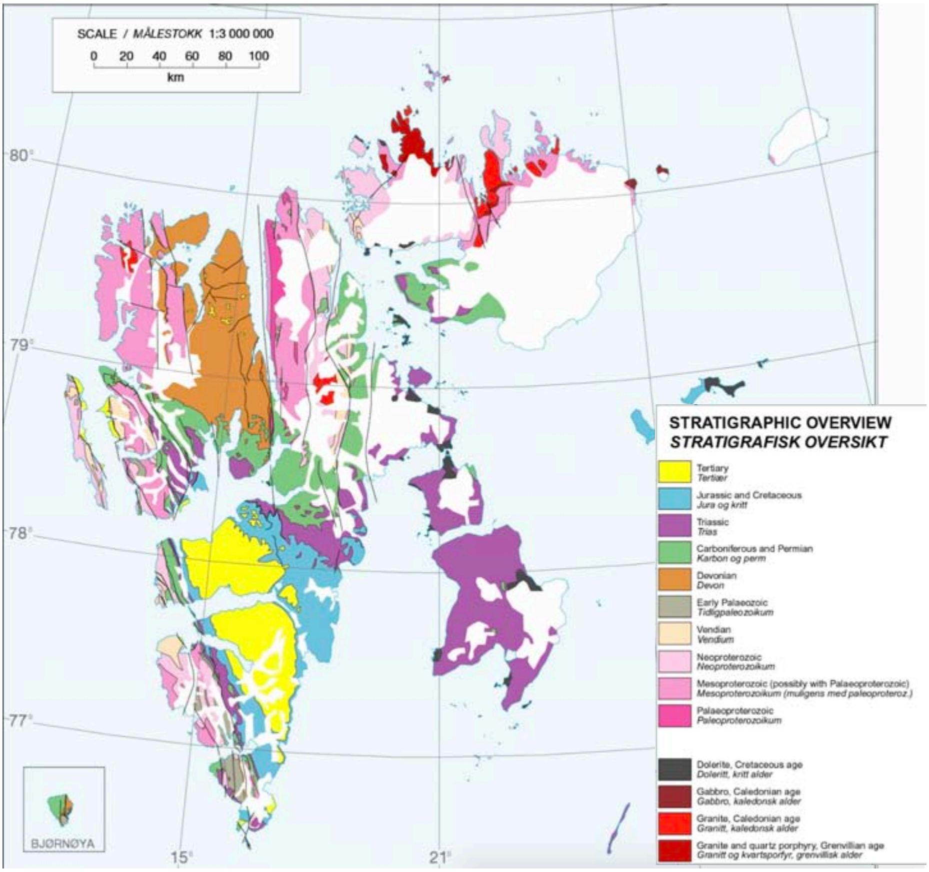


Fig. 7 – *Geological map of Svalbard*

Source: from Elvevold et al. (2007, p. 34, modified)

Sea wildlife include fish in the Svalbard area and surroundings [Norwegian Polar Institute, 2020a].

> «Fish […] can be grouped into pelagic fish (e.g. capelin and herring) and demersal fish (e.g. cod, haddock, pollack, redfish, cusk, halibut and Greenland halibut). Arctic species include Arctic cod, common snailfish, snakeblenny and eelpout), Greenland shark is also present, probably in fairly large number, although precise information about its quantity and distribution is lacking».

As other Arctic regions, Svalbard were famous in the past for the abundant presence of whales and seals. «Seals dominate in terms of numbers, while wales dominate in terms of biomass».

Five species of whale can be commonly encountered in Svalbard,

> «While around ten other species occur more or less rarely. There are three whale species that breed and remain in this area all year round: beluga whale, narwhal, and bowhead whale. […] In addition, a number of other whale species visit the Svalbard area from the south in order to hunt for food during the summer, the most common of these being the minke whale, fin whale and humpback whale» (*ibidem*).

Four species of seals are found in Svalbard: ringed seal (the most common species), bearded seal (about 2,000 individuals), harp seal, harbour seal (about 2,000 individuals, but the specie is on Norway's red list and totally protected). A case of its own is the walrus, whose population, widespread in the area between Norwegian and Russian territories, was actually increasing as of 2016 (Eeg-Henriksen and Sjømæling, 2016, p. 7). The most spectacular representative of Svalbard fauna, i.e. the polar bear is considered to be a marine mammal, «as they spend much of the year out on the sea ice and almost exclusively obtain all their nourishment through marine species» (Norwegian Polar Institute, 2020a). Among «Svalbard slogans» a popular one is that the archipelago has about 2,000 inhabitants and about 3,000 polar bears (Norum, 2016, p. 46; Sellari, 2016, p. 476). A 213-flight-hour helicopter census survey was performed in 2004 yielding such total number of individuals, but in the entire Barents Sea region (Stange, 2012, p. 114). Svalbard bears appear to belong to the Barents Sea population: 685 animals were counted in the Svalbard and Norwegian area in 2004 and 975 in 2015, «however, these figures are subject to considerable uncertainty» (Norwegian Polar Institute, 2020a).

Land mammals include the Svalbard reindeer and the arctic fox as the most typical representatives. Human presence introduced dogs and, more recently (probably between 1920 and 1960) sibling voles (Eeg-Henriksen and Sjømæling, 2016, p. 6; Norwegian Polar Institute, 2020b).

1.2 *An Arctic place*

In the course of history, Svalbard transitioned from the status of a no man's land in an overall anecumenical region, to that of a base-camp for international competition in the race for the North Pole, to being one of the most relevant geographical laboratories for studying opportunities, challenges and experiences in the upcoming «territorialization» of the Arctic.

Svalbard was a *terra nullius* or *res communis* for a long part of its history (Rein Bore et al., 2012, p. 3; Arlov, 2020, 9, f.n. 4). The toponym dates back to a Norse chronicle for 1194, but it is uncertain whether it referred to the archipelago as we know it, or rather to other regions, e.g. in Greenland, or even the Arctic pack. The word *per se* means «cold-edge». Officially, the islands were discovered by Willem Barents in 1596 and given the name – reported with some variants in time – Spitsbergen, i.e. «jagged mountains», as the Dutch explorer was obviously stricken by the sight of high mountains while his fleet was cruising along the western coasts of the archipelago (*ibidem*, p. 6). In 1607, British navigator Henry Hudson arrived on the northern coasts of the islands and returned news about the Arctic wildlife (Sellari, 2016, p. 467). In 1612 whale hunting began in the area, resulting in a direct competition – including geopolitical demands – between the Dutch and the British states, and other countries such as, among others, France, Spain, Denmark-Norway (Jasinski and Zagórski, 2013, p. 318)[8]. The latter asserted in those years – and later as well – its claim to the archipelago, even sending ships to it in 1615. Nevertheless, the islands remained *terra nullius*, with little dispute, from 1620 on (Arlov, 2020, p. 7), due to several European parties' intention of exploiting the local resources (Avango et al., 2011, p. 30).

> «The first stage of geographical recognition of the archipelago was achieved at that time. After extermination of almost all the population of the Greenland whale (Balaena mysticetus), the Spitsbergen coasts deserted […]. The Russian (Pomor) hunting industry stations were distributed sparsely but more regularly (also in the east) in the form of single huts or small settlements including a few huts with their infrastructure […]. Prior to the Russian hunters' departure in the middle of the 19th century, the first Norwegian trappers had appeared at the end of the 18th century. Since the 19th century, they have dominated the local hunting activity» [Ziaja, 2019, p. 52].

Between the end of the 18th, and the 19th century, much international effort was spent in exploring and documenting the Polar regions, including the then-called Spitsbergen archipelago. Among these experiences, it is worth mentioning work conducted by the British, beginning with an exploration by John Phypps in 1773. Norwegian geologist Balthasar Mathias Keilhau visited the islands during a Swedish expedition in 1827 and clarified the potential of the area for coal mining (Sellari, 2016, p. 468). French expedition «La Recherche» visited the area in 1838-1839 (Eeg-Henriksen and Sjømæling, 2016, p. 2). A major exploration effort was put forth by Sweden and Norway in the second half of 1800s, leading to the 1874 publication of a detailed cartography by Adolf Erik Nordenskiöld.

(8) The authors add also an interesting description of how this primeval industry operated in the area: «In general, there were two main types of whaling – bay whaling, where the slaughtered animal was towed onto the land and processed at stations built on the shore, and pelagic whaling which took place far out at sea, close the pack ice, where the blubber was either cooked to produce oil on board the ships or packed into barrels to be processed back in the home country».

> «Precise topographical maps current for 1899-1900 at a scale of 1:50,000 and 1:200,000 […] made a huge progress in the quality of the island's cartographic picture. These maps are a very valuable material for today's comparative studies on the [Spitsbergen] island landscape changes because the turn of the 19th century became the end of the Little Ice Age with the maximum Holocene extent of glaciers» [Ziaja, 2019, p. 53].

During the 1800s, as interest towards the Arctic region in general and to the North Pole was rising, several locations along the Arctic coasts were deemed suitable to establish base-camps as well as wintering stations and exploration bases. Among them, Svalbard turned out to be particularly convenient: the islands had been repeatedly visited in the past and settlements had been established by fishermen, sailors and travellers. Furthermore, the archipelago was relatively close to continental Europe but at the same time it was sufficiently deep in the Arctic region so as to serve as advanced starting point for reaching the North Pole and also as a safe area for transit or stop-overs. A famous example was that of polar ship FRAM which stationed temporarily in Virgohamna under the command of Otto Sverdrup in 1896, on her way back to Norway during Fridtjof Nansen's expedition. In that occasion, it met the Swedish expedition led by Salomon August Andrée, waiting to depart for its polar flight.

By the end of 1800s, the islands' potential as coal mining sites was discovered. At the beginning of the new century exploitation of the relevant local reserves was initiated. Remarkable interests on the area were shown by many European countries and powers at the time. Among the pioneers, a major role was played by American entrepreneur John Munro Longyear, who established, through the Arctic Coal Company, a full-blown mining community on the southern shore of Isfjorden in 1906. He was to hand his creature over to a Norwegian governance in 1916 (Avango et al., 2011, p. 35), but gave birth to the current northernmost administrative community in Norway and whole Europe: Longyearbyen (fig. 8). After Norway's separation from Sweden in 1905, the establishment of a Norwegian sovereignty over the Spitsbergen archipelago became once again a theme of debate and a major nation-building topic for the newly independent country. The growing interest in exploration records, territorial control and access to resources contributed to boosting nationalist rhetoric, notwithstanding some *de facto* cooperation at a scientific and technological level (Capelotti, 1999, pp. 34-35; Drivenes and dag Jølle, 2006, p. 40; Lajus and Sörlin, 2014).

The sovereignty issue was finally resolved in 1920, when the «Spitsbergen Treaty» was signed in Paris, assigning Norway sovereignty over the archipelago under the condition that the country granted rights, to all signatory states, to establish settlements and conduct revenue activities in the area. Possibly taking into some account that the obtained sovereignty was not perceived – even internally – as unalloyed (Grydehøj, 2020, p. 271), when the treaty became effective, in 1925, Norway took over the archipelago and renamed it Svalbard, an act of high symbolical meaning, rooted in a deep, socially shared «Svalbard myth» or «Svalbard principle» (Kristensen, 2019, p. 76; Arlov, 2020, pp. 12-13; Grydehøj, 2020, p. 268).

Meanwhile, as the «rush to the Pole» continued through the end of the 19th century into the first decades of the 20th, the islands hosted several expeditions; among them, it is worth mentioning some of the most innovative, which tried to reach the Pole by air. Such was the case for Salomon August Andrée (Sweden, 1896-1897) who attempted to use a hydrogen balloon; for Walter Wellman (USA, 1906-1909) the first to use an airship in the Arctic; for Roald Amundsen (Norway, 1925), who headed for the Pole by flying boats; for the Amundsen-Ellsworth-Nobile expedition (Norway-USA-Italy, 1926), first successful transarctic flight from Europe to America by airship NORGE; for Umberto Nobile (Italy, 1928), who deployed the first geographic flying laboratory in the region, i.e. airship ITALIA; finally, for the wide international search and rescue operation by several countries to recover the stranded survivors of ITALIA (1928-1931). Andrée and Wellman departed from Virgohamna, Danskøya; Amundsen, Ellsworth and Nobile all took off from Ny-Ålesund, Spitsbergen. The rescue operations for ITALIA used many different bases and spots in the archipelago.

The favourable geographic situation of Svalbard in the Arctic region, and the relevant scientific effort developed during the rush for the Pole contributed to qualifying Svalbard as a location for scientific research; a vocation which was to bring about important results later.

With the intensive coal-mining activity started between 1901 and 1912, and the tardy adherence of the Soviet Union to the Svalbard Treaty in 1924 (Norum, 2016, p. 39; Sellari, 2016, p. 468), the leading parties in coal mining became Norway and the Soviet Union, as from 1925 the active presence of firms from other countries – particularly Dutch, Swedish and British – progressively disappeared (Umbreit, 2013, p. 38). Starting from 1916, the Norwegian mining activity and the Longyearbyen area were managed by the Store Norske Spitsbergen Kullkompani Aktielskap (Pelliccioni, 2016, p. 2) which, for many decades, controlled all services – even a local currency (Grydehøj et al., 2012, p. 104). The Russian interest in the archipelago had begun in 1912 with an expedition by Vladimir Alexandrovich Rusanov, who visited the areas of Bellsund, Van Mijenfjorden, Isfjorden, Grønfjorden, Adventdalen and Colesbukta. After the operational establishment of Norwegian sovereignty in 1925, both Norway and the Soviet Union began purchasing areas and lands in Svalbard which had been previously claimed by other owners. The USSR began mining activities in Grumantbyen in the early 1920s. It took over Pyramiden from a Swedish company in 1927 and Barentsburg from a Dutch company in 1938. Soviets made their management converging to state company Trust Arktikugol', founded in late 1931, which became a monopoly for managing USSR's mining activity in the Arctic. Settlements and activities in the archipelago were radically disrupted by WWII events, but resumed quickly after the war. Despite Grumantbyen's shutdown in 1961 (Kinossian, 2020, p. 97) population from the Soviet Union in Svalbard increased up until the early 1980s – a demographic peak phase for the entire archipelago – bringing the total population to about 4,000 people, with Soviets outnumbering, though temporarily, Norwegian inhabitants (Eeg-Henriksen and Sjømæling, 2016, p. 10).

While the core activity in Svalbard economy was the mining industry and related sectors, the system was essentially depending on fluctuations in the market and commercial demand for coal. In spite of century-long efforts, coal production and export from the archipelago proved a challenging business, often requiring subsidization by the governments supporting each party (Norum, 2016, p. 33); the geopolitical implications of presence and activity in Svalbard were evident, but mining ended up being – on the long run – a poorly competitive business for the region (Grydehøj, 2020, p. 271). Population involved in mining activities in the archipelago, therefore, began to decline during the 1990s – with major decreases in the Russian settlements – and by 1997-1998 Russian policies for the area changed. Arktikugol', in spite of a remarkable yearly production of about 400,000 tons of coal, opted to shut down Pyramiden (which was to remain virtually as a ghost-town for about twenty years) and reduce presence and activity in Barentsburg, whose population dropped to less than 500 inhabitants. In 2007 coal production in the archipelago was over 4 million tonnes, with a total of about 22 million tonnes for the mining activity around Longyearbyen since its beginning (Elvevold et al., 2007, p. 31).

As of 2016, production was down to slightly over 1 million tonnes, the only operating mine in Svalbard was Adventdalen mine no. 7, feeding coal to a modest export for industrial purposes and providing fuel to Longyearbyen thermal electric power plant (Eeg-Henriksen and Sjømæling, 2016, p. 8).

In the second half of the 20th century, oil drills and surveys were also attempted for other mineral resources in several areas of the archipelago; however, no commercial opportunity emerged from these alternative proposals (Elvevold et al., 2007, p. 32; Ziaja, 2019, p. 54).

In the meanwhile, scientific research began to thrive in Svalbard. Some interest towards this field, paradoxically, was added by military efforts. During WWII, Svalbard was identified as an effective meteorological observatory for both the Arctic and the North Atlantic regions. A network of meteorological stations was therefore established in the area, particularly by the German forces. It is worth noting that the very last active German unit was at the «Haudegen» weather station (80°02'N, 22°31'E), deep in Rijpfjorden (Nordaustlandet), evacuated in September 1945 (Stange, 2012, p. 220).

In 1956 Poland established a full blown, though relatively isolated, scientific base in Hornsund. An accident in the mining station of Ny-Ålesund in 1962 virtually stopped any similar activity in the area and the old settlement became, through the following decades, the largest scientific research town in the archipelago, gathering stations from different countries (tab. 1).

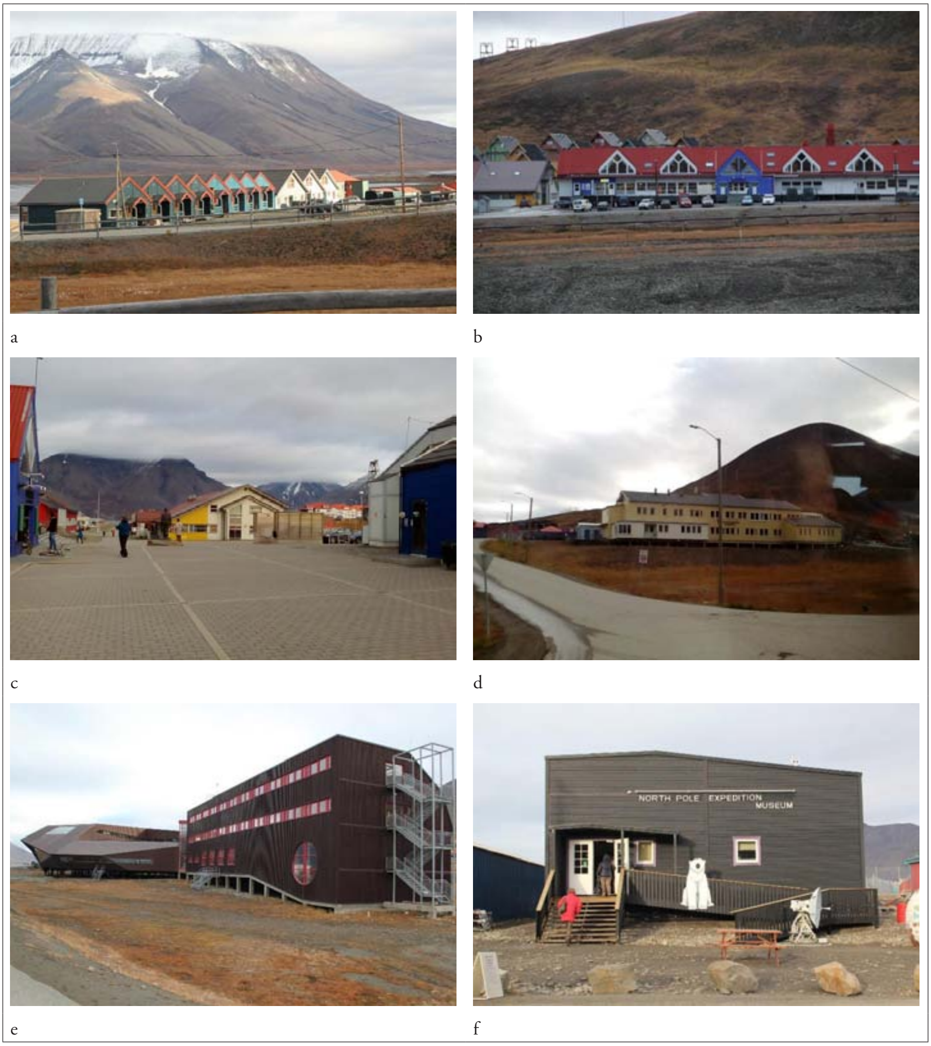


Fig. 8 – *Views of Longyearbyen, the main town of the archipelago: a) residential buildings; b) the town centre; c) main Square; d) hospital; e) University Centre in Svalbard; f) North Pole Expedition Museum*

Source: ph. by G. Pietrantoni (2016)

Tab. 1 – *Research stations in Ny-Ålesund*

Station's name	Research Institute	Country	Year established	Main research fields
Jean Corbel (AWIPEV)	Alfred Wegener Institut - Institut Polaire Français P.-É Victor	France - Germany	1963	Hydrology, glaciology
Zeppelin	Norsk Polarinstitutt	Norway	1988	Atmosphere
Japanese Station	National Institute of Polar Research	Japan	1990	Meteorology, glaciology, oceanography, biology
British Station	British Antarctic Survey	United Kingdom	1991	Earth Science
Koldewey (AWIPEV)	Alfred Wegener Institut-Institut Polaire Français P.-É Victor	France - Germany	1991	Atmospheric physics and chemistry, geology
VLBI	Kartverket	Norway	1992	Interferometry
Arctic Station	Rijksuniversiteit Groningen	Netherlands	1995	Ecology
Dirigibile ITALIA	Italy's National Research Council	Italy	1997	Environment and climatology
Rocket Range	Andøya Rakettskytefelt	Norway	1997	Space probes
Rabot (AWIPEV)	Alfred Wegener Institut - Institut Polaire Français P.-É Victor	France - Germany	1999	Atmosphere and biosphere
Sverdrup	Norsk Polarinstitutt	Norway	1999	Various
Dasan	Korea Polar Research Institute	South Korea	2002	Atmospheric chemistry, glaciology
Arctic Yellow River	Chinese Arctic and Antarctic Administration	China	2004	Glaciology, marine ecosystem, meteorology
Marine Laboratory	Kings Bay	Norway	2005	Marine biology
Himadri	National Centre for Antarctic and Ocean Research	India	2008	Marine ecosystems and pollution

Source: Sellari (2016, p. 478)

Here it is also worth mentioning another scientific research site, the relatively large Danish-Finnish-Swiss scientific station established in Kinnvika, Nordaustlandet, in 1957-1959 and reactivated between 2009 and 2011. The then semi-abandoned installation was briefly visited by Polarquest2018.

Beginning from the 1980s, a significant and more general evolution began in Svalbard and involved its nature «as a place». From a remote space for technicians, mine-workers and scientists, the archipelago began a slow but constant turn towards the model of a peculiar – but in many ways ordinary – human community on the edge of a millenary frontier. No longer just a technical or scientific base-camp, the archipelago appeared increasingly as an incubator for proving and demonstrating future human settlements in a new, vast region of the planet which had been inaccessible so far.

In 1975, Longyearbyen's commercial airport was opened, providing year-round connections to the archipelago[9]; a few years later communications were also improved by establishing telephone services in 1978 and by bringing TV signals to the archipelago in 1984. Digital technology and broadband data arrived between 2003 and 2010 (Eeg-Henriksen and Sjømæling, 2016, p. 3). Obviously, when Polarquest2018 visited the region, the islands appeared to be, at least in some of their locations, a very different place from what they had used to be in the heroic days of polar explorers and almost heterotopic company-towns for coal mining.

In recalling his past research on Svalbard in a writing for a seminar held in Longyearbyen by the Italian Geographical Society in 2016, geographer and anthropologist Franco Pelliccioni underlined that Longyearbyen – the very centre of Norwegian policy for the archipelago – appeared to be, at the time of his first study in 1994 – involved in a struggle for a sort of transition from the identity of a «company town» to the narrative of a «normal community» (Pelliccioni, 2016, pp. 2-3). Yet, such «normal community» had in 1994 a definite nature as an *ad hoc* social and organizational entity, very far from the physiognomy of a natural community, as it was evidently mining-oriented and mostly consisting in a population of young, male workers, devoting little attention to circulation of external visitors and non-mining related activities. This was even more evident among the shrinking Russian-Ukrainian communities.

Several steps forward took place for Svalbard on the way of the «normal community», and now the process appears to be well developed, but not completely; some role in this incompleteness – especially in terms of the integration between Norwegian and Russian communities – may also be played by practical difficulties in access to telecommunication network and physical mobility. A cost-based technological divide, the uneven development of communication means across Svalbard and restrictions to movement and operation in the area due to environmental regulations are factors to this difficulty. A certain gap seems to still exist between tourists (and tour operators) and local inhabitants, with the former «wandering around» several locations, while the

(9) Technically speaking, the airport was not the first one to be built in Svalbard; an airstrip was created during WWII by German forces and other provisional facilities were used until 1975, but did not provide full-blown and year-round commercial aviation services.

latter spend most of their time in the same working and living places, enjoying *de facto* more or less limited external mobility (Vlakhov, 2019, pp. 1516-1518).

> «A place of hardship, starvation and death in the early years of colonization, nowadays Svalbard is being transformed into a tourist resort and a research base. Although Svalbard remains a place of hard labour and unforgiving nature, the Norwegian and Russian settlements seem to compete in offering tourist services, and sometimes restaurants, representing an almost hedonistic style of consumption. In this pursuit of modernity, "normality" and comfort, something seems to be lost of Svalbard's true nature. The Russian settlements [particularly Pyramiden] show how loss and the void make themselves delt in a haunted landscape» [Kinossian, 2020, p. 90].

Beyond the official residents, in 2016 a small number of other Svalbard inhabitants were in charge of individual stations or settlements even though they were not classifiable as residents according to Statistics Norway; Ny-Ålesund scientific base hosted a year-round personnel of about 40, and a seasonal population of about 100 researchers from several different countries. The Polish Scientific Station in Hornsund hosted about 10 people (Stange, 2012, p. 15). The majority of Svalbard inhabitants comes from Norway, the most numerous minority is Russian; 537 persons in the statistics come from 46 other countries. In total, 55% of the community is men, 45% women, indicating a convergence to equal values, while in the past Svalbard was essentially a male community. As of 2015, there were about 300 different enterprises in Longyearbyen, mostly involved in the tertiary sector (Eeg-Henriksen and Sjømæling, 2016, p. 8), particularly tourism, administration, law enforcement, research and academics. Employees in mining industry were a minority (*ibidem*, p. 14). Nevertheless, several elements suggest how such a social and economic configuration reflects a deep nature of a frontier community, somewhat artificially maintained (Norum, 2016, p. 55).

On the one hand, Svalbard is a tax-free, relatively high-wage context; on the other hand, by central policy (both of the Norwegian and of the Russian governments towards their respective communities) it is designed to be a place for work, not for a life-long living (Vlakhov, 2019, p. 1517, f.n. 1).

The population's turnover is high, most of the residents stay for a time between six months to a few years; only about 25% actually stays more than ten years. More than a half of the inhabitants are relatively young, between 25 and 49 years of age (Eeg-Henriksen and Sjømæling, 2016, p. 10), about half of the private households have single-occupants (52.3% in 2020[10]). As several slogans repeat, Svalbard is a place where there are no births and no burials – the albeit well equipped hospital is small and intended to only provide E-R services. «While Longyearbyen has childcare and

(10) Statistics Norway (2020b).

schooling provision, there is no long-term healthcare and social care provision, even for Norwegian citizens» (Grydehøj et al., 2012, p. 105; Grydehøj, 2020, p. 277).

In the configuration of such a geographical space, still periodically subject to geopolitical and geocultural claims, one should question – and so did the Polarquest2018 workgroup – what is the current nature of Svalbard as an inhabited place. From the demise of the Soviet Union and through the difficult time of the following decades, the «cold war» atmosphere in the Norwegian-Russian relations with regard to the archipelago has somewhat eased, but a claim dialectics remains between the two national communities and besides the material legacy of the respective pasts, geocultural heritage remains as well (Vlakhov, 2019, p. 1519). In an overall different political setting, the Norwegian and Russian communities are formally pursuing more cooperative and friendly relations. In those, however, Russian communities appear to more or less explicitly reaffirm their economic, but also social and cultural identity and autonomy as the only other main character in the story of the archipelago. Although this is happening within the framework of a formal compliance with the Norwegian governance, the observers' impression is that Barentsburg – and this might well also be a possible, medium/long term scenario for Pyramiden – aims to become a *de facto* Russian exclave (Sellari, 2016, p. 468), also partially due to a certain degree of containment in the Norwegian policy towards the Russian components. It is worth noting that in recent years, taking advantage of the increasing tourism in the archipelago, the Russian component succeeded in re-affirming its presence – and therefore its territorial grip – not only in Barentsburg, still active in the traditional mining industry – but also in the once lost Pyramiden, which is regaining some kind of existence in the incomer's view. It is, obviously, a peculiar type of existence. It basically testifies a past phase of Svalbard territories and therefore acts as a referent to a sort of «historical right to presence». Remarkably, while Barentsburg is presented as a visible example of a current Russian settlement in the Arctic, Pyramiden remains – more and more proudly, in its transition from the status of a ghost-town to that of a large museum – as a testimony of the Soviet era (González-Ruibal, 2013, p. 42; Kinossian, 2020, p. 91).

In search for profitable alternatives to mining, both the Norwegian and Russian components, through the last decades, developed strategies to differentiate their governance and business policies.

> «Store Norske was responsible for the provision of all community services. In 1989, these functions passed to the subsidiary Svalbard Samfunnsdrift AS, which became a fully public corporation in 1993 […]. Store Norske also transferred functions to other new companies: Spitsbergen Travel AS (tourism operations), Svalbard Næringsutvikling AS (commercial development), and Svalbard Næringsbygg AS (commercial property). Differentiating these functions from mining operations made truly diversified development possible» [Grydehøj et al., 2012, p. 105].

With Pyramiden shut down in 1998 and Barentsburg's community being tenaciously maintained for political motives, Trust Arktikugol' tried to differentiate its business by fostering tourism through a subsidiary company with a historic and evocative name: «Grumant». As of 2018, the attempt had proved only partially successful (Grydehøj et al., 2012, pp. 110-111; Norum, 2016, p. 46).

A somewhat provocative, but interesting point is made by Grydehøj (2020, p. 278):

> «It is a paradox of Norway's Svalbard policy that efforts to boost sovereignty claims have simultaneously led to the loss of Norwegian state control over Longyearbyen and to the reinforcement of Russian state control over Barentsburg. By seeking to stymie private enterprise and economic diversification in Barentsburg, Norway has inadvertently prevented the settlement from evolving out of company town status and Soviet-style centralized control».

As a matter of fact, the Soviet geocultural heritage – technically speaking, a different thing from the post-Soviet Russian establishment – appeared to initially survive in the local perception at least for a few years after the dissolution of USSR[11]. It is being now – so to speak – recovered as a specific feature of Svalbard's human and historical geography.

Beginning from 2006, the financial weight of «tourism and culture» became prevalent in Svalbard's economy. From that year on, yearly guest nights exceeded 80,000 and dwelled on that value until a sharp increase in 2013, with a boom over 100,000. About 35,000 tourists landed from cruise ships in 2013 – about 75,000 in 2016 (Olsen et al., 2020, p. 309) – and about 65,000 from the air (Sellari, 2016, p. 480).

Tab. 2 – *The 10 most visited sites in Svalbard by expedition cruises*

No.	Site	Area location	Reason for interest
1	*Ny-Ålesund*	Kongsfjorden	Scientific bases
2	*Trinityhamna/Gravodden*	Nordvesthjørnet	Cultural and natural heritage
3	*Barentsburg*	Isfjorden	Mining town
4	*Pyramiden*	Isfjorden	Abandoned mining town
5	*Julibreen/-Bukta*	Krossfjorden	Glacier
6	*Trygghamna/Alkhornet*	Isfjorden	Cultural heritage
7	*Poolepynten*	Forlandet	Walrus colonies

(11) This view is expressed in González Ruibal (2013, p. 42). Pelliccioni (2016, p. 3) cites a letter dated June 29th, 1994 by Arild Moe, Deputy Director of the Fridtjof Nansen Institute: «Until recently the Soviet (*sic*) communities were in practical terms closed for private, spontaneous visits […]. In the last five years or so the level of contact between Soviet/Russian (80% of the "Russian" miners are in fact from the Ukraine) and Norwegian settlements have increased considerably. But we are speaking about visits, not any "organic" integration».

No.	Site	Area location	Reason for interest
8	*Dolerittneset/Kapp*	Edgeøya	Cultural heritage
9	*Smeerenburg*	Nordvesthjørnet	Cultural heritage
10	*Skansbukta*	Isfjorden	Cultural heritage

Source: Evenset and Christensen (2011, p. 69) (modified by G. Casagrande)

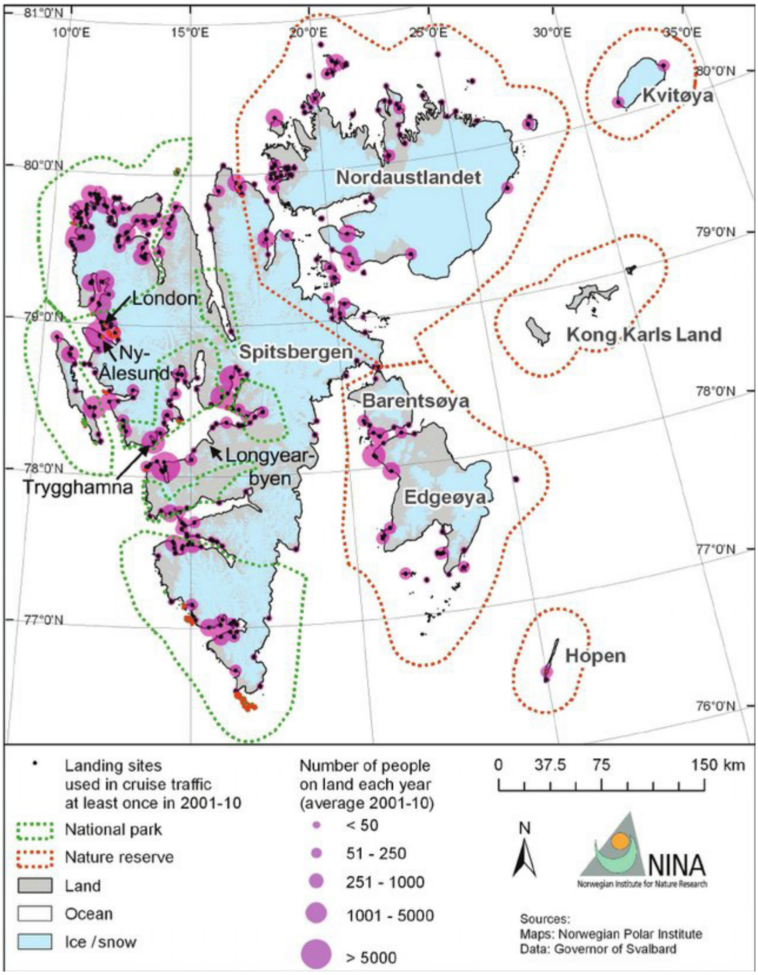


Fig. 9 – *Landing sites used in cruise traffic and average number of people on land each year, for the 2001-2010 period*

Source: Hagen et al. (2012, p. 3)

Figure 9 indicates the tourist presence around Svalbard, showing that most tours and visits concentrate in coastal areas (and are therefore organized by various types of vessels). Prevailing landings are in the western area of Spitsbergen. This reflects a clear trend in the commercial demand for tourist services in Svalbard, with likely higher number of «sedentary», massive-tourism activities. Land tours and hikes are limited by their more challenging technical nature, by the lack of comfortable communication paths and by the strict regulations on activities allowed in the wilderness.

The switch from a prevalence of mining to a prevalence of wilderness/nature related tourism facilitated the development of a set of regulations specifically aimed to preserving and protecting the natural assets of the archipelago. The overall framework of Norway's strategy for Svalbard is at the core of the

> «Svalbard Environmental Protection Act of June 15th 2001, no. 79, relating to the protection of the Environment in Svalbard, whose article 1 states: "The purpose of this Act is to preserve a virtually untouched environment in Svalbard with respect to continuous areas of wilderness, landscape, flora, fauna and cultural heritage". "Norway's Svalbard policy aims to uphold the nations's sovereignty over the archipelago, protect its wilderness and cultural heritage sites and maintain Norwegian settlements […]". Management plans for Svalbard's economy list three core activities: coal mining, scientific research and tourism, with environmental protection having priority over natural resource extraction such that the archipelago can be seen as "one of the best managed wilderness areas in the world"» (Hagen et al., 2012, p. 2).

It should be observed that, throughout history after 1925, Norway's sovereign right to protect the environment of the archipelago gave the country a *de facto* control over international rights of activity in the region as per the Svalbard Treaty terms (Zjaia, 2019, p. 54). This is certainly an aspect of geopolitical relevance, although Norwegian authorities are acting in their own – internationally recognized – right. On the other hand, however, it should be underlined that Svalbard is actually, nowadays, an example of overall virtuous environmental management of an Arctic region. From the point of view of environmental protection, different solutions appear to be in place. A first set of environmental protection areas was established in 1973 with the creation of two natural reserves, three national parks and 15 bird reserves (*ibidem*, p. 55)· In 2004 the total protection area was extended and in 2018 a total of 65% of the archipelago surface (up to 85% including territorial waters) was under a specific environmental protection regime (Sellari, 2016, p. 482; Zjaia, 2019, p. 56). There were 7 national parks, 6 nature reserves, 15 bird sanctuaries and 1 geotope (Eeg-Henriksen and Sjømæling, 2016, p. 4).

The reasons for Svalbard's popularity among tourists and tour operators has deep roots in the history of the place and its peculiar geographical charachter. A dense synthesis for this phenomenon was presented by Paolo Sellari (2016, pp. 477-478), citing also Viken (2006) and Hall and Saarinen (2010). According to these authors' interpretations, Svalbard is naturally connected to the Arctic's historical dimension associated with heroic efforts and achievements (Norum, 2016, p. 47), and also – maybe even more – to its environmental value as one of the last paradises on the planet (Saville, 2019, p. 5); such views may create in the visitor the feeling of a remote and precious sanctuary, where time and space appear to have a different meaning than that familiar to most domestic and international visitors. At the core of the increasing popularity of Svalbard is its nature as a geographical referent for a «symbolical North, iconized through images of immense spaces, different, wild as the wildlife populating it, somewhat «exotic» as the polar bear and the walrus, spaces in which the environmental destiny of the planet would be at stake. All that shapes a product that can be sold to the consumerism of the south» (Sellari, 2016, p. 479, my translation). Similar perceptions also appear to affect the view of Norwegians who – not by chance – are still the prevailing component of Svalbard's tourism (Eeg-Henriksen and Sjømæling, 2016, p. 16). In this case, the general aforementioned perception appears to be quite reinforced by the country's century-long affection for the Arctic as a deeply rooted space for the projection of a cultural identity. Such an identity has been intimately cultivated within the Scandinavian, and particularly within the Norwegian society, by the long tradition of both famous and obscure explorers, travellers and seafarers, and it deeply contributed also to the «Svalbard myth» itself (Arlov, 2020, pp. 12-13). The result of this complex cultural mechanism is a booming tourism involving Norwegians as an international audience. Once again, it makes Svalbard an important laboratory. In this case, the topic is to understand the relationship between human perceptions, views and aspirations regarding the Arctic, in this phase of transition, before – if ever – massive territorialization develops in the region.

Svalbard's *genius loci* saw a first major change when explorers, fishermen, hunters, whalers and trappers gave way to miners and scientists; another radical change occurred as tourism and culture replaced the former as dominating activity.

A certain degree of «Arctic pride», naturally, is a major part of both the local identity and the tourist marketing. The commercial product is a «land of extremes» in which so many elements are «the northernmost» ones (Norum, 2016, p. 46; Grydehøj, 2020, p. 267). Messages and slogans, on the one hand, promote the local wilderness and adventures, still a relatively uncommon experience among market services. On the other hand, the «normality» of life in this peculiar community advertises a «Norwegian way of living the Arctic» as an appropriate and well developed geocultural approach. The achievement of an overall virtuous territorialization in the archipelago is, unquestionably, a major asset for the entire polar region and, in the international perspective, it justifies Norway's sought and obtained sovereignty. If the relationship of humankind in general with the Great North is often associated with some emotional pull, that is even more inherent to the cultural and identity-related narrative of Scandinavian peoples and of Norwegians in particular. The latter have a special relationship with nature as a profoundly and sincerely felt element of their socially shared worldview. This translates into a century-old tradition of adaptive and intimate, respectful adherence towards the environment. Norwegian territorialization in Svalbard, therefore, remains consistent with these traditions of sustainability and integration with material contexts (Sellari, 2016, pp. 482-483). Obviously, this general view does not lack some contradictions, as both Norway's and Russia's policy with regard to the mining activity and its environmental impacts remain more connected to geopolitical interests than to economic convenience or environmental protection (Norum, 2016, pp. 51-53). Demonstration of presence and authority in Svalbard – like in the Arctic in general – is a most powerful driver of territorialization processes and policies; worldviews about spaces and places, however, do play a major role in territorial management as an expression of presence and authority.

Once basic problems are solved and material control is established over a certain area, then perceptions and regulatory approaches kick-in. This typical and very complex geographical process is thoroughly described in Vallega (2004); as far as Svalbard is concerned, it appears to be particularly evident for the events of the past century. After both Norwegians and Russians had established control over natural resources, then respective priorities and goals began to shape landscapes.

From this point of view, there is little doubt that the Norwegian relatively «lightweight» approach had a historical counterpart in a narrative of humanization of anaecumenical spaces. This was the Soviet view, e.g. in Barentsburg and Pyramiden. The latter were originally meant to be – among other things – two important show-sites for the socialist achievements in the territorialization of the Arctic region.

For much of its history – before and after the 1920 Treaty – Svalbard was recognized as a «geographical gate to the Arctic», a status which is particularly clear in the current geopolitical scenarios. This is a technical fact and a clearly perceived concept both at a governance and geopolitics level as well as in the common citizen's mind (at least in the region). The old view lasts to this day as Norway keeps – as it always did throughout its national history – its Arctic policy as a fundamental pillar of national identity and international action (Grydehøj et al., 2012, p. 100). In the days in which Polarquest2018 was in Svalbard, its crew had the chance of directly experiencing this strong Norwegian passion for the Arctic – and for Svalbard as its crown-jewel and crucial referent – in the most solemn and evident way. The Royal Family was making a private visit to the archipelago onboard their yacht NORGE. For a few days, small S/Y NANUQ had repeated encounters with the Royal convoy, enjoying the opportunity of a quite uncommon proximity in the small harbours and natural anchoring spots of the islands.

Parallel to this «national» view is Svalbard's persistent nature as an international and – so to speak – global interest hub. The archipelago has developed, through time, its landmarks and its general communication profile, which suggest a continuous reference to the «world heritage» nature of the islands. It is in the intentions of the sovereign authorities to maintain and uphold this view, intentionally in the spirit of the 1920 Treaty on the one hand, but also as a necessary recognition that the initial, theoretically monolithical Norwegian's state authority on the area had become way more open to private and – remarkably – foreign action in the last decades (Grydehøj et al., 2012, p. 114; Norum, 2016, p. 55)

Among the aforementioned «landmarks» one should include direct referents such as the Global Seed Vault, opened in 2008 as a world's «biodiversity capsule», and the University Centre in Svalbard (UNIS) created from a 1994 agreement among four Norwegian Universities. While still primarily connected to its hard-environmental science origin and to its national academic network, UNIS is enjoying increasing interest for international and interdisciplinary cooperation (Misund et al., 2017).

On the one hand, domestic and foreign human activity in Svalbard are thoroughly kept under monitoring and control; on the other hand, international presence and contributions are allowed by authorities. This gives other countries important – sometimes unique – opportunities, as long as they operate within the framework of a strict but impartial regulation, see the *Guidelines for research in Svalbard* issued by the Sysselmannen på Svalbard (Governor of Svalbard, 2020). The official priority is environmental protection, which may pose, in some cases, severe limits to actions – even scientific ones (Saville, 2014).

In the current international scenario, many countries – including historically non-Arctic powers – are claiming official rights of presence and action in the region also based on the terms of the Svalbard Treaty. This way, they practically take advantage of a formal lever to pursue wider long-term political strategies (Grydehøj et al., 2012, p. 112; Sellari, 2016, p. 477, f.n. 10). The prospective geopolitical and geo-economical configuration of the polar area is rather unclear today; in this context, Norway's effort to shape Svalbard based on sustainable management and international cooperation is relevant. Whether or not transarctic navigation will develop across a shrinking Arctic pack; whether or not massive land and sea-grabbing around the North Pole will occur (Craig, 2016-2017), it appears clear that technological developments, even more than other forms of global change, will increase human potential to access and use the natural and environmental riches of the area. The big question remains the simplest one: whether this access and use will happen in a responsible manner, «or not».

Sustainability in these processes will be paramount for the health of the region and the whole planet, and this is objectively finding important elements of experience in Svalbard, where overall interaction between human presence and environmental contexts is being put at an important test in these decades. Much of the future can be observed happening today – and can be properly understood – in the archipelago: an opportunity which should not be lost.

1.3 *Local and global: Anthropic pressure and pollution*

With regard to increasing human pressure on the polar regions in general, Svalbard give important indications both in terms of local impacts, and as far as long-distance, global phenomena are concerned. A historical, strong influence caused by human actions on the archipelago's environment was obviously caused by wildlife hunting. Both sea and land mammals suffered heavy losses or were endangered of extinction. In the 17th century, several species of whales were ruthlessly exterminated and driven out from their habitats in the archipelago; hunting continued, in the practical absence of any control or limitation, until 1925, after which some forms of monitoring, regulation and protection were considered. The walrus in Svalbard was seriously endangered and protection measures were adopted in 1952, yielding the positive result of an evident recovery in the population of the species in recent years. The Polar bear was hunted until about 1973, after which a strict protection regime was established and is still in effect (Eeg-Henriksen and Sjømæling, 2016, p. 7).

Since the time of industrial development, differentiated forms of pollution and environmental degradation appeared and grew. Mining activities and fuel consumption left their usual environmental impacts.

> «The largest greenhouse gas emissions on Svalbard include carbon dioxide (CO_2) and methane (CH_4). Figures for these emissions, which also include Russian activities, are very uncertain, and do not include emissions from ships, aircraft and light vehicles. Until 2013, from when we have the most recent figures, the emissions as measured in CO_2 equivalents have amounted to approximately 300,000 tonnes. CO_2 emissions from the coal-fired power plant and methane emissions associated with coal extraction have been the main sources materials» [*ibidem*, 2016, p. 5].

Mining produces obvious quantities of pollutants and extraction residues, which are released into the environment in a more or less invasive proportion depending, among other factors, on handling policies. Furthermore, abandoned mine-installations (e.g. in Pyramiden) may be difficult to clean-up of hazardous materials (*ibidem*). Local sources of pollution in Svalbard are settlements and ships – among which one should count the increasing number of cruise and tourist ships, a primary factor of local atmospheric pollutions due to their relatively massive emissions.

Cruise ships, in particular:

> «Concentrate their activities in the vicinity of Hornsund, Bellsund, Isfjord and north-western coast of Spitsbergen, but they reach also Nordaustlandet and Edgeøya. Not only they burn fuel and pollute the air, but they also allow thousands of tourists visiting coastal parts of these islands (mysteriously, they land most frequently in places occupied by Red Listed plant species). Even organic air pollution can be of local origin, e.g. in Longyearbyen snowmobile traffic causes in April and May "rush-hour" maxima of aromatic hydrocarbons in the air (up to 10 ppb). However, the main

source for pollution [in] Svalbard is the long-range transport of contaminants, and their persistence due to Arctic haze phenomenon […]. A deposition and remobilization theory, that includes both [air and water] transportation media is a possible solution to this question […]. The deposition of pollutants in the Svalbard archipelago is determined by its position (high geographical latitudes) and climatic factors. Low temperatures recorded in this area mean that a condition for survival for many species of animals is the consumption of lipids, which are the main source of energy. Fats, however, are a very good solvent for a large group of pollutants, which contribute to their penetration into the food chain» [Ruman et al. 2012, pp. 572-573].

The increase in air and marine traffic poses also the question of measuring the entity and assessing the effects of several types of environmental disturbances; beyond cargo and cruise ships, sightseeing vessels are increasingly popular for tourism in the area (Eckhardt et al., 2013, p. 8402); all discharge several types of pollutants in the water and, along with expanding land-tours with different transportation means, facilitate wear and tear on flora, fauna and other delicate environmental features (Kavan and Anděrová, 2020, p. 59). Cultural heritage, particularly on the coasts is also at risk in case of massive and indiscriminate tourist pressure, which adds to other causes of stress such as environmental and climate evolution (Holmgaard et al., 2019).

Air inorganic and organic pollutants were detected in Svalbard, with indication of a long history of accumulation[12] (Ruman et al., 2012, p. 577). Furthermore, PAH and heavy metals were observed to have a definite local distribution around human impact areas (Gulińska et al., 2003, pp. 705-706).

Another obvious environmental impact is that of waste production, which appears to be less invasive in Svalbard than in other contexts, but still on non-negligible values. In 2009 a total of over 2,500 tonnes of waste were produced in Longyearbyen and largely shipped to the mainland for processing, but the overall efficiency of waste elimination is increasing and reached a value of about 1,700 tonnes in 2015, in spite of an increasing flow of tourists and visitors (Eeg-Henriksen and Sjømæling, 2016, p. 5). On the other hand, there are forms of material transfer which reach Svalbard regardless of activity in Svalbard. Along the beaches of the islands a historically familiar presence is driftwood, i.e. the accumulation of tree branches, trunks and wood fragments carried – sometimes from very long distances – by sea currents.

«Floating marine debris is advected by surface currents and by winds; therefore the knowledge of surface water dynamic patterns is mandatory to understand how plastic

(12) According to the cited authors, pollutants detected in Svalbard include: n-alkanes, PAHs (polycyclic aromatic hydrocarbons, including naphthalene, phenanthrene, fluorene, acenaphthene, fluoranthene, pyrene) and n-alkanoic acids, polybrominated diphenyl ethers, hexachlorocyclohexane, hexachlorobenzene, organic acids (e.g. ocalic, succinic, malonic), polychlorinated biphenyl (PCBs), organophosphorus and other pesticides. There is also evidence that Persistent Organic Pollutants remarkably affected the food chain in the past and currently are, although some legacy substances are apparently reducing their impact due to discontinued use in anthropic activities (e.g. DDT).

> debris arrives in the Arctic and how it leaves the Arctic. The surface circulation within the Arctic basin has two main currents: the Transpolar Drift from the East Siberian continental shelf to East Greenland through the North Pole and the vortex of Beaufort (Beaufort Gyre) which, looking from the North Pole, usually turns clockwise in the Beaufort Sea, in the North of Alaska. The water trapped in the Beaufort Gyre can circulate the Arctic for many years while if it is trapped in the Transpolar Drift usually leaves the Arctic quickly, on average a couple of years» [Aliani et al., 2020, p. 94].

These currents are also conveying impressive quantities of plastic (macro, micro and nano plastic fragments)[13] which accumulate on the seafloor, in the water column and, with high-density, on the shores of Svalbard. «Microplastics are generally defined as plastic items smaller than 5 mm. These can originate from weathering of larger plastic items due to the influence of e.g. UV-light, mechanic abrasion, waves and temperature fluctuations (so-called secondary microplastics), or from direct emissions of plastics that were manufactured smaller than 5 mm (so-called primary microplastics)» (Knutsen et al., 2019, p. 8). Accumulation dynamics depend upon the nature of the pollutant itself (e.g. whether plastic fragments are heavier or lighter than water) regardless of the fact that they were released in proximity to the archipelago or very far from it (Falk-Andersson and Strietman, 2019, p. 39). Although these authors concluded that marine litter observable on Svalbard beaches appear, in prevalence, to have been released in relatively close regions and due to fishery activity, «through ocean currents, the region is potentially influenced by pollution coming from other parts of the world. A by-product of this connection could be that large amounts of plastic litter arrive in the region every day» (*ibidem*, p. 9). Plastic poses, *per se*, an important set of problems to environmental protection, but may also be an indication of a more complex set of phenomena related to waste and litter dispersion and circulation. Detecting and monitoring the presence of plastic fragments of different size and type in water and on land in the archipelago was one of the important goals of the expedition and is the typical kind of phenomenon whose observation can take advantage of properly coordinated and supervised citizen science (*ibidem*, p. 41).

Even more than plastic, air pollution by noxious or toxic substances is also a typically global phenomenon and obviously affects the archipelago as well. PCB, a pollutant monitored in Svalbard (Eeg-Henriksen and Sjømæling, 2016, p. 5) can be detected and measured by relatively simple devices and methods and gives an indication of global patterns of pollution spreading and dispersion. A PCB monitoring device was installed in Kongsfjorden as one of Polarquest2018 expedition's activities, with help from the Institut Polaire Français «Paul-Émile Victor» and monitored by the University of Savoie Mont-Blanc.

---

(13) Falk-Andersson and Strietman (2019, p. 8) accept the general distinction between macroplastics (>5 mm) and microplastics (<5 mm), but proposes for research purposes a classification of plastic debris by size: a. macroplastics (>200 mm), b. mesoplastic (4.76-200 mm), c. large microplastics (1.01-4.75 mm), d. small microplastics (0.33-1.00 mm), e. nanoplastics (<100 μm).

2. *Polarquest2018: Technical and organizational aspects*

This chapter summarizes the various technical and organizational components of the expedition *per se*. The part of the organization which was related to communication and story-telling activities is discussed in Chapter 7.

Fig. 10 – *S/Y NANUQ underway off the coasts of Norway in 2019*

Source: ph. by M. André

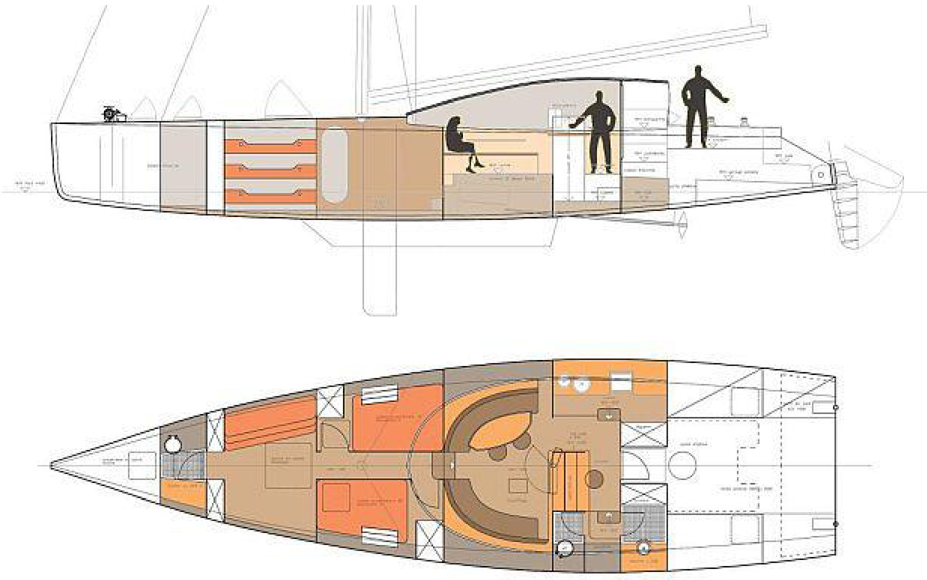


Fig. 11 – *NANUQ's internal space in the initial design arrangement*

Source: design and drawing by P. Gallinelli (2017)

Fig. 12 – *Left: NANUQ's hull during its first rotation in 2010 at Dujardin Icofrance ship yard, Rouen, France. Right: the Passive Igloo cabin under completion in 2011 at Sailworks workshop in Switzerland*

Source: ph. by M. Ryan (left) and P. Gallinelli (right)

2.1 *The boat*[14]

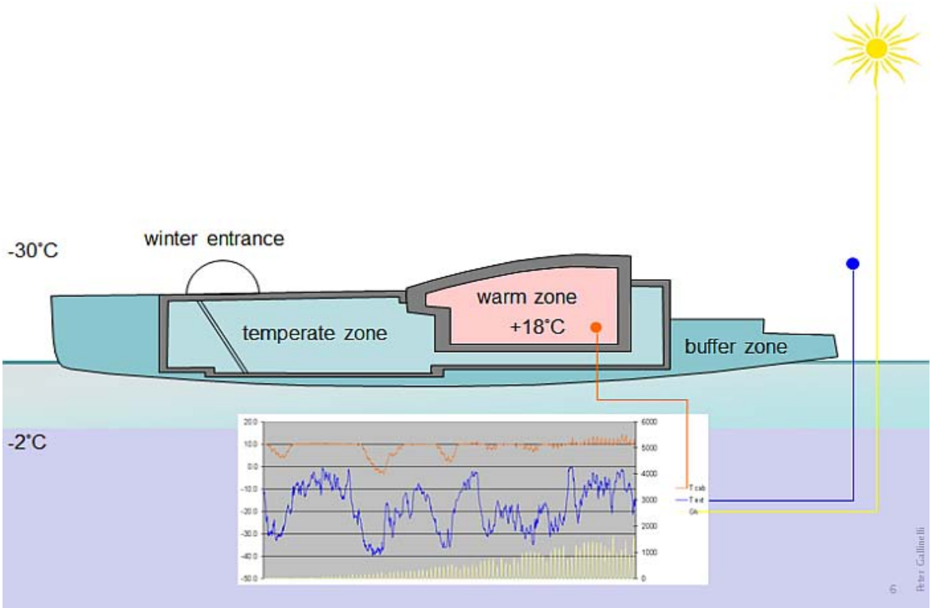


Fig. 13 – *NANUQ's thermal zones*

Source: design and drawing by P. Gallinelli (2017)

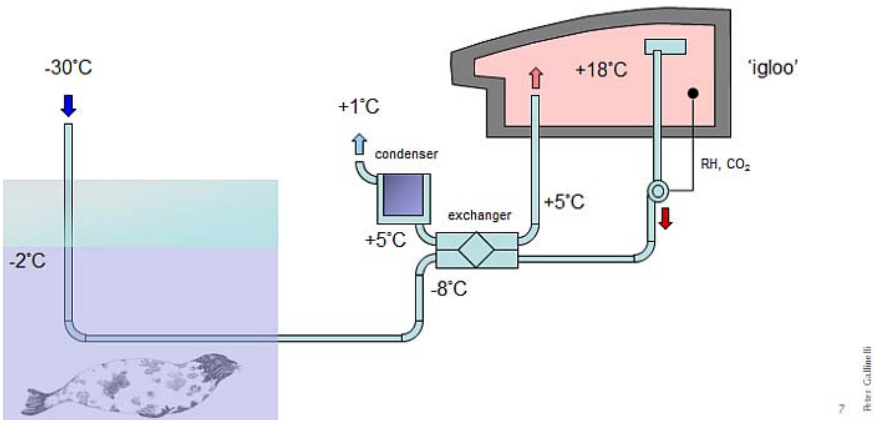


Fig. 14 – *NANUQ's ventilation and heat-recovery system*

Source: design and drawing by P. Gallinelli (2017)

(14) *http://igloo.sailworks.net/boat_e.htm.*

NANUQ is a 17.8 m long, 4.7 m wide sailboat, displacing 18 tons (up to 23 at maximum load). Rigging includes three sails: Jib, mainsail and mizzen for a total surface of 165 m^2. The boat is also fitted with an 85 Hp inboard diesel engine.

She was designed by architect and skipper Peter Gallinelli and built by Sailworks (*www.sailworks.net*) with the specific purpose of demonstrating high energy-efficiency and low environmental impact solutions for polar-environment sailboats and dwellings in cold climates. Launched in 2014, after a first cycle of tests at sea that year, in 2015 NANUQ was deployed for 14 months – including the entire wintering period – in Greenland (Gallinelli, 2018a). During Polarquest2018 she conducted her 13th, 14th and 15th navigations north of the Arctic Circle. The boat is capable of reaching and exceeding 10 knots (18.2 km/h) on sail. The engine allows her to cruise at 6.5 knots (11.7 km/h) with sufficient fuel (1,200 litres) for a continuous navigation up to 2,000 nautical miles (3,600 km) on engine only. She can accommodate a maximum crew of 12, provided with sufficient fresh water (800 litres) and food supplies for 2-3 months of complete self-sufficiency. Her structure and technical solutions make it possible to stand more severe weather and sea conditions than normal boats of similar architecture and size.

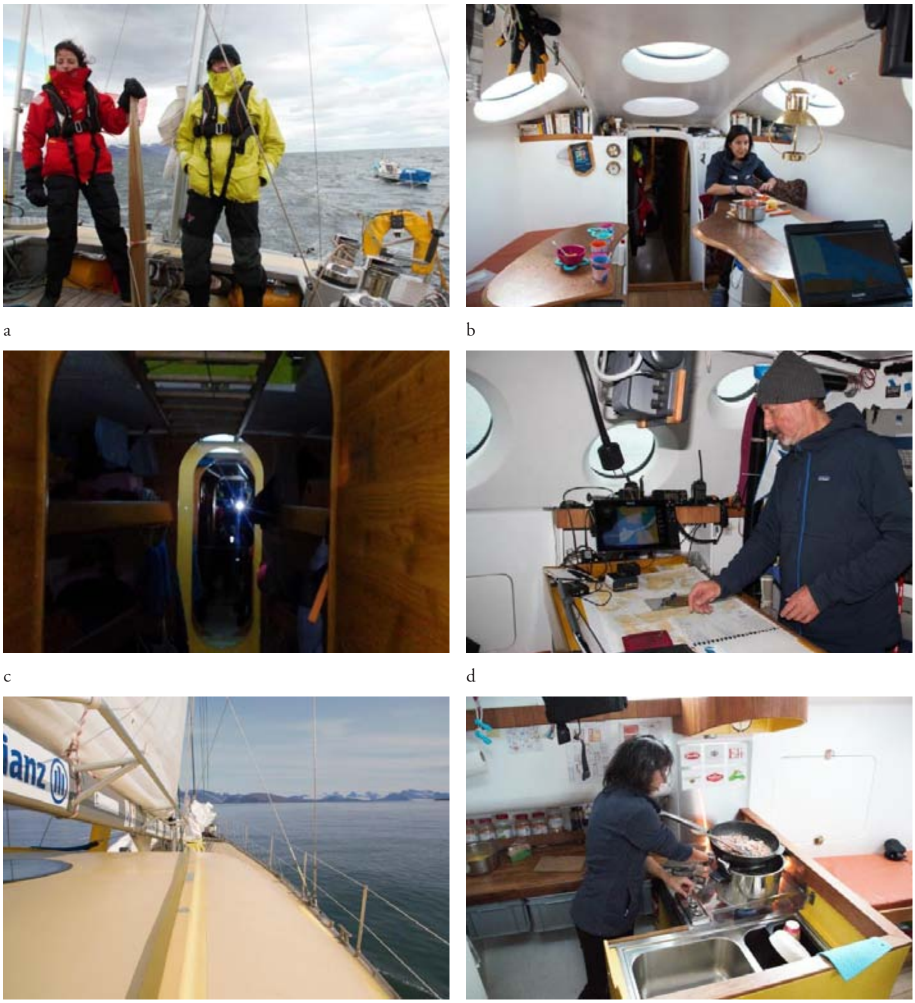
The aluminum hull is fitted with a fixed, short central keel and two lateral retractable fiber-glass daggerboards. Draft normally varies between 1.45 and 2.4 meters, allowing for safe navigation even in shallow waters. The hull is designed for high mechanical resistance, with over-dimensioned girders and frames and a fairly thick skin, to ensure that the boat can stand impacts at low speed with floating ice or to remain completely blocked in ice for long time without any damage. The fiberglass daggerboards are designed to break-up in case of major impact with ice, ground or other obstacles, in a way to avoid excessive stress on the hull structure.

The helm mechanism actuates a couple of redundant, twin rudders; the mechanism is made of aluminum but the rudders are fiberglass fins, installed on the opposite sides of the hull. They are mounted so as to swing rearwards up to 90° into horizontal position in case of impact with ice, a floating or submerged object, so as to reduce the probability of permanent damage. In case of major impact, the building concept of the system is to have the fiberglass rudder break-away from its mounting without damaging the helm mechanism and remain floating so as to be recovered and possibly repaired. Redundancy, offered by having two independent rudder fins far from one another, increases probability that at least one remains operable allowing to keep control of the boat.

These solutions, the overall simplicity of configuration and the quite robust materials (including cabin, windows, hatches and rigging elements) allow the boat to safely operate even in quite rough sea conditions.

The basic concept demonstrated by NANUQ in her 2014-2018 voyages is that of a highly eco-sustainable, optimized boat for operations in the Polar regions at any time of the year, with potential trans-oceanic capabilities.

These characters mostly depend upon the so-called «Passive Igloo Project», i.e. the set of technical solutions which are used in building the boat and her interiors. Internal walls, portholes and spaces are either built or insulated with high-energy efficiency materials, capable of storing heat emitted by human bodies as well as internal equipment and devices (instruments, computers, kitchen etc.).



a b c d e f

Fig. 15 – *The boat: a) helm station; b) central Passive Igloo cabin; c) berth cabin; d) command desk; e) typical view from starboard (right) watch station; f) kitchen*

Source: ph. by G. Casagrande

The boat's design includes a high efficiency thermal management architecture (figg. 13 and 14), which allows comfortable permanence and operation onboard both in summer and in winter. A full description of the architecture can be found in Gallinelli (2017)[15].

The crew would generally work inside the Passive Igloo central cabin (so called «warm area»), and rest in the front section of the hull (so called «temperate area»). There are two resting cabins (one on each side of a central aisle), each one fitted with a double bed and one bunk for an additional person; farther above, there are 6 berths (three on each side). The kitchen area is the rear section of the central cabin, on the port (left) side, it allows for cooking with gas fires and has a basin with a pedal-pump freshwater faucet. A quick-access food storage is located aft from the kitchen (in the so-called «buffer area»). In the rearmost section of the hull, starboard (right) side, there is a lavatory whose hydraulics use seawater for the toilet and freshwater in the basin. An additional basin providing freshwater is located in a small changing room at the bow, just aft of the anchor mechanisms.

The navigator's station is in the central igloo, starboard (right) side. The remaining volume of the cabin is occupied by seating benches and by two tables, fixed to the cabin floor.

Being designed for operation in polar environments, NANUQ does not feature any refrigerator (goods can be stored in non-insulated lockers in the rear hull); hot water is produced in the kitchen. There is no shower. Electric lights are available and supplementary heating can be provided, but the latter was almost never used in the boat's operation before Polarquest2018. During Polarquest2018 leg 14 navigation, temperature in the central igloo cabin remained in the order of +16/+18°C while, in the berths area temperature was in the order of +12/+14°C. This allowed the crew-members to comfortably use -10°C degree-class sleeping bags.

NANUQ draws her power supply from a generator connected to the engine (when the engine is running), from a wind-powered generator mounted on the aft starboard (right) side, and from a total of 4 solar panels installed two on each side of the cockpit external railing. When stationary, the solar panels can be detached from the railing and placed on the surface of the ice or quay to obtain a better exposure to solar radiation. If the other energy sources are temporarily unavailable, the main battery can supply power to the boat's grid during several days. The technical features of NANUQ's power supply system are the following (*ibidem*):

a) wind: two blade, three-phase AC wind generator 1.5kW, 24V + an identical wind turbine for back-up (used when stationary);
b) wind: one 3 blade wind generator 200W 24V mounted on a pole;

(15) *http://www.sailworks.net/igloo/passive_igloo_e.htm.*

c) sun: 4 mono crystalline solar panels of 50 Wp each, 12V + MPPT regulator (maximum power point tracker);
d) back-up (diesel electricity): alternator on propulsion motor 24V, 30A;
e) batteries: lead acid, liquid electrolyte 6x 4V 550Ah @ C20, series mounting.

The basic onboard systems and instrumentation (2018 configuration) include:

1. Autopilot and navigation system: B&G H5000 Pilot and CPU[16];
2. Radar: FURUNO Model 1835 including individual GNSS;
3. Sonar: StructureScan 3D Transducer and Module;
4. Navigation and charting system: B&G Zeus3-12 multi-function display (000-13247-001), including independent redundant C-MAP charting;
5. Class B AIS Transponder: Furuno FA-50, including individual GNSS, connected to OpenCPN navigation software;
6. Information and data management computer: Toughbook laptop computer;
7. Meteorological data acquisition: Iridium-GO[17] + laptop-computer with OpenCPN (navigation software) + GRIB files;
8. VHF Radio onboard station: ICOM Model M323 (including individual GNSS);
9. Handheld Radio: ICOM Model M91D (including individual GNSS);
10. Engine instruments (VDO);
11. Mechanical clock (Plastimo);
12. Mechanical barometer + thermometer (Plastimo).

In addition to the above, NANUQ was obviously equipped with paper maps and charts, and traditional navigation instruments.

Support and routing information were provided by Drift & Noise. Relevant navigational information and weather information were prepared in forms of extracts and transferred via Iridium during the expedition. This service proved essential for the safe development of Polarquest2018.

For Polarquest2018, NANUQ was fitted with instruments and tools in addition to her normal equipment, which were intended to conduct or support the intended research and exploration activities. Such supplementary equipment included: PolarquEEEst Cosmic ray detector POLA-1; NORBIT Subsea iWBMS multibeam sonar, operating at 200 kHz; Informasistemi Time-Lapse Camera; Samsung 360 GEAR cameras.

During Polarquest2018, two Garmin Inreach devices were with the expedition, assigned to Michael Struik and the author respectively, for determining position and assuring safety-critical and/or service-related communication. Furthermore, two portable AIS beacons for the dinghy and land operations were available.

(16) Including H5000, 3D Motion Sensor (000-11551-001), precision-9 compass (000-12607-001), GPS Antenna B&G ZG100 Module Pack (000-11048-001), MHU Standard Pack (wind sensor) (213-PK-12-213), RF300 Rudder Angle (20193744).

(17) The device was assigned to the Expedition Leader, as it also had safety comms and positioning options.

2.2 *Onboard scientific research programmes*

2.2.1 *PolarquEEEst*

The activity was coordinated by the Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi (CREF) as part of the collaboration «Extreme Energy Events» (EEE) with the support of researchers from Italy's National Institute for Nuclear Physics (INFN), the University of Bari, the University of Bologna, and the . The experiment called for conducting systematic, contemporary measurements of cosmic rays at different latitudes, by the use of three identical detectors («POLA-01», «POLA-02» and «POLA-03»), respectively installed onboard NANUQ (POLA-01)[18], at Nesodden (Norway)[19] (POLA-02) and Bra (Italy)[20] (POLA-03), for allowing data comparison. The final assembly of POLA-01 was carried out at CERN in by Italian, Swiss and Norwegian high-school students, under the supervision of professional physicists. The three «POLA» detectors were built according to specifications set for installation onboard NANUQ, hence they featured smaller dimensions and power consumption, in comparison to standard devices. Moreover, the hardware of the detector was custom-built including cutting-edge technology components and also some low-cost components. The onboard leading scientist for the PolarquEEEst program was Dr. Ombretta Pinazza, PhD (INFN and CERN). During Polarquest2018, the three detectors operated continuously – with the only exception of POLA-01 brief shut down during NANUQ Recherchefjorden run-aground (August 2, 2018) and some other minor interruptions – allowing to acquire new important data for study in this field, summarized in Nania and Pinazza (2019). After the expedition, following an agreement between CREF and CNR, all three detectors were transferred and installed at Ny-Ålesund scientific base to gather a further series of long-term observations.

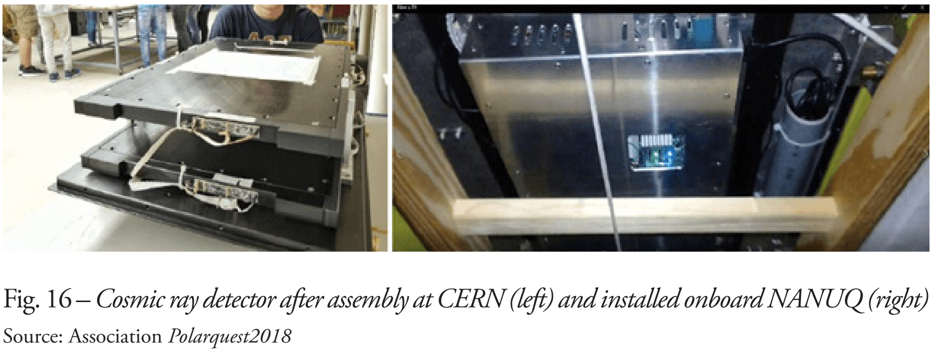


Fig. 16 – *Cosmic ray detector after assembly at CERN (left) and installed onboard NANUQ (right)*
Source: Association *Polarquest2018*

(18) Latitudes in the range 66°05'N - 82°07', longitudes in the range 23°27'W - 28°33'E.
(19) Latitude: 59°48'N, longitude: 10°39'E.
(20) Latitude: 44°42'N, longitude: 07°51'E.

Nania and Pinazza (2019) effectively summarize the outcome of the scientific experience:

> «POLA-01 cosmic ray detector has taken data almost continuously, integrating at the end about 861 hours of data with a global efficiency of about 91%, with small breaks due to various reasons (main power down, difficult weather conditions, detector reset etc.). POLA-02 and POLA-03 were functioning during the whole period, with essentially 100% efficiency. In total, more than 110,000,000 tracks per detector were collected. Data from POLA-02 and POLA-03 could be verified and analyzed online by the students in Nesodden and Bra. This was not possible with POLA-01 because an Internet connection was not available onboard. Instead, all data was regularly reconstructed and stored on NANUQ, checked by the scientist on board, and a small set of trending information was sent daily using a satellite phone to allow a more precise verification by the experts. All the data is presently stored at INAF-CNAF computer centre and is available also for all students in the standard EEE data repository, via web access[21]. […] An example of the capability to calibrate the detector is reported in fig. [17, in this excerpt]: on the 30th of July NANUQ stranded in shallow waters and rolled on one side; at the same time, POLA-01 measured the inclination of the vertical angle and a lower rate, and it was possible to correct the data using the accelerometer sensors. […] In the upper panel of fig. [18, in this excerpt]: – the measured rate of the three POLA detectors, corrected for pressure and inclination of the boat, is compared with the OULU neutron monitor rate in the same period, confirming similar fluctuations related to primary cosmic ray flux variation. Note that the POLA-03 shows a lower rate mostly explained by the presence of dense material on the roof above the detector. The lower panel of fig. [18, in this excerpt] reports the variation with latitude of the POLA-01 rate compared with the one from POLA-02: with the present level of calibrations (1-2% level) no variation is observed in the latitude interval between 66° and 82°N, establishing for the first time the saturation of the cosmic ray flux at ground level also in these extreme regions near the North Pole. […] In conclusion, the PolarquEEEst experiment has successfully collected data on cosmic rays between 66° and 82°N latitudes, a region with, up to know, very few measurements. The detector performed excellently, despite the tight constraints imposed by its integration inside a sailing-boat. The choice of involving high-school students in this experience received great enthusiasm and interest and proved, once more, the success of the idea to combine a physics experiment with a science dissemination program, as done for the first time by the EEE project of Centro Fermi»

(21) *https://eee.centrofermi.it/*.

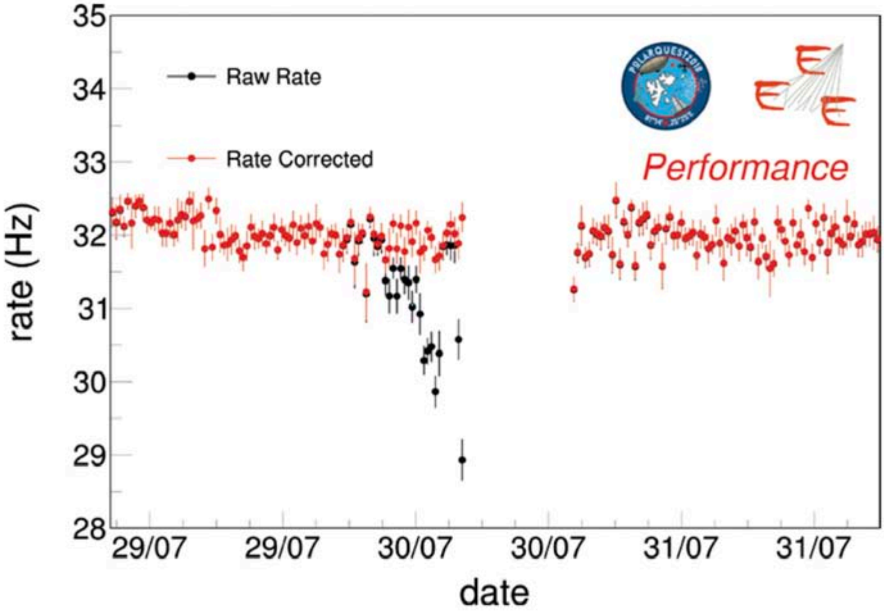


Fig. 17 – *Measurements of rate of detections by POLA1 before shut-down after the July 29th run-aground event, showing the calibration capability of the system due to accurate attitude of the onboard system. After NANUQ's run aground the boat progressively tilted to her left altering the rate of detections; as the increasing roll angle was measured, detection rate could be corrected and proved consistent with pre-event measurements. The gap in the recordings between July 30th and July 31st is due to the system shut-down called by the Skipper for safety reasons*

Source: Nania and Pinazza (2019)

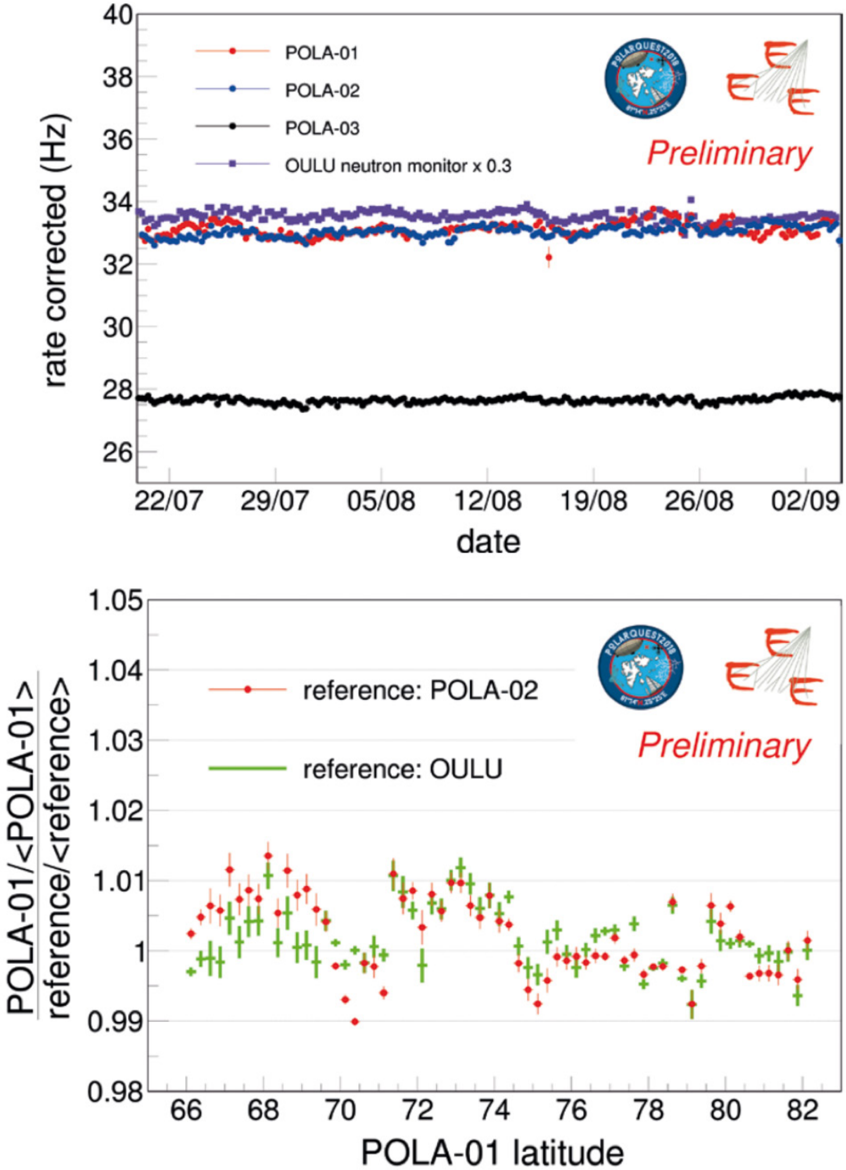


Fig. 18 – *Measured rate of the three POLA detectors, corrected for pressure and inclination of the boat, is compared with the OULU neutron monitor rate in the same period*

Source: Nania and Pinazza (2019)

2.2.2 *Microplastics (a.k.a. MANTANET)*

Thanks partially to a series of previous experiences by NANUQ's workgroup, a floating microplastics sampling programme was carried out, both during leg 13 and 14. The aim of the project was to conduct a series of samplings of superficial sea waters by the use of a specific device (so-called «MANTANET»). It consists in a sampling net trailing behind NANUQ navigating at low speed. Alternatively, in less favourable conditions, by a sampling bucket and a bottle. The project was directed by the Institute of Marine Sciences of the CNR (CNR-ISMAR) under the supervision of Dr. Stefano Aliani, PhD and coordination by scientific director Frédéric Gillet and skipper Peter Gallinelli. Observations onboard NANUQ were carried out by two young operators, environmental activist Safiria Buono (age 19, Italy) and co-skipper Mathilde Gallinelli Gonzalez (age 22, Switzerland).

Fig. 19 – *MANTANET trailing from NANUQ during a sampling run*
Source: ph. by G. Casagrande

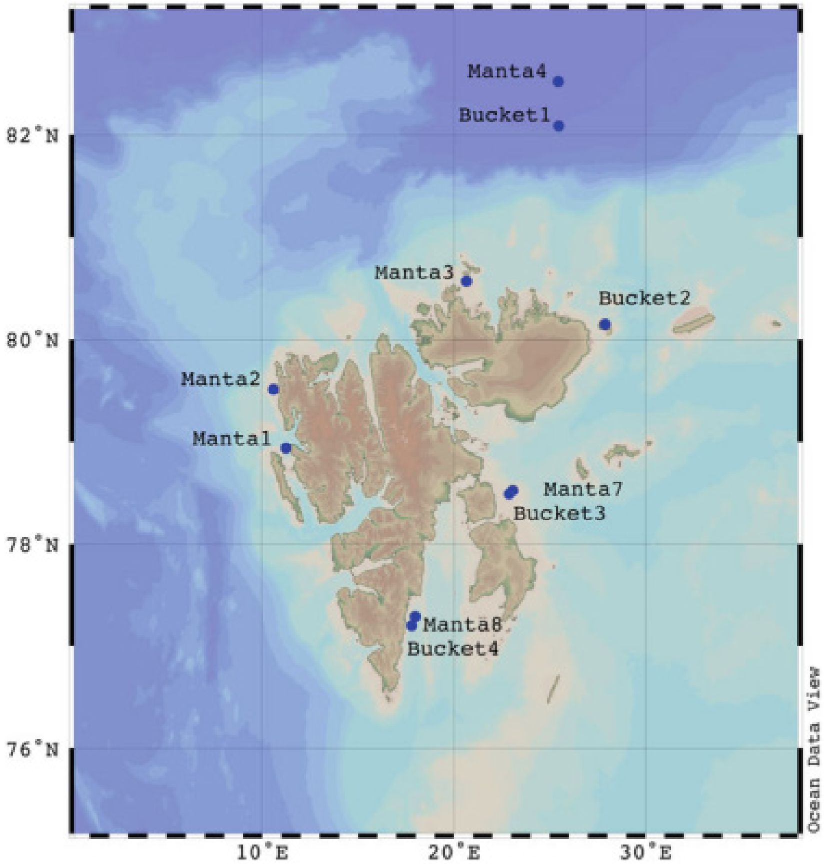


Fig. 20 – *Map of Polarquest2018 microplastics sampling locations*
Source: Aliani et al. (2020, p. 105)

The activities in the programme are summarized in Aliani et al. (2020, pp. 103-107):

> «After leaving Longyearbyen, the expedition sampled microplastics from NANUQ in eight locations during its circumnavigation of Svalbard archipelago's main island […]. The presence of macro debris on the sea surface and beaches in remote zones was explored by non-quantitative visual sightings and by drones flying over the beaches. Microfibres and microplastics were collected trawling a manta-net according to standard monitoring protocols and filtering surface water collected in a 10 l metal bucket. The manta-net had a metal rectangular opening of 0.7 m x 0.5 m and two lateral floats of 0.1 m in diameter, one for each side. It was equipped with a 330 µm mesh 2.5 m long. The cod-end was fixed to the Manta with a metal ring. The nets were towed behind the boat for about 30 min at a vessel speed of around

3-4 knots (except for Manta #3 which was towed at approximately 7 knots) [fig. 20, in this excerpt]. Coordinates and time of starting and ending sampling points were recorded along with sea state conditions and water temperature. After retrieving the net from the sea, the cod-end was removed and transferred to clean jars and stored for laboratory analysis. It was possible to collect eight manta samples and they were stored in eight different cod-end nets. Two cod-end nets were lost during the sampling process due to bad weather and limited operator experience. Bulk surface seawater was sampled using a 10 l metal bucket. The water was gravity-filtered through a 28 µm mesh and remaining particles were trapped in the 3 cm diameter metal filter that was put in closed envelopes after filtration. The samples have been opened again only in the laboratory for sorting an FTIR analysis. Polarquest2018 succeeded to collect samples and sightings and we can consider the expedition on small sailing boat NANUQ as a successful way to collect this kind of samples from the Arctic».

Fig. 21 – *Left: Mathilde Gallinelli and Safiria Buono separate the MANTANET cod-end before sample storage. Right: Buono filtering micro-plastics from a 10 litres metal bucket*
Source: ph. by M. Struik, both from Aliani et al. (2020 pp. 106-107).

2.2.3 *AURORA (a.k.a. Polar Drones)*

The AURORA programme (the acronym stands for «Accessible UAVs for Research and Observation in Remote Areas») was jointly coordinated by Italian Geographical Society (IGS) and by the European University of Rome through its Geographic Research and Application Laboratory (GREAL). It consisted in a proof-of-concept of observations and geographical documentation in Arctic environments, to be conducted by low-cost commercial drones, sensors and consumer-level software. Actual expeditive surveys and methodological tests were carried out at different places, where specific survey and observation profiles could be verified. Such profiles spanned from qualitative observation and aerophotogrammetry, expeditive cartography, landscape observation in the thermal and near infrared. Attention was also paid to verifying the effectiveness of the equipment in documenting and story-telling Arctic environments. This was considered to be relevant in a region like Svalbard, currently in transition from being an anecumenical context into being a space increasingly subject to settlement, usage and tourism. The person in charge of the programme was the author.

Fig. 22 – *DJI Phantom 4 Pro drone taking off from NANUQ at Virgohamna*
Source: video-frame by A. Courcy

Fig. 23 – *Customized DJI Phantom 4 Pro drone with a FLIR-ONE thermal camera + smartphone supplementary payload*
Source: ph. by G. Casagrande

Fig. 24 – *Other two types of drone platforms used in the AURORA programme. Left: an FTD-customized variant of the DJI Spark; right: a standard DJI Mavic Air*
Source: ph. by G. Casagrande (left); DJI (right)

2.2.4 *The crew*

Polarquest2018 formally included 33 persons (not counting the descendants of ITALIA's crew). They were divided into workgroups: one group included the so-called «Onboard team»[22] and a second one the «Onland team»[23]. A third group, «Communication and Support»[24], was in charge of fostering institutional relations and of managing info, news and reports.

The core of the expedition took place during leg 14: during that phase, there was a permanent crew of 10 people onboard: 4 of them were mainly in charge of navigation and operations; 6 of research and communication activities. On particular occasions, for a brief time, passengers were also admitted onboard. The following table summarizes NANUQ's crew composition and permanence onboard.

(22) Based on *http://www.Polarquest2018.org/team/*: Paola Catapano, Michael Struik, Peter Gallinelli, Remy Andrean, Mathilde Gallinelli Gonzalez, Gianluca Casagrande, Frédéric Gillet, Ludovico Machet, Ombretta Pinazza, Safiria Buono, Alberto Rolandi, Alwin Courcy, Kai Struik.

(23) Based on *http://www.Polarquest2018.org/team/*: Stefano Aliani, Valeria Catapano, Marco Garbini, Ivan Gnesi, Marcello Abbrescia, Daniele Cavazza, Antonio Flammini, Mario Nicola Mazziotta, Marco Malavasi, Aleksandra Kruss, Roberto Demontis, Pietro Zanarini.

(24) Based on http:*//www.Polarquest2018.org/team/*: Stefania Capobianco, Katarina Antony, Roberto Sparapani, Maddalena Monge, Paolo Sirigu, Dorothée Adam-Mazard, Gavino Paddeu, Victor Charnier.

Tab. 3 – *Polarquest2018 crew for legs 13 and 14*

Name	Country	Role on board	Presence dates
Andrean, Remy	France	Sailor	July 21 – September 4
Belloni, Filippo	Italy	Representative of the ITALIA crew's descendants	August 4 – August 5
Buono, Safiria	Italy	Mantanet operator	July 21 – August 24
Casagrande, Gianluca	Italy	Geographer	August 2 – August 24
Catapano, Paola	Italy	Project Leader	August 2 – August 24
Courcy, Alwin	France	Cameraman	August 2 – August 24
Gonzalez, Dolores	Spain	Sailor	August 2 – September 4
Gallinelli Gonzalez, Mathilde	Switzerland	Co-skipper	July 21 – September 4
Gallinelli, Peter	Australia	Expedition Leader	July 21 – September 4
Gillet, Frédéric	France	Scientific Coordinator	August 2 – August 7
Machet, Ludovico	Italy	PolarquEEEst support student	August 24 – September 4
Monge, Maddalena	Italy	Communication staff	August 4 – August 5
Pinazza, Ombretta	Italy	PolarquEEEst Physicist	July 21 – August 24
Rolandi, Alberto	Italy	PolarquEEEst support student	July 21 – August 2
Struik, Kai	Netherlands	Photographer	July 21 – August 2
Struik, Michael	Netherlands	Technical Coordinator	July 21 – August 24

Source: Association *Polarquest2018*

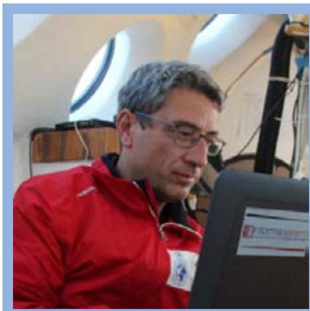
Permanent crew-members for leg 14

1. **Peter Gallinelli** (Australia)
Expedition Leader, President of Association Acapela, *Naval architect, Skipper*

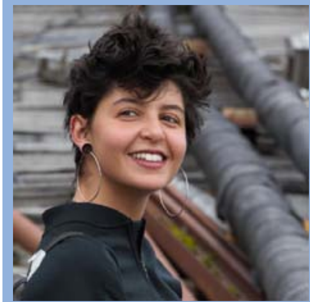
2. **Paola Catapano** (Italy)
Project Leader, President of Association Polarquest2018,
science journalist, audiovisual communications team leader CERN

3. **Michael Struik** (Netherlands)
Technical Coordinator, Association Polarquest2018, *engineer, CERN*

4. **Ombretta Pinazza** (Italy)
PolarquEEEst project Scientist, Physicist, INFN and CERN



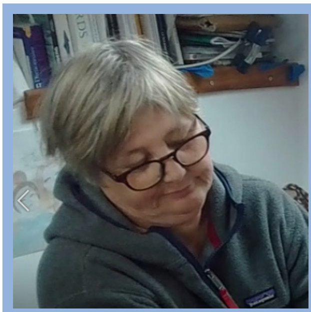
5. **Gianluca Casagrande** (Italy)
Geographer, AURORA project director, Italian Geographical Society and European University of Rome



6. **Safiria Buono** (Italy)
MANTANET operator, Association Polarquest2018

7. **Remy Andrean** (France)
Navigation and operations, Association Acapela

8. **Mathilde Gallinelli Gonzalez** (Switzerland)
Navigation and operations (co-skipper), Association Acapela



9. **Dolores Gonzalez** (Spain)
Navigation and operations, Association Acapela

10. **Alwin Courcy** (France)
Cameraman and photographer, Flair Productions

2.2.5 *Safety aspects*

Polarquest2018 required two high-sea crossings (leg 13 and leg 15[25]) and a mixed, high-sea and coastal navigation (leg 14). NANUQ was normally cruising on sail when wind and navigational conditions were favourable (normally with 3 Bft wind or above and safe waters), and on engine in all other cases. Most of the time, during the circumnavigation of Svalbard, meteorological conditions were overall stable. When navigation occurred in fog, radar for ice and naval traffic monitoring was available and actually used during leg 13; during leg 14, visibility remained normally adequate for visual navigation and the radar was never used. Two observers were on watch during most of the expedition, in the cockpit area, one on each side of the boat, ensuring good visibility to the front through the rear.

Regular watch service was only interrupted – and substituted by visual observation by the helmsman or by the Skipper – during short haul transfers or during specific manoeuvres in fjords or harbours. Unless in completely safe conditions – e.g. mooring at a quay or anchorage in safe position and foreseeably settled meteorological conditions – watch was never discontinued.

(25) From an organizational point of view, leg 15 Longyearbyen to Tromsø was not considered part of Polarquest2018, rather just a necessary transfer from Svalbard to an appropriate wintering location for the boat.

NANUQ was equipped with survival equipment including two inflatable rescue rafts each with 6-person capacity fitted with an emergency locator transmitter, two 30-meter, 200 kg-rated throwing strops, emergency flares and food supplies, VHF-DSC equipment and EPIRB.

Beyond standard safety measures for Arctic operations, additional, mission specific safety aspects regarded two possible operational conditions: onboard and onland work, respectively.

2.2.5.1 *Onboard safety* – Onboard equipment was meant to allow for safe operation inside the boat or outside during watch, manoeuvres etc. When operating outside the cabin or the cockpit, it was mandatory for crew-members to wear a safeline and to keep it attached to structural elements of the boat or lifeline. Each crew-member was also required to wear an individual Crewsaver ErgoFit 190N OS jacket. The device would have automatically inflated in case of fall into the water, raising the person to surface – even in case of unconsciousness – in the proper head-up attitude. Both measures (safe-line and life-jacket) were deemed necessary to prevent the «man overboard» emergency and to extend survival time in case of rescue operations. Before departing for the expedition, the crew had a specific demo about the use of the life-jackets in Geographic Research and Application Laboratory. The briefing was given on June 23rd, 2018 by two manufacturer's representatives. The crew was also briefed about this kind of emergency at the beginning of each leg.

During legs 13 and 14, Nanuq had onboard 2 fully equipped, 4 m long motor rubberboat dinghies, with internal combustion engines. The primary was inflated and secured on NANUQ's rear platform. The secondary one was kept deflated in the boat as a backup in case of need.

2.2.5.2 *Onland safety* – Onland operation safety was mostly centered on the possibility of facing attacks by polar bears and on the consequent need of properly wearing and operating weapons. Procedures were developed based on the requirements and recommendations of experts and territorial authorities (Andersen, 2017; Aars et al., 2005).

The prescribed protocol, repeatedly briefed by the Technical Coordinator to the crew before and during the expedition, called for the following, progressive, safety measures. On approach to land and immediately after landing in the wilderness, crew-members were supposed to initially conduct a thorough observation of the surroundings so as to identify the possible presence of bears. When possible, the so-called «bear-flights» were conducted by drones: they were intended to be rapid surveillance observations to ascertain the safety of a relatively wide area around the workgroup.

After these preliminary checks, activities could start with at least one person (two, when possible) carrying a semi-loaded weapon[26]. This/these person(s) were specifically in charge of constantly observing for the possible arrival of a bear. The other members of the group, at that point, were expected to keep general attention and situational awareness of the area and also to keep in close contact with the colleagues, avoiding unnecessary separation.

If the presence of a bear was suspected or detected, then the self-defence protocol was to be activated: it called, progressively, for interrupting the activity and slowly and orderly leaving the area if possible; for discouraging the bear from approaching the workgroup by causing noises and lights and by firing flares (either flare-sticks or flashbangs, or both). If the bear had continued to approach the group and showed aggressive behaviour, armed crew-members were to fire at the bear – aiming at the chest. Shooting the bear was intended to be a last-resort solution only if the animal would have posed an immediate, unavoidable danger and no other option was available.

As intimidatory weapons, the crew was equipped with 2 flareguns, each with 6 flares, and 4 single-use flare-sticks.

Safety equipment for the crew included 3 big-game hunting, bolt-action rifles: a Husqvarna, with telescopic sight and two Mauser Mod. 98, the latter in the post-WWII modified version, formerly in use of the Norwegian armed forces. The Mausers were rented at an official store in Longyearbyen and were therefore in full compliance with local regulations.

Ammunition was a total of 30, 30-06 caliber Springfield cartridges. Since the simple availability of an adequate weapon was considered insufficient for safety without appropriate training, the crew underwent specific exercise in handling firearms. A first session was held at Centre Tir, Yverdon, Switzerland on June 24th, 2018. In this occasion, several possible weapons were demonstrated, including big-game rifles and shot-guns.

A second session was held in Longyearbyen on August 3rd, at the local shooting range, handling the very three weapons which were to be used during the expedition. Practical training was also given, on that occasion, on the use of flareguns and flashbangs.

It should be underlined that the training, besides being required by local regulation, proved essential for the overall safety of the expedition. It allowed the crew – especially the least trained members – to familiarize themselves not only with actual shooting, but also with other essential actions such as preparing, loading, unloading and re-packing the weapons. Indeed, proper handling is necessary for reliability; given that rules stress firing at bears to be the extreme defense option, the ability of rapidly, efficiently and safely prepare the gun for use makes an important difference.

(26) Semi-loading (also «half-loading») a rifle consists to have cartridges in the magazine but an empty chamber and barrel. The Mauser Mod. 98 rifle allows to have 4 cartridges in the magazine and a 5th one on top of them, ready for loading but forced down by the bolt. By pulling and then pushing back the bolt in position, the 5th bullet is pushed into the chamber quickly and is ready to be fired.

As a further remark, it is worth adding that an important safety factor is the inherent usability of the weapon itself, when operated by a non-expert person under the rush and stress associated with a bear attack.

During the training session in Longyearbyen, a gap in this sense could be seen between the Husqvarna rifle and the Mausers; the former showed a frequent tendency to jam when operated quickly and with some degree of uncertainty, while the Mausers remained generally operable with equal reliability by both expert and non-expert shooters.

Fig. 25 – *Safiria Buono on watch for polar bears on the shore of Alpiniøya (August 15th) while a group of crew-members is making observations in the area. She is keeping in radio contact with the boat and carries a Mauser rifle*
Source: ph. by G. Casagrande

2.2.6 *Ceremonial components and plans for the «first sonar search» of ITALIA's wreck*

Polarquest2018 took place in the 90th year after the expedition of airship ITALIA. That endeavor, also known as «Spedizione Polare Italiana 1928» was led by Gen. Umberto Nobile. It was formally conducted under the aegis and financial management of the Reale Società Geografica Italiana (Royal Italian Geographical Society), but in practice it used equipment and contracted personnel of the country's Royal Air Force and Navy. Funding was obtained from private ventures. The expedition brought the first full-blown geographical observation flying laboratory, airship ITALIA, into the Arctic (Nobile, 1938). The blimp was a 18,500 cube-meter, 3-engine, hydrogen airship built in

Rome and flown to King's Bay in early May 1928. The expedition conducted three Arctic flights, gathering data about several earth-science and geography related phenomena. During the third flight, on May 24th, 1928, the airship reached the North Pole (Nobile, 1930, p. 178), two years after the first successful transpolar flight by sister-ship NORGE under the Amundsen-Ellsworth-Nobile Polar Flight expedition (1926). During the final leg of a challenging return towards Ny-Ålesund, the ITALIA crashed on the ice pack, presumably in proximity of 81°20'N, 24°00'E (Nobile, 1975, pp. 256-257, Alessandrini and Casagrande, 2019, p. 22), about 180 nautical miles north-east of its intended destination, close to the northern shores of Nordaustlandet. In the impact sequence, which caused the structural failure of the airship's gondola and of the rear engine car, 10 out of the 16 crew-members were released onto the pack, with one of them dying immediately thereafter, and other two – including the ship commander – getting seriously injuried[27]. The remaining 6 men were trapped onboard the airship, which took off again, due to the sudden weight release, and disappeared in the Arctic. The survivors of the crash found themselves surrounded by wreckage, supplies and equipment, including a radio, that was soon reactivated. While broadcasting SOS messages – finally picked up by the support ship – the men were able to organize an emergency camp by raising a small tent. It was temporarily painted with purple-stripes obtained from fuchsine, a fluid colorant previously stored onboard the airship for drift and altitude measurements. This detail gave origin to the epic story of the so called «red-tent».

The Polarquest2018 expedition was meant to commemorate ITALIA's endeavor and loss, by meeting with the identified descendants of the airship's crew in official encounters.

Among these were: An official encounter among ITALIA's descendants with the President of CNR, Prof. Massimo Inguscio on May 3rd, 2018 (fig. 26); participation to the «ITALIA 90th Anniversary Memorial Conference», on May 24th and 25th, 2018, an international scientific event organized by the Italian Geographical Society directed by the author (fig. 27). A reunion of descendants held on July 3rd, 2018 at the *Casa dell'Aviatore* Italian Air Force club in Rome, directed by Giuseppe Biagi (jr). All these events saw an official and active participation by Association *Polarquest2018*.

Taking advantage of financial support provided by a spin-off agency of Italy's National Research Council (CNR) and other internal resources, Association *Polarquest2018* was able to fund and organize, with technical endorsement by the CNR itself, a visit for a group of descendants to the Ny-Ålesund base. This visit was to be held during the expedition.

---

(27) Stranded on the ice: Umberto Nobile (commander, seriously injuried), Adalberto Mariano (first officer), Filippo Zappi (second officer), Alfredo Viglieri (third officer), Felice Trojani (senior engineer), Natale Cecioni (chief technician, seriously injuried), Giuseppe Biagi (radio-operator), Finn Malmgren (meteorologist), František Běhounek (physicist), Vincenzo Pomella (rear nacelle engineer, dead soon after impact). Missing with the airship: Renato Alessandrini (rigger), Ettore Arduino (chief engineer), Calisto Ciocca (left-nacelle engineer), Attilio Caratti (right-nacelle engineer), Aldo Pontremoli (physicist), Ugo Lago (reporter).

Fig. 26 – *May 3rd, 2018. The Italian Geographical Society hosts an official visit of the President of Italy's National Research Council, Prof. Massimo Inguscio, Polarquest2018 Project Leader Paola Catapano and of a group of descendants of airship ITALIA's crew*

Source: ph. by F. Ruggieri

Fig. 27 – *Vigna di Valle, Italy, May 25th 2018: a moment of the commemoration for the 90th anniversary of the ITALIA expedition, conducted in 1928 under the aegis of the then Royal Italian Geographical Society. Institutional representatives, high-ranking military officials and a group of descendants from the ITALIA's crew gather at the expedition's memorial located in the Italian Air Force Museum*

Source: ph. by G. Vinci

A commemoration at sea was also planned for the time when NANUQ would have reached Lat. 81°14'N, Long. 25°25'E. That was the position at which ITALIA's commander Umberto Nobile (1931, 1975) and senior engineer Felice Trojani (1962) indicated that the «red-tent» group had been able to broadcast an SOS with the first ascertained post-crash coordinates on May 26th, 1928.

Finally, Polarquest2018 was also to perform the first intentional sonar search of the wreck of ITALIA, 90 years after the disaster. In the design-phase of the expedition, a provisional plan was sketched to include, among the scientific research programmes, a full-blown, goal-aimed sonar scan of the sea-bottom in search of the lost wreck of the ITALIA.

The hypothesis called for the installation, onboard NANUQ, of a sufficiently small sonar. Alternative formulas were considered, either side-scanning or multibeam systems; the device should have been operated by NANUQ so as to cover the largest possible area within a hypothetical search zone. Informally called *Arco di Nobile* («Nobile's Arc») within the workgroup, the zone was defined from the available information about ITALIA's mishap. The search area had already been considered immediately after the disaster by Nobile and Trojani (Nobile, 1930, p. 239 and 1975, p. 304; Trojani, 1964, p. 458), and the hypothesis was later reinforced by additional work, specifically developed for the Polarquest2018 expedition (Alessandrini and Casagrande, 2019).

According to the initial estimations, the search would have required two months of survey, assuming sufficiently good weather throughout the period. The estimated time was far beyond the total available for the entire expedition under reasonable conditions. On the contrary, the time estimated by Gallinelli as available for any scanning in the search area was limited to 2-4 days. This fact, along with the advisers' opinion that NANUQ should have maintained, during the scan, a speed of not more than 4 knots (with the need of perfect weather conditions), made it clear from the very beginning that the scan could have not covered a relevant sea-floor area.

A hypothesis was formulated, to basically divide the expedition in two groups, with separate tasks. The first one would have been conducted by NANUQ, i.e. the three scientific research programmes; the second one would have involved an additional boat, to specifically take care of the sonar survey. The idea of splitting Polarquest2018 in two separate sub-expeditions would have remarkably increased the organizational complexity and costs; nevertheless, the issue was thoroughly examined and found viable, provided that an additional, specialized partner could be found.

Contacts were therefore established with institutions and private parties, but no final agreement could be reached for a second boat.

In late March 2018, an agreement was struck between Polarquest2018's project leader Paola Catapano and Norwegian manufacturer NORBIT SUBSEA, based in Trondheim. NORBIT would have lent Polarquest2018 an iWBMS compact multibeam system whose weight and size were adequate for fitting to one of NANUQ's two daggerboards. An appropriately built bracket was to be prepared for the purpose.

The goal of the Norwegian company was to explore technical implications of using the multibeam on board of a sailboat like NANUQ, navigating at relatively high Arctic latitudes – in fact exceeding those at which the innovative sensor was normally used.

The sensor and its complementary hardware were believed to be compatible with the boat configuration and dynamics, but these were to be tested in practice.

During discussions with Polarquest2018, NORBIT did not require the system to be at disposal of the expedition in the assumption that the wreck of ITALIA would have been likely to be found. Since the available scanning time in the search area was foreseen to be too limited and the wreck location was completely unknown, cooperation between the two partners was limited to testing the deployment of the system on that specific boat at those latitudes, and getting feedback about its usability by a crew with very limited technical training on that type of device.

Between April 14th and 16th 2018, Project Leader Catapano and Technical Coordinator Struik underwent basic training on the multibeam at NORBIT's Trondheim headquarters. Training at sea was conducted on a motor-rubberboat navigating the fjord.

The training was on the initialization of the multibeam system and its use in obtaining a 3D map of the sea floor. As a designated target for the exercise, the crew used the sunken wreck of a large WWII British Short S25 Sunderland flying boat. Its position in the Trondheim fjord was known, but not to the Polarquest2018 crew for the exercise. The activity, recorded by a RAI TV crew, was successful (fig. 28) and the wreck depth was measured to be 65 meters.

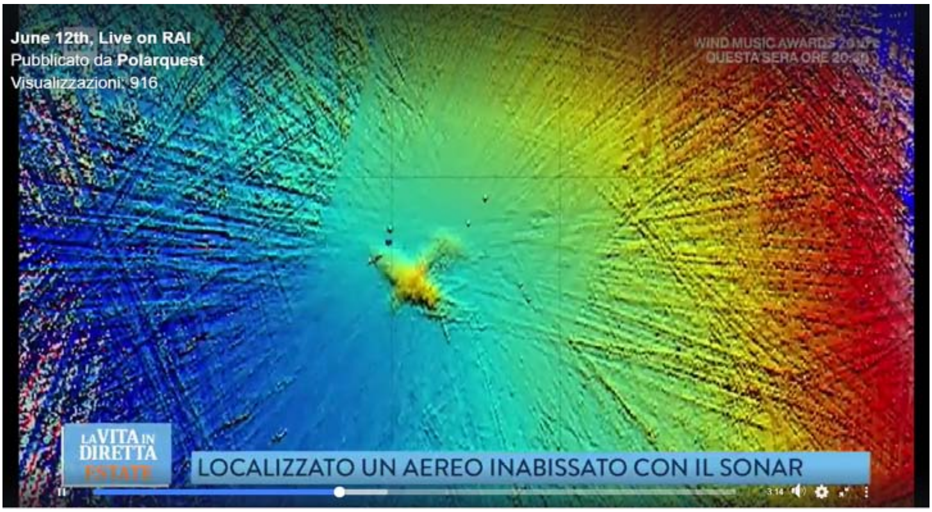


Fig. 28 – *A screenshot from* La Vita in Diretta, *an Italian broadcast, of June 12th, 2018, showing Polarquest2018 training identification of an aircraft wreck lying on the sea bottom near Trondheim*

Source: RAI (2018)

The exercise was also an opportunity to verify the resolution of the equipment. The wreck was very well visible on the sea bottom, with details of wings and tail. The Polarquest2018 was well aware, however, that the search in the Arctic much greater depths were expected and so lower resolutions. Furthermore, even if NANUQ had -by pure luck- scanned any wreck from ITALIA, there was no certainty that the large but thin skeleton of the airship would be anyway intact or recognizable.

The technical issues of installing the sonar onboard NANUQ were discussed between expedition leader Gallinelli and technical coordinator Struik, and the bracket was designed and scheduled for construction and static tests either in Ísafjörður or in Longyearbyen. The former was later chosen as the best location, given that the Icelandic port and yard was supposed to ensure more time and possibly technical support available than in Svalbard, where NANUQ was supposed to only make a brief stopover. Furthermore, Association *Acapela* had had previous contacts with technicians in Ísafjörður and NANUQ was already known in that harbour. The multibeam would have only been handed over in Svalbard, so the technical crew had to pre-calculate the bracket based on the device available specs, and to postpone any physical test.

The sonar was delivered to Longyearbyen by engineer surveyor Dr. Aleksandra Kruss. On the same day of NANUQ's arrival to Longyearbyen, August 2nd, the equipment was transferred onboard and stored in NANUQ's aft «buffer zone» bay.

3. *Chronographical report*

3.1 *Iceland to Svalbard*

The Polarquest2018 expedition was scheduled to depart from Ísafjörður on July 21st, 2018 and to cross the Greenland Sea reaching Longyearbyen, Svalbard on August 2nd. A stop-over in Jan Mayen was considered as a possibility, depending on weather and sea conditions. During the previous days in Ísafjörður, NANUQ underwent keel cleaning, installation of new instruments and of an upgraded propeller (fig. 29). This work was performed by the boat's sailing crew assisted by the Technical Coordinator, other crew-members and by technicians from the harbour, under the Expedition Leader's supervision.

Fig. 29 – *Keel cleaning and repainting; propeller change, July 20th, Port of Ísafjörður*
Source: ph. by O. Pinazza and A. Margotti

At the same time, two technical teams were also conducting activities. The first one, a group of Italian film-makers from Addictive Ideas (Milan), was shooting scenes and interviews to be included in a documentary about the expedition. The second team included scientists and technicians from INFN and the University of Bari, at work in a laboratory made available by the port authority. The group set up and calibrated the cosmic ray detector. After these preliminary operations, the device was installed onboard at 17.20 local time on July 20th. The attachment point was to the external frame of the removed central-aft hatch (fig. 30).

Both the crew and the technical equipment were onboard and ready for an on-schedule departure. However, upon request by the Project Leader, a 24-hour delay was granted by the Skipper in order to allow for some additional food supplies to be delivered, as per agreement with sponsor Marramiero.

Given the extra amount of available time, Gallinelli decided to perform a test at sea, so NANUQ left the harbour at 19.05. There was a little wind from the NE (1-2 Bft), barometer 995 hPa, with stratus cloud and rain. Visibility was 1 nautical mile (NM). During the tests it stopped raining and the wind progressively increased to 2-3 Bft. At the same time, the sea remained overall smooth and visibility improved to 4 NM, allowing to test navigation on engine, sail + engine and sail only. NANUQ returned to Ísafjörður at 23.00[28], fully tested and ready for the Arctic crossing. The fuel tank was filled-up by adding 300 litres, bringing the total amount of fuel onboard to 800 litres. The same quantity of fresh water was also loaded (pp. 1-2). A crew of 10 was onboard for the first leg[29].

Fig. 30 – *POLA-01 cosmic ray detector during installation on board (left) and ready to operate (right). The device is protected by an ad-hoc built fiberglass cover*
Source: ph. by O. Pinazza

Departure from Ísafjörður was at 18.35 in good visibility (10 NM), cloud cover was alto-stratus, barometer at 998 hPa. At 20.10 heading was set to Hesteyri (fig. 31). During this phase, Gallinelli conducted a safety briefing for the crew. In spite of wind up to 2-3 Bft, navigation was entirely on engine.

NANUQ anchored in front of Hesteyri at 21.55 (p. 2). She departed at 06.45 the day after (July 23rd), setting for Ritur two hours later. She left the fjords in good meteorological conditions, with alto-cumulus and shining sun. The Skipper ordered the crew to begin continuous watch, as it was always the case during long-haul navigations. Wind of variable but moderate intensity (2-5 Bft in the morning), prevailingly from the NE, allowed to navigate on sails steadily at 7 knots soon after departure. At 11.10 NANUQ was at 66°38'N, 23°23'W and the Skipper reported in the logbook to have crossed the Arctic Circle, heading 030. Wind turned a bit, blowing from the east in the early afternoon, but sail-only navigation proceeded at 6 then 5 knots up until early evening, when wind dropped and the boat had to proceed with the aid of the engine so as to keep the desired pace (6.5-7 knots).

(28) Crew onboard during this exercise: Peter Gallinelli, Eva Neumann, Elizabeth Golay, Mathilde Gallinelli, Remy Andrean, Michael Struik, Davide Sosso, Emanuele Licitra, Safiria Buono, Kai Struik, Alberto Rolandi., shooting videos for a planned documentary.

(29) Crew onboard during first leg 13: Peter Gallinelli, Mathilde Gallinelli, Remy Andrean, Michael Struik, Ombretta Pinazza, Safiria Buono, Kai Struik, Alberto Rolandi. Two other sailors from Association *Acapela* were also onboard, i.e. Mrss. Eva Neumann and Elizabeth Golay.

Fig. 31 – *Left: Ísafjörður harbour. Right: Hesteyri coast*

Source: ph. by O. Pinazza

Fig. 32 – *First icebergs spotted, as viewed from the boat*

Source: ph. by O. Pinazza

Fig. 33 – *Aerial view of NANUQ standing still close to an iceberg*

Source: ph. by M. Struik

At 19.49, Michael Struik sent an Iridium message to Polarquest2018 headquarters: «First big icebergs, we are halfway Iceland to Greenland, wind is dropping. Mike on NANUQ». At that moment, NANUQ was at 67°19'N, 23°15'W, with a NNW course, with a speed of 4 knots[30].

Occasionally, patches of fog were crossed later in the evening. Heading was set towards Cape Tobin.

At 00.20 on July 24th NANUQ was at 67°57'N, 22°49'W. An iceberg was spotted and the boat had fog ahead, hence Gallinelli decided to turn on the radar. NANUQ entered a relatively large fog patch and proceeded at 6.5-7 knots for the rest of the night. Visibility improved during the morning; at 14.40 the boat was 50 NM south of Kap Brewster, in sight of several icebergs (figg. 32 and 33). She proceeded towards the coast in decreasing visibility and some floating ice. It was impossible to see the coast from a distance of less than 4 NM (p. 37) As wind continued to be very light, sails were lowered and navigation proceeded on engine. At 18.00 visibility was approximately 2 NM and decreasing. Navigation along the coast continued by radar until, circa at 20.00, at 69°54'N, 22°45'W visibility began to improve again, allowing for a wonderful sight of the coast. The boat was then north of Steward Island, approaching the shore. At 21.20 NANUQ anchored in position 69°57'N, 22°49'W and an onland excursion was conducted (fig. 34).

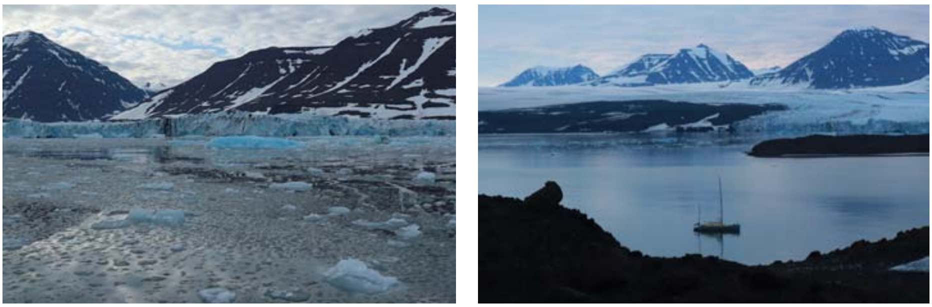


Fig. 34 – *Approach and anchorage in Greenland*

Source: ph. by O. Pinazza

At 01.15 on July 25th the expedition left the anchorage and at 02.55 was 2.5 NM south of Kap Russel, experiencing fog again. NANUQ had then to cross an area of shallow waters, without any inconvenience, using sails and engine. Navigation in fog continued for the rest of the night, with visibility approximately 1 NM and slowly increasing wind.

(30) *www.polarquest2018.org/timeline/first-iceberg.*

At 09.15, NANUQ was abeam Scoresby Sund and proceeding on sail at 6 knots. The sun appeared and the fog dissolved with visibility improving rapidly to 10 NM. Wind increased to 4 Bft and occasionally up to 5. Three and a half hours later, at 12.45, approximately in position 70°39'N, 21°23'W, Gallinelli set heading for Svalbard, putting for the Greenland Sea crossing. Wind dropped substantially. At 14.20 NANUQ was 10 NM off Liverpool Land, heading 060 in excellent weather conditions (visibility over 10 NM, shining sun) but weak wind (1 Bft) from the south, requiring the use of the engine to keep a speed of 5.5 knots. Navigation was swelly with 0.5-meter waves.

At 16.40 Gallinelli annotated the beginning of the crossing and the presence of isolated icebergs in sight along the route. NANUQ was then at 70°56'N, 20°43'W (p. 4). At that time the boat entered a patch of fog but increasing wind allowed to switch back on sails and increase the overall speed to 7 knots (p. 4).

Similar conditions were found for most of the evening, isolated blocks of ice were seen in the waters around the boat. Wind began to increase to 3-4 Bft and NANUQ speed reached 7-8 knots for most of the night. In the early hours of July 26th fog gave way to shining sun conditions, allowing the crew to appreciate the beautiful sight of the night sun (p. 5). Air pressure rose slowly throughout the day from 1009 to 1012 hPa. Icebergs and smaller floating ice were seen repeatedly, visibility remained good for the entire day with the exception of a patch of fog crossed early in the afternoon. In the evening, at 21.30, NANUQ was at 72°59'N, 12°43'W cruising uneventfully towards Svalbard. Navigation was still conducted on sail; speed remained relatively high (6-7.5 knots) for the rest of the day and throughout the night. Weather was good, though with consistent cloud-cover (stratus) since the afternoon. The day after, July 27th, at 12.10 Gallinelli observed a decrease in speed, annotating: «Wind decreasing… the route becomes longer» (p. 5, my traslation).

Just over an hour later it became necessary to restart the engine in order not to slow down the crossing.

In the afternoon at 16.15, Gallinelli made the following entry in his logbook: «Cruise serene with e[ngine] + sails – but where is the forecasted wind?» (p. 6, my traslation).

MANTANET operator Safiria Buono vividly described her feelings during that part of the journey in a dispatch sent via Iridium to the Polarquest2018 headquarters. The message was promptly posted on the expedition's social networks and website:

> «Time is different on the boat. No night, no day, no meal hours. Everything is at the rhythm of our shifts. Everything also takes longer: getting dressed, cooking, everything. You enjoy the little things: a small and shy sun ray trying to show itself through the fog; the offer of a beer or a banana; two more knots of wind; a card game; or the fact that there is *Cenovis* on board (only people living in Switzerland can understand this one, it's like marmite). The meals are the definitely the best part of the day. It's the moment when we're finally all together, otherwise some people sleep

> while other do things and *vice versa*. But everyone wakes up with the smell of good food! We finished 5 litres of wine, and more than a half of one of our 5 hams in only two days! It seems that nothing but us exist anymore. No airplanes, no boats. Only few birds… We have seen a few dolphins, a whale, an iceberg crumbling down. And we had two beautiful, beautiful sunsets to inaugurate the expedition. The sky was on fire, but now the sun no longer sets.
>
> We are organised by shifts: 2 hours on shift, then 7 hours of free time. I have had incredible shifts with warm sun and beautiful landscape; and others that end at 4am with cold and fog, checking your watch every two minutes, trying to pass the time singing or finding some games to play. The more time passes, the more time shifts. If you're lucky, you are on shift when we organize our appetizer!
>
> We're also getting into some habits. For example, Alberto always stays during Kai's shift to talk, and then he leaves us his music when he goes to sleep (always about 20 minutes after I start my shift). We have to wake up the person who does the shift after us, and I'm usually woken by Kai. Sometimes with a cup of tea, sometimes he let me sleep 5 minutes more. It's sweet.
>
> During my shifts, I work on the microplastics project. Carrying out sampling with the bottles takes longer than I had thought. The filter is always full of little unidentifiable things: little filaments, and once a small piece of pink plastic. The most important part for sampling was between Greenland and Jan Mayen, because two currents meeting there and can create an accumulation of microplastics. We are now exactly in that zone, so I'm doing 3 samples a day»[31].

Wind had increased again by 23.00. At that time, it was possible to cease engine-assisted navigation and continue on sails. There was a 0.5-1 m swell. Early in the morning of July 28th, the expedition crossed the Greenwich Meridian, continuing navigation on sails, at speeds varying from 5 to 7.5 knots. Sky was overcast, with fog appearing from time to time.

At 20.20 the wind had dropped down to less than 1 Bft and the sail had become useless. Navigation continued on engine, heading 050 and then 060.

Exactly at midnight on July 28th NANUQ was at 76°29'N, 4°31'E, cruising at 6 knots. She had travelled 907 nautical miles from her departure. Navigation continued on course, prevailingly on heading 060, under a constantly overcast sky and fog.

Gallinelli's notes in that phase reveal his perplexity for the unexpected absence of wind, along with the minor nuisance of small maintenance issues at the lavatory system. Wind remained light for the rest of the night and during the following day. NANUQ was now approaching the Svalbard archipelago. The sky was overcast and the boat kept crossing extensive fog areas. Air pressure had consistently increased from 999 to 1020 hPa from July 24th (p. 6).

(31) *http://www.Polarquest2018.org/dispatch-NANUQ/*.

At 20.55 on July 29th NANUQ arrived in proximity of Bellsund; soon thereafter, wind became strong enough (3 Bft) to allow for stopping the engine and proceed on sail. Visibility was then 5 NM. The boat entered Bellsund at 23.40, then headed for Van Keulenfjord in decreasing visibility. At 02.25 on July 30th, while approaching Recherchefjorden, NANUQ found herself in a patch of fog, calm sea and insufficient wind. Gallinelli was checking cartography on the autopilot display and, due to a usability issue in the interface, inadvertently set a different heading, directing the boat towards the coast. Part of the crew was meanwhile busy in lowering the sails. A few minutes later, the boat was surrounded by a large group of belugas and this caused a rapid gathering of most crew-members in the small space of the cockpit. In that crucial phase, Gallinelli realized that NANUQ was very close to shore and tried to assess the situation by monitoring the instruments; the view of some of the indicators, however, was blocked by the presence of crew-members, virtually preventing the Skipper from evaluating the appropriate escape manoeuvre. The boat went aground, striking with the keel and the right daggerboard a shoal just beneath the water surface. After the impact, NANUQ remained stuck, pinned to the rocks by the damaged daggerboard (p. 7).

A sequence of manoeuvres was attempted to move the boat away from the rocks; first by using the engine, then by deploying the dinghy and using it to pull NANUQ's mast so as to cause the boat to roll away from the rocks.

During these operations, belugas were still spotted in the area as were also, at a certain distance, two fairly large fishing vessels. Since NANUQ's conditions were not critical in any case, no contact took place between the boat and either one of the fishing ships.

Sometime after the incident, Michael Struik sent via IRIDIUM brief updates to Polarquest2018 headquarters, one of them ended up posted on the expedition website:

> «I was sleeping while it happened: there was a big crunch noise and everyone was rushing out. I jumped into tender with Kai with 50m rope and started pulling mast sideways while 8 belugas were surfacing around us. Then mist lifted. All the while, a huge reindeer was overlooking it all from a cliff! When the tide went down and the boat tilted, we all had to sleep on the sidewalls. No panic and everyone in good spirits and helping. Peter calm. Then the mist lifted and the amazing landscape was all around us»[32].

It soon appeared that refloating was impossible as low-tide was developing at the time. Attempts were suspended at about 03.25. The boat slowly settled with a 48° tilt to port (left) (fig. 35). In NANUQ's design, the hull was a full metal, very strong and impact-resistant structure. Both fiberglass daggerboards were designed as fail-safe components, so that in case of impacts they would have given way to the obstacle without

(32) *http://www.Polarquest2018.org/dispatch-shock*.

Fig. 35 – *NANUQ stranded, waiting for the high tide to attempt refloating*
Source: ph. by M. Struik

causing excessive structural stress on the rest of hull. The latter, therefore, suffered no damage during the entire sequence of events; the only damage occurred to the right daggerboard, which was later cut in two and the parts recovered onboard so as to allow free motion of the rest of the hull.

No crew-member suffered any injury. A decision was made to wait for the high tide, general conditions onboard were relatively comfortable in spite of the considerable heeling angle.

The only snag was that, during that phase, it was impossible to use either the kitchen or the lavatory.

For safety reasons, the captain asked to switch off all electrical equipment, including the cosmic ray detector, which was able to record data up to a 23° tilt, before its shut down.

A descriptive account of the unusual situation is once again by Safiria Buono:

> «On the 30th of July, NANUQ arrived in the Svalbard archipelago. After one week of fog and open sea, we were happily sailing in the Recherche fjord, looking for a place to moor. Sun was at *rendez-vous*, and so were the belugas, one of the animals that most inspired the fish-tailed mermaid legend. (Now, thinking back to the event a few days later, I can say that maybe the tale is not the only thing in common

> between sirens and belugas.) We were surrounded and, obviously, enchanted. You could feel the excitement of the crew, who were finally going to relax after the one week crossing between Iceland and Svalbard. But suddenly, we felt a big shock under the boat. People who were inside rushed outside: "What was that?! We're blocked? We're blocked. Wow".
>
> The boat had just been stranded. The right daggerboard, the one on which we were supposed to put the sonar, was broken, stuck, but still attached to the boat. We quickly tried to get the boat out: first with engine; then with a rope attached to the mast, pulled by the dinghy; and several other techniques that didn't really work.
>
> We were fighting against time. The tide was getting lower and lower, and the daggerboard was still stuck. We ended up cutting it in two halves it with a saw, and we put the broken piece on board. After that, the only way out was to wait for the tide to come up again: 12 hours at least. We were not even at 1/3 of the low tide yet, and we were already inclined […].
>
> And yet the light was incredible, the belugas were still there, and the entire crew was surprisingly positive about the situation. So we started joking about it, playing games, figuring out how we would go to the toilet (we couldn't use the normal toilets, as the boat was too inclined), taking pictures, reading, chilling out, and eating energy bars because we also couldn't cook. Some people went to sleep, others couldn't because their beds were out of reach, on the upper side of our stranded boat» (*ibidem*).

During the wait, a careful inspection was conducted by the sailors in order to verify the boat's condition. She was finally declared «ok» at 12.10, while water level was raising again.

In an article published a few months after the expedition, scientist Ombretta Pinazza (2019) recalls the long wait:

Upon a Skipper's request, Technical Coordinator Struik flew a drone to document the boat situation and position, with the main purpose of clarifying the configuration of the shallow seafloor around NANUQ (fig. 36). The flight allowed to plan a safer sequence of manoeuvres for refloating and departure. The drone also made it possible to catch interesting views of the boat for documentary purposes, taking advantage of highly improved visibility.

> «I profit from the forced pause to observe the wilderness around; low tide means lunch time for dozens of Arctic sterns plunging for fish into the sea just nearby. On the shore, reindeer graze the low scarce vegetation, and in the background, a beautiful glacier dominates the landscape. Slowly, the boat inclination reaches a bank of 48° while everyone is waiting patiently, seated or lying down on surfaces which are usually flanks or side walls. Nine hours later the high tide starts visibly flooding the bay and soon the boat can roll back and regain freedom».

At 13.05 the boat was successfully refloated and moved towards the inner section of the fjord. That was reached at 14.40 in good weather and NANUQ anchored in 18 m of depth, though the sea-floor in the area showed poor hold (p. 7).

The boat remained at anchorage for slightly less than a full day. Two groups disembarked and visited a small bay. Several reindeers were spotted around the remnants of an abandoned whaling settlement (fig. 37).

Fig. 36 – *Aerial view of NANUQ aground*

Source: ph. by M. Struik

Fig. 37 – *Remnants of a whalers' settlements in Reinholmen. Left to right: Alberto Rolandi, Dolores Gonzalez and Peter Gallinelli*

Source: ph. by O. Pinazza

She departed at 10.30 on July 31st, passing Mariasundet at 12.35 and proceeding to Fridtjovhamna to anchor there at 14.30. The sky was clear so far, but then appeared alto-cumulus clouds and, later, stratus. The five members of Polarquest2018 team moved on land for an excursion, leaving the other five people onboard: Peter Gallinelli, Remy Andrean, Mathilde Gallinelli and the two passengers. At 20.15 NANUQ left the anchorage and navigated on engine for an hour reaching Steinneset at 21.15, anchoring in the new location.

The expedition crew on land spent this first phase at Svalbard visiting the area and familiarizing with the environment. Aerial video documentation was acquired by flying drones and picture collections were also taken, particularly by Michael Struik, Kai Struik and Ombretta Pinazza. During this excursion, no animals were spotted, but the group could document several fossils, plants and stunning views of the fjord (figg. 38 and 39).

Fig. 38 – *Fossils, musks and plants spotted on the sides of Sundhøgda*
Source: ph. by O. Pinazza

Fig. 39 – *Light-tower in Sundodden (left); southern slope of Sundhøgda (centre); Akseløya from Sundhøgda (right)*
Source: ph. by O. Pinazza

At Steinneset, the land observation group was recovered onboard at 01.15 on August 1st, and the expedition departed again.

NANUQ reached Kapp Martin at 02.30 and Lågneset at 03.15; at the time visibility was decreasing and fog was developing on the calm sea. At 08.55 the boat moored at Barentsburg (fig. 40), the second largest town of Svalbard, inhabited then by ca. 450 people, mostly Russians and Ukrainians (p. 8).

Barentsburg

Coordinates: 78°03'N, 14°12'E

Mining town owned by Russian firm Trust Arktikugol', on the north-eastern side of Grønfjorden. In 2018 it was the second largest community in Svalbard.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Fig. 40 – *Buildings in Barentsburg*

Source: ph. by O. Pinazza

The crew disembarked and enjoyed a visit to the town. Technical Coordinator Struik flew his Mavic Air drone over the small harbour, documenting the conditions of the area and the existing infrastructures.

NANUQ left Barentsburg at 12.15 in generally good weather, with fading mist and shining sun, calm sea and rapidly decreasing wind. She proceeded on engine deeper into the Isfjorden, heading to Longyearbyen for a brief stop to enable some crew-members to disembark at 19.00[33]. She then continued on, towards Borebukta and finally moved to the south-west, anchoring in view of Nansenbreen at 22.45. Around midnight, the crew-members took an excursion on the west coast of the bay.

(33) Michael Struik, Kai Struik, Alberto Rolandi and Safiria Buono.

A few hours later weather conditions changed and wind increased in strength to 4-5 Bft from the east. Gallinelli decided to search for another anchoring point at 01.55 (August 2nd), leaving the west side of the bay and moving downwind from Ratangen at 02.50 (p. 9). The boat remained in the new position up until 07.55, departing on sail and temporarily also on engine until returning to Longyearbyen, where it finally moored at 11.00.

Since its departure from Ísafjörður, NANUQ had travelled 11 days and 1,240 nautical miles (p. 10).

During the 2-day call at Longyearbyen, a scheduled turnover of the crew took place. Leg 13 crew-members Alberto Rolandi, Kai Struik and the two other *Acapela* sailors prepared to leave the boat while Project Leader Paola Catapano, sailor Dolores Gonzalez, cameraman Alwin Courcy and the author as expedition geographer gathered in Longyearbyen and engaged into preliminary activities and briefings. On August 2nd, during the day, the author met in Longyearbyen harbour with expedition onland scientist Aleksandra Kruss and received a 4-hour briefing on the use of the NORBIT multibeam device. The activity involved an exercise about system assembly and operational use onboard a rubberboat – assigned to the Polish Scientific expedition – moored at the pier. The exercise was successful in spite of worsening weather conditions and intermittent rain. As the workstation and the sonar's complementary hardware were for indoor use only, they were provisionally covered with a large tarpaulin. It was not possible to make a full test of the equipment on board NANUQ because the right daggerboard, which was supposed to have the sonar installed on, was still damaged. The sonar bracket symmetry, moreover, did not allow to install the sensor on the other daggerboard.

During Polarquest2018's call at Longyearbyen, the Royal Yacht «NORGE», hosting members of the Norwegian Royal Family, arrived in the harbour. She was moored to a pier in front of Pole Position's terminal. An escort military ship remained anchored in Isfjorden. The NORGE was taking the Royals in a private visit to Svalbard and her route would be similar to NANUQ's for a stretch along the western coasts of the archipelago.

On August 3rd a group of crew-members (Gallinelli, Catapano, Struik, Andrean, the author and Buono) had an additional shooting training session at Longyearbyen range, directed by a local instructor. The difference with the previous training session – held in Switzerland in June 2018 – was that in this case training was specific to operational needs of self-defence against polar bear attacks: different shooting techniques were illustrated and training with flareguns was also given.

3.2 *Circumnavigation of Spitsbergen and Nordaustlandet*

Longyearbyen

Coordinates: 78°13'N, 15°37'E

Located in Longyeardalen, on the southern side of Adventfjorden, it is the main town of the archipelago. It is the site of a well-equipped commercial harbour and international airport, the headquarters of the Norwegian governor, a small hospital, a university centre, two museums and several commercial activities.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

NANUQ departed Longyearbyen at 21.00 on August 4th in good weather. Gallinelli (p. 11) reports wind 4 Bft from the south, visibility 10 miles, stratus clouds and barometer 1010 hPa. At the moment of departure, the boat was moored with its starboard (right) side to another similar vessel and was moved to the supply facility to fill up the tanks with diesel fuel and drinking water. Food supplies were also at design capacity. The boat then left the port of Longyearbyen with her crew of 11 plus 2 passengers[34], and proceeded to exit the Isfjorden. Cruise was on engine power at about 6 knots in good visibility, calm weather and a light swell. The Skipper ordered to resume watch and personally began the first shift. At 00.50 (August 5th), the boat reached the end of Isfjorden and turned north, along the western coast of Spitsbergen. Planned route was through Forlandsundet. As NANUQ was cruising in the strait, wind dropped to zero and the sea was calm. In this phase, watch was performed by experienced crew-members while the newcomers, including the author, were familiarizing with the boat.

The high number of people on board and the remarkable amount of volumes occupied by equipment required particular attention by the less experienced crew-members. It was necessary to rapidly get acquainted with cramped spaces without interfering with crew's operation and rest. Both the author and Courcy got quickly used to the

(34) Crew: Peter Gallinelli, Paola Catapano, Michael Struik, Frédéric Gillet, Mathilde Gallinelli, Remy Andrean, Dolores Gonzalez, Ombretta Pinazza, Gianluca Casagrande, Safiria Buono, Alwin Courcy. The two passengers were Maddalena Monge (Polarquest2018 communication staff) and Filippo Belloni (a member of the delegation of descendants of ITALIA airship's crew and sailor himself).

new environment without any problem. Expedition-related activities conducted in this phase included a briefing about MANTANET sampling by Gillet to Buono, photo/video documentation by Courcy, Struik and the author.

During the cruise towards Kongsfjorden, cloud cover progressively decreased and the sky became clear.

At 08.35 NANUQ exited Forlandsundet and at 11.40, having passed Kvadehuken, she entered Kongsfjorden, approaching Ny-Ålesund scientific station (fig. 43). Arrival was at 13.05 and the boat moored with her port side at the inner quay of the small harbour.

3.2.1 *Ny-Ålesund*

Ny-Ålesund

Coordinates: 78°55'N, 11°55'E

Former mining site (until 1963) and base for polar exploration, currently a year-round community of scientific stations. Located in Kongsfjorden, also historically known as King's Bay or Kings Bay.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Upon arrival, the crew and passengers were greeted by a group of descendants of the ITALIA expedition and representatives of research institutes sponsoring the scientific programmes: Prof. Luisa Cifarelli, President of Centro Fermi and her daughter Laura Strolin, Prof. Marcello Abbrescia (INFN and University of Bari), Dr. Annalisa Bonfiglio and Dr. Emanuela Falqui (President and staff member of CRS4, respectively), Mr. Roberto Sparapani[35] and Mrs. Cristina Battaglia[36] (official representatives of CNR) and Katarina Antony (Polarquest2018 communication staff). The group had arrived earlier from Longyearbyen by air, in a Lufttransport Dornier Do-228 aircraft. A com-

(35) Roberto Sparapani was a technical member of CNR, former director of the Italian research station at Ny-Ålesund from its establishment in 1997 to 2015. He participated in Polarquest2018's organization as a representative of CNR and also as a representative of the Italian Geographical Society.

(36) Cristina Battaglia was the chief scientific secretary of CNR President Prof. Massimo Inguscio, in Ny-Ålesund as a representative of the presidential staff.

memoration of ITALIA's expedition was scheduled for the early afternoon of August 5th. Later in the morning, while interviews and preparations for the ceremony took place, contacts were made between the boat technical crew and the scientific stations in the base. Italian CNR «Dirigibile ITALIA» station offered a lab-room and some of its equipment for Peter and Mathilde Gallinelli to organize repairing of the broken daggerboard (fig. 42). Crew-members and communication staff of the expedition were allowed to work and rest in the base during a few hours. Institutional communication was managed through the station Internet infrastructure. The use of Wi-Fi and other forms of wireless transmission is forbidden in Ny-Ålesund as it may interfere with critical receiving sensors and antennas.

While these activities were ongoing, scientific director Frédéric Gillet made a previously planned contact with the French-German scientific base in order to conduct an activity which was part of Polarquest2018. It consisted in the placement, in a specific test-area of Kongsfjorden, of a PCB pollutant sampling device. The equipment was supposed to be left there for 2 years and to be retrieved in Summer 2020 for analysis.

In the early afternoon of August 5th, the planned commemoration took place.

The group of Italian guests, along with Polarquest2018 expedition members, visited the old airship mooring mast and then gathered at the *Monumento delle Otto Croci*[37] («Eight Crosses Memorial») (fig. 44). The «Prayer of the Explorers of Airship ITALIA»[38] was read aloud by Mrs. Paola de' Grassi di Pianura[39] and a wreath was ceremonially

(37) The «Eight-Crosses Memorial» was established at some distance from the airship mooring mast in 1963, due to an initiative by Italian teacher and traveller Tina Zuccoli. The memorial is intended as a tribute to the 8 crew-members of airship ITALIA who died in the expedition. It is a 3 m tall welded iron structure. Its base holds several hundred kilograms of stones coming from different regions of Italy.

(38) The *Preghiera degli Esploratori dell'Aeronave ITALIA* was composed for the expedition and its text was embroidered on a small series of individually numbered napkins. Each crew-member of the airship was given a napkin in the occasion of a Holy Mass celebrated by Fr. Paolo Gianfranceschi before the polar flight. The original text in Italian is hereby reproduced, followed by a translation into English by Prof. Antonio Ventre, director of the Museo Umberto Nobile, Lauro, Italy: *Da queste solitudini / senz'albe, senza tramonti / ti giunga Iddio, la preghiera / nostra, che non ha sosta / come tregua non ha questa fatica./ Dacci la forza de l'antica / gente cristiana / e benedici noi con la Croce / che ci commise la tua Chiesa Romana / e qui recammo affinché tutta la Terra / fosse santificata nel segno / della Crocefissione./ Benedici la nostra Patria / benedici la nostra nave, / benedici la nostra orazione / unanime e sola / che sempre a te sale, anche se il freddo / mozzi sulle nostre labbra / la devota parola. / E ci consola, e fa che ogni giorno / troviamo la perigliosa via / fino al ritorno. E così sia* («From these solitudes/where no sunrises and no sunsets are / to You, oh Lord, let our prayer / come, that has no rest / like this labour that has no break. / Give us the strength / of the ancient Christian people / and bless us with the Cross / that your Roman Church gave us / and here we brought, / so that the whole Earth / could be sanctified in the sign / of Your Crucifixion./ Bless our Homeland, / bless our ship, / bless our prayer, / unanimous and alone / which always goes up to You, / although this cold / stops the pious words on our lips. / Console us and let us find every day / the dangerous path of our return. Amen»).

(39) Mrs. de' Grassi di Pianura is the granddaughter of Adalberto Mariano (1898-1969), first officer of airship ITALIA. Mariano was among the survivors of the «Red Tent group» and one of the three men who attempted to march across the pack to reach Svalbard on foot. In his ordeal he was to lose part of a foot due to frostbite and subsequent gaingrene. He was rescued by Soviet icebreaker Krassin on July 12th, 1928. A few years after the

put by Dr. Sergio Alessandrini[40]. At the end of the commemoration, the wreath was formally handed over to NANUQ's crew for releasing it at sea as close as possible to the airship crash spot. The ceremony is further described in Biagi and Unia (2019).

After the event at the memorial and a common dinner in the cafeteria of the scientific base, project Leader Paola Catapano, along with the author and Prof. Marcello Abbrescia (scientific leader of the PolarquEEEst project) gave a briefing to the Kings Bay personnel and employees, summarizing the intent and the purposes of the expedition.

Fig. 41 – *At Ny-Ålesund quay, August 6th*

Source: ph. by G. Casagrande

On the night between August 5th and 6th, meteorological conditions were exceptionally good (fig. 41): clear sky and excellent visibility, perfect photography conditions. The author therefore decided for a brief excursion within the Ny-Ålesund base, in order to acquire some images. 7 usable 360° videos and 52 pictures were acquired, documenting the landscape at the base.

ITALIA expedition he left the Royal Italian Navy and reached high-rank positions in Italy's Public Administration.

(40) Dr. Alessandrini is the grandson of Renato Alessandrini (1890-1928), rigger of airship ITALIA. Alessandrini was one of the six crew-members who disappeared with the lost airship (Alessandrini, 2019).

Fig. 42 – *Left: Ny-Ålesund, CNR «Dirigibile ITALIA» Research Station. Right: Peter and Mathilde Gallinelli begin repairing NANUQ's broken daggerboard. The Italian base provided Polarquest2018 with assistance during this essential work*
Source: ph. by Association *Polarquest2018*

In the morning of August 6th, Peter Gallinelli and Remy Andrean evaluated that the daggerboard under repair at the CNR station was in adequate condition for limited use. It could therefore be installed back onboard. The element was therefore returned to the pier. According to plan, NANUQ was supposed to leave Ny-Ålesund on that day. Minor logistical issues, however, caused the decision to delay the departure by 24 hours.

While NANUQ was moored at Ny-Ålesund several tourist ships arrived and departed the small harbour. On August 6th, NORGE Royal convoy arrived in Kongsfjorden and the large Yacht moored at the opposite side of the same pier where NANUQ was stationed. Polarquest2018 crew-members, along with a small crowd of personnel from the base and tourists in transit, had the opportunity of a close-view of the arrival of the Royal family. Preparations were made on NANUQ for departure, including filling up the freshwater reserve.

Frédéric Gillet was proposed to remain a few days with the French-German scientific group in Ny-Ålesund, to discuss research activities; Maddalena Monge was returning to Longyearbyen with the other communication staff member Katarina Antony, and Filippo Belloni had joined back the group of descendants. NANUQ's crew was now reduced to 10 permanent members for the rest of the expedition leg.

Fig. 43 – *Views of Ny-Ålesund scientific town when visited by Polarquest2018. The area is the northernmost permanent community on Earth: a) Nordpol Hotellet, established in early 20th century and currently used to host visiting researchers; b) historical narrow-gauge mining train, preserved with a small restored section of original rails in proximity of the quay; c) the main road into the scientific settlement; d) a view of the central area of the base; e) central canteen; f) geodetic station at Hamnerabben airstrip*

Source: ph. by G. Casagrande

Fig. 44 – *CNR personnel stands at the Eight Crosses Memorial with some of the descendants of the ITALIA's crew. Left to right: Luigi D'Aqui (University of Florence), Stefano Ventura (CNR), Roberto Sparapani (CNR), Alessandra Amore (University of Florence), Mattia de' Grassi di Pianura[41], Filippo Belloni[42], Giuseppe Biagi[43], Paola de' Grassi di Pianura [44], Cristina Battaglia (CNR), Michele Tomaselli[45], Sergio Alessandrini[46] and Orsola Climinti*
Source: ph. by M. Struik

NANUQ left the pier at Ny-Ålesund at 10.10 on August 7th, but remained in vicinity for allowing Alwin Courcy to take footage of her to be included in the planned documentaries. She came back in to pick the cameraman and his gear up onboard again, and finally departed the place at 10.30 on engine power at about 6 knots. Weather conditions were good, with clear sky and visibility over 10 miles, wind 3 Bft from the North (p. 12). Around 13.00 wind was reported to be 4 Bft from the NW and the Skipper annotated that the boat was proceeding into Krossfjorden so as to be protected from the wind. A temporary mooring was established downwind from Scoresbyfjellet.

(41) Descendant of Adalberto Mariano, first officer and navigator.
(42) Grandson of Filippo Zappi, second officer and navigator.
(43) Grandson of Giuseppe Biagi, radio operator.
(44) Granddaughter of Adalberto Mariano.
(45) Grand-grandson of Cesco Tomaselli, onboard news reporter
(46) Grandson of Renato Alessandrini, rigger.

3.2.2 *Lillieöökfjorden, Signehamna and Magdalenefjorden*

After a short wait, the boat left that position and moved about 20 km to the north into Lillieöökfjorden, mooring at a better site (10 m depth, good hold) in Signehamna, close to Gunnarpynten (p. 12). A brief onland exploration of the area ensued: the primary expedition dinghy was deployed in two different trips to allow personnel to observe the area. One group (Gallinelli, Struik, Catapano, Pinazza) went to reach, visit and document the abandoned German WWII radio station located in Signehamna(fig. 45)[47].

Signehamna

Coordinates: 79°16'N, 11°32'E

Uninhabited bay on the western side of Lillieöökfjorden, featuring low and flat shores. It is particularly suitable for landing small boats and dinghies.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Fig. 45 – *Remainings and cairns around the Signehamna German radio station, abandoned in 1943*
Source: ph. by O. Pinazza

(47) The radio station was called Knospe (bud) between 1941-1942, then Nussbaum (walnut tree), according to Aasheim (2008). See also Stange (2019, p. 219).

A second group (Andrean, Buono and the author) proceeded onboard the rubberboat to visit the front of glacier Lillieöökbreen from NANUQ's anchoring spot. The latter group then returned onland; Safiria Buono and the author were deployed on the northern shore of Lillieöökfjorden to perform a first test-mission of one of the two Phantom 4 Pro drones. The images acquired allowed to later process an expeditive low-resolution ortophotograph of the small bay coastline. In that operation the author served as drone pilot and acted as observer. She also took care of watch for the possible presence of polar bears.

Navigation was resumed at 07.30 the next morning (August 8th) since the wind had lost strength during the night. NANUQ cruised at 5-6 knots and headed towards Kroneflua, which was passed at 09.45. Beginning from about 13.25, watch shifts were resumed. The boat then acquired distance from the coastline up to 2 nautical miles, due to doubts about the depth information from the published charts.

At 16.10 NANUQ reached Magdalenefjorden (fig. 46), where visual contact was re-gained with the Royal convoy (fig. 47). Both ships were already anchored in the fjord, NANUQ passed beyond them and stopped closer to the glacier front. Weather conditions were good, with clear sky and calm sea, 1 Bft northerly wind and slowly increasing barometric pressure.

Magdalenefjorden

Coordinates: 79°34'N, 10°52'E

Uninhabited fjord, typical target of tourism due to its landscape and wildlife. It is the northernmost destination of many maritime tours by cruise ships in Svalbard.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Fig. 46 – *Moving away from the inner part of Magdalenefjorden in a rather deglaciated scenario. Glacier Miethebreen is visible on the left, the foremost part of the Waggonwaybreen is on the right*

Source: ph. by G. Casagrande

Fig. 47 – *The NORGE, Norway's royal yacht, in Madgalenefjorden at 17.20 on August 8th*

Source: ph. by G. Casagrande

3.2.3 *Virgohamna, Bockfjorden and Trollkjeldene*

Navigation resumed at about 17.15, with the boat proceeding towards Sørgattet then into Smeerenburgfjorden and further north. Gallinelli turned west into Danskegattet and reached the waters of Virgohamna historical site at 19.50, in position 79°43'32"N, 10°54'21"E. NANUQ anchored in 13 m depth approximately. Weather was good, the sky was overcast with cloud base at about 300 m, visibility under the cloud cover was over 5 miles.

The situation was assessed to be appropriate for attempting an expeditive survey by the use of small drones. The survey, involving the author as drone pilot, Gallinelli and Struik as observers was conducted by launching a DJI Phantom 4 Pro drone from the boat and retrieving it onboard after about 20-minute flight. A later additional flight by the second Phantom 4 Pro at disposal of the expedition, piloted by Michael Struik was also performed to cross-check magnetometric malfunctions reported by the first drone. During both flights, drone control system malfunctions were observed and interpreted as depending upon environmental factors, most of all to proximity to the magnetic North Pole. Apparently, malfunctions were triggered by a reported «Compass Error», and at times caused sudden – even remarkable – erratic behaviors. Occasional datalink stability issues appeared. The unsuitability of drones of that type for use in the polar regions had generically been stated by the manufacturer (DJI, 2017, p. 47), but not further specified, so the problems had to be assessed by the Polarquest2018 crew on their own. Both pilots could conclude that the drones were controllable, in general, and could perform the needed operations. A provisional processing of aerial imagery from the first flight was then conducted by the use of an image-based modelling software, in order to assess the results of the operation; since the image coverage was considered to be adequate for a more thorough processing in the lab after the expedition, NANUQ departed Virgohamna on engine power at 22.10. The boat proceeded with a NW heading. At 23.45 Sabineodden was passed, then Velcomstpynten and at 5.25 the boat entered Woodfjorden. She then continued on towards the south and approached Bockfjorden, where arrival was at 08.00 in calm conditions under a thick cloud cover (p. 13). Anchorage was completed about 45 minutes later in a 18 m shallow area towards the north-eastern side of Bockfjorden. The primary dinghy was prepared for departure, while an onland exploration group got ready to reach, on foot, the Trollkjeldene thermal springs area, about 14 km to the south-south east of NANUQ's current position. The excursion group included: Peter Gallinelli, Paola Catapano, Michael Struik, Gianluca Casagrande, Ombretta Pinazza, Alwin Courcy. The activity on land had three primary purposes: the first one was to conduct a general observation of the area between the northeastern edge of Bockfjorden and the Trollkjeldene zone. The second one was to conduct an expeditive aerial survey test of the Trollkjeldene thermal springs (figg. 51 and 53) and oblique aerial observation of the Karlsbreen glacier (fig. 52) immediately uphill of the former, towards the south. The flights were supposed to acquire imagery in the visible light and in the thermal infrared, the latter by the use of a custom-configured FlirONE low cost sensor. The third goal of the activity had been included upon request of the CNR research group in Ny-Ålesund. Three recording probes had been left in the warm springs by the research group in 2008 for a long-term datalogging. They had been supposed to be recovered at a later time. However, due to plan changes, the recovery expedition had never been dispatched and therefore the probes had been abandoned in the warm springs. The CNR group had therefore requested Polarquest2018 to visit the site, try to recover the probes and return them to Longyearbyen.

Trollkjeldene

Coordinates: 79°23'N, 13°26'E

An area of ancient volcanism in north-western Spitsbergen, showing residual idrothermal activity. It features characteristic warm ponds, travertine formations and well-developed local ecosystems.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

The land observation group left NANUQ onboard of the dinghy and landed on a nearby flat, sandy shore. A non-negligible amount of plastic debris appeared to be scattered all over the place, including fairly large fishing plastic floaters. Given the expected long trek on foot, the group was fully equipped with weapons (two Mauser rifles), flare-guns, hand-held flares. Food supply was limited to energy bars and drinking water.

The area was completely uninhabited and no other person, nor expedition gear or dinghy was seen throughout the activity. Weather was good, the sky was completely overcast as far as visible (5 NM), the air was calm (less than 1 Bft), barometer slowly increasing above 1000 hPa. After having left the beach the group proceeded towards the inner area of the fjord and the valley (fig. 48).

Fig. 48 – *Large driftwood elements in the landing area on the western shore of Bockfjorden (August 9th, 10.57). Crew-members begin to walk towards Trollkjeldene just after having left the dinghy on the beach. Left to right: Catapano, Gallinelli, Pinazza*

Source: ph. by G. Casagrande

Fig. 49 – *Landscape of the Bockfjorddalen looking towards the south (11.29)*

Source: ph. by G. Casagrande

The terrain was generally low, only slightly higher than the sea-level and gently sloping uphill towards the mountains on the western side of the fjord. In that area, a fairly thick layer of tundra was pretty uniform and quite flourishing. It was very well developed on top of a pretty irregular stony surface. Colors of landscape in the area was extensively brownish-red on the slopes and the beaches, large surfaces of very dark gray stones were also visible. The environment appeared to be quite rich in water streams, most of them small or tiny, all converging towards the wide valley bottom. Since the mountain slopes above the cloud cover were not visible, the observers could not assess the condition of the ice cover above the cloudbase; the area crossed by the group was mostly deglaciated (fig. 49).

About two hours into the trek, in the humid area crossed by a stream descending from the mountain slope, the group discovered the remains of a young polar bear, mostly consisting in skeletal parts.

The skull, the spine and some ribs appeared to be in relatively undisturbed position; many other bones were scattered in the surrounding area for about 10-15 meters. Fragments of the bear skin were found and Struik noticed that one of them had still a plastic element attached to it, apparently a locating electronic apparatus. The device was recovered by the group to be later returned to RIS in Longyearbyen.

The valley bottom appeared to be mostly sandy and gravelish, generally light gray and often crossed by extensive ramifications of streams. This abundance of water forced the observation group to often stop and cross the streams, often changing direction.

In most cases, water depth appeared to be between a few centimeters to half a meter. In the case of the relatively few largest and deepest streams, water depth was apparently exceeding 1 meter.

In crossing one of the streams, Courcy, who had been consistently filming the activity from the time of the landing, had his right ankle sprained «I really thought at that moment I had to go back to Longyearbyen by helicopter» – he would have commented later – «but in my head I could [not] give up»[48] The injury was quite painful and it was quickly examined by Gallinelli and Struik. Courcy, nevertheless, stated and showed that it was possible for him to walk and the group continued on the trek without the need of slowing down (fig. 50).

At about 13.00, the group reached the area where terrain increased in slope and height. The springs, on a relief, appeared to be evidently marked by the presence of large travertine formations. In the spots were a sufficiently thick layer of soil was present, it was covered with thriving vegetation compatible with milder climate, including probably *taraxacum brachyceras* (fig. 54). This was evidently due to the local microclimate and higher average temperature from the thermal sources in the ground.

(48) A. Courcy, text from a written interview sent to the author on August 29th, 2020.

Fig. 50 – *Deeper in the Bockfjorddalen (12.23). Left to right: Courcy and Gallinelli*
Source: ph. by G. Casagrande

Fig. 51 – *Aerial view of the Trollkjeldene area from the south. Bockfjorden is visible in the background*
Source: ph. by M. Struik

Fig. 52 – *Aerial view of the northern moraine of Karlsvatnet, with the lake and the terminal part of the Karlsbreen in the background. The view is from the north*
Source: ph. by M. Struik

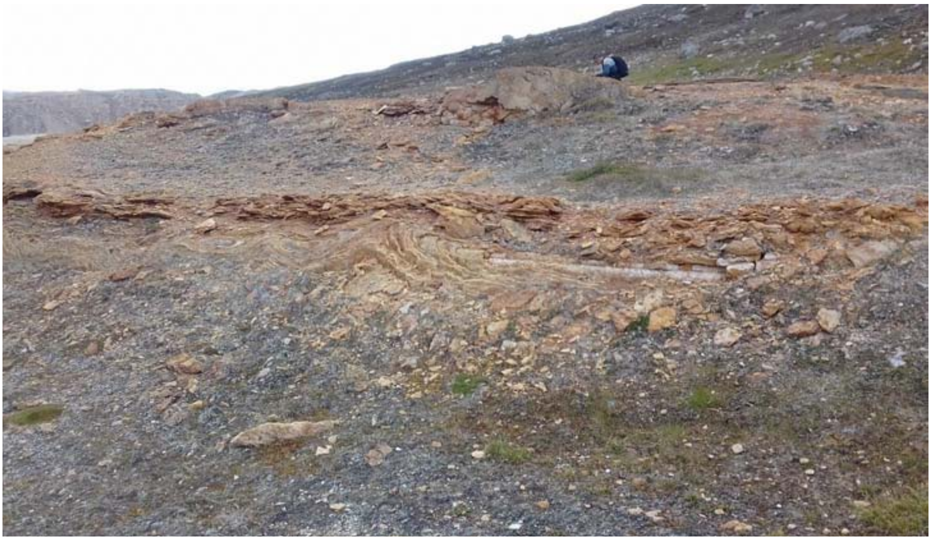


Fig. 53 – *Geological formations at Trollkjeldene*
Source: ph. by G. Casagrande

Fig. 54 – *The milder local climate and the presence of hot-spots underneath the ground allow for the development of thriving vegetation around the thermal springs*
Source: ph. by G. Casagrande

A few minutes after reaching the warm springs area, the group considered to inspect of the ponds (whose temperature was about 25°C) for locating and retrieving the CNR probes. The springs appeared to be very rich in vegetation and small aquatic animals. No probes were visible and they were assumed, if still present in the ponds, to be deeply intermingled with the vegetation cover. The author suggested that a thorough inspection of the ponds with hands or tools was very likely to disrupt and damage the delicate ecosystem which was clearly established inside the springs. Gallinelli and the rest of the group expressed the same idea and no search for the probes was attempted.

The aerial survey was conducted according to plan. A first series of two flights was made by the author, with the use of the FTD Spark microdrone, which was at its first flight in the area; as it was expected after the survey of Virgohamna, the drone proved flyable but quite unstable on the yaw axis. Since the possibility of a «fly-away» could not be excluded, the activity was limited to the acquisition of oblique views for qualitative evaluation and image-based processing. The drone was safely recovered without any further inconvenience.

Fig. 55 – *Gallinelli and Courcy observe Struik's drone hovering above a warm spring in Trollkjeldene*
Source: ph. by G. Casagrande

The second flight session was conducted by Struik with his DJI Phantom 4 Pro, with assistance from the author and Gallinelli as observers (fig. 55). The drone was flown to take qualitative pictures and videos and to allow for image-based modelling. During the flight, the pilot reported «Compass Error» warnings but no unexpected behavior from the drone. After this initial documentation of the site, the UAV was landed and prepared for the experimental thermal acquisition. The VIS+TIR payload rack was installed and flown. Taking into account the short available time for testing, the technique proved very effective and with great potential for future applications. However, the specific system proved complex and poorly reliable due to hardware/software compatibility issues.

During the return trek, the group kept, in general, an adequate pace; Struik, nevertheless, had to repeatedly advise several group members to keep closer to each other as per safety recommendations. As it had been decided earlier, when the group gathered in proximity of the place where the remnants of the polar bear were, Courcy, whose injury was very painful but had not hampered him in keeping-up his documentation duties, filmed some additional scenes.The group returned onboard NANUQ about 11 hours after the beginning of the observation trek.

The boat departed at 20.35, on engine, under regular navigation watch. She returned towards the end of Woodfjorden under low clouds and an irregular breeze from the north (from less than 1 Bft to 2 Bft). During navigation, visibility increased significantly from 2 NM to more than 10 NM.

3.2.4 *Kinnvika, Kapp Rubin and Nordkapp*

Kinnvika

Coordinates: 80°02'N, 18°13'E

Site in west Nordaustlandet, at the north-western extremity of Murchisonfjorden, where a Swedish-Finnish-Swiss scientific base was established in 1957-1959. Semi-abandoned thereafter, it was occasionally visited and used. Temporarily reactivated in 2007-2011 by an international, interdisciplinary workgroup, the base was again semi-abandoned and still usable, but in partial degradation, in 2018. The remote site is difficult to reach by land or sea.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

At 01.00 (August 10th) NANUQ turned around Gråhuken and proceeded north-east towards Mosselhalvøya, then east to Ringertsøya. At 9.15 the boat stopped and anchored in 15 meters depth in front of Kinnvika (fig. 56), first stop on the coasts of Nordaustlandet. Skipper Gallinelli performed a technical check of the boat, verifying that her functionality was according to norm (p. 14). Most of the crew landed to visit the unmanned and semi-abandoned research station (fig. 57).

Several buildings and much equipment from the first 1957-1959 operation, the sporadical later visits and the 2007-2011 reactivation phases were still in place and partially intact: they included food supplies, furniture and various material. In front of the main building there was one tracked transportation vehicle and four trailers. They appeared to have been carefully parked, but then abandoned and in an evident state of decay.

An aerial documentation of the site was conducted by the author.

Fig. 56 – *NANUQ at her anchorage with Kinnvika in the background*
Source: ph. by G. Casagrande

Fig. 57 – *Buildings in the central area of Kinnvika station*
Source: ph. by G. Casagrande

Nordkapp

Coordinates: 80°32'N, 19°59'E

Nordkapp is the northernmost extremity of small Chermsideøya island, whose southern extremity is about 1 km off the coasts of Nordaustlandet, beyond Beverlysundet strait. The uninhabited area features steep reliefs.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

NANUQ departed from the anchorage at 15.40 having Kapp Rubin as her destination. After about an hour, at 16.45, the boat was approximately at 80°03'N, 17°41'E and was experiencing a 3-4 Bft wind from SSE, allowing to stop the engine and use the sails. This condition was temporary, however; the wind dropped early in the evening, as recorded at 19.02, when the boat was about 5 miles west of Hudsonodden. By 23.50 NANUQ had passed Kapp Rubin and entered Beverlysundet. Twenty minutes later, she anchored in proximity of the east shore of Kapp Rubin.

The purpose of the visit to the area was mostly geohistorical in nature: it consisted in trying to spot stone cairns known to have been established there in 1928 during the massive international search and rescue efforts for ITALIA's survivors. Accounts of such presence can be found in Albertini (1931) and Christensen (2019). Traces of the Albertini's expedition had been identified by Italian polar guide and Svalbard expert Stefano Poli, but additional documentation about the site was deemed as useful.

While NANUQ was moored, a visual exploration of the surroundings was made by the crew using binoculars and camera tele-lenses, in search for the distinctive presence of cairns. It was expected to find them with relative ease, as the very purpose of cairns in general – and of those particular cairns in 1928 – was to be very visible, even from long distances, from both land and sea. Cairns were built to contain messages, supplies and equipment in a time in which visual evidence was paramount because other means of communication among expeditions were either inexistent or unreliable.

As NANUQ was stationing in position 80°30'N 19°42'E, visibility from the boat allowed for relatively clear view of several possible places towards Nord Kapp and, much closer, Kapp Rubin.

In the case of the latter, however, the coast appeared quite steep; furthermore, Kapp Rubin was very close to the observers, so many forms of the coast were not in sight because their view was actually blocked by other features. Gallinelli, Catapano and Struik decided to conduct a drone flight towards the higher parts of Kapp Rubin in order to have a more general look at the area. The dinghy was therefore prepared and dispatched to a point very close to the steep coast, at the northernmost place of the cape, about 1 km north-west from NANUQ. This particular survey was to be performed by the author as drone pilot and by Mike Struik managing the dinghy and acting as an observer. The dinghy landed on a narrow beach and the drone was launched very close to the slope. The UAV was guided so as to make a rapid observation of the plateau which was on top of the high coast. The terrain appeared to be regular and no evident cairn or artificial building could be spotted in the images (fig. 58). The drone was then landed and the observers returned onboard NANUQ.

Fig. 58 – *Aerial view, towards the south, of the top plateau of Kapp Rubin*
Source: ph. by G. Casagrande

Meanwhile, possible cairns had been spotted by the boat's crew in several locations of the area, but identification was uncertain; therefore Gallinelli and Catapano decided to change position and at 02.40 on August 11th NANUQ started up her engine and moved to a new position at 80°31'N 19°54'E, anchoring at 03.15, much closer to Nordkapp. Two possible cairns were identified close to the top of the local cliff and two land observation teams were dispatched. The first one included Peter Gallinelli (leader), Mathilde Gallinelli, Dolores Gonzalez, Ombretta Pinazza, with the task of exploring the area up to the top of the cliff by trekking in order to reach the visible cairns and observe for the possible presence of other ones in the surroundings. The team was deployed by the dinghy (piloted by Struik) on the northern shore of Nordkappbukta. Struik then returned to NANUQ to embark and deploy the second team. This group included Paola Catapano (leader), Michael Struik, the author, Safiria Buono and Alwin Courcy. Soon after landing, on the western shore about 0,5 km from the cliff, the author launched his Phantom 4 Pro drone and performed a general observation of the area, heading to the north-east. A similar activity was being performed, at the same time, by Struik with the DJI Mavic Air towards the east and to the south of the group. After a general observation for the possible presence of polar bears, this aerial survey had two purposes: first, to spot cairns and, if possible, identify features of the two objects which had been indicated as cairns on top of the cliff. The author's drone was climbed up to 120 m and directed towards the cliff. As already experimented in the previous flights, intermittent «Compass Error» warnings and automatic switchings from GPS Mode to ATTI mode were indicated. However, as expected, the drone remained flyable and signal transmission was steady. Four minutes into the flight the drone was approaching the top of the cliff at almost the same altitude and both cairns were visible (fig. 59). Attention was focused on the left one and a close-up approach was done in FPV mode. At 4'4" into the flight, the remote-control station cache filled up and as the automatic cache overwriting function had not been selected, the RCS (Remote Control Station) iPad stopped recording the live datalink images. The author identified the acoustic signal as an indication that the iPad was no longer recording, but decided to not interrupt the flight as the FPV was still operating and the drone was already recording hi-res images in its internal memory.

In order to acquire more video documentation, the author turned the drone around the cairn and slowly moved it a few ten meters beyond the cliff, in time for observing the first team reaching the place. The author therefore decided to bring back and land the drone so as to change battery and continue the survey. During the re-entry trajectory the drone appeared to be slow in navigating towards the homebase and apparently drifted slightly to the right (west). In this phase, the remote-control display showed that the drone was skimming a cloud layer at an altitude of about 100 m and visibility was slowly dropping. The author then continued in FPV to keep track of the instrumental data and tried to increase the descent rate in order to stay well below the cloud layer. This was apparently moving towards the west. While descending, the author also tried to increase the horizontal speed for expediting return, and started looking for the best approach trajectory. In this phase, while descending through 70 m a.g.l.[49] the remote-control station screen went blank showing the warning «Aircraft Disconnected».

(49) A.g.l.: above ground level.

Fig. 59 – *Two cairns on top of Nordkapp cliff as observed by the drone during its approach*
Source: ph. by G. Casagrande

No further visual nor telemetric contact with the drone occurred. The team tried to visually spot the UAV in flight and Catapano contacted by radio the other team as it was possible that the UAV might have been drifting back in the vicinity of the cliff. Gallinelli replied that a drone had been in sight a few moments earlier but he could no longer see it. Furthermore, since there were two drones in the area at that moment, it was uncertain whether the observed UAV was the disconnected one or the one being flown by Struik.

At the moment of disconnection, the drone had 8 minutes battery left and it was in ATTI mode with evident erroneous indications of position and heading. It was therefore impossible to ascertain how long it had remained in flight and in which direction it had drifted; most of the area surrounding the flight zone was sea; a light wind was blowing towards the west, and it was possible that in ATTI mode the drone would have drifted towards the sea. After about 10 minutes it was obvious that the drone could no longer be in flight. Visual observations were therefore discontinued. Struik and Catapano suggested that the team go back to the boat and examine available data to consider a search. A series of image acquisitions was performed by Struik with his UAV in the attempt of surveying the area for the possible presence of the lost drone.

In the meanwhile, Gallinelli's team was descending from the cliff to return to their initial landing spot and wait for the dinghy to pick them up. During this phase, members of the team noticed the possible presence of one or more polar bears at long distance but possibly converging towards their position. The information was immediately radioed to Catapano's team. Struik, in control of the dinghy which had just departed the shore, immediately changed heading and proceeded, at full speed, towards the position indicated by Gallinelli. He also instructed the team members onboard to prepare for helping the colleagues. About two minutes later, while the two teams were keeping in radio contact, Gallinelli reported that the sighting was verified as negative and that the dinghy may proceed towards NANUQ. Struik acted accordingly, but quickly left the team members on the boat and expedited the return onland to collect the second group.

Once onboard, the crew evaluated the possibilities and Gallinelli indicated the attempt of finding the drone as possible and therefore worth trying. He suggested to move as many crew-members as possible onland to explore the presumable zone where the drone had been lost, covering the widest possible area. Images from the «Search Flight» performed by Struik were rapidly checked but the lost drone was not identified and a sufficiently thorough study of the entire imagery for such a small detail would have taken too much time. The exploration was done as per Gallinelli's instructions: the dinghy made two trips to transfer all available crew-members with two rifles and two flareguns on land. Catapano, Andrean and Courcy remained onboard.

The search group established to walk in a transversal row, with each person at a distance of about 30-50 meters from the next ones, moving from the south beach towards the cliff. Particular attention was kept, initially, in not inappropriately increment the distance and to always keep visual contact among all the observers. As the search developed, however, such safety measure was not always maintained. No sight of polar bears was reported during the search.

While the ground observers were exploring, Struik had the second Phantom 4 Pro drone flying over the area, in the attempt of locating the other UAV on the ground from aerial FPV views. During this flight, however, the UAV suffered similar problems to its control system and the overall situation was made worse by the increasingly thick low cloud cover. The latter forced Struik to periodically descend to avoid flying into the clouds. Struik noticed that navigating the drone around the cliff was difficult as the UAV, similarly to what had happened to the other, appeared somewhat «slushy» in its behavior. As the drone was being guided from the cliff back to the search area, along a path which was in some degree similar to the last controlled trajectory of the lost drone, Struik noticed that the machine had begun drifting towards the west with apparent major controllability issues. The pilot then decided to interrupt the flight and land as soon as possible to avoid another fly-away, so he used the residual controllability of the drone to direct it towards his own position on the ground. During the re-entry controllability became once again acceptable and landing was uneventful. However, in examining the drone, Struik and the author found it wet and covered with water droplets in its entire surface, including the camera lens. A decision was made to not further attempt drone flights.

The ground search took about 3 hours and had no results, so the expedition gave up the attempt, having concluded that all reasonable effort had been put, to search for the lost machine in such a remote area. NANUQ left its anchorage at 19.35 on August 11th, having spent about 16 hours in proximity of Nordkapp (pp. 15-16).

3.2.5 *Phippsøya and commemoration at sea*

Phippsøya

Coordinates: 80°34'N, 22°39'E

The largest among the small, completely uninhabited «Sjuøyane» (Seven Islands) group.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Leaving Nordkapp NANUQ headed towards the Sjuøyane archipelago and reached the northern side of small Phippsøya. During navigation some concerns were expressed about Alwin Courcy's ankle condition: «The three first days after I twisted my ankle were the worst: fever, pain and I must say it a bit of wonder: my ankle was all blue and very swollen» [50]. Anchorage in shallow water (6.5 m) was at 13.15 on August 12th, in position 80°41'N, 20°57'E. The site had been selected by the Skipper as the last useful anchorage for assembling the NORBIT multibeam sonar system. The plan was to set up the hardware and the software in a few hours, to make sure that the system was operational as planned. At that point, a decision would have been made on whether to navigate all the way up to 81°14'N, 25°25'E with the sonar operating, or rather to perform a simple test, remove the sensor and re-apply it after reaching the planned position. Gallinelli informed the author that his intention was to limit as much as

(50) A. Courcy, Text from a written interview sent to the author on August 29th, 2020.

possible the duration of stay in Phippsøya, due to some uncertainties about the possible evolution of weather. The author's understanding of this indication was that the expected stay in proximity of the small island should have not exceeded four hours. Struik and the author then extracted the disassembled components of the multibeam system from the boat rear right bay. During this work the author was astonished by the continuous presence, in the crystal-clear waters around the boat, of different types of jellyfish; they had been often visible in other occasions as well, but the relatively quiet situation in which NANUQ was at the moment made noticing easier. The intra-cabin hardware was installed and cabled by Andrean. The Skipper lowered the right daggerboard into the water and then Struik, assisted by the author, started attaching the sonar to the aluminum bracket. Courcy was filming this phase of the work. When this operation was over and the cables were connected and physically checked, the bracket-sonar complex was carefully taken to the right side of the deck, in position for being lowered into the water and secured provisionally by two ropes against accidental falls. Struik released the dinghy and slowly moved it along NANUQ's hull until reaching the right daggerboard. At that point the sonar was lowered by hand by Gallinelli and the author down into the water between the boat and the dinghy. Struik then inserted the aluminum socket into the daggerboard and the bracket was then hoisted up in position. Once the assembly was completed, as per manufacturer's instructions, accurate measurements were made by Struik and Andrean in order to physically calculate the reciprocal 3D positions of the sonar and the two GPS antennas which were part of the system. The primary antenna was attached to the aft extremity of the cockpit roof, right from the boat centerline. The secondary antenna was attached forward from the mast, in a central position.

Evident concerns were related, on the one hand, to the actual visibility of the GPS constellation at such a high latitude; on the other hand, it was impossible to exclude that by having the antennas attached close to the boat centerline, several objects of the boat rigging might have caused dissimilar signal reception between the two antennas.

The subsequent work consisted in activating and testing the hardware and software. When the system was booted, it failed to acquire adequate position data so that the overall scanning workflow could not be performed as expected. The multibeam was «pinging» properly and scanning settings (depth, angular scanning) were easily verified. In the next hours, up until about 04.00 (August 12th), verifications were made in order to troubleshoot the system and what appeared to be the most critical issue, i.e. the disagreement in the GPS constellation visibility between the two antennas.

The system also required GAMS test, i.e. the type of calibration that allows to find correct heading between antennas and motion unit built inside the multibeam. In order to achieve that, Gallinelli, Struik and the author agreed to start the boat engine, raise the anchor and have NANUQ perform repeated 360° turns on the left and on the right in a «8-shaped» sequence of turns. These manoeuvres were initiated at 12.30 on August 12th. The procedure was only partially successful and the system was not ready to operate. After about an hour of calibrating manoeuvres, at 13.15 anchorage was resumed in position 80°41'N, 20°57'E.

An Iridium satellite voice phonecall was made from NANUQ to the NORBIT's technical staff in Trondheim. Checklists were tried to solve the problems, but to no avail, mostly due to communication difficulties. Gallinelli indicated that it was impossible to extend the wait in Phippsøya any longer, and it was necessary to move. In addition to the need of keeping a close monitoring of meteorological conditions in a geographical area for which forecast were less reliable than elsewhere, an excessive delay would have seriously hampered the expedition's schedule.

Furthermore, Gallinelli had measured the boat main battery charge which he had found to be at 72.4% (lower than usual), possibly also on account of the long use of much electricity in the anchorage without a running generator.

Struik and the author decided that it was not worth to continue working on the sonar issues but after some discussion, it was agreed to not completely disassemble the multibeam system, in order to allow for another attempt at a later time. The sonar, still attached to its bracket, was removed from the daggerboard, hoisted on NANUQ's front deck and securely fastened with ropes and belts.

First SOS point

Coordinates: 81°14'N, 25°25'E

Point known as the spot from which the first SOS with ascertained position coordinates was sent after the ITALIA mishap. The message was sent by radio operator Giuseppe Biagi by a short-wave radio device «Ondina 33» on May 26th, 1928.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

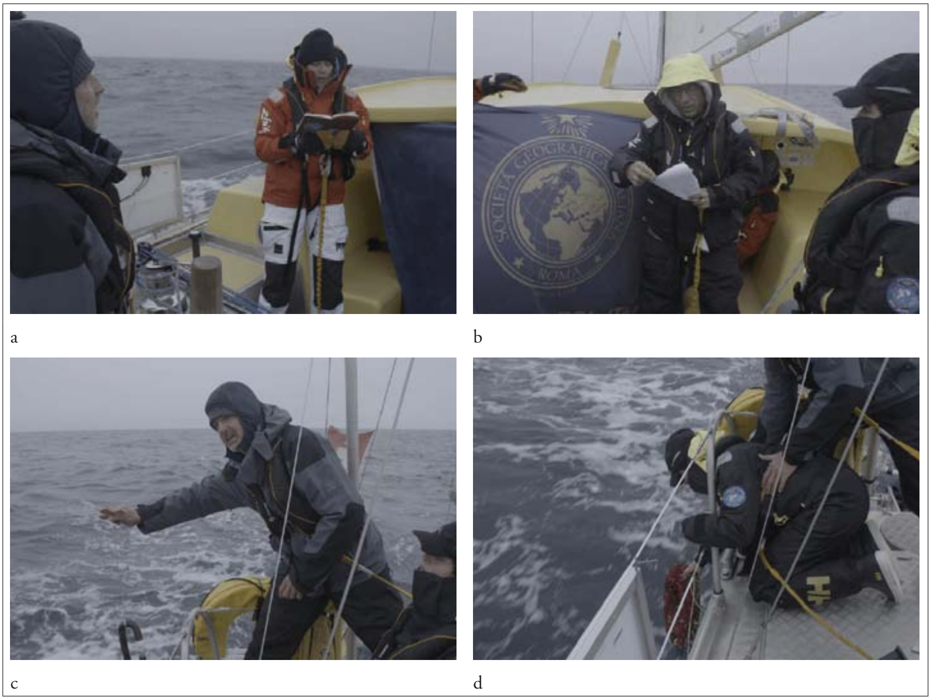
NANUQ departed Phippsøya at 16.15 on August 12th (p. 17). She took a northeast heading in generally fair wind and sea conditions. Air pressure remained relatively constant in the evening and through the night up to the next morning (1007-1008 hPa), wind was generally 3 Bft, occasionally as low as 2 and up to 4 Bft, consistently from the north with relatively modest sea swell. Navigation was done on sail and, occasionally, on engine. The sky remained overcast with stratus clouds up until about 05.30. Later, NANUQ found slowly increasing low clouds and mist conditions, with occasional veiled sun in the early afternoon. Cruising speed in the entire period was variable between 5 and 7 knots. At 03.50 on August 13th NANUQ reached position 81°13'N, 25°13'E and it was about 2 miles from the planned «SOS point». She cruised to 81°15'N, 25°27'E, at which position – reached at 05.02, Gallinelli and Catapano decided to conduct the planned memorial ceremony for the fallen of airship ITALIA (fig. 60). Sails were lowered and the boat was allowed to drift. Meteorological conditions were relatively uncomfortable, with 3-4 Bft wind, air temperature below 0°C, moderate sea swell. Visibility had decreased, through the night, from 10 NM to 5 NM and was currently 2 NM, with overcast sky. Part of the crew gathered outside of the cabin, between the cockpit and the helm: Gallinelli, Catapano, Struik, Courcy, Buono, Gonzalez, the author. Catapano prepared for release into the sea a small wooden cross given to the crew by ITALIA airship's descendant Giuseppe Biagi (jr.)[51] and the flags and emblems of the Italian Air Force and the Italian Navy. The author attached a large flag of the Italian Geographical Society, with signatures of the Polarquest2018 crew and the descendants of the airship men, from one side to the other of the cockpit. Buono took out the flower wreath given by the descendants in Ny-Ålesund, which had been stowed in NANUQ's rear left bay. The crew was pleased to see that the flowers were relatively well preserved after 9 days, thanks obviously to the very cold and dark storage conditions.

Expedition Leader Gallinelli announced in French the beginning of the ceremony. Project Leader Catapano read a message in memory of the lost airship and her crew (in French and Italian), on behalf of Polarquest2018, the Italian Geographical Society, the Italian Air Force and the Italian Navy, i.e. the three institutions which organized the 1928 expedition.

The author was then asked to read aloud the «Prayer of airship ITALIA's explorers» in Italian. Gallinelli, standing on the right side of the boat, left into the sea the wooden cross, attached to an iron weight so as to drop to the sea bottom.

Safiria Buono then released onto the sea surface the wreath, which drifted away remaining visible to the boat for a relatively long time. The ceremony was filmed by Courcy and photographs were taken by Struik.

(51) Biagi received the cross from the Pontifical Gregorian University in Rome, Italy. The university had been the affiliation institution of ITALIA's expedition chaplain, Fr. Gianfranceschi in 1928.



a b c d

Fig. 60 – *Commemoration at sea: a) Project Leader Paola Catapano reads an introduction; b) the author reads the «Prayer of ITALIA's polar explorers»; c) Skipper Peter Gallinelli releases into the sea the wooden cross; d) Safiria Buono puts the red-rose wreath to the sea*
Source: video-frames by A. Courcy

3.2.6 *Navigation to 82°07'N and multibeam mapping*

At about 11.30, Norwegian Coast Guard ship SVALBARD contacted NANUQ by radio reporting to have the boat in AIS contact and requesting information about the captain's intentions. Gallinelli briefly reported the intention of proceeding further north and requested information about weather, ice position and conditions. SVALBARD confirmed to have spotted ice at 82°20'N the day before and communicated that their plan was to remain in the area for another two days, should any assistance be required. After the radio contact was over, Gallinelli decided to head north and reach the margin of the pack or any significant part of it, and to perform a MANTANET sampling at that point. As navigation proceeded, Gallinelli observed and annotated increasing icing conditions (fig. 61). At 13.35 the anemometer went out of service due to ice formation. External air temperature dropped progressively from 3.6°C to 2.7°C. At 15.10 NANUQ crossed 82°00'N.

Fig. 61 – *Co-Skipper Mathilde Gallinelli at the bow of NANUQ while sailing towards the edge of Arctic pack*
Source: ph. by G. Casagrande

Fig. 62 – *The first group of ice blocks detached from the polar ice pack, just reached by NANUQ in the afternoon of August 14th*
Source: ph. by G. Casagrande

The sea was calm, wind was consistently 3 Bft from the north with slight variations, visibility between 1 and 2 NM, but the sun was shining in clear sky above the mist layer. External air temperature was 2.7°C and two observers were constantly on watch for presence of ice, yet no ice was in sight. Temperature dropped further to 2.5°C, visibility slowly decreased in the order of 1-2 NM, a thicker cloud cover appeared above the mist. Ice was now forming on the rigging and sails; pieces of ice regularly fell onto the deck. At 16.15 first floating ice blocks – small size – were seen; at 16.50, a large section of floating ice was spotted by the two observers on watch at the time, i.e. Struik and the author. The ice was reached at 82°07'N, 25°25'E (fig. 62). Gallinelli had the boat stop in proximity and the crew prepared for several tasks. Mathilde Gallinelli and Safiria Buono were in charge of preparing the MANTANET sampling, while Catapano and Courcy took video documentation; Struik, the author and Pinazza took photo documentation.

The author focused on observing the conditions of the ice: it appeared to be consisting in large floating blocks, about 1-2 meters high above water level, pretty irregular in size and shape. A large group of birds was on the ice and showed no sign of being disturbed when approached by the boat. They were resting and flying around her.

After this first phase of activity, as the boat was slowly drifting along the ice in calm water the crew began to work again on the multibeam sonar operation. The sonar and its bracket were detached from the front deck; as it had been tested in Phippsøya, Struik, standing on the dinghy, installed the sensor back to the right daggerboard with assistance from other crew-members (fig. 63).

Fig. 63 – *The multibeam sonar, attached to its aluminum bracket, is lowered into the water for installation onto the right daggerboard*

Source: video-frame by A. Courcy

When the system hardware was installed, further tests were performed and, once again, discrepancy in signal acquisition appeared to be between the two GPS antennas, causing problems in achieving the expected performance.

At 22.45 NANUQ headed towards the initial point of the experimental sonar survey, whose coordinates were 81°50'N, 26°13'E (p. 18).

In order to perform the multibeam scanning, since the indication was to proceed as slow as possible, speed was reduced to 5.5 knots and navigation continued on engine power. At 03.00 the scanning navigation was regular, under improving visibility conditions; mist subsided and the sky remained overcast with stratus clouds. Around 04.00 Technical Coordinator Struik, who was in charge of the multibeam scanning, realized that the position data as recorded by the system appeared to be finally adequate for full operation. In spite of this, the crew was unable to verify whether the acquisition was effective or continuous.

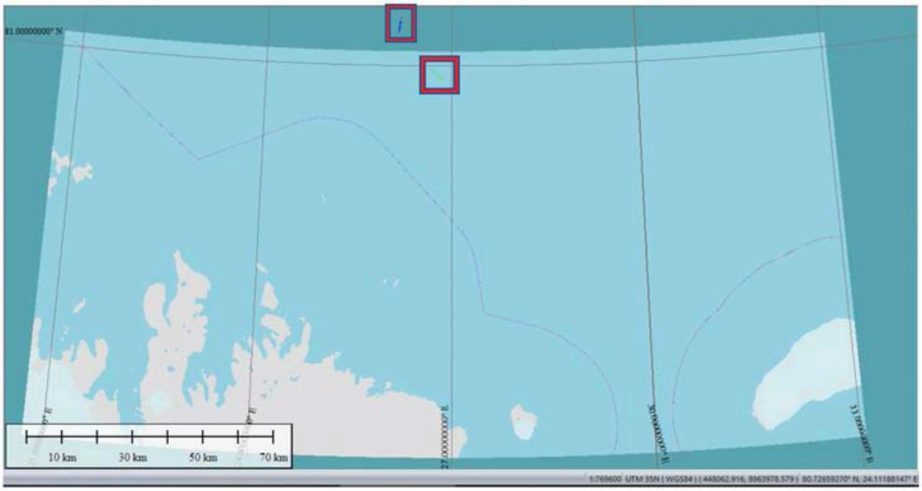


Fig. 64 – *The two valid scanning zones, north-east of Nordaustlandet*

Source: data processing by A. Kruss

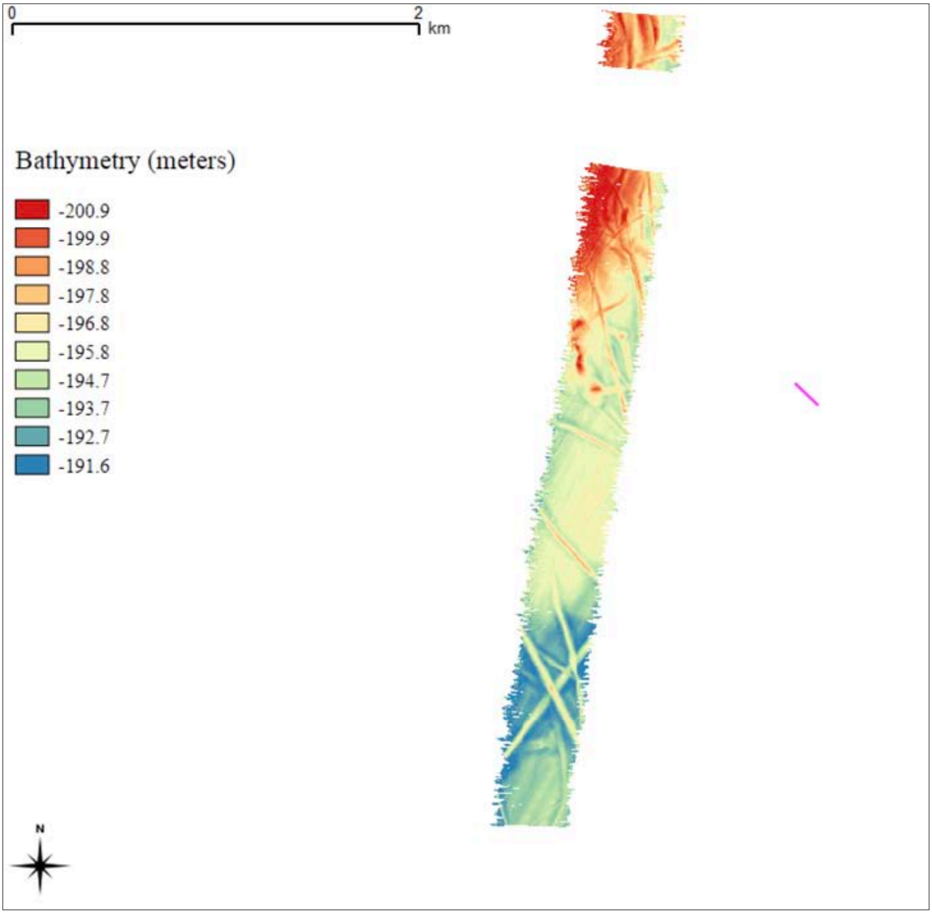


Fig. 65 – *Bathymetry collected by NORBIT iWBMS Long Range sonar, segment 1*
Source: data processing by A. Kruss

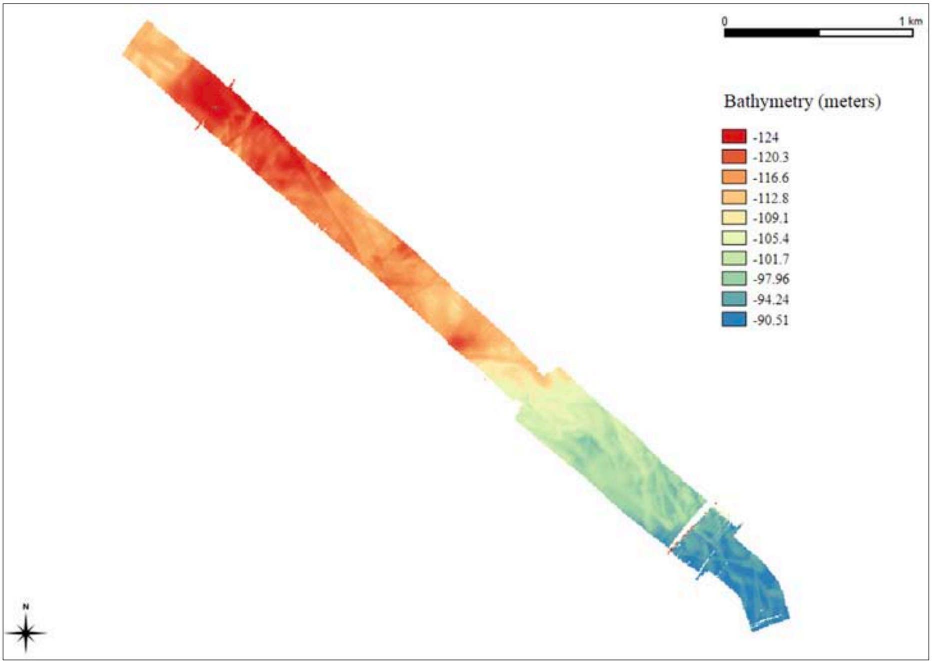


Fig. 66 – *Bathymetry collected by NORBIT iWBMS Long Range sonar, segment 2*
Source: data processing by A. Kruss

He therefore told the Project Leader, who informed the author – then resting in his berth. Wind was progressively growing from 3 to 4 Bft. By 07.45 visibility had increased to 10 NM and the sky was clear with shining sun. At that time, the author took over the multibeam acquisition from Michael Struik who was preparing to perform some other tasks and then go to rest. During this phase the electrical bus to which the sonar system was connected went offline. The cause was some energy management operation being performed, in the meanwhile, elsewhere in the boat. For this reason, the system switched off. The author immediately reported the problem and energy to the bus was restored. The multibeam quickly rebooted and recording was restarted; however, the positioning system failed to resume its «all green» status. At 12.25 cruising speed was reduced to 4 knots – navigating on engine only – in order to try to regain positional data, but to no avail. Sonar survey was terminated at 15.10 and speed was increased again to 5 knots on sails only. The partial data visualized by the sensor in real-time during the scanning enabled the Skipper and the Technical Coordinator to reach an important conclusion; important discrepancies seemed to appear between the published navigation chart data and the sonar readings: in some cases, differences were in the order of 50 metres.

During the post-expedition in-lab work, in late 2018, recordings from the iWBMS system were processed. Even though only a few lines of data were collected with proper quality (figg. 64-66), it was possible to determine that the NORBIT system was fully capable of mapping the seafloor, at the observed depth, and still produce outputs of adequate resolution for the expedition's search purposes. In her analysis work, Dr. Kruss was able to recognize, on the seabed, long scours left by ice formations thousands years ago; such scours were only a few meters in width.

3.2.7 *Alpiniøya, Storøya and Austfonna*

Alpiniøya

Coordinates: 80°21'N, 24°45'E

Uninhabited islet located at the northernmost extremity of Finn Malmgrenfjorden, less than 1 km north-west of Bergströmodden. The island is overall flat and prevailingly rocky, with no substantial permanent ice cover in the summer.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Gallinelli took a heading towards Foynøya and exactly two hours later the boat passed to the east of the island. Peter and Mathilde Gallinelli, along with Remy Andrean, were at the time monitoring weather forecasts. There was the possibility of depressionary areas to develop along the boat's route. Passing abeam of Foynøya, a decision was made to proceed direct to the «Alpini island» and then to find a protected anchorage in the south of it. Arrival was at 23.25 and NANUQ stopped a few hundred meters from the shore (p. 18).

An onland expeditive observation was conducted by two different groups and aerophotographic tests were conducted over the island by drones (FTD Spark around the dinghy landing area and DJI Phantom 4 Pro over the entire island) (fig. 67). A ground inspection of environmental conditions of the island was also performed. A large quantity of plastic debris of different types and shapes was found scattered around the landing area (fig. 68) and in several other zones of the island.

Fig. 67 – *Aerial view of the solitary Alpiniøya's south-western beach during a surveillance «bear flight» before commencing the survey. NANUQ is visible in her mooring position; bottom right it is possible to see the group of observers just landed, next to the dinghy*
Source: ph. by M. Struik

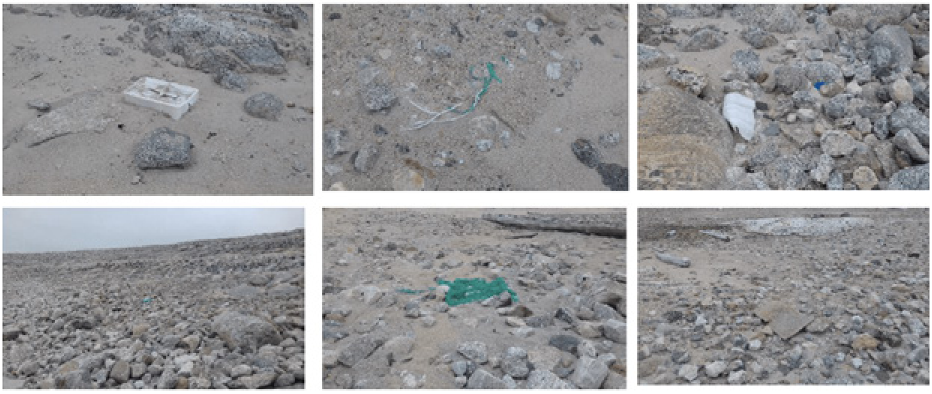


Fig. 68 – *Examples of plastic debris widely scattered on the southern shore of the island*
Source: ph. by G. Casagrande

Departure from Alpiniøya was at 15.10 on August 15th. NANUQ left the island and, at 15.45, passed Bergströmodden (p. 19).

During the rest of the afternoon and the night the sky remained consistently overcast with stratus clouds but visibility was generally very good, over 10 NM with barometer steadily increasing from 1007 to 1010 hPa. The sea was calm. At 18.40 NANUQ was passing 10 NM off Leighbreen and cruising at 6.5 knots in extremely calm water. Skipper Gallinelli annotated in the boat's logbook: «Grey sky over a sea of oil» (p. 19, my translation).

Storøya

Coordinates: 80°05'N, 28°04'E

A uninhabited island to the east of Nordaustlandet, featuring flat shores and a large permanent ice cap.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

At 21.30 the boat was 6 NM north of Storøya and the island presented the crew with the beautiful sight of a huge, white bow glacier, appearing in perfect solitude on the grey background of the clouds. Gallinelli turned towards the south and approached the north-western coast of the island. A brief stop-over had been planned there. French National Centre for Scientific Research (CNRS) had requested Polarquest2018 to reach the coordinates of the last possible position of two floating polar probes. They had been originally deployed to the North Pole and had drifted towards Svalbard, recording data and sending out signals that were eventually lost. The probes were considered to have possibly gone ashore on Storøya and the CNRS had requested NANUQ, in case the crew had spotted the instruments, to recover them. NANUQ therefore anchored temporarily in position 80°08'N, 27°53'E at 22.25. The anchoring was in a shallow and uncharted area in proximity of a long, stony and gravelish, gently sloping beach; it was assumed to be a temporary position, with the sole purpose of allowing the convenient deployment of the dinghy for a rapid survey in search of the French probes. The crew for the survey included: Peter Gallinelli, Michael Struik, Mathilde Gallinelli and Alwin Courcy. Struik brought the DJI Phantom 4 Pro drone in order to take aerial pictures over the search area, which was roughly extrapolated from the last known position of the probes. The group was to land, launch the drone for a standard «bear-flight» and then search on foot, using the drone to get a wider view of the surroundings.

While approaching the shore, about 1 km away from the boat and in proximity to the landing spot, Mathilde Gallinelli reported the possible presence of a polar bear. The sighting was not certain. If it were really a bear, the animal was only a few hundred meters from the expected landing area. The group decided first of all to ensure safety by suspending arrival and incrementing the distance of the dinghy from the shore. The possible sighting of a bear was reported to NANUQ by radio. Since what was possibly the bear appeared to be completely stationary on the beach among several other objects, the identification remained uncertain. Struik prepared the drone for takeoff and a flare was shot upwards to prompt the bear – if it were indeed a bear – to move in the opposite direction from the dinghy. The flare allowed to determine that it was a polar bear, because it apparently rose its head, but then hid away and did not move from its position. As the identification was no longer in doubt, the group decided to abort landing and remain on water at a safe distance; hence it was decided to perform the search for the probes by drone only (fig. 69). The UAV was flown from the dinghy and explored the surroundings at low altitude (5-15 m a.g.l.) identifying the presence of a large amount of driftwood and artificial debris.

Fig. 69 – *One of the numerous «patches» of driftwood and plastic debris seen from the drone on the shore of Storøya*
Source: ph. by M. Struik

The drone was later flown towards the bear for monitoring its position and intentions. The animal too was viewed from above quite more clearly than from the surface, and found in the middle of an area cluttered with driftwood and plastic debris.

As no trace of the two probes could be recognized in the live FPV images, the group returned to the boat for a more thorough examination of the higher-resolution recorded video footage.

The search for the CNRS probes was unsuccessful.

Taking advantage of the first available opportunity, Project Leader Paola Catapano reported to RIS (Research in Svalbard organization) by email (sent through Iridium channel) the sighting of the polar bear and the previous loss of the DJI Phantom 4 Pro in Nordkapp. NANUQ left her temporary anchorage at 01.20 on August 16th and at 03.00 she was cruising at 6 knots, 3 NM to the east of Storøya; she then headed south and after another five hours was in proximity of the long icy front of Austfonna. Weather conditions remained excellent for motor cruising, with overcast sky (stratus clouds), barometer around 1010, visibility 10 NM or more and calm sea (p. 19).

Austfonna

Coordinates: 79°46'N, 24°40'E

A large glacier whose eastern, floating ice front marks the eastern boundary of Nordaustlandet. It is the largest of its kind in the northern hemisphere.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Fig. 70 – *A calving event from the margin of Austfonna glacier as viewed from the drone*
Source: video-frames by M. Struik

Fig. 71 – *Floating ice blocks along Austfonna*

Source: ph. by G. Casagrande

Navigation along the floating front of Austfonna, at 5 NM distance or less, continued until 10.25, at which time the boat closed-in to the glacier and reduced speed to 4 knots. Navigation was conducted in the area of water between the glacier front and a long zone of small floating icy debris. Crew-members involved with the watch or other activities onboard could then notice an obvious consequence of navigating along the ca. 150 km long eastern front of Austfonna: a clear drop in air temperature. During this part of the navigation, Struik and Courcy took photo and video documentation (fig. 70). Meanwhile, Safiria Buono was asked to take pictures of the boat from the top of the mast, so she was equipped with a harness and hoisted to the 20 m high position, with a reflex camera. In the meanwhile, Struik was requested to take aerial videos of Austfonna and the boat navigating along it. A few instants after takeoff, while the drone was filming NANUQ, a large section of the glacier front almost perfectly in the background of the boat was seen detach from the front and collapse into the water, raising an evident wave (fig. 71). Gallinelli, who was personally at the helm, immediately increased throttle to gain speed and turned hard to starboard (to the right); NANUQ performed a quick 90° turn and took the series of waves perpendicularly to its longitudinal axis. After the initial waves had passed, the boat was turned about 180° to her right and moved away from the glacier front She crossed an area of floating icy debris and resumed her navigation in open sea, at the normal cruising speed of 6 knots. At 14.15 heading was set to Freemansundet.

3.2.8 *Freemansundet, Sundbukta and bad weather*

Freemansundet

Coordinates: 78°13'N, 21°41'E

Freemansundet is the sound between Barentsøya (north) and Edgeøya (south).

Sundbukta

Coordinates: 78°13'N, 20°50'E

Sundbukta is a bay at its western extremity, providing a safe anchoring area and flat landing space in case of strong winds from the north, the east and the west.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Weather forecast indicated the approach of a large depressionary area; Gallinelli and Andrean considered possible protected anchoring positions along Freemansundet and beyond its south-western end. At 19.15 weather conditions had not changed significantly, speed was 6.5 knots (p. 20). At 23.30 NANUQ was in position 78°26'N 22°42'E, still about 10 NM to the north-north-east of the entrance into Freemansundet, proceeding at 6.5 knots, still in very good weather conditions: wind less than 1 Bft, variable wind directions and sky overcast with stratus clouds. Visibility at surface was over 10 NM. Barometer had only slightly dropped from 1010 to 1009. At 00.40 on August 17th, the Expedition Leader decided to precautionally anchor in proximity of Ritterflya in position 78°22'N, 22°15'E. Meteorological conditions remained virtually unchanged through most of the night. At 07.45 NANUQ departed the anchorage and entered into Freemansundet from the north-east, accelerating to 8 knots; at 09.25 the boat was approaching the exit of the sound, maintaining the higher speed. Wind began to increase from 1 to 2 Bft and air pressure started to drop (1007 hPa). At 11.05 NANUQ entered Sundbukta (78°13'N, 20°59'E) in stronger wind (4-5 Bft, from the East). Another safety anchoring position was established. All sails were lowered with the only exception of mizzen in order to improve the boat stability and several safety measures were put in place to detect bad anchor hold: Alerts were set in the main GPS receiver and h24 watch was maintained with specific briefings and instructions by the Skipper. At 19.00 wind had increased to 6-8 Bft (East-North-East), barometer had dropped to 998 hPa, visibility was down to about 5 NM. At 20.45 wind was 7-8 Bft (East-North-East), gusts up to 40 knots, air pressure 993 hPa. Conditions continued to worsen. At 00.30 on August 18th, wind was 8-9 Bft (NE), with anemometric values up to 50 knots, and a rapid further fall in pressure to 988 hPa. The sea remained slight.

During this phase the author happened to be on watch and was therefore monitoring with particular attention the behavior of the boat as per the Skipper's instructions. As one of the least-trained crew-members, he was quite surprised to observe that the boat, in her particular configuration at the moment, showed an astonishing stability in the wind, with only minor motions.

At 09.30 on August 18th, Peter Gallinelli annotated: «The calm has returned, at the centre of the depression» (p. 20, my translation): less than 1 Bft, barometer 982 hPa. NANUQ left the anchorage and resumed her navigation at 10.50, leaving Freemansundet behind at 12.10. About 1 hour and 10 minutes later, she was abeam of Storfjorden, and at 15.00 in vicinity of Agardhfjellet. For this entire period, visibility remained in the order of 5 NM, air pressure low (982-981 hPa). At 17.45 heading was set to Inglefieldbukta, where anchoring was established at 19.15 (p. 21).

3.2.9 *Observations in Inglefielbukta and encounter with ALBEDO (Row Around Svalbard)*

Inglefieldbukta

Coordinates: 77°53'N, 18°13'E

Bay on the western side of Storfjorden. It features a mountainous configuration and is surrounded by glaciers.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

Polarquest2018 had been requested to visit the area by the VAGABOND workgroup; they had been conducting research there in previous years, but it was not possible for them to deploy any team in the area during 2018. A first goal was to visit an automatic data acquisition station positioned there by the CNRS, and take notice of its exterior conditions, particularly if the infrastructure appeared to be damaged or in need of repair.

The dinghy was deployed from the anchorage position with Peter Gallinelli, Ombretta Pinazza, Paola Catapano, Mathilde Gallinelli and the author. The landing area included gently sloping beaches, with large zones of sand and thawing permafrost, with tundra vegetation covering the top parts of small reliefs. The automatic station was on top one of those reliefs (fig. 72): it was reached after a few minutes walk from the beach, although with some difficulty, due to the wide and deep muddy areas. A large quantity of driftwood was scattered all over the place. At least one large element was clearly artificial, possibly a girder. When reached by the workgroup, the automatic station was found intact and apparently without any visible damage. However, many polar bear footprints were seen; Gallinelli and Catapano identified traces indicating that bears had scratched, superficially, on the outer walls of the station.

Fig. 72 – *French meteo station located southeast of Inglefieldbukta*
Source: ph. by O. Pinazza

The group documented the site's condition then returned to the boat. NANUQ stationed at Inglefieldbukta until the next morning, making it possible, for the crew, to have a full night of rest.

On the day after, August 19th, at 10.35, engine was started again and the boat moved across the bay to approach the front Inglefieldbreen. The glacier had been monitored by the VAGABOND group in previous years, but no similar observation had been possible in 2018, hence they had requested Polarquest2018 to document on their behalf.

Gallinelli discussed with the author and Michael Struik the possibility of mapping the front of the glacier by an expeditive photogrammetric survey. The operation was performed (figg. 73 and 74) starting at 12.45, with initial position at the southern extremity of the glacier. NANUQ moved slowly, stopping periodically every 20-25 minutes to facilitate launch and recovery of the UAV.

At 14.15 the operation was over and the boat moved away from the northern side of the glacier; she exited the bay and turned south (p. 22). Putting again to sea, the boat found scattered clouds, calm wind conditions and a swell with waves about 0.5 m high; barometer was steady at 982 hPa for most of the day. Later during the evening and the night, wind varied from 1 to 2 Bft, but conditions remained good and during the night the sun reappeared. At about 23.15, while NANUQ was cruising along the coast, the two observers on watch, i.e. Michael Struik and the author, noticed on the AIS display the presence of a vessel – a few miles ahead of NANUQ – named «ALBEDO». As the ship was not visible with naked eye in spite of very good visibility (10 NM or more), the author took the binocular and scanned thoroughly the horizon. Struik could not

Fig. 73 – *Aerial view of Inglefieldbreen, southern area. Image oriented towards the west*
Source: ph. by M. Struik

Fig. 74 – *Aerial view of Inglefieldbreen, northern area. Image oriented to the west*
Source: ph. by M. Struik

identify any vessel ahead of the boat either. While he was searching visually, the author went back inside to check the AIS display and found that ALBEDO was straight ahead of NANUQ but the distance was decreasing. NANUQ was travelling on autopilot at a constant speed of 6 knots. As the other ship was impossible to see, the matter was discussed between the author and Struik, and reported to the sailors. Going back to the AIS display, ALBEDO appeared to be closer. Evidently, she must have travelled slower than NANUQ. Apparently, however, she was not standing in a still position. At that point the author was going off-shift and went to rest. Some time later, much to the crew's surprise, ALBEDO was finally spotted and revealed to be a small, composite-built rowing boat manned by two Swedish adventurers, Sören Kjellkvist and Glenn Mattsing (fig. 75). They had departed Longyearbyen on July 28th and were close to completing the circumnavigation of Svalbard on row. The entire NANUQ's crew gathered out of the cabin between the cockpit and the helm to see the two athletes.

Fig. 75 – *ALBEDO leaving NANUQ after the first encounter at sea. Mattsing waves goodbye, Kjellkvist is rowing*
Source: ph. by G. Casagrande

One of them, Mattsing, was injured to a rib and he stated to be taking pain-killers in order to be able to row. ALBEDO requested NANUQ to remain in the area for some more time, but to let them finish their planned record. Since ALBEDO's plan did not prevent that, the Polarquest2018 crew gave the Swedish colleagues, much to their surprise, some pizza that had been baked by Catapano in the boat's kitchen a few hours earlier.

NANUQ proceeded ahead after this brief encounter and stopped at 02.25 anchoring at Isbukta (p. 22). Departure was the day after, August 20th, at 09.00, and NANUQ reached Randberget.

At 11.00 on August 21st, while sailing in 5 Bft of wind from the west-south-west in clear sky and under light swell, NANUQ received a radio call from ALBEDO communicating that they had successfully completed their activity and were requesting tow. Gallinelli set therefore course towards Kikutodden.

The small boat and her occupants were met and taken on tow exactly half an hour later, in position 76°36'N, 17°04'E. The two fatigued athletes were greeted by the crew and invited to move onboard NANUQ, for some food and rest. Mattsing, injured, accepted and was welcomed into the cabin; Kjellkvist on the other hand, declined preferring, for the moment, to take several hours of sleep in ALBEDO's cramped cabin, also to keep an eye on the status of the rowboat. Glenn Mattsing was interviewed by Catapano, Struik and Courcy, giving information about ALBEDO's expedition, called «Row Around Svalbard», and reporting on several aspects of its development. After a relatively long conversation, the Swedish adventurer could finally take a few hours rest in a berth which had been cleared of equipment for him.

NANUQ, towing ALBEDO in overall good weather but moderate swell, reached and passed Sørkapp at 13.20, cruising at 5 or 6 knots (p. 23). Visibility was about 10 NM with alto-cumulus clouds, wind 5 Bft from the west.

Later that afternoon, as the boat was proceeding along the coast with a considerably different heading (from SW to NW), Gallinelli noticed that navigation was a bit more demanding. At 16.05, in position 76°27'N, 16°10'E, he made the following entry in his logbook: «We are proceeding against the wind and sea / Tow OK» (p. 23, my translation). Barometric pressure was slowly rising.

Early in the evening, at 20.45, wind had dropped to 2-3 Bft, but visibility had fallen also dramatically from 10 to 2 NM and the boat encountered thick mist. Nevertheless, cruising speed was maintained at 6 knots. Entrance into Hornsund took place in those conditions and the boat, under light but variable wind, proceeded towards Hansbukta.

3.2.10 *Hornsund*

Hornsund

Coordinates: 76°58'N, 15°42'E

A relatively large sound open to the west, bordering Sørkapp Land from the north. It is at the centre of Sør-Spitsbergen Nasjonalpark. Due to the presence of the Polish Scientific Station, the geography and environment of the area are among the most studied in Svalbard.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

At 22.45 NANUQ, with ALBEDO on tow, stopped and anchored in front of the Polish Scientific Polar Station-Hornsund (fig. 76) (p. 23).

Gallinelli proposed that some crew-members go on land to pay a visit to the famous base and greet the local group of scientists.

The dinghy was prepared for deployment; sea was calm, wind was very light at that point. Weather remained heavily misty and humid, with thick and low clouds. There was an intermittent rain. As in other occasions, the dinghy made two trips, landing two groups of crew-members on the small beach equipped by the Polish station. Taking advantage of the opportunity, the author boarded the dinghy with other colleagues operating a small 360° camera in order to take an immersive video of the trip and surrounding landscapes.

Two boats, belonging to the station, were ashore: one fiberglass and one rubber-boat. The latter was fitted with a metal frame for a couple of GPS antennas, indicating it was used for multibeam mapping. Struik and the author could not help but to comment that such an accessory might have contributed to solving the functionality problems suffered on NANUQ by the sonar GPS system.

A relatively wide path allowed to conveniently walk from the small beach, across a gentle slope, to the building of the Polish Station, where incoming Polarquest2018 crew was welcomed by Polish researchers. The team could enjoy a cup of hot tea and a friendly conversation with local scientists and technicians, learning more about the workgroup activities and research programmes.

Fig. 76 – *The Polish Scientific Station at Hornsund*

Source: ph. by G. Casagrande

Fig. 77 – *Left: an amphibious heavy-load tracked transporter parked in front of the station. Right: Polish researchers accompany Polarquest2018 crew-members for a visit to the facility*
Source: ph. by G. Casagrande

During the visit, a polar bear was reported to be approaching the station and a DJI Phantom 4 Pro drone of the base was launched to observe the surroundings. The bear was actually spotted at a few hundred-meter distance and its progress was monitored during a 15-minute flight. The animal, undisturbed by the drone flying at high altitude, passed at a safe distance from the station and NANUQ's crew could move with no concern around the buildings (fig. 77). Having spotted a large patch of tundra vegetation between the station and the beach nearby, the author flew the smallest available drone, i.e. a DJI Spark with an additional modded Mobius camera, to test it for sensitivity over the tundra cover.

The drone was overall flyable but revealed critical magnetometric issues and additional flight control problems. As soon as the test-flight provided a sufficient number of digital images for later processing, the drone was landed and packed.

By 14.45 all the crew was back onboard and NANUQ left her anchorage in front of the Polish station, proceeding towards the inner part of the fjord (p. 24). ALBEDO had been left in the anchorage for being towed again later. During the brief cruise, Gallinelli indicated to the author an interesting relief to the right side of the boat. The two discussed the possibility of trying to make a sequence of photo shootings as the boat was slowly passing by, to obtain a 3D model at a later time. The author, therefore, engaged in this activity for several minutes, then returned inside. The mountain was later identified as Bautaen. As NANUQ was closing in to the inner part of the fjord, around 17.25, while most of the crew was inside the cabin, Gallinelli, who was manually maneuvering the boat, peeped inside and announced that a group of polar bears was in sight. All of the crew rushed out of the cabin and gathered on the deck to observe and take images and videos. NANUQ's engine was slowed down to the minimum safe speed; at less than 100 meters, slightly to the right of the boat, three bears were standing on a group of small icebergs floating in calm water. The bears were an adult female and two cubs (fig. 78).

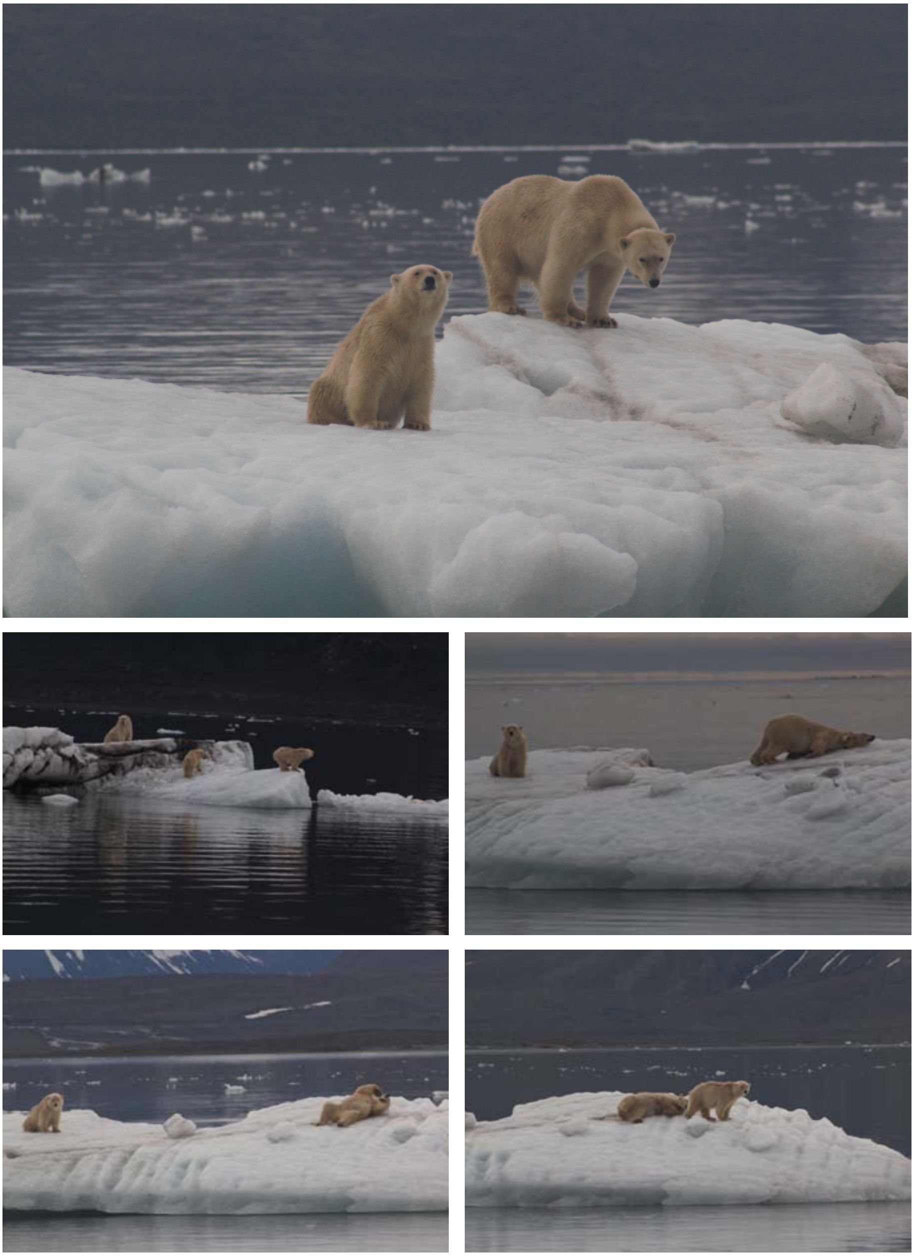


Fig. 78 – *Polar bears on an ice block in the inner part of Hornsund*

Source: ph. by G. Casagrande

They had just been feeding on a seal, whose almost entirely consumed carcass was visible nearby. Gallinelli's and the crew's main concern was not to frighten the animals, which were observing the boat with increasing attention. Particularly the mother was carefully tracking the arriving vehicle and all movements onboard. As NANUQ was closing in, several details became clearer: the she-bear had a GPS collar. One of the cubs was keeping close to her, staring at the boat; the other cub was still biting the prey and only occasionally looked towards NANUQ and the mother. Gallinelli took the boat as close as about 30-40 m distance from the icebergs and very gently turned all around them into a very slow 180° curve. In the initial part of this turn the cub who was eating, at a certain point appeared to notice that the icy block with the food was slowly drifting away from the larger one where the mother and the other cub were. The cub therefore began to call the mother, who showed little attention for this and, in no way disturbed by the passing boat, began to lazily kneel with her head and chest on the ice; then she rolled over on her back, apparently relaxing and interacting with the closer cub. Neither one paid any further attention to the relatively noisy NANUQ and the people observing them from so little a distance. From the point of view of the boat crew, the situation appeared so inherently safe, that in spite of the very small distance with the bears no weapon or flare-gun was prepared, nor even unpacked. After completing the turn Gallinelli discontinued the manoeuvre to avoid disturbing the bears and headed back towards the Polish station, increasing speed up to the usual 6 knots. The author took images of Bautaen as NANUQ passed it by again on her way back. Meteorological conditions were very good, with very light wind (about 1 Bft), stratus cloud and visibility of about 10 NM.

3.2.11 *Navigation to Isfjorden and Pyramiden*

At 20.25, NANUQ stopped in front of the Polish station to retrieve ALBEDO from the anchorage and resume tow. She then headed towards Isfjellbukta, which was reached at 23.50. NANUQ anchored in 9 meters, some hundred meters from a low, sandy beach in position 77°10'N, 14°34'E, north-west of Isfjellbukta.

The purpose of this stop was a visit to the wreck of a WWII military airplane, a German Junkers Ju-88. After a successful emergency landing on September 14, 1942, the airplane crew destroyed the aircraft and marched away to safety; many parts of the wreck were systematically removed by random visitors in the following decades. A brief summary of the story can be found at: *https://tihlde.org/~ktsorens/flyvrak/borthen.html*[52].

(52) The crash landing occurred on September 14th, 1942. The event is described as follows: «Junkers Ju-88 A-4 Kapp Borthen, Svalbard. 8./III./KG 30 4D+GS WNr.2121. […] The aircraft made a successful belly landing on the sandfloes at Kapp Borthen, after an attack on Allied Convoy PQ.18. Ofw.Paul Füllborn. Uffz. Wilhelm Mietz. Uffz. Meinhard Spielberg and Ofw. Siegfried Matschke were all uninjured. After landing they destroyed the aircraft. Two days later they were discovered by a searching He 111H-6 (von Gall), [which] dropped a message with instructions to march north to base Sönak. They reached the base later on the same day and were rescued

The position of the wreck had been previously shown to Struik by one of the Polish researchers. The twin-engine airplane had landed on a flat sandy area near Kapp Borthen, in position 77°11'26"N, 14°29'13"E (fig. 79).

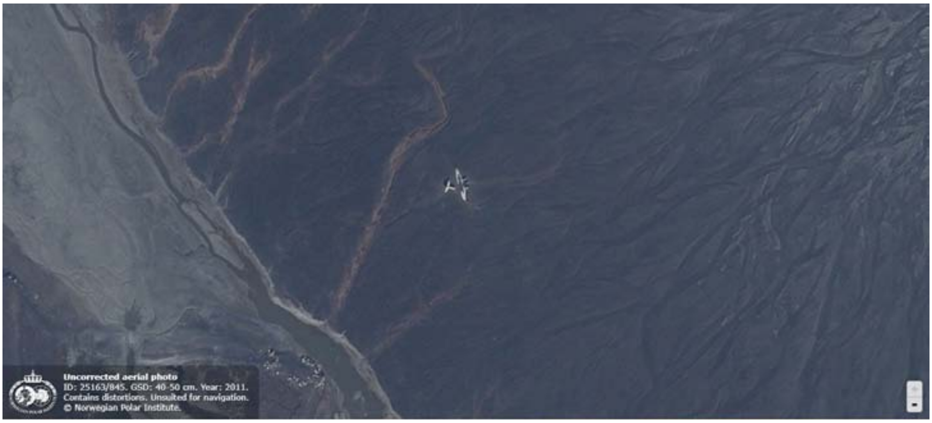


Fig. 79 – *The wreck of the Junkers Ju-88 as visible on the TopoSvalbard database. The tail section of the aircraft appears to be separated from the wings and the fuselage front section*
Source: Norsk Polarinstitutt

Michael Struik prepared the dinghy. The landing group included Struik, Courcy, Mathilde Gallinelli, Ombretta Pinazza. After landing, they had to do a brief trek on soft terrain; the area is widely flat and clear of obstacles for a long distance.

The wreck of the mostly aluminum-made airplane appeared to be in overall good condition – considering the environment (fig. 80). Surfaces showed no evident paint coating, the cockpit area contained no instruments, removed long time before. A remarkable amount of ammunition from the aircraft weapons was scattered all around the front section of the wreck.

At 03.00 AM on August 22nd, NANUQ departed the anchorage, beginning to proceed along the coast, in calm weather conditions. Barometric pressure had been slowly rising and cloud cover, generally stratus clouds, became thinner and scattered. At 08.00 NANUQ was approaching the entrance of Bellsund and ended up finding amazingly good weather, with clear sky and bright sun throughout the rest of the day. Due to the lack of wind, navigation was entirely on engine at 6 knots. At 13.55 NANUQ was in proximity of Røvigflaket and approached Isfjorden from the south; it then entered the fjord and kept cruising along the coast up to reaching the entrance of Adventfjorden.

back to Banak in von Gall's Heinkel. Two months later KG 30 was transferred to the Mediterranian. On 9. November they were all killed when their plane was shot down off North Africa».

Fig. 80 –*The German Ju-88 crash-landed in 1943 in Slamøyra, a short distance to the east of stream Slambekken, visible in the background*
Source: ph. by O. Pinazza

She turned towards Longyearbyen. As the boat was cruising up the Isfjorden the crew was able, for the first time in 20 days, to get cell-phone and wi-fi access to make phone-calls and share files with their distant families.

At 19.30 Polarquest2018 left ALBEDO. Kjellkvist and Mattsing boarded their tiny vessel in a warm goodbye by NANUQ's crew. Tow was released 2 NM off Longyearbyen harbour. NANUQ then turned back towards Isfjorden and began crossing it, north-eastbound towards Pyramiden. At 21.35 the boat was 3 NM south-west of Billefjorden. At 23.45 NANUQ began its approach to Pyramiden harbour. This was conducted with specific caution because, although the semi-abandoned harbour was regularly visited by tourist boats and ships, safety conditions of local infrastructures were not fully known to the crew (fig. 81).

NANUQ moored with its left side to the quay at Pyramiden at 00.30. It was the first time the boat was actually still at a pier in a harbour since the departure from Ny-Ålesund two weeks earlier. Weather conditions were good and the overall environment appeared to be quiet, so most of the crew decided to take the opportunity for sleeping the entire night. Gallinelli approached the author and proposed to do a brief excursion in the historical site, that he was visiting for the first time, while the author had already

Fig. 81 – *Pyramiden harbour appeared fitted with minimal equipment and services to allow for small to medium boat/ship activity. Much of the Soviet day infrastructure for larger ship traffic was in an evident state of decay. In the foreground, the wreck of a sunken boat surfaces from the shallow waters; Nordenskjöldbreen is visible in the background*
Source: ph. by O. Pinazza

been there in 2016. The two prepared for leaving the boat, then disembarked carrying a rifle and a flaregun. Although Pyramiden, in 2018, was no longer entirely abandoned, in practice it was considered a wilderness scenario and self-defence equipment was still mandatory. Soon after leaving the quay, the two were reached by Mathilde Gallinelli, Remy Andrean and Ombretta Pinazza.

While walking from the port to the first buildings, a distance of about 500 m, Gallinelli noticed what might have possibly been a polar bear, about 600 m to the south-west of the group's position, in the open landscape to the left of the road. In spite of waiting for several minutes, it was impossible to observe whether it was indeed a stationary bear or some other object, therefore the party continued on and reached the centre of the abandoned town. After a fairly long walk in the built area, they returned to the harbour; Gallinelli, Pinazza and the author climbed onto a large abandoned structure at the pier in order to explore its conditions; it appeared to be in serious decay and quite unsafe in general. A large Soviet-era bulldozer parked on the quay looked in rather poor conditions and abandoned, but was to prove efficient and operable the day after.

Pyramiden

Coordinates: 78°39'N, 16°19'E

A former Soviet and Russian mining-town, abandoned in 1998 and under surveillance, by a small group of custodians and tour-guides, as a cultural heritage landmark in 2018. When populated, it hosted a relatively large community, and the northernmost in Svalbard.

Cartography from TopoSvalbard, Norsk Polarinstitutt, (*https://toposvalbard.npolar.no/*).

The group then returned to the boat to rest for the remainder of the night. Late in the morning a second, very long excursion was made by the entire crew. During this observation, a series of guided tours was being made in the area, as a tourist ship, POLARGIRL, had arrived and moored at the same quay, on the opposite side of NANUQ's position. The guided tours included dozens of people, yet guides appeared quite attentive in preventing tourist from stepping on the delicate tundra spots. After having registered at the harbour office in the Tyulpan hotel, the Polarquest2018 crew divided into smaller groups in order to move in the area and try to document the less visited, or still poorly accessible, spaces of the abandoned town. Several of these were actually reached and documented. NANUQ departed Pyramiden at 21.50 and headed back to Longyeabyen, where it arrived at 03.00 on August 24th, 2018 (fig. 82), ending leg 14 of the expedition with a total of 1,405 nautical miles logged in the circumnavigation (p. 24).

A change in crew occurred during the following 24 hours. Catapano, Struik, Pinazza, the author, Buono and Courcy disembarked and a third crew reported onboard NANUQ to transfer her to the wintering location in continental Norway. Among them, student-physicist Ludovico Machet took charge of the cosmic ray detector, after a thorough briefing session with Ombretta Pinazza. He was the only Polarquest2018 representative left on board during the *convoyage de retour*.

AURORA and Microplastics research programmes had been completed according to plan. The operators left on August 27th to return home, after having had their equipment shipped to different laboratories. The iWBMS multibeam system was also shipped back to NORBIT SUBSEA headquarters in Trondheim. The sonar mount assembly, designed and built for Polarquest2018, was retained onboard NANUQ, in anticipation of possible future activities.

NANUQ left Longyearbyen with full reserves of fuel, freshwater and food on August 25th. As the boat was crossing the Barents Sea heading for Tromsø, in north Norway, the cosmic ray detector was kept operational and logged data which were later transferred to PolarquEEEst programme management centres at INFN, for processing and analysis.

NANUQ reached Tromsø and finally moored there at 16.05 on September 4th, after a quite rough journey in occasionally adverse weather. The transfer crew disembarked at that point. As a long-term stationing in Tromsø was not considered practical due to heavy maritime traffic and high permanence fees in that harbour, Gallinelli made arrangements for NANUQ to winter in a smaller and more quiet location in Fjordcamp. NANUQ, therefore, departed Tromsø at 08.30 on October 23rd and reached her destination at 11.45 on October 25th, mooring at the local pontoon in position 68°46'N, 14°42'E. She had logged, in her transfer to Norway, an additional 919 nautical miles. Preparations were made for the boat to safely remain in the harbour until the next season (pp. 26-38), then the crew repatriated.

Fig. 82 – *NANUQ's crew immediately after arrival in Longyearbyen. Standing, from left to right: the author, Paola Catapano, Peter Gallinelli, Alwin Courcy, Safiria Buono, Mathilde Gallinelli, Dolores Gonzalez, Michael Struik. Seated on the cosmic-ray detector: Ombretta Pinazza and Remy Andrean*

Source: ph. by L. Machet

Part II

Subject-Specific Reports

4. *The former airship base at Ny-Ålesund*

The airship base at Ny-Ålesund was established and inaugurated in a brief period of time, between the beginning of October 1925 and the end of February 1926. Its area, immediately south-east of the then mining town, had already been used during the Amundsen-Ellsworth polar flight of 1925 with two Dornier Wal flying boats. The base was supposed to serve airship N-1 NORGE during the Amundsen-Ellsworth-Nobile Transpolar Flight, planned to take place in spring 1926. The N-1[53] was a 18,500-cube meter capacity semi-rigid hydrogen airship built by the Stabilimento Costruzioni Aeronautiche (SCA) of Rome, Italy, in 1923. It had been modified for the polar flight by the same firm. The Aeroclub of Norway purchased the airship from the Italian Government, re-christened it NORGE and assigned it for the first transarctic flight between Europe and America. The 1926 expedition was to be led by Norwegian explorer Roald Amundsen and mostly financed by American tycoon Lincoln Ellsworth. The blimp had been designed by Italian Royal Air Force Colonel and engineer Umberto Nobile who also served as commander of the ship, while the expedition was led by Amundsen and called for an international Norwegian-Italian flight crew. Compared with other similar machines of the time, the NORGE was a medium-size, rather simple but quite robust and reliable airship, which turned out to be the most successful design of the time for Arctic long-range aerial exploration. Though much smaller and easier to operate than other blimps of the time, the NORGE required adequate infrastructuring for its airfield. This would have ended up being, in any case, much more complex than any field for contemporary polar airplanes such as the Dornier Wal. Initially, the plan was to moor the 106 m long airship attaching its nose to a 35 meters tall mast built in iron carpentry. The head of the mast could rotate 360° in order to allow the airship to always keep the nose into the wind, rotating as necessary (figg. 83 and 84). This solution allowed to minimize drag and to keep the airship in position in case of strong winds. The mast was designed by Umberto Nobile and four examples were built in Rome. One was placed at Ciampino airport for testing and training purposes (Ferrante, 1986, I, pp. 164-169); the other three were shipped, disassembled, to Oslo, Vadsø and Ny-Ålesund, three critical stop-over sites along the planned route.

While the work on the airship and the several bases were underway – Amundsen's and Nobile's agreement for the expedition was struck during the summer 1925, less than a year before the polar flight – Nobile decided that the mast was not sufficient. Ny-Ålesund was the last base-camp before the polar attempt. At that stage it was necessary to consider the possible need of major maintenance or relatively long stay in the base. This implied the necessity to protect the airship in case of bad weather before the Arctic crossing.

(53) The aircraft had been simply called «N-1» in Italy (N being the initial of the designer's name, Nobile), with registration I-SAAN.

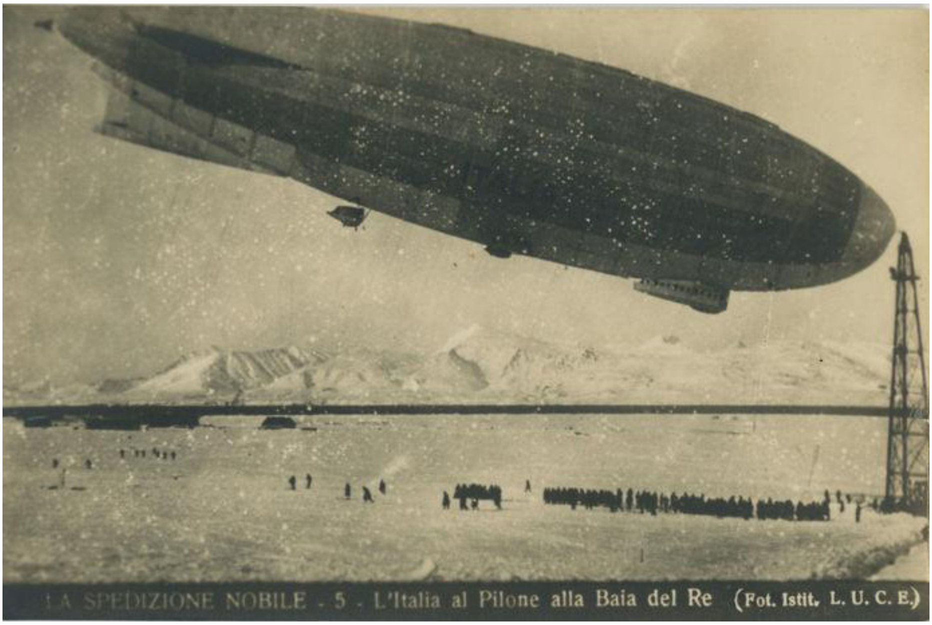


Fig. 83 – *Airship ITALIA moored at Ny-Ålesund mast*
Source: photoarchives of the Italian Geographical Society

Fig. 84 – *The modular mooring mast for airships NORGE and ITALIA stands at Kings Bay in position 78°55'17.6"N, 11°56'46.4"E*
Source: ph. by G. Casagrande

For such cases, a mooring-mast was, by far, a too precarious solution: standard airship operation at the time would have called for a hangar to protect. Given the available time, the Arctic environment and budget constraints, building a normal hangar in Ny-Ålesund was extremely difficult, and this was probably why Nobile was reluctant to propose it. Nobile's right-arm man in Rome, Eng. Felice Trojani, was equally skeptical about the idea, but, when questioned on the matter, put forth an alternative. Since the concept was to merely shelter the airship from severe weather during only a few-days of stay at Ny-Ålesund, a lighter solution was viable.

Instead of building a full-blown metal frame hangar, the expedition could have built a relatively essential wind-shelter using wood for the structure and fabric for the walls. The architectural concept was not new at Svalbard: it had already been used in Virgohamna by the Walter Wellman's expeditions, but Trojani had in mind the previous, much smaller and stronger «Balloon House» of the Andrée's 1896-1897 polar attempt (Trojani, 1964, p. 178).

Trojani's project called for building two strong side-walls long almost exactly as the airship and with enough room between them to conveniently but tightly host it. The goal was simply to protect the airship by putting it between two barriers against the wind. For this to be achieved, the orientation of the structure's longitudinal axis had to be perpendicular to the direction of the dominant local air currents. Furthermore, as any other airship hangar, the shelter was supposed to allow for proper ground-handling of the blimp; this means that its site had to be sufficiently open, regular and free of obstacles so that the large machine could be safely moved around it depending on needs. The top sections of the walls were designed with some inclination, in order to facilitate deflection of wind currents.

It was useless – even dangerous – to think of building a roof for the hangar: it would have required a far heavier structure for the walls, and no roof would have safely stood the weight of snow and ice in case of massive precipitation (figg. 86a and 86c).

Trojani's proposal was accepted by Nobile; the hangar was designed and fully calculated in less than 24 hours on August 30th, 1925. Data were handed over by Nobile's staff to Hjalmar Riiser-Larsen who left Rome on September 1st, heading back to Norway (*ibidem*, pp. 176-178).

In the following days, a low-scale model of the hangar was built in Rome, fitted with a small blimp resembling the real one, and tested in a wind tunnel. The conclusion was that the real building was probably safe and adequate for the mission. According to these tests, if the wind had blown longitudinally to the hangar, i.e. between the barriers, the airship – provided it had been properly moored – would have been better protected without doors or fabric covers. For this reason, they were not recommended by Trojani, but were anyhow installed in the end. The Norwegian partners approved the project and construction began. The first problem was to transfer the required materials to Ny-Ålesund. Piesing (2018) summarizes the construction stages and the building's feature. Materials were transferred to Kings Bay before the ice closed the small harbour. Ship SORLAND delivered cement, steel poles and steel bolts for the NORGE's mast; Ship ALEKTO arrived on October 23rd with 22 workers, 600 cubic metres of timber, 50 tonnes of iron and equipment. Works were to be directed by Eng. Joh Höver and by master carpenter Ferdinand Arild. The mining organization, which could provide equipment and technical competence, built a 400 m extension of the local railway to facilitate transport of materials from the quay to the site selected for the hangar construction, which was higher (about 15-20 m) and on a slightly sloping surface. The working personnel was obviously hosted in two barracks in the mining village. The hangar structure was erected – a non-standard practice – in the months of the Arctic darkness, with scarce electric light provided by the local power plant. Workers operated – mostly by manual tools – in temperatures as low as -20° and up to a height of 30 metres above ground, with additional complications due to snow and ice. As planned, the hangar was covered with 10,000 m^2 of sailcloth, delivered at the beginning of 1926. When completed, on February 15th, 1926, the hangar was 110 metres long, 34 metres wide and 30-metre-tall; just enough larger than the airship. According to Piesing (2018) – who interviewed Olav Gynnild, senior curator at the Norwegian Aviation Museum – the hangar was the largest building in the Arctic at that time. The NORGE arrived in Ny-Ålesund on May 8th, 1926 and was pulled into the hangar, after landing. There remained safely until May 11th, when it departed bound for the North Pole. In the end, the NORGE had not used the mooring mast, but rather the wind shelter (fig. 86b). The Ny-Ålesund airship base was temporarily deactivated but recommissioned in 1928. In that year, Umberto Nobile obtained permission to use it again for the polar exploration with airship ITALIA, formally organized by the Reale Società Geografica Italiana (Royal Italian Geographical Society). The airship, almost a twin to NORGE, conducted three flights over the Arctic region. In between these operations, ITALIA moored at the mast or was hosted in the hangar, testing virtually all operational conditions envisaged in its design and building. ITALIA reached the North Pole on May 24th, 1928; however, it crashed during the return flight. The airship base was practically abandoned after 1928. The hangar collapsed during the 1930s, giving way to the Arctic weather. «Wood is scarce on Svalbard. Its timbers quickly found a new use in buildings across the islands. A bridge for the narrow-gauge railway made from the hangar's wood still stands today» (Piesing, 2018).

The area of the former airship base is more or less intact, after almost a century (fig. 85). Though very close to the scientific village – merely a few hundred meters from the closest buildings and about 1 km from the quay – the zone is considered outside of the settlement and therefore in a wilderness area. This makes access with weapons required.

Fig. 85 – *Aerial view of the former airship base at Ny-Ålesund (1926-1928) in its 2018 conditions*

Source: basemap TopoSvalbard, annotations by G. Casagrande

Taking as a reference the historical Nordpol Hotellet, now in the centre of the scientific village, the mast is located at 500 meters – bearing 132°. The northern entrance of the hangar was located approximately at the same distance, bearing 160°. The longitudinal axis of the hangar was apparently oriented (130°/310°). Access to the area is currently possible along an unpaved road exiting the scientific station from the south and crossing the old airfield from the north west to the south east, approximately along the path of an abandoned narrow-gauge railway. The most visible remainings of the building are armoured-concrete attaching points installed in the ground. A series of 8 is clearly visible in summer when the snow cover melts. They are aligned in the tundra-covered ground, at a 60-70 meters distance from the road. Apparently, the road itself obliterated another, parallel series of structural elements (figg. 86e and 86f).

The position of the aforementioned attaching-points series was about 200 meters distant from the mast. It is therefore possible to observe than when the airship was moored at the mast, if wind had blown from the north-east, it would have made the blimp rotate correspondingly, hence its tail would have ended up at about 100 meters from the hangar. This was normally a convenient separation, but would have implied the need of quick and appropriate manoeuvres in case of accidental detachment. Such circumstance did not occur, but was actually among the crew's concerns (Trojani, 1964, pp. 290-291).

An element of the wooden structure of the hangar is preserved in the local Ny-Ålesund museum (fig. 86d), as well a hydrogen canister used for loading the airships' gasbags.

The mooring mast, known to the local topography as «Norge-masta» remained as a memorial to the historical expeditions. In spite of a considerable degradation of materials, it is still, to this day, a distinctive feature of the Ny-Ålesund skyline. The structure appears to be overall intact and still theoretically accessible. Time and weather contributed to a minor inclination of the mast axis – carefully monitored – and the concrete foundations show evident signs of degradation. The structural elements, when visited by Polarquest2018, appeared in overall good conditions in spite of evident rust and corrosion. Some original elements, once present, are now missing: the water and fuel tanks as well as hoses and connections to allow refuelling/refilling for the airship.

When Ny-Ålesund-Hamnerabben airstrip was built, on a small and flat relief, north-west of the scientific settlement (i.e. right on the opposite side from the abandoned airship base), Nobile's mast was one of the tall objects requiring installation of anti-collision red-lights for aircraft. By the way, it should be noted that, although not very high in absolute sense, the mast is pretty close and fairly aligned with the airport runway. The mast also contributes to the scientific activities of the research stations by hosting a differential GPS antenna, for high precision topographic measurements.

Considered a memorial, the historical mast was fitted, through time, with plaques celebrating the events associated with it and is now frequently visited by tourists.

About 100 meters south-west of the mast, halfway between the mast and the hangar, in 1963, the so call «Eight-Crosses Memorial» was placed, to commemorate the eight ITALIA's crew-members who died in the expedition. The monument can be considered a cenotaph to the disappeared men.

Fig. 86 – *Historical pictures and current remnants of the polar airship base at Kings Bay; a) the hangar before application of sailcloth covers; b) NORGE being pulled into the hangar; c) scale model of the hangar; d) surviving element of the hangar; e) element of the hangar structure* in situ*; f) traces of hangar structures along the road*

Source: ph. from the public domain (a-b); by G. Casagrande (c-f)

5. *The AURORA research programme: Method and activities*

In one of the research activities onboard, programme AURORA, Polarquest2018 aimed to conduct a series of geographical observations and expeditive surveys, along with methodological tests with drones and auxiliary technologies in the «low-cost» and/or «open-source» categories. The purpose was to evaluate the efficacy of such technologies in some research profiles, as well as in future use in the field of citizen science. This section of the book presents the most relevant results of such activities, adding comments about the performed work, the observed phenomena and the acquired data.

Several documentation methods and survey profiles were tested, in different fields, including geo-history/archaeology, environmental observation and monitoring. Particularly in the latter field, tests were conducted to assess the efficacy of consumer-level and citizen science-level hardware and software. Aerial documentation was conducted by small drones and the collected data were later processed and analyzed in the lab. The general workflow used in the main expeditive surveys i.e. Virgohamna, Kinnvika, Alpiniøya, Inglefieldbreen is presented in figure 87.

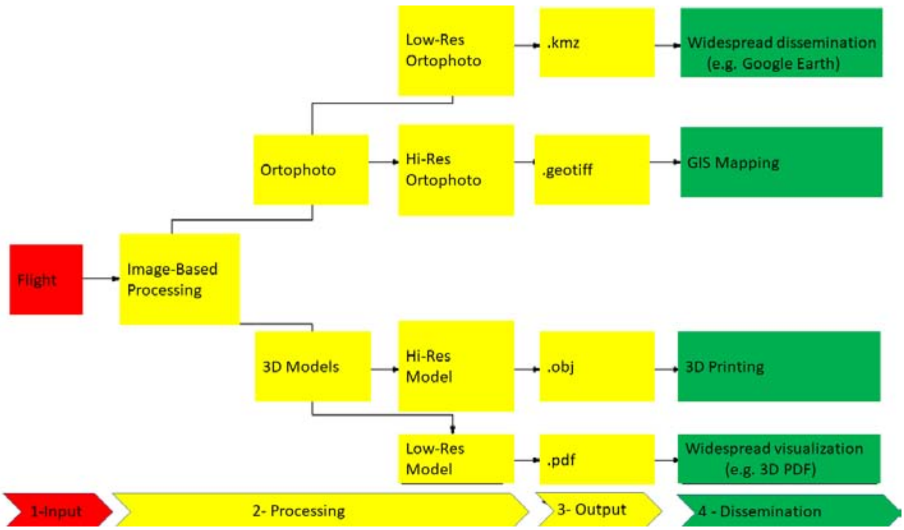


Fig. 87 – *Data acquisition-processing-presentation workflow in the AURORA programme*
Source: AURORA (processing by G. Casagrande)

Depending on conditions, drones were launched from the boat and recovered onboard, while she was either moored or in slow motion along the coastline or a glacier front. In other cases, it was flown from the ground during on-land activities. Depending on specific needs, acquired images were high-resolution stills (often shot in «time-lapse» mode with a 3-second interval), or video, nadiral or oblique. Typically, images had a standard size of 20 Mpx.

In the Kinnvika low-res mapping, the used workflow was similar, with the difference that input images were at lower resolution (960 x 640 pixels).

During sensor-test flights, an additional payload was installed onboard the drone; in the Trollkjeldene activity the additional sensor was a visible light/thermal infrared camera.

When image-based-modelling was the object of the activity, data were processed in the lab according to the standard workflow «align-build dense cloud-build mesh-build texture», with the use of Agisoft Photoscan Pro 1.2 (Agisoft, 2016) and/or Metashape Pro 1.5 (Agisoft, 2019), with different settings depending on needs. These procedures yielded descriptive 3D models (in *.pdf* and *.obj* formats) and ortophotographs (generally in high-resolution *.geotiff* and low-resolution *.kmz*)

3D models, exported in PDF, are meant for visualization even on modest-performance computers; those in *.obj* are supposed to be used in other forms of processing, including 3D-printing. Similarly, the .kmz ortophotos were created for visualization on widespread GoogleEarth™ platform, while that in *.geotiff* is for other types of analysis.

For two places of interests, i.e. Virgohamna historical site and Alpiniøya environmental POI, the high-resolution ortophotographs were imported as raster in a Geographic Information System, on which elements of interest have been documented in appropriate vector layers. The application used for this purpose was QGIS 2.18.14.

In all cases, surveys were conducted with expeditive techniques, without any reference to ground control points (GCPs). In other words, they were conducted relying only on the non-differential GNSS embedded in the drone and on data derived from the flight control system. Unlike the usual procedure followed in this type of operation (Szabó et al., 2018), a sort of expeditive «direct georeferencing» was used instead. Being achieved by non-differential positioning, a larger error was to be budgeted both in terms of absolute positioning and in metric reconstruction of the objects. Such error was deemed acceptable for the purposes of the expected documentation (Pfeifer et al., 2012). Collected images, associated with positional metadata, allowed for the creation of georeferenced photogrammetric models by the use of «image-based-modelling» software. This approach implied two diverse, but related, problems in terms of survey accuracy: on the one hand, accuracy in local positioning (a.k.a. «relative») and the accuracy in global positioning (a.k.a. «absolute»). The former corresponds to the capability of rendering the correct geometry and relative position of ground objects; the latter is to be intended as the capability of the workflow to accurately reproduce the position of the objects on the surface of the Earth.

If GCPs and exact topographical references are not available, it is necessary to rely on approximate measurements (Putch, 2017, p. 14). Relative accuracy can be assessed by comparison to known object size – as acquired in «ground truth» observations.

The accuracy in global positioning, however, is virtually impossible to ascertain with meaningful precision, beyond the normal limits to be expected from a non-differential GNSS system, if external references are missing. In anthropized geographical contexts, for which reliable reference cartography or high-accuracy remotely sensed imagery is available, the issue can be solved. This is not the case, unfortunately, when such material is not at disposal, as it happens in north Svalbard, due to the peripheral nature of the region with regard to anthropic contexts and services (Gallia, 2019).

As far as it was possible to ascertain from Polarquest2018 data, the orto-photographs and the expeditive cartography obtained during the expedition appeared to bear a relative positioning error in the order of 0.5 meters, sometimes less than that. It was impossible to exactly quantify the error in absolute georeferencing, although it can be expected to be in the normal values of a non-differential GNSS as the one used. A metrical estimation of such value, however, is conjectural because the comparisons of photogrammetric models with topographic maps and low-resolution satellite images did not allow to observe any significant offset.

For the sake of a possible repetition of the surveys by other workgroups, it is considered useful to share that if the general concept and the operational activity of the AURORA project proved largely satisfactory and even, in some cases, successful above expectations, the same cannot be said with regard to the specific drone platforms in terms of reliability and usability . In the author's opinion, this issue can be easily overcome by the use of other drone platforms from the same technical category, built from different hardware or with a differently designed flight control system.

5.1 *An expeditive survey of the Virgohamna historical site*

This section is an edited and expanded translation into English of a previous work by the same author (Casagrande, 2019), integrated with some comments and elements from another work (Casagrande, 2020).

The historical site of Virgohamna, also known with the English name of Virgo Bay, has been the location of some relevant episodes in Arctic exploration (fig. 88).

The area is at the interface of the two small islands of Danskøya (Danes Island) and Amsterdamøya (Amsterdam Island, fig. 89), at the north-western edge of the archipelago.

The two islands are divided by a relatively narrow sea strait, only about 1.5 to 3 km wide. Despite relatively shallow waters, the area is nevertheless favourable for mooring boats and small ships. Virgohamna is a well-characterized bay on Danskøya northern coast. Its mostly relevant historical area features a fairly stony and gently sloped beach, with approximately 600 m length and about 300-metre width. It is almost circular and its western and southern edges are surrounded by fairly steep mountains and hills.

The entire area of the two aforementioned islands is part of one of the large protected zones of the Svalbard archipelago: the Nordvest-Spitsbergen Nasjonalpark, or North-West Spitsbergen National Park.

Fig. 88 – *General view of Virgohamna from the north (August 8th, 2018)*
Source: ph. by G. Casagrande

Fig. 89 – *Aerial view of Amsterdamøya towards the north-west, from Danskøya*
Source: ph. by G. Casagrande

Fig. 90 – *Aerial view of Virgohamna. The white arrows point to the locations of the 1896-1897 Andrée's expedition balloon house (1) and Wellman's 1906, 1907 and 1909 expeditions airship hangar (2)*
Source: ph. by G. Casagrande

The place was already known in the first half of the 17th century as a base for whalers (Friolo, 2007, p. 27). The ancient toponym of Houcker Bay (Bjerk and Johansen, 2007, p. 8; Stange, 2012, p. 314) is due to them. The site was at a relatively short distance from a more developed settlement, located on the opposite side of the strait, on the south-eastern part of Amsterdamøya. It was called Smeerenburg (Umbreit, 1991, pp. 57-58). On the beach at former Houcker Bay it is still possible to identify traces of the ancient whalers' village, despite the many remnants of later polar expeditions.

In 1888, Arnold Pike, a wealthy British citizen, had a house built on the shore, for himself. The building was later remembered as the Pike's House. In 1896, the VIRGO, a support ship to the Swedish Andrée's polar expedition scouted the area and selected it as advanced base for an attempt to reach the North Pole by flying a manned balloon. The bay, which had been practically abandoned for quite a long time, was then renamed Virgohamna and such toponym was later maintained. From 1906 to 1909, the place was also used as a base-camp for a series of Arctic exploration attempts, known as Wellman's expeditions (fig. 90). In 1928, a Swedish expedition stationed in the area during the wide international search and rescue campaign to recover the survivors of the ITALIA. The airship commander, Umberto Nobile, was airlifted there for later hand-over to the Italian support ship CITTÀ DI MILANO.

Throughout the 20th century, Virgohamna was the object of increasing interest among Arctic tourists. In most cases, visits are in the form of guided tours.

Both Amsterdamøya and Danskøya, and a wide region surrounding them, are uninhabited. The closest settlement is Ny-Ålesund about 90 kms SSE.

A present-day visitor to Virgohamna will be impressed by the silence and apparent peace which dominate the place. It is currently forbidden to land – and even to transit – within a certain distance from the historical place, without being issued, in advance, a specific clearance by the Sysselman (Norwegian governor of Svalbard). Due to such limitation, the place appears quite solitary and lives an impressive solemnity, which effectively gives the observer not just the physical view, but also the emotional feeling of its historical *genius loci*. In this sense, Virgohamna retains – also thanks to the access limitations established by Norwegian authorities – a high value as a «performative memorial» of the old times of polar exploration (Winter, 2006, p. 12).

The expeditive survey of the area by Polarquest2018 focused on two specific chapters of the story, i.e. the Andrée (1896-1897) and the Wellman (1906-1909) expeditions. The presence of abundant traces and remnants of both exploration attempts is well documented in the literature as well as in informal material published by generations of visitors and tourists.

5.1.1 *Salomon August Andrée's Arctic expedition (1896-1897)*

Towards the end of the 19th century, an international competition developed among explorers for setting the first step on the North Pole. Swedish engineer Salomon August Andrée (1854-1897) envisaged a technically daring method for reaching the goal. Since many parties who were trying to reach the Pole by surface were experiencing often overwhelming difficulties due to ice, blocking seaways and hampering surface routes, Andrée considered a totally different formula. He proposed to fly over the Arctic region in a manned balloon (McCormack, 2008, pp. 415-416). In previous years, other candidate explorers had proposed to use aerostats for travels through the polar regions; however, such ideas had not been put into practice (Lewis-Jones, 2008).

Andrée intended to use a hydrogen balloon, assuming it would have been possible to insert such ship into large air currents moving all across the Arctic region. Such currents would have not been deviated or disrupted by large reliefs or land areas; therefore, they could have effectively carried an aerostat across long distances. Naturally, this concept was based on the assumption that such wind currents would have had adequate direction. Then, of course, it would have been necessary to find a way – yet undiscovered in Andrée's time – so that the aerostat could have been somehow directed in its flight path.

Any balloon is indeed completely carried by the wind, so it basically tends to travel in the same direction and at the same speed. It is then only possible to have it climb, descend or, at best, stabilize its altitude. Andrée was convinced to have been able to invent a system to make the balloon at least partially *controllable*.

By applying draglines to the aerostat, it would have been possible to maintain constant contact with the surface of land, sea or ice; this would have appropriately stabilized the balloon's tendency to climb or descend, but, most of all, it would have allowed to slow-down the aerostat generating aerodynamic drag. Once this was achieved, a system of sails, appropriately mounted on the balloon, would have allowed to steer it in some degree from the wind direction. Andrée had tested this method on experimental balloon SVEA, reporting that it would have been possible to obtain steering up to 27° from the wind direction (Nobile, 1975, p. 26). His technical solution was unprecedented and lacked widespread verification, but he did not hesitate to adopt it, as he made an agreement in 1895 with aerostat manufacturer Henri Lachambre of Paris. Lachambre's workshops prepared the balloon for Andrée's polar attempt[54]. It was larger than the SVEA, and it was called ÖRNEN («Eagle» in Swedish).

Andrée's successful fundraising campaign was mainly due to his ability to present the project as feasible, to the charming effect of his daring plan on the public opinion and also to the imprecise knowledge about the Arctic meteorology at the time. National pride was also involved, and the project received support by most authoritative sponsors, such as the King of Sweden and Alfred Nobel. Those contributions gave Andrée an important endorsement in his country, in the very same months when Norwegian explorer Fritjof Nansen's expedition was coming back from the Arctic after having set a latitude record with his specially designed ship FRAM.

When Virgohamna was selected as a base-camp, a wooden-made balloon house was built on the eastern extremity of the beach, next to the surviving Pike's House – Arnold Pike had granted permission for using his building. Following Andrée's directives, the

(54) Features of the balloon are summarized in Nobile (1975, pp. 26-27). The aerostat was elliptical in shape with vertical major axis. The volume was 4,800 m^3 (in the 1897 configuration). The gasbag was made of silk with an additional coating to reduce the natural leakage of hydrogen through the seams; it was covered from the top by a hemp net, connected to 48 ropes, which in turn helm the balloon rim. The latter was a ring-shaped element, a fundamental structural element and, at the same time, a convenient place for equipment and for allowing aeronauts to take some rest from the often-bumpy permanence in the main nacelle, hanging from the rim itself. The nacelle was built with light wooden elements. The top of the nacelle was an observation platform; an internal space underneath was to allow the crew some protection and enclosure. For directional control, Andrée intended to use three sails (a larger one and two smaller ones) for a total of about 75 m^2. The three guide-ropes, each one of which was about 300-meter-long, hung from the rim, alongside the nacelle and down to the surface of land, sea or ice. Andrée was planning to constantly navigate between 150 and 200 meters, given that the guide-ropes had the double function of applying drag to the balloon – so that the sails could operate – and, at the same time, to vertically stabilize the aerostat by compensating with their weight for ascending or descending tendencies, caused by environmental conditions.

camp included a plant for locally producing the hydrogen required to fill the aerostat. This solution was righteously considered more practical than having hydrogen transported from the mainland.

After its completion in France, the ÖRNEN was directly shipped to Svalbard without any specific test by Andrée.

Fig. 91 – *The crew of the 1897 Andrée polar expedition. Left to right, Svedenborg (back-up), Strindberg, Fraenkel and Andrée (seated)*
Source: ph. by G. Florman (1897) from public domain

The crew selected by Andrée included expert meteorologist and explorer Nils Heckolm (1848-1923) and physicist and photographer Nils Strindberg (1872-1897).

The three explorers left Stockholm with great popular support and arrived to Virgohamna in the second half of June 1896, preparing for their flight. When all equipment was ready, however, wind conditions remained unsuitable for the attempt. On August 17^{th}, it was necessary to acknowledge that it was too late in the season for a safe attempt and the party had to give up.

The ÖRNEN was packed-up and loaded onboard support ship SVENSKSUND. The group left Danskøya, planning to return the following summer. Back to Sweden, after a while Heckolm quit the expedition due to disagreements with Andrée about the reliability of the aerostat. As the ÖRNEN was standing inflated in the balloon house at Virgohamna, waiting for the opportunity to take off, Heckolm had been monitoring its technical conditions and had realized that the gasbag appeared to have unsatisfactory gas-tight qualities[55]. Heckolm was replaced by engineer Knut Fraenkel (1870-1897). As a reserve crew member, Vilhelm Svedenborg (1869-1943) joined the expedition (fig. 91). On May 30th, 1897, the party returned to Virgohamna for its second attempt (Andrée et al., 1931, p. 65). On July 11th, weather conditions appeared to be overall adequate for the flight. As planned, a large portion of the balloon house top was dismantled in a few hours to let the ÖRNEN out. This formula made it impossible to abort departure without causing the entire expedition to fail.

Fig. 92 – *The ÖRNEN leaving Virgohamna. The aerostat is at low altitude and drifts towards the north-east*

Source: Andrée et al. (1931, facing p. 53, detail)

(55) This element, which would play a crucial role in the expedition, was variously discussed. Strindberg commented, in a letter to his brother (cited in *Letters from Andrée Party*, 1898, p. 405), that the ÖRNEN leaked, in the 1897 configuration, 45 kgs of lift every 24 hours; this would have allowed for a one-month endurance. Chemist Axel Stake, who supervised the inflation works at Virgohamna (p. 409), believed that Andrée, in his estimation that the ÖRNEN could remain in flight for six weeks, was far too optimistic. Umberto Nobile (1975, p. 45) assumed that the loss of lift was greater, i.e. 84 kg/24 h. In his opinion the overall endurance of the balloon would still have been adequate to a long flight over the Arctic region. However, according to this author, the expedition would have had higher probabilities of success had a free flight be conducted, instead of the dragged one, so tenaciously pursued by Andrée.

The ropes holding the ÖRNEN on the ground, with Andrée, Strindberg and Fraenkel onboard, were released at 13.46 GMT (*ibidem*, p. 68). The balloon began to fly north-east, drifting over the sea (fig. 92). As planned, the three large control ropes were dragged onto the beach and through the water, leaving a definite trail. The balloon – loaded with much equipment and ballast – descended and dipped in the water. The three aeronauts then threw 9 ballast bags weighting 23 kgs each (for a total of 207 kgs) in order to lighten the balloon. More or less at the same time, the main elements of the draglines unexpectedly detached from the aerostat because of flawed screw-connectors. Another 530 kg were therefore abandoned (*ibidem*, 70). Right after take-off, then, the ÖRNEN had already lost about 700 kgs of ballast out of the ca. 1,700 initially onboard.

Such weight should have been released progressively during the navigation, so as to compensate for the natural and inevitable loss of hydrogen from the gasbag.

Consequently, a phase of unexpected static unbalance followed. The balloon was too light and for the moment there was no way to control it directionally. Both circumstances were against Andrée's plan and should have suggested to abort the flight immediately. However, the three aeronauts continued on. The ÖRNEN climbed up to an altitude of 600 meters and flew north, then north-east. It disappeared from the ground-crew's sight after about an hour (McCormack, 2008, pp. 420-421). From that moment on, and for 33 years, very little was known about the Andrée expedition[56].

On august 6th, 1930, sealing ship BRATVAAG, on a research and hunting trip in east Svalbard, made a stop-over at the small island of Kvitøya (White Island). Crew-members found the remnants of Andrée's last camp. Expedition journals, photographs and equipment were also found, in good preservation conditions. Two skeletons were recovered – soon identified as Andrée's and Strindberg's. Fraenkel's remainings, along with other equipment, were found a few weeks later by a second ship, the ISBJORN, rushed on the site after the news of the first discovery.

(56) Some faint trace contributed to deepen the mystery. Four days after the expedition departure, fishing boat Alken received a carrier pigeon sent by Andrée with a message for Swedish newspaper «Aftenbladet» (*Letters from the Andrée Party,* 1898, p. 411; Nobile, 1975, pp. 30-31). The dispatch, sent at 12.30 GMT on July 13th (*ibidem*, p. 31) reported that the balloon was flying east but without any difficulty. Between 1899 and 1900, in different times and places of Svalbard, three Andrée's messaging buoys were found. Two of them contained messages reporting about the initial phases of the flight, the third one did not contain any message. It was the one that Andrée had reserved for a ceremonial drop over the North Pole and, apparently, it had been released as ballast. All received messages were describing a free-flight phase and provided no relevant information about what might have happened next. Barr (2006) writes that German reporter Gerard Lerner, who had witnessed ÖRNEN's departure from Virgohamna, a few days later participated also in a mission to prepare supply depots for Andrée's party at Sjuøyane (a.k.a. the «Seven Islands», north Svalbard). During such activity, Lerner would have briefly sighted the balloon, in the early hours of July 14th, about 35 km North-East of Sjuøyane. If Lerner's report is accurate, that would have been the last sighting of the ÖRNEN's flight.

The three Swedish aeronauts received solemn state funerals in Stockholm, in October 1930. Meanwhile, it had been possible to examine the documents and to develop the films, obtaining 93 images. Many aspects of the tragic endeavor could then be clarified. The ÖRNEN had actually flown for about three days, up until July 14th, 1897 (Amundson and Malmér, 1931, p. 107). During approximately half that time, the balloon had remained at very low altitude, in a stressful series of attempts to use the draglines and the sails. The only result of such action was to dilapidate gas and ballast, with no relevant controlling effect. The aeronauts had finally decided to land on the pack, and an excruciating journey on foot began, first towards Franz Josef Land and later towards Sjuøyane (the «Seven Islands»). Neither destination was finally reached, as ice drift in the area was erratic and faster than the explorers' ability to move. Under impending Arctic darkness, on October 5th, the three men were finally able to reach Kvitøya. They could establish a camp, but apparently died shortly after (Lithberg, 1931; Broadbent and Oloffson, 2000).

The discovery of Andrée's lost expedition, with its wealth of documents, made international sensation. Journals, pictures and accounts of both the 1897 journey and the discoveries at Kvitøya were presented in a publication which was nothing less than an «instant book»: *Med ÖRNEN mot Polen.* It was edited by the Swedish Society of Anthropology and Geography with publisher Albert Bonniers. The book was widely translated and circulated in several languages.

Historical opinions about Andrée are mixed. A tranchant yet effective synthesis comes from Capelotti (1994, p. 275): «Andrée had attempted […] only to vanish, his fate a mystery, his method ignored».

The expedition itself turned out to be a controversial case; nevertheless, some authoritative experts in Polar exploration and aerostatic flight acknowledged the pioneering value of Andrée's technical and human effort (Nobile, 1975, pp. 45 and 111; Trojani, 1964, p. 177). A letter written as a good wish message, which ended up being a moving epitaph for Andrée and his companions bears the name of the famous explorer and scientist Fridtjof Nansen: «And so, farewell! In the time that is coming many friendly thoughts will be sent to you from a friend who believes that he is able, whatever fortune may bring, to judge a man according to his merits and not according to his success» (excerpt from a *Letter by Fridtjof Nansen*, May 20th, 1897, cited in *Andrée's Diaries*, 1931, facing p. 37).

Andrée's, Strindberg's and Fraenkel's endevour remains to this day a particularly relevant chapter in the history of Polar explorations and retains quite a paradigmatic value both in its technical aspects and in its human story, as discussed in Capelotti (1999), Popat (2016); *Anna's Heart* (2000), McCormack (2008).

5.1.2 *Walter Wellman's expeditions (1906-1909)*

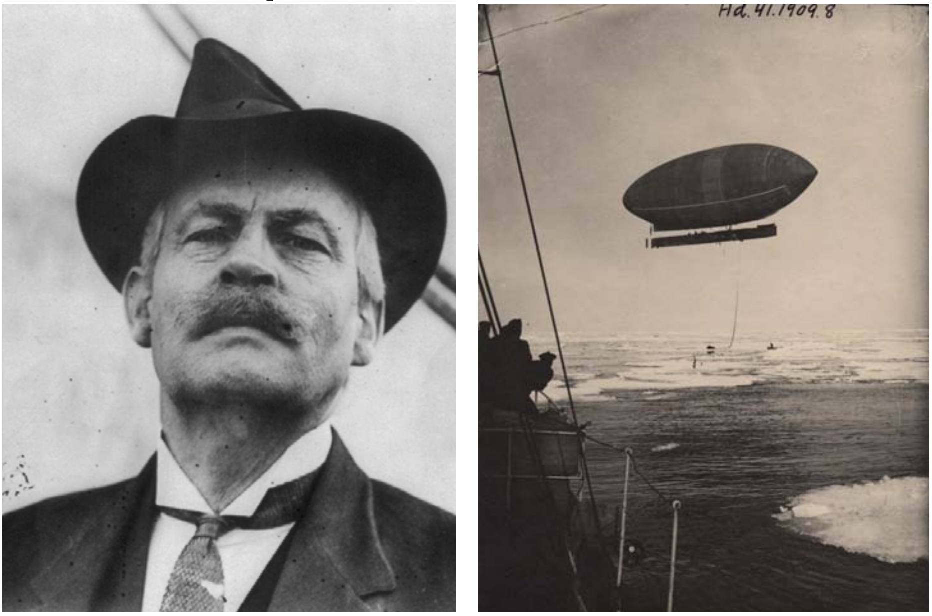


Fig. 93 – *Left: Walter Wellman. Right: airship AMERICA on August 15th, 1909*
Source: ph. by Bain Photo Company (left); Norsk Polarinstitutt (right)

American journalist Walter Wellman (1858-1934) was the first to try to reach the North Pole by airship, at the beginning of the 20th century (fig. 93). Wellman was not a rookie in Arctic expeditions. He had already conducted explorations by surface in the previous years. He followed with interest the technological developments of his time, and had clear awareness of the limitations of aerostatic flight. Although at a very early development stage, airships were in theory the best possible solution for flying towards the Pole: they were self-powered, they had long range capabilities and they were steerable[57].

Wellman obtained conspicuous funding from the Chicago Record – Herald and was able to deploy the first airship equipped with internal combustion engines in the Arctic. Though christened AMERICA, the blimp had been designed and built in France. It featured a non-rigid gasbag, filled with hydrogen, 15.6-meter-wide and 50.3-meter-long in the 1906 configuration. Length was incremented to 56.4 meters in 1907 (Nelson, 1993, pp. 278). The crew, the engines and the equipment were hosted

(57) The concept would have developed further and finally proved successful about twenty years later, when Italian-built airship NORGE reached the North Pole on May 12th, 1926.

inside a gondola covered with cloth and suspended by ropes and cables to the gasbag. In the 1906 configuration, the gondola had a wooden structure. It had been built by French manufacturer Godard, but the overall system proved a failure, and the gondola had to be replaced. In two later configurations, for 1907 and 1909 respectively, a new gondola was built by American engineer Melvin Vaniman. It featured a prevailingly metal structure while retaining the fabric clothing (Capelotti, 1994, p. 268).

Having chosen Virgohamna as base camp for his expeditions, Wellman established a full-blown infrastructure on the site, which would have become known as Camp Wellman (Cailliez, 2006). The base, extending in a relatively large area from the centre to the western edge of the beach, included a hangar for the airship – a wooden structure with fabric clothing –, workshops, a hydrogen production plant and a building to house personnel. Materials for these structures were mostly freighted by support ships. In some cases, e.g. the floor of the hangar, some materials were re-used from the remaining and abandoned Andrée's balloon house, still present at the opposite side of the beach (Capelotti et al., 2007, p. 70). Just like its predecessor aircraft, the ÖRNEN, airship AMERICA was sent to Svalbard disassembled, without thorough testing, and delivered in July 1906. The hangar was being built in the meanwhile under the direction of Swiss engineer Alexander Liwentaal (*ibidem*). Being inevitably a light structure, it proved quite fragile against bad weather. In the intervals between expedition attempts, it collapsed and was re-built three times, with significant modifications from one phase to the other (Capelotti, 1994, p. 270). At about the half of September 1906, airship AMERICA was completely assembled and ready for testing. The propulsion systems (two engines and propellers) failed catastrophically during the initial ground tests. Damage was so extensive that there was no time for repairs at that point, as the Arctic summer was nearly over.

On September 2nd, 1907, after major modifications to the airship and equipment, Wellman took off from Virgohamna onboard AMERICA, in a crew of three. Soon after departure the airship found bad weather and strong winds which quickly exceeded the modest airspeed and manoeuvrability of the blimp. It was then dragged to the east, towards a mountainous area of Spitsbergen. Wellman struggled to regain control of the airship but then decided for an emergency landing on Fuglepyntbreen glacier, at 79°40'N 11°E, approximately 15 km NE of Virgohamna (Capelotti, 1997, p. 17; Bristow, 2018, p. 320, f.n. 3). He and the other crew-members were soon rescued and the airship was recovered.

Year 1908 was spent in search for further funding and extensive modifications to the airship. Then came 1909 and Wellman, with his workgroup, planned a third attempt on August 15th (Nelson 1993, p. 279). The airship departed Virgohamna and proceeded Northbound. After a 64 km navigation it began to fly over the Arctic pack. With a technical solution somewhat similar to Andrée's draglines, the AMERICA used a long rope to drag a ballast bag on the surface of water or pack. Such bag – containing food – and the line attaching it to the blimp were meant to vertically stabilize the airship. However, the system suddenly failed and the ballast detached. The airship suddenly lost vertical stability and the four aeronauts decided to turn back towards the base. They later ditched in proximity of Norwegian ship FARM which had noticed the incident and was steaming to their rescue. Wellman left Virgohamna leaving instructions for a further attempt, but he was soon informed about the dispute between Cook and Peary, both claiming to have reached the North Pole. The aeronaut journalist gave up his Arctic goals and never returned to Virgohamna. Wellman's ambitions also received mixed evaluations and are still somewhat controversial. Again, it is worth quoting the opinions of Fridtjof Nansen and Umberto Nobile. The Norwegian explorer's opinion about the American adventurer was harsh:

> «[Wellman was] a strange man who demonstrates how one may, with the help of the great art of advertising, keep the world's newspaper's attention year after year without having one single thing of interest to report. It's simply a matter of knowing what sort of material the newspapers crave in order to satisfy the world's spiritual needs – and in this area the man was truly great» [Nansen, 1920, p. 145, as quoted in Bristow, 2018, p. 293].

A more benign opinion came from Umberto Nobile. In his view, Wellman was indeed a pioneer of aerostatic flight in the Arctic and he certainly had an acute vision: he had conceived the use of an airship to reach the North Pole, at a time when the technology – which was to finally succeed – was in its earliest days.

An intermediate position seems to be that of Peter J. Capelotti. This author studied both Andrée's and Wellman's endeavors in historical and archaeological perspectives. Assessing Wellman's approach, on the one hand he defines the American as «incautious, hurried, without method» (Capelotti, 1999, p. 38). On the other hand, he notes that a contributing factor to Wellman's failures might have been «the application of technology inappropriately matched to the geographic objective» (*ibidem*). He also seems to suggest that a certain role could have been played by some sort of geocultural dimension related to Arctic exploration of that time (*ibidem*, p. 39).

Beyond archival documents, Wellman's expeditions left relevant traces at Virgohamna and not only there. An interesting surviving piece is preserved at the North Pole Expedition Museum in Longyearbyen, directed by Italian Arctic guide Stefano Poli. The object is an emergency escape boat – prepared for the case of ditching – which flew onboard the AMERICA in 1907 and 1909.

5.1.3 *Polarquest2018's expeditive survey of Virgohamna*

For an appropriate understanding of the historical site of Virgohamna, the works by Capelotti (1994 and 1997) remain a fundamental source. This author conducted an archaeological survey of the site in summer 1993, and his writings imply the concept that Virgohamna is much more than a mere archaeological repository. The place evolved, with time, so as to become a major «landmark» in its capability of catalyzing a deep sense and feeling of human projection towards the Arctic frontier. On the remnants of an ancient whalers' settlement dating back to the 17th century – literally in the middle of the ruins of their buildings and of their graves, Briton Arnold Pike wanted to put a house. Years before trying himself as an aeronaut, Walter Wellman visited the then-called Houcker Bay in 1894 during one of his Arctic expeditions (Capelotti et al., 2007, p. 64). Two years later, Andrée had his balloon house and hydrogen plant set up around the Pike's House. After the mysterious disappearance of the three Swedish aeronauts, Right at the opposite side of the beach, within a solemn boundary of stony and tundra-covered hills and mountains, Wellman established his futuristic airship base. In other words, apparently the various expeditions had taken account of the previous ones (*ibidem*, p. 65).

Then it was all over. The century had turned, the *Belle Époque* faded away with its dreams of a humankind made invincible by technology; and silence returned immense on Virgohamna. When Nansen visited the place in 1920, all he found were already memories of a far past (Nansen, 1920, p. 145).

This amazing layering of historical events and public emotions, all associated to a small, remote beach, explain its century-long popularity as a destination for tourist and also motivates the awareness developed by Norwegian authorities about the need for its preservation. Since excursions and visits to Virgohamna had started to exercise a relevant pressure and impact on the historical traces, the Norwegian governor finally issued an official regulation to limit indiscriminate access to the site (Directorate for Cultural Heritage, 2000).

The expeditive survey of the historical area by Polarquest2018 was conducted on August 8th, starting at 20.48 UTC, in two separate missions. Drones were launched from the boat which had been moored at a distance as per regulation. They were flown over Virgohamna beach and then recovered back onboard NANUQ. The first flight, about 20 minutes long, was conducted by the author and allowed to obtain 4 videos in the 4K format during approach to survey area and return flight. A total of 179 jpg, 20 Mpx images was acquired over the survey area. The second flight, lasting about 5 minutes, was performed by Michael Struik, using a second, identical drone, with the purpose of verifying technical conditions and of acquiring additional imagery.

5.1.4 *Data from «image-based» processing report and related comments*

The images collected during the first flight were processed in an image-based-modelling workflow. A first, «quick and dirty» provisional processing of all the 179 images was performed onboard NANUQ using a laptop computer with Agisoft Photoscan™. In this procedure, the lowest and fastest available settings were used for the entire standard workflow (align images, build dense cloud, build mesh, build texture). The purpose of this preliminary operation was to ensure that the survey area had been completely covered and advanced processing could be successflully performed. Once this had been ascertained, the expedition could depart the site. The full-blown processing and analysis of data began at GREAL after the author's return to Italy in early fall 2018. The work took several months due to the need of optimizing the processing workflow, fully process 3D models and ortophotos in appropriate formats and properly analyze the obtained data.

Of all the images acquired during the flight, 70 were selected for final processing in Agisoft Photoscan™ (fig. 97). Later, a second, independent processing was conducted, on a different platform, using Agisoft Metashape™ (figg. 94-96 and 98). Obtained results in the two separate processes were consistent, but the following data are from the Metashape process, considered to be the final one. Like in the «quick and dirty» procedure, the standard workflow was followed in both processes (Agisoft, 2016 and 2019). It consisted in the following steps: image alignment (with resulting creation of a sparse point cloud), dense point cloud building (establishing vertices for a computer reconstructed 3D model), mesh building (reconstructing the 3D model), texturization (draping of the mesh with a photorealistic texture from the source images). In order to clarify the qualitative aspects of the work, data from the software-generated report are hereby presented. The report provides information – mostly numerical data and operational settings – about the type and quality of input data and the processing variables. The presented data are related to the final ortophoto. Figure 94 presents the area covered by the expeditive survey and the number of overlapping images used in determining the terrain geometry. In general, the higher the number of images viewing the same ground object in the scene is, the higher the quality of the reconstructed model. Considering that, in stereoscopy, the minimal quantity of images that are necessary to obtain a tridimensional representation is two, practical experience of expeditive image based photogrammetry show that more images are required for better quality of reconstruction.

During the Polarquest2018 survey at Virgohamna, each object in the Pike's House and Andrée's installation area had a coverage of 3-4 images. Wellman's Camp area is widely covered with 8, 9 or more overlapping images per object.

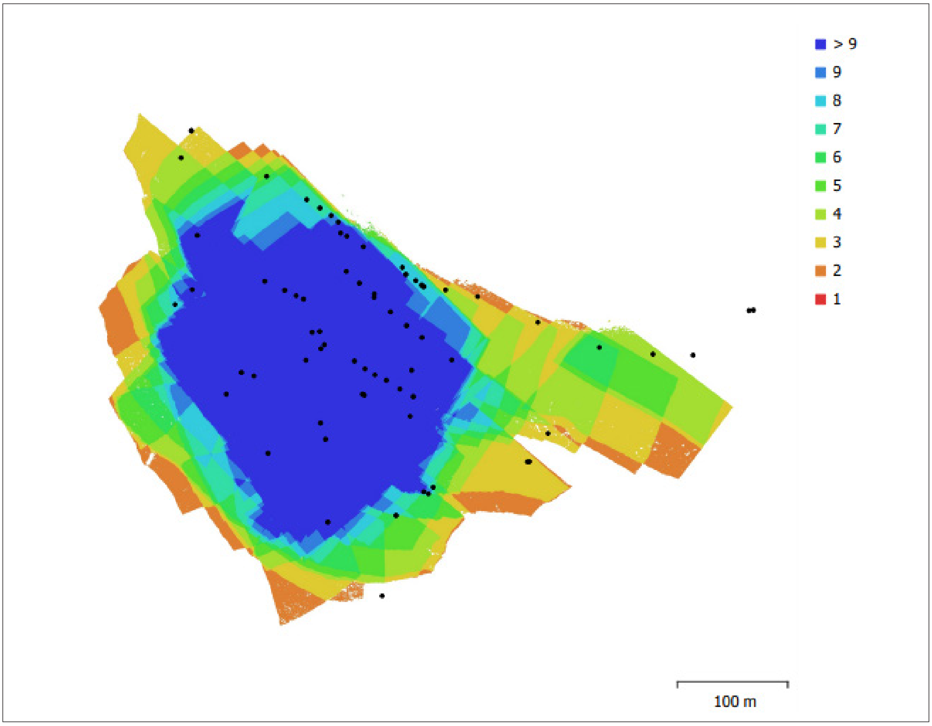


Fig. 94 – *Number of overlapping images over each zone of the survey area. Black dots indicate the camera position associated to each shot*
Source: Agisoft (processing by G. Casagrande)

Tab. 4 – *Basic survey data*

Number of images	**70**	**Camera positions**	**70**
Average survey height[58]	131 m	Tie Points	100,023
Ground resolution	3.23 cm/pixel	Projections	527,380
Total coverage area	0.132 km^2	Reprojection error	0.365 pixel

Source: Agisoft (processing by G. Casagrande)

Camera calibration data – as computed *ex post* by the software, are presented as follows.

(58) As calculated by the drone flight control system from the take off point, i.e. the boat's cabin roof.

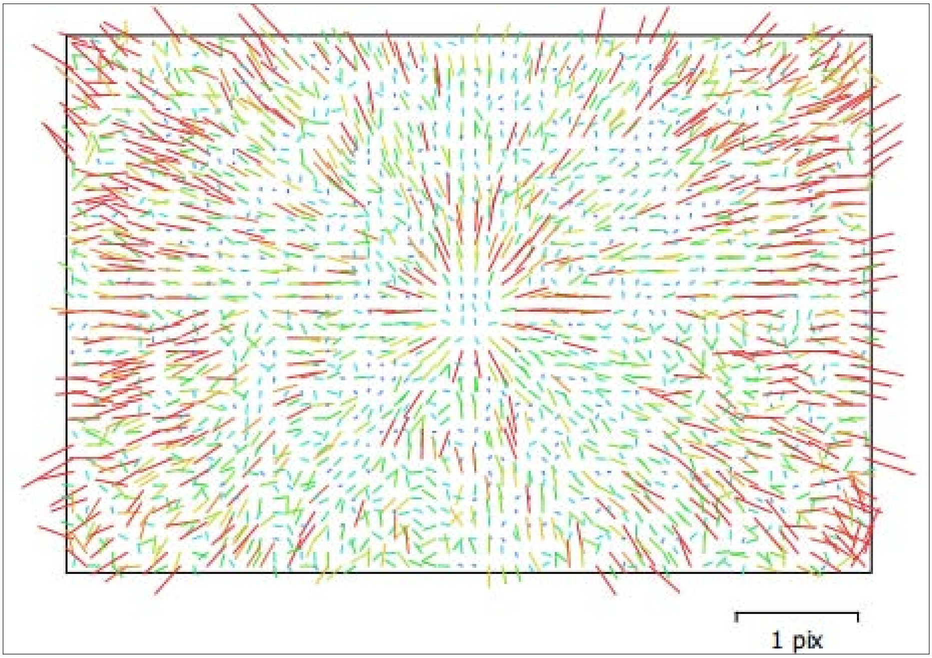


Fig. 95 – *Image residuals for photocamera FC6310 used during the expeditive survey. Image size: 5472 x 3648 pixel; focal length: 8.8 mm; pixel dimension: 2.41 x 2.41 µm*
Source: Agisoft (processing by G. Casagrande)

Tab. 5 – *Calibration coefficients and correlation matrix*

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	3648.51	0.69	1.00	0.12	-0.92	0.81	0.17	0.17	-0.22	0.30	-0.36	-0.03	-0.07
Cx	-16.1788	0.18		1.00	-0.16	0.12	0.90	0.05	-0.04	0.06	-0.06	0.53	-0.13
Cy	29.0345	0.62			1.00	-0.96	-0.24	-0.16	0.22	-0.30	0.36	0.04	0.18
B1	-0.509421	0.13				1.00	0.21	0.12	-0.21	0.28	-0.33	-0.06	-0.03
B2	0.233128	0.061					1.00	0.05	-0.06	0.07	-0.08	0.15	-0.14
K1	0.009843	4.3e-005						1.00	-0.90	0.86	-0.80	0.02	-0.21
K2	-0.0473773	0.0002							1.00	-0.98	0.95	-0.00	-0.00
K3	0.0853066	0.0004								1.00	-0.99	0.00	0.00
K4	-0.0508311	0.00027									1.00	-0.00	-0.00
P1	-0.00062184	6.3e-006										1.00	-0.05
P2	0.000377905	7.8e-006											1.00

Source: Agisoft (processing by G. Casagrande)

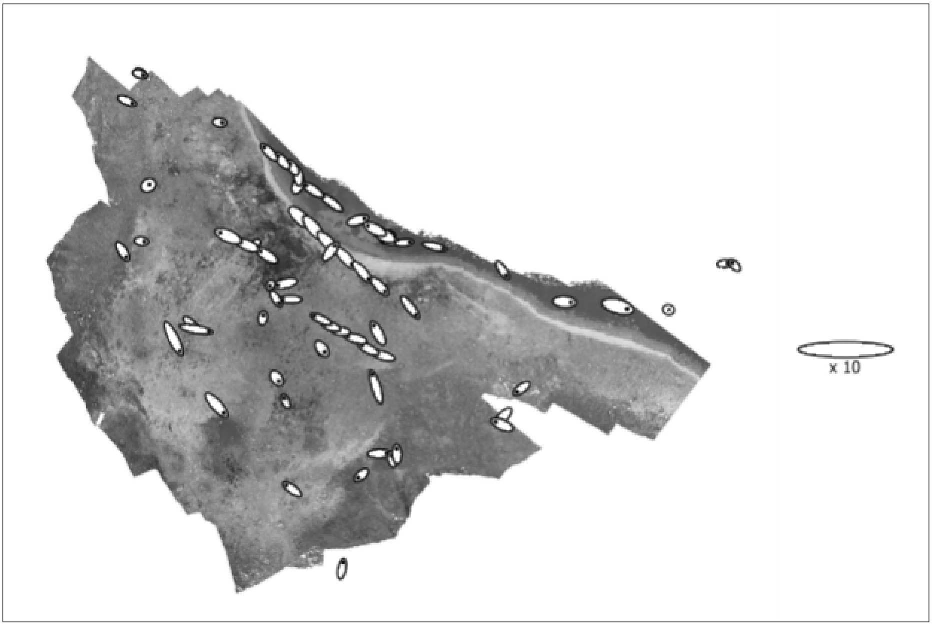


Fig. 96 – *Estimated camera positions (black dots) and evaluation of possible estimation errors Combined errors in longitude and latitude (indicated as x and y respectively) are represented by the size of ellipses' axis (multiplied by 10 for better clarity) and orientation*
Source: Agisoft (processing by G. Casagrande)

Tab. 6 – *Average error in estimated camera positioning*

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
0.906451	0.760511	0.910943	1.18323	1.49327

X– Longitude; Y – Latitude; Z – Altitude
Source: Agisoft (processing by G. Casagrande)

Tab. 7 – *Processing parameters*

General			
	Cameras		70
	Aligned cameras		70
	Coordinate system		WGS 84 (EPSG::4326)
	Rotation angles		Yaw, Pitch, Roll
Point Cloud			
	Points		100,023 of 107,142
	RMS reprojection error		0.176641 (0.36506 pix)
	Max reprojection error		0.530317 (5.74095 pix)
	Mean key point size		2.11177 pix
	Point colors		3 bands, uint8
	Key points		No
	Average tie point multipicity		5.70799
	Alignment parameters		
		Accuracy	Highest
		Generic preselection	Yes
		Reference preselection	Yes
		Key point limit	80,000
		Tie point limit	8,000
		Adaptive camera model fitting	Yes
		Matching time	8 minutes 3 seconds
		Alignment time	1 minutes 8 seconds
	Software version		1.5.5.9097
Dense Point Cloud			
	Points		196,734,205
	Point colors		3 bands, uint8
	Depth maps generation parameters		
		Quality	Ultra High
		Filtering mode	Mild
		Processing time	11 hours 31 minutes
	Dense cloud generation parameters		
		Processing time	1 hours 43 minutes
	Software version		1.5.5.9097

Orthomosaic			
	Size		20,018 x 14,583
	Size Coordinate system		WGS 84 (EPSG::4326)
	Colors		3 bands, uint8
	Reconstruction parameters		
		Blending mode	Mosaic
		Surface	Mesh
		Enable hole filling	Yes
		Processing time	2 minutes 48 seconds
	Software version		1.5.5.9097
Software			
	Version		1.5.5 build 9097
	Platform		Windows 64

Source: Agisoft (processing by G. Casagrande)

In order to evaluate the quality of the expeditive survey it is important to ascertain, approximately at least, the metric accuracy of the ortophoto. The main difficulty in this sense is that the survey could not establish topographically determined ground control points, either absolute or relative. Therefore, the ortophotograph was georeferenced by correlation of positional data included in the source images with data from the geometrical processing of the image-based model. Hence, errors may affect both the metric restitution of objects in the ortophoto, and also the absolute spatial position of an object even if it might be correctly represented from a morphological point of view. Since no «ground truth» was possible on site and neither topographic nor remotely sensed reference of adequate quality was available, this second type of inaccuracy is more difficult to assess. Consequently, the following remarks are mostly referred to the morphological restitution of objects.

The only large objects visible on the ground, for which the workgroup had reliably documented measures was Wellman's hangar. Its structure, however, is ruined and it is hard to identify reference objects in order to validate measurements. As documented in Capelotti et al. (2007, p. 72), the hangar measures were 57 meters in length, 26 in height, 28 in width. It is possible to attempt a length measurement of the transversal floor joists a few dozens of which appear to be *in situ* and relatively intact, although in many cases damaged at their extremities. These elements' measures on the ortophoto are typically between 27 and 28 meters. Even harder is to measure the apparent length of what is left of the hangar. It is possible to approximately do it by using, as a reference, the last joist visible at the south-western extremity of the structure and the first at the north-eastern one, apparently very degraded but well-aligned with a regular pattern of stones which was likely underneath the edge of the hangar floor. The resulting measure on the ortophoto is 56.5 meters.

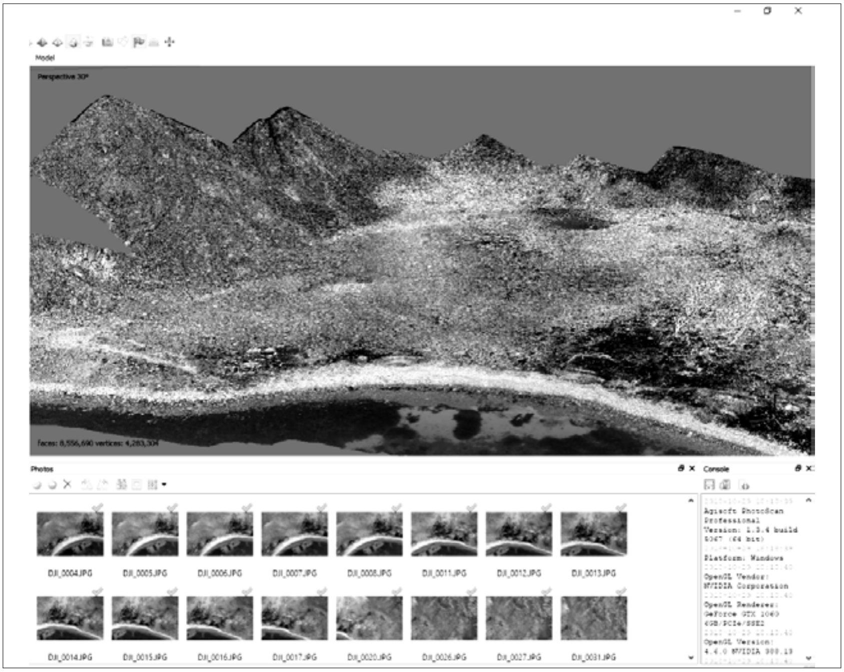


Fig. 97 – *The 3D model developed from selected images in the PolarQuest 2018 first flight series. The overall roundish shape of the beach is clearly recognizable*
Source: screenshot from Agisoft Photoscan™ (processing by G. Casagrande)

In both the aforementioned cases, then, the error can be reliably assumed to be under 1 meter. Another group of objects on which it is possible to attempt a measure check includes three surviving metal cylinders which were part of the fuel tank of Vaniman's airship-gondola described in Capelotti (*ibidem*, pp. 64-66). The three elements were respectively identified as «southern», «middle» and «northern». Naturally, one cannot exclude that through the years from Capelotti's research those elements have suffered fragmentation, deformations and other types of decay, changing, albeit in small degree, their dimensions. On the 2018 expeditive ortophoto, it is clear that the «southern» and «middle» elements have been moved and are now about 25 and 17 meters north from their 1993 position. The «northern» appeared to be still in the position it occupied when the American archaeologist documented it. Nevertheless, evident traces of rust can be seen in the ortophoto, still marking the 1993 positions of the moved elements, allowing for easy comparison. For each one of the fuel tank elements, Capelotti's measures are hereby indicated, followed by that of the rust ground mark if available and the element's measure as derived from the ortophoto. For the «southern» element, Capelotti indicates 22 feet, 6 inches, corresponding to 6.86 meters. The 2018 rust mark on the ground for that element was found to be 6.8 meters, the element itself 6.2 meters. For the «middle» element, Capelotti indicates 24 feet, 8 inches, i.e. 7.52 meters. The trace on the ground is 7.3 meters, the elements itself 7.3 meters. Finally, the «northern» element, still in its 1993 position, was indicated by Capelotti to be 23 feet, 5 inches, equivalent to 7.14 meters. In the ortophoto, the element appears to be 6.9 meters. Based on these comparisons, discounting the possibility of morphological changes in the elements, the dimensional error of the ortophoto would be less than 0.5 meters. It is worth noting that both Wellman's hangar and the remnants of Vaniman's fuel tank are in the area where at least 7 source images are available for viewing the same object. The accuracy degree in such conditions should be higher than that for the Pike's House or Andrée's installations, where coverage was limited to 3-5 images as previously reported. In the final analysis, it is deemed likely that in the best coverage zones of the ortophoto, error in the morphological restitution of objects can be considered in the order of 0.5 meters or less. In general, anyhow, its value should be considered less – possibly much less – than 1 meter.

Fig. 98 – *Ortophoto of Wellman's hangar. The advantage of using a* .kmz *exported ortophoto is that it can be visualized on general use webGIS platforms, both online and offline, even on low-tech computers*

Source: screenshot from Google Earth™ (processing by G. Casagrande)

5.1.5 *GIS documentation and observation comments*

Based on the data identified on the ortophoto, a GIS documentation of the area was conducted. The ortophoto was input in a GIS through QGIS software and the following layers and attributes were defined. The GIS documentation of the area was designed to be modular and to be further augmented by adding records and data in the future (fig. 99).

The following section contains general considerations about the historical site of Virgohamna based on what it is possible to observe in the 3D model and the ortophoto. Specific comments on what appears to be relevant with regard to both Andrée's and Wellman's expeditions are developed and discussed in the subsequent paragraphs.

Virgohamna is a small bay indenting the northern shore of Danskoya. Both Andrée's and Wellman's installations were located in the western area of the bay, on a small beach facing North-East.

Tab. 8 – *Layer description and attribute table record for the geohistorical documentation of Virgohamna*

Layer (Description)	Data-type	Attribute (type)	Attribute description
monitored_mobile_objects Layer documenting the mobile objects of particular geo-historical and archaeological relevance	Polygon	*id (int)*	Ordinal number
		me_name (String)	Object name
		exp_leader (String)	Leader of the expedition(s) which used the object
		descript (String)	Nature and functions of the object
		year(s) (String)	Year(s) of use. The variable is String data type instead of numerical or date, because more years or periods could be specified.
		notes (String)	Possible additional comments
		status (int)	Preservation status (1=severe decay, 2=intermediate decay, 3=minor decay)
		references (String)	Main literature citing or reporting about the object (author, date)

Layer (Description)	Data-type	Attribute (type)	Attribute description
approx_footprint_areas Layer documenting the approximate perimeter or general area, if recognizable, of objects or artifacts associated with the studied historical phases	Polygon	*Id (int)*	Ordinal number
		a_name (String)	Area name
		exp_leader (String)	Leader of the expedition(s) which used the area
		descript (String)	Nature and features of the area
		year(s) (String)	Year(s) of use. The variable is String data type instead of numerical or date, because more years or periods could be specified.
		notes (String)	Possible additional comments
		status (int)	Preservation/identification status of the area (1=almost unrecognizable, 2=partially recognizable, 3=well recognizable)
virgohamna_markers_f Layer documenting the position of object(s), artifact(s), ruin(s), fragment(s) or group(s) of mobile object(s)	Point	*Id (int)*	Ordinal number
		m_name (String)	Name of the marker
		expedition_leader (String)	Leader of the expedition(s) which used the element to which the marker refers to
		descript (String)	Nature and features of the object(s), artifact(s), ruin(s), fragment(s) or group(s) of mobile object(s)
		year(s) (String)	Year(s) of use. The variable is String data type instead of numerical or date, because more years or periods could be specified.
		notes (String)	Possible additional comments
		status (int)	Preservation/identification status of the element (1=almost unrecognizable, 2=partially recognizable, 3=well recognizable
		references (String)	Main literature citing or reporting about the area (author, date)

Source: GIS processing by G. Casagrande

As far as it was possible to observe from historical images dating back to the discussed expeditions, as of 2018 the beach had remained substantially unchanged in terms of coastal front and surface. It was covered by a regular mass of stones and rocks and was slightly sloped towards the sea.

Fairly steep hills, surrounding the area, are a good shield against southern winds. Obviously, this does not prevent different types of turbulence, such as downdrafts, rotors etc.

In general, however, it would have proved an appropriate base for both supporting ships moored close to the shore and most of all, naturally, for aerostatic aircraft such as Andrée's balloon and Wellman's airship. Both of them, actually, needed to be able to climb towards the north, counting on a sufficient extent of sea to gain altitude so as to clear the mountains of Amsterdamøya.

Both Andrée and Wellman, upon their arrival at Virgohamna, found and used the so-called Pike's House. The building can be seen in several historical pictures of the site. It was dismantled and removed in 1925; its materials were transferred to Barentsburg (Capelotti, 1994, pp. 266 and 272). At Virgohamna, however, part of its foundation remains *in situ*, and it is very easy to recognize.

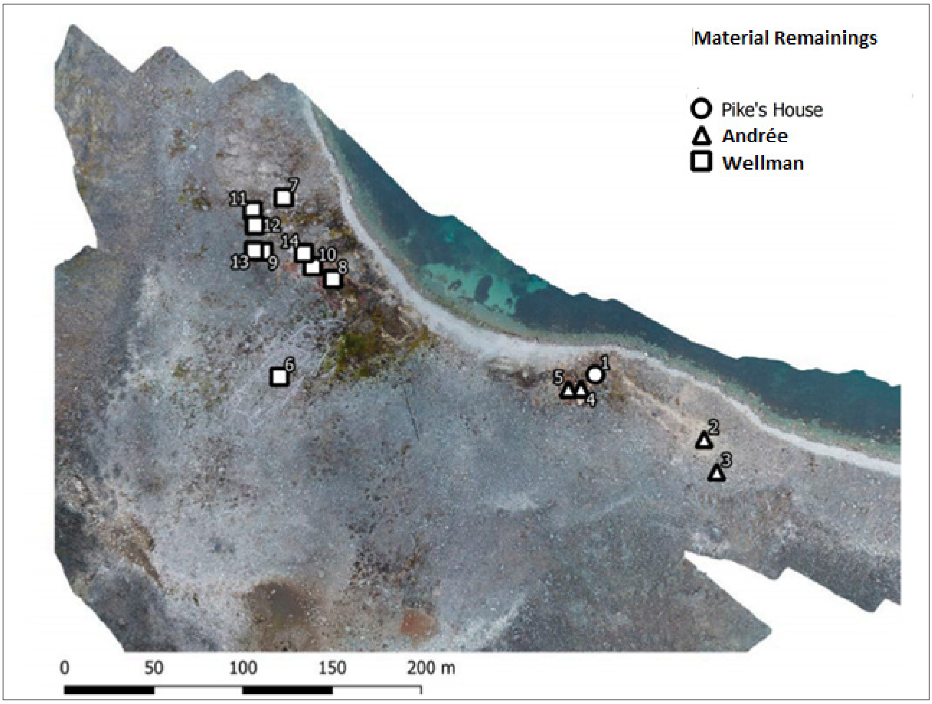


Fig. 99 – *General ortophoto of Virgohamna historical sites. The circle marks the position of the Pike's House; triangles point to elements from Andrée's expeditions (1896-1897), squares indicate remainings of Wellman's expeditions (1906-1909)*

Source: GIS processing by G. Casagrande

Tab. 9 – *Main point of interest in Virgohamna historical site (as mapped in fig. 99)*

Id.	**Name / Description**	**Expedition(s)**	*Notes*
1	Pike's House	Pike 1888	*House built to allow British citizen Arnold Pike's to winter at Virgohamna, in proximity of remainings from ancient whalers' base. After the house removal in 1925, part of the wooden structure of the foundations remains, apparently in good conditions.*
2	Area of the ÖRNEN's Balloon House	Andrée 1896, 1897	*The boundary of the Balloon House «footprint» is currently difficult to define from the August 8th, 2018 data. Andrée's expedition memorial appears to be slightly eccentric relative to the former building.*
3	Fragments of Andrée's structures	Andrée 1896, 1897	*Residual fragments of the Andrée's expedition structures. Much of the surviving materials from the 1897 expedition were re-used in Wellman's camp in 1906.*
4	Hydrogen Filter	Andrée 1896, 1897	*The filter was part of Andrée's hydrogen production plant established at Virgohamna according to chemists Ek's and Stake's instructions. It is currently the only surviving element of the plant and appears to be in fair preservation status. The main elements are built in wood and iron.*
5	Hydrogen Production Plant site	Andrée 1896, 1897	*The site is still easy to spot thanks to evident traces of rust in the terrain. No significant element of the formerly existing plant appears to survive in the area.*
6	Hangar	Wellman, 1906, 1907, 1909	*The hangar was built in wood and covered in fabric under Swiss engineer Alexander Liwentaal direction in 1906. It collapsed and was rebuilt repeatedly, as it was used in all Wellman's expeditions. Abandoned in 1909, the hangar eventually collapsed in 1912, most likely due to strong winds and lack of maintenance. Part of the flooring re-used elements from Andrée's Balloon House, the rest of the structure was built with timber transported to Virgohamna from continental Norway on board of support ship FRITHJOF (Capelotti et al., 2007, p. 70). Some materials from the hangar were removed and transferred elsewhere for reuse.*
7	Wellman's Hut	Wellman, 1906, 1907, 1909	*Primary building in Camp Wellman. It could host up to 40 people (*ibidem*). Foundations and many fragments of its structures survive. According to (Capelotti 1994, p. 272), it is possible that the building had collapsed under severe weather after having been abandoned. Part of its materials might have been removed and transferred elsewhere in the archipelago between 1912 and 1938.*
8	Fuel barrels	Wellman, 1906, 1907, 1909	*Iron barrels, in evident progressive decay. They were meant to store fuel for airship AMERICA's internal combustion engines. They were originally stacked in virtually the same area where they appeared to be scattered in 2018. Fuel residues, still in measurable quantities but no longer in toxic concentrations were identified in the superficial layer of local ground by Capelotti in his 1990s investigations (Capelotti, 1994, p. 267; Capelotti, 1997, p. 76).*

Id.	Name / Description	Expedition(s)	*Notes*
9	Ceramic elements	Wellman, 1906, 1907, 1909	*Heavily fragmented ceramic elements, probably meant to be used for building pipes in the area. According to Capelotti (1994, p. 271), they were never actually used.*
10	Metal debris	Wellman, 1906, 1907, 1909	*An area heavily occupied by decaying metal fragments.*
11, 12 and 13	Element of airship gondola fuel tank 1907-1909	Wellman, 1907, 1909	*Melvin Vaniman had designed a gondola for airship AMERICA to be flown in the 1907 and 1909 expeditions. The gondola was supposed to transport fuel needed for the air trip to the Pole in a cylindrical tank at the bottom. Three surviving elements of this fuel tank were recognized in the 2018 ortophoto, in a state of terminal decay.*
14	Hydrogen plant 1906-1909	Wellman, 1906, 1907, 1909	*Remnants of the hydrogen production plant of Wellman Camp. Large amounts of wood elements from the building structures and evident metal remainings from the plant mechanisms remain* in situ.

Source: G. Casagrande

An annotated copy of the ortophoto with basic indications of some of the objects of interest is annexed to this book (Annex 1).

5.1.6 *Andrée's base*

The exact spot from which the ÖRNEN took off is well documented by historical sources. When Wellman was at Virgohamna in 1906, a short film was taken[59] (part of a longer film, discussed in Diesen and Fulton, 2007). In the footage, the American explorer is portraited next to a small memorial which had previously been established in the place of Andrée's base; this makes it possible to see the status of the area in 1906. Wellman's workgroup had spoiled materials from the abandoned balloon house to re-use wooden elements in the floor of the new airship's hangar. The stone memorial was renewed in 1958 (Polar Record, 1958, p. 25) and although it is not certain that the currently existing monument coincided with the previous one, it may still serve as a positional marker. A map by Capelotti (1997, p. 32) shows the 1958 memorial as slightly eccentric with reference to the hangar centre, towards the north (see also Friolo, 2007, p. 33). The general picture of Virgohamna published by Capelotti (1994, 273, p. 8) show the beach in summer 1993 and allows to observe – in spite of some difficulty due to distance and view angle – that some trace of Andrée's balloon house was still recognizable. From Overrein (2015), we know that as of that writing, metal elements, wiring, wooden fragments from the 1896-1897 expedition were still visible.

The survey by Polarquest2018 could not identify any reliable trace of the perimeter of the hangar, in spite of the evident presence of structural elements scattered among the stones all around the place.

(59) An extract with Wellman at Virgohamna can be seen at the following url: *https://www.youtube.com/watch?v=7vKEfkpV1es*.

Nevertheless, the general area of Andrée's base could be easily recognized.

The hangar had been built on a rough surface, basically obtained by regularizing the stony area of the beach. A wooden floor had been subsequently built on top of that surface, and a thick layer of felt (Strindberg in *Letters from the Andrée Party*, 1898, p. 405) was laid on it. Images from the drone allow to observe, all around the area where the memorial stands, a remarkable quantity of small fragments of wood, most likely from the decay of Andrée's hangar structures.

Elements appear to be small and dispersed, but this is understandable because the balloon house had – for the most part – a relatively light structure. Pieces that are clearly visible on the ortophoto are, in many cases, 1 to 1.5 meters in length. The previously cited Overrein's indication about the presence of metal fragments and wiring cannot be surely discriminated in the drone images.

The general area where the balloon house stood appears clearly in the ortophoto and is still connected – in substantial continuity with the past – by two trails (cleared

Fig. 100 – *Virgohamna historical site in 1907-1909. From the left to the centre, Wellman Camp; close to the evident shape of the airship hangar, towards the centre of the image, it is possible to recognize two technical buildings, i.e. the hydrogen generating plant and the workshops. Right beyond them, the Wellman's Hut is visible. The right side of the image shows, much closer to the observer, the Pike's House surrounded by scattered remainings of the Andrée's expedition. Andrée's hydrogen generating plant stands, abandoned, next to the house*
Source: Norsk Polarinstitutt

of stones) with the area where the Pike's House was (fig. 100). Similar trails connected the hangar with the small building at the time of the expedition. Very little is left of the Pike's House, yet it appears as an evident reference in the area. Seen from above as well as from the ground, the «footprint» of the house is indicated by the clear, rectangular foundation, on top of which a few but evident joists remain. These remnants, for the very reason of their readability in the surrounding landscape, are a popular subject on tourist photos widely available on the Internet.

A few meters west from the Pike's House a large stain of rusty material on the ground corresponds to the place where Andrée's hydrogen plant was located. The wreck of the machine was still visible in 1906 and, partially, in 1928 (Andrée et al., 1931, f.n. 63) (fig. 100).

All that survives of it – the only part, but still in relatively good preservation status – is the large hydrogen filter (Capelotti, 1997, p. 78). The device is perfectly visible in the images from the drone and its 2018 material condition appeared to be relatively similar to that of 1993.

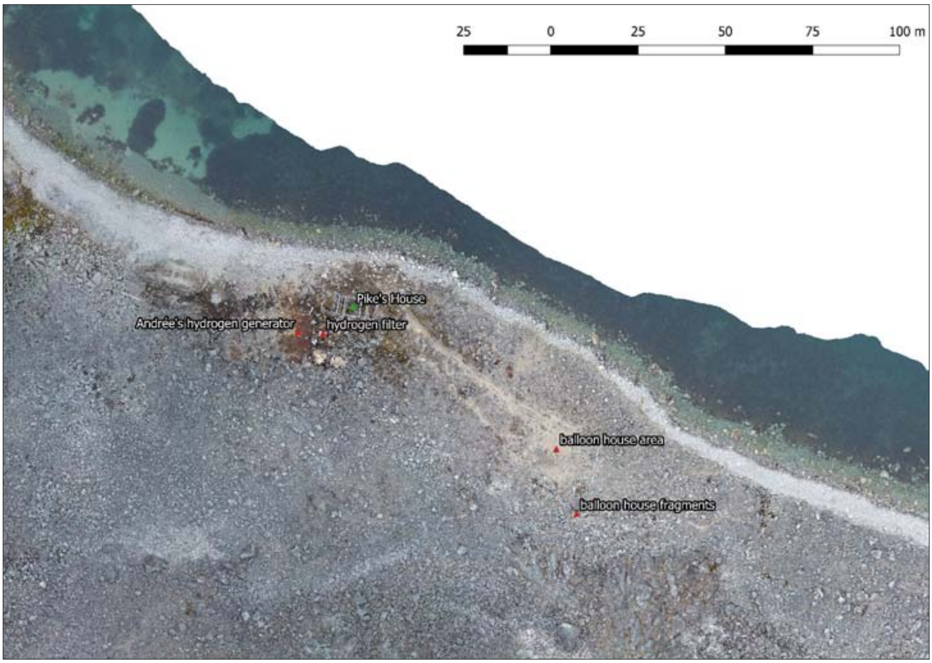


Fig. 101 – *Annotated ortophotograph of Andrée's base*

Source: aerial images and GIS mapping by G. Casagrande

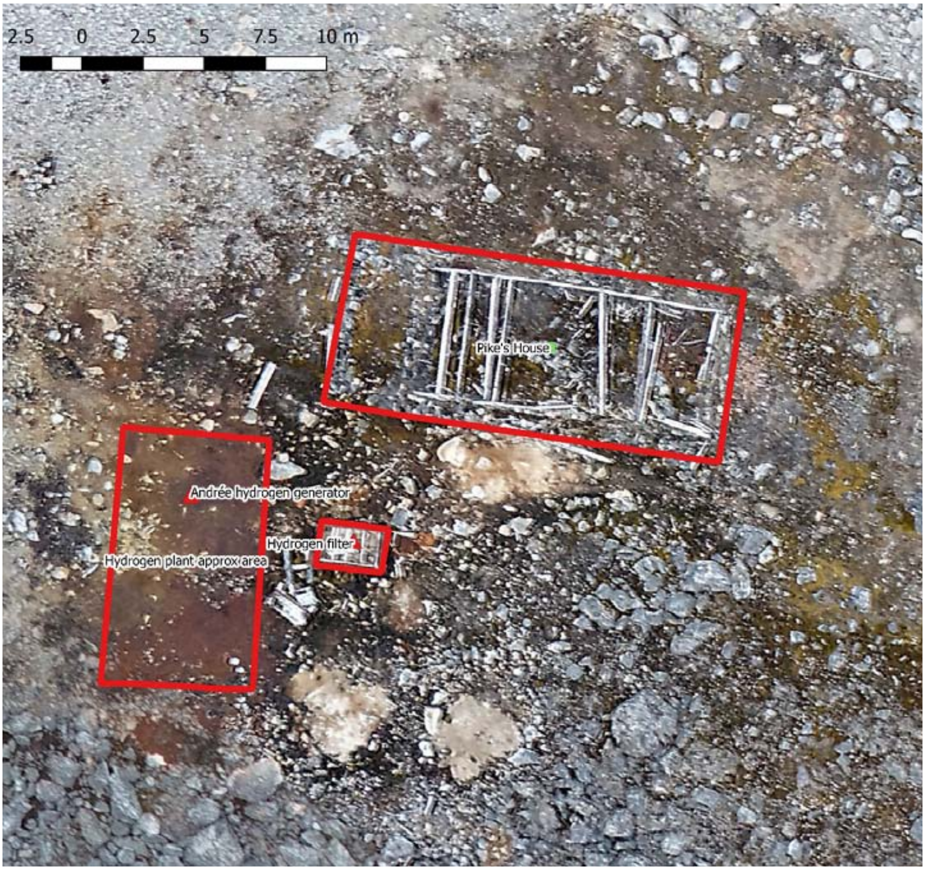


Fig. 102 – *A detail view of the Pike's House area*
Source: aerial images and GIS mapping by G. Casagrande

5.1.7 *Camp Wellman*

The area of Wellman's installations is the richest in material evidence and offers much information. The most evident remainings as seen from above are obviously those of the airship's wood-and-fabric hangar. What is left of its numerous structural elements maintains, in remarkable degree, shape and spatial relation to the surrounding materials, in spite of the obvious mobility and light weight of many fragments. It is therefore relatively easy to perceive the nature and size of the building; it is also obvious it had collapsed «forward», downhill the gently sloping ground, towards the sea, i.e. towards the north-east (figg. 103-106)

Layered on top of the remainings of the floor, the large ribs which once held the fabric side-walls and roof can be recognized. As it is frequent in Svalbard and the rest of the Arctic, wooden fragments survive for long time with limited or minimal decay, changing their natural color to a typical greysh or whitish palette.

Wellman's hangar had an almost symmetrical shape, with a mobile front gate (towards the sea) and a rear, curvilinear wall, similar to an apse. On the left side of the hangar, i.e. north-west from it, housing and service buildings were placed. The westernmost building accommodated Wellman and his workers: it was therefore called «Wellman's Hut» (fig. 106-top). It was a roughly a 10x10 meter square-based building, whose stone foundations are still visible. Immediately east from the Hut, a two-building technical facility was established. A workshop, a boiler room and a steam engine were hosted there, among other equipment. The southern building left many fragments of its structure; only a few remnants indicate the presence of the northern building.

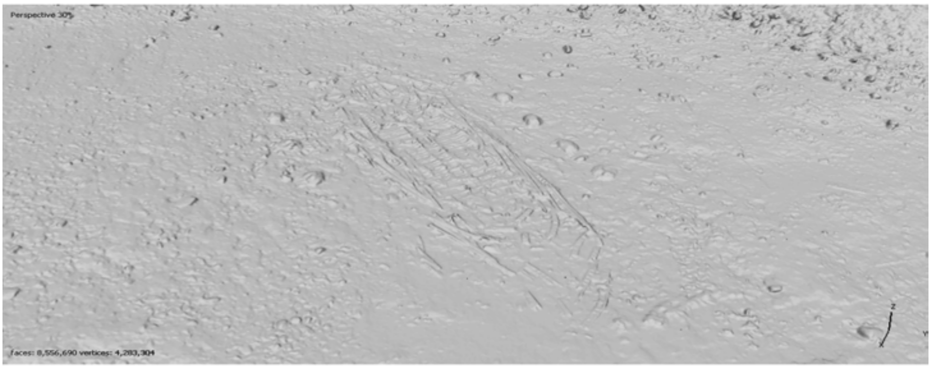


Fig. 103 – *The mesh (tridimensional reconstructed model) of Wellman's hangar as developed from the drone images. On both sides of the hangar it is possible to recognize bases for holding the structural wiring*
Source: ph. by G. Casagrande

East of the workshop there was the hydrogen generation plant, which can be recognized in the 2018 ortophoto in proximity of the hangar entrance (fig. 106-centre). Ceramic elements originally stacked for use in building pipes are fragmented but still on the spot, similarly to the iron fuel barrels which appear scattered around their initial position (fig. 106-bottom). They are slowly disgregating into a thick layer of rust which marks the area. A similar condition involves the «giant heap of rust» (Capelotti, 1994, p. 272), another wide zone of ferrous material in a more south-western position. That includes metal debris and parts from workshop activities and is visible in the aerial images.

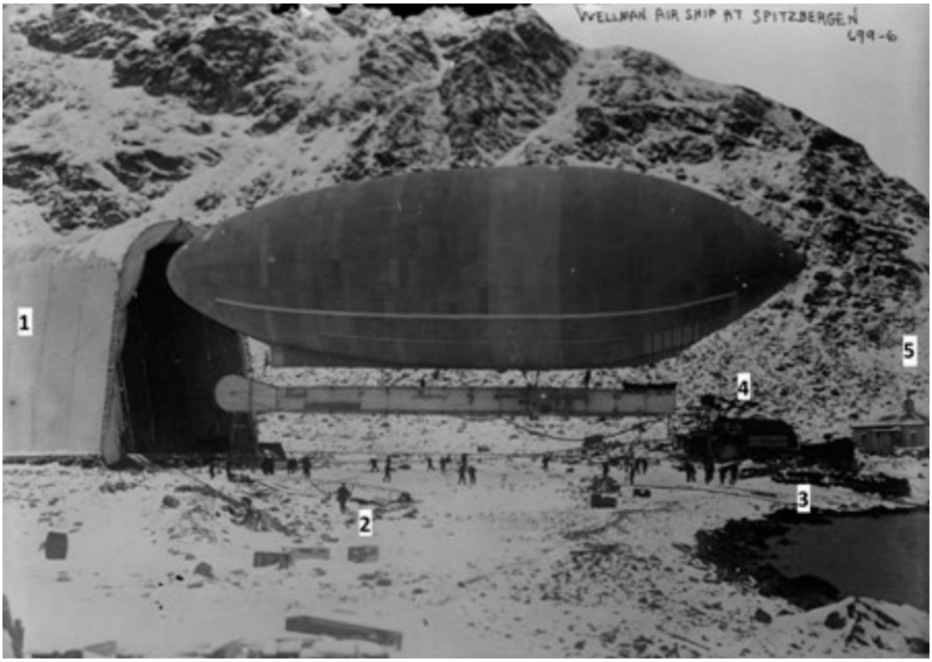


Fig. 104 – *Airship AMERICA at Virgohamna just outside of the hangar (1), in 1907. In the foreground, an object laying on the snow next to a standing person could possibly be the structure – after removal of the fabric cover – of the first airship gondola, built by Godard for the 1906 expedition (2). On the right, it is possible to see the large stack of fuel barrels (3). Technical buildings are visible in the background (4) and so is Wellman's Hut (5). Over a century after this image, even very lightweight and mobile objects were still visible approximately in the same locations. This is evident by comparison with figure 105*
Source: base image from the public domain

A surprising fact is that in the 2018 ortophoto it is still possible to identify – in spite of the mobility and degradation of materials, wood and iron respectively – elements from the two gondolas of airship AMERICA. They were both abandoned at Virgohamna in 1906 and 1909 respectively. The two wrecks were identified and documented by Capelotti (1994 and 1997). Based on this author's work, and much to our surprise, the analysis of the 2018 data allowed to recognize both objects, over 112 and 110 years after their abandonment, though both were clearly in terminal decay. For what it was possible to observe from the drone data, the wreck of the 1906 gondola – if correctly identified – appears to consist in few elements of its wooden structure; they are separated from one another and possibly on the way of being dispersed.

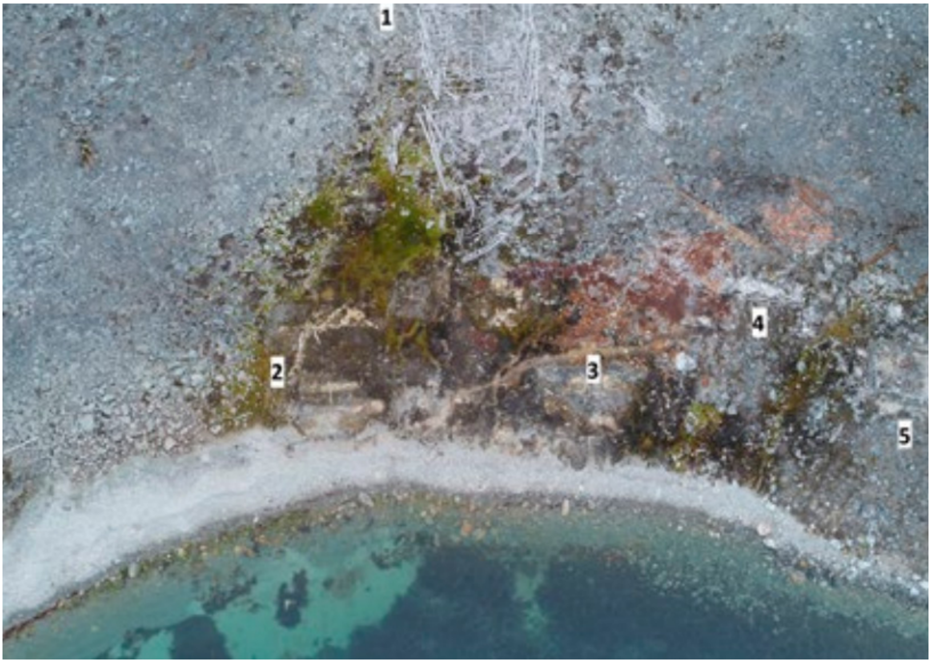


Fig. 105 – *A pseudo-nadiral picture of the area visible in fig. 104, with an indication of visible objects*
Source: ph. by G. Casagrande

The largest parts left of the 1907-1909 gondola (fig. 108) are the three tubular elements of the fuel tank, mentioned in the previous section. Capelotti also indicated the presence of smaller structural elements of the nacelle, but they could not be re-identified on the ortophotograph, so far. As previously stated, the surviving fragments of airship AMERICA are clearly in a different position than that documented in 1993 and still reported as such in 2007 (Bjerk and Johannesen, p. 2007, pp. 6 and 32). They also appear in a more advanced state of decay (fig. 107).

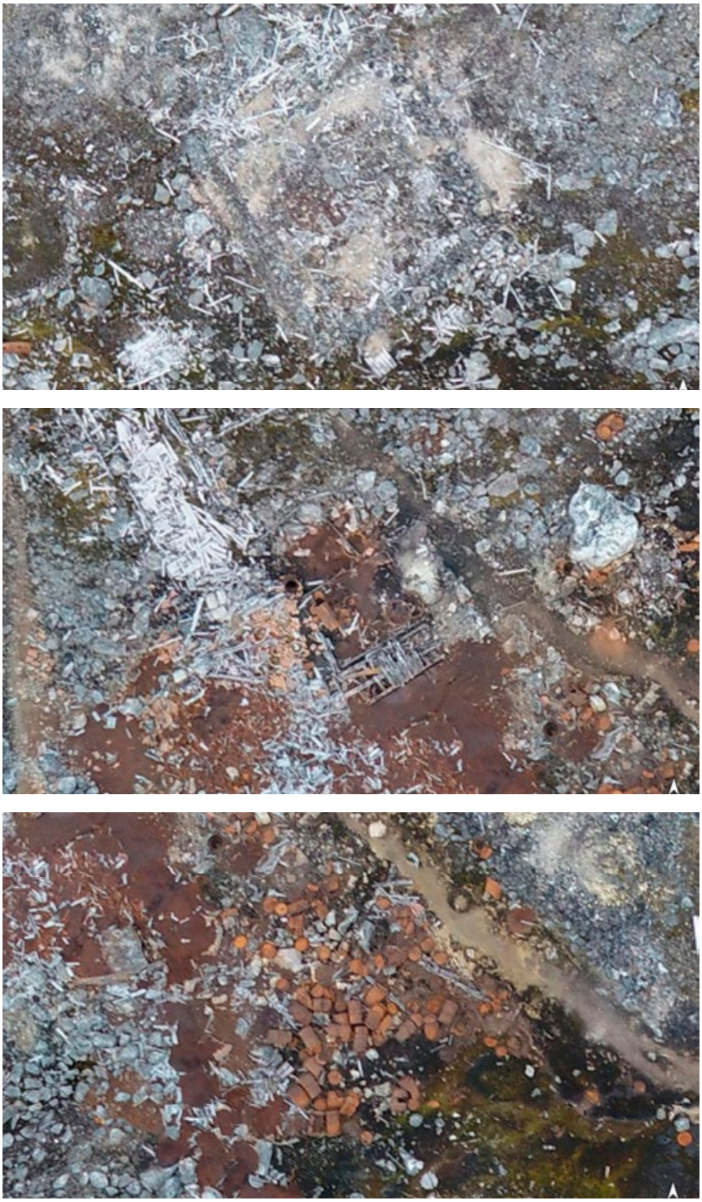


Fig. 106 – *Fixed and mobile remnants of Wellman expeditions. Top: Wellman's Hut. Centre: Hydrogen generating plant. Bottom: fuel storage barrels*

Source: ph. by G. Casagrande

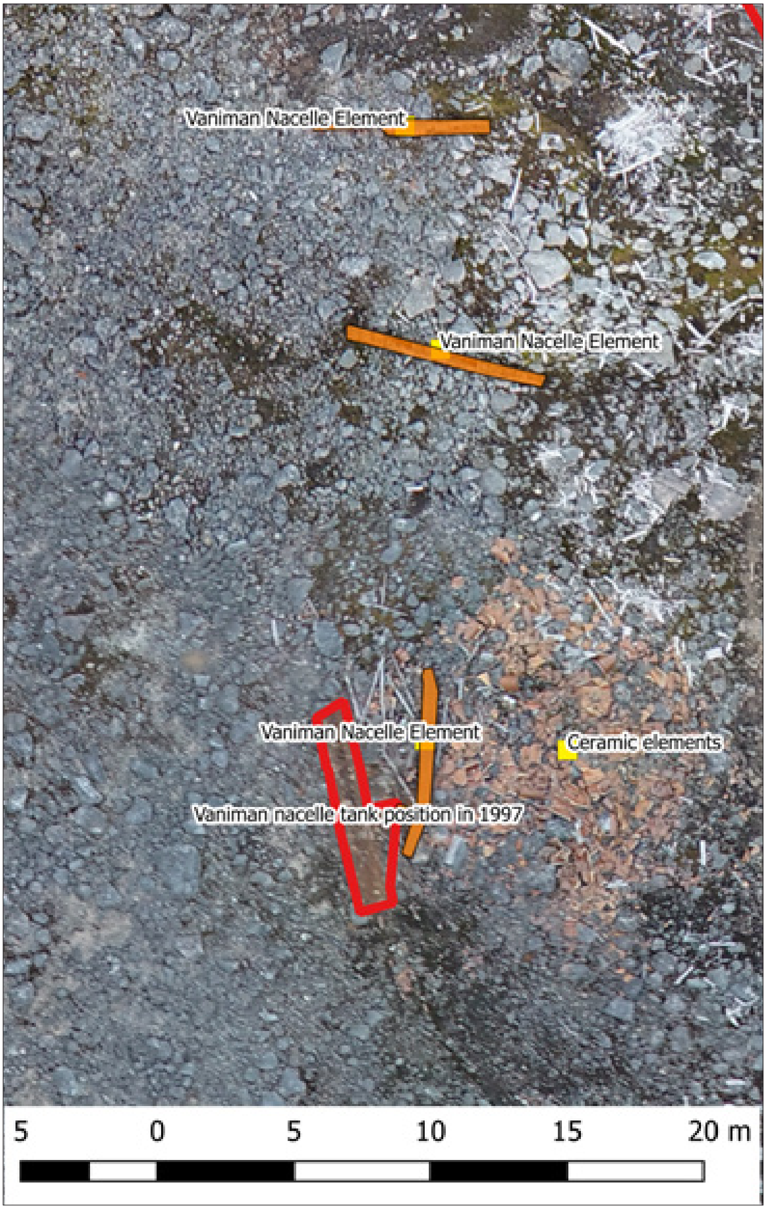


Fig. 107 – *The three surviving tubular elements from the fuel tank are the most evident remainings of Vaniman's gondola in the 2018 ortophoto*

Source: aerial images and GIS mapping by G. Casagrande

Fig. 108 – *The wreck of Vaniman's gondola at Virgohamna after the failed 1909 flight. The bottom tank appears to be broken into parts which were to remain abandoned on site for over a century. Left in the background the «Wellman's Hut» is visible. An interesting detail is that the entire scene appears to be in an evident state of seasonal deglaciation, in a rather similar condition to that found by Polarquest2018*

Image: Norsk Polarinstitutt, also published in Capelotti (1997, p. 24).

5.1.8 *Conclusions about the Virgohamna expeditive survey*

In comparison with the survey conducted by Capelotti in 1993, the Polarquest2018 observation could not physically access the historical site. Nevertheless, considering the expeditive cartography provided by the American scholar after 18 days of research, the 2018 drone flight stands out for acquisition brevity (20 minutes) and processing time (ca. 72 hours of computer-time in the final, definitive workflow), to obtain a tridimensional photogrammetric model and an ortophoto. Both products featured a high level of detail and image resolution, allowing for a relatively complex documentation through data entry in a GIS. The proposed technique, i.e. an expeditive overflight and data processing through low-cost or even open source technology, is certainly recommendable for a long-term periodical monitoring of the historical place. Such monitoring would be highly advisable, given the vast amount of archaeological mobile materials on site. Those materials are, additionally, subject to progressive degradation, especially in view of current trends of global change: warmer climate and more air humidity in the area means, indirectly, faster decay of historical materials such as iron and wood. Given the very high memorial value of Virgohamna, Norwegian authorities have taken the courageous decision to keep the place in its historic material status. This means focusing on reducing tourist pressure by limiting access and defining paths to prevent inadvertent destruction of archaeological evidence. Since remnants left by the old expeditions are not being removed for protection, their material preservation becomes more difficult and monitoring of their evolution on the site may be important from archaeological and historical points of view.

5.2 *Survey Test 1. Detection of thermal variations in the ground surface: The Trollkjeldene hot springs*

Trollkjeldene is an area about 5 kilometers south of the southern extremity of Bockfjorden, in the north-western region of Spitsbergen. Its coordinates are 79°23'25.4"N, 13°26'21.1"E. The Norwegian toponym can be translated into English as «Springs of the Trolls» and it refers to a group of hydrothermal springs and ponds whose temperature is in the order of 25°C. They are surrounded by well-recognizable travertine formations (Jamtveit et al., 2006). The spring waters and the soil in their vicinity are rich in vegetation and, in the ponds, it is possible to observe a thriving ecosystem of small organisms and aquatic plants.

The expedition visited the area on August 7th, 2018, with the plan of performing an aerial observation. The primary purpose of the activity was to conduct a test for detecting thermal variations in the soil surface, because there were obvious «hotspots» around the springs. In those areas, ground surface showed evident warming from the accumulation of hot waters underneath.

This methodological test was intended to verify whether it was possible to obtain a meaningful qualitative map of the thermal variations on a certain surface of the Trollkjeldene area by the use of a bottom-class thermographic sensor. Accurate thermal measurements were not in the plan, and in fact the visible light+thermal (VIS+TIR) frames used for detecting the hotspots did not have any thermographical metadata associated to the graphical matrix. A series of frames, as produced by the VIS+TIR sensor, was to be stitched – and therefore georeferenced - onto an ortophotograph derived from the drone's internal camera. The overlay was to be obtained through a GIS software, essentially to visualize the correspondence between the indicated warmest hotspots and the ground features as recognizable in the aerial imagery.

5.2.1 *Test methodology and results*

An appropriate test area of Trollkjeldene was first of all selected. In the first place, it was necessary to obtain an ortophoto from the drone internal camera. Such ortophoto was to serve as a georeferencing background upon which the VIS+TIR images were to be stitched.

The drone, a DJI Phantom 4 Pro, was fitted with a carbon-fiber rack holding, as a supplementary payload, a FLIR-ONE VIS+TIR sensor connected to a smartphone for control and recording.

The operation was conducted by one pilot and two observers. Two flights were done, at ca. 200 meters above ground level, for an overall time of about 20 minutes. During the flight, the drone video/photocamera shot nadiral time-lapse 20 Mpx images with a 3-second interval, while the VIS+TIR sensor was recording a video. At the end of the mission, a total of 294 images in the visible light and 1'35" video in the VIS+TIR had been obtained. The still images in the visible from the internal drone camera included GNSS data along with other associated «exif» information, and this allowed, as previously specified, to obtain an approximately georeferenced ortophoto. Images in the VIS+TIR did not include either positional or radiometric data. As a first step, the visible-light images were processed through the standard «imaged-based-modelling» workflow, yielding a 3D model and ortophoto, the latter being exported in *.geotiff*. This background raster was then input in a QGIS project. A total of 9 individual VIS+TIR frames, extracted from the recorded video, were manually stitched on-top of the reference ortophoto by the use of QGIS Raster Georeferencer plugin.

From the collected and processed imagery, a description of thermal variation patterns in a small sector of the Trollkjeldene area was obtained.

An obvious problem was that the background image was generated from 20 Mpx, sharp stills, whereas the VIS+TIR frames had a mere 120 x 160 pixel image size, with possible additional distortions and noise due to the extraction from a video.

In spite of the difficulty of correctly aligning the stitched images, by finding the proper correspondences between objects resolved in the visible and their traces on the much less clear VIS+TIR frames, the overlay was successful. It provided an effective visualization and mapping of hotspots surrounding the main springs.

It was therefore possible to validate the survey technique. Figure 109 shows, at the top and bottom regions, two thermal springs, in light color. The surrounding zones indicated by light shadings are warm spots on the ground surface.

It appears evident that this type of expeditive survey allows to obtain maps of thermal anomalies which – albeit metrically approximate, especially at very large cartographic scale – offer, nevertheless, a level of detail which may compete, in some types of informational value, with other forms of remote sensing of the same phenomenon.

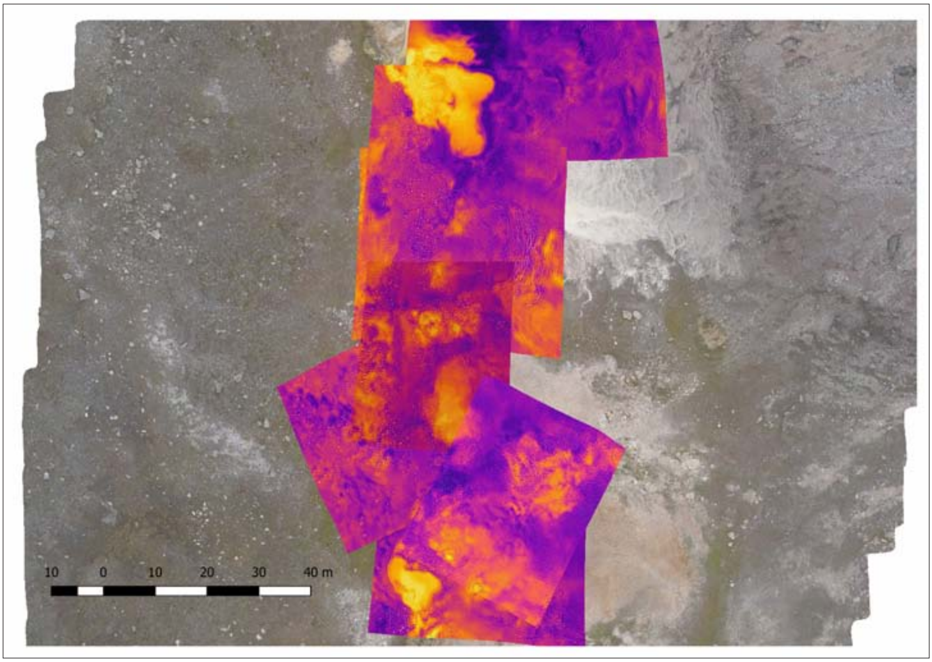


Fig. 109 – *Overlay of visible + thermal infrared images onto a visible light ortophoto representing a sector of the Trollkjeldene*

Source: aerial images by M. Struik; data processing by G. Casagrande

5.2.2 *Thermal mapping test* vs. *full-blown cartographic application: A few remarks*

A few remarks should be added from a technical point of view, to share with other researchers some specific caveats of this activity. The mapping test was primarily expected to verify what kind of general thermal variation patterns were visible in the VIS+TIR imagery, and the feasibility of meaningfully overlaying VIS+TIR frames onto a higher-resolution VIS ortophoto. As mentioned, used VIS+TIR images were not associated to thermographic metadata, whereas such information would allow, if validated with standard ground-truth thermal measurement other standard thermography correction protocols, to obtain a measurement of the temperature of individual hotspots. A feature of the FLIR-ONE sensor used to collect the VIS+TIR frames is that each recorded frame – at least in video mode – integrates the image acquired by the thermal sensor with an image acquired by a small visible camera. Both frames are superimposed in a single video image; this image shows the thermal scene and the visible-light scene, allowing to more easily recognize the object that produces a certain thermal emission.

In our experience, this overlaying is essential to obtain a good alignment among different images during stitching. However, it must be noted that the hardware and system integration operate in such a way that scene acquisition is not exactly contemporary by the thermal sensor and by the integrated visible camera. As a matter of fact, if the image acquisition platform is not sufficiently slow or even still at the time in which the scene is acquired, the generated frames show inconsistent alignments between the «thermal» scene and the corresponding visible-light scene. This means that from one frame to another the relative position between a certain physical feature on the ground and its correspondent thermal emission might appear to be changed.

Furthermore, as it is typical of many low-cost thermal sensors, the FLIR-ONE adjusts the color palette of each frame depending on the maximum and minimum indicated temperature values that the sensor «sees» in the viewed scene. If the interval in a certain scene is remarkably shorter or longer than that visible in an adjacent scene (e.g. if the latter contains relatively much «colder» or «warmer» spots), the color palette of the two frames would be different and post-processing manipulation, though possible for a better visual rendering of the hotspots, might be difficult or inappropriate in a test like the one hereby described, where colors are not associated to any quantitative – albeit relative – thermal information. This particular problem is, obviously, completely overcome if used frames contain thermographic metadata – which was not our case – as the proper chromatic adjustment (and thermographic scaling) can be performed on the individual frames before exporting them for stitching on the map.

5.2.3 *Conclusions on the Trollkjeldene test*

The experience at Trollkjeldene allowed to validate the general protocol for data acquisition and allowed to produce a high-detail, though purely indicative in nature, map of the spatial patterns of thermal variations on the ground surface, with no numerical measurement of temperature. Thermal information would require the use of frames associated to thermographic metadata, yet these can be obtained by the use of the same flying-platform and payload rack with a different thermal sensor installed. Given the relevant difference in spatial resolution between the drone built-in visible camera and the thermal camera, alignment of TIR imagery during overlay could prove challenging, unless the thermal frame is already associated to a corresponding visible light scene, whose details can serve as minimal reference during the stitching process.

In a full blown application of the tested technique, both the reliance to topographically determined ground control points for georeferencing of the background image, and «ground truth» measurement of reference thermal sources to validate the remotely sensed images would allow to map thermal variation patterns at ground level with high level of accuracy, both in spatial and in thermographic terms.

5.3 *Observations at Kinnvika*

When Polarquest2018 visited the Kinnvika research station site, the initial intention was to conduct an expeditive aerophotogrammetric survey of the area, similar to that in Virgohamna. All geolocalized and high-res images taken in Kinnvika, however, were lost when the hard-disk containing them was accidentally damaged later in the expedition. The only remaining data were the low-resolution, non-georeferenced images which had been downlinked on the remote control iPad during the flight, so processing could only be undertaken on those. Considering that the site of the old station appeared to be mapped in low resolution even on the TopoSvalbard platform and the public geodata provided by Norsk Polarinstitutt, the author considered that the albeit poor aerial documentation available, associated with other images and information acquired by the technical coordinator, did retain some documentary value. It was then decided to elaborate on the available data.

Fig. 110 – *An aerial view of the former Swedish-Finnish-Swiss scientific base*
Source: aerial images by G. Casagrande

Fig. 111 – *Individual buildings in the research station, with reference to fig. 110: a) main building, B-1; b) building B-2; c) building B-5; d) building B-4; e) building B-7; f) buildings B-2, B-4 and B-5*

Source: images by M. Struik (a-d); G. Casagrande (e and f)

Fig. 112 – *Details of the Kinnvika station: a-b) dormitory; c) blackboard with old writings; d) food remnants; e) sauna; f) toilet; g) wood stack and whale bones; h) wreck of the Weasel transporter and trailers*

Source: ph. by M. Struik (a-g); G. Casagrande (h)

5.3.1 *Historical summary on the operation of the Kinnvika Research Station*

On the occasion of the International Geophysical Year (1958), a scientific base was established in July 1957 on the northern side of Murchinsonfjorden, Nordaustlandet in the site of Kinnvika. It was supposed to host the «Swedish-Finnish-Swiss International Geophysical Year Expedition to Nordaustlandet», conceived as a year-round research facility. The initial plan had been to have a Swedish scientific station in Cape Linné, in Isfjorden; the idea had been later discarded, apparently, for political reasons given that such plan would have involved a proximity to the Soviet mining area of Barentsburg, an undesired circumstance during the cold war. Sweden had therefore opted to establish a joint research expedition with Switzerland and Finland, being – beyond authoritative scientific partners – two «non-aligned» countries (Doel et al., 2014, p. 76)

The so called «wintering party» left Stockholm on July 6th and arrived to Kinnvika on July 15th 1957. It included 13 persons[60], who were supposed to work at the establishment of the base with other four technicians (Polar Record, 1958, p. 24). The facility was quickly built, beginning scientific operations by August 15th, when the first meteorological reports were sent. The base (figg. 108-110) consisted of prefabricated wooden buildings: main building (including living quarters featuring a sauna, kitchen and laboratory), reserve building, power house, cosmic ray hut, balloon hut, chemistry hut, terrestrial magnetism hut, auroral camera hut, terrestrial magnetic variation hut, rotating frame aerial (Polar Record, 1958 and 1959). Provisions and supplies were transferred to the station by ship, while fresh water was transported from a nearby lake by a Studebaker M29C Weasel tracked vehicle, equipped with trailers. The expedition established several infrastructures around the base between 1957 and 1958, including a three-room snow cave in Vestfonna, occupied for two weeks in April 1958, and a 1200 x 30 m snow runway for airplane activity. The airstrip was actually used at least on May 8th, 1958 by a Norwegian Air Force Catalina amphibian aircraft. The three-nation workgroup left the base, relieved -with technical difficulties due to bad weather and ice conditions (Polar Record, 1959, pp. 338-339) – by a smaller Swedish scientific unit to man the station for the 1958-1959 winter[61].

During its activity, the base received several visits from international scientists and conducted high-profile observations. After the 1957-1959 operation, however, the base was abandoned, partly due to being quite remote and difficult to reach either by sea or air in bad weather.

---

(60) G. H. Liljequist (Sweden), leader, meteorologist; M. Aro (Finland), medical officer; C.A. Bäckstedt (Sweden), radio operator, meteorologist assistant. P. Wasserfallen (Switzerland), atmospheric electricity; E. Dyring (Sweden), cosmic rays; H. Engström (Sweden), electrical engineer; E. Gröndahl (Finland), radio-sonde; K.E. Heikkilä (Sweden), cosmic rays; I. Helimäki (Finland), meteorologist, radiosonde. A. Junod (Switzerland), atmospheric electricity; S. E. Molander (Sweden), instruments; E. Tollén (Sweden), electrician, cook; K.E. Wärme (Sweden), chemist.

(61) W. Bischof, leader and meteorologist; L. Andersson, Physicist (AURORA and Cosmic Rays); S. Hagberg, mechanic; I. Klang, radio operator and physicist (terrestrial magnetism); P. Wasserfallen (Switzerland)

For several decades, the base was seldom visited but overall monitored and partially maintained by the Sysselmannen på Svalbard.

In anticipation of the International Polar Year 2007-8, the semi-abandoned facilities at Kinnvika were visited in 2005 by an international and interdisciplinary workgroup of eight researchers (from Finland, Sweden and Norway). The group was led by Prof. Veijo Pohjola (Uppsala University) and found the station buildings in unexpectedly good conditions from a structural point of view, yet in some degradation in terms of usability (Moore, 2005). Nevertheless, the base was deemed adequate for reactivation and began a new phase of full-blown international scientific operation from 2007 to 2010. The project was named IPY-KINNVIKA including six spring and summer expeditions with a total of 69 researchers operating on parallel programmes on 11 work-packages from 10 nations. Actual manned operation at the research base was complemented by a set of automatic and unmanned data acquisition (particularly during the winter). Disciplines included studies on cryosphere, geosphere, atmosphere, biosphere, environmental science, logistics and outreach (Pohjola et al., 2011, pp. 201-202). Some activities in 2005 were also humanities- and historical-geography related, by investigating testimonies of human presence and action from the past in the area (Moore, 2005). Involved nations in the research program were Finland, Poland, Sweden, Norway, Germany, United Kingdom, Denmark, Canada, Luxembourg and United States (Pohjola et al., 2011, pp. 201-202). Although activities were mostly related to scientific research, a specific attention was given to public dissemination of results as well (*ibidem*, p. 205). Expedition summaries and reports about the 2007-2010 activities can be found at: *https://www.kinnvika.net*.

5.3.2 *Expeditive observation and GIS documentation of the area*

When the Polarquest2018 visited the Kinnvika site, it found the buildings in overall good conditions and still hosting relatively intact equipment and even food supplies, along with other materials in decay. Mould and evident traces of humidity were visible in many internal spaces of the base. Chalk-writings on a blackboard in the main building (already pictured in 2005 by IPY-KINNVIKA, and apparently never altered later), showed indications of visits to the base during its official de-activation periods. A recommendation was also included: «Leave this place in as good order as it was when we left on 27. Aug 1966. Valter Schytt. P.S. There is more wood in the sauna house».

A significant number of permanent ink-marker writings was visible on the walls with dates and names of visitors, apparently from different countries. At the southern side of the base, in a relatively flat area between the main buildings and the shore, there were the original Weasel transporter and a set of trailers meant to be used for moving materials around the base. This equipment was apparently from the 1957-1959 operation. They were orderly aligned on the southern side of the station. The vehicles, however, appeared to be in rusty conditions and the Weasel was more or less in the state of wreck, with significant portions of the sides giving way to corrosion, in spite of the surviving presence of olive green paint in some other areas.

For the planned documentation, an ortophoto, missing georeferencing points, was prepared based on the low-res aerial images. It was georeferenced by manual stitching on top of the available cartography, even though the existing reference points would allow for relatively modest accuracy. The background cartographic files were downloaded from Norwegian Polar Institute Map Data and Services, and the following reference layers were chosen:

a) - *100S_Tekniske_Posisjon_p* (type: point). This is a layer indicating the position of technical sites.
b) - *100S_land_l* (type: line): this layer indicates the shoreline.
c) - *100S_Vade_l* (type: line): this layer indicates water streams and the external boundary of lakes and ponds.

Since other indications and references were missing, an assumption was made that the coordinates of the points in layer *100S_Tekniske_Posisjon_p* corresponded, in Kinnvika, to the coordinates of the centre of each surviving building, and georeferencing was conducted by stitching the centre of each building's roof as visible in the ortophoto to the points marked in the basemap shapefile. Other reference points were associated to individual features of the coastal ponds which were indicated by the *100S_Vade_l*

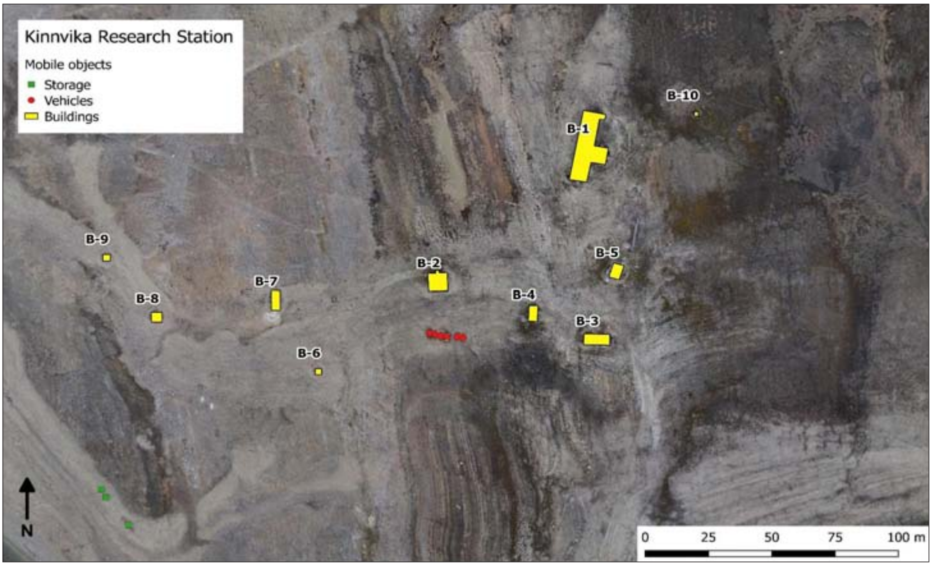


Fig. 113 – *Map of the Kinnvika site. Buildings are indicated by «B» and an ordinal number*
Source: aerial images and GIS processing by G. Casagrande

shapefile and appeared consistent to those on the ortophoto; this reference was considered to be approximate but at least partially reliable. No reference point was set on the coastlines (bordering the base from the west and the south), because there was no reliably identifiable correspondence between the shoreline as visible on the ortophoto and on the *100S_land_l layer*.

Once the ortophoto was georeferenced, two ESRI shapefile layers were created. The first one was a polyline vector layer, used to indicate an approximate footprint for each building. The second one was a point layer, used to indicate mobile objects such as transportation vehicles or storage containers as identified on the ortophoto. Different icons (circles for vehicles, squares for containers were used to distinguish the two different themes to allow for easier recognition).

5.4 *General ortophoto of Alpiniøya and mapping of artificial litter on its shores*

Alpiniøya is a small rocky island in position Lat. 80°21'03"N, Long. 24°45'09"E, close to the northern coast of Nordaustlandet. Its surface is about 1.5 km^2 and, when deglaciated, it shows large extents of bare rock and masses of stones and pebbles. It rises a mere 33 meters from the sea-level and shows very gentle slopes on all sides. The island was discovered during the summer of 1928 by Italian officer Gennaro Sora (1892-1949), a Captain of the Alpine Corps, while he was crossing – along with Dutch Arctic guide Sjef van Dongen – the northern region of Svalbard in the attempt of reaching the survivors of ITALIA. Sora was the first to report the existence of the place, naming it «Alpini Island»[62] (Bosco and Stone, 2004, p. 306) and the toponym was registered by Norwegian authorities in their own language. The island is completely uninhabited and only occasionally visited by scientific expeditions, adventure tourists and, obviously, by Norwegian Coast Guard.

Polarquest2018 conducted an aerophotogrammetric survey of Alpiniøya, in order to obtain a 3D model and a high-resolution ortophoto. As a secondary goal, traces of macroplastic and other artificial debris/litter on the shores of the island were to be documented. A group of four operators (1 drone pilot, 3 observers, 1 cameraman) was deployed on land from the boat anchored about 600 meters far. The landing occurred on the south-western beach of the island, circa in position 80°21'03.04"N, 24°43'28.88"E. An observation was conducted there for purposes of «ground truth»

(62) The fact was also mentioned by geographer Franco Pelliccioni in his communication *Le scienze umane e geografiche nell'Artico, priorità e prospettive: una sintesi introduttiva*, presented on May 15[th], 1997 at the International Seminar held in Ny-Ålesund, at the official inauguration of Italy's National Research Council's Arctic Base «Dirigibile ITALIA»: *http://users.libero.it/f-pelli/f-pelli.documento2.htm*.

and photographic documentation, finding abundant artificial debris intermingled with large masses of driftwood. The group then moved about 90 meters north on a modest rocky relief and established a take-off spot for the drone (positions in seconds only: 06.07"N, 30.47"E). A total of three flights was conducted at an almost constant height of 150 meters above ground level for a total of about 60 minutes.

5.4.1 *Data from «image-based» processing report and related comments*

After the return of the survey group onboard NANUQ, a first, «quick and dirty» provisional processing of all the acquired images was performed using the available laptop computer with Agisoft Photoscan™ at the lowest available processing settings for the entire standard workflow (align images, build dense cloud, build mesh, build texture). Just as in the case of Virgohamna, the purpose of this preliminary operation was to ensure that the survey area had been completely covered and advanced processing could be successfully performed. Once this had been ascertained, the expedition could depart the site. The full-blown processing and analysis of data began at GREAL after the author's return to Italy in early fall 2018 and lasted several months due to the need of optimizing the processing workflow, of processing 3D models and ortophotos in appropriate formats and analyze the obtained data. During the in-lab analysis after the expedition, 662 nadiral images were used for two independent processing workflows, the first one aiming to create a medium-quality 3D-model and ortophoto by the use of Agisoft Photoscan™, the second one aiming to create a very high-quality ortophoto by Agisoft Metashape™. The latter was obtained as a composition of 17 parts, all in *.geotiff* format by GREAL member Dr. Emiliano Tondi, PhD. Considering the distinction between «relative» and «global» positioning and related issues, as mentioned in the Virgohamna case, it should be underlined that Alpiniøya presents a widely different scenario than Virgohamna. The latter implied detail documentation of small archaeological remainings in a space spanning, in each direction around, a few hundred meters. Alpiniøya, instead, presented two basic documentation goals: the primary one was a classical physical-geography-oriented aerophotogrammetric acquisition of the entire island; the secondary one was a basic mapping of artificial debris on the ground, insofar as it could be identified on the ortophoto.

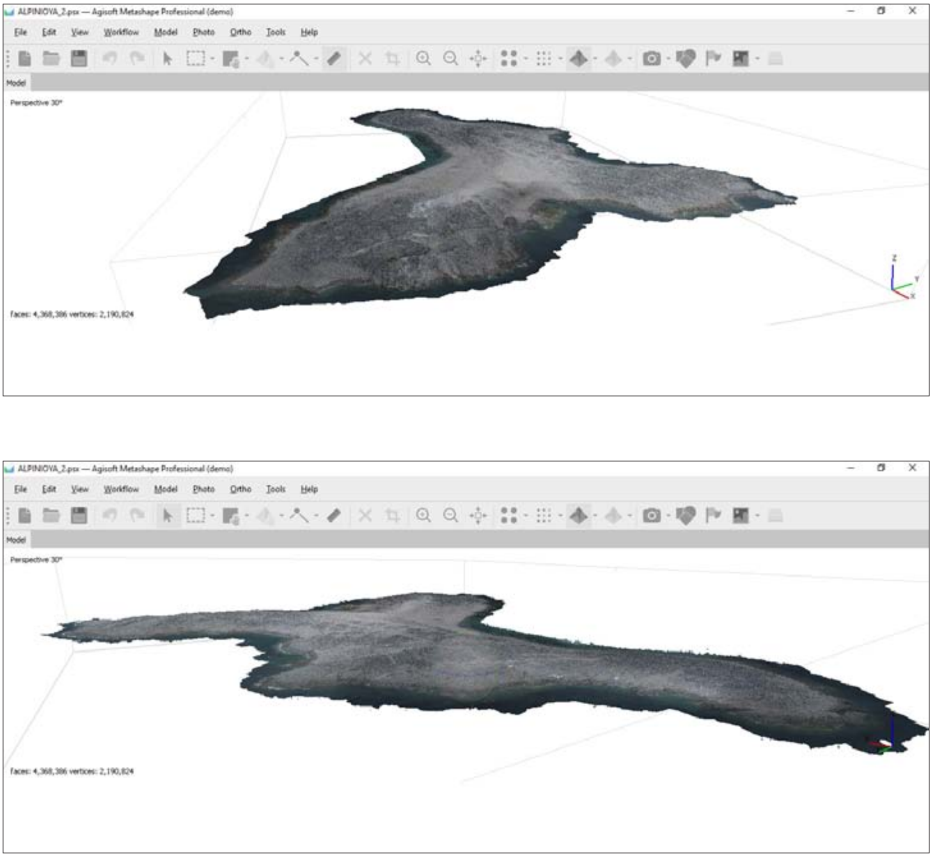


Fig. 114 – *Alpiniøya 3D model from the aerophoto acquisition by Polarquest2018*

Source: processing by G. Casagrande

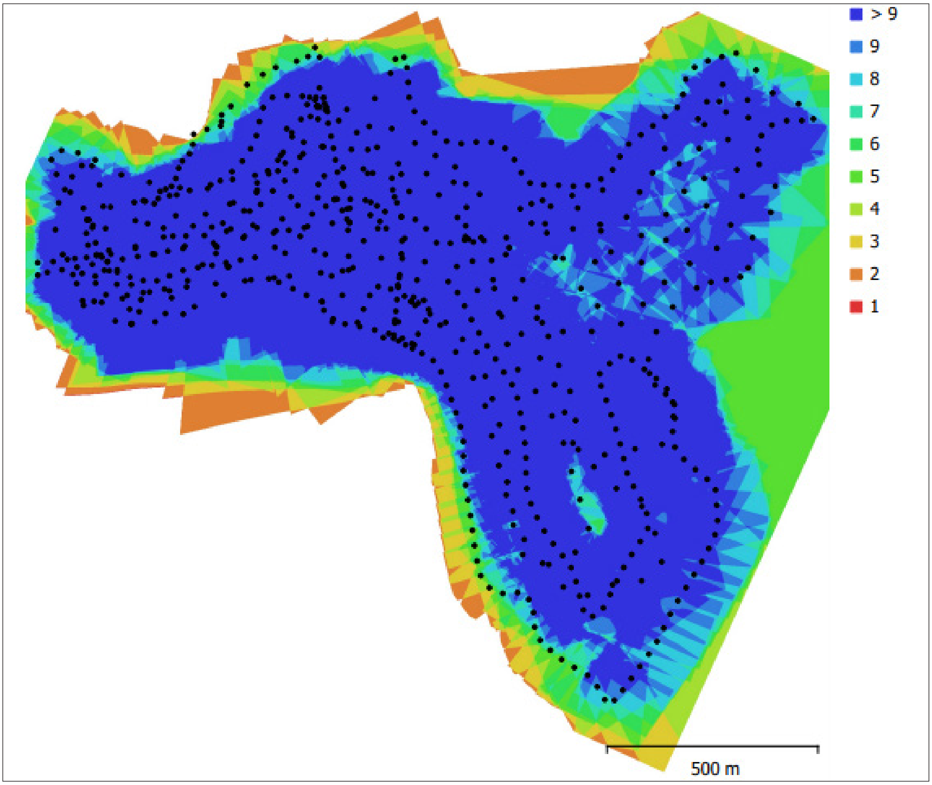


Fig. 115 – *Number of overlapping images on each zone of the survey area. Black dots indicate the camera position associated to each shot*

Source: Agisoft (processing by GREAL)

Tab. 10 – *General survey data*

Number of images	**662**	**Camera positions**	**662**
Average survey hight[63]	154 m	Tie Points	70,342
Ground resolution	3.9 cm/pixel	Projections	638,035
Total coverage area	2.04 km^2	Reprojection error	0.501 pixel

Source: Agisoft (processing by GREAL)

Camera calibration data – as computed *ex post* by the software, are presented as follows

(63) Above ground level from takeoff point.

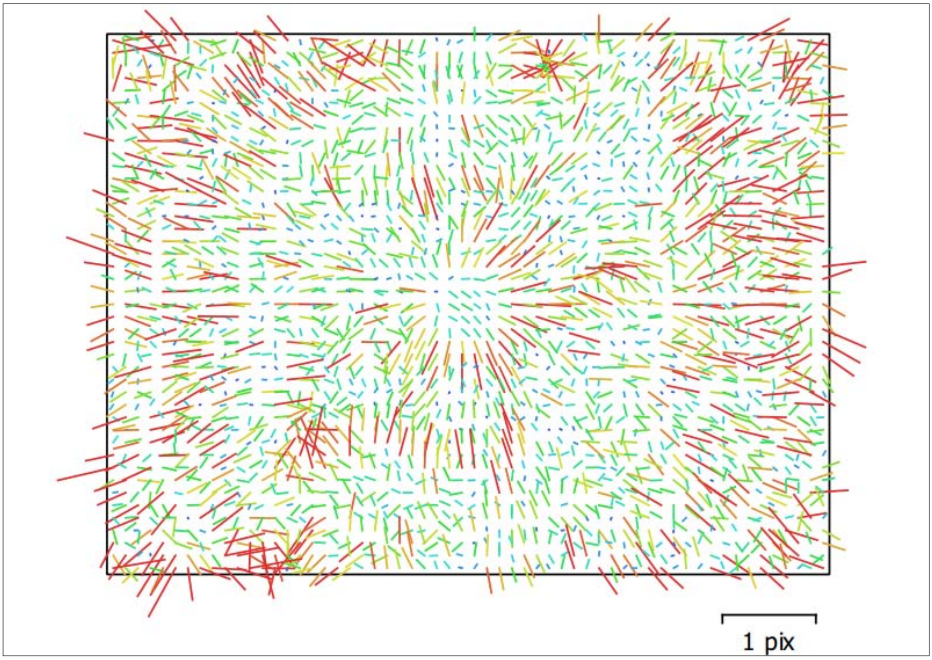


Fig. 116 – *Image residuals for photocamera FC6310 used during the expeditive survey. Image size: 4864 x 3648 pixel; focal length: 8.8 mm; pixel dimension: 2.61 x 2.61 μm*
Source: Agisoft (processing by GREAL)

Tab. 11 – *Calibration coefficients and correlation matrix*

	Value	**Error**	**F**	**Cx**	**Cy**	**B1**	**B2**	**K1**	**K2**	**K3**	**K4**	**P1**	**P2**	**P3**	**P4**
F	**3671.15**	0.069	1.00	0.02	-0.39	-0.06	-0.05	-0.10	0.10	-0.08	0.07	0.01	-0.02	0.01	-0.01
Cx	**39.2436**	0.025		1.00	0.03	0.10	0.25	-0.01	0.01	-0.01	0.02	0.43	0.17	-0.20	0.16
Cy	**29.9353**	0.025			1.00	-0.19	0.12	-0.02	0.01	-0.02	0.02	0.10	0.31	-0.10	0.09
B1	**2.09949**	0.0036				1.00	0.00	0.03	-0.03	0.02	-0.01	0.05	0.01	-0.03	0.03
B2	**0.0177388**	0.0036					1.00	-0.00	0.00	-0.00	0.01	0.04	0.06	-0.03	0.03
K1	**0.0229668**	5.3e-005						1.00	-0.97	0.93	-0.88	-0.04	-0.06	0.06	-0.07
K2	**-0.100664**	0.00031							1.00	-0.99	0.96	0.05	0.05	-0.08	0.10
K3	**0.198922**	0.00069								1.00	-0.99	-0.07	-0.06	0.10	-0.12
K4	**-0.132719**	0.00053									1.00	0.08	0.07	-0.12	0.14
P1	**0.0024337**	3.3e-006										1.00	0.72	-0.88	0.80
P2	**0.00119327**	1.8e-006											1.00	-0.76	0.69
P3	**0.394829**	0.0051												1.00	-0.98
P4	**-0.385033**	0.0062													1.00

Source: Agisoft (processing by GREAL)

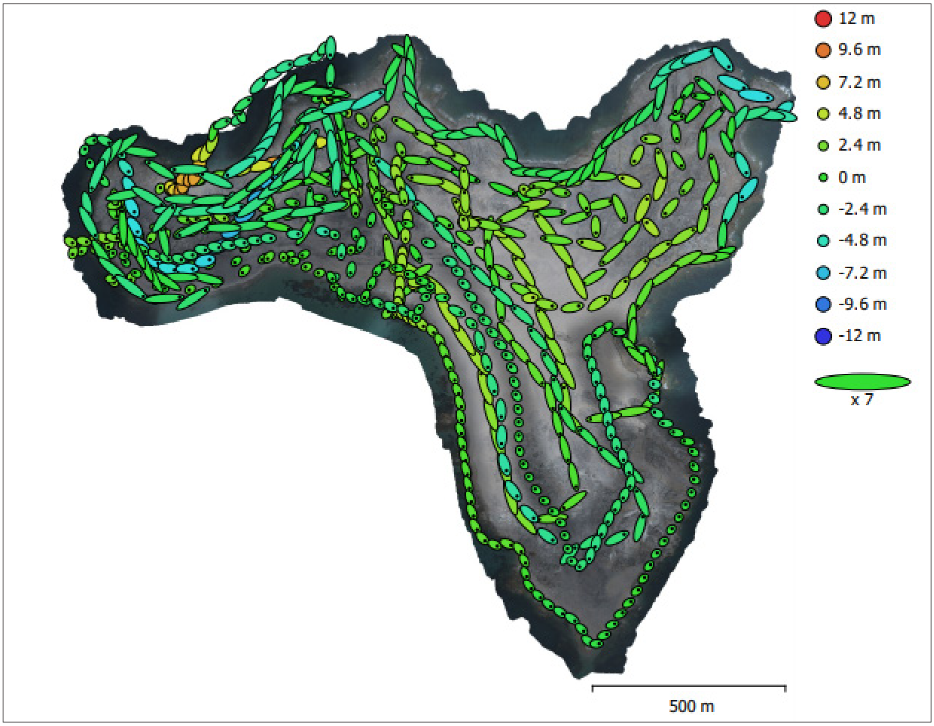


Fig. 117 – *Estimated camera positions (black dots) and evaluation of possible errors. Combined errors in longitude and latitude (indicated as x and y respectively) are represented by the size of ellipses' axis (multiplied by 7 for better clarity) and orientation. The color shading of each ellipse indicates the possible vertical estimation error*

Source: Agisoft (processing by GREAL)

Tab. 12 – *Average error in estimated camera positioning*

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
4.23918	4.29219	2.66717	6.0327	6.59601

X – Longitude; Y – Latitude; Z – Altitude

Source: Agisoft (processing by GREAL)

The processing parameters can be listed as follows:

Tab. 13 – *Processing parameters*

General			
	Cameras		662
	Aligned cameras		662
	Coordinate system		WGS 84 (EPSG::4326)
	Rotation angles		Yaw, Pitch, Roll
Point cloud			
	Points		70,342 of 102,262
	RMS reprojection error		0.188588 (0.500749 px)
	Max reprojection error		0.598112 (4.01894 pix)
	Mean key point size		2.69837 pix
	Point colors		3 bands, uint8
	Key points		No
	Average tie point multiplicity		8.89872
	Alignment parameters		
		Accuracy	High
		Generic preselection	Yes
		Reference preselection	No
		Key point limit	80,000
		Tie point limit	1,000
		Adaptive camera model fitting	No
		Matching time	3 hours 50 minutes
		Alignment time	1 minutes 46 seconds
	Optimization parameters		
		Parameters	f, b1, b2, cx, cy, k1-k4, p1-p4
		Adaptive camera model fitting	No
		Optimization time	16 seconds
Depth Maps			
	Count		662
	Reconstruction parameters		
		Quality	Medium
		Filtering mode	Aggressive
		Processing time	1 hours 51 minutes

Dense Point Cloud			
	Points		67,400,355
	Point colors		3 bands, uint8
	Reconstruction parameters		
		Quality	Medium
		Depth filtering	Aggressive
		Depth maps generation time	1 hours 51 minutes
		Dense cloud generation time	41 minutes 10 seconds
Model			
	Faces		4,368,386
	Vertices		2,190,824
	Vertex colors		3 bands, uint8
	Reconstruction parameters		
		Surface type	Arbitrary
		Source data	Dense
		Interpolation	Enabled
		Quality	Medium
		Depth filtering	Aggressive
General			
		Face count	4,529,279
		Processing time	1 hours 0 minutes
DEM			
	Size		15,825 x 14,928
	Coordinate system		WGS 84 (EPSG::4326)
	Reconstruction parameters		
		Source data	Dense cloud
		Interpolation	Enabled
		Processing time	2 minutes 18 seconds
Orthomosaic			
	Size		48,653 x 42,653
	Coordinate system		WGS 84 (EPSG::4326)
	Colors		3 bands, uint8
	Reconstruction parameters		

		Blending mode	Mosaic
		Surface	Mesh
		Enable hole filing	Yes
		Processing time	2 hours 36 minutes
Software			
	Version		1.5.1 build 7618
	Platform		Windows 64

Source: Agisoft (processing by GREAL)

As an experimental work, a digital elevation model (DEM) was processed, and then a contour-line ESRI shapefile was computed, with a 1-meter vertical equidistance. Since the DEM was likely accurate in terms of relative positioning but clearly contained a major vertical error in terms of absolute positioning, a correction procedure was performed. Since the island's maximum height was measured to be 33 meters by Norsk Polarinstitutt, a pair of approximate 30 meter a.s.l. contour lines was identified by comparison with the topographic raster «S100 Raster» obtained from *https://geodata.npolar.no*. Based on this «maximum altitude» reference, altitude levels for the remaining contour lines were set through the raster calculator and a 0-meter contour line was determined. Below-zero contour lines created by the system, as well as other contour lines in the water area surrounding the island were deemed unreliable or ratty data and were eliminated. It is the author's opinion that the determined contour lines, as well as the altimetry values are to be considered approximate, but probably overall reliable and quite effective documentation-wise. An annotated copy of the orthophoto, with the obtained contour lines is annexed to this book (Annex 2).

Given the concept and operational profile of this particular mapping activity, it is important to underline that the complex discussion of accuracy issues as presented with regard to Virgohamna do not apply here in the same degree. If considered in relation to the size and dimensions of the island, the inaccuracies in absolute positioning suffered by the drone's non-differential GNSS system are less significant than in the previous case study; at the same time, the possible anomalies in morphological reconstruction of objects on the ground, due to relative positioning errors in the reconstruction workflow, are far less relevant.

The mapping of artificial debris scattered on a remote Arctic beach expresses the interest to count the very large number of objects, and to give a simple interpretation of their nature and accumulation patterns. For none of these types of required information is very accurate mapping needed in any case.

What can be pointed out as mostly relevant in this case is the high quality and level of detail obtained for the entire island by the use of simple, consumer-level aerophotogrammetric platforms and workflows. The extremely brief survey time and overall modest in-lab processing time allow to indicate this technique and survey profile as a most efficient one for documenting geomorphology, ice cover variations and evolution trends of scarcely documented sites. What appears to be relevant in the secondary activity, i.e. the aerial mapping of artificial debris, is that this kind of observation is relatively easy, cheap and efficient to conduct and repeat in long-term monitoring programmes. For these applications, small drones are far more efficient and affordable than traditional helicopters or airplanes. This is true, equally, for low-budget scientific workgroups, citizen scientists and to all persons, operators and offices which should be appropriately involved in surveillance and environmental protection (Falk-Andersson and Strietman, 2019, p. 33). In our opinion, this technique could effectively complement traditional autoptic observation and sample collections, because drones allow to obtain, in a brief time, descriptive images of large areas. On the one hand, this may be less effective than direct ground survey: only larger size debris can be identified in aerial images, and it is far harder or impossible to recognize small details indicating the origin of the debris. On the other hand, however, a thorough aerial survey may allow for a more comprehensive view of plastic scattering in the area; it also allows to perform periodical monitoring of the phenomenon, particularly if monitoring is subject to severe time constraints. A general aerial observation may be recommended if wide scale monitoring of plastic litter is to be planned.

5.4.2 *GIS documentation and observation comments*

The high resolution ortophoto was input as a background raster into a QGIS project. As Polarquest2018 did not include geological observation in its immediate goals, the discussion of geo-morphological aspects and analysis based on the acquired ortophoto is beyond the scope of this report and will hopefully be the subject of future research contributions.

The observation and description of plastic pollution in the reached points of interest was, instead, a primary goal of the expedition and the GIS documentation and analysis was therefore centered on this aspect. A vector, point type layer was then created, to mark the approximate position of artificial debris of sufficient size, and basic information was associated in the related attribute table.

A second layer, purely indicative in nature and therefore even more approximate in terms of element counting, was created in vector line data type, with no attributes for the feature other than the basic id number; this layer was used to do an approximate mapping of driftwood elements.

This type of debris is typical of many Arctic beaches and was very abundant in Alpiniøya when it was visited. For the most part, driftwood includes tree trunks and branches, coming from other, far regions, because Svalbard is deprived of any arboreal vegetation. Occasionally, driftwood includes artificial objects (wooden beams, nautical wrecks and equipment, remnants of ruined structures etc.). Distinction between natural and artificial driftwood on the ortophoto was not attempted. It is worth mentioning that the very approximate nature of driftwood mapping was due – in most cases – to the fact that this material appeared to be chaotically lumped in large and thick heaps; hence it proved extremely difficult to univocally identify and map an individual element.

Nevertheless, the indication of accumulated driftwood associated to mapping of artificial debris has the advantage of allowing for a correlation, albeit indicative, of the two types of object.

Tab. 14 – *Attribute table fields for the layer documenting artificial debris at Alpiniøya*

Layer	data-type	Attributes (type)	Attribute description
artificial_debris	Point	*id (int)*	Ordinal number
		descript (string)	Object description
		length (double)	Max length
		width (double)	Max width
		Ident_clas (int)	Identification class
		notes (string)	Possible additional comments

Source: GIS processing by G. Casagrande

After the data analysis conducted on the ortophoto, the following remarks are possible. A large quantity of anthropic objects was actually identified on the shores of Alpiniøya. In many cases, it was possible to recognize or at least to hypothesize some of their features (dimensions, functions, materials). Based on this, a classification of the objects was attempted. Most of them had a maximum size between 0.3 and 0.5 meters, with some exceptions (up to a few meters). In many cases, the shape (e.g. round, prismatic etc.) and/or the color when it could be associated with industrial standards (e.g. yellow, green, blue and red) suggested a possible identification of the objects as plastic debris; elements likely built in different materials were also visible.

For convenience, the objects deemed to be artificial were assigned, during the analysis, to one of three possible classes: 1. Probably classified; 2. Possibly classified. 3. Unclassified. In general, objects with minimum size of 0.5 meters or more were well recognizable; they were therefore assigned to class 1. Objects whose maximum size was between 0.2 - 0.5 meters were in many cases included in class 2, since the identification of their shape and of their integrity status proved somewhat difficult. Finally, objects whose maximum size did not exceed 0.2 meters were particularly difficult to identify,

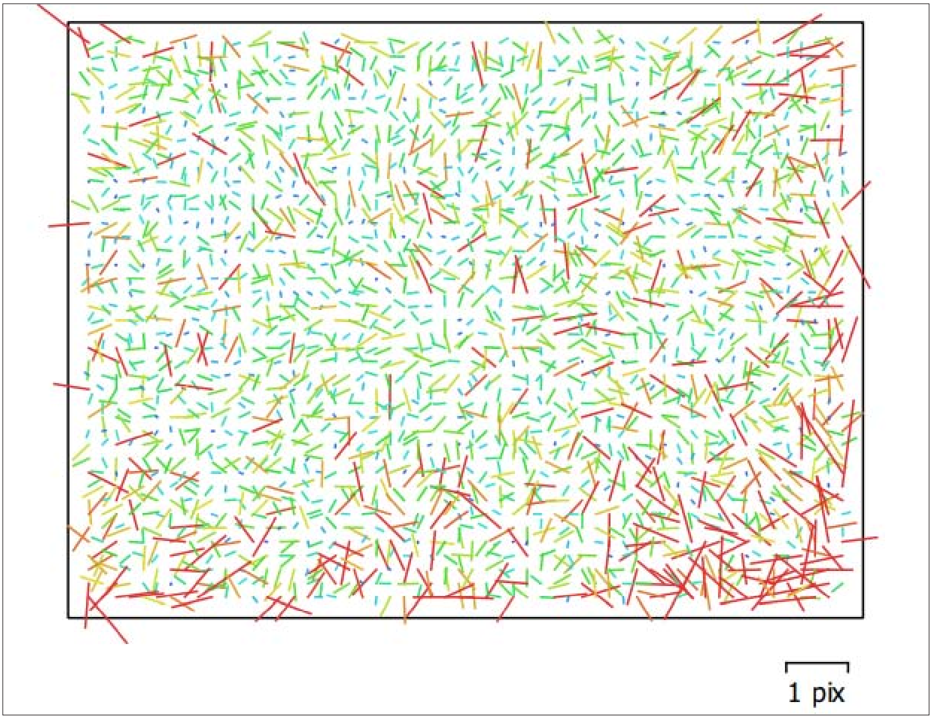


Fig. 121 – *Image residuals for photocamera FC6310 used during the expeditive survey. Image size: 4864 x 3648 pixel; focal length: 8.8 mm; pixel dimension: 2.61 x 2.61 µm*

Source: Agisoft (processing by G. Casagrande)

Tab. 16 – *Calibration coefficients and correlation matrix*

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
F	**3678.61**	0.76	1.00	0.20	-0.39	-0.06	0.11	-0.08	0.14	-0.14
Cx	**48.5664**	0.45		1.00	-0.07	0.03	-0.01	0.01	0.84	-0.07
Cy	**30.5305**	0.45			1.00	-0.08	0.03	-0.03	0.03	0.74
K1	**0.012596**	0.00038				1.00	-0.96	0.90	0.06	-0.07
K2	**-0.0360221**	0.0014					1.00	-0.98	-0.02	0.02
K3	**0.037455**	0.0016						1.00	0.02	-0.02
P1	**0.00355025**	3.6e-005							1.00	0.00
P2	**0.00145637**	3.2e-005								1.00

Source: Agisoft (processing by G. Casagrande)

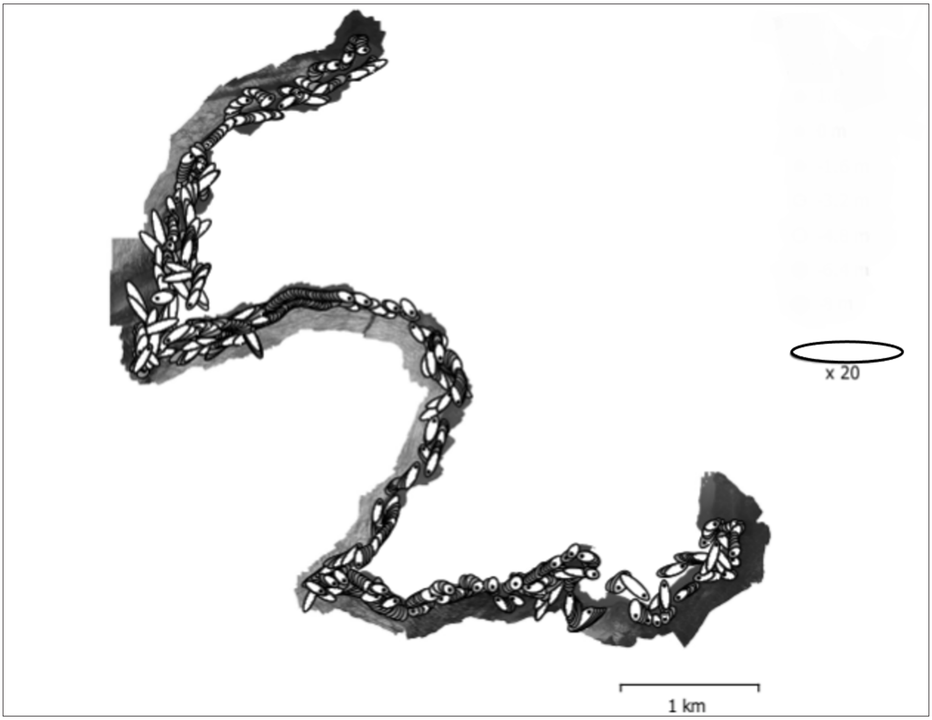


Fig. 122 – *Estimated camera positions (black dots) and evaluation of possible estimation errors. Combined errors in longitude and latitude (indicated as x and y respectively) are represented by the size of ellipses' axis (multiplied by 20 for better clarity) and orientation.*
Source: Agisoft (processing by G. Casagrande)

Tab. 17 – *Average error in estimated camera positioning*

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
3.8964	3.43743	1.64859	5.19595	5.45121

X – Longitude; Y – Latitude; Z – Altitude

Source: Agisoft (processing by G. Casagrande)

especially if their color had been similar to natural ones on the island (e.g. white, black, brown). Due to this difficulty, many objects which could have been included in class 3 were not identified at all and therefore they were not included in the GIS layer.

Figure 118 shows an example of screenshot from the GIS visualization, with indication of two identified objects. The two squares show object «container (38)» (a plastic, light blue container) as it was seen and pictured during the ground truth session (right) and in the ortophoto (left). When the nature of the object allowed to do so (for class 1 normally and for some cases in class 2), the very function of the object was hypothesized and entered in an appropriate field of the attribute table.

In many cases, observed materials were interpreted as debris from high-sea fishing activities (net fragments, fish boxes, small buoys or floaters); in other cases, the specific origin of objects appeared to be less obvious (tarpaulins, wooden structural fragments, fluid containers, bottles). In some cases, objects of probable artificial origin proved difficult to identify.

Fig. 118 – *Documentation of artificial debris. Top: georeferenced ortophoto with points marking the position of debris. Left: a plastic fluid container as visible in the enlarged ortophoto. Right: the same container as observed during the ground truth session*

Source: aerial images: M. Struik; ortophoto and ground image: G. Casagrande

Most classifiable objects in our survey were interpretable as derived from fishery activity, in this sense the outcome of the described observation is consistent with the conclusions presented by Falk-Andersson and Strietman (2019, p. 34).

Fig. 119 – *Examples of artificial objects mapped on the Alpiniøya ortophoto. Top: fish box; centre: fishing net; bottom: industrial pallet*

Source: aerial images: M. Struik; ortophoto and ground image: G. Casagrande

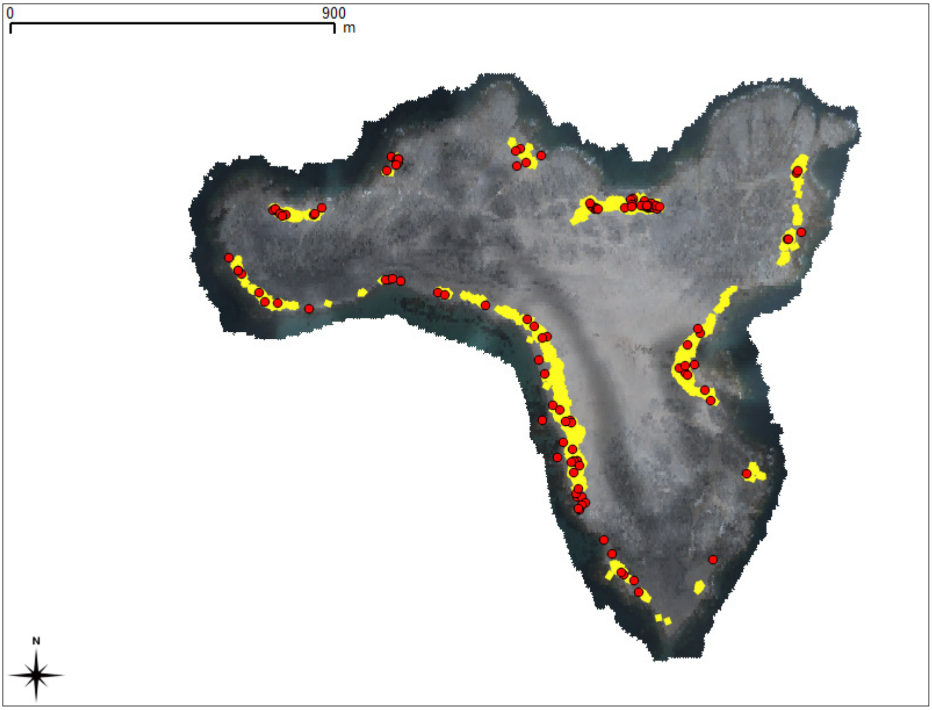


Fig. 120 – *Schematic map of probable artificial debris and driftwood accumulation areas*
Source: aerial images: Michael Struik; cartographic processing: G. Casagrande and E. Tondi

5.5 *Survey Test 2. Expeditive aerophotogrammetry of the Inglefieldbreen glacier front*

On August 19th, 2018, the expedition reached the front of the Inglefieldbreen whose centre is approximately in position Lat. 77°53'15.8"N, Long. 18°10'14.5"E. A decision was made to conduct an expeditive survey for monitoring purposes. Before Polarquest2018, communications were exchanged between the Expedition Leader and the VAGABOND French scientific workgroup. The peculiarity of the observation area is to develop along a relatively long front, the total chord of the glacier being about 5 km. The front has an M shape, oriented towards the north-east, a morphology which appears to be typical of the glacier since several years.

The VAGABOND workgroup had detected, in the previous years, a trend to a substantial retreat of the glacier front (Brossier, 2009, p. 16). Since a corresponding measurement of its status in summer 2018 was not possible for VAGABOND, that group had requested Polarques2018 to acquire information.

Given the total length of the glacier front, in the order of 10 kilometers, a decision was made to perform an expeditive aerophotogrammetry and also to acquire videos and qualitative oblique photographs, paying special attention to the calving area in the immediate vicinity of the terminal wall. A total of 4 flights was performed, for a 110 minute duration, at altitudes between 400 and 460 meters a.s.l. During this flight, images were collected in two ways: nadiral shots, in order to cover the top part of the glacier front, and oblique views of the front wall in order to obtain at least a very basic, approximate, shape of the calving area.

5.5.1 *Data from «image-based» processing report and related comments*

As in the other cases, a first «quick and dirty» processing of images was conducted by software Agisoft Photoscan onboard NANUQ immediately after the survey, for the usual coverage completeness check. A far more complex and accurate image processing took place in the lab after the expedition, by the use of two independent procedures, the first one by Agisoft Photoscan and the second one by Agisoft Metashape. A selection of 723 nadiral and oblique images of the glacier front was then processed.

Data extracted from the processing report are hereby presented.

Tab. 15 – *General survey data*

Number of images	**723**	**Camera positions**	**723**
Average survey height[64]	200 m	Tie Points	93,941
Ground resolution	5.17 cm/pixel	Projections	352,806
Total coverage area	4.68 km^2	Reprojection error	4.03 pixel

Source: Agisoft (processing by G. Casagrande)

Camera calibration data – as computed *ex post* by the software, are presented as follows:

(64) Above ground level from the boat deck.

The processing parameters can be listed as follows:

Tab. 18 – *Processing parameters*

General			
	Cameras		723
	Aligned cameras		723
	Coordinate system		WGS 84 (EPSG::4326)
	Rotation angles		Yaw, Pitch, Roll
Point Cloud			
	Points		93,941 of 117,183
	RMS reprojection error		0.138587 (4.02764 pix)
	Max reprojection error		0.429572 (80.945 pix)
	Mean key point size		26.7542 pix
	Point colors		3 bands, uint8
	Key points		No
	Average tie point multiplicity		4.22689
	Alignment parameters		
		Accuracy	Lowest
		Generic preselection	Yes
		Reference preselection	Yes
		Key point limit	40,000
		Tie point limit	4,000
		Adaptive camera model fitting	No
		Matching time	12 minutes 56 seconds
		Alignment time	6 minutes 40 seconds

Dense Point Cloud			
	Points		5,424,775
	Point colors		3 bands, uint8
	Depth maps generation parameters		
		Quality	Lowest
		Fitering mode	Aggressive
		Processing time	24 minutes 50 seconds
	Dense cloud generation parameters		
		Processing time	4 minutes 38 seconds
Model			
	Faces		117,801
	Vertices		62,388
	Vertex colors		3 bands, uint8
	Texture		18,000 x 18,000, 4 bands, uint8
	Depth maps generation parameters		
		Quality	Lowest
		Fitering mode	Aggressive
	Reconstruction parameters		
		Surface type	Arbitrary
		Source data	Dense cloud
		Interpolation	Enabled
		Processing time	6 minutes 16 seconds

	Texturing parameters		
		Mapping mode	Generic
		Blending mode	Mosaic
		Texture size	18,000
		Enable hole filling	Yes
		Enable ghosting filter	Yes
General			
		UV mapping time	31 seconds
		Blending time	52 minutes 26 seconds
Orthomosaic			
	Size		112,096 x 89,761
	Coordinate system		WGS 84 (EPSG::4326)
	Colors		3 bands, uint8
	Reconstruction parameters		
		Blending mode	Mosaic
		Surface	Mesh
		Enable hole filing	Yes
		Processing time	30 minutes 2 seconds
	Software version		1.5.5.9097
Software			
	Version		1.5.5 buid 9097
	Platform		Windows 64

Source: Agisoft (processing by M. S. De Angelis and G. Casagrande)

Since the glacier front had an overall extent of over 10 kilometers and the number of acquired images – associated with their respective GNSS metadata – was relatively high, both the relative and the absolute positioning errors were deemed acceptable for a reconstruction of the current status of the glacier front line. For the purposes of the required survey, the dimensional accuracy and the georeferencing quality of the orto-photo were considered to be reliable.

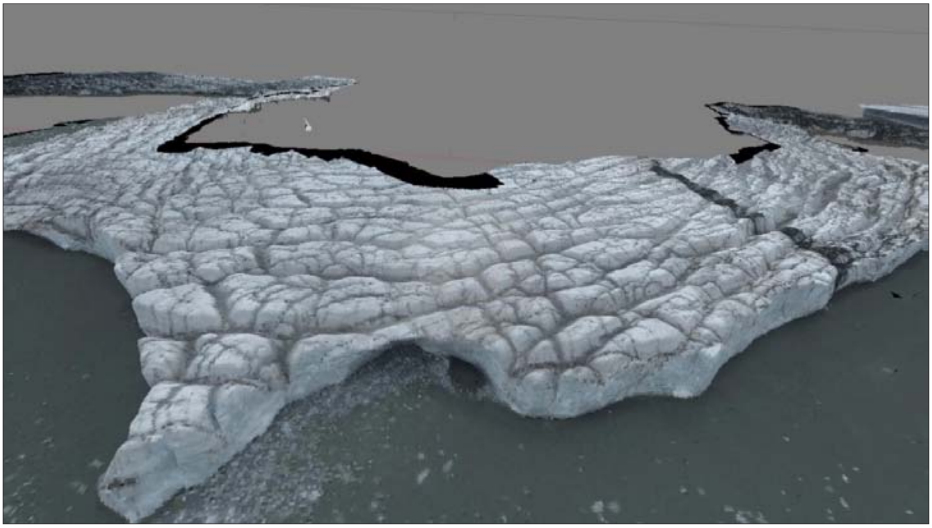


Fig. 123 – *A screenshot of the 3D «quick and dirty» expeditive model processed onboard NANUQ before leaving Inglefieldbreen*
Source: Agisoft (processing by G. Casagrande)

Fig. 124 – *Comparison of Inglefieldbreen front as found by the expedition on august 19th, 2018, overlaid on the image from Google Earth showing the glacier on June 29th, 2010*
Source: aerial images: M. Struik, processing G. Casagrande

5.5.2 *Conclusions on the Inglefieldbreen glacier front mapping test*

From the point of view of geographic and environmental observation, the acquired data can have some statistic relevance if associated with a series of periodical measurements, like those acquired by VAGABOND. Given the size of the object and the usable cartographical scale, the obtained ortophoto is easy to correlate with satellite or high-altitude aerial imagery. It is worth noting, however, that given the relatively low altitude at which the drone acquisition took place, the achieved level of detail is very high and it is easily possible to «zoom» into the ortophoto for observing relatively small objects; this suggests, once again, the advantage in performance which can be obtained by this kind of survey for some types of study or monitoring. The acquisition technique, furthermore, proved to be quite effective and relatively simple, suggesting the possibility of its use in association with more developed protocols and more complex, standard, and methodologically established techniques (Bühler et al., 2016; Immerzeel et al., 2017). On the other hand, it should be noted that the simple protocol followed during the Polarquest2018 expeditive survey might have yielded much higher precision data – though the obtained ones were already believed to be of sufficiently good quality – if it had been conducted by the use of – even similar – drone platforms fitted with a RTK GNSS system instead of the actually available non-differential GNSS.

6. *Polarquest2018's visit to Pyramiden*

Fig. 125 – *Left: Pyramiden's monument at the eastern entrance to the town. The «last coal cart» is at its foot. Right, top: an Arctic fox pictured at the back-side of Hotel Tyulpan; bottom: Lenin's bust in front of the Culture House*
Source: ph. by G. Casagrande

6.1 *A former ghost-town in the Arctic*

Pyramiden was founded in 1910 in Billefjorden. The settlement, created by a Swedish enterprise, was named after the mountain (937 m a.s.l.)[65] located immediately to its north, featuring a natural but characteristic «pyramid-like» top. In 1927 the property was acquired by Soviet company Russky Grumant, which later handed it over to Trust Arktikugol', which remains to this day as the owner of the area. Under its administration, the settlement developed remarkably.

During 1980 and 1990, Pyramiden reached its highest population, totalling about 1,000 inhabitants, mostly Ukrainian miners, and was conceived to be the «capital of

(65) *https://toposvalbard.npolar.no/.*

Russian Svalbard» (Koroleva, 2014, p. 194). Coal mines were located high in the flank of mount Pyramiden and were accessible through long rope-ways which climbed and descended to convey personnel and materials. A total of 9 million tons coal was extracted, and about 1 million was used to power the settlement itself.

During the ages of its operation, Pyramiden ended up being, similarly to Barentsburg, a major «show-room» of the Soviet approach to «civilization in the Arctic», i.e. an effective propaganda space. It maintained the typical structure of a standard Soviet-era industrial town, with a rational and fully planned urban structure, including classical landmarks of socialist settlements in the USSR.

The urban architecture called for separate functional areas, which are described based on the map in figure 126.

Fig. 126 – *Schematic map of Pyramiden. Thin dotted lines indicate sightseeing trails established to allow tourist flows around the town. By limiting circulation to those specific paths, it is possible to reduce wear-and-tear on fragile tundra vegetation thriving in summer amid the abandoned buildings*

Source: *Openstreetmap.org* (modified by G. Casagrande)

The town was developed along an east-west axis, from the harbour towards the inner centre with the Culture House at the western extremity. The settlement area is open and relatively flat, gently sloping uphill from south to north and from east to west; its northern boundary is the foot of the mountain, raising steeply northbound. The town centre is practically a rectangle with community and institutional buildings aligned on the sides of a boulevard. The latter consists in a large artificially created grass area – basically, a huge lawn[66] – in the centre, bordered by concrete-paved roads. Smaller paved roads and paths connect buildings to the main roads and some buildings with each other.

As the boulevard is panoramically sloping downhill from west to east, the northernmost Arctic monument to Lenin, located in front of the Culture House, appears to look over Pyramiden and, beyond the lower building roofs, towards Billefjorden and Nordenskjöldbreen.

The Culture House was conceived according to a typical Soviet concept of multifunctional complex. It included social spaces, a multi-purpose gym, music equipment, a library with 50,000 books, a cinema/theatre with a collection of 1,000 films. The latter facility has been reactivated in recent years and can be used. In general, however, when presented during guided tours, power supply to the entire building remains disconnected and flashlights might be necessary to grasp details in the less illuminated spaces.

Immediately north of the Culture House, in the Gagarin Sports Complex (Kinossian, 2020, p. 92) there was a unique public swimming pool, once filled with warm sea water; an actual marvel in its genre and the northernmost facility of the type in the world.

At the centre of the boulevard a monumental sign, painted on a metal structure, celebrated Pyramiden with a minor poetical license in rounding its latitude to a solemn 79°N (it is actually 78°39'N).

On the southern side of the boulevard there was the centralized mass, providing restaurant services to the entire town community. The building is no longer in use; it is practically composed of two sections, a northern one, with social spaces and a large dining room at the first floor, large windows on three sides and a large mural on the fourth wall. Service rooms and a large industrial kitchen were installed in the southern section; equipment and furniture are still in place.

Immediately south from the town centre are multi-story buildings which used to house Arktikugol' employees; a part of the same block, to the east, is Hotel Tyulpan.

In a more southern position, detached from the centre, stand the abandoned farming buildings. Pyramiden and Barentsburg had special greenhouses for producing vegetables and flowers and heated stables for raising domestic animals such as pigs, cows and chickens (Koroleva, 2014, p. 195). The idea was to provide the mining community with fresh vegetables, meat and milk.

> «Pyramiden was built as an exemplar Soviet town. Splendid Palace of Culture. Good library. Modern hospital. Sport hall. Swimming pool. School. Kindergarten. Museum. Pyramiden looks like it was built forever, or at least, to last until the Victory of Socialism, not for the purpose of temporarily accomodating people who, over the course of several decades, will empty one mineral deposit field and will move on to empty the next one» [Kinossian, 2020, p. 91].

(66) Soil for the lawn was transferred to Pyramiden from southern European Russia Ukraine in 1983, see: Kinossian (2020, p. 92); Krajcarová et al. (2016, p. 2).

On the opposite side of the town, i.e. at its northern margin, there is a group of technical buildings. As it was previously mentioned, coal mines were relatively high in the flanks of the mountain; personnel and materials transport up and down the mines were ensured via funicular railways. This service system was located on a small relief marking the northern boundary of the settlement and funicular railway lines departed straight northbound. They climbed the side of the mountain up to the upper station at mine entrance at about 400 m a.s.l. A narrow-gauge railway was supposed to connect the lower station to the harbour.

To the east of the mine's lower station, immediately south of the railway, buildings were in place to ensure technical services to the various infrastructures. As most of mining activity in Svalbard was marginally profitable and required state subsides, Pyramiden suffered obvious loss of resources when the Soviet Union collapsed. Although activities were taken over by Russian government, mining was considered increasingly difficult to support. Pyramiden was gradually abandoned. By 1994, total population was down to about 300 people, most of women and children had been transferred to Barentsburg.

Pyramiden operated as the northernmost Russian mining settlement in Svalbard until 1998, when coal extraction was stopped and the population was transferred by ship back to homeland. The site remained virtually a ghost town until 2007. During that period, it was rarely visited by excursionists and sometimes by other Svalbard inhabitants in search for pieces of furniture, equipment or other materials which had been left in the closed buildings. Beginning from 2010-2011, a permanent surveillance was re-established, while maintenance interventions and restorations were conducted in order to upgrade the town facilities for tourist purposes (Koroleva, 2014, p. 193). The Tyulpan hotel was re-opened. Initially, a provisional housing facility had been made available in the harbour, close to the quay, by adapting shipping-containers to host visitors; most present-day incomers, however, are now accommodated in the hotel.

The Tyulpan was the only fully operational and continuously, year-round accessible building on the site in 2018, and was also the main service providing facility. In order for the town to be able to welcome tourists, some infrastructures were re-established through ex-novo work, i.e. a power plant. A shuttle bus service was established to connect the town area with the harbour quay. When tourist boats moor upon their arrival, mostly from Longyearbyen, passengers are handed over to the Russian guides and transferred to Pyramiden's centre.

Fig. 127 – *Buildings in Pyramiden: a) Culture House; b) Gagarin Sports Complex; c-d) personnel quarters; e) Hotel Tyulpan with a tourist shuttle bus in the foreground; f) stable; g) central dining hall; h) swings in a children's playground*

Source: ph. by G. Casagrande

6.2 *Remarks from the Polarquest2018's visit and observations on the site*

The visit by Polarquest2018 to Pyramiden allowed the workgroup to take notice of various facts about cultural heritage and industrial archaeology in the area. As it is common for many historical settlements in the world, general safety measures and protection for visitors and heritage are not homogeneous: in fact, they depend on the status and functions of each location. Hotel Tyulpan appeared obviously to be in perfect efficiency as hub for guided tours and free-travelling visitors. A vivid description of Pyramiden's peculiar community in the summer of 2018 was provided by art photographer Valentina Tamborra:

> «A cook for 11 persons. In the old Pyramiden's hotel 9 people live, all on the second floor. Only the governor and his wife have a private residence, that is, the electric power plant. If any tourist would ever decide to stay overnight, they would be hosted on the fourth floor […]. Petr Petrovich[67] drives the tourists [on the shuttle bus]. Petr is the governor. He does not speak Norwegian, nor English. 11 years in Pyramiden, 11 years in which he never left Ukraine» [Tamborra, 2019, pp. 17 and 25].

The areas and buildings in the town centre which are normally subject to visit, e.g. the Culture House, or the common mass, retain much of their historic furniture, accessories and equipment. Many other buildings are closed and can be visited by requesting permission, but appear to be in overall good preservation state.

Although under guardian's care, much of the city did not appear to be under a massive restoration process. That would not be necessary, at least in 2018, for conservation purposes, and would probably be inappropriate in terms of tourist marketing; virtually all the buildings appeared, at least at first sight, in good structural conditions and virtually intact in all of their main elements. Just like Barentsburg, Pyramiden gives an evident example of an alternative approach to reification – the Soviet one – in comparison to the one typically visible in Longyearbyen, that is, the Norwegian approach. Both systems dealt – historically – with the local conditions and they did so by adopting necessarily common solutions: both «Norwegian» and «Russian» engineering, for instance, is forced to avoid the problems of building on permafrost by basically putting inhabited spaces on poles, columns or pillars to keep the buildings separate from the ground. In the space between the ground and the base of the buildings, and between buildings sharing services, pipes and wirings are suspended, ducted and/or variously insulated to prevent weathering and heat exchange. Both systems would carefully manage choices in terms of building, insulation etc. Both take advantage of the natural cold outdoor environment for achieving cooling when needed, e.g. for obtaining refrigeration, and

(67) Pyotr Petrovich – as of 2018 – works as chief technician supervising services in Pyramiden.

carefully take into account elements such as landforms and aspect. Other than this general criteria, technical solutions appear to be rather differentiated.

Norwegian reification seemed historically to prefer relatively small, low buildings and houses; dominant material for construction in Svalbard, for Scandinavian communities, was timber. These traditional choices reflected intentional and necessary adaptation of those communities to the need of dealing with a very harsh environment, while at the same time having to do so with the less possible expense in terms of resources and work. Furthermore, they would also take into account the need of a light-weight approach in order to reduce unnecessary disruption of the environment where the settlement was established. The latter concept was certainly rooted in an ancestral respect towards nature, but also in the pragmatic awareness that a too invasive human presence might have caused drawbacks on the life of the settlement itself. The Soviet approach, on the other hand, was actually trying – and claiming - to establish human presence at the humans' conditions in a geographical area which had been considered as anecumenical for centuries. This had certainly some degree of ideological content as well: Socialism, work and science would have overcome century-old limitations and allowed to humanize a place which would be inherently not suitable for human presence and activity (Kinossian, 2020, p. 91). This strategy, just like the Soviet rationally planned organization of spaces and services, and just like the soil and grass transferred from the far-away homeland to pave Pyramiden's public spaces was a geo-philosophical statement as much as it was a geopolitical demonstration of efficiency and power.

Operational efficacy, inherent robustness and technical power mark clearly the approach of Soviet reification: large, armoured concrete multi-story buildings, often featuring flat roofs, designed and built to stand heavy snow accumulation rather than progressively discharging it like Norwegian sloping roofs; centralized heating was generated and abundantly distributed where needed.

More than assisting their inhabitants in their environment-induced adaptation to the Arctic, the Soviet settlements appeared to have been built with the intention of showing that it was possible to work-around the environmental givens, in order to provide citizens with the way of life ideally advertised in the homeland.

Tour guides seen at work by the Polarquest2018 group – employees of the Arctic Travel Company Grumant, a subsidiary of Arktikugol' (*ibidem*, p. 92) – showed high professionalism and caution in making sure that both their clients and casual visitors in the area respected adequately the objects in the town, the tundra vegetation and the wild animals which moved rather freely throughout the area. Among the spotted wildlife, a remarkable number of Arctic foxes, apparently well adapted to the setting and probably, *de facto*, semi-domesticated. As specified in the expedition chronography, Pyramiden is still considered to be an area of wilderness – not a permanent settlement – and therefore requires self-defence equipment and measures to be in place at all times. Tourists under guide service are accompanied by armed escort, free travellers and visitors are obviously required to keep their weapons ready even when vising the town. Polar bears do enter in the old area from time to time.

When visited by Polarquest2018, some zones of the harbour and the whole area of the technical buildings appeared to be far less under conservation control. Between the formerly inhabited site and the harbour, it is possible to observe apparent traces of pollutant residues. In the technical buildings, the spaces observed by the workgroup appeared to be littered with wreckage of materials and machinery, debris of furniture, common use objects (empty bottles, documents, papers) in a fairly advanced state of decay. Nevertheless, when the workgroup visited some spaces, a few elements suggested that those places were indeed subject to visit, as the position of some objects appeared to be intentionally and – so to speak – «scenographically» altered.

The Polarquest2018 workgroup reached the narrow-gauge railway station at the foot of the two long wooden tunnels which climbed the mountain towards the mining entrance. The eastern one appeared to be practically complete of equipment and intact in its structure, although in an advanced state of decay. The parallel tunnel appeared to be in similar conditions, for what was possible to observe from the outside.

The eastern funicular railway was littered with debris of degraded insulation and suggested the presence of contaminants, including, possibly, asbestos. At the top of the tunnels, the station and its structures appeared scattered with wrecked equipment and showed signs of widespread contamination.

Some comments can be outlined at this point, based on the observations made during the brief visit of the expedition group on August 22nd-23rd, 2018.

After being virtually a ghost-town from its closure in 1998 until 2007, Pyramiden is no longer so, but is quite effectively evolving to the status of a museum-town bearing both the value of a tourist attraction and a symbolical one as a paradigmatic historical landmark demonstrating the Soviet worldview towards territorialization in that region. It does retain, in a certain degree, an emotional impact as a memorial of a geographic object and a geocultural experience, even though this particular feature could possibly change in the future, as tourism in the Arctic increases and the town becomes more and more equipped to welcome it. When Polarquest2018 visited the site, an evident disparity was found between places which were already suitable for tourist access (particularly the town centre and southern area), places in evident degraded conditions (harbour infrastructures and technical buildings) and places which were in a highly contaminated and potentially hazardous material status.

This has no immediate impact on the safety of tourist access – especially as far as guided tours are concerned – and Pyramiden is not different, in this sense, from any other abandoned mining settlement in Svalbard. In comparison to these, however, Pyramiden currently appears to have far greater potential as tourist attraction and, most probably, a much higher documentary value.

It should be noted that after about twenty years of almost complete abandonment, Pyramiden is now increasingly looked after and taken care of; vandalism and removal of artifacts would be sanctioned; some restoration and place-keeping actions are being undertaken; an objectively positive convergence of intent can be recognised – in this case – between Arktikugol', Russian and Ukrainian keepers, and the Norwegian authorities who granted protection to the town and its heritage.

As of 2016-2018, i.e. during the author's two visits to the place, there were many signs of the managers' intention to keep Pyramiden in general, and particularly its most symbolical buildings, in their quite fascinating status of time capsules, somewhat frozen in time due to their sudden abandonment. This included the scenographic «last coal cart» parked in front of the Soviet-era city gate and, more importantly, the fully furnished and equipped buildings showing the signs of a sudden death as the whole population was rapidly transferred away. This status has itself – in the author's opinion – an objective geo-historical sense and deserves to be presented: in fact, it is a major part of the town's *genius loci* as a Soviet-era memorial and reflects an element of reality, even though it appears to be emphasized, sometimes, by a certain touch of rhetoric. After all, this is a shared expectation for the increasing number of tourists. The «symbolical rationale» of Pyramiden is effectively described by Kinossian (2020, p. 90):

> «Engagement with the haunted landscape of an abandoned town generates fascination and amusement that visitor (consciously or unconsciously) seek to experience. Such engagement involves various senses, including vision, audition and olfaction. Haunted landscapes fail to represent or communicate a message, except for disconnected, fragmented signals that the observer has difficulty reading. Consequently, imagination kicks in, thereby opening the landscape for interpretation. […] People who visit abandoned or haunted places contemplate what the lives of the former residents might have been like. […] This involves reflection on the possible behaviour of an individual put in similar conditions or facing similar existential choices».

It is out of question, however, that in some cases the «charm of the haunted place» might be more appropriate to ghosts than it is to people, and if Pyramiden has to consolidate its value as cultural heritage in the future, this will be hampered unless pending infrastructural and environmental issues are properly addressed.

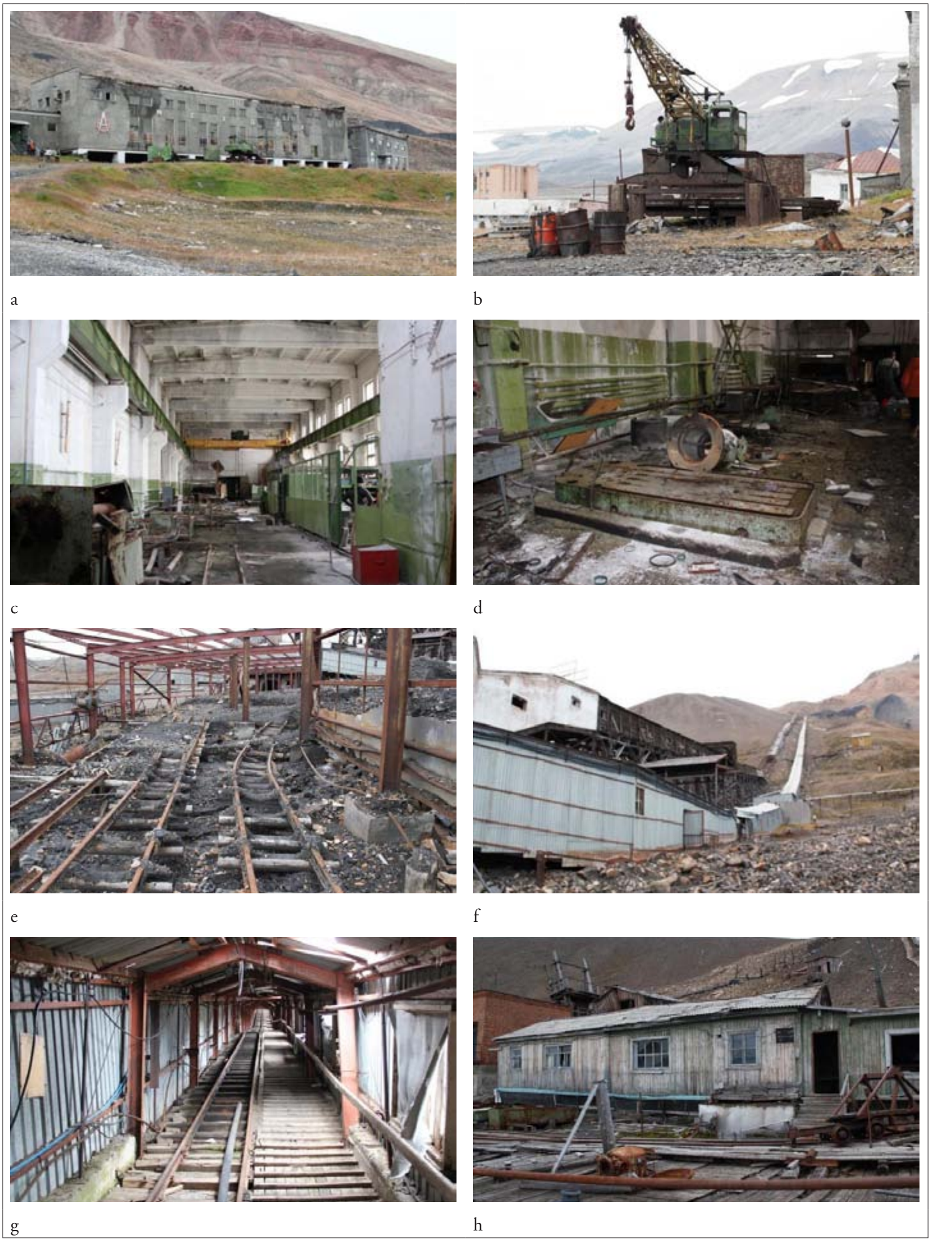


Fig. 128 – *Pyramiden: a) the mechanical workshop building; b) abandoned bulldozer; c-d) inner views of the mechanical workshop; e) narrow gauge railway station; f) view of the funicular railway from the station; g) eastern tunnel; h) the area of the mine's infirmary at the top of the funicular railway*

Source: ph. by G. Casagrande

Fig. 129 – *Two spaces inside the «*МЕХ ЦЕХ*» building. «Casual» food and beverage in a technical space and documents scattered on a desk in the office are good material for art photography and story-telling*
Source: ph. by G. Casagrande

Significant portions of the town's northern area are in serious decay and cannot be safely accessed. More importantly, they can be counted as cases of industry-related pollution and hazards, bearing a potential risk to the environment itself and to visitors, especially those not involved in guided tours. An appropriate clean-up of the area and safety measures in all historical buildings appear to be necessary and may become urgent if tourism is to see major increases in the near future. It is worth noting that Pyramiden – in this being one of many possible instances, in Svalbard and beyond – is also an interesting example of complex habitat for vegetation and wildlife, born from the interaction between natural and artificial systems in the area (Koroleva, 2014, p. 210)[68].

In principle, an overall «recovery work» for the former mining town might affect, in the medium term, its strong historical «echo», i.e. the powerful feeling of Pyramiden being a sort of Arctic «Pompeii». Nevertheless, if properly managed from a material point of view, and as long as narration will not prevail on historical accuracy, Pyramiden's nature as a place remains an adamant and charming example of an historical approach and a worldview about territorialization in the socialist utopia (Gasparini,

(68) This author indicates that different environmental zones can be distinguished in the area: «1. Zone of natural Arctic tundra which contains a complex of typical habitat types of Arctic tundra with its species diversity and structure of plant cover […] 2. Zone of naturally disturbed habitats, which experience devastating effects of running water from glacier melt. 3) Zone of anthropogenically disturbed landscapes with no rare habitat types, but gradually recovering vegetation cover». In the latter some habitats are valuable, i.e. «anthropogenic Poa alpigena dominated grasslands of historical and recreational value, and the complex colony and ornithogenic meadows on the border of the town, as prospective areas for bird watching». Large colonies of birds, particularly kittiwakes (*genus rissa*), developed, in time, of some historical buildings, particularly one close to the Tyulpan hotel at the eastern boundary of the central *boulevard* and some structures at the bottom of the mining rope-ways. In the latter case, the presence of soil under the structures invaded by birds allowed the development of a thriving nitrophytic meadow.

2019). Compared with many other examples of Arctic cultural heritage, additionally, Pyramiden seems to be physically far more robust and easier to maintain: this will certainly play a role towards its preservation, making it possible for the town to effectively live on through time, and teach important lessons to future generations.

Fig. 130 – *The whole town of Pyramiden viewed from the mine entrance*
Source: ph. by G. Casagrande

7. «Story-telling» about places and the expedition: The role of communication and outreach activities

Fig. 131 – *Polarquest2018 original mission emblem*
Source: image by M. Struik

The official Polarquest2018 emblem was designed by Kai Struik in early 2018. The «mission patch» is, traditionally the synthesis of any scientific expedition. In this case, the Svalbard archipelago appears to be at the centre. Airship ITALIA is shown at the top-left, pointing to a red «X» north-east of the islands, i.e. its crash point. A drone is visible at the top right, indicating project AURORA's geographical mapping mission, in some way parallel to the airship exploration. On the left side of the logo, three evident plastic bottles point to the pollution theme inherent to the Microplastics research program. On the opposite side, a beam of cosmic rays falls towards a small NANUQ depicted in a red-ring, symbolizing her circumnavigation of Svalbard.

Story-telling was an essential component of Polarquest2018, from its initial development, throughout the expedition and up to the presentation of the final results.

In an interview with the author on July 13th, 2020, Paola Catapano summarized the overall communication and story-telling strategy followed before, during and after the expedition.

> «Scientific research and communication […] cannot be separated; they are really the soul and the essence of the whole Polarquest2018 project. One cannot go without the other. The expedition could not exist without the scientific partners, but communications and outreach were an essential tool to share the knowledge, and get the expedition funded. […] Communication and story-telling, in this case, are the same thing. Some of the partners we were looking for to pay the expenses of the expedition were not knowledgeable in science. We targeted the general public through a crowd-funding platform, that was mainly addressed to American citizens and philanthropists; ours was the only project with science in it, […] but we played the key element of environmentalism […] focussing on our microplastics research in particular. But we had to translate the scientific priorities into a language that was telling something to people. […] Story-telling, there, was a crucial tool. Without triggering their feelings and their emotions we could not trigger them to provide funding, and in triggering the emotions of somebody who is not a scientist to fund an essentially scientific project it was necessary to tell them about polar bears, thinning ice and the people onboard. The whole [expedition's] Website is story-telling, and the documentary we produced after the expedition was welcomed as a real movie. There were kids that, when the documentary was shown, asked: "are those real people, or actors? Is this story a real story?" […] All the communication tools were conceived this way. And for us the best story was the story of the explorers of the past, and in particular Umberto Nobile, a story with a fantastic plot for a movie […]. We used this as well, and said: "we want to follow the tracks of this incredible airship and of these incredible explorers of the past. […] When we were setting the communication strategy, the communication plan and contents for each tool, it took some time before we decided that microplastics were going to be the 'battle horse" of the [American] crowd-funding website; but when we were addressing Italian partners, both scientific, cultural or just commercial sponsors in Italy, we would use the story of Nobile. When we would address Italian media we would use that as a central part of our story-telling, and to 'seduce' the physicists, we would use some elements of the story of Nobile, in particular the scientists he had onboard his airship who were measuring Earth magnetism and cosmic radiation as well. We were taking the very complex entity of the project, dividing it into threads and using, as main thread, one of the elements, depending on whom we were talking to. For the cosmic ray part, it was important for scientists to know that nobody had reached the latitude that we would have reached in measuring cosmic radiation. For the environmentalists, it was more the story […] of the North Pole [ice pack] disappearing, polar bears being threatened. For school and kids, it was both the plastic discourse and the environmental discourse […]. This kind of story-telling was really one of the convincing arguments to get people to believe in us, to fund us, to take us onboard with them, to give us tools […]. Using these stories was crucial, and we used them according to the strategic objective and according to the cultural background of our counterpart. We

> were absolutely not sure that we would be able to reach any of the objectives that we were setting for our itinerary in Svalbard. There was no guarantee that we would have reached anything beyond the 79th parallel, there was no guarantee that we would reach the SOS point […]. It was completely uncertain that we would have circumnavigated the Svalbard archipelago, so improvisation in the communications context was our daily challenge. We were saying: "we'll try to do this, but the Arctic, like in the past, is full of unknowns". And actually, we were playing on the unknowns, to create some suspense».

A full description and analysis of the project's communication (as well as «communications») and story-telling would be out of the scope of this work. It should be underlined, however, that much of the activities in these fields before, during and after the expedition involved story-telling of places, environments, exploration and human experience. In this sense, the expedition's communication was more or less relevant from a geographical point of view. This chapter intends to mostly comment on these aspects.

Geography is, by tradition, an interdisciplinary subject; it integrates data, methods, approaches spanning from earth-science to humanities and social science. Although this complexity may be hard to fully manage, it is a fact that most geographical activities through the centuries – including polar exploration – involved technical, quantitative and objective materials, along with human experience and subjective perception. The latter aspect proved often crucial in making it possible to share the exploration and its data with the very explorer's community. The great journeys of the past had the typical result of conveying back to homeland some information, knowledge and impressions of he newly «discovered» lands – impressions that were quite often biased by the story-teller's cultural identity. Yet, this «mediative» role of the traveller as «witness of the other place» is still alive today, even if the great age of discovery as it was understood in the past is obviously over. The human sense of visiting the unknown, and the desire of telling tales about that, lives on today in «adventures», conceived as personal stories.

By conveying the experience of a journey, be it for science, sport or tourism, subjective accounts are a most powerful way through which knowledge of remote places is shared with those who did not travel. The channel is often activated by emotion: facts and events are described so as to involve the audience's participation. Once the link is established, the story-teller's priorities and most relevant information are conveyed.

The core communication concepts for the expedition could be, quite broadly, summarized in the following points:

a) Polarquest2018 was in historical continuity with ITALIA's expedition and was responding to three main aspirations by the 1928 crew's descendants. First, to commemorate their ancestors in the 90th anniversary of the events. Second, to institutionally gather in a memorial reunion and – third – to ceremonially visit some crucial places of the historic ITALIA's expedition.
b) Polarquest2018 was conducting a record-breaking physics experiment by measuring cosmic-rays through an innovative detector at the highest latitude ever reached for such type of activity;

c) Polarquest2018 was to document and spread awareness about urgent Arctic environmental issues, such as deglaciation, temperature increase/macro and micro-plastic presence/distribution in the area. In this case, too, acquired data were original and innovative.
d) Polarquest2018 was to conduct high-detail expeditive mapping of some locations in the Svalbard's region.

The order in which the points are mentioned above does not refer to any priority; furthermore, not all these points or «connection triggers» were used at the same time. Rather, they were all paratactically presented through the main communication channels of the expedition and one or some were specifically highlighted according to need (sponsorship, public event, mass-media events etc.). Given the self-supported nature of the expedition, crowd-funding campaigns and contacts with sponsors were continuous before, during and after the expedition; each initiative was appropriately «calibrated» to the specific target in terms of contents and purpose.

In general, before, during and after the journey, Polarquest2018 dedicated several of its human resources to managing different communication channels, to make sure that the expedition's activity could be relayed in real-time (or quasi-real time) to the widest possible audience in the most effective manner.

Before and after the expedition, Project leader Catapano was invited to several TV programmes in Italy, France and Switzerland and organized – or was invited to participate in – public events in all three countries, either alone or with additional speakers (crew-members, land-scientists or ITALIA's descendants) whose role was to present topics of interest in the specific context. Some events were directly attended by other crew-members or members of the workgroup.

Polarquest2018 developed, in the early preparation phases since November 2017, a website and social networks accounts (particularly *Twitter* and *Facebook*) to relay information. It should be noted that specific arrangements had to be made to ensure that these communication channels could operate effectively in the most crucial phases of the expedition, particularly when it was necessary to relay information from the boat – in remote areas – to the land group. In fact, several long phases of the boat's journey took place out of any mobile phone/data network coverage. In those phases, NANUQ could only communicate by radio with other vessels and land stations, and via Iridium satellite connection with other addressees. The standard Iridium service provided relatively modest bandwidth: it was only possible to communicate by SMS on cell-phones and via email, although connection was so slow that it could only conveniently be used for sending text emails, possibly with very few, low-resolution, images attached. An extra service, as per contract, allotted sufficient bandwidth for a few minutes of live video connection every day. This was supposed to be reserved for brief connections with TV broadcasts following the expedition daily. Furthermore, 2 hours in total of live voice connection were reserved for similar purposes.

Bandwidth availability problems did not obviously affect the information flow anytime the boat was in reach of standard cell-phone lines and wi-fi stations. At those times, bursts of audio/visual materials were sent for publication on the website and socials or to serve as archive material for future posts. Before departure from Iceland, a thorough video-documentation had been prepared by Italian Addictive Ideas TV production, through a crew deployed at Ísafjörður harbour. During leg 13 (Iceland-Greenland-Svalbard), communication onboard was shared by MANTANET operator Safiria Buono (text dispatches) and Michael Struik (information updates, photographs and video footage). A second photographer/videographer onboard was Kai Struik. During leg 14 (Svalbard's circumnavigation), Kai Struik was replaced by Alwin Courcy embarked to provide services for the planned documentaries. Michael Struik maintained his functions as photographer and drone video-operator. Struik, an engineer and multimedia expert at CERN, was well experience in piloting drones so as to obtain descriptive and spectacular footage. His work was important both for scientific and communication activities. Struik used the usual Phantom 4 Pro drone with a 4K video capability, and a DJI Mavic Air, equally effective camera platforms. The Mavic, apparently, proved more reliable than the Phantom in terms of control system stability in spite of its shorter endurance.

Project Leader Paola Catapano boarded in Longyearbyen on August 1th, and could directly manage communications, sharing press releases on achievements and a daily blog, assisted by Buono and – for the first few days – by a communication staff temporarily present at Longyearbyen and Ny-Ålesund. During leg 14, NANUQ was in reach of high-bandwidth wireless communication services only during her stay in Longyearbyen and shortly after departure. When in Ny-Ålesund, wireless communications were forbidden to avoid electromagnetic interference to the scientific stations. However, activity was handled with no major disruption through the Italian CNR base's wired ethernet network. After departure from Kings Bay, NANUQ was on radio and Iridium only during the entire circumnavigation, up to her arrival back to Isfjorden. There, high-bandwidth wireless connection was available again for the brief trip to Pyramiden and return. With much of the expedition's core work to be covered in the Iridium-only area, Catapano chose to limit transmission of images to occasional low resolution frames attached to e.mails. Rather, a continuous feed of text dispatches was posted on Twitter and Facebook. At the same time, the main expedition website was kept updated by the communication staff in France and Switzerland. When meaningful archival multimedia materials were available, they were used to integrate information coming from the boat. Much of this material had been produced by Catapano and Struik during a brief pre-expedition visit to Svalbard in April 2018. Other materials were prepared by the communication staff during their brief stay in Longyearbyen and Ny-Ålesund.

An intense communication work took place in the days between the expedition's arrival to Longyearbyen (August 24th) and departure for repatriation (August 27th), when Catapano was obviously very busy in relaying data, imagery and information, as well as in coordinating activities by her staff abroad.

After this brief synthesis of technical aspects, it is worth summarizing and commenting about the story-telling contents of the project's communication. It should be once again underlined that the following analysis will not be comprehensive of all aspects, but only cover the geographically relevant ones: first, how the expedition's «spaces», «places» and «actions» are described; second, how geographically relevant phenomena or messages are conveyed.

A list of topics is presented and each one is discussed.

7.1 *Website and social networks*

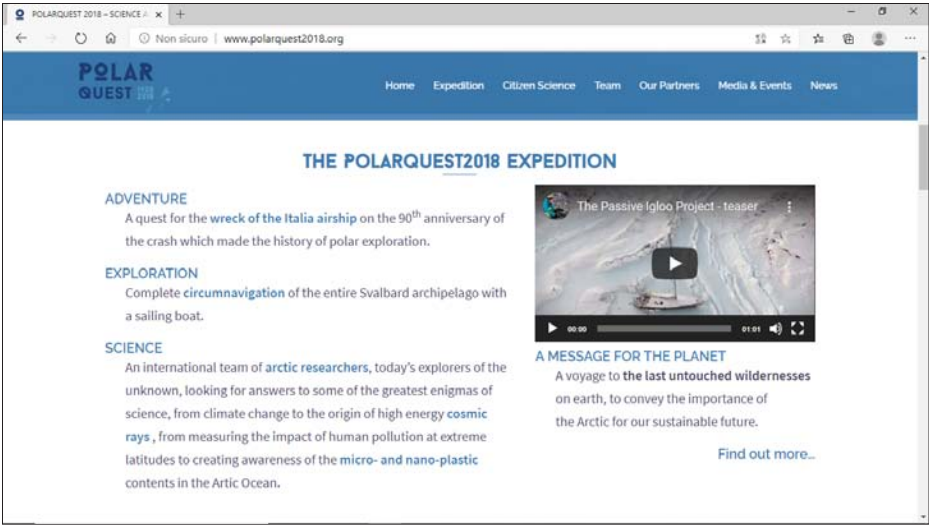


Fig. 132 – *A screenshot from a Polarquest2018 website page*

Source: *www.Polarquest2018.org*

The expedition's website (*www.Polarquest2018.org*) was developed so as to collect news, information and references. Contents on the main pages were presented in a comprehensive manner, with relatively wide descriptions. The website was continuously edited and materials added, even though the general structure of the site tree and the overall content architecture did not change significantly. The following comments refer to the Website in its August 2020 development.

For a wider outreach, the expedition opened also accounts on *Facebook* and *Twitter* (*@Polarquest2018*), to publish more compact information.

The purpose of the aforementioned platforms was to present both the communication side of the expedition, and the scientific part of it as well, with a prevalence of the former, in terms of tone and contents. The main categories presented on the site were: First, «Home», a sort of essential «abstract» of the workgroup activities. Second: «Expedition», pointing to four subcategories: «Aboard NANUQ», «Expedition Logbook», «Timeline» and «Meet the ITALIA descendants». The third category, labelled «Science on Board» in 2018, was later changed to «Citizen Science», with subcategories «Cosmic Rays», «Microplastics», «Chemical Pollutants», «Polar Drones». It is worth noting that the change in title did not occur during the expedition or in its aftermath, but was done in 2020. At this time, the Association is turning its mission towards citizen science as a vocational trait and will progressively include it in future activities. It should be remarked, however, that none of the 2018 research activities could be fully described as «citizen science», as they saw a direct and prevailing involvement of scientific institutions, laboratories, academics, technical staff. Nevertheless, the general project was directed by Paola Catapano, not personally a scientist but rather a communication professional, and it did use technologies or methods compatible with those of citizen science. A fourth category on the Website, «Team», grouped participants in the project as «project leaders», «NANUQ's crew», «Onboard: Scientists», «Onboard: Communication experts», «Onland: Scientists», «Onland: Communication and support team». Fifth category was «Partners», divided into «Scientific Partners», «Gold Sponsors», «Technical Sponsors», «Ship's store Sponsors». A sixth category, «Media & Events», listed links to press clippings, video-recordings of TV interviews and web information. A seventh and final category included «News» with articles describing events and a blog related to the Expedition since November 9th, 2017. This section is being updated as of this writing with news regarding the expedition results, documentaries, awards etc.

News about Polarquest2018 as it was unfolding were published on the Website at the page «expedition logbook», beginning records on July 22nd and ending in September 4th. Contents were loosely arranged in thematic categories. The following topics are presented: July 22nd «NANUQ departs from Iceland» (brief news + video). July 23rd «Crossing the Polar Circle» (brief news and low-res picture). July 23rd «Encountering the first iceberg» (brief news and low-res picture + screenshot of Struik's Iridium positional data). July 24th «Towards the 69th Parallel» (brief news + map). July 24th «NANUQ arrives at Illoqortormiut» (brief news + web photo)[69]. July 25th «NANUQ departs from Greenland» (longer news + low-res image gallery). July 26th «Reaching the 72nd parallel North» (brief news about plastic sampling activities + photos). July 27th «Dispatch from NANUQ: Last sunset» (brief news + dispatch + image). July 30th «Land – At Last» (Brief news + low-res image). July 30th «Dispatch from NANUQ: Arctic Pollution» (brief news + image + dispatch). August 1st «NANUQ arrives in Longyearbyen» (brief news + image + press release). August 2nd «Dispatch from NANUQ: "We felt a big shock under the boat"» (brief news + image + dispatch). August 4th «Next stop: Ny-Ålesund» (brief news + tweet including video). August 5th «Arrival in Ny-Ålesund» (brief news + tweet). August 6th «Dispatch from NANUQ: (Mis)Adventures in Svalbard», formerly «Of Belugas and Daggerboards» (longer news + images + dispatch). August 6th, «The Arctic Adventure Begins!» (brief news + image). August 8th, «Dispatch from NANUQ: On the Heels of a Polar Bear» (brief news + tweet + dispatch). August 8th, «Dispatch from NANUQ: Unsustainable tourism» (brief news + image + dispatch). August 10th, «NANUQ reaches 80°!» (brief news + screenshot of Iridium map). August 11th, «Found! Signs of the "Albertini Group"» (longer news + image + dispatch)[70]. August 13th «Crew says prayer for airship ITALIA» (longer news + tweet + article). August 13th «Northernmost microplastics measurement taken!» (brief news + photo + dispatch). August 14th «Following the red tent» (brief news + tweet). August 15th «AURORA Teams create 3D Model of Alpiniøya Island» (brief news + image + article + second article). August 16th «Search for Buoy Leads to Polar Bear Encounter» (brief news). August 20th «Encounter with ALBEDO – A Rowboat circumnavigating Svalbard» (long news + images). August 21st «Arrival at Magical Hornsund» (brief news + image + dispatch). August 22nd «NANUQ completes circumnavigation of Svalbard!» (brief news + image + press statement in English + press statement in Italian). August 23rd «Exploring an Abandoned Russian Town» (brief news). August 30th «Crossing the Barents Sea» (long news in Italian by Ludovico Machet + image). September 4th «Expedition Complete! NANUQ arrives in Tromsø» (brief news).

The considerable amount of content in the listed pages reveals the natural intent of the Website, i.e. to highlight, in a rather powerful journalistic style, the achievements of the expedition. This strategy brings sometimes to some simplification in the content for the sake of clarity and impact, and sometimes caused imprecisions, which were often (but not always) corrected by further interventions.

(69) Given the difficult communications via Iridium between NANUQ and Polarquest2018 headquarters, a misunderstanding occurred. The news post was released at the expected time of a planned visit to the small community in Greenland; the visit, however, did not take place, as NANUQ's crew landed at a different location for a brief stop-over and land observation.

(70) The identification of the cairns observed by the drone and then reached by Gallinelli's team cannot be proved within the framework of this research, but may be considered in further works based also on the expedition's data.

Dispatches, i.e. pieces of literary text which were more extensive than brief or longer, were normally handled by Safiria Buono during leg 13 and by Paola Catapano during leg 14. Buono, a background in environmental and social activism, at 19 years of age was the youngest member of the crew but nevertheless had previous experience of navigation and technical work at sea. Safiria proved to be a brilliant writer, with an effectively descriptive and personal style. Her dispatches appeared to mostly be focused on describing a Polarquest2018 crew-member's impressions and feelings about the mission, with a sincere enchantment for the beauty of nature. Paola Catapano's dispatches, instead, are more focused on the expedition in its – so to speak – strategic developments. Her writings summarize activities and highlight the most relevant «turning points». Her dispatches and tweets show the typical effectiveness of a long-time expert professional in communication, dealing with the complexity of a quite composite expedition, while at the same time fulfilling information duties towards many institutional, technical and financial sponsors.

The overall concept of the website before and during the expedition was not to focus on the research contents or findings. As a matter of fact, scientific results, independently managed by different workgroups, took about two years or more to make their way through the processing protocols and the oftenpainstaking procedures of academic publication. The Website, rather, pointed out, at each moment, what was the most relevant topic, issue or goal in the expedition's (and, more broadly, in the Polarquest2018 Association's) activities. It should be noted that the coordination of a comprehensive website with well-organized social networks and a communication strategy as described above, reached most of its goals. It made Polarquest2018 a known and appreciated endeavor, between science, citizen science and history of exploration, in front of a numerous and widespread audience.

7.2 *Meeting the descendants*

Much of Polarquest2018 story-telling was based on the narrative of the continuity with airship ITALIA's expedition 90 years earlier; as Polarquest2018 came in contact with some descendants of the ITALIA's crew, Catapano's workgroup aimed to offer them opportunities for gathering under institutional events and places, on the one hand to assist them in formalizing their memorial aggregation; on the other hand, to affirm the project's goal to put itself in direct connection and continuity with the human story of the past expedition. This goal was pursued by bringing the descendants closer to the object of their family memories, by accessing the very places where the history of the 1928 expedition had begun. It was, in some respect, a geographical experience about places. This turned out to be the case, for instance, when Paola Catapano requested the Italian Geographical Society to host a meeting of the descendants with the President of Italy's National Research Council, Prof. Massimo Inguscio. The meeting took place at Palazzetto Mattei in Rome, headquarters of the Italian Geographical Society, on May 3rd, 2018, and included a display of historical documents from the archives, reserved for the guests. The presentation was given in the same room, the *Sala del Consiglio*, where the 1928 expedition had been discussed and approved. Along the same line, was Catapano's proposal of a ceremony for the descendants to be staged in Ny-Ålesund, a pivotal place for the history of ITALIA, and yet a place which had been inaccessible to the descendants for generations, literally. This event was made possible by hospitality provided by Italy's National Research Council (CNR) with financial support by Polarquest2018 Association. The subsequent geographical «point of interest» would have been at sea, in the place of the crash of the airship. The exact coordinates of this remain uncertain – though hypothesized in Alessandrini and Casagrande (2019, p. 22) to be in proximity of 81°20'N, 24°00'E.

The group elected to consider, as the reference landmark, the first ascertained post-crash coordinates, broadcasted from the red-tent, as indicated by Nobile (1975, p. 216) and Trojani (1964, p. 334): 81°14'N, 25°25'E. Regardless of climate trend variations after 90 years, that point was presumed – due to seasonal variations – to be covered by ice pack in May (the airship crash occurred on May 25th, 1928), but probably free of ice in August, when the expedition was due to reach it; the assumption proved correct.

Early in the project, a proposal had been considered, to have all the descendants attend the ceremony at sea at that location, on a second vessel; the idea was dismissed when it became clear that the expedition would have involved NANUQ only. An alternative proposal considered to host one representative of the descendants aboard NANUQ. However, the long distance to be covered in a small sailboat with minimal comfort, with most of the place taken by the crew and equipment, discouraged Catapano and Gallinelli from taking that additional responsibility.

Nevertheless, Polarquest2018 did reach the immediate vicinity of the SOS point and accomplished the task of holding a ceremony at sea, in direct connection to the descendants' will and intentions. It was meant to commemorate the explorers of airship ITALIA on behalf of their relatives and of the institutions who had participated in the 1928 expedition.

A value of this effort, put forth by Paola Catapano and, jointly, by her partner institutions and their representatives, was to be able to commemoratively take the descendants from the place where the journey of their ancestors had been decided, to the place where it had begun, to the place where it had ended.

7.3 *Leg 13*

The first expedition leg from Iceland to Svalbard via Greenland brought about a series of relevant events in story-telling which were represented in various ways by highly suggestive pictures shot by Michael and Kai Struik. The first one, which was to become most iconic in the expedition, a sort of «logo» image, was the encounter with a large iceberg, high in the misty ocean off Greenland. The iceberg was photographed by several crew-members from the boat and was the subject of a drone flight conducted by Struik. A second audiovisually relevant moment was when the boat ran aground and subsequently settled on the drying seafloor. The incident was captured only in a brief – non-professional – scene taken by a cell-phone: a crew-member who was shooting views of the many belugas surfacing around NANUQ happened to record the sound of the hull striking the rocks and the initial moments of confusion onboard. This video ended up being posted on the Polarquest2018 social networks. It was, at the same time, a frank admission of operational shortcoming, but also an effective demonstration of serenity and problem-solving. The episode becomes a story in the story, suggestively described by images and dispatches. The initial attempts to refloat by using the dinghy and the final settling of the boat on her side onto the almost dry sea bottom, the long hours of wait, became another interesting picture. While Kai took an interview with Safiria to have her explain the crew's mood, Michael Struik shot several aerial views of the stranded boat; additionally, the Skipper's request to acquire images of the boat in her position so as to obtain awareness of the seafloor around gave Struik the chance to take long views of NANUQ in her solitary, stationary condition. Several scenes of the boat settled on her keel and left hand side conveyed the message of a temporary inaction, while at the same time effectively reaffirming the strength and integrity of the all-aluminium experimental boat and the overall quietness of the scene, with crew-members placidly waiting for the tide to come and let them resume their journey.

7.4 *Landscapes and objects*

In several occasions during the expedition, places were meaningfully described by Struik's aerial footage as well as by the massive video-photographic production by other participants. As far as drone photo/video documentation was concerned Struik was clearly the chief operator. He obviously differentiated his image acquisition strategy depending on whether the subject was a natural landscape, a built one or wildlife in its habitats.

In the first case, the scene was meant to provide a description and, most of all, the feeling of the «natural marvels» of the Arctic. This was generally obtained by high-altitude aerial views, with appropriate variations in camera angle and generally cautious yaw turns – critical due to the aforementioned magnetometer problems. As it is common in this type of videomaking, in order to obtain a pleasant scrolling of the viewed landscape, it is necessary to move the drone at full speed – quite a challenging task in a location where the drone controllability was evidently precarious. Examples of this kind of work are, for instance, aerial videos recorded in Bockfjorden, Trollkjeldene, Inglefieldbreen and Alpiniøya. The iconic iceberg image represented well the idea of the small sailboat, venturing in her quest for science and history in the still intact, though endangered, domain of nature. Not by chance, the picture was used, as a symbol of the entire expedition, in several public occasions and communications material.

In the second case, i.e., when video documentation was meant to describe human current or past settlements, footage was obviously focused on the artefacts, implying generally lower altitude and relatively closer proximity to the objects of interest. This type of aerial view usually left the landscape context as a background to the prevailing object of interest. This was the case, particularly, in Signehamna (German WWII radio station), Kinnvika, Barentsburg, Pyramiden.

In the third case, wildlife views were acquired with the intention of showing the animals in their habitats, while «telling the story» of their actions at the moment. A video taken by Struik shows a couple of reindeers crossing a pond; another video showing a polar bear in the wilderness was taken – with the use of a DJI Phantom 4 – by a Polish researcher at Hornsund station, Tomasz Wawrzyniak[71], with the same criteria. Particularly, in observing wildlife, attention should be paid so that no disturbance is given to the animals; in fact, it can be easily observed, from other experiences elsewhere, that drones are cause of fear and stress – particularly to polar bears and land mammals.

One reason could be that, beyond their noise and unusual shape, drones often appear to animals as showing a «rational» behaviour and, by coming closer, an «aggressive» attitude too. Appropriate aerial footage by drone should therefore be taken so as to attract minimal or no attention whatsoever from the animal: this generally means to shoot from relatively far and possibly high altitudes.

As far as ground videography and photography were concerned, it should be noted that they required the full capability of all the professional figures onboard, even though much additional documentation was also acquired by other crew-members whose primary purpose onboard was not multimedia documentation (particularly Pinazza and the author).

It is worth commenting that the work of a professional cameraman and photographer like Alwin Courcy, in charge of producing all the material necessary for planned documentaries, was all but obvious. Courcy worked based on a series of notes and

(71) Department of Polar and Marine Research, Institute of Geophysics, Polish Academy of Sciences.

checklists prepared for him by film director and producer Dorothée Adam-Mazard based on the initial plan of the expedition; he then had to deal with a complex series of changes and updates, always constrained by the need of bringing back home enough material, and of enough quality, to enable the preparation – *ex post*! – of a meaningful documentary. Although some scenes were actually shot by Courcy with a certain degree of staging preparation and were even repeated to allow for better editing, most of the others had to be shot quickly, in rather sudden and unexpected situations. Such was the case at any time of the day or night: fast reflexes, improvisation, well-recharged batteries and sleep deprivation were daily business.

Furthermore, Courcy had to keep and operate his delicate and cumbersome equipment in the cramped spaces of the boat, while constantly maintaining awareness of many parallel activities and rapidly choosing what to document and how; Struik's work was not easier, in this matter: besides his coordinating role in the expedition, he was in charge of many documentation activities, including those required as per sponsor's agreements. The latter proved often challenging because images were supposed to be potentially usable for advertisement and therefore required attention to very specific and often non-trivial details.

7.5 Polarquest *documentary (2018)*

Fig. 133 – *Alwin Courcy taking video documentation from NANUQ's port (left) central area*
Source: ph. by G. Casagrande

Documentary *Polarquest*, produced by Flair (France) for USHUAIA TV (France) was directed by Dorothée Adam-Mazard, an expert Arctic documentarist, from footage by Alwin Courcy. The film was completed in November 2018 and first broadcast in December 2018, with re-runs in March and April 2019. It is a 56 minutes documentary, presented in a French-dubbed and French-narrated version. Versions with English and Italian subtitles were prepared in the following months for international audiences and public events. The documentary received two international awards: *Terres Film Festival 2019* (Sustainable Tourism and Ecology Award) and *Deauville Green Awards 2019* (Silver Trophy)[72]. The documentary features a soundtrack composed by Claire Mazard, also an experienced Arctic traveller; music pieces span in moods from suspense to emotion, adapting to various different tunes of story-telling in the film.

The film begins with aerial views of Inglefieldbreen and a message introducing the concept at the very foundation of the expedition:

> «The Arctic, an immaculate scenario on top of the world, fascinates. Explorers, navigators, scientists… this region has always stirred curiosity. The conquest of the Pole is caused by a thirst for adventure in the first place: a desire of exploring the incomparable. In the past, numerous men lost their lives. Today, it is its harsh conditions and difficult access that still protect it».

NANUQ is introduced on her day 2 of navigation between Greenland and Svalbard and the purpose of her journey is explained.

> «Her name is NANUQ, "polar bear" in Inuit language, a tribute to her destination. North of Norway, the Svalbard archipelago – whose main island is called Spitsbergen – counts more bears than people. Onboard NANUQ, a multicultural scientific crew is venturing on the footsteps of one of the earliest Polar scientific expeditions…».

ITALIA's odyssey is then summarized, and reaching the point of the airship's crash is explicitly indicated as the primary purpose of Polarquest2018: «The purpose [*le but*] of the expedition is to reach the last known position of the airship»; this particular aspect shows the prevalence of the exploration/adventure side in this instance of story telling the expedition, even though the rest of the documentary describes, synthetically but overall appropriately, several scientific activities as conducted by the crew. In the end, the film accurately shows Polarquest2018 as a research expedition endowed with a commemorative role.

---

(72) Public screenings were also – but not only – held in 2019 at TOTAL Renewables Seminar at Anglet (June 14th), Erice (September 9th), Marsala (September 14th), International Maritime Film Festival (September 27th), FIFEL Lausanne (October 12th), Image Montagne at Pau (November 7th), Explor Images (Nice, November 11th), CERN Globe (November 17th).

In the following scene, MANTANET sampling procedures, with several takes involving Frédéric Gillet and Safiria Buono, assisted by Peter Gallinelli and others, introduce the research programme in the expedition. While Polarquest2018 and its activity move around Svalbard, a well-balanced attention appears to be devoted, in the documentary, to spaces and places. Ny-Ålesund, effectively described in its nature as scientific settlement by a sequence of clips showing science buildings and equipment, serves as the background for presenting Polarquest2018's contribution to studying a present-day environmental issue, i.e. monitoring of airborne pollutants. This activity is conducted by scientific coordinator Frédéric Gillet at an appropriate location in the fjord, far from the station. Subsequently, with a different narrative pace and attention, Ny-Ålesund becomes the peculiar location for the emotional account of the descendants' gathering at the «Eight Crosses Memorial». The scene is focused on a brief, touching comment by Giuseppe Biagi (jr.)[73], and on the silent deposition of a wreath by Sergio Alessandrini[74] and Orsola Climinti. The next scene describes the activities at Virgohamna, with a compact but dense account of the drone survey. It should be noted that at the time when the documentary was made, data processing from the activities was still initial and very few data could be made available to Adam-Mazard. Furthermore, the relatively adventurous conditions in which the survey was conducted, added a certain degree of «epic» taste to the scene; a handy montage of ground scenes, actual voice recording and FPV images for the second flight (conducted, in reality by Michael Struik) render – pretty accurately – the feeling of the sequence of events. Images of the author commenting with Gallinelli and Struik the «quick and dirty» provisional 3D model, just developed onboard NANUQ to cross-check the proper image coverage, are sufficient to explain the rationale of the research. Throughout the scene, Virgohamna appears as the solitary, remote place of an ancient exploration story, even though, by highlighting its remoteness and a general «feeling of discovery», these characters seem to prevail on the fact that the site is relatively well known and documented. The drones – which represented well, in the documentary, a «dynamic» perception of the research component – with additional pathos given by the recurrent compass issues – are also dominant in two other scenes: the thermal survey test at Trollkjeldene and, later, the search for Albertini's cairns at Nordkapp. In the former, spectacular aerial views taken by Struik appear to be functional to the central focus on the thermal anomaly test, whose experimental nature is suggested but not fully described. Once again, this is mostly due to the fact that final data from the test were not ready at the time. After Trollkjeldene, about half way into the documentary, a presentation of PolarquEEEst

(73) Grandson of Giuseppe Biagi, radio-telegraph operator of airship ITALIA, rescued on July 12th, 1928 by icebreaker Krassin.

(74) Grandson of Renato Alessandrini, rigger of airships NORGE and ITALIA, disappeared with the airship.

activities occurs; the somewhat accelerated pace of previous scenes appears to slow down both in the choice of image rhythms and in the soundtrack. The subject is now cosmic rays. Narration, therefore, deals with phenomena that were generated thousands and millions of lightyears far in the universe; these radiations, constantly coming from every direction, are monitored by a silent and most sophisticated instrumentation. The contemplative rhythm of the scenes is well tuned to the serene and friendly presentation given by onboard scientist Ombretta Pinazza, quietly describing what was, in fact, one of the most record-breaking research programmes in the expedition. This research, in particular, could be presented – and indeed was - in conceptual continuity with research conducted onboard ITALIA by an international team of physicists, particularly Italian Aldo Pontremoli and Czech Fraňtišek Behounek. A chronological change, between the real expedition and the film, is at this point proposed.

NANUQ is shown approaching Latitude 82°, describing, through explanations by Paola Catapano, the ordeal of ITALIA survivors waiting for rescue by icebreaker Krassin. Their condition is compared to that of the Polarquest2018's crew in their much more comfortable life onboard. Both themes appear to be presenting, in reality, the life of explorers in the context of the Arctic harshness at different historical and operational phases. At this point, in the film, scenes of the encounter between Polarquest2018 and the «bear family» in Hornsund are then presented, with a considerable chronological shift, though in perfect thematic continuity: it is indeed presented as another experience of 21st century explorers as they penetrate further into the heart of mother nature. The encounter with the bears is presented vividly, showing the peaceful attitude of the animals. They appear – as they truly were – undisturbed by the boat, in an overall serene scene of their relationship, deep in the quietness of their natural environment. The scene, apparently, aims to convey a sense of nature's inherent harmony, even in its harshness, barely referred to by the peripheral presence of the killed seal that the bears have been feeding on. NANUQ, here, is a human nutshell bringing witnesses – who came from so far away for this – to contemplate this beauty. The moment was perceived and narrated as a pivotal event in the expedition.

> «To have seen that mother polar bear with her two bear cubs on that very small iceberg eating a seal in the middle of this magnificent fjord. This image is incredible obviously because the human beeing is not supposed to see this but also because this is rare […] And this is all what is about. If we went there, it was to testify the presence of the plastic into the sea, to show that the icebergs are melting too quickly and under our eyes that the wildlife is seriously threatened. If we still want to have the chance to see this, we have to react»[75].

(75) A. Courcy, text from a written interview sent to the author on August 29th, 2020.

The scene clearly intends to highlight the emotional effects of the encounter with the bears, with Catapano describing her feelings, somewhat confirmed by an intense close view on a thoughtful and tenderly smiling Mathilde Gallinelli. General comments on global change affecting wildlife, at that point, are presented by the film director using archival footage of polar bears on the ice-pack (a sight that Polarquest2018 never got to actually see). Another chronological shift, at that point shows planning and work of the expedition in Nordkapp.

In the Nordkapp scene, the disappearance of the drone is once again dramatically presented by integrating different pieces of footage from the FPV control station downlink recording and of a drone in flight. It nevertheless renders very effectively the development and the general mood of the events. After the drone loss, the main «narrative power» of both the drone flights and onland observation in general comes to an end. Narration moves on, at that point, entirely on the sea, with other chronological shifts: other scenes of life on the boat and the first encounter with the Swedish adventurers in ALBEDO. Scenes from assembly of the sonar in Phippsøya are then presented with comments by Struik; the painstaking work to set the system operate properly in its various components is presented once again with adherence to the real sequence of events. This section too, however, is chronologically inverted with the subsequent one. After experiencing the wonder and frailty of the Arctic environment, after struggling with technological innovation and wrestling it to yield expected results, the last scene of the film presents the ceremony at sea, with a more solemn and thoughtful rhythm. The scene re-creates well the true atmosphere of solitude in those misty and cold waters, immensely surrounding the small NANUQ's and her travellers. Release of the flower wreath at the end of the memorial ceremony on the ITALIA SOS site is the conceptual accomplishment of Polarquest2018 symbolical mission: the crew pays a tribute of love and remembrance on behalf of the descendants to the ITALIA's expedition and its rescuers, and to their epic story of science and suffering. In perspective, this might also mark a symbolical wish that their sacrifice in contributing to knowledge about the Arctic is not forgotten, and that their legacy lives on in the work of today's and tomorrow's researchers and explorers.

Working on the several hours of video recordings and interviews returned to France by Courcy, Adam-Mazard has applied a careful and very strict selection of contents, trying to develop the core message, the «spirit of Polarquest2018» so to speak, by removing redundant or not relevant contents and focusing on some pivotal situations of the expedition. «During two weeks, I stood in a dark office living the expedition. I watched about 40 hours of footage and I wrote down every single event. I also wrote down all interviews. After all I had a 100-page documentation of the materials. Then I worked the structure of the documentary[76]».

When background narration, occasionally, suspends describing the expedition and presents more general concepts, Adam Mazard inserts, here and there, footage by herself from previous documentary material, visualizing scenes which were not actually shot during Polarquest2018; these minor insertions, however, help to give the watcher a more direct and meaningful perception of what is being said.

For a Polarquest2018 crew-member – but certainly not for the general public, the real target of the film – an element which may at first be a bit puzzling, while watching the documentary is the omission of some episodes and the many chronological changes in the sequence of some events.

> «I had to build suspense in order to keep the spectator awaken so it was not possible just to make it chronological. I had to re-think the itinerary but not to be too far away from reality. I also wanted to find a good balance between history, science and adventure. […] Yes, unfortunately some people do not care about environmental problems. But this is, for me, the strength of the documentary. It covers three subjects: history, science (and environmental issues), adventure. People who are interested in history or adventure can watch it, and they also hear the environmental issues».

In her work, Adam-Mazard had to face different problems: first, how to calibrate scene duration and pace so as to keep within standard commercial constraints. Second, how to obtain a well-tuned integration between reporting about facts and rendering an emotionally attractive depiction of moods and feelings in each scene. Asked about her «artistic cut» in making the documentary, she summarized her views:

> «Human part was very important for me. I wanted to show each crew member in his or her daily life during the expedition time. […] It was important to humanize the scientists with laughing moments, dinner times or even difficulties, for example when the drone is lost or the sonar does not work. […] Concerning the Arctic, I just wanted to highlight its beauty and vulnerability. That's why I added my personal footage to illustrate animals and landscapes. It is important to show the beauty of the place in order to raise awareness about its fragility»

Having been onboard, the author thinks that such depiction turned out accurate and really conveyed the sense of how Polarquest2018 «felt like» to those being there.

(76) D. Adam-Mazard, text from a written interview sent to the author on August 11th, 2020 (as for the following quotes).

7.6 Nanuq *documentary (2020)*

Addictive Ideas TV producer (Milan, Italy) has announced the release of a documentary about Polarquest2018, with the plan or having it broadcast by Italian Focus TV network between October and November 2020. The documentary is written and directed, by Emanuele Licitra.

Paola Catapano served as scientific consultant. A pre-release copy of the film was submitted to the author in August 2020 for a discussion in this report, and the following comments are based on that. Compared with the French documentary, this 55-minute film shows a different cut and the narrative about the expedition has a different focus. Image digital post-processing and editing is particularly developed, to create a highly suggestive impact on the audience. Once again, the first reference is to the ITALIA's ordeal, but the introduction presents the philosophical view which is the core of the documentary and its consistent *Leitmotiv*. Similarly, to Adam-Mazard's documentary, NANUQ opens with footage from the ITALIA expedition and aerial views of Inglefieldbreen. An environmentalist narration then begins, with a clear reference to the effects of the 2020 Covid19 pandemic:

> «Human thirst for knowledge has always pushed us to overcome our limitations and travel into the unknown. By our very nature, we are our own best opportunity and our worst enemy. We have ignored our planet's warning signals, choosing instead to trust forecast for the future that are as evocative as they are misleading. The events of 2020 are only the latest in an ever-escalating disaster, so systemic that it is challenging our very perceptions of time and space. Ours is the time of frantic progress and irresponsible development. Our world is one so globalized and hyper-connected that each individual action has dramatic consequences at a planetary level. Now we have been forced to slow down, in claustrophobic and restrictive spaces, we peer into ourselves. We have discovered our lives to have become so fast-paced as to have made us almost ubiquitous. Yet, at the same time, our ignorance has made us more culpable, more vulnerable and afraid than ever. Nature has reclaimed its space. For the time being, it is breathing again. Edgar Morin tells us we need to find a way. A way to start over and become worthy, responsible citizens of the Earth, if we want a chance at a future at least. A way of consciousness and knowledge. A way of listening».

The documentary begins in Ísafjörður with preparations for NANUQ's departure and a presentation of the boat, also showing archival footage of her construction, with a description by Peter Gallinelli of the concepts related to her design, building and use; footage of the cosmic ray detector installation follows, presenting its purpose. Rather spectacular images of the crossings to Greenland, remarking concern for environmental issues such as the presence of plastic in water and the thinning of the ice. Microplastic samplings by Safiria Buono are then described. In the next scene NANUQ appears to be stranded on the rocks at Recherchefjorden, with Safiria explaining the events and footage of Gallinelli and Andrean removing the broken starboard (right) daggerboard, with the workgroup resilience becoming the next theme of the narration, as miscellaneous scenes follow: shooting training in Longyearbyen, drone views of NANUQ at Pyramiden's quay, re-installation of the daggerboard (Ny-Ålesund). The mounting of the sonar on the daggerboard is demonstrated by footage from the Phippsøya work.

A focus on the airship's story and the search objectives is then summarized by Roberto Sparapani; and the commemoration at Ny-Ålesund is synthetically presented, with thoughts expressed by the descendants. Compared with the *Polarquest* documentary, *Nanuq* aims to cover more themes and events in about the same running time; the general pace of scenes is therefore faster and descriptions are more synthetic in nature.

Another theme is introduced next: global warming and deglaciation. Scenes from the visit to Magdalenefjorden, showing extensive signs of seasonal and long-term trend ice retreat are presented, as well as a scene of the crew relaxing in the boat external cockpit. The moment had some degree of poetical licence. It was shot on a sunny day – a phase of particularly warm weather along Spitsbergen's west coast, while that boat's area was further heated by the running engine under the floor. The combination of circumstances made it feel like, as joyfully stated by Safiria: «*Sicilia col sole!*» («Sicily with the sun!»). The following subject of the narration is the AURORA project and Virgohamna survey. The sequence includes, this time, the original FPV recording of the re-entry showing glitches in the signal and stabilization problems as they appeared. The «quick and dirty» Photoscan process is shown and explained, but editing included also images from ortophoto after final in-lab image-based-modelling and GIS development. Ombretta Pinazza's presentation of the PolarquEEEst activity is then presented; then the scene moves to Trollkjeldene and the thermal anomaly detection test is effectively described. As the onland group is presented in its return to NANUQ at Bockfjorden, with the finding of the bear skeleton and footprints, attention switches back on plastic pollution, with an effective statement by Peter Gallinelli:

> «We are at the edge of the world, where one would expect to find a totally intact environment, and yet we are finding the same waste that can be found on any beach in the world. This is an important signal, because this environment is completely uninhabited and so should be devoid of any direct human impact».

The next scene shows the visit to Kinnvika, according to a similar idea. Paola Catapano's statement «We might well feel like explorers of the future, but we end up stumbling on leftovers of the past»; the leftover being implicitly, in this case, the semi-abandoned scientific station, whose connection with Polarquest2018 is indicated by Catapano's remark that: «This research station was home to a cosmic ray research instrument in 1957». The Nordkapp survey for Albertini's cairns is then described. The drone tells this time the story of recognizing the passage of the Italian rescuers in 1928 by sending images of their cairns just before disappearing; plastic sampling again on the way to Phippsøya, with Safiria Buono and Mathilde Gallinelli at work. The two young operators working together on plastic sampling are the focus of the scene and were considered by the Project Leader as a major asset of the expedition, particularly for fund-raising-oriented communication. An interesting narrative aspect begins at 34'50", when Safiria is seen stating: «I haven't caught any macroplastics yet, plastic that is visible to the naked eye», which would lead the audience into feeling that NANUQ is crossing relatively uncontaminated waters, now that she is sailing so far in the Arctic; it is indeed just a preparation for a disillusion meant to make the audience reflect. Two scenes later at 41'00", Peter Gallinelli comments the plastic sampling at Lat. 82°07'N: «At the closest point to the North Pole ice shelf we find plastic visible to the naked eye, after just one sampling tow. Incredible!». The view closes-in at that point, on the fragment of blue plastic captured by the MANTANET, with a suggestive passage of the soundtrack; the entire scene is designed to show how pervasive plastic pollution is and, with it, humankind's threat to the environment and to itself. The other scenes between the two moments depict the ceremony at sea and the sonar scanning, respectively; both are framed in comments and graphics showing the retreat of the ice cap and the absence of icebergs throughout NANUQ's route in the region; global warming is the main concept in this sequence. Scenes from the multibeamer installation at 82°07' are then presented. Image of Struik commenting with Gallinelli discrepancies in measurements acquired by the instrument from depth indication on sea charts are narrated in an effective way to show that Polarquest2018 navigated through approximately charted seas and contributed to better documentation of some areas, a result which was actually achieved. In this section, at 40'09" editing included images from the post-expedition processing of sonar data, by Aleskandra Kruss, visualized on a QGIS software interface. The shown raster is one of the two valid «stripes» obtained from the system. This can be considered a «poetical license», useful to clarify the real outcome of the sonar scanning, even though Polarquest2018 crew did not get to have such view during its voyage. The next scene tells the story of the onland visit to Alpiniøya, connecting the place to the history of the 1928 expedition by Sora and van Dongen and focusing on the heavy presence of plastic debris. Then the expedition is shown along Austfonna with some among the most spectacular video images of the documentary, including the boat crossing floating ice and the impressive calving captured by Struik's Phantom; these are used to introduce further remarks on global warming and the so-called «Arctic amplification». The two encounters at sea with ALBEDO are condensed in one effective moment, in which Mattsing and Kjellkvist are shown being welcome onboard and talking to the crew about their «Row Around Svalbard» expedition; their adventure shares, with Polarquest2018's adventure the sense of the need of higher responsibility and joint international efforts to reduce environmental impacts of human activities. The documentary conveys this concept in the very Swedish adventurers' words. At about 50'25" the pace of narration slows down suddenly, in the depiction of the encounter with the «bear family» in Hornsund, associating its images of serenity to the quite powerfully expressed concept of «Solastalgia»:

> «[It]is a term created by philospher Glen Albrecht [Albrecht, 2005]. It combines the words solace, comfort, and "algia", pain, and described the nostalgia one feels for one's own habitat, as one watches it go through distressing change. It is experienced only by some, but should be felt by all of us, as we all share a common destiny as the Earth's inhabitants».

It is worth, at this point, adding a few brief comments about the differences between the two documentaries.

Unlike Adam-Mazard's documentary *Polarquest*, Licitra's *Nanuq*, being edited at a later time, could rely on information about the scientific outcomes of the expedition: several results were already published and other were being prepared for publication at the time. A difference in style between the two works is that *Polarquest* operated a selection of themes, appearing to prefer to tell a story of the expedition with particular attention to the participants' nature and feelings. It also tried to describe the life onboard, with repeated attention to how people individually adjusted to their tasks and what their perception about the sense of their presence on the boat was. This kind of narration needed a certain amount of time for each individual «story» to be told and constrained Adam-Mazard to remove some events from her account. Licitra's documentary, in turn, focuses more on the expedition in general, on the background of its environmentalist component, which is presented as prevailing. Individual crew-members are presented as members of a team with a unique purpose, each one of them bearing a personal and individual contribution. *Nanuq* proves quite effective in summarizing the content of each Polarquest2018 event in a short time; brief scenes are powerfully edited to render the sense of the presented situation; a definitely fast pace of the documentary then results. Both documentaries succeed in keeping the audience's attention high throughout the screening, albeit through a different style and approach to narration. *Polarquest* suggests the audience to focus on the work of the persons who travelled the Arctic, thinking about the future of environmental research in a direct connection with the past; *Nanuq* puts its audience in front of a strong and direct call to prevent a future of environmental catastrophe by adding Polarquest2018 findings to a widespread communication about environmental issues.

CONCLUSIONS

Polarquest2018 marked the first «institutional» return of the Italian Geographical Society to the Arctic as an operational component of a research expedition after exactly 90 years, the immediate precedent being airship ITALIA's flights in 1928. While there is no reasonable technical or operational continuity between the two expeditions, a common conceptual line is nevertheless shared by experiences so different from any other point of view. It is a similarity in some concepts and purposes. ITALIA's journey was meant to deploy the first full-blown technological demonstrator of a long-range flying laboratory for geographical and environmental observations in the Arctic. In spite of nationalistic propaganda stirred-up by the endeavor in the involved countries, the 1928 exploration and, *a fortiori*, the subsequent search and rescue operations, required a wide international effort. Both elements, i.e. technological development and international cooperation were the premise to the future of research and travel in the Arctic. At that time, the question was how to ensure that human presence and activity become «possible» in a region which had never allowed that to happen before. Less than a century later, that perspective is a reality and a new challenge is now ahead: how to make human presence and activity «sustainable», in a global scenario in which industrial activities and consumeristic expectations in many countries are causing severe environmental impacts. In its organizers' intentions, Polarquest2018 aimed to propose innovative strategies to encourage a reflection on a fundamental problem. Given that it is theoretically possible to massively inhabit the Arctic and exploit it as it had never occurred in the past, how can it be possible to design solutions allowing humankind to sustainably settle and operate in those regions? From this question, another one stems: what are the appropriate ways towards a more affordable set of techniques and methods to do effective research, communication and education about the Arctic, so that awareness of geographical and environmental issues can be disseminated among future generations?

Polarquest2018 was one of the Arctic expeditions designed to conduct research with innovative techniques aiming to foster sustainability, accessibility and efficiency. Other similar operations have been conducted in previous years and will be conducted in the future. Small boats – often sailboats – are involved in observation campaigns about geographic and environmental phenomena in the region. However, in this wide set of experiences, Polarquest2018 and its floating laboratory S/Y NANUQ, under Paola Catapano as the Project Leader, collaborating with Association *Acapela,* and Peter Gallinelli as the Expedition Leader have certainly demonstrated a particularly virtuous example of integration between scientific and technical components on one side, and communicational/educational aspects on the other.

Similarly indeed, in this aspect, to the ITALIA's expedition, Polarquest2018 tried to propose the instance of a new *modus operandi* to aggregate a set of useful action strategies and technical solutions. These were built around a core idea, i.e. to plan and conduct an expedition based on sustainability, simplicity, flexibility and reliability. Like many of its historical precedents, NANUQ's journey had to intimately connect rigorous scientific goals with the need of communicating the events as they were unfolding. It was precisely the ability of spreading news and knowledge of any scientific expedition's work, that always made the endeavour both socially attractive and culturally relevant. This was the organizers' goal and, as far as the author could observe, it was achieved. From this point of view, Polarquest2018 can be considered a winning model for future experiences.

Looking back at the expedition's development, at no time the search for the wreck of airship ITALIA could appear feasible, and in fact it never was.

The expedition's attempt of obtaining a high resolution, 3D map of the sea floor by applying the multibeam sonar, in the specific system integration, fell short of the expected results. This individual outcome, however, involved an activity for which adequate procedures and training could not be properly developed due to time constraints and route schedule. The sonar option just came in too late to be effectively deployed, although both the expedition's and manufacturer's workgroups did their best to get things work out.

Having said so, it must be emphasized that Polarquest2018 was a full success in all of its other, much more developed and thoroughly planned activities. As a matter of fact, in spite of the many different tasks and snags, virtually all of the expected results were achieved. This is true, in the first place, with regard to scientific research, as all the three programmes fulfilled their plans and published original data. It is also true with regard to communication, with a remarkable number of public events, TV, mass-media, Web presentations and one award-winning documentary, while another one is soon to be released on the market. Finally, it is true with regard to the expedition's commemorative side, since Polarquest2018 was able to catalyze, 90 years after the ITALIA's odyssey, public events and gatherings of the 1928 crew's descendants on the very places of their family epic.

These achievements resulted from the will of the leaders and the joint work of scientists, technicians, communicators and volunteers, all individually contributing with their professional and cultural backgrounds.

For the Italian Geographical Society, participation to Polarquest2018 has been another opportunity, among many, to fulfil its historical mission of promoting geographical research and culture.

ACKNOWLEDGEMENTS

At the end of this long work, I would like to express my gratitude for the contribution given by so many people to the development of this research, and to the preparation of the book itself. The first heartly «thank you» goes to Paola Catapano, Peter Gallinelli, Michael Struik and Roberto Sparapani for having offered me the opportunity to travel onboard NANUQ in the expedition; another goes to the Italian Geographical Society and the European University of Rome for having allowed me to institutionally represent them during Polarquest2018. I also would like to thank NANUQ's crew and the whole expedition's workgroup for sharing so many important research activities and great human experiences during our month together around Svalbard. Among the colleagues, I am particularly grateful to Ombretta Pinazza and Aleksandra Kruss for the kind, friendly – and patient! – scientific and technical advise and also for providing data and images. Thanks also to Emanuela Falqui, Dorothée Adam-Mazard and Alwin Courcy for images and valuable comments.

I feel particularly obliged to acknowledge the support, contributions of ideas, proposals, friendly revisions and corrections from so many colleagues, during the two years from our arrival at the quay in Longyearbyen to the final revision of these pages: Prof. Claudio Cerreti and Prof. Margherita Azzari, president and vice-president of the Italian Geographical Society, Prof. Andrea Riggio, president of the Association of Italian Geographers for their support and encouragement during the preparation of this work and other publications related to Polarquest2018; Prof. Giuliano Bellezza, former president of the International Geographical Union and Prof. Ester Cecioni for sharing comments and proposals in the first development phases of this work; Prof. Annalisa D'Ascenzo (Italian Centre for Historical-Geographical Studies) for her attentive reading of my previous reports and writings on Polarquest2018 and particularly on Virgohamna, as well as for providing me with valuable advise on the preparation of cartographies; Dr. Else L'Orange, of the Norwegian Embassy in Rome, for sharing important thoughts about exploration as a human experience; Prof. Steinar Aas (Nord University, Bodø) for giving me precious insights on the history of the relations between Norway, Svalbard and polar expeditions; Dr. Rossella Belluso, PhD, Secretary General of the Italian Geographical Society, and Dr. Gianfredi Pietrantoni PhD for the assistance and friendly support in the not-always-easy days of data processing and lab-work; Mr. Iakov Lebedev (Saint Petersburg) and Mr. Stefano Poli (Longyearbyen) for kindly contributing «first hand» information about Svalbard. I am also grateful to Norsk Polarinstitutt and to Photolibrarian Ann Kristin Balto for having approved the publication of images from the Institute's Photoarchives.

Needless to say, this publication would have never been completed without crucial technical and scientific help and advise, for which I wish to thank Dr. Andrea Caracciolo (Informasistemi), Prof. Arturo Gallia (Laboratorio Geocartografico G. Caraci, University of Roma Tre), Mr. Sandro Russello (FlyToDiscover), Dr. Emiliano Tondi (GREAL).

A warm «thank you» also to Mr. Davide Del Gusto, Mr. Francesco Battaglini and Dr. Eleonora Guadagno for their precious help in revising the drafts of this work and the preparatory writings.

Last, but not least, a grateful thought is for Prof. Cristina Gemo (to whose memory this book is dedicated) and her husband Prof. Orazio La Greca, for their dear presence in the story of my participation in Polarquest2018 and in my whole research work.

Gianluca Casagrande

REFERENCES

Aasheim S. P. (2008), *Norges nasjonalparker – Svalbard*, Oslo, Gyldendal Norsk Forlag AS.

Aars J., Andersen M. and Kovacs K. M. (2005), *Polar Bears in Svalbard*, Tromsø, Norwegian Polar Institute.

Agisoft LLC (2016), *Agisoft Photoscan User Manual: Professional Edition*, Version 1.2.

Agisoft LLC (2019), *Agisoft Metashape User Manual: Professional Edition*, Version 1.5.

Albrecht G. (2005), *"Solastalgia". A New Concept in Human Health and Identity*, in «PAN: Philosophy Activism Nature», 3, pp. 41-55.

Alessandrini S. (2019), *In dirigibile al Polo Nord. Storia di Renato Alessandrini, dalla prima trasvolata dell'Artide col "NORGE" all'ultimo volo con l'"ITALIA"*, Rome, Società Geografica Italiana.

Alessandrini S. and Casagrande G. (2019), *La scomparsa del dirigibile ITALIA (Oceano Artico, 25 maggio 1928). Considerazioni preliminari*, Rome, GREAL.

Aliani S., Casagrande G., Catapano P. and Catapano V. (2020), *Polarquest2018 Expedition: Plastic Debris at 82°07' North*, in Streit-Bianchi M., Cimadevila M., Trettnak W. (Eds.), Mare Plasticum – *The Plastic Sea*, Cham, Springer.

Amundson K. A. B. and Malmér I. (1931), *Balloon – Technical Commentaries on the Journey of the "Eagle", on the 11-14th July, 1897*, in Andrée S. A., Strindberg N., Fraenkel K., *The Andrée Diaries: Being the Diaries and Records of S.A. Andrée, Nils Strindberg, and Knut Fraenkel*, London, John Lane The Bodley Head, pp. 107-120.

Andersen M. (2017, February 14th), *Polar Bear Safety*, Arctic Safety Centre Seminar (*https://www.unis.no/wp-content/uploads/2017/06/Polar_bear_safety_MagnusAndersen.pdf*).

Andrée S. A., Strindberg N. and Fraenkel K. (1931), *The Andrée Diaries: Being the Diaries and Records of S.A. Andrée, Nils Strindberg, and Knut Fraenkel*, London, John Lane The Bodley Head (authorized translation from the official Swedish edition by Edward Adams-Ray).

Anna's Heart is Buried with 1897 Explorer (2000, February 27th), (*https://search.proquest.com/docview/269234195?accountid=26252*).

Arlov T. B. (2020), *Maps and Geographical Names as Tokens of National Interests. The Spitsbergen vs. Svalbard Case*, in «Nordlit», 45, pp. 4-17.

Avango D., Hacquebord L., Aalders Y., De Haas H., Gustaffson U. and Kruse F. (2011), *Between Markets and Geo-Politics: Natural Resource Exploitation on Spitsbergen from 1600 to the Present Day*, in «Polar Record», 46 (01), pp. 29-39.

Barr W. (2006), *Polarfahrer: Im Banne der Arktis (Polar Traveller: Under the Spell of the Arctic)*, in «Arctic», 59, 1, 98.

Biagi G. and Unia G. (2019), *Ritorno al Polo Nord. La Tenda Rossa 2.0*, Cuneo, Nerosubianco.

Bjerk A. H. B. and Johannesen L. J. (2007), *Virgohamna, Lufta mot Nordpolen*, Longyearbyen, Sysselmannen på Svalbard.

Bosco P. and Stone I. R. (2004), *Black Feathers in Svalbard: the Alpini Expeditions, 1928*, in «Polar Record», 40 (215), pp. 303-308.

Bristow D. L. (2018), *Flight to the Top of the World. The Adventures of Walter Wellman*, Chapel Hill, NC, University of Nebraska Press.

Broadbent N. D. and Oloffson J. (2000), *Archaeological Investigation of the S.A. Andrée Site, White Island, Svalbard 1998 and 2000*, Umark 23, Arkeologisk rapport, Institutionen för arkeologi och samiska studier, Umeå, Umeå Universitet.

Brossier E. (2009), *Damocles Project/Vagabond 2008-2009 Wintering Report*, (*https://vagabond.fr/pdf/Report_Vagabond_2008-2009.pdf*).

Bühler Y., Adams M. S., Bösch R. and Stoffel A. (2016), *Mapping Snow Depth in Alpine Terrain with Unmanned Aerial Systems (UaSs): Potential and Limitations*, in «Cryosphere», 10 (3), pp. 1075-1088.

Cailliez J. C. (2006, October 12th), *Première tentative d'Atteindre le Pôle nord en dirigeable : l'expédition W. Wellman (1906-09)*, (*http://www.pionnair-ge.com/spip1/spip.php?article199*).

Capelotti P. J. (1994), *A Preliminary Archæological Survey of Camp Wellman at Virgohamn, Danskøya, Svalbard*, in «Polar Record», 30 (175), pp. 265-276.

Capelotti P. J. (1997), *The Wellman Polar Airship Expeditions at Virgohamna, Danskøya, Svalbard: a Study in Aerospace Archaeology*, Oslo, Norsk Polarinstitutt.

Capelotti P. J. (1999), *Virgohamna and the Archaeology of Failure*, in Urban Wrakberg (Ed.), *Proceedings of a Conference on S.A. Andrée and the Agenda for Social Science Research of the Polar Regions: The Centennial of S.A. Andrée's North Pole Expedition*, Stockholm, Royal Swedish Academy of Sciences, pp. 30-41.

Capelotti P. J., Van Dyk H. and Cailliez J. C. (2007), *Strange Interlude at Virgohamna, Danskøya, Svalbard, 1906: The Merkelig Mann, the Engineer and the Spy*, in «Polar Research», 26 (1), pp. 64-75.

Casagrande G. (2019), *Il sito storico di Virgohamna (Svalbard) e le spedizioni artiche di Andrée e Wellman. Considerazioni a seguito di una ricognizione speditiva con droni*, in «Bollettino della Società Geografica Italiana», 13, 2(2), pp. 99-116.

Casagrande G. (2020), *In the Silence of Virgohamna. Traces of the 1897 Swedish Polar Expedition between Geohistorical Observation and Memory*, in «Geostorie», 28 (1), pp. 5-29.

Craig K.W. (2016-2017), *The Arctic Frontier in International Relations*, in «Florida Political Chronicle», 25, 1 pp. 85-107.

Diesen J. A. and Fulton N. (2007), *Wellman's 1906 Polar Expedition: The Subject of Numerous Newspaper Stories and One Obscure Film*, in «Polar Research», 26 (1), pp. 76-85.

Directorate for Cultural Heritage (2000, May 3rd), *Regulations concerning area protection and regulation of access to Virgohamnain Svalbard*, (*https://www.sysselmannen.no/globalassets/sysselmannen-dokument/english/regulations/regulations_concerning_area_protection_and_regulation_of_access_to_virgohamna_in_svalbard__engelsk__ifuzr.pdf*; last accessed October 31st, 2018).

DJI (2017), *Phantom 4 Pro/Pro+User Manual V1.2 2017.03*, Shenzen, DJI.

Doel R. E., Friedman R. M., Lajus J., Sörlin S. and Wråkberg U. (2014), *Strategic Arctic Science: National Interests in Building Natural Knowledge – Interwar era Through the Cold War*, in «Journal of Historical Geography», 44, pp. 60-80.

Drivenes E. A. and dag Jølle H. (Eds.) (2006), *Into the ice. The history of Norway and the Polar regions*, Oslo, Glydendal Norsk Forlag.

Eckhardt S., Hermansen O., Grythe H., Fiebig M., Stebel K., Cassiani M., Baecklund A. and Stohl A. (2013), *The Influence of Cruise Ship Emissions on Air Pollution In Svalbard – A Harbinger Of A More Polluted Arctic?*, in «Atmospheric Chemistry and Physics Discussions», 13 (16), pp. 8401-8409.

Eeg-Henriksen F. and Sjømæling E. (2016), *This is Svalbard 2016. What the Figures Say*, Oslo-Konvinger, Statistics Norway.

Elvevold S., Dallmann W. and Blomeier D. (2007), *Geology of Svalbard*, Tromsø, Norwegian Polar Institute.

Evenset A. and Christensen G. C. (2011), *Environmental Impacts of Expedition Cruise Traffic around Svalbard*, Tromsø, Akvaplan-niva, (*http://aeco.no/documents/Finalreport.pdf*).

Falk-Andersson J. and Strietman W.J. (2019), *Svalbard Beach Litter Deep Dive. SALT rapport 1033*, Tromsø, SALT Lofoten AS.

Ferrante O. (1986), *Umberto Nobile*, Rome, Claudio Tatangelo Editore, 2 voll.

Friolo R. (2007), *I porti scomparsi*, Rome, Rivista Marittima.

Fürst J. J., Navarro F., Gillet-Chaulet F., Huss M., Moholdt G., Fettweis X., Lang C., Seehaus T., Ai S., Benham T.J., Benn D. I., Björnsson H., Dowdeswell J. A., Grabiec M., Kohler J., Lavrentiev I., Lindbäck K., Melvold K., Petterson R., Rippin D., Saintenoy A., Sánchez-Gámez P., Schuler T. V., Sevestre H., Vasilenko E. and Braun M. H. (2019), *The Ice-Free Topography of Svalbard*, in «Geophysical Research Letters», 45 (21).

Gallia A. (2019), *Cartografia storica e strumenti digitali per il monitoraggio dei terrazzamenti e la mitigazione del rischio idrogeologico*, presentation given at the «Convegno annuale dell'Associazione Italiana di Cartografia», May 8th-10th 2019, Noto, Italy.

Gallinelli P. (2017). *The Passive Igloo Project. Feedback from an Arctic Winter in a Self-Sufficient Passive Habitat*, (*http://www.sailworks.net/igloo/passive_igloo_e.htm*).

Gallinelli P. (2018a), *NANUQ au Groenland 2015-2017*, Sailworks.

Gallinelli P. (2018b), *Livre de bord, NANUQ 2018,* unpublished.

Gasparini M. L. (2019), *Una città fantasma alle soglie del Polo Nord: Pyramiden da luogo abbandonato a luogo recuperate*, in Salvatori F. (Ed.), *L'Apporto della Geografia tra Rivoluzioni e Riforme*, «Atti del XXXII Congresso Geografico Italiano, Roma, 7-10 giugno 2017», Rome, AGeI, pp. 2099-2105.

González-Ruibal A. (2013), *Embracing Destruction*, in Driessen J. (Ed.), *Destruction – Archaeological, philological and historical perspectives*, Louvain-la-Neuve, UCL - Presses Universitaires de Louvain, pp. 37-51.

Governor of Svalbard (2020), *Guidelines for researchers in Svalbard*, (*sysselmannen.no/en/researchers/guidelines-for-researchers-in-svalbard/*).

Grydehøj A. (2020), *Svalbard: International Relations in an Exceptionally International Territory*, in Coates K.S. and Holroyd C. (Eds.), *The Palgrave Handbook of Arctic Policy and Politics*, London, Palgrave Macmillan.

Grydehøj A., Grydehøj A. and Ackrén M. (2012), *The Globalization of the Arctic: Negotiating Sovereignty and Building Communities in Svalbard, Norway*, in «Island Study Journal», 7 (1), pp. 99-118.

Gulińska J., Rachlewicz G., Szczuciński W., Barałkiewicz D., Kózka M., Bulska E. and Burzyk M. (2003), *Soil Contamination in High Arctic Areas of Human Impact, Central Spitsbergen, Svalbard*, in «Polish Journal of Environmental Studies», 12 (6), pp. 701-707.

Hagen D., Vistad O., Eide N. E., Flyen A. C. and Fangel K. (2012), *Managing Visitor Sites in Svalbard: From a Precautionary Approach Towards Knowledge-Based Management*, in «Polar Research», 31 (1).

Hagen J., Liestøl O., Roland E. and Jørgensen T. (1993), *Glacier Atlas of Svalbard and Jan Mayen*, Tromsø, Norsk Polarinstitutt.

Hall C. M. and Saarinen J. (Eds.) (2010), *Tourism and Change in Polar Regions: Climate, Environments and Experiences*, London, Routledge.

Holmgaard S. B., Thuestad A. E., Myrvoll E. R., Barlindhaud S. (2019), *Monitoring and Managing Human Stressors to Coastal Cultural Heritage in Svalbard*, in «Humanities», 8(1), 21.

How accurate is my map? (2019), *https://support.dronedeploy.com/docs/accuracy*.

Humlum O., Instanes A. and Sollid J. L. (2003), *Permafrost in Svalbard: A Review of Research History, Climatic Background and Engineering Challenges*, in «Polar Research», 22 (2), pp. 191-215.

Immerzeel W. W., Kraaijenbrink P. D. A. and Andreassen L. M. (2017), *Use of Unmanned Aerial Vehicle to Assess Recent Surface Elevation Change of Storbreen in Norway*, in «The Cryosphere Discussions».

Jamtveit B., Hammer Ø., Andersson C., Dysthen D. K., Heldmann J. and Vogel M. L. (2006), *Travertines from the Troll Thermal Springs*, Svalbard, in «Norwegian Journal of Geology», 86, pp. 387-395.

Jasinski M. E and Zagórski P. (2013), *Human activity*, in Zagórski P., Harasimiuk M. and Rodzik, J. (Ed.), *The Geographical Environment of NW Part of Wedel Jarlsberg Land (Spitsbergen, Svalbard)*, Lublin, Faculty of Earth Sciences and Spatial Management Maria Curie-Skłodowska University, pp. 316-359.

Kavan J. and Anděrová V. (2020), *Impacts of Increased Tourism on Polar Environment - Case Studies from Svalbard and Iceland*, in «Czech Polar Reports», 10 (1), pp. 59-68.

Kinossian N. (2020), *Svalbard's Haunted Landscapes*, in «Nordlit» 45, pp. 86-103.

Knutsen H., Singdahl-Larsen C. and Bonnevie Cyvin J. (2019), *Microplastics in Svalbard Fjords and Biørnøy Transect Sediments*, Oslo, Trondheim, Houston, Perth, NGI Report.

Kohler J., James T. D., Murray T., Nuth C., Brandt O., Barrand N. E., Aas H. F. and Luckman A. (2007), *Acceleration in Thinning Rate on Western Svalbard Glaciers*, in «Geophysical Research Letters», 34 (18), L18502.

Koroleva N. (2014), *Phytosociological Evaluation of Terrestrial Habitat Types in Pyramiden Area (Svalbard, Norway)*, in «Czech Polar Reports», 4 (2), pp. 193-211.

Krajcarová L., Novotný K., Chattová B., Elster J. (2016), *Elemental Analysis of Soils and Salix Polaris in the Town of Pyramiden and its Surroundings (Svalbard)*, in «Environmental Science and Pollution Research», 23 (10), pp. 10124-10137.

Kristensen M. (2019), *L'ultimo viaggio di Amundsen*, Milan, Iperborea.

Lajus J. and Sörlin S. (2014), *Melting the Glacial Curtain: The Politics of Scandinavian-Soviet Networks in the Geographical Field Sciences Between Two Polar Years: 1932/33-1957/58*, in «Journal of Historical Geography», 44, pp. 44-59.

Letters from the Andrée Party (1898), in *Smithsonian Report for 1897*, Washington, Government Printing Office, pp. 401-412.

Lewis-Jones H. (2008), *"Balloonacy": Commander Cheyne's Flight of Fancy*, in «Polar Record», 44 (4), pp. 289-302.

Lithberg N. (1931), *On White Island*, in Andrée S.A., Strindberg N. and Fraenkel K., *The Andrée Diaries: Being the Diaries and Records of S.A. Andrée, Nils Strindberg, and Knut Fraenkel*, London, John Lane: The Bodley Head, pp. 201-220.

Martín-Español A., Navarro F., Otero J., Lapazaran J. and Błaszczyk M. (2015), *Estimated of the Total Volume of Svalbard Glaciers, and their Potential Contribution to Sea-Level Rise, using New Regionally Based Scaling Relationships*, in «Journal of Glaciology», 61 (225), pp. 29-41.

McCormack D.P. (2008), *Engineering Affective Atmospheres on the Moving Geographies of the 1897 Andrée expedition*, in «Cultural Geographies», 15 (4), pp. 413-430.

Misund O.A., Aksnes D.W., Christiansen H.H. and Arlov T.B. (2017), *A Norwegian Pillar in Svalbard: The Development of the University Centre in Svalbard (UNIS)*, in «Polar Record», 53 (3), pp. 233-244.

Moore J. (2005, September 16th), Travel Log, Slide Show and Photo Album from the 2005 Expedition (*kinnvika.net/Expeditions/2005-Expedition*).

Nania R. and Pinazza O. (2019), *Measuring Cosmic Ray Showers Near the North Pole with the Extreme Energy Events Project*, in «Il Nuovo Saggiatore», 34, pp. 5-6 (*https://www.ilnuovosaggiatore.sif.it/article/179*).

Nansen F. (1920), *En ferd til Spitsbergen*, Kristiania, Jacob Dybwads Forlag.

Nelson S.B. (1993), *Airships in the Arctic*, in «Arctic», 46 (3), pp. 278-283.

Nobile U. (1930), *L'"ITALIA" al Polo Nord*, Milan, Mondadori.

Nobile U. (1938), *La preparazione e i risultati scientifici della spedizione dell'"ITALIA"*, Milano, Mondadori.

Nobile U. (1975), *Ali sul Polo. Storia della conquista aerea dell'Artide*, Milan, Mursia.

Nordli Ø., Wyszyński P., Gjelten H.M., Isaksen K., Łupikasza E., Niedźwiedź T. and Przybylak, R. (2020), *Revisiting the Extended Svalbard Airport Monthly Temperature Series, and the Compiled Corresponding Daily Series 1898-2018*, in «Polar Research», 39.

Norum R. (2016), *Barentsburgand Beyond: Coal, Science, Tourism, and the Geopolitical Imaginaries of Svalbard's "New North"*, in Huggan G., Jensen L. (Eds.), *Postcolonial Perspectives on the European High North*, London, Palgrave MacMillan, pp. 31-65.

Norwegian Polar Institute (2018, March 2nd), *Polar Bear*, (*https://www.environment.no/topics/the-polar-regions/the-arctic-region/polar-bear/*).

Norwegian Polar Institute (2020a), *Fauna in Svalbard*, (*https://npolar.no/en/themes/fauna-svalbard/*).

Norwegian Polar Institute (2020b), *Sibling vole* (Microtus levis), (*https://www.npolar.no/en/species/sibling-vole).*

Olsen J., Hovelsrud G.K. and Kaltenborn B.P. (2020), *Increasing Shipping in the Arctic and Local Communities' Engagement: A Case from Longyearbyen on Svalbard*, in Pongrácz E., Pavlov V. and Hänninen N. (Eds.), *Arctic Marine Sustainability. Springer Polar Sciences*, Cham, Springer, pp. 305-331.

Overrein Ø. (Ed.), Henriksen J., Fossli Johansen B., Prestvold K. (2015, June), *Virgohamna [79° 40' N 10° 30' E],* (*http://cruise-handbook.npolar.no/en/nordvesthjornet/virgohamna.html*).

Parmesan C. (2006), *Ecological and Evolutionary Responses to Recent Climate Change*, in «Annual Review of Ecology, Evolution, and Systematics», 37, pp. 637-669.

Pelliccioni F. (1997), *Le scienze umane e geografiche nell'Artico, priorità e prospettive: una sintesi introduttiva*, (*http://users.libero.it/f-pelli/f-pelli.documento2.htm*).

Pelliccioni F. (2016), *Longyearbyen, ovvero il lungo viaggio verso la "normalizzazione sociale" di una cittadina retta da quasi un secolo da una compagnia mineraria di carbone*, Communication written for the seminar «The "NORGE" and beyond: from heritage to the future», September 18th, 2016, Longyearbyen, Svalbard, (*https://www.researchgate.net/publication/339238943_LONGYEARBYEN_2016_comunicazione_FRANCO_PELLICCIONI*).

Pfeifer N., Glira P. and Briese C. (2012), *Direct Georeferencing with on Board Navigation Components of Light Weight UAV Platforms*, in «International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences», 39 (B7), pp. 487-492.

Piesing M. (2018, September 18th), *The Giant Hangar Built for an Arctic Airship*, (*https://www.bbc.com/future/article/20180911-the-giant-hangar-built-for-an-arctic-airship*).

Polar Record (1958), *Swedish-Finnish-Swiss International Geophysical Year Expedition to Nordaustlandet 1957-1958, Operations in 1957*, in «Polar Record», 9 (58), pp. 24-25.

Polar Record (1959), *Swedish-Finnish-Swiss International Geophysical Year Expedition to Nordaustlandet, 1957-1958 and Swedish Expedition to Nordaustlandet 1958-59: Season 1957-1958*, in «Polar Record», 9 (61), pp. 338-339. Popat S. (2016), *Missing in Action: Embodied Experience and Virtual Reality*, in «Theatre Journal», 68 (3), pp. 357-378.

Pohjola V.A., Kankaanpää P., Moore J.C., Pastusiak T. (2011), *Preface: The International Polar Year Project* "kinnvika" – *Arctic Warming and Impact Research at 80°N*, in «Geografiska Annaler Series A Physical Geography», 93 (4), pp. 201-208.

Prach K., Košnar J., Klimešová J. and Martin H.M. (2010), *High Arctic vegetation after 70 years: a repeated analysis from Svalbard*, in «Polar Biology», 33 (5), pp. 635-639.

Putch A. (2017), *Linear Meeasurement Accuracy of DJI Drone Platforms and Photogrammetry*, San Francisco, DroneDeploy.

Rein Bore R., Andreassen I., Kristiansen J.E. and Modig I. (2012), *This is Svalbard 2012. What the figures say*, Oslo/Konvinger, Statistics Norway.

Ruman M., Kozak K., Lehmann S., Kozioł K. and Polkowska Ż. (2012), *Pollutants Present in Different Components of the Svalbard Archipelago Environment*, in «Ecological Chemistry and Engineering. S = Chemia I Inżynieria Ekologiczna», 19 (4), pp. 571-584.

Salvatori R., Casacchia R., Grignetti A., Valt M. and Cagnati, A. (2005), *Snow Surface Classification in the Western Svalbard Island*, in «Proceedings of the 31st International Symposium on *Remote Sensing of Environment: global monitoring for sustainability and security*», Saint Petersburg, Saint Petersburg State University.

Saville S. (2014), *Political Ecologies of Knowledge: Locating value(s) of Knowledge Production at the (Scientific) Field Sites of Svalbard*, paper presented at the *Locating Value: Ecologies session* at the «Royal Geographic Society (with Institute of British Geographers) Annual Conference, 28th August 2014», (*https://www.academia.edu/8267871/Political_Ecologies_of_Knowledge_Locating_value_s_of_knowledge_production_at_the_scientific_field_sites_of_Svalbard*).

Saville S. (2019), *Value and decision making in Svalbard*, Technical Report.

Sellari P. (2016), *Svalbard, frontiera artica*, in «Bollettino della Società Geografica Italiana», 13, 9, pp. 467-487.

Stange R. (2012), *Spitsbergen Svalbard. A Complete Guide Around the Arctic Archipelago*, Rolf Stange.

Statistics Norway (2020a), *Population of Svalbard*, updated April 7 (*https://www.ssb.no/en/befolkning/statistikker/befsvalbard/halvaar*).

Statistics Norway (2020b), *Private households and persons in private households by size of household (Longyearbyen and Ny-Ålesund*, , updated April 7 (*https://www.ssb.no/en/befolkning/statistikker/befsvalbard/halvaar*).

Strzelecki M.C., Szczuciński W., Dominiczak A., Zagórski P., Dudek J. Knight J. (2020), New fjords, New Coasts, New Landscapes: The Geomorphology of Paraglacial Coasts Formed After Recent Glacier Retreat in Brepollen (Hornsund, Southern Svalbard), in «Earth Surface Processes and Landforms», 45 (5), pp. 1325-1334.

Szabó G., Bertalan L., Barkóczi N., Kovács Z., Burai, P. and Lénárt, C. (2018), *Zooming on Aerial Survey*, in Casagrande G., Sik A., Szabó G. (Eds.), *Small Flying Drones - Applications for Geographic Observation*, Cham, Springer, pp. 91-126.

Tamborra V. (2019), Mi Tular - *Io Sono il Confine*, in «I quaderni di *Après-coup Arte*», 9 (*http://www.apres-coup.it/Catalogo_TAMBORRA_APRILE_2019-LR.pdf*).

Trojani F. (1964), *La coda di Minosse. Vita di un uomo, storia di un'impresa*, Milan, Mursia.

Umbreit A. (1991), *A Guide to Spitsbergen,* Chalfont St. Peters, Bradt.

Umbreit A. (2013), *Svalbard (Spitsbergen) with Franz Josef Land & Jan Mayen*, Chalfont St Peter, Bradt.

Vallega A. (2004), *Le grammatiche della geografia*, Bologna, Patron.

Viken A. (2006), *Svalbard*, in Baldacchino G. (Ed.), *Extreme Tourism. Lessons from the World's Cold Water Islands*, New York, Elsevier Science, pp. 129-144.

Vlakhov A.V. (2019), *Mobility, Telecommunication and Energy Regimes in Svalbard*, in «Journal of Siberian Federal University. Humanities and Social Sciences», 8 (12), pp. 1506-1521.

Wawrzyniak T., Osuch M., Napiórkowski J. and Westermann S. (2016), *Modelling of the Thermal Regime of Permafrost During 1990-2014 in Hornsund, Svalbard*, in «Polish Polar Research», 37 (2), pp. 219-242.

Winter J. (2010), The Performance of the Past: Memory, History, Identity, in Tilmans K., Van Vree F. and Winter J. (Eds.), *Performing the Past: Memory. Memory, History and Identity in Modern Europe*, Amsterdam, Amsterdam University Press, pp. 11-22.

Ziaja W. (2019), *Geographical Investigations in the Management of the Svalbard Environment*, «Quaestiones Geographicae», 38 (3), pp. 51-57.

INDEX OF NAMES

Between July 22nd and September 4th 2018, an international Arctic expedition called «Polarquest2018» was conducted onboard the eco-sustainable boat NANUQ. The 17.8-meter sail-yacht cruised for over 3,500 miles, most of which north of the Arctic Circle. The crew carried out a series of activities and observations in the framework of three research programmes, focused on Physics, Environmental Science and Geography respectively. The work was documented, while in progress and later on, in several scientific publications and communication initiatives.

The core of Polarquest2018 involved the circumnavigation of Spitsbergen and Nordaustlandet, the two largest islands of the Svalbard archipelago; in that phase, NANUQ visited several sites and areas of scientific and historical interest, in a region that is living the crucial transition from being a barely accessible frontier to becoming a place for human presence and activity.

The expedition's journey proposed an innovative approach to scientific research and cultural dissemination. The wide use of low-cost and high-sustainability technologies and operational methods allowed to test and validate new techniques to complement traditional ways of doing and communicating science in the Arctic. Such step opens new opportunities to envision a wider contribution of citizen science to observing and monitoring delicate environmental contexts in remote areas. This book reports about the expedition, focusing on some of its geography-specific aspects; a complete overview of what was done is hereby provided, in the perspective of sharing experience and encouraging the development of future work.

Gianluca Casagrande, born in Rome in 1974, is Associate Professor of Geography at the European University of Rome and Scientific Director of the Geographic Research and Application Laboratory (GREAL). His current main research interests are in the field of geographic information science and technologies, particularly with regard to low-cost and citizen science level tools. His scientific work covered topics in historical and applied geography with a main focus on fieldwork research.

ISBN: 978-88-85445-06-2

9 788885 445062