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Review Article

Review of Scientific Research Conducted in Horseshoe Island Where Potential Place for Turkish Antarctic Base

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Abstract

The Antarctic Continent, which has the most challenging environmental-field conditions such as high cost logistics needs, extreme weather events, and natural elements that makes impossible to live for most of the living things including humans, in terms of carrying out scientific research, has been hosting scientific projects of Turkish scientists in recent years. Turkish Antarctic Expeditions, continuing since 2017, have concentrated on Horseshoe Island, located in the Marguerite Bay on the west coast of the Antarctic Peninsula, where ice melts are recorded the most due to global climate change. Since Turkey plans to establish a research station in the upcoming years on Horseshoe Island, reviewing all disciplines in the literature of polar research that has been done and can be done on the island is of great importance in the national polar strategy and in laying the foundation of scientific research to be carried out in the future. In this study, the researches of especially British and Turkish scientists in the region were reviewed: it was seen that many interdisciplinary studies and social science projects were also carried out. Despite the many scientific projects completed, it is seen among the results of this study that many polar research disciplines that can be applied and can give direction to world science can still be conducted in the region.

Keywords: Polar Sciences, Climate Change, Antarctica, Horseshoe Island

Introduction

The Antarctic Continent began to be discovered and explored by sailors in the 1800s, with the realization of the landmasses under the glaciers and ice cap. Scientists from many countries such as Belgium, France, England, Norway and Russia started the first research on the white continent centuries ago; researchers from more than 50 countries visit the continent every year to carry out a wide range of interdisciplinary studies in the scientific stations of approximately 30 countries and the extreme Antarctic terrain (ATS, 2021).

Almost every inch of the continent is covered by white; ice and snow. Only 2% area stays ice-free and half of it taking extra special attention. Those regions had been taken under special protection as a result of scientific studies, which applied on the continent and surroundings. Especially the regions where the ecosystem reproduce form colonies and sensitive life forms are protected as Antarctic Specially Protected Area (ASPA) or Antarctic Specially Managed Areas (ASMA). Rather than natural areas and living things historical constructions are also taking attention. Old buildings of historical importance and shipwrecks are also protected as Historic Sites and Monuments (HSM). Every activity, including scientific research in such fields, is limited and subject to special rules according to Porotocol on Environmental Protection to the Antarctic treaty Annex V (ATS, 2021). Apart from these structures, the only other human-made structures that we could see on the continent are the active scientific stations nowadays. 40% of the approximately one hundred scientific stations built in Antarctica are located in the Antarctic Peninsula Region. Only a few of these bases are located within the Antarctic Circle, that is, further south of 66˚33' South latitude. In the southernmost part of the Peninsula, there are only three scientific stations close to Horseshoe Island (COMNAP 2017). These were known as the British Rothera Station (48 km), Argentinian San Martin Base (40 km) and Chilean Carvajal Station (71 km), with approximate air distances. Other scientific stations are located much further away. Due to these distances from the stations, Horsehoe Island and its surroundings have hosted very little scientific studies in previous years. The specific areas and neighboring islands with the detailed surroundings of Horseshoe are shown in Figure 1.The topography of Horseshoe Island, which is mostly rocky, is covered with glaciers and ice cover, including snowfalls that can reach 3-4 meters (Bayik et al. 2019). In the period when the highest temperature was recorded on Seymour Island in Antarctica which was 20.75˚C in 2020 (National Geographic, 2020), it was also observed that the glaciers were melting at a noticeable rate on Horseshoe Island during the Turkish Antarctic Expeditions (TAE). While the diversity is very low in Antarctica, cryptogamic plants were found on the island.

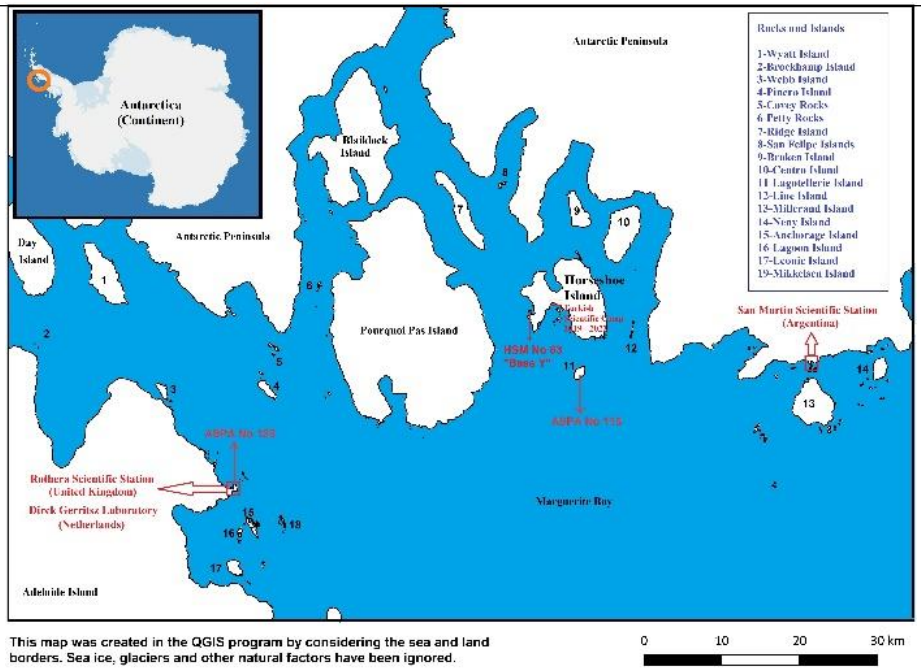

Fig. 1. Horseshoe Island Location and Surroundings.

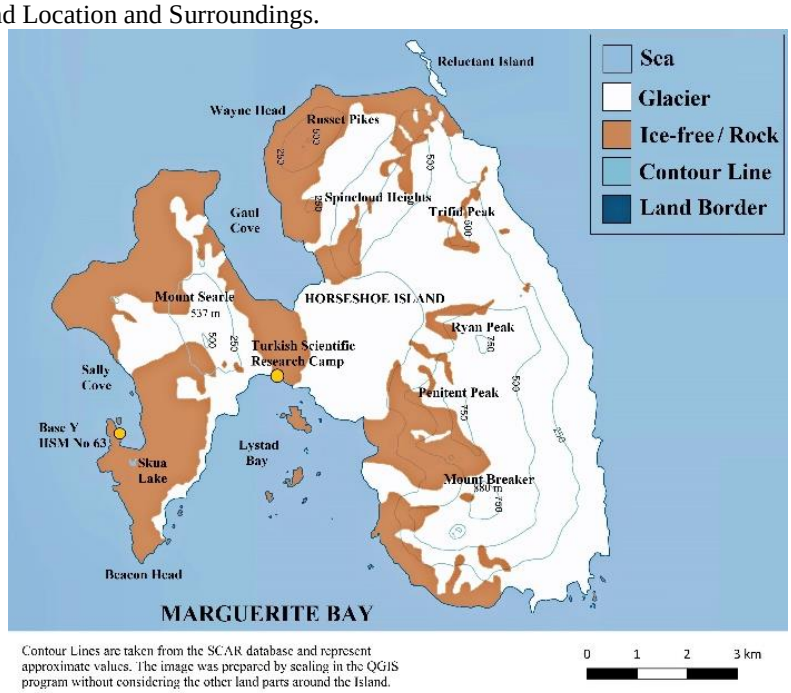

Fig. 2. Horseshoe Island Map with Contour Lines.

It could host 29 kinds of lichens, 15 kinds of moss, a few species of birds from the gull family, Adelie penguin, crab-eater seals on its surface area that covers approximately 60 km^2 above water (ATS, 2021). In addition, the sea ice that completely covers the Southern Ocean during the winter creates an ecosystem for bios including underwater life. In summer, the first year sea ice melts completely. As a result of sea ice research, it is seen that Horseshoe Island is an important part of Antarctica and is a platform where significant research could be carried out in its seas, including aquatic researches, especially whales. (Newman et al. 2019).

In this study, scientific researches carried out before and after the initiation of the studies of Turkish Scientists in 2017 on Horseshoe Island and its surroundings were compiled.

Discovery and Nomenclature of Horseshoe Island

Undiscovered geographical shapes in underwater parts, different minerals in glaciers and discoveries in many different areas could be named by its explorer. In addition to being the last continent to be discovered, the places and parts of the Antarctic Continent are named in almost every geographic part. Naming on Horseshoe Island could be seen in Figure 2. The discovery of Horsehoe Island was made and named by John Riddoch Rymill during his aerial and ground mapping studies

between 1936 and 1937 with the British campaigns to Graham's Lands (Ergüven et al., 2022).

The studies of the Turks about the Polar Regions go back to the World Map of Piri Reis in 1513. Furthermore, some geographical shapes on the Antarctic Continent have been given international approval after the valuable studies of our scientists, such as Kaarali Rocks, Inan Peak and Tilav Cirque (SCAR Gazetteer, 2021). Within the scope of the Turkish Antarctic Expeditions (TAE), which have been carried out in the region for the last five years, different microorganisms, bacteria and their derivatives were discovered and officially accepted and named in the Gene Bank (PRI, 2021).

It was named “Horseshoe” because of its horseshoe-like geographical shape (Alberts, 1995). It is scanned in the literature with the name "Horseshoe Island" in the Geographic Names Information System of the United States Geological Survey (USGS, 2021). The translation of Horseshoe Island is known in Spanish as “Isla Herrradura” for Chileans and Argentines, appears to be used by that name on many local maps and can also be searched by this name in the Geographic Dictionary of the Scientific Committee for Antarctic Studies (SCAR., 2021).

Stations Established on Horseshoe Island

Through their maritime culture, the British have discovered many parts of the world and have much more knowledge and experience about the world by carrying out scientific research on a large scale (Paine 2013). The British, who had a role in the exploration of different parts of Antarctica and the in-depth examination of many parts, started to establish a scientific station in the 1900s and collected many scientific data (Martin 2016). One of these stations was established by the British on March 11, 1955, to be used in the summer months, and is now called "Base Y" which is known as "Historic Site or Monument - No 63" (Historic Sites or Monuments – HSM) according to the decision taken at the Antarctic Treaty Consultative Meeting (ATCM) in 1995 (BAS, 2021). Base Y, seen in figure 3, was used actively from the year it was founded until 21 August 1960. Meteorology and topography and geology surveys were carried out in Base Y, which can host 4-10 people in total. It has also been used as a logistics base for expeditions to the surrounding regions with sled dogs within a hundred kilometer radius. Inside the base, there were basic items such as a sled repair shop, kitchen, diesel generator, emergency box, warehouse, radio room, food, fuel and living space, while outside there were two wooden rowboats, a weather balloon cabin, and two high masts (BASSR-113).

As part of the Third Turkish Antarctic Expedition held in 2019 (TAE III), the “Turkish Scientific Camp 2019 – 2022” seen in Figure 4 was established on the island and put into service of scientists (ATS EIES, 2021). In line with the Protocol on Environmental Protection requirements of this station, which was established in Antarctica, the Initial Environmental Evaluation Report was presented to the international community and was put into service to serve for three years (ATCM 42, BP8). In the same year, the first automatic weather station (AWS) in the polar regions of Turkey was installed on the Horseshoe Island with the cooperation of the General Directorate of Meteorology Meteorology (ATCM 42, IP65). The energy of AWS is provided from renewable energy sources. In Antarctica, where the world's highest wind speed is measured at 327 km per hour, AWS provides information on wind speed and direction, temperature, relative humidity, precipitation, pressure, snow thickness, solar radiation and sunshine duration. The data it collects regularly contributes to scientific studies every year (Ozsoy et al. 2020).

Fig. 3. Base Y British Former Scientific Station.

Fig. 4. Turkish Scientific Camp 2019 – 2022.

During the Fourth Turkish Antarctic Expedition in 2020 (TAE IV), two of the three Global Navigation Satellite System (GNSS) stations were established in the Horseshoe Island / Antarctic Peninsula Region within the scope of the project carried out in cooperation with Yildiz Technical University and Istanbul Technical University (ATIP 2019/2021). The data of the stations is collected regularly every year, which will also contribute a great deal of data to scientific research (Selbesoglu et al. 2019). The other GNSS station was installed on Dismal Island by the General Directorate of Mapping (Ozdemir 2019).

The latest update about the stations known to be carried out on Horseshoe Island is that the Draft Comprehensive Environmental Evaluation (CEE) Report of Turkish Scientific Station (TARS) has been shared with the

Antarctic Treaty System (ATCM 43, WP18). In the coming years, the scientific station that is suggested to be established on Horseshoe Island will give a great direction to scientific research on the Island and its surroundings.

Completed Scientific Studies Before 2017 on Horseshoe Island, Antarctica

The scientific research made specifically for Horseshoe Island were examined and those research-based disciplines found that studied by few nations; meteorology in physical science disciplines, physical oceanography; topography, geodesy, geology, geomorphology, sea-lake geology and geophysics and magnetism-geodynamic studies in earth science disciplines; In life sciences, it is seen that projects are carried out in many fields, especially in sedimentology, lake ecosystems, ornithology, fungi and algae (Yirmibesoglu et al. 2018).

Earth Sciences Research

Scientific studies carried out in the region within the scope of earth sciences are examined in this section: It is seen that many scientists conducted research in this region within the scope of geological studies that started in 1937. Geological field studies were carried out during the British Graham Lands Expeditions (BAS, 2021). Although rock studies and field studies have been carried out on the island since 1937, few of them have been published. Geological map of Horseshoe Island and Lagotellerie Islands was revealed as a result of a detailed examination of landforms such as ponds and published in 1983 by Matthews.

Under-ice rocks have been studied for many years in the scope of petrology in the Graham Lands Region with different studies and have taken their place in the archives of the British Antarctic Survey (Adie, 1954). In one of the granite sections of the Island, an upper intersection age of 431-12 Ma was found from the metaconglomerate section as a result of the evidence for the presence of a mid-Paleozoic time basement in the Graham Lands Region. It was stated that the results of the review confirm the already assumed minimum early Paleozoic age for the Antarctic Peninsula (Tangeman et al. 1996).

British researchers carried out earth science studies and special flights over the Antarctic Peninsula between 1959 and 1984, including the Horseshoe Island region to explore gravitational anomalies and conduct aeromagnetic research, and shared detailed results in their reports. Measurements were made by covering a distance of 36000 km (Renner et al. 1985).

According to the article published by Pankhurst in 1982, Rubidium - Strontium dating studies were also applied to the Marguerite Bay in the Antarctic Peninsula (Pankhurst, 1982).

During the USARP/Deep Freeze 85 and 86 voyages, marine geological and geophysical data were collected from the western part of the Antarctic Peninsula, especially from the Marguerite Bay. It has been observed that the samples taken were from Horseshoe Island - Lystad Bay. The main subject of the study is to examine the history of Glacial-Marine sedimentation and Quaternary Glaciation in Marguerite Bay with collected samples (Kennedy and Anderson 1989).

A glacier 10 thousand years ago covered the Marguerite Bay and other developments and Skua Lake on Horseshoe Island could be isolated from 1860 years ago, and the results were discussed by conducting historical geological studies (Wasell and Hakansson 1992). When the samples collected from the two lakes in March 1989, were compared with the samples from the other lakes in the project, the nitrogen and total phosphorus concentrations in the water were found to be close to the others on average, and the presence of skua and penguins around the lake was also noted (Hansson and Hakansson 1991). Another sediment sampling study of Skua Lake was completed during the Swedish Antarctic Expedition (SWEDARP 88/89) and its results took place in the literature as a preliminary report (Wasell 1990).

Physical Sciences Research

Scientific studies within the scope of physical sciences are explained in the following section: The ability to conduct scientific research at the polar regions directly depends on the weather conditions, and therefore, the first thing to be done and known is weather forecasting with regular monitoring. While there are advanced devices for meteorological measurements in British stations in Antarctica, historical data have been recorded by using many different methods such as weather balloons in the past (Mansfield 1957). In 1974, Limbert examined the average annual temperature changes in the Antarctic Peninsula between 1904 and 1972 for 4 different areas, including the Marguerite Bay Region. However, Horseshoe Island data appears to be only available for active dates of Base Y (Limbert, 1974).

Between 1966 and 1970 (except 1968), scientific research with airplanes was carried out on glaciers with the "Radio Echo Sounder" device (the device that uses ultrasonic sounds with radio frequency) (Ewen-Smith 1972). In the studies carried out on the Antarctic Peninsula, data were also collected from Horsehoe Island, but data from the Antarctic Peninsula and the Larsen Ice Shelf, located in the East of the Island, stand out (Renner 1980).

In the BAS bulletin published in April 1973, the research completed in 1969 within the scope of glaciology under the earth science on Horseshoe Island, was shared. Gravity survey data of Shoesmith Glacier, which is the largest glacier on the island with an area of approximately 10 km^2, were processed and its geological features were also mentioned (Smith 1973).

In the study of examining the environmental changes of the last 0.5–1.0 million years with the inferences made from lakes and rising shores, research was carried out on Horseshoe Island using the radiocarbon dating method.

Many results were encountered on the Island 30,000 years ago, such as a non-corrosive glacial regime and water levels that were meters higher (Hodgson 2013).

Between 2009 and 2019, many equipment flights (Operation IceBridge) over Antarctica were carried out by the National Aeronautics and Space Administration (NASA) of the USA, and new models and data were revealed. As a result of NASA's studies, the geographical shapes underlying the ice cover of Antarctica were also presented as international open data in the digital environment with models (icebridge., 2021).

Life Sciences Research

Among the studies in life sciences, studies focused on lichens, mosses and penguins were observed: During the field observations on the Emperor Penguins carried out in the early 1900s in the Dion Islands which are at the entrance of Marguerite Bay and about 60 km from Horseshoe Island. It has been recorded that Emperor Penguins live and breed in sea ice reaching a thickness of 1.2 - 1.6 meters (FIDSSR-6). While Base Y was used during the expedition, the eggs of Adelie Penguins on Lagotellerie Island, 3.25 km away, were used by the personnel. Reports include that 800 eggs were retrieved in 1955, and the number of breeding penguins dropped to around 1,000 between 1959 and 1960. In March 1981, it was determined that 1,000 baby penguins died as a result of natural factors (ASPA-115).

British researchers have been observed and sampled lichen species in the field during their research (Lamb, 1964). Species also seen on Horseshoe Island are reported (Lamb, 1968). Although many studies were carried out in the Continent until the 1970s, the flora of all of them was not fully studied (Greene et al. 1970).
Although it is seen in the literature that many studies have been done in life sciences, the number of studies specific to Horseshoe Island is less. In the terrestrial single-celled specimens collected from different parts of the Antarctic Peninsula in the 1970s, it was observed that sampling was also taken from the islands in the Marguerite Bay. However, this research could not be done on Horseshoe Island (Smith 1976). Likewise, it was observed that the rotifer samples were close to Horseshoe Island, but samples were taken from different regions (Dartnall and Hollowday 1985).

Social Sciences and Humanities Research

Within the scope of social sciences and humanities research, it is seen that the most important study on the Island is the acceptance of the rules and behaviors that regulate the behavior of tourists and visitors. Looking at the Antarctic Treaty System reports and documents, special rules have been published regarding visits to Base Y on Horseshoe Island in line with the rules taken at the 32nd and 37th Antarctic Treaty Consultants Meetings (ATCM). These rules contain important information such as the Island's structure, fauna, flora, recommendations and obligations for ships and visitors (ATCM-32,37). The closest protected area around Horseshoe Island is; For Lagotellerie Island, ASPA No. 115 has been adopted and implemented in the ATCM (ASPA-115).

Studies Conducted After 2017 during Turkish Antarctic Expeditions in Horseshoe Island, Antarctica

Turkey has increased its polar research studies considerably in recent years and has taken its place in many international scientific societies. After being an associate member of the Scientific Committee on Antarctic Research (SCAR), which acts as the umbrella for scientific studies organized in and around the Antarctic Continent, in 2016, Turkey was accepted as a full member in 2021 (ATCM 43, IP 69; PRI, 2021). As a member of the European Polar Commission (European Polar Board - EPB), it has joined the 19 countries that carry out deep-rooted studies in the polar regions such as Britain, Norway and France (ATCM 43, IP68). Joint studies were also carried out with the Asian Forum for Polar Sciences (AFOPS) (PRI: 01.03.2021). In addition, the Council of Managers of National Antarctic Programs (COMNAP), to which Turkey became an observer in 2018 (and a full member in 2021), and the TUBITAK MAM Polar Research Institute carry out coordinated studies and share common interests in logistics issues in both sea and land operations. Within the scope of scientific research in the Southern Ocean, Turkey, which sponsored the Southern Ocean Observing System (SOOS) in 2021, also supports the participation of Turkish scientists in international scientific processes (PRI, 2021).

Following the ratification of the Antarctic Treaty in 1996, Turkey also ratified the Madrid Environmental Protection Protocol and all of its Annexes in 2017, and the relevant regulation was adapted to domestic law and published by the Ministry of Environment and Urbanization in 2020 (ATIP IP 15; ACKPDY-2020). The Procedures and Principles Regarding the National Polar Science Expeditions and Activities, which are subject to the researches to be carried out on Horseshoe Island, entered into force in 2020 (ATCM 43, IP 67; UKBSFUE-2020).

Projects, activities, publications, seminars and other applications in all fields from social sciences to science in the Turkish Antarctic Expeditions and polar research studies carried out in Turkey completed within the scope of the National Polar Science Program 2018 – 2022 (UKBP), which put into effect by the Ministry of Science, Industry and Technology. Studies conducted are published under the roof of UKBP in six months intervals (UKBP-R-18-19-20). When the scientific studies conducted in Antarctica are examined as the literature, it is seen that Turkey maintains a strong polar research and strategy (Depledge et al. 2020).

According to the information in the National Polar Science Programs Monitoring Reports: In addition to the direct studies on Horseshoe Island, activities such as conferences, seminars, workshops, and collaborations that indirectly affected the projects were also held.

Researchers from many countries such as Bulgaria, South Korea, Spain and Chile have been invited to Turkey to hold international workshops. Polar Sciences Workshop has been held annually since 2017, and such activities have been increasingly continued. The first findings of many studies described or briefly mentioned here could be found in the workshop abstract books. According to UKBP Reports; Undergraduate and graduate students completed their thesis on polar related issues, Polar Sciences Master's Program was opened at Istanbul Technical University in 2021, Polar Studies was added to the application themes of Council of Higher Education PhD scholarship, and many more studies were observed. Within the scope of the Turkish Polar Expeditions, researchers from countries such as Belarus, Bulgaria, Chile, Czechia, Germany and New Zealand were invited to Horseshoe Island as guest researchers. The collaborations have been reported to the Antarctic Treaty Consultative Meetings as information papers. These researchers also conducted studies in many fields from earth sciences to life sciences (MacDonell, 2021). The results of their studies will be published as scientific publications in a short time.

First National Antarctic Expedition of the Republic of Turkey carried out in 2017, a team of 9 people consisting of sailors, cartographers, lawyers and ecologists, traveled north-south and south-north directions over 6 latitudes in the Antarctic Peninsula region including Horseshoe Island. They have completed various scientific researches, measurements and observations on the coastlines. They also carried out studies on Horseshoe Island, enabling Turkish scientists to reach this region for the first time. The data and observation results collected during the expedition in 2017 were examined with scientific evaluations, and it was revealed that the Horseshoe Island Region provided more opportunities for science in different fields (Yavasoglu et al. 2019). Since 2017, it has been observed that the scientific projects carried out by many universities and institutions in our country, Turkish scientists and project teams on Horseshoe Island are mainly carried out in the following sub-areas; astronomy, fisheries, botany, biodiversity, biotechnology, glaciology, environment, sea ice observations, aquatic research, marine biology, maritime, education and awareness, ecology and pollution, lake-fresh water, surveying studies, polar technologies and materials, geodesy, geology, meteorology, microbiology, oceanography, sedimentology studies, remote sensing, medicine, volcanism. (ATS EIES, 2021). These studies; According to the scientific disciplines under the National Polar Science Program funded by the Ministry of Industry and Technology if the projects successfully passed the scientific peer-review and logistics evaluations as a result of the open call. Today, project calls are opened with the code TUBITAK KUTUP 1001 (PRI, 2021).

Earth Sciences Research

Different projects were carried out including glacier studies on Horseshoe Island during the Second Turkish Antarctic Expedition (TAE II). In 2018, the ice core sampling study on the glacier on the slope of Mount Searle was completed within the scope of the project focused on crystallization - mineral detection and the analysis continues. (Genceli-Guner et al. 2018).

In two other studies published on glaciers, rock fragments drifted by the glacier were collected in the field on Horseshoe Island, and cosmogenic age data studies were conducted to understand the late quaternary history of rapid glacial melting and ice retreats in the Antarctic Peninsula (Ciner et al. 2019). In the study conducted by Yildirim (2019): A geomorphological map of Horseshoe Island was created using the observations made during the fieldwork in March 2018 during the TAE and using Google Earth images. It is stated that the ice cover in the non-erosive northern part, the glacier-rich region in the middle part, and the shearing glaciers and glacial erosion in the southern part, are in 3 main geomorphological forms. While the prepared map shows the geometry and model of the landforms, it constitutes a source for future glacier researches.

In the 42nd ATCM held in Czechia in 2019, Rear Admiral Tim Lowe from the British Hydrographic Society underlined that new and accurate information has been added to the world's maritime knowledge thanks to the multi-beam echosounder and bathymetry study carried out on the west coast of Horseshoe Island in Turkey (ATCM 42 FR). Marine mapping studies carried out in cooperation with the Naval Forces Command's Department of Navigation, Hydrography and Oceanography have continued since 2018, aiming to reveal a detailed underwater depth map of Horseshoe Island and its surroundings. The first Turkish underwater mapping studies in known Antarctica were carried out by the authors in 2017 (ATCM-FR-2019). Also, this study covers multidisciplinary research such as physical and earth sciences as many others.

Horseshoe Island stands out in the research conducted using the Geographical Information System and Analytical Hierarchy Method as an area that may be suitable for base construction in the Antarctic Peninsula, approximately six latitudes to the South from King George Island (Senel and Yavasoglu, 2020). Turkey has prepared the Draft CEE Report as a result of the successful studies it has completed in recent years and submitted it to the 43rd ATCM. In the report, it is stated that the planned station will be able to host an average of 24 and a maximum of 50 people, will enable many studies to be done with minimum effect to the environment, and will provide the team with logistics and subsistence support in field studies, and will provide the opportunity to collect samples for longer periods and in larger quantities, and to analyze in the station laboratories (TARS- CEE-2021).

Physical Sciences Research

The first Automatic Weather Station (AWS) of Turkey on the Antarctic Continent was established in Horseshoe Island in 2019 (ATCM 42, IP65). Today, the data of the AWS in Antarctica can be viewed on the website of the General Directorate of Meteorology (MGM, 2021).

Although the polar climate is often widely applied as modeling studies, local weather stations are always needed. In the study put forward by scientists in 2021, scenarios of change in precipitation and temperature amounts were created in line with the high emission values of the Antarctic Peninsula between 2020 and 2044 (Bozkurt et al. 2021).

Table 1: GenBank Data and Titles

Title / Definition	*Nomenclature*	*GenBank No*
Isolation, characterisation and identification of Psychrophile bacteria able to degrade 2,2Dichloropropionic acid isolated from Galindez island, Antarctica.	TaeBurcu001	MN061637.1
Isolation, characterisation and identification of Psychrophile bacteria, Psychrobacter sp. TaseBurcu001) from Svalbard Islands.	TaseBurcu001	MN923049.1
Psychrobacter sp. strain TaeBurcu002 16S ribosomal RNA gene, partial sequence.	TaeBurcu002	MN960390.1
Description of five Antarctic novel bacterial taxons recovered from a gentoo penguin (Pygoscelis papua) with panophthalmitis and evaluation of pathological findings together with the microbiological outcome.	TAE3-ERU1	MT444110.1
Corynebacterium ciconiae strain TAE3-ERU2 16S ribosomal RNA gene, partial sequence.	TAE3-ERU2	MT444111.1
Cardiobacteriaceae bacterium strain TAE3-ERU3 16S ribosomal RNA gene, partial sequence.	TAE3-ERU3	MT444112.1
Actinomyces sp. strain TAE3-ERU4 16S ribosomal RNA gene, partial sequence.	TAE3-ERU4	MT444113.1
Dermabacteraceae bacterium strain TAE3-ERU5 16S ribosomal RNA gene, partial sequence.	TAE3-ERU5	MT444114.1
*Isolation, characterization and identification of Chlorella variabilis isolated from Horseshoe Island, Skua Lake, Antarctica	YTU. ANTARCTIC.001	MN372092.1
*Isolation of Blastomonas sp. from Horseshoe Island, Skua Lake, Antarctica.	YTU.POLAR.001	MN384971.1
*Isolation of Achromobacter sp. from Horseshoe Island, Skua Lake, Antarctica.	YTU.KUTUP.001	MN396385.1
*Isolation, characterization and identification of Auxenochlorella pyrenoidosa strain Ozcimen.001 isolated from Horseshoe Island, Skua Lake, Antarctica.	Ozcimen001	MT951391.1
*Isolation, characterization and identification of Chlorella sorokiniana strain Egemen.001 isolated from Horseshoe Island, Skua Lake, Antarctica.	Egemen.001	MW147167.1
Pseudochlorella pringsheimii strain TASE-Ozcimen.001 small subunit ribosomal RNA gene, partial sequence.	TASE-Ozcimen.001	MW147154.1
Flamella balnearia strain YTU.ARCTIC.001 small subunit ribosomal RNA gene, partial sequence.	YTU.ARCTIC.001	MW147173.1
Chlorella sorokiniana strain Egemen.002 small subunit ribosomal RNA gene, partial sequence.	Egemen.002	MW454367.1
Paracercomonas sp. strain TAE3-YTU.004 small subunit ribosomal RNA gene, partial sequence.	TAE3-YTU.004	MW485507.1
*Isolation of Flamella balnearia strain TAE3-YTU.005 from Horseshoe Island, Skua Lake, Antarctica.	TAE3-YTU.005	MW487484.1
*Isolation of Flamella arnhemensis strain TAE3-YTU.006 from Horseshoe Island, Antarctic.	TAE3-YTU.006	MW513457.1
Flamella arnhemensis strain TAE3-YTU.007 small subunit ribosomal RNA gene, partial sequence.	TAE3-YTU.007	MW485950.1
*Isolation of Paracercomonas sp. TAE3-YTU.008 from Horseshoe Island, Skua Lake, Antarctica.	TAE3-YTU.008	MW521096.1
Identification and Characterization of novel Pseudomonas mandelii KGI_MA19 strain from Antarctica.	KGI_MA19	CP081178.1

** Performed as a result of samples taken from Horseshoe Island.*

The changes in the air temperatures of the regions close to the surface were taken from the meteorological stations in the Antarctic Peninsula and the SCAR database, and various studies were revealed. According to the data examined between 1978 and 2020, it was noted that after the warming periods in the late 1900s and mid-2010s, a cooling period occurred. In addition, the annual trends of the western part of the Antarctic Peninsula show a warming trend, while the eastern part shows a cooling trend (Carrasco et al. 2019).

Since sea ice is a natural formation that can cover an area as large as the Antarctic Continent by forming on the ocean in winter, it has a negative effect on all other scientific studies and logistics operations but has a positive effect on the environment and nature. Many studies have been carried out by the authors on sea ice, and master's thesis and scientific publications have been put forward. Due to the fact that sea ice covers very large areas, it is important to examine the sea ice with remote sensing method and to create models of Antarctic sea ice thicknesses and to control and develop them with terrestrial measurements (Kern et al. 2017).

Life Sciences Research

Within the scope of the Food Web Structure project carried out during TAE III, samples were collected from a total of 13 lakes and ponds, including those on Horseshoe Island. Within the scope of the chemistry of the sampled waters; elements and nutrients that are low in the environment, such as magnesium, cobalt; as its biota; pigment, plankton, etc., and are studied in laboratories within the scope of the research of stable isotopes such as N15-C13. According to the first

findings, it was seen that among the results, there was also the event of being transported from the sea by creatures such as penguins living in the environment (Ozkan et al. 2020). In one of the studies carried out by the inter-university project groups, it was aimed to compare the species diversity of the western part of the Antarctic Peninsula with environmental DNA and DNA barcoding methods by examining the marine invertebrate samples taken from Horseshoe Island and different regions (Karaman et al. 2019). Under the scope of life sciences from Horseshoe Island, eight new microorganism discoveries were made as a result of the examination of samples taken from Skua Lake in laboratory research. Their naming was reported to the International Gene Bank, and Table 1 is given together with the discoveries made in the Turkish Polar Science Expeditions (Ozcimen et al. 2019, 2020, 2021; PRI.01.03.021). The analysis of the samples continues to be examined in the university laboratories of Turkey. Kirkinci et al. (2021) draws attention to the examinations of their habitats and biotechnology and try to inform about the detailed information studies about the examination of the samples collected from the horseshoe island related to TAE.

Social Sciences and Humanities Research

Although human beings can adapt to any environment, the fact that no indigenous people have lived in Antarctica until today still shows how challenging the Continent is. Researches on measuring the changes were carried out by applying psychological and medical tests to the researchers participating in TAE expeditions before, after and during the voyage (Hayriye et al. 2020). Studies such as measuring the level of stress and anxiety of expedition participants, especially in the extreme Antarctic conditions, in field studies on Horseshoe Island, where the expedition was carried out, were investigated in 2020 (Hepdurgun et al. 2020).

As stated in Article 3 of the Antarctic Treaty, scientific data obtained from the Antarctic Continent must be made available to international open access. In this context, the studies of Turkish scientists reach scientific articles first and then open access. In addition, the Turkish Polar Data Center, which is under construction with the initiatives of TUBITAK MAM Polar Research Institute, will be a system where these data can be accessed when it comes into service in the future (Yavasoglu et al. 2020).

PolSTeam and the Association of Polar Early Career Scientists (APECS) Turkey organized many seminars, presentations, games, and painting competitions for students, teachers and the public within the scope of the Turkish Antarctic Science Expeditions in our country. Those activities were completed for the Education and Awareness Studies for the Polar Regions and played an important role in the transfer of scientists' science to other audiences (UKBP reports). The Polar and Climate themed paintings drawn by more than 600 students were also taken to Horseshoe Island during the Turkish Antarctic Expeditions and photographed while being exhibited by scientists and delivered to the owners. The book "Celebrating Antarctica", which describes the Antarctic Treaty written by Julie Hambrook Berkman and Allen Pope in children's language, was translated into Turkish and distributed to students in Turkey (Berkman and Pope, 2017). Many studies on polar regions are also carried out in the journals of TUBITAK Popular Science Books and journals (Bilim Çocuk, Bilim Teknik, Meraklı Minik), which are published every month and introduce our young people to popular sciences and lead them to science, research and curiosity. In 2021, a comic book titled Antarctic Adventures in Science Child Magazine describes the work of scientists at a science base on Horseshoe Island (Yirmibesoglu and Oktar 2021). For the first time in our country, the Polar Festival was organized with the participation of thousands of students and teachers from more than 50 cities on the online platform in 2020, under the coordination of TUBITAK MAM Polar Research Institute, and nearly 30 scientists who went to the polar regions met with students and held a popular polar science presentation (PRI, 2021). In 2021, with the cooperation of TUBITAK Directorate of Science Fellowships and Grant Programs (BIDEB) and TUBITAK MAM Polar Research Institute, the polar-themed 2204 – C High School Students Polar Research Projects competition was opened for the first time and nearly one thousand applications were received with the teams formed by 3 students and 1 advisor. In case of viable projects emerge, the projects can be realized on Horseshoe Island in the future (PRI, 2021).

In addition, within the scope of the cooperation with the Ministry of National Education, a teacher was taken to Antarctica in 2020 with the Educators Supporting Collaboration on Polar Regions Project (KEDI). The teacher observed our scientists while they are doing their research on Horseshoe Island and collected many materials and data for her students. With KEDI, a crucial step has been taken in the studies of raising the new generation with polar awareness (PRI, 2021).

National athlete and world record holder diver Sahika Ercumen and international professional diver Jonathan Sunnex from New Zealand were also invited to the Third Turkish Antarctic Expedition (TAE III) in 2019 to make demonstration dives so that scientific studies can be heard widely and awareness can be raised (TRTSPOR, 2021).

Thanks to the cooperation between the Postal Telephone Telegraph (PTT) institution and the TUBITAK MAM Polar Research Institute, a stamp and philatelic envelope study was carried out to raise awareness in our country (PTT, 2021). The team photograph taken by the 1st author during the First Turkish Antarctic Expedition on the Island in 2017 was included, and after the stamps issued by the British Antarctic Institution in 1957 and 2015, new stamps representing the Island were added to the archive as in Figure 5.

Fig. 5. Stamps of Horseshoe Island

The expedition was attended by leading institutions in the television and journalism sector of our country, such as TRT World, TRT Documentary, Anadolu Agency, and a total of 3 documentaries, two of them were in English, were screened to increase awareness of the public on polar regions (ATCM 43, BP11; PRI, 2021).

The Polar Science House, which was opened by the authors and funded by Tuzla Municipality, in order to reach more people in the education and awareness activities, welcomes thousands of visitors every year and introduces the polar regions with a room that can cool down to -17°C and models of polar animals. It was opened in 2018 on December 1, World Antarctica Day, and continues to provide free service and bring visitors inside the vision of Polar Regions (PRI, 2021). Also, this Polar Science House becomes the first permanent place in Turkey for Education & Outreach of Polar Research.

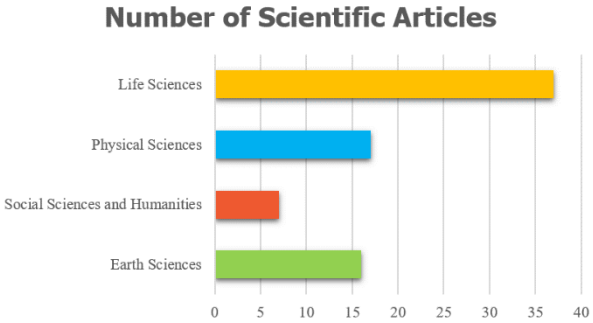

Fig. 6. Current Publication Status of National Polar Science Expeditions

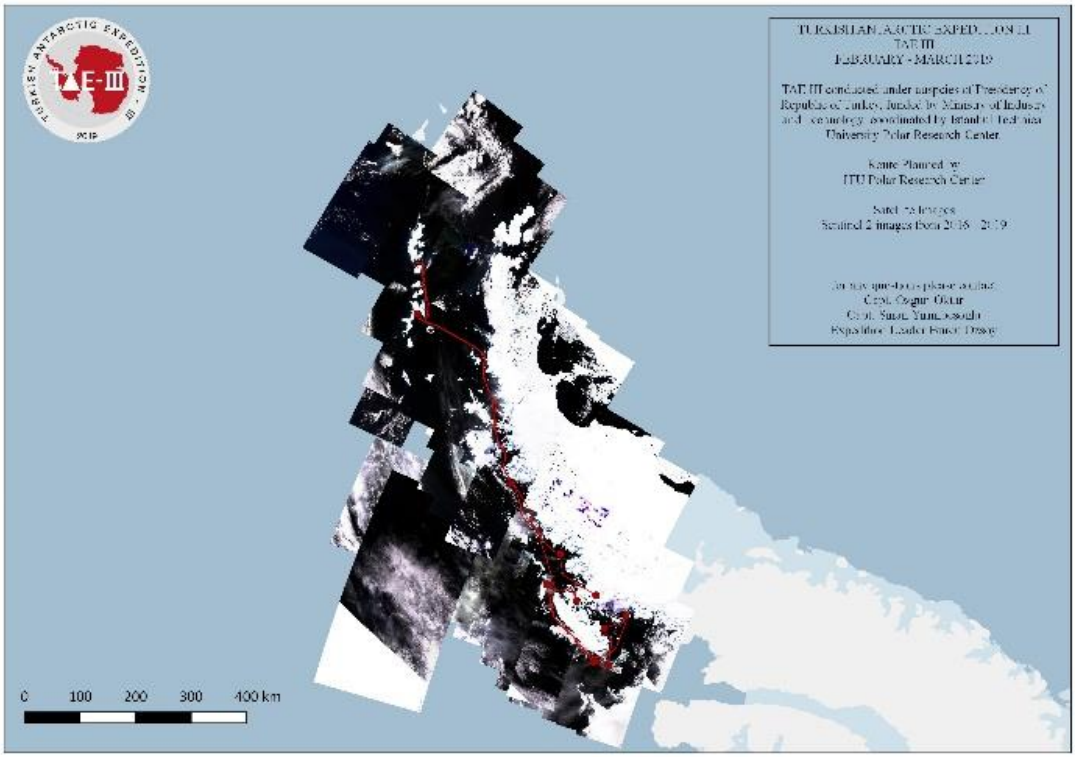

Fig. 7. TAE III Expedition Route with Satellite Data

Publications of National Polar Science Expeditions

Many researches carried out by our country from 2017 to November 2021 within the scope of both Arctic and Antarctic have taken their place in the literature as scientific publications. In Figure 6, the diffractions of scientific articles of these studies in four main areas are given (PRI, 2021). While publications and species discoveries are carried out mostly in life sciences, it is seen that the number of studies in social sciences and humanities researches are less. The physical and earth science studies were carried out with a similar amount of publications.

Logistics Studies

In the Turkish Antarctic Expeditions, the scientific research ship is actively used in logistics operations where more than 40 tons of material is moved each year, and cargo transportation, including the cold chain, is carried out in the intercontinental travel of the expedition equipment and samples collected from Antarctica. Although the works are carried out successfully thanks to the trade and cargo transportation between developing countries, especially sea ice occurrence, plus icebergs, in the Southern Ocean hinders logistics operations on a large scale. Meteorological conditions and sea ice assessments before each voyage are made with open-source satellite data operated by institutions such as NASA and ESA, as can be seen in Figure 7, and the routes are checked regularly and the weather, iceberg and sea ice conditions are monitored regularly throughout the expedition. The headquarter team also is ensured that logistics activities are not interrupted during expeditions (Yirmibesoglu, 2019). In addition to the active / passive microwave and radar equipment used, satellites such as national satellites *Göktürk 2* and *RASAT* which optical images could be obtained in cloud-free weather, are also used (AA, 2021).

Results

When the studies related to Horseshoe Island in the literature were examined; it has been observed that researches have been carried out in many of the polar sciences under the main and sub-branches of our country's National Polar Science Program (UKBP 2018 - 2022). The UKBP covers the scientific scope of the Scientific Committee on Antarctic Research – SCAR, which we became an associate member in 2016, and a full member in 2021. Our country's aim is to protect the Continent with peace and science, to carry out its scientific studies at least as well as other countries within the Antarctic Treaty System, to support Turkish researchers at the Polar Regions and to cooperate with other countries will make great contributions to scientific studies. It is recommended to focus also on studies within the scope of social sciences and humanities and to aim to conduct studies at the same rate in all four main science fields.

It proved that hosting researchers from other countries increased scientific diversity during the Turkish Antarctic Expeditions, and it continues such studies by signing a Memorandum of Understanding (MoU) with other countries. Considering the publications made in the last five years, it is predicted that many scientific articles will be published about Antarctica in the coming years and contribute to the literature. In addition, if the establishment of a scientific station takes place on Horseshoe Island, which is surrounded by higher mountains on three sides and has a relatively sheltered structure, this number will increase because of the more productive environmental conditions compared to other regions.

In order to carry out all these scientific researches, advanced logistics operations are needed, as seen in other countries' expeditions. The sea ice became the biggest obstacle to reach stations by the sea in the Southern Ocean before icebergs. In particular, for the implementation of scientific studies on Horseshoe Island and its surroundings, the changes of sea ice characteristics such as formation, width and thickness, which had been studied a few in the literature, should be examined. Average conditions for previous years should be studied with remote sensing and it is necessary to make predictions for the following periods by following the sea ice concentration.

While it is important to monitor sea ice, which prevents the navigation of ships and boats, with local methods in limited times during the Turkish Antarctic Expeditions; It is foreseen that it will be useful to analyze the remote sensing data in order to examine the historical data and the conditions during the periods of no in-situ observations. Thus, it will contribute to the efficient and realistic organization of the logistics planning of scientific studies to be carried out on Horseshoe Island and its surroundings. It is underlined that it is extremely efficient and important to maintain the Logistics capabilities that have been put forward during the TAE carried out in recent years.

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