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MASTER

S U R T S E Y

TECHNICAL PROGRESS REPORT

OF

BIOLOGICAL RESEARCH ON

THE VOLCANIC ISLAND SURTSEY AND ITS ENVIRONS

FOR THE PERIOD 1965-1978

Submitted to

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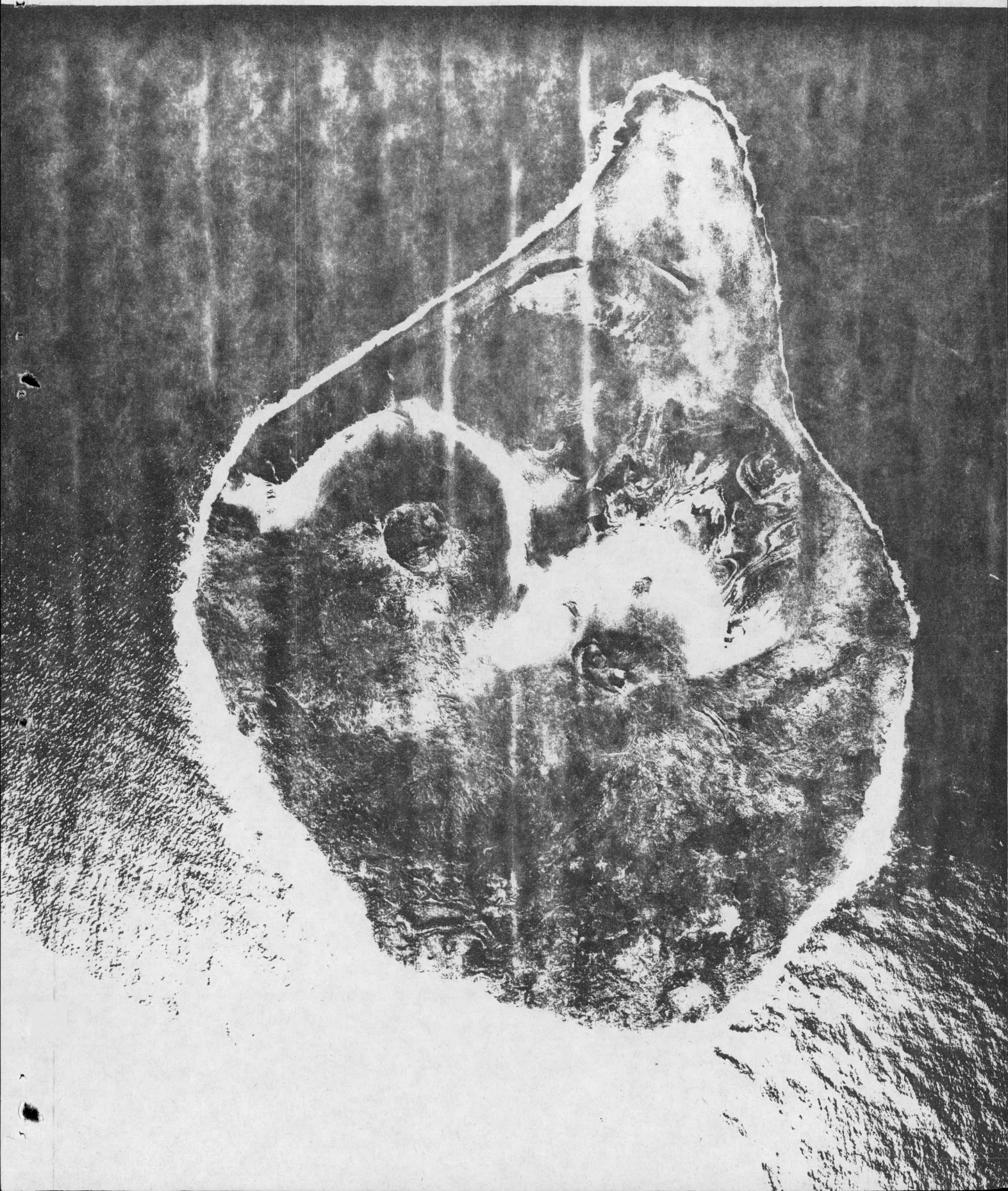


On November 14, 1963, a volcanic eruption started on the ocean floor off the south coast of Iceland, resulting in the formation of an island from a depth of 400 feet. The island was named Surtsey. This year, 1978, marks the fifteenth anniversary of the island.

Soon after the island had been built up, sea gulls were observed resting on the warm cinder, and undoubtedly various micro-organisms were, at the same time, being carried by air and ocean to the island. Surtsey then started to awaken interest among biologists.

My first visit to the island took place on May 14, 1964, and since then I have led the investigation of the terrestrial biota on the island. The investigation has been generously supported by the U.S. Department of Environment under contract No. EY-76-C-02-3531. A number of Icelandic and foreign researchers have taken part in the program, which has required espertise in various fields of science. Reports on the work of these scientists have appeared in the Annual Technical Progress Reports 1965-1976, submitted to the Department of Environment, as well as in the Surtsey Research Progress Report I (1965, II (1966), III (1967),

IV (1968), V (1970), VI (1972), VII (1974) and VIII (1978). The first four of these were mimeographed and are no longer available.

My book Surtsey (published by Butterworths, London, 1975), gives an account of these investigations. This book reports on the various scientific studies carried out on the island and the vicinity during its first years of existence and describes the evolution of the ecosystem. The book Surtsey, Iceland - The Development of a New Fauna (by Lindroth et al., Munksgaard, Copenhagen, 1973, Supplementum 5 of Entomologica Scandinavica) describes the terrestrial invertebrates of Surtsey and other islands in the Westman Islands archipelago as well as the southern part of the mainland of Iceland. The algae were studied by Schwabe, and have been reported on in Surtsey, Island, Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein, special volume, Kiel, 1970. This volume also contains various other Surtsey studies. An overview of theSurtsey research is also given by Schwabe in an article: "Seizure of the Land on Surtsey" (pp.178-208) in the book Iceland by Franz-Karl von Linden and Helfried Weyer, Almenna bókafélagið, Reykjavík, 1974. Articles on the

Surtsey research have appeared in various other journals (see the bibliography at the end of this report). Two books and an article are being submitted with this report.

A Review of the Surtsey Research.

The Changes of the Island.

Ever since the island's formation during the volcanic activities in 1963, its shoreline and surface have been constantly changing. During the first years, while the volcanoes were still producing lava, the island continued to grow towards the south, but at the same time a rapid erosion took place. The volcanic phase came to an end in the spring of 1967 and in the following years there have been great changes in the shoreline. The southerly storm waves erode 30 m high cliffs in the lava on the southern side, which results in a retreat of a maximum yearly average of 40 m. The material is carried from the lava cliffs to the east and to the northern ness as coarse boulders or pebbles and finer sand and is deposited on the leward side where it forms flat terraces.

At the end of the eruption the area of Surtsey was 2.8 km^2. Since then it has decreased by an annual average of 7.5 hectares, or a loss of 60 hectares by 1975.

The sandy tephra cones have also been eroded by wind an water. The 140 m high tephra wall on the western side is becoming steeper and gradually the eastern part of the barren lava is being filled up with drifting sand from the tephra cones and from the northern peninsula (ness).

The heat from the volcanic shaft is emitted through easier outlets further from the center. Thus the thermal area is gradually expanding while the temperature is becoming lower. At present it measures 60-70°C at 100 cm depth.

As the palagonite hardens the water retention increases and as a result dissolved minerals are not as easily washed away. On high points, on the peninsula and on the lava edge, birds roost and add to the fertility of the future soil by their excreta, supplying both minerals and organic matter. The chemical analysis of "soil" indicates an increase in total nitrogen in comparison to earlier data from 1967, especially in respect to NH_4-N and organic nitrogen. The tephra is extremely low in available phosphates except where there are bird droppings or carcasses but it is relatively high in Mg, Ca and Na. The pH of the substrate has gradually become more alkaline

(6.6-6.8) compared to earlier records of 4.5-6.8 in 1965 Table I).

Table Analyses of the virgin lava and tephra sand of Surtsey compared with cultivated soils from Uppland, Sweden.

	mg / 100 g air dried soil		
Constituents	Surtsey sample 14/1972 Lava	Surtsey sample 18A/1972 Tephra	Means from 6 Swedish wheat fields
Phosphorus, P-AL	12.7	6.3	11.3
P-HCl	81.	77.	69.
Potassium, K-AL	13.3	15.5	27.6
K-HCl	370.	360.	388.
Magnesium, Mg-AL	56.0	61.0	29.6
Mg-HCl	3.550.	3.900.	950.
Calcium, Ca-AL	112.	122.	860.
Ca-HCl	3.200.	3.125.	1.060.
Sodium, Na-AL	60.	65.	10.6
Na-HCl	2.018.	2.190.	38.
Sulfur, S	20.	68.	52.
Nitrogen, NH_4-N	6.	7.	6.
NO_3-N	<1.	<1.	26.5
N-Kjeldahl	2.0	2.0	290.
Iron, Fe-AL	193.	200.	31.
Copper, Cu-HCl	40.4	43.7	3.2
Manganese, Mn	0.40	0.31	0.50
Boron, B	0.53	0.16	0.90
Spec. conductance, 20°C	90·10-6	100·10-6	50—190·10-6
pH	6.6	6.8	6.2—7.4

(Henriksson and Henriksson, 1974)

Colonization of Plants.

Micro-organisms are rather quickly carried to Surtsey by air, ocean and animals. During the first years of Surtsey's existence, while the eruption was still active, bacteria and molds were collected on petri-dishes. These were carried to the island as spores mostly during northerly

winds which brought dust from the mainland. These became widely distributed throughout the surface of the Surtsey substrate, but in the beginning there were only small amounts of organic source energy for these micro-organisms and the tephra was not suitable for supporting growth because of high salinity and low moisture content. Such bacteria as Thiobacillus, Beggiatosa and Azotobacter have been found but the nitrogen fixation of these is rather small.

The Surtsey soils are low in organic matter but nitrification processes are taking place with Nitrosomas and Nitrobacter occurring everywhere on the island. Also the denitrifier Thiobacillus denitrificans has frequently been observed in the substrate, indicating that a representative part of the nitrogen cycle is already established on Surtsey.

The algae were similarly dispersed to Surtsey fairly early, a long list of genera have been reported discovered there. In a few cases they have been found to be pioneer plants in moist spots. Most of these algal mats are formed by the cocoid green algae, but not blue-green algae. However, such algae are present and both Anabaena and

Nostoc are known to be fixing small amounts of nitrogen on the island. Some of the fumaroles have various gradients of temperature and moisture where different micro-organisms may find favorable habitats.

In the high temperature areas surrounding steam vents the thermophilic species Mastigocladus laminosus is found at temperatures between 57-64°C At lower temperatures around the fumaroles the moisture is sufficient to allow a colonization of an active population of algae with over 100 species including Cyanophytes and Diatoms. Some of the rare species may predominate there in the new territory still free of competition or even form pure populations.

Lichens were first discovered on Surtsey in 1970 when three species were found there, these were; Placopsis gelida, Trapelia coarctata and Stereocaulon vesuvianum. Since then additional lichen species have been discovered. Some of the species are evenly distributed throughout the lava and have probably been dispersed by wind, such as Stereocaulon vesuvianum, S. Capitellatum, Placopsis gelida and Lepraria. Others like

Xanthoria candelaria was probably brought by birds.

It is suggested that some of the lichens such as Stereocaulon and Placopsia distribute seperately as blue-green algae and the fungus. And, that the algae, which may be found free living on the island (such as Nostoc), are captured there by the fungus.

The new lava fields offer good opportunities for study of the development of the young lichen thalli. Some species colonize the tiny surface cavities formed as air bubbles in the molten lava, and start growing as single lobes out of many adjacent cavities. These small colonies must derive from one diaspore and the fungus spread to nearby cavities.

The mosses were first seen growing in 1967 when the species Funaria hygrometrica was found growing as a pach on a sand-bank. In 1972 the species had increased to 63 and since then there has only been a slight increase in species but a great increase in distribution. The first colonizers were dispersed by spores which apparently came mostly from the mainland by air.

Since moss became well established on the island they have developed reproductive organs and are consequently capable of distributing more rapidly. Thus the species Racomitrium lanuginosum was found bearing capsules in 1972 and has, at present, become one of the most common species on Surtsey. The lava on the island is a favorable habitat for the moss and the moss has virtually colonized most of its area, although the total cover is still rather sparse. The Racomitrium, Bryum and Fumaria having obtained the most extensive cover.

The organic matter produced annually by the moss is increasing and one may expect a gradual development in the coverage of moss on the island in the coming years. The moss will play an important part in soil formation on the lava, and is thus a valuable pioneer for higher plants in this habitat.

Vascular plants

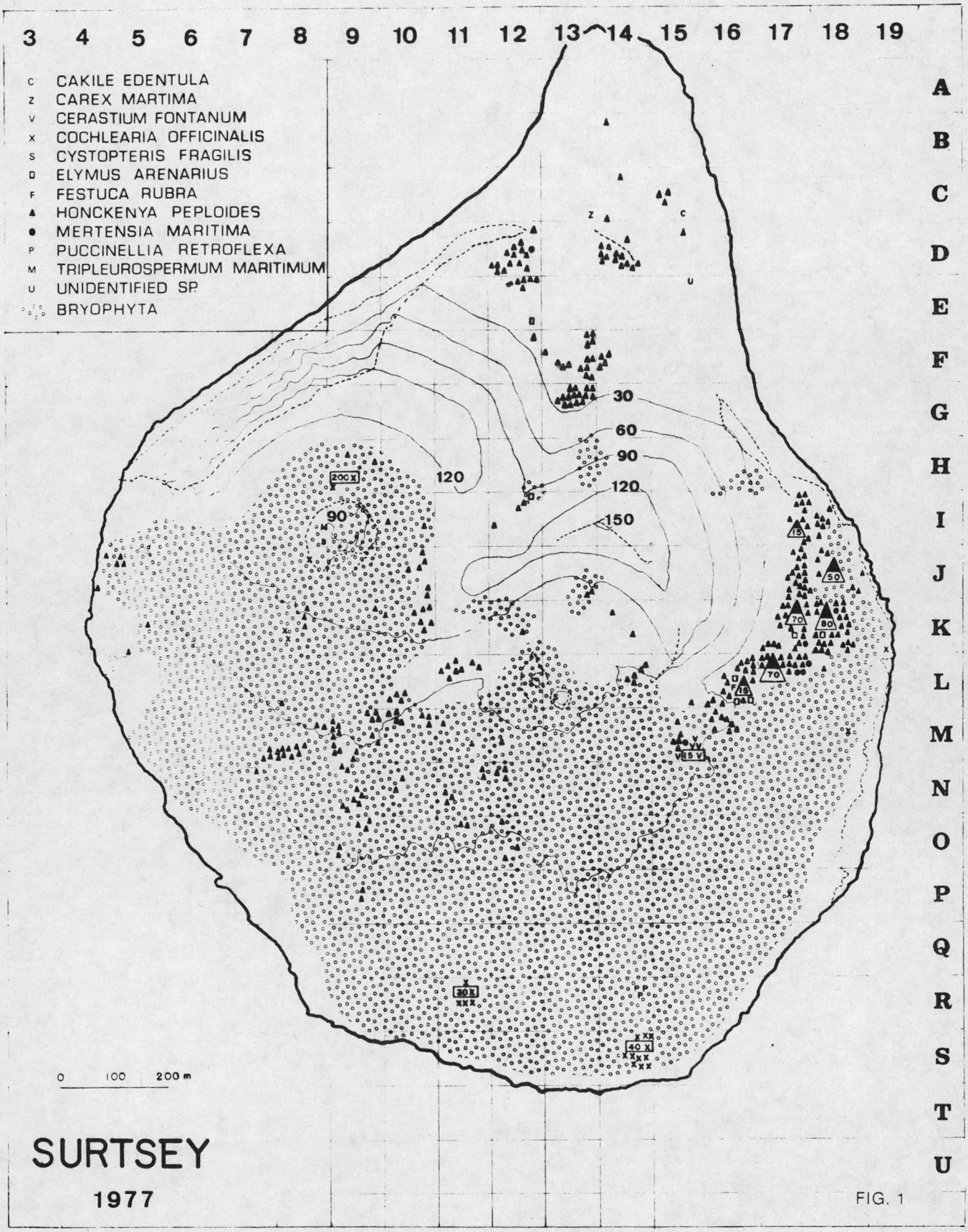
In 1965, the second summer of the island's existence, the first higher plant was discovered growing on Surtsey. This was a sea rocket, Cakile edentula. It apparently derived from seaborn seed as the young plants were found growing at the high tide line in a mixture of sand and decaying sea weed.

The previous year, seed of this and various other species was found on the Surtsey shore, showing that viable seed could float to the island. Later it was found that seeds and other plant parts were carried to the island by other means such as by air and birds, or attached to flotsam.

In 1968 the second plant, lyme grass Elymus arenarius, was found growing on the shore, and on the average one new species per year has been discovered since then, i.e., 17 species of higher plants have been recorded growing on Surtsey during the last 15 years.

In 1967 a sea sandwort, Honckenya peploides, was first observed growing on the island. It has been the major colonizer and is the most common higher plant on the island, with a population of 3080 plants in 1978.

After the first higher plant was observed on Surtsey, plans were made to record all plants using the following method: Early in the summer all overwintering plants were counted and marked on a map. The map has a grid consisting of quadrants of 100 m square each, which are marked numerically and alphabetically. Thus, the location


3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
A B C D E F G H I J K L M N O P Q R S T U
C CAKILE EDENTULA
Z CAREX MARTIMA
V CERASTIUM FONTANUM
X COCHLEARIA OFFICINALIS
S CYSTOPTERIS FRAGILIS
D ELYMUS ARENARIUS
F FESTUCA RUBRA
▲ HONCKENYA PEPLOIDES
● MERTENSIA MARITIMA
P PUCCINELLIA RETROFLEXA
M TRIPLEUROSPERMUM MARITIMUM
U UNIDENTIFIED SP.
BRYOPHYTA
30
60
90
120
150
120
90
200 X
80 X
40 X
0 100 200 m
SURTSEY
1977
FIG. 1

of the plant can be plotted. Aerial photographs were also used to get a more precise location of the plants within the quadrant.

In the latter part of summer any new plants were marked with stakes and given serial numbers. Descriptions were then made of individual plants, indicating length and number of branches, leaves and flowers, and development of fruits.

The distribution of moss was plotted on the same maps. The complete series of maps available was printed in the Surtsey Research Progress Reports (See Fig. 1).

The maps reveal that the main area of colonization of plants has been on the northern peninsula, especially, on its easternmost part. The plants there have grown from seed carried by the ocean, and some have been blown around the eastern cone by the wind into the eastern part of the lava. In that area a sandy lee has been formed from the prevailing S-W wind which provides a root-hold and is gradually filling up the lava hollows.

Other areas of colonization are in the central part of the lava near the craters and on the lava edge. These spots are frequented by

birds and the plants there have most likely derived from seeds borne by birds. These are plant species such as Cochlearia officinalis, Stellaria media, Cerastium fontanum, Festuca rubra and Carex maritima.

Feathery seed has often been found on the island, carried by wind from the mainland, such as the seed of cotton grass. And the wind has played its part in carrying spores of Equisetum arvense up to the crater. The brittle bladder fern, Cystopteris fragilis, which is growing in the crater, presumably started from windblown spores.

After successful reproduction of the colonizer, a new phase of distribution takes place with a radial spread of organisms from the source plant. This has been demonstrated on the island in the case of the sexual reporduction of Cochlearia and the vegetative propagation of Carex maritima.

Perennial species, such as Honckenya and Elymus, are slow to mature. Elymus, a later colonizer has not yet developed flowers on the island. It takes three years for a Honckenya plant to reach the state of flowering.

So a number of plants of this species are reproductive on Surtsey and the colonies are increasing rapidly.

Establishment of communities is such a recent development that the data are incomplete. However, some of the higher plants are growing in the vicinity of moss colonies and some of the Honckenya plants are close to the Elymus plants. These are in the first stage of forming a dune association. And it will be highly interesting to follow this process.

The pioneer species of flora that have so far established themselves on Surtsey are all common inhabitants of the neighbouring islands. But the flora on Surtsey may become more varied than on the rest of the archipelago due to Surtsey's greater size and diversified topography. There is only limited competition so far between the scattered individuals and, as yet no succession among the higher plants. By comparing the vegetation on Surtsey with that of adjacent islands and with isolated lava flows and nunataks on the mainland much can be learned and predicted about the future development of the juvenile community of Surtsey.

The microfauna.

To start with there was a minimal amount of organic matter produced by vegetation on Surtsey for the support of any substantial amount of life at higher tropic levels. Most of the animals

observed on Surtsey were visitors belonging to other ecosystems. A few were partial occupants, so members of the microfauna soon became permanent colonizers.

The pioneers of the microzoa were capable of reproducing asexually, readily becoming resting forms that could in this stage be transported to the island. Among the tephra on Surtsey flagellated protozoa were pioneers, and in 1971 scientists observed nematodes of species which are known to survive desiccation and other severe environmental conditions.

All the forms hitherto encountered of Amoebida, Testecea and Bdelloidea feed on algae,bacteria or detritus, and thus the ecological pyramid consists of only the two lowest tropic levels, as no predators have yet been found among the micro-organisms.

The number of species is yet rather small and has not increased noticeably in the last year. The developmental curve of this biological group is still considered to be in the lag phase of the primitive ecosystem of the island.

The land invertebrates have gradually increased in numbers since the first diptera fly was observed in 1964. In 1965, five more species of flies and midges were collected. In 1970, the number had increased to 112 species of Insecta and 24 of Arachnoidea. And, in 1976 the number of arthropods had increased further by 33 new species.

The introduction of invertebrates to Surtsey can take place through several means, such as by wind, water, other animals and man, or by their own wing support.

All the insects discovered so far have been winged. Many of these, such as butterflies and moths are excellent flyers and have come to the island on their own; other smaller ones were aided by favourable winds.

Spiders have been carried to the island on the thread secreted by these organisms. It has also been demonstrated that certain invertebrates have been transported directly by the sea, as for example, the puparia of Diptera, which arrived in the flotsam and later produced the parasitic wasp Eupteromalus fusicola Walk, which is indigenous to the Westman Islands. The pupa presumably

became infected outside Surtsey and the inhabiting wasp managed to survive the oceanic transport.

In other instances invertebrates may be carried by all sorts of flotsam. Thus in 1966 mites were observed on a gatepost which had drifted ashore, and repeatedly floating tussocks of grass have been shown to carry hundreds of individuals of a number of species of invertebrates. This transport may be of great importance for the establishment of soil fauna on Surtsey. It was also demonstrated that birds were carrying insects on the exterior of their bodies and even in their alimentary tracts.

Although there are strict regulations regarding visitors, they may be responsible for bringing in certain insects. It is believed that at least two species of flies - Drosophilia and Musca - were most likely transported inadvertently with the provisions of visiting scientists.

Most of the invertebrates on Surtsey have come from the neighbouring islands and the mainland. Consequently, the fauna in these areas was investigated in order to determine the distance of dispersal

for the various species. Most of the insects found so far are casual visitors with little chance of survival. Others, however, have become permanent inhabitants and find food source in plant colonies, among the carcasses, or other organic matter that has washed ashore. Three species are known to breed there, i.e., the fly Heleomyza borealis, the collembola Archistoma and the midge Cricotopus variabilis. Eight species of spiders have been found on Surtsey and some are known to breed there.

The birds were among the first living beings to arrive on Surtsey. Sea-gulls are common at the Westman Islands and frequently roosted on Surtsey during its eruption. Since then the local sea-birds have occupied the island and are a major influence in the island's ecosystem supplying fertilizer with their excreta, both in the form of minerals and organic matter, and by transporting diaspores and various invertebrates to Surtsey. The island is the sourthernmost dryland of Iceland and it is commonly visited by migratory birds in spring and autumn. It is also frequented by stragglers that drift off course. Over 60 species of birds have been recorded on Surtsey. It has been observed that some of these birds, i.e., both

geese and snow buntings have carried seed to the island. But apart from that, these visitors play a minor role compared with the local birds.

The ornithological work carried out on Surtsey has been important for demonstrating the exact time of arrival of various migrants to Iceland, their physical condition after the flight across the ocean and the part they play in transporting other organisms, as well as the time of exodus in the autumn.

In 1970 the first birds started nesting, i.e., the fulmar and the black guillemot since then three more species have started to lay eggs on the island, i.e., kittiwakes, black-backed gulls and a tern. The first three species occupy the sea-cliffs on the southern coast, but the black-backed gull has bred on the lava. All the birds, except the tern, are now breeding permanently on the island and their colonies are becoming an integral part of the island's ecosystem, although they have to obtain food to feed their young from the nearby ocean.

The nesting places of the black-backed gulls have been of special interest. The birds collect vegetation nearby to place in their nest, or build

it in a plant colony and thus have an effect on the vegetation. A nesting ground may be of importance as a center for colonization of both plants and invertebrates from where these may spread to other areas of the island.

The mammals on Surtsey are represented by seals that often come ashore and lie on the beaches. Females of common seal are accompanied by their young and some of the families may be considered permenent residents of Surtsey, thus most divisions of the plant and animal kingdom have been introduced in the island's ecosystem. It will be very interesting to follow further developments in the communities of these first colonizers.

Future trends

Surtsey's ecosystem is only 15 years old. During this time there has been a tremendous change in the topography on the island. High sea cliffs have been formed as well as coastal planes with sand, pebbles and boulder terraces. Surtsey is very vulnerable to erosion but just the same it will remain an island for thousands of years to come.

During these 15 years numerous species of plants and animals have been recorded on the island, but only a few have become successful colonizers. On various occasions it has been possible to demonstrate the origins and means of dispersal, and it has been surprising to see how the many different ways are available for transporting organisms to a remote island.

For a better understanding of the dispersal routes it was necessary to study species on the adjacent land masses. The Surtsey study has thus led to a close investigation of the biota of other Westman Islands and well as the southern shore of the mainland. The vicinity is therefore more thouroughly studied than most other parts of Iceland.

On Surtsey it has been possible to demonstrate step by step how the most durable organisms succeed in surviving the transport and the inhospitable environmental conditions on the island, their means of forming colonies, and the development of communities.

So far, only the pioneer are present on the island, and no successors have been recorded. But by comparison with older communities on other Westman islands as well as those on lava fields of

different ages on the mainland and mountain isolates and nunataks, much can be surmised about the future development of the Surtsey communities. Similarly, the Surtsey biota may be compared to that of other islands of different size, age, topography, remoteness, climatic conditions and differences in available species of the neighbourhood. Such subjects are discussed in one of the last chapters of my book on Surtsey 1975. References to other articles on the Surtsey Research are found in the attached list which gives titles of some 150 papers dealing with the biological studies on Surtsey's environment. The results of the study on birds and vegetation on Surtsey and environs for the years 1977 and the summer of 1978 is given in appendixes.

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Observations of Vascular Plants on Surtsey, Summer 1977.

Plants were observed on excursions to the island from June 15 - June 23 and July 27 - August 8.

Eleven plant species were recorded on Surtsey in the summer of 1977. In addition to the 10 species which grew there in 1976, Cakile edentula was now found, which had been found quite often on Surtsey before. One plant was also found which may be of the species Atriplex patula, but because of its small size it was not possible to determine its classification. If it is patula, this is the first time that this species has been found on Surtsey.

Of the 1132 plants which were recorded on Surtsey in autumn 1976, 489 were found living in the spring of 1977. 473 new plants were found in the summer of 1977, and 962 plants were registered on Surtsey in the autumn of 1977, 170 fewer than in 1976. This decrease was primarily caused by the fact that only 256 seedlings (all scurvy-grass) were recorded in 1977, while in 1976 there were 452 (scurvy-grass and cerastium), so that the mature scurvy-grass and cerastium fontanum plants have considerably decreased since 1976.

In spite of this the total number of mature plants increased from 680 in 1976 to 706 in 1977, which results from the continual spread of sea-sandwort - Honckenya peploides.

It is probable that more numerous seedlings would have been found, both of scurvy grass, cerastium, and sea-sandworts, had the plants been examined later in the summer, but they were not observed after August 4.

Two plant species flowered for the first time on Surtsey in 1977: Mertensia maritima and Tripleurospermum maritimum. Both species probably developed seed. Six plant species in all flowered on Surtsey in 1977, in addition to those named above, there were sea rocket, scurvy-grass, cerastium and sea-sandwort. (Table 1 and 2)

Individual Species

Honckenya peploides (L)

There was little decrease in sea-sandwort from 1976 to 1977. 422 of the 500 plants which grew on Surtsey in 1976 were there in 1974, or 84%, which may be the highest percentage to have survived between years. 210 new plants in all were found in the summer of 1977 and there were 632 sea-sandwort plants recorded on Surtsey in the autumn of 1977.

TABLE I

VASCULAR PLANTS IN SURTSEY 1977.

Year of Marking:	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	TOTAL
Species:											
HONCKENYA PEPLOIDES MARKED	10	1	9	6	4	52	20	62	168	90	422
UNMARKED										210	210
											632
COCHLEARIA OFFICINALIS OLD PLANTS			1	8	11	2		3	3		30
SEEDLINGS			8	26	20			2	200		256
											286
CAREX MARITIMA										1	1
TRIPLEUROSPERMUM MARITIMUM									1		1
PUCINELLIA RETROFLEXA							1		1		2
CYSTOPTERIS FRAGILIS					1					1	2
ELYMUS ARENARIUS						2	5		1		8
MERTENSIA MARITIMA							4	2		2	8
FESTUCA RUBRA										1	1
CERASTIUM FONTANUM								9	10		19
CAKILE EDENTULA										1	1
ATRIPLEX PATULA (?)										1	1
											962

Overwintering Plants: 489

New Plants: 473

962

Seedlings (of Cochlearia off.): 256

Mature Plants: 706

962

TABLE 2

TOTAL NUMBER OF PLANTS IN SURTSEY PR. YEAR, 1965-1977.

Year:	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
ecies:													
KILE EDENTULA	23	1	22		2			1	33	2	5		1
YMUS ARENARIUS		4	4	6	5	4	3		66	26	12	10	8
NCKENYA PEPLOIDES			24	103	52	63	52	71	548	856	428	500	632
RTENSIA MARITIMA			1	4				15	25	41	11	6	8
CHLEARIA OFFICINALIS					4	30	21	98	586	377	863	501	286
ELLARIA MEDIA						4	2	2	1				
STOPTERIS FRAGILIS							1	4	3	3	2	2	2
GELICA ARCHANGELICA								2	2				
REX MARITIMA								1	1	1	3	2	1
CINELLIA RETROFLEXA								2	1	9	8	8	2
IPLEUROSPERMUM MARITIMUM								1	5	2	2	2	1
STUCA RUBRA									1	1	2	1	1
RASTIUM FONTANUM											106	99	19
UISETUM ARVENSIS											2		
LENE VULGARIS											1		
GINA SP											1		
NCUS SP											1		
RIPLEX PATULA (?)													1
IDENTIFIED PLANTS				1			4	2	1	1	2	1	
TOTAL	23	5	51	114	63	101	83	199	1273	1320	1449	1132	962
LANTS FROM PREVIOUS YEAR					23	18	40	49	104	537	446	502	489
OF THE PREVIOUS YEAR S LANTS SURVIVING					20%	29%	40%	52%	52%	42%	34%	35%	43%

TABLE 3

H O N C K E N Y A P E P L O I D E S

Settlement, increase and development of Honckenya peploides plants in Surtsey.

Year	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
Plants from previous year	0	0	23	18	31	38	41	197	261	337	422
New plants found in summer	24	103	29	45	22	33	507	659	167	163	210
Total number of plants in autumn	24	103	52	63	53	71	548	856	428	500	632
% of the previous year's plants surviving		0	22	35	49	73	58	36	31	79	84
Number of plants with flowers	0	0	0	0	5	12	18	28	28	73	166
Number of plants with mature seeds	0	0	0	0	1	7	12	12	17	36	108

FIG.2

HONCKENYA PEPLOIDES

Flowering and seed-formation of Honckenya peploides plants in Surtsey 1971 - 1977.

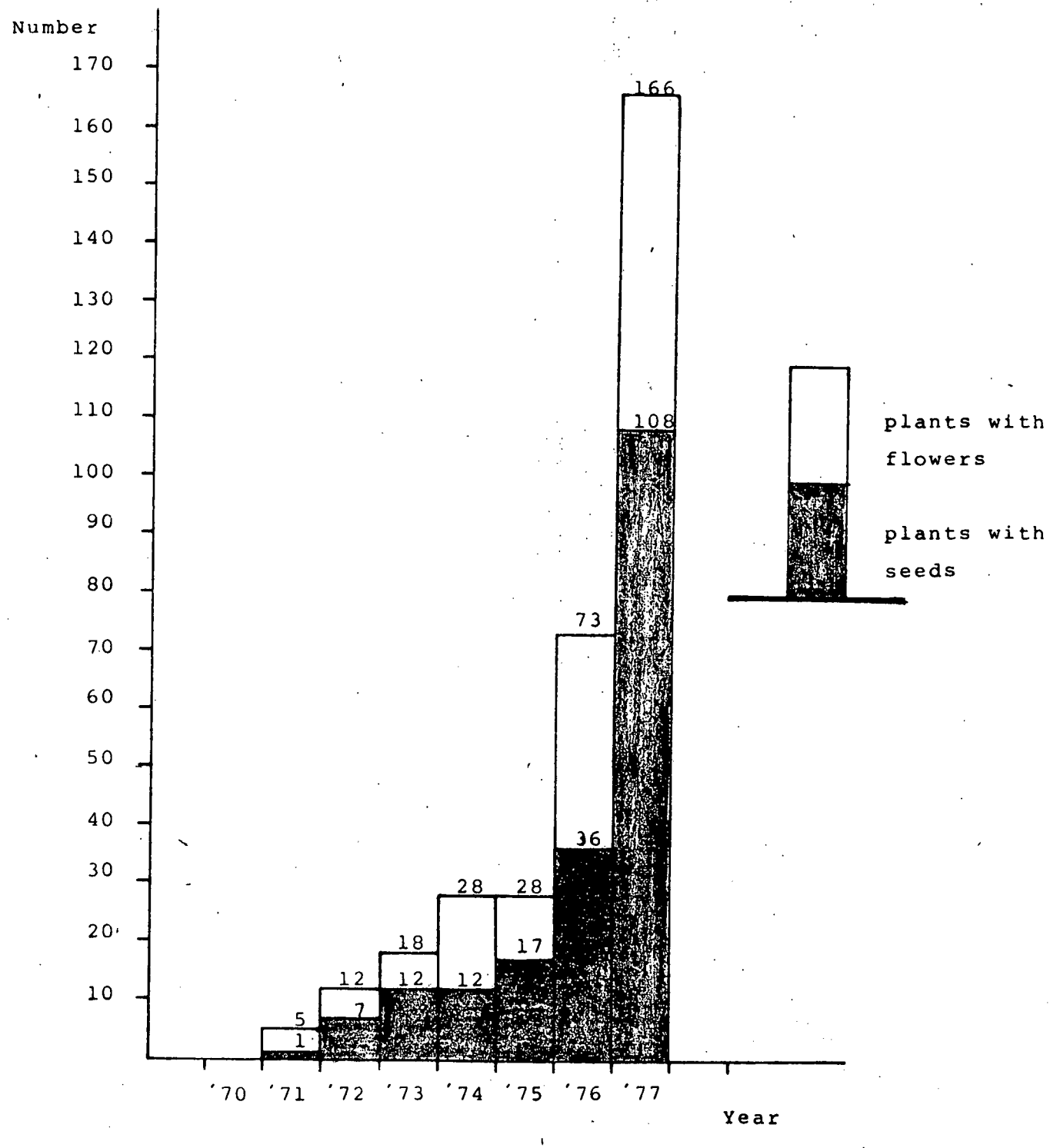
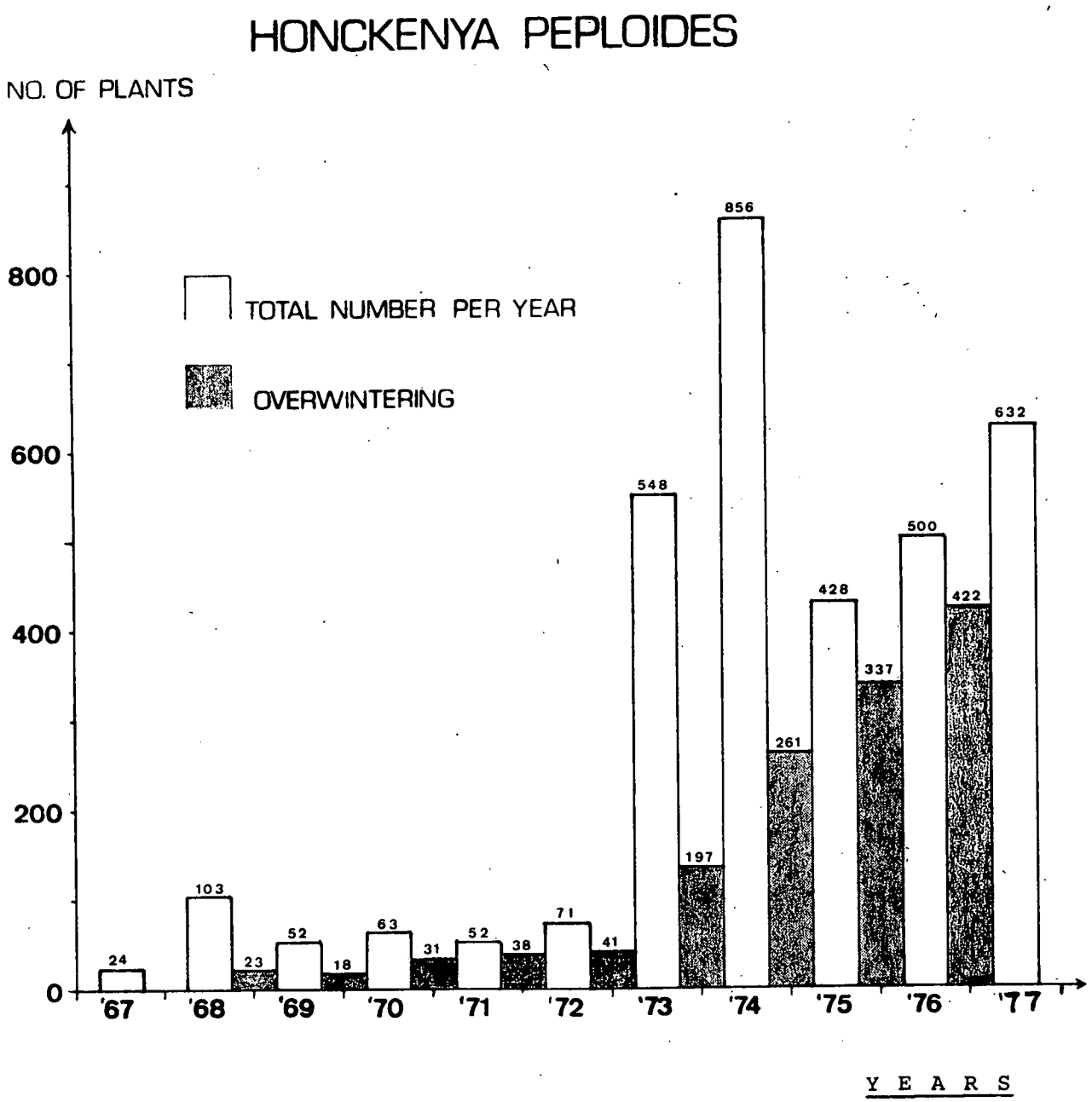


FIG. 3


HONCKENYA PEPLOIDES
NO. OF PLANTS
800
600
400
200
0
TOTAL NUMBER PER YEAR
OVERWINTERING
24
103
23
52
18
63
31
52
38
71
41
548
197
856
261
428
337
500
422
632
'67
'68
'69
'70
'71
'72
'73
'74
'75
'76
'77
YEARS

A large number of plants - 166- flowered in 1977, the greatest number so far (see Table 3 and Figures 2 and 3). Of these 166 plants, 108 plants were recorded as bearing fruit in 1977. In 1976, 73 plants flowered and 36 bore fruit, the greatest number at that time. This shows how the growth of sea-sandwort plants has jumped since 1976. It is probable that this great rise in seed production will lead to a considerable increase of sea-sandwort plants on Surtsey in the coming years.

The largest sea-sandwort plants now cover over 1 square meter, and the plants which have achieved this size are: 70-37 (110 x 95 cm), 70-39 (120 x 100 cm), 71-43 (120 x 90 cm).

A breeding pair of black-backed gulls used plant 71-69 as a nest and laid 3 eggs there in the spring of 1977. Three young broke through the eggs between June 18-20. At that time the plant was 50 x 40 cm with about 30 flowers. The nest formed approximately a 20 x 30 cm basin, but within this depression the growth was mostly destroyed. The abundant gull droppings caused a great burst of growth in the plant, as by the end of July it has become the largest and most luxuriant plant on the island, with a little more than 100 flowers, although fruit had not then appeared.

It had consolidated itself anew and the nest basin was scarcely visible. The plant had increased its area from approximately 2000 square centimeters (50 x 40 cm) to approximately 12,000 cm^2 (120 x 100 cm) in 6 weeks. Other sea-sandwort plants of similar size in June (2000 cm^2 which grew under ordinary conditions without droppings, by and large did not attain twice their area by the end of July, which indicates the influence which the droppings had on the growth of plant 71-69.

Sea-sandwort plants ran somewhat afoul of the black-backed gulls which bred on Surtsey, but they used some of the sea-sandwort plants for their nests. The traces of this can be seen in scarcely 40 plants.

Cochlearia officinalis L.

Scurvy-grass decreased considerably on Surtsey from 1976 to 1977. Of the 501 plants recorded in 1976 391 were seedlings. In 1977 only 30 "large" plants were found, of which 2 were new, and there were 256 seedlings. The total number of scurvy-grass plants in autumn 1977 was 286. Only 3 of these 30 "large" plants flowered, plants 71-71, 75-66 and 76-172, but near the last-named about 200 seedlings had developed at the beginning of August 1977.

Seed had not germinated around the other two plants at that time, but it is possible that this occurred later. Scurvy-grass was found in 9 quadrats in 1977 and in 7 in the previous year. A plant was now found in quadrat K-19, where there was none in 1976. Plant 71-71 in quadrat P-10 dropped out of the register in 1976, but reappeared in 1977.

Carex maritima GUNN

Plant no. 70-72 in quadrat M-11, which a black-backed gull pair disturbed for nesting in 1976 and nearly destroyed, had completely disappeared in 1977. It seemed that it could not tolerate that gull invasion in 1976 and was killed in the winter of 1976-1977. Plant 75-10 in quadrat M-19, which vanished in August 1976, had not grown again and may be counted among the departed.

A new Carex maritima was found on July 29 in quadrat C-13, and it was given the number 77-96. This tiny plant consisted of 1 culm with 3 small leaves. The location of this plant indicates that the seed from which it grew was carried to Surtsey by the sea. This plant was not destined to live long, for kittiwakes pulled it up on August 2 and destroyed it. Thus birds have destroyed all the sedges on Surtsey.

Tripleurospermum maritimum (L) Koth.

The daisy, 72-40, in quadrat S-14 had vanished in 1977, but the daisy which was found in the lava crater, Stori-Gígur, in 1976 (76-171) was doing well. It bore about 40 leaves and reached a diameter of about 15 cm. Then it flowered and there were two heads on the same stalk. This was the first time that daisies had flowered on Surtsey. Conditions in the crater seemed to be extremely good for the daisy and it is probable that there will be an increase in daisies on the island should this plant succeed in ripening seed.

Pucinellia retroflexa (Curt.)Holmberg.Borealis Holmberg.

Out of 8 Puccinellia which were on Surtsey in 1976, only 2 lived through the winter. No new plant was found in 1977. The two plants which are now growing on Surtsey are: 74-89, which consisted of 6 culms and 27 leaves, and 76-142, which consisted of 1 culm and 4 leaves. Neither plant flowered in 1977.

Cystopteris fragilis (L) Bernh.

Plant 72-113 in I-8 survived the winter, but plant 73-599 disappeared in 1977. A new plant was found in 1977, number 77-89, which grew in a moss tuff on a vertical lava face in Litli-Gígur in

quadrat L-16. This plant consisted only of 1 frond of about 1 cm in length.

Plant 72-113 thrived during the year. It had 5 fronds and 2-3 buds at the end of July. The longest frond was about 15 cm. It was not fertile.

Elymus arenarius L.

Out of 10 lyme-grass plants in 1976, 8 survived the winter. No new plants were found in 1977. Plant 74-51 in quadrat K-18 was, as before, the largest lyme-grass plant on Surtsey, and it increased markedly over the summer but did not bloom. On August 1, 1977, the plant had 24 culms with 96 leaves; the longest leaves were 50 cm. There was about 160 cm between the ends of the culms. In 1976, this plant had 6 sprouts and 28 leaves. Plant 74-55 did well, having 14 culms and 42 leaves on August 1, 1977, with 55 cm between culms then. In 1976 it had 4 culms and 14 leaves. Plant 74-78, in L-16, has also become of great size; on August 1, 1977, there were 12 culms and 27 leaves, while in 1976 it had 7 culms and 21 leaves. Other lime-grasses had 1-5 culms and 3-17 leaves.

Although lyme-grass decreased on Surtsey in the last year, it is clear from the plants that do

grow there that the conditions on Surtsey are favorable for lyme-grass. The limit of seed dispersal or lack of germination on Surtsey rather than the growing conditions on the island is probably the main cause of the scarcity of lyme-grass. The plants that have achieved a certain development on Surtsey propagate only by roots, without attempting to flower as of yet. If nothing unexpected occurs, the largest plants should be bearing seed within a few years, which must lead to the increase of the lyme-grass and the area it covers.

Mertensia maritima (1) S.F. Gray.

All 6 Mertensia maritima from 1976 survived the winter. In 1977 two new plants were also found. Two plants flowered on Surtsey in 1977, which had never occurred before. Plant 74-53, on quadrat K-18, bore 4 clusters of flowers with 28 blossoms in all. On August 1, 1977, about 10 seeds had dropped, which lay nearby the plant. Plant 75-6 flowered as well and bore 4 clusters of flowers, but birds destroyed it during the summer and it did not bear seed.

Festuca rubra L.

The Festuca rubra in quadrat L-12, which

a pair of great black-backed gulls used as material for nest-building in 1976, did not appear in 1977 and is most likely dead. An extremely small Festuca rubra was found in quadrat L-16 and numbered 77-90. This plant had only 1 culm with 2 leaves.

Cerastium fontanum, Baumg.

There was considerable decrease in Cerastium fontanum from 1976 to 1977. In 1976, 38 mature plants were found, which were all overwintered. On July 31, 1977, there was a total of 96 culms, or an average of 5 per plant. Of the plants,13 bloomed in 1977.

Cakile edentula (Bigel) Hook.

One Cakile edentula was found on Surtsey in 1977, but none in 1976. This plant is number 77-94 and is located in quadrat D-15, consisting of 1 branch with 5 leaves. It bore 3 flowers on August 2, but no fruit.

Cakile edentula,which is an annual, has not managed to find a firm foothold on Surtsey. It is conceivable that meager soil hinders the plant from achieving the level of development necessary to maintain the minimum seed production to establish itself firmly.

Most of the Cakile edentula which have been found on Surtsey have been very puny and seed production has been extremely small. Occasional plants have nevertheless come to maturity and achieved considerable seed production, but that is not sufficient to ensure the preservation of Cakile edentula on the island. The existence of Cakile edentula on Surtsey is almost totally dependent on dispersed seed and there are obvious yearly changes in the number of plants on the island.

Table 4

Year	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
Number	23	1	22	0	2	0	0	1	33	3	5	0	1

It would be interesting to investigate during the coming years what connection exists between the number of Cakile edentula and seed production on Heimaey and the number of plants on Surtsey the following year. Still, it is more likely that the weather or the prevailing wind following the fall of seed on Heimaey and on the southern coast of Iceland is the deciding factor for whether seed is dispersed in any quantity on Surtsey.

Atriplex patula L.

As was mentioned above, a plant was found in quadrat E-15, numbered 77-94, which is possibly

of the species Atriplex patula, but the smallness of the plant prevented a firm decision. This plant grew together with some sea-sandwort on the high tideline and there is no doubt that the seed from which it grew was carried to Surtsey by the ocean.

Atriplex patula is a common beach plant on Iceland and also on Heimaey.

List of Vascular Plants discovered in Surtsey in 1977

No.	Quadrat	Species
68-8	J-18	Honckenya peploides
68-21	J-18	" "
68-22	J-18	" "
68-24	J-17	" "
68-56	K-18	" "
68-64	J-18	" "
68-70	J-18	" "
68-83	K-17	" "
68-87	J-18	" "
69-62	F-13	" "
70-4	J-18	" "
70-20	J-18	" "
70-25	J-17	" "
70-31	J-18	" "
70-37	E-12	" "
70-39	G-13	" "
70-42	F-13	" "
70-60	F-13	" "
70-64	I-17	" "
70-74	S-14	Cochlearia officinalis
71-35	J-4	Honckenya peploides
71-43	F-13	" "
71-47	F-13	" "
71-54	S-14	Cochlearia officinalis
71-57	P-17	" "
71-63	J-13	Honckenya peploides
71-68	J-5	" "
71-69	N-10	" "
71-71	P-10	Cochlearia officinalis
71-75	R-11	" "
72-30	J-4	Honckenya peploides
72-34	S-14	Cochlearia officinalis
72-37	S-14	" "
72-41	S-14	" "
72-42	S-14	" "
72-44	S-14	" "
72-53	S-14	" "
72-56	K-5	Honckenya peploides
72-83	F-14	" "
72-113	I-8	Cystopteris fragilis
72-114	K-5	Honckenya peploides
73-48	I-17	Honckenya peploides
73-51	I-18	" "
73-65	I-17	" "
73-165	G-13	" "
73-170	F-14	" "

No	Quadrat	Species
73-222	I-17	Honckenya peploides
73-265	K-17	" "
73-272	K-17	" "
73-275	K-17	" "
73-276	K-17	" "
73-278	L-17	" "
73-282	L-17	" "
73-285	L-17	" "
73-287	K-17	" "
73-305	J-17	" "
73-317	J-17	" "
73-318	J-17	" "
73-320	J-17	" "
73-321	J-17	" "
73-322	J-17	" "
73-324	J-17	" "
73-344	K-17	" "
73-347	K-17	" "
73-349	K-17	" "
73-351	K-17	" "
73-352	K-17	" "
73-353	K-17	" "
73-354	K-17	" "
73-355	K-17	" "
73-356	K-17	" "
73-357	K-17	" "
73-361	K-17	" "
73-363	K-17	" "
73-364	K-17	" "
73-365	K-17	" "
73-372	L-11	" "
73-385	K-17	" "
73-388	L-17	" "
73-390	K-17	" "
73-395	L-17	" "
73-409	L-16	" "
73-423	L-16	" "
73-437	L-17	" "
73-440	K-17	" "
73-444	K-18	" "
73-448	J-18	" "
73-449	J-18	" "
73-509	J-18	" "
73-538	K-18	" "
73-545	K-17	" "
73-567	K-17	Elymus arenarius
73-580	L-16	Honckenya peploides
73-587	K-17	" "
73-594	L-16	Elymus arenarius
73-596	R-11	Cochlearia officin.
73-600	M-18	" "

No	Quadrat	Species
74-2	M-10	Honckenya peploides
74-4	M-9	" "
74-5	M-9	" "
74-6	M-9	" "
74-7	M-10	" "
74-9	K-10	" "
74-11	I-10	" "
74-13	J-10	" "
74-15	J-10	" "
74-18	J-10	" "
74-19	J-10	" "
74-21	J-10	" "
74-22	K-10	" "
74-23	K-10	" "
74-24	K-10	" "
74-27	I-10	" "
74-29	M-8	" "
74-30	M-9	" "
74-31	M-7	" "
74-32	M-8	" "
74-51	K-18	Elymus arenarius
74-52	K-17	Honckenya peploides
74-53	K-18	Mertensia maritima
74-55	K-17	Elymus arenarius
74-62	L-17	Mertensia maritima
74-68	L-17	" "
74-73	K-17	" "
74-78	L-16	Elymus arenarius
74-79	L-15	" "
74-89	R-14	Pucinellia retroflexa
74-90	I-12	Elymus arenarius
75-1	S-14	Cochlearia officinalis
75-6	M-15	Mertensia maritima
75-7		Honckenya peploides
75-8	M-15	" "
75-9	M-16	Cerastium fontanum
75-12	N-12	Honckenya peploides
75-13	M-11	Honckenya peploides
75-15	M-12	" "
75-16	L-11	" "
75-17	L-11	" "
75-18	N-11	" "
75-19	M-9	" "
75-20	L-11	" "
75-22	M-9	" "
75-23	M-12	" "
75-24	M-9	" "
75-25	M-9	" "
75-26	M-9	" "
75-27	N-9	" "
75-28	M-9	" "
75-31	M-9	" "
75-32	M-9	" "
75-33	M-8	" "
75-34	M-9	" "
75-35	M-8	" "
75-36	M-8	" "
75-38	N-9	Honckenya peploides
75-39	M-8	" "
75-40	H-9	" "
75-41	M-8	" "
75-42	M-9	" "
75-43	O-9	" "
75-44	M-8	" "
75-45	M-8	" "
75-46	O-9	" "
75-47	M-7	" "
75-48	N-9	" "
75-49	N-9	" "
75-50	O-9	" "
75-52	L-17	" "
75-53	M-15	" "
75-56	N-9	" "
75-57	N-9	" "
75-58	N-12	" "
75-59	L-17	" "
75-60	D-12	Mertensia maritima
75-61	G-13	Honckenya peploides
75-63	J-18	" "
75-65	L-16	" "
75-66	J-8	Cochlearia officin.
75-67	K-10	Honckenya peploides
75-69	K-8	Honckenya peploides
75-72	K-8	" "
75-76	K-8	Cochlearia officin.
75-78	O-11	Honckenya peploides
75-105	P-9	" "
75-106	N-11	" "
75-107	N-11	" "
75-108	K-18	" "
75-109	K-18	" "
75-111	D-14	" "
75-112	D-12	" "
75-114	D-12	" "
75-115	D-14	" "
75-116	D-14	" "
75-118	D-14	" "
75-119	I-12	" "
76-1	L-10	Honckenya peploides
76-2	K-10	" "
76-3	M-9	" "
76-4	L-10	" "
76-5		" "
76-6	L-14	" "
76-7	L-10	" "
76-8	M-10	" "
76-9	M-14	Cerastium fontanum
76-10	L-14	Honckenya peploides
76-11	M-9	" "
76-12	L-10	" "
76-13	L-11	" "
76-14	M-10	" "
76-15	M-10	" "
76-16	L-14	" "

No	Quadrat	Species
76-18	M-16	Honckenya peploides
76-19	M-16	" "
76-20	M-16	" "
76-21	L-16	" "
76-22	L-16	" "
76-23	L-16	" "
76-24	L-16	" "
76-25	L-16	" "
76-26	L-16	" "
76-27	L-16	" "
76-28	L-16	" "
76-29	L-16	" "
76-30	K-17	" "
76-31	L-16	" "
76-32	L-16	" "
76-33	L-16	" "
76-34	L-16	" "
76-35	L-16	" "
76-36	L-16	" "
76-37	K-17	" "
76-38	L-16	" "
76-39	L-16	" "
76-40	L-16	" "
76-41	L-17	" "
76-42	L-17	" "
76-43	K-17	" "
76-44		" "
76-45	L-17	" "
76-46	L-17	" "
76-47	L-17	" "
76-48	L-17	" "
76-49	L-17	" "
76-50	L-17	" "
76-51	L-17	" "
76-52	L-17	" "
76-53	L-17	" "
76-54	L-17	" "
76-55	L-17	" "
76-56	L-17	" "
76-57	L-17	" "
76-58	L-17	" "
76-59	L-17	" "
76-60	K-18	" "
76-61	K-17	" "
76-62	K-17	" "
76-63	K-17	" "
76-64	K-17	" "
76-65	L-17	" "
76-66	K-17	" "
76-67	L-17	" "
76-68	L-17	" "
76-69	K-18	" "
76-70	K-17	" "
76-71	L-17	" "
76-72	K-18	" "
76-74	K-18	" "
76-75	K-17	" "

No	Quadrat	Species
76-77	K-17	Honckenya peploides
76-78	K-17	" "
76-79	K-17	" "
76-80	F-14	" "
76-81	J-17	" "
76-82	F-13	" "
76-83	G-13	" "
76-84	F-13	" "
76-85	I-17	" "
76-86	G-13	" "
76-87	I-17	" "
76-88	I-17	" "
76-89	G-13	" "
76-90	J-18	" "
76-91	F-13	" "
76-92	I-18	" "
76-93	G-13	" "
76-94	I-17	" "
76-95	I-17	" "
76-96	I-17	" "
76-97	F-13	" "
76-98	I-17	" "
76-99	I-17	" "
76-100	E-13	Elymus arenarius
76-101	J-18	Honckenya peploides
76-102	J-18	" "
76-103	J-18	" "
76-104	J-18	" "
76-105	J-18	" "
76-107	J-18	" "
76-108	K-17	" "
76-109	K-17	" "
76-110	J-18	" "
76-111	J-18	" "
76-112	J-18	" "
76-113	K-17	" "
76-114	J-18	" "
76-115	J-18	" "
76-116	J-18	" "
76-117	J-18	" "
76-118	J-18	" "
76-119	J-18	" "
76-120	J-17	" "
76-121	K-17	" "
76-122	K-18	" "
76-123	K-17	" "
76-124	K-17	" "
76-124	K-17	" "
76-125	K-17	" "
76-126	K-17	" "
76-127	K-17	" "
76-128	K-17	" "
76-129	K-17	" "
76-130	K-17	" "
76-131	K-17	" "
76-132	K-17	" "
76-133	K-17	" "

No	Quadrat	Species
76-135	L-11	Honckenya peploides
76-136	K-17	" "
76-137	K-17	" "
76-138	K-17	" "
76-139	K-17	" "
76-140	K-17	" "
76-141	K-18	" "
76-142	R-14	Pucinellia retroflexa
76-143	L-17	Honckenya peploides
76-144	K-18	" "
76-146	R-11	Cochlearia officinalis
76-147	M-14	Cerastium fontanum
76-149	S-14	Cochlearia officinalis
76-150	L-11	Honckenya peploides
76-151	K-18	" "
76-152	S-14	Cochlearia officinalis
76-153		Honckenya peploides
76-154	K-18	" "
76-155	K-18	" "
76-156	K-18	" "
76-157	K-18	" "
76-158		" "
76-159	K-18	" "
76-160	K-18	" "
76-161	K-18	" "
76-162	K-18	" "
76-163	K-18	" "
76-164	K-18	" "
76-165	K-18	" "
76-166	K-18	" "
76-167	K-18	" "
76-168	K-18	" "
76-169	K-18	" "
76-170	K-18	" "
76-171	K-19	Tripleurosp. maritimum
76-172	H-9	Cochlearia officinalis
76-173	D-12	Honckenya peploides
76-174	D-12	" "
76-175	D-12	" "
76-176	E-12	" "
76-177	E-12	" "
76-178	E-12	" "
76-179	E-12	" "
76-181	D-12	" "
77-1	J-10	" "
77-2	I-17	" "
77-3	I-17	" "
77-4	J-18	" "
77-5	I-18	" "
77-6	J-18	" "
77-7	J-18	" "
77-8	J-17	" "
77-9	I-17	" "
77-10	J-18	" "

No	Quadrat	Species
77-11	I-17	Honckenya peploides
77-12	I-17	" "
77-13	K-18	" "
77-14	J-18	" "
77-15	J-18	" "
77-16	O-9	" "
77-17	J-5	" "
77-18	I-17	" "
77-19	J-18	" "
77-20	J-18	" "
77-21	J-13	" "
77-22	J-17	" "
77-23	I-18	" "
77-24	J-18	" "
77-25	J-17	" "
77-26	K-17	" "
77-27	K-18	" "
77-28	K-18	" "
77-29	K-18	" "
77-30	K-17	" "
77-31	J-18	" "
77-32	K-18	" "
77-33	K-18	" "
77-34	K-17	" "
77-35	J-18	" "
77-36	K-18	" "
77-37	K-17	" "
77-38	J-18	" "
77-39	K-18	" "
77-40	J-18	" "
77-41	K-17	" "
77-42	K-14	" "
77-43	K-17	" "
77-44	O-12	" "
77-45	K-18	" "
77-46	K-17	" "
77-47	L-17	" "
77-48	K-17	" "
77-49	M-16	" "
77-50	K-17	" "
77-51	L-11	" "
77-52	L-11	" "
77-53	L-17	" "
77-54	K-17	" "
77-55	N-11	" "
77-56	L-17	" "
77-57	L-11	" "
77-58	M-15	" "
77-59	L-17	" "
77-60	K-18	" "
77-61	K-18	" "
77-62	L-17	" "
77-63	L-17	" "
77-64	L-16	" "
77-65	L-17	" "
77-66	L-17	" "

No	Quadrat	Species
77-68	L-17	Honckenya peploides
77-69	I-12	" "
77-70	I-12	" "
77-71	M-7	" "
77-72	F-13	" "
77-73	H-9	" "
77-74	J-10	" "
77-75	D-12	" "
77-76	F-13	" "
77-77	J-10	" "
77-78	D-12	" "
77-79	D-14	" "
77-80	K-10	" "
77-81	M-8	" "
77-82	D-12	" "
77-83	D-12	" "
77-84	F-13	" "
77-85	D-12	" "
77-86	K-8	Cochlearia officinalis
77-87	L-18	Honckenya peploides
77-88	K-19	Cochlearia officinalis
77-88*	L-17	Mertensia maritima
77-89	L-17	Honckenya peploides
77-90	L-16	" "
77-91	K-14	" "
77-92	L-16	" "
77-93	D-15	Mertensia maritima
77-94	D-15	Cakile edentula
77-95	E-15	Atriplex patula
77-96	C-13	Carex maritima
77-89*	L-13	Cystopteris fragilis
77-90*	L-16	Festuca rubra

Moss Productivity on Surtsey 1977

The moss crop was measured in quadrat J-8, M-11 and K-18 in August, as in previous years. Three 25 x 25 cm (625 cm^2) samples were taken in each quadrat. An attempt was made to choose spots where the moss was densest in the above-mentioned quadrats. All moss and organic matter was removed from the sample areas, and the sample thus shows the results of many years' production. A comparison of total yield of organic matter in the sample areas each year gives an estimate of the annual production.

The sand was washed from the moss samples, which then were dried at 80°C for one day and then weighed.

The yield measurements for 1977 are shown in Tables 5,6,and 7 along with totals from previous years beginning in 1971. (See also illustration 1 in the 1976 report).

As can be seen in the tables, the biomass of moss has increased considerably since 1976. Samples in J-8 were taken down in the large crater, Stóri-Gígur, where the moss is densest and farthest developed on Surtsey; The density had become so great that the samples which were chosen in 1977 had nearly 100% moss cover. There was no increase in the biomass of moss in quadrat K-18, most likely because considerable sand had invaded the quadrant in the last two years and generally spoiled the conditions for moss growth in the area.

TABLE 5

Biomass of moss from Surtsey 1971 - 1977.

(Dry matter in g/m^2)

Year	Quadrat	Sample weight	Average weight
1971	J-8		0.338
	M-11		1.020
	K-18		0.196
1972	J-8		8.671
	M-11		0.460
	L-18		0.096
1973	J-8	3.698	4.002
	J-8	5.301	
	J-8	3.008	
	M-11	5.256	4.815
	M-11	5.114	
	M-11	4.074	
	L-18	1.738	1.418
	L-18	0.779	
	L-18	1.738	
1974	J-8	17.60	35.99
	J-8	8.48	
	J-8	81.89	
	M-11	8.00	6.99
	M-11	2.40	
	M-11	10.56	
	K-18	1.12	1.60
	K-18	2.72	
	K-18	0.96	
1975	J-8	211.60	185.43
	J-8	170.90	
	J-8	173.78	
	M-11	61.36	36.90
	M-11	28.51	
	M-11	20.82	
	K-18	48.85	31.72
	K-18	12.18	
	K-18	34.13	

TABLE 6

Biomass of moss from Surtsey 1971-1977.

(Dry matter in g/m^2)

Year	Quadrat	Sample weight	Average weight
1976	J-8	218.40	332.96
	J-8	394.88	
	J-8	385.60	
	M-11	30.40	36.64
	M-11	55.84	
	M-11	23.68	
	K-18	1.92	3.84
	K-18	5.76	
1977	J-8	318.88	625.44
	J-8	865.28	
	J-8	692.16	
	M-11	125.44	77.39
	M-11	56.00	
	M-11	50.72	
	K-18	0.48	3.47
	K-18	5.60	
	K-18	4.32	

TABLE 7

Biomass of moss in Surtsey 1971-1977.

(average weight in quadrats d.m. g/m^2)

	YEAR						
Quadrat	1971	1972	1973	1974	1975	1976	1977
J-8	0.338	8.671	4.002	35.99	185.43	332.96	625.44
M-11	1.020	0.460	4.815	6.99	36.90	36.64	77.39
K-18	0.196			1.60	31.72	3.84	3.47
L-18		0.096	1.418				

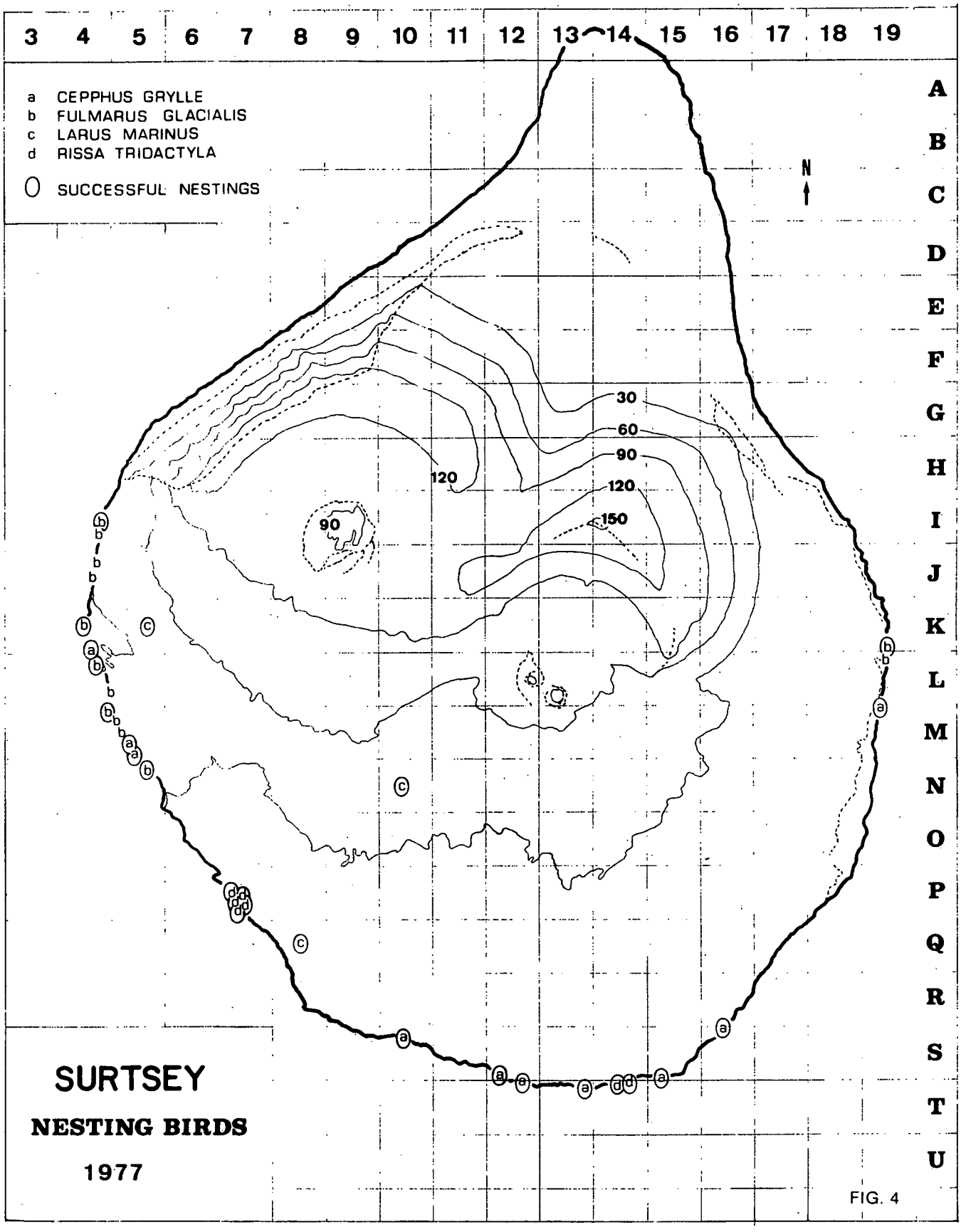

3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
A B C D E F G H I J K L M N O P Q R S T U
a CEPPHUS GRYLLE
b FULMARUS GLACIALIS
c LARUS MARINUS
d RISSA TRIDACTYLA
O SUCCESSFUL NESTINGS
N
30
60
90
120
150
90
120
SURTSEY
NESTING BIRDS
1977

FIG. 4

OBSERVATIONS OF BIRDS ON SURTSEY

Summer 1977

Birds were observed on two trips made to the island of Surtsey, from June 15-23 and July 27-August 8, 1977. Emphasis was placed primarily on nesting birds, but attention was also paid to other species, and all observations that were thought noteworthy were recorded.

Nesting birds:

Four species of birds bred on Surtsey in 1977, all of which had nested there previously. These species were: the FULMAR, which has been nesting there every year since 1970; the BLACK GUILLEMOT, which has also been nesting there yearly since 1970; the GREAT BLACK-BACKED GULL, which has been nesting since 1974, and the KITTIWAKE, which has been nesting since 1975.

All the above-named species produced young in 1977. The different nesting patterns will now be described. (The location of nests is shown in figure no. 4).

FULMAR:

The fulmar's nesting pattern now is similar to that of previous years. A total of 13 nests were found in the cliffs in June. Most were located in the cliffs on the western part of the island, as in former years. Half of these nests were plundered during the summer, since young were found in only 6 of them in the beginning of August. When fulmar breeding begar in1970, there was only one nest on the island, but in 1971 the

number increased to 11; little noteworthy change has occurred since, and breeding has continued in the same manner. The greatest number of nests - 17 - was found in 1975; in other years that number ranged from 8 to 13. These counts refer to those numbers of nests which were found in the first half of the summer; in actuality, on the average the nests undergo an attrition rate of 50% or more.

The instability of the cliffs and their continual erosion no doubt constitutes the primary reason for the difficulties encountered by the cliff birds on Surtsey. One result of this is that the birds cannot use the same nesting place year after year and that no stable vegetation develops near their abodes. Thus it has conceivably some influence on the colony that birds which loose their nests from collapse of the rocks or high seas, may not try again to nest on the island and instead look elsewhere.

It is clear that the nesting-places for the fulmar on Surtsey are difficult and that it can do no more than keep the status quo. (It is doubtful that there will be a significant change in the breeding patterns of the fulmar on Surtsey while the instability of the cliffs prevails.)

BLACK GUILLEMOT:

The guillemot nests were located and counted in the beginning of August, at which time the bird carries food to its young and it is thus possible to find the nests by following the bird into its breeding hole in the cliff. An unusual number of nests were

found - 10 - which is the largest number yet. It is possible that more nesting pairs had attempted to breed but the nests were destroyed, as always will happen; but this cannot be definitely established. It is not known how many young were raised, but without the usual attrition in August, 15 young birds might be expected.

GREAT BLACK BACKED GULL:

Three breeding pairs of black-backed gulls nested in 1977 as in 1976, and it is probable that the same pairs are in question in each instance, as the location of all the nests was almost identical in 1976. The black-backed gull breeding has never been as successful as in 1977, when 7 young birds were raised from 3 nests.

One of the nests was within quadrat Q-8, about 50 meters from the rock edge, and this was the third summer in a row that a nest was found in this location. On June 17 there were two week-old fledglings in the nest. The nest was on a level lava-field and to it had been carried honckenya plants, feathers and fish bones. Both fledglings survived infancy and were beginning to fly in early August.

A second nest was found in quadrat K-5, where a nest was also located in 1976. The nest was in sandy lava, and the building materials were the same as in the nest in Q-5. On June 17 one cold egg lay outside the nest and one fledgling several days old was found in the neighborhood of the nest. Later is was found that there were 2 young, the pair having laid 3 eggs. Both young survived and were flying in the beginning of August.

The third nest was in quadrant N-10, and there was also a nest there in 1976. This nest was in the Honckenya plant area no. 71-69. On June 17 one newborn bird was found in the nest together with 2 unbroken eggs, but these fledglings also broke through and all three were flying in the beginning of August.

The presence of the birds had a great effect on the Honckenya plants in which the nest was placed. In 1976 the plants were somewhat bitten andused in the black-backed gull nests which were in area N-10; their measurement on August 12, 1976 was 80 x 70 cm and the plant was blooming. On June 18, 1977, when eggs and young birds were in the middle of the plants, their measurement was 40 x 50 cm and about 30 were blooming. A bare spot was in the middle where the nests were placed. The plant increased its size greatly during the summer, and on July 30, 1977 its measurements were 120 x 100 cm and it had over 100 flowers. It had become very dense and luxuriant. No bald spot was visible where the nest had been. It was obvious that the bird droppings had had a very beneficial effect on the growth of the plants, which was extremely good compared to the growth of other Honckenya plants on Surtsey.

In 1977 soil samples were taken for analysis of the black-backed gull nests on Surtsey. The intention was to study more closely the distribution of the fertilizing influence. (This would be distinguished from the analytical results at other locations.) (Fig.5)

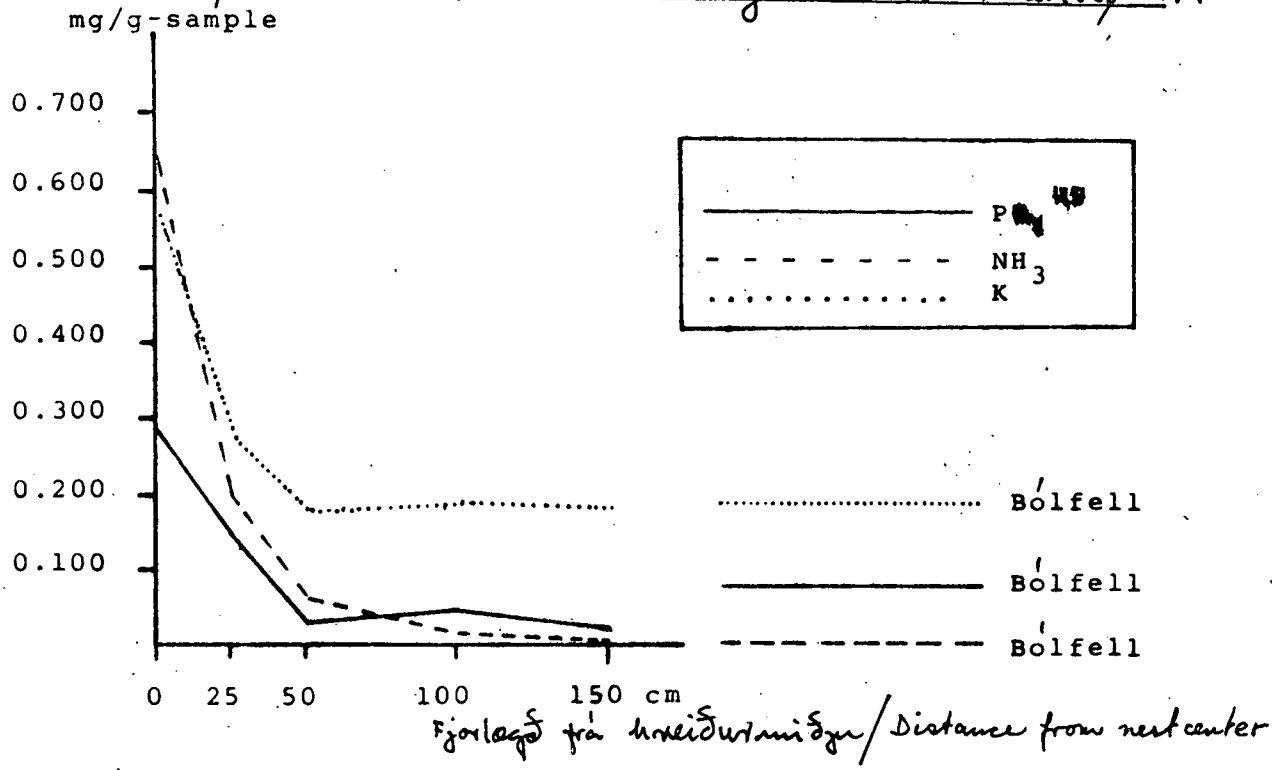
KITTIWAKE:

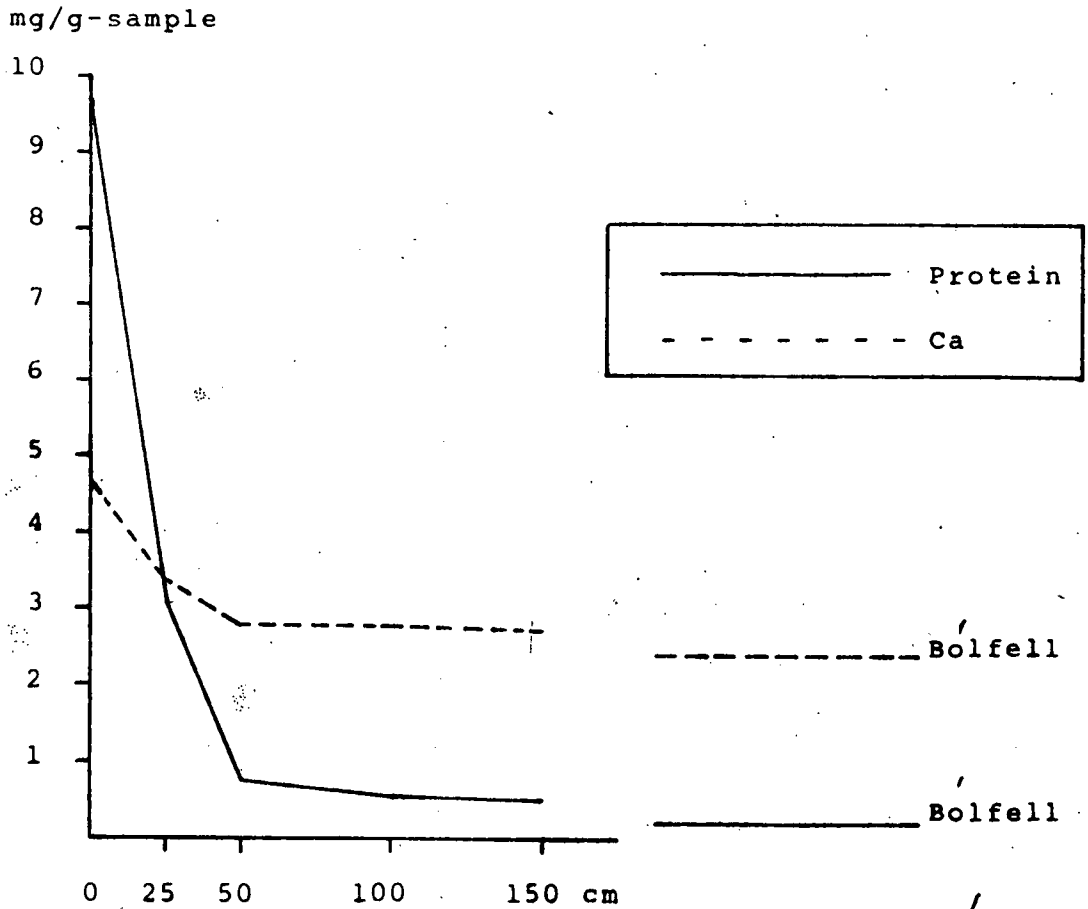
In 1975 8 kittiwake nests were found in one location in the cliff in the SW-section of the island and 4 fledglings were raised. In 1976 no kittiwake nests were found. In 1977 the kittiwake bred again and this time chose two locations in the cliff.

Fig.5

EFNAGREINING Á SVARTBAKSHREIÐRUM Í SURTSEY 1977.

Analysis of soil in black-backed gulls nests on Surtsey 1977





Another nesting was found on June 17 in quadrat P-7. At this time there were two nests and a bird was seen bringing material for a third. In all there were 5 nests in this location; on July 27 there was a fledgling in one of them and an egg had been laid in another. At the end of July another breeding place was found in area T-14; two nests were observed there with one young bird in each. It is not known how this nesting turned out in August or how many young were raised.

The kittiwake used primarily kelp and other seaweed for its nests, but it was not possible to discover whether it searched for plants up on the island.

The 1977 breeding shows that the kittiwake nesting of 1975 was no accident, and the kittiwake has probably arranged a durable niche among the nesting birds on Surtsey. The instability of the cliffs is doubtless the biggest stumbling block to the Kittiwake's breeding as with the fulmar and the black guillemot.

An unusually large kittiwake flock were on Surtsey in the summer of 1977, especially in the latter part, probably because of the abundance of food in the ocean surrounding the island at that time. The flock comprised tens of thousands of birds on some days, and the greatest crowd sat on the northern headland. There was little connection between the birds in this flock and the nesting birds; this large flock probably consisted of young birds which were not breeding, and year-old birds were conspicuous in the crowd.

OTHER SPECIES:

Tern: In addition to the nesting birds, the tern was one species which regularly dwelled on the island in the summer of 1977. In 1975 and 1976 tern eggs were found on the island, but in neither year were young birds raised. No eggs were found in 1977 and there was no obvious nesting behaviour among the terns.

30 terns were seen on Surtsey in June, with very few young in the group (1-3). At the end of the month of July the terns had increased to 300 and a greater percentage were young birds. For the most part these were probably birds from the mainland on their way south with their young.

The other species here listed were seen very seldom and did not stay long on or near the island when the observers were there. These species were:

Great Northern Diver: 2 birds were seen off the headland on June 16-22, but this species had so far as is known not been recorded near Surtsey before. The diver is a rather common nesting bird in Iceland and it breeds near most of the large bodies of water. It survives primarily on fish from the lakes. In winter it almost exclusively occupies the seacoast areas.

Harelequin Duck: One male bird was seen diving near the cliff at the southern end of the island on August 2. This species has not been seen before at Surtsey as far as is known. The harlequin duck breeds inland by rivers and is found all over the mainland. During the winter it occupies the coasts.

Merganser: One bird was seen at the headland on June 11, July 30, and July 31.

Red-necked phalarope: The phalarope was seen near Surtsey in 1977 and in the previous summer. One bird was seen on June 19, and from July 28 to August 2 there were approximately 300 birds, principally on the ocean off the headland, and also seeking food to a small degree up on the beach.

Golden plover: 2 birds were seen on the South-eastern portion of the island on June 17, which is an unusual time to see golden plover on Surtsey: they are most often observed in the later part of August.

Herring Gull: 2 birds were seen on the headland on June 16 and one bird on the ocean on June 18 and June 20.

Iceland gull: 3 birds were seen on the headland on June 18 and 1 on July 27.

Raven: 2 ravens came to the island on August 1, but this did not occur at any other time.

Wheatear: 2 birds were on the island all day on June 19, but were not seen again.

Wagtail: 1 bird came to the island on August 1 and was only seen on that day.

Some species have not been mentioned here which breed on the Westman Islands and are seen near Surtsey almost daily during thesummer: they are the gannet, puffin, guillemot and auk.

VASCULAR PLANTS ON SURTSEY 1978

Of the 962 plants that were recorded on Surtsey in the fall of 1977, 697 plants were found living in the summer of 1978, or 72%, which is the highest percentage of plants that have overwintered between years on Surtsey thus far.

In the summer of 1978 the vascular plants began to thrive increasingly well on Surtsey. Two new species were found, Rumex acetosella and Cardaminopsis petraea, both of which have borne seed and multiplied on the island. A few well developed individuals of Festuca rubra and Carex maritima were found, although both species have had difficulty in developing on Surtsey during the past years. Of the vascular plants on Surtsey in 1978, Honckenya peploides had the most marked increase with a total of 2512 new individuals recorded. Of other species 218 new individuals were found, making the total number of new individuals 2730 in addition to the 697 plants that overwintered. A total of 3427 vascular plants was registered on Surtsey in the fall of 1978.

Twelve species of vascular plants were recorded on Surtsey in 1978: Honckenya peploides, Cochlearia officinalis, Elymus arenarius, Mertensia maritima, Cystopteris fragilis, Carex maritima, Pucinellia retroflexa, Tripleurospermum maritumum, Festuca rubra, Cerastium fontanum, Rumex acetosella, Cardaminopsis petraea.

Individual Species:

Honckenya peploides (L) Ehrh.

Of the 632 Honckenya peploides plants recorded in 1977, 568 overwintered, or 89%, which is the highest average for this plant so far. A very large number of

new individuals were found, or 2512, making a total of 3080 Honckenya plants recorded on Surtsey in 1978. This is a tremendous increase compared to previous years, and can only be attributed to the large seed production by the Honckenya poploides plants on Surtsey in the fall of 1977. If seed productions and the increase in Honckenya plants on Surtsey are viewed from the beginning (Table 1) it is found that seed production begins in 1971 when the first plant matured seed; from then on the species increases gradually. In 1975 seed bearing plants are 17, in 1976 they were 36, and in 1977 108 plants were recorded maturing seed. Another increase occurs in the fall of 1978 when 190 plants are recorded with matured seed.

Until 1971, when seed production started on Surtsey the increase of Honckenya plants was completely dependent on dispersal of seed. During the summers of 1967 to 1972 few new plants were found compared to what comes later. In 1973 and 1974 there is a marked increase in the number of new plants recorded, but it is unlikely that they are the result of local seed production in 1972 or 1973 but rather the result of extensive dispersal. In 1973 and 1974 an unusually large number of individuals of the species Elymus arenarius and Mertensia maritima were also recorded, which adds support to the theory of increased dispersal, as the seed of these two species are dispersed to Surtsey by sea, and neither one had begun seed production on Surtsey at the time. During 1975 and 1977 considerably fewer new Honckenya plants are recorded than in 1973 and in 1974, although their number is markedly higherthan during the years 1967-1972. The local production of seed at this time is starting to have an effect on

the increase of Honckenya peploides plants as in this period the number of new individuals of the species Elymus arenarius and Mertensia maritima recorded on Surtsey decreases considerably from what it was in 1973 and 1974.

The great increase in Honckenya plants in 1978 can safely be attributed, mainly, to large local seed production in 1977. The greatest increase in Honckenya plants occurred in the areas where mature and seed bearing plants of the species were most numerous beforehand. Furthermore, relatively few individuals of the still un-reproductive species Elymus arenarius and Mertensia maritima are recorded in 1978 as compared to the years 1973 and 1974.

The increase of Honckenya plants on Surtsey is no longer as dependent on seed dispersal as it was early in the island's existence. The species has now achieved a secure foothold on the island and its annual increases derive mainly from local seed production. Seed import, however, is bound to continue and although it has a much lesser effect than before on the increase of Honckenya plants, it plays an important role from a genetical point of view.

It is not unlikely that the large increase in Honckenya plants on Surtsey in 1978 marks the beginning of greater things to come considering the fact that seed producing plants recorded in 1977 numbered 108 and had increased to 190 in 1978.

In spite of the large increase in 1978, there was little change in the spread of Honckenya plants. The increase occurred, usually, in quadrats where Honckenya plants grew already. In 1978 Honckenya plants were recorded in only 3 new quadrats; H-8, D-11, and L-15.

The largest Honckenya peploides plant observed in 1978, No. 70-39, was in quadrat G-13 and measured 1.95 m^2 on 27.7. Five other plants measured over 1 m^2 this year.

If this rapid increase of Honckenya on Surtsey continues, it will become necessary to change the methods of recording the plant's progress. It will no longer be feasible to record each individual plant that survives its first winter and then record its development, as is currently done. Instead, samples of the species will be observed. However, it will be necessary to monitor the number of individuals as well as changes in their spread, flowering and germination.

Cochlearia officinalis:

In 1978 scurvy grass decreased to 160 plants from 268 in 1977; only 50 seedlings were found, as opposed to 256 in 1976. The "large" plants have, however, increased in number from 30 in 1977 to 110 in 1978, which shows that the species is well established on the island. In 1978 new plants were found in 6 new locations. Only five plants flowered in 1978, and it is likely that all developed seed. Seedlings were observed alongside three plants. The majority of the Cochlearia plants are, as in previous years, rather underdeveloped, and it is obvious that the unfertile soil on Surtsey is unsuited for the species and hinders its increase and spread.

Elymus arenarius:

Of the 8 Elymus arenarius plants recorded on Surtsey in 1977, 6 overwintered and 8 new plants were observed, making a total of plants recorded in 1978 14.

All the new plants were located on Þórsnes, and it is therefore rather certain that they were dispersed to Surtsey by sea.

Older plants matured although none of them flowered. The largest plant, no.74-51, in quadrat K-18 had 65 culms at the end of July 1978 and had increased by 41 stolons in one year. There were about 2 meters between the far ends of the culms, and 1.6 meters between them last year. Black-backed gull youngs sought shelter in the plant for awhile during the summer and the soil became very abundant with droppings, which should have benefitted the plant.

The second largest plant, no. 74-55, was in quadrat K-17. On July 29 it had 40 culms but had only 14 culms at the same time in 1977. There was a distance of 1 meter between the far ends of the stolons, but 55 cm last year. A breeding pair of black-backed gulls nested close by the plant in June, resulting in an abundance of droppings and food-leavings in August. Two young were raised in the nest and they sought shelter in plant no. 74-51 as has been mentioned earlier.

The development of other old plants is from 2 - 15 culms, making them considerably smaller than the two above mentioned plants.

Of the new plants found, 7 were quite far from the sea, in quadrat E-13, and should be relatively safe from ocean waves. It is, therefore, probable that at least part of them will survive.

Mertensia maritima:

Six of 8 Mertensia maritima plants recorded on Surtsey in 1977 survived the winter and were observed

again in 1978 along with 3 new Mertensia maritima plants. During the summer of 1977 a Mertensia plant, no.74-53, flowered for the first time and dropped seed. Two new plants were found next to this plant in 1978, proving that Mertensia has managed to propagate on the island, thereby making its expansion less dependent on seed dispersal. In 1978 two plants dropped seed, no. 74-68 and 77-89.

Cystopteris fragilis (L) Bernh. :

Plant no 72-113 survived the winter but plant no. 77-89 disappeared. Eight additional Cystopteris plants were found in 1978, making a total of 9 plants recorded. Plant no. 72-113 had grown considerably and had 6 fronds and two buds on July 27. The longest frond was 20 cm in length. For the first time the plant formed spores on 5 fronds.

Two of the new plants were found in a small mossy cavity where the species has been observed before (73-113 in Q-13). These may be older plants and therefore the previous number was kept. Each plant had two fronds.

A new plant was found in a crevice in Stóri-Gýgur in I-8. It had 3 fronds on July 27, the longest being 6 cm. Six tiny plants, one frond each, were found in two mossy cavities in quadrats Q-15 and P-15.

All Cystopteris plants on Surtsey grow in moss tufts, which seem to offer requisite conditions not otherwise found on the island. It is possible that the plants find the necessary moisture in the moss colonies.

Carex Maritima Gunn.:

There was no Carex maritima plant alive in the fall of 1977. During the summer of 1978 4 new plants were found, 2 of which were well developed and had 28 culms (no.78-148 in K-8) and 23 culms (no.78-161 in I-8). Neither, however, had developed flowers. The two remaining plants consisted of 4 and 1 culms. The location of the larger plants indicates that they were not dispersed by sea, but rather that they have grown from seed carried to the island by birds. The two smaller plants, no. 78-142 and 78-182, both grew close to the sea. The former is located at the high tide line of the previous winter, indicating that the seed from which it grew was almost certainly brought to the island by sea. The latter could also have been brought by sea.

Pucinellia retroflexa (Curt)Holmb.Borealis Holmberg:

Two Pucinellia retroflexa plants were recorded on Surtsey in 1977 and both survived the winter. In 1978 4 additional plants were recorded, making a total of 6 plants recorded in August 1978. Plant no.74-89 had 1 panicle. Two new plants were adjacent to it, but neither flowered. A small non-flowering plant was found by stake no. 72-90 but no plant was there in 1977.

A new plant was found in Stóri-Gýgur in quadrat I-9. It had 14 culms and 7 panicles on August 1. This is the most well developed Pucinellia plant which has been observed on the island. It is likely that its propagation has been due to conditions in the crater, which appear to be much more favorable than those of the plant's other habitat on Surtsey.

Tripleurospermum maritimum:

Only one plant was found alive in 1977, no. 78-171 in I-8, and it flowered then. The plant was alive in 1978, alongside two tiny seedlings. This is the first time that the species has propagated on Surtsey. The motherplant did not flower in 1978 and was not well developed. A new tiny unflowering plant was found in F-15.

Although the daisy managed to propagate on Surtsey, its future does not look very promising. It is obvious from the present state of the plant's development that the conditions on Surtsey are not too well suited for this species and that it may have difficulties in its colonization.

Festuca rubra:

One Festuca rubra plant was alive in 1977 but it did not survive the winter. An unusually large number (5) of plants was found in 1978, most of which were well developed. Two of the plants flowered, representing the first time that the species has flowered on the island. It is no known whether these plants managed to bear seed in 1978. Their numbers are: 78-32 in M-16, which had 45 culms and 4 panicles; 78-18 in I-9, with 15 culms and 2 panicles. Other plants are No. 78-133 in N-12, 78-160 in M-12 and 78-176 in I-8.

It is interesting to note that so many well developed plants are observed on the island at the same time. Their locations indicate that the seed was brought to the island by birds last fall and germinated then.

Cerastium fonantum Baumg.:

Of the 19 Cerastium fontanum plants recorded on Surtsey in 1977, only 6 were found in 1978, 5 of which flowered. No new plants were found in 1978.

Cerastium does not thrive well on the island. The individuals have become fewer, and the species's increase has remained unchanged since it was first observed in 1975, inspite of the fact that the species has managed to develop seed on the island.

Rumex acetosella L.:

On August 1, 124 Rumex acetosella plants were found in one area of abt. $1m^2$ in quadrat N-11, no. 78-128. This species has not been observed on Surtsey before. Most of the plants were very tiny, with 5-10 leaves, the red colour of the leaves indicates a lack of sufficient nutrients in the soil. Ten plants looked relatively well developed, and three of them had flowered.

It is likely that Rumex seed was brought to Surtsey during the summer or fall of 1977 and that a plant grew up from it and managed to drop seed the same year. It is also possible that the plant is still older (i.e., from 1976) but went unnoticed last summer. The location indicates that the seed was dispersed by birds. If it was brought by sea, it must have been blown over a long distance filled with obstacles to reach its location.

The rapid increase of Rumex on Surtsey in its first year indicates that the species can thrive there in the future, propagate and increase its spread.

In Iceland Rumex acetosella is common on the lowlands, especially by populated areas. It thrives best in a gravelly or sandy soil and should therefore do well on Surtsey.

Cardaminopsis petraea (L) Hiit.:

On August 1, 5 Cardaminopsis plants were found in quadrat M-6, no.78-136. They all grew in the same spot. This species has not been observed on Surtsey before. The largest plant had 2 flowers and 2 fruits and was 7 cm long. The others did not flower and were from 1 - 4 cm in length. As with Rumex acetosella species, it is likely that Cardaminopsis seed was brought to Surtsey last summer, or earlier and that a plant grew up and dropped seed; however, seed was most likley brought by a bird.

Cardaminopsis is a common plant all over Iceland and thrives well on sand flats. The conditions on Surtsey are probably favorable for this species and it is likely that it will continue to increase in number and spread and become a permanent settler on the island.

Unidentified species:

In quadrat K-18 a lone plant was found. It consisted of only 2 cotyledons but could not be identified. It was assigned number 78-83.

TABLE 8

HONCKENYA PEPLOIDES

Settlement, increase and development of the species in Surtsey.

Year	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78
Plants from the previous year	0	0	23	18	31	38	41	197	261	337	422	568
New plants found in summer	24	103	29	45	22	33	507	659	167	163	210	2512
Total number of plants in autumn	24	103	52	63	53	71	548	856	428	500	632	3080
% of the previous year's plants surviving		0	22	35	49	73	58	36	31	79	84	89
Number of plants with flowers	0	0	0	0	5	12	18	28	28	73	166	299
Number of plants with mature seeds	0	0	0	0	1	7	12	12	17	36	108	190

TABLE 9

HONCKENYA PEPLOIDES

Number of quadrats with Honckenya peploides plants during the years 1967-1978. Also shown are the annual total number of Honckenya plants and average number of plants per quadrat:

YEAR:	Number of Quadrats with Honckenya plants:	Total Honckenya plants:	Honckenya Plants per Quadrat:
1967	4	24	6.0
1968	19	103	5.0
1969	15	52	3.5
1970	19	63	3.3
1971	20	53	2.6
1972	25	71	2.8
1973	40	548	13.7
1974	55	856	15.6
1975	50	428	8.6
1976	51	500	9.8
1977	55	632	11.5
1978	53	3080	58.1

TABLE 10

Vascular Plants on Surtsey 1978

Year:		68	69	70	71	72	73	74	75	76	77	78		TOTAL
SPECIES:														
HONCKENYA PEPLOIDES	Old	10	1	8	4	4	50	21	60	157	84	169	568	3080
	Seedlings												2512	
COCHLEARIA OFFICINALIS	Old			13	16	28	1		4	41	1	6	110	160
	Seedlings			2	25					25			50	
PUCINELLIA RETROFLEXA						1		3		1		1		6
CYSTOPTERIS FRAGILIS						1	2					6		9
ELYMUS ARENARIUS							1	4		1		8		14
MERTENSIA MARITIMA								4	1		1	3		9
CERASTIUM FONTANUM									1	5				6
TRIPLEUROSPERMUM MARITIMUM									3(c)			1		4
FESTUCA RUBRA												5		5
CAREX MARITIMA												4		4
RUMEX ACETOSELLA												124		124
CARDAMINOPSIS PETRAEA												5		5
UNIDENTIFIED												1		1
														3427

Overwintering plants 697

New plants 2730

3427

Moss Productivity on Surtsey 1978.

The moss crop was measrued in quadrats J-8, K-11 and M-11 as in previous years. Samples from three 25 cm x 25 cm areas were taken in each quadrat. All moss was removed from the sample areas, washed and dried at 80°C for 24 hours, and weighed thereafter.

Results of the measurements are shown in the following table:

TABLE 11

Biomass of moss on Surtsey 1978, drymatter g/m^2

Quadrat	Sample weight	Average weight
J-8	499.36	
J-8	597.76	592.05
J-8	679.04	
K-18	0.32	
K-18	2.08	2.24
K-18	4.32	
M-11	56.96	
M-11	17.60	27.47
M-11	7.84	

In comparison with measurements for 1977 the productivity has decreased in all the quadrats, while comparatively the biggest decreases are in quadrats K-18 and M-11. In these quadrats there is heavy movement of sand, which in time destroys the moss, and this is obviously the case here as the moss is scarse in many places.

J-8 is the only sample area where the moss is well developed and is becoming denser. Samples in J-8 have always been taken in Stóri-Gígur, the moss on Surtsey being densest there.

Although productivity in J-8 is somewhat less in 1978 than in 1977, there is no indication that the moss is retreating in the area. This slight difference in yield could be due to the variance in sampling areas from year to year.

Observations of Birds on Surtsey, Summer 1978.

Birds on the island of Surtsey were observed first in the middle of June and then again at the end of July. The purpose of both trips was to observe nesting birds on the island. Five species nested on the island in 1978: Fulmar (26 nests), Black guillemot (11 nests), Black-backed gull (6 nests), Kittiwake (2 nests), and Tern (1 nest). 46 nests were found although fledglings did not survive in many of them. All of the above mentioned species have previously nested on Surtsey.

Fulmar,black-backed gull, black guillemot and kittiwake raised young, but it is not certain whether the tern young was raised.

Nesting Birds:

FULMAR: A total of 26 fulmar nests were found in June which is the largest number of fulmar nests on the island so far. The largest number found previously was 17 nests in 1975. As before, most of the nests (17) were located in the cliffs on the western and southwestern part of the island. The remaining nests (9) were located in the cliff on the easternmost part of the island. No nests were found on the southern or southeasternmost parts of the island. In the beginning of August there were fledglings in 13 nests, and most of them were expected to survive.

BLACK GUILLEMOT: Eleven nests were located at the end of July, which represents a slight increase over

the number of nests (10) counted in 1977. It is possible that additional pairs nested last spring and that some of the nests were destroyed during the summer. It is not known how many young were raised and survived infancy.

BLACK-BACKED GULL: The black-backed gull greatly increased its range on Surtsey in 1978. In all, 6 nests were found, as opposed to 3 nests in 1977. Four of the nests were in new locations, i.e., quadrats K-17, O-11,Q-11 and P-7. There were also nests in quadrats Q-8 and K-5, where nests have been located since 1976. It is possible that an additional nest was located in quadrat Q-16 as a fledgling was found there and the end of July as well as what may have been the remains of a nest.

At least 8 young survived. Two survived in a nest in K-5 and were flying at the end of July. Two more in a nest in K-17 were ready to fly in the middle of August. One young survived in a nest in Q-11, and another was found in quadrat O-16, almost ready to fly at the end of July although it is not certain that the nest was located in the quadrat itself. No young birds were raised in the nests in quadrats P-7 and O-11.

The nest in quadrat K-17 was located in the island's main vascular plant area, about 50 cm from sea lyme grass plant 74-55, with numerous plants in the surrounding area. This means that an unusual number of plants have benefitted from the bird droppings as well as the from food leavings deposited in the soil. The largest sea lyme grass plant on the island grows abt. 20 meters from the nest, and the two fledglings sought shelter there for a while, which was probably also beneficial for its growth.

KITTIWAKE: In the cliff in quadrat P-6 were 2 kittiwake nests. At the end of July there was 1 young in one of the nests and an egg in the other. Only a few hundred kittiwakes were observed in 1978, whereas in 1977 there were thousands of kittiwakes and seven nests on the island.

TERN: One tern nest was found in quadrat B-14 on August 1. It contained 1 egg, which was being incubated by the mother bird during the entire observation period. Tern eggs have been found on Surtsey before (i.e., 1975 and 1976), but they had not been hatched. The bird found nesting in 1978 was unusually late, as the tern usually lays its eggs around the middle of June in Iceland. This may have been a young burd in its first season. It is unlikely that a fledgling survived from this nest because the egg was laid so late in the summer. In June, an average of 150 - 200 terns were seen on Surtsey; however, around the beginning of August they were somewhat more numerous.

Other Birds:

17.6 EIDERDRAKE seen in the ocean near Surtsey.

18.6 HERRING GULL seen near Thorsnes.

20.6 OYSTER CATCHER seen on the beach on the eastern part of the island.

28.7 PUFFIN seen flying from the cliff in quadrant N-5. This species had not been seen in the cliffs on the island previously.

31.7 ICELAND GULL seen off Thorsnes, WAGTAIL near the observers' hut "Palsbær" (seeking insects or seeds?).

1.8 Two RAVENS came to the island, were seen and also heard for a few hours.

3.8 COMMON GULL seen by "Palsbær".

TABLE 12

NESTING BIRDS ON SURTSEY 1970 - 1978

Year:	1970		1971		1972		1973		1974		1975		1976		1977		1978	
SPECIES:	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young	Number of nests	Nests w/young
FULMARUS GLACIALIS	1	1	11	6	13	6	8	3	?	7	17	4	13	4	13	6	26	13
CEPPUS GRYLLE	1	1	7	?	7	?	?	?	4	?	4	?	4	4	?	10	?	11
LARUS MARINUS									1	1	1	1	3	2	3	3	6	5
RISSA TRIDACTYLA											8	4	0		7	7	2	1
STERNA PARADISEAE											1	0	4	0	0		1	?

Investigation of Black-Backed Gull's Nesting on Kvíárjökull 2. June, 1977

Introduction:

The colonization and increased nesting of the black-backed gull on Surtsey 1974-1976 caused great attention to be paid to it during the summer of 1977, both on Surtsey and in Iceland. The black-backed gull has increased considerably in Iceland since the turn of the century, and has begun to nest in new areas. Some of these areas have had little or no vegetation when the black-backed gull began to nest there, but constant nesting has widely led to the vegetation becoming more dense and luxuriant. Such areas are noteworthy in connection with the nesting of the black-backed gull on Surtsey, as they can provide clues as to the result of continuous nesting will have as time passes.

For the best comparison, it was attempted to choose the nesting area whose conditions most approximated conditions on Surtsey, that is, the area should be somewhat isolated from continuous vegetation and certainly little or no vegetation should exist at the nesting area when the breeding begins.

The black-backed gull breeding ground on Kvíárjökull in Öræfi was chosen; Kvíárjökull is a glacier southeast of Öræfajökull, which is the southernmost and highest part of Vatnajökull.

Hálfdán Björnsson, farmer and naturalist at Kvísker in Öræfi, published an article called "Bird-life in Öræfi, A-Skaft." in volume 46, parts 1-2 of the periodical Náttúrufræðingurinn. This article led to our investigation into the above-named breeding ground. Hálfdán says the following: "In the previous 30-40 years at most probably 15-20 pairs of gulls have bred on Kvíárjökull. This nesting is on top of the glacier and there is a 10-20 cm thick layer of stones and gravel on the ice where the black-backed gull nests. Grass has grown on the nesting place, and among other plants there is a particularly large amount of saxifraga. There was a similar black-backed gull breeding ground on Breiðamerkurjökull at the Jökulsá between 1920-1960. The glacier was covered with grass and many wildflowers, although the soil cover was only 10-20 cm thick. As the inlet of Jökulsá increased in size, more and more broke off of the glacier and in the spring of 1960 there were only 3 grass-covered icefloes left, which were 20-50 m in diameter. In addition to different species of grass there was

also much saxifraga and sedum acre on these ice floes. That year there were 32 pairs of black-backed gulls on these three ice floes."

The conditions on Kvíárjökull are somewhat reminiscent of those on Surtsey. In the first place it may be claimed that the area was almost without vegetation when the black-backed gull began to nest there; secondly, the soil in the area was gravelly as on Surtsey, although somewhat rougher; thirdly, the area was somewhat isolated, and the vegetation is not continuous with the surrounding area. The vegetation in the nesting ground may all be considered dispersed.

On June 2, 1977 investigation of this breeding area began. Hálfdán Björnsson accompanied the expedition and was of great assistance to the investigation.

The categories for investigation were:

1. General description of the breeding ground
2. Size of the nesting (nests,birds)
3. Vegetation at the nesting area (flora)
4. Density of the vegetation at the nesting area
5. Vegetation surrounding the nests
6. Material in the nests
7. Soil samples taken at the nests
8. Small animals collected at the nesting area.

Description of the breeding ground.

Kvíárjökull drifts down between two mountains, Vatnafjall to the north (955 m high) and Staðarfjall to the southwest (1036 m high). These mountains pinch the glacial tongue together somewhat. At its crest it is about 700 meters broad, but as it advances downwards it widens almost to 1500 meters, when the lateral mountains no longer compress it. The glacial tongue is about 6.5 km long.

On the edge of the glacial tongue gravel and deposits of moraines are spread widely, formed, on the one hand by avalanches which have fallen from the steep mountain slopes on either side of the advancing glacier, and on the other hand by deposits of crushed rocks on the glacier edge, which are formed by the action of the glacier up on the substrate at its margins. The edge of the glacier abrades the rock most at the gap on the eastern side of the glacial drift and the greatest part of the moraines on the northeast edge originated there. How far the layers of gravel extend into the glacier varies, but in many places it is over 100 meters from the edge.

The nesting ground on Kvíárjökull is on the northeastern edge of the glacier, not quite 1 km below the above-named gap (see Fig. 6).

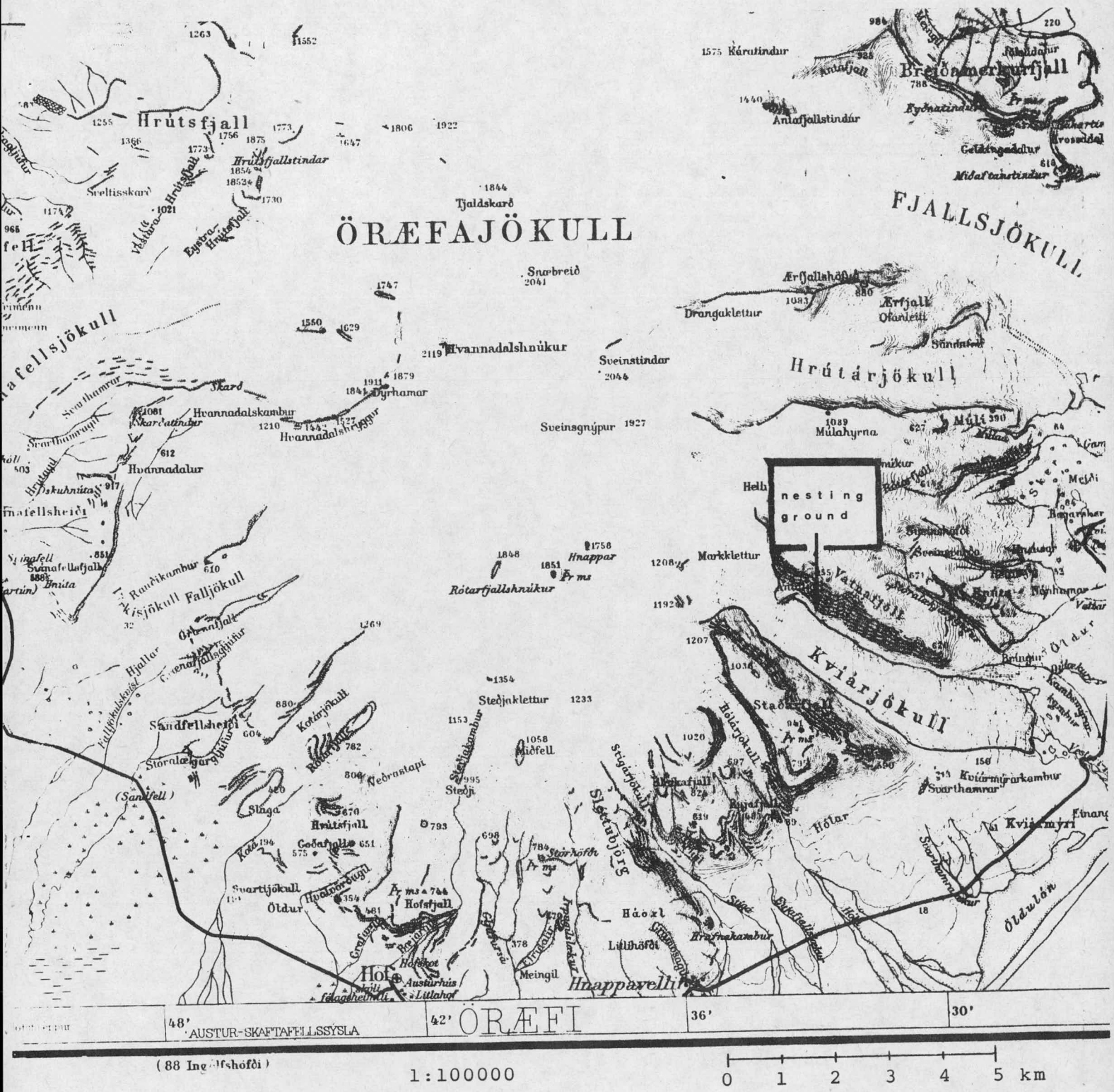


Figure 6. Map of Öræfajökull and district.
The arrow points to the nesting ground of the Great Black-Back Gulls at Kvíárjökull.

(eftir korti Landmælinga Íslands, 1972)

The breeding area is called Bleikskambur (Pink Crest) after the pink color of the palagonite layer in the mountain over the area. The size of the breeding ground is a little more than a hectare, about 250 meters long and about 70 meteres at its widest point. The gravel layer lies on the undulating glacier and thus the nesting area is uneven. The thickness of the moraine on the glacier at the nesting area measured 15 cm at the thinnest point, and at the thickest it was close to 2 meters. The gravel layer insulates the surface from the glacier as the cold slowly penetrates through the gravel.

The nesting area is not completely overgrown. The nests are preferably established on top of or in a gravel crest where there is more vegetation than below. Vegetation covers the gravel ridges more than the hollows between them, which in many places have very little growth, though this is not the universal rule.

Age and size of the breeding ground

Hálfdán Björnsson points out in his article that the great black-backed gull has bred on Kvíárjökull for the past 30-40 years. Closer investigation indicates that the nesting is somewhat older.

It is not accurately known when it began, but in the spring of 1925 Ari Björnsson of Kvísker went to take eggs from the breeding area and gathered enough eggs to fill an entire bucket as well as the scarf he had with him. He remembers that there were 50 eggs and that the nesting was completed, with three eggs in each nest. At that time there were probably 15-20 nesting pairs, similar to present conditions. Ari does not remember the condition of the vegetation at that time.

This description indicates that the nesting area has changed little in the last 52 years. When Ari entered the breeding ground in 1925 it was not the first time he had collected eggs. Egg-collecting from Kvísker had been done each spring for some time. It is almost certain that eggs had been collected at least before 1925, probably before the turn of the century.

On June 2, 1977, 12 nests with eggs were found, 11 in the main breeding area and an additional one on a cliff a little away from the main area. Four nests were found empty, but this could mean that the nest had been plundered somewhat before and probably eggs were not laid again in all the nests.

28-29 gulls were counted and there were probably 14 pairs at that time. There is slight indication that the herring gull nested alongside the great black-backed gull in the last years, and now 2 nests were found and 5 herring gulls seen.

Vegetation and nesting area

a) List of Flora: Hálfdán Björnsson recorded the major plant species in the area, and his list follows (Table 13). He grouped the species according to how often he thought they appeared, that is, how common they were. His list is divided into 9 groupings.

b) Measurement of ground cover: The ground cover was measured on the vegetated parts of the nesting area. A 30 m tape measure was used, which was laid over the vegetated ridges; the plants underneath the tape measure were recorded at 25 cm intervals. In this way a rather rough estimate of the most common species in the ground cover at the nesting area should be obtained. Three transects in all were taken. As the transects were only taken in the vegetated areas of the breeding ground, the results showed too much total ground cover, i.e., the non-vegetated part of the breeding area was relatively larger than appeared. The results are shown in Table 14.

c) Vegetation surrounding the nests: Five nests were selected for investigation. The vegetation around the nests was inspected. A tape measure was laid out from the centre of each nest to all cardinal points and species recorded at 10 cm intervals, up to 150 cm. Species in the neighborhood of the nests which did not happen to fall within these measurements were also listed. An overview of the nests is shown in Table 15..

There is little difference between the vegetation at the nests and of the breeding ground as a whole. However, there is somewhat more of the grass species Poa alpina, and Festuca at the nests than further away. It seems that the vegetation has progressed further at the nests than away from them, which is probably influenced by the greater amount of fertilizer during the first part of the nesting season.

d) Vegetation adjacent to the nesting area: Unfortunately, no detailed investigation was made of the vegetation adjacent to the breeding area, but it must be said that outside this nesting oasis very little vegetation can be found. Outside the nesting area, there is almost no growth on the gravel layer on top of the glacier. On the glacial tongue above the nesting area the vegetation is

very sparse and nowhere is there continuous cover, only isolated plants of a few species.

Some growth can be seen in a few places on the belt of crags above the glacier, but it could not be investigated closer. From a distance it seemed to consist mostly of moss and grasses.

Soil samples and insect collections

Soil samples were taken at the 5 nests which were investigated. The sampling was done just as on Surtsey in 1977 and the purpose was the same, that is to study the influence of fertilizer from the black-backed gulls on and near the nesting area. Samples were taken from 5-7 cm surface layers in the center of the nests and at 25, 50, 100 and 150 cm from it in four directions. The samples have not yet been analyzed and thus the results have not been correlated with those of the black-backed gulls' nests on Surtsey in 1977.

Collection of small invertebrates (insects, spiders etc.) was performed at the nesting site. The insect life at the area is rather rich, and the nesting can be seen to have supplied survival conditions for several species. The nest itself aeems to have a considerable attraction for crawling insects and for a lagre number of earthworms.

Comparison of the nesting areas on Kvíárjökull and on Surtsey.

It goes without saying that the rich vegetation to be found at the nesting area on Kvíárjökull can be attributed to the change in conditions(by fertilization) following the colonizing of the great black-backed gull. Before breeding began in the area, it had almost entirely lacked vegetation, as did adjacent areas. The results of the nesting on Kvíárjökull thus indicate what may be expected at the black-backed gull's nesting areas on Surtsey.

Those species found at the Kvíárjökull nesting site have probably not dispersed from far away. Dispersion of plants into the area where conditions have been adapted for them has met with much less hindrance than the dispersion of plants to Surtsey.

On Kvíárjökull plants are dispersed over land, possibly carried by birds, and the route is relatively short compared to the dispersal route to Surtsey, which in addition is over the ocean.

Conditions for growth of vegetation on the nesting grounds of the great black-backed gull creates for vegetation Kvíárjökull. It is likely that Surtsey's isolation and the slower and more

restricted dispersal of plants to it will cause the new habitat of the gulls to develop more slowly and in a different way on Surtsey than on Kvíárjökull. The evolution of life on Surtsey will in all probability have fewer species and more dominance of individual species than on Kvíárjökull.

Sources.

Björnsson, H.:

Fuglalíf í Öræfum, A-Skaft.
Náttúrufræðingurinn, 46, 1-2 p.56-104

Björnsson, A: Oral communication.

TABLE 13.

List of vascular plants in the nesting area of the black-backed gull at Kvíárjökull 2.6.1977

Species:	Abundance:
Poa alpina	Very abundant
Cerastium cerastoides	Abundant
Phleum commutatum	Very common
Alchemilla alpina Cerastium fontanum Festuca rubra Festuca viviparum Hieracium sp. Oxyria digyna Rumex acetosa Saxifraga caespitosa Sedum annuum Sedum roseum Taraxacum sp.	Common
Cardaminopsis petraea Cerastium alpinum Calium normanii	Rather common
Angelica archangelica Deschampsia alpina Draba rupestris Luzula spicata Ranunculus acris Saxifraga oppositifolia	Here and there
Alchemilla filicaulis Arabis alpina Epilobium sp. Luzula multiflora Montia lamprosperma Polygonum viviparum Rumex acetosella Sedum acre Silene vulgaris Thymus arcticus	Rare
Salix herbacea Salix phylicifolia	2 plants found
Carex atrata Empetrum nigrum Salix lanata Sibbaldia procumbens Silene acaulis	1 plant found

Total 40 species.

In addition, the following species were found nearby in the scree:

Agrostis stolonifera
Potentilla crantzii
Salix callicarpaea
Veronica fruticans

TABLE 14.

Measurements of coverage of vegetated area at the breeding ground at Kvíárjökull on 2.7.1977.

		% Coverage				
		snið 1	snið 2	snið 3	$\bar{X}$	
	Bare	46.7	27.1	7.4	27.1	
	Wilted grass	0.8	9.3	4.1	4.7	
	Moss	9.8	23.7	5.7	13.1	
	Lichen		0.8		0.3	
Monocots	Phleum commutatum		1.7	4.9	2.2	46.2
	Agrostis stolonifera	0.8		4.1	1.6	
	Poa alpina	24.6	11.0	28.7	21.4	
	Poa glauca		7.6	14.8	7.5	
	Festuca	10.7	11.0	15.6	12.4	
	Luzula spicata		1.7	0.8	0.8	
	Luzula multiflora			0.8	0.3	
Dicots	Rumex acetosa			3.3	1.1	8.4
	Rumex acetosella		1.7	0.8	0.8	
	Oxyria digyna		0.8	4.9	1.9	
	Cerastium cerastoides	1.6			0.5	
	Cerastium alpinum	2.5	0.8		1.1	
	Cerastium fontanum	1.6	0.8		0.8	
	Cardaminopsis petrea			0.8	0.3	
	Saxifraga caespitosum	0.8	1.7		0.8	
	Alchemilla alpina			2.5	0.8	
	Taraxacum sp			0.8	0.3	
		99.9	99.7	100.0	99.8	

TABLE 15.

Description of 5 nests and vegetation around the nests.

Nest 1

Nest material: Most common grasses; Poa alpina and Festuca also moss (Racometrium) and feathers.

Size: 55 cm diameter

Vegetation according to frequency measurements:

Cm.	N	S	E	W
10	nest	nest	nest	nest
20	"	"	"	"
30	Poa alpina	0	Poa alpina	Poa alpina
40	"	0	"	"
50	"	0	"	"
60	"	0	"	"
70	"	0	"	"
80	"	0	0	"
90	"	Festuca r.	Poa alpina	"
100	"	"	0	"
110	Cardam.pet	0	0	"
120	"	0	0	"
130	Poa alpina	0	0	"
140	"	Poa alpina	0	"
150	"	"	0	"

Other common species around the nest:
Sedum annuum, Saxifraga Caespitosa, Oxyria digyna, Alchemilla alpina, Sedum roseum, Luzula spicata, Polygonum viviparum, (Racometrium sp.).

Nest 2.

Nest material: grasses, moss, feathers, Oxyria digyna, Galium normanii.

Nest size: 35 x 70 cm, depth about 15 cm.

Vegetation according to frequency measurements:

Cm	N	S	E	W
10	nest	nest	nest	nest
20	"	"	"	"
30	0	Racometrium sp.	0	0
40	0	0	0	0
50	0	0	0	0
60	0	0	0	0
70	0	0	0	0
80	Cerastium cerst.	0	0	0
90	0	0	0	0
100	0	0	0	0
110	0	0	0	0
120	0	0	0	0
130	0	Festuca rubra	0	0
140	0	"	0	0
150	Wilted grass	0	Poa alpina	0

This nest is outside the main nesting area and the surrounding vegetation is very sparse. Species: Poa aplina, Saxifraga caespitosa, (Racometrium sp.).

Nest 3.

Nest material: grasses, moss, Cerastium alpinum, Sedum roseum, lichens, willow branches.

Nest size: 42 x 37 cm

Vegetation according to frequency measurements:

Cm	N	S	E	W
10	Nest	Nest	Nest	Nest
20	"	Poa alpina	"	"
30	Wilted grass	Festuca r.	0	Festuca r.
40	"	"	Poa alpina	"
50	"	"	"	"
60	0	"	Wilted grass	"
70	Poa alpina	0	0	"
80	Racometrium sp.	Moss	Poa alpina	0
90	Wilted grass	"	0	Wilted grass
100	Festuca r.	0	0	0
110	"	0	Poa alpina	0
120	"	0	0	0
130	"	0	0	0
140	"	0	0	0
150	"	0	Festuca r.	0

Other species which are common around the nest: Taraxacum sp., Rumex acetosa, Cerastium alpinum, Draba rupestris.

TABLE 15 continued

Nest 4

Nest material: Grass, Lycopodium selago, moss and feathers

Nest size: 55 x 45 cm

Vegetation according to frequency measurements:

Cm.	N	S	E	W
10	Nest	Nest	Nest	Nest
20	"	"	"	"
30	Festuca rubra	Algae	"	Poa alpina
40	"	0	Poa alpina	"
50	Moss	Algae	"	"
60	"	Poa alpina	0	"
70	Poa alpina	"	0	Algae
80	Cerast.cerast.	0	0	Poa alpina
90	Moss	0	Wilted grass	0
100	0	0	0	Poa alpina
110	0	0	0	Phleum commut.
120	Wilted grass	Poa alpina	0	Poa alpina
130	0	"	0	0
140	0	"	0	0
150	Poa alpina	0	0	0

Other species around the nest are:
Oxirya digyna, Cerastium alpinum, Saxifraga caespitosa, Poa glauca, Cerastium cerastoides, Sedum annuum, Alchemilla alpina.

Nest 5

Nest material: Grasses and moss, Saxifraga caespitosa.

Nest size: 35 x 40 cm

Vegetation according to frequency measurements:

Cm.	N	S	E	W
10	Nest	Nest	Nest	Nest
20	Wilted grass	"	"	"
30	Festuca r.	Festuca r.	Wilted grass	Festuca r.
40	"	"	0	"
50	"	Wilted grass	0	"
60	"	"	Racomet. sp.	0
70	"	"	0	0
80	Racomet.sp.	0	0	0
90	Poa alpina	0	Racomet.sp.	0
100	Festuca rubra	0	Festuca r.	0
110	Poa alpina	0	"	0
120	moss	Festuca r.	Wilted grass	0
130	0	"	Festuca r	0
140	Cerast.alpina	"	"	0
150	0	"	0	0

Other common species around the nest are:
Poa glauca, Oxirya digyna, Cerastium cerastoides.

Investigation of Vegetation in Lavafields by Mt. Hekla, Summer 1978.

In July 1978, the Surtsey Research Society sponsored a three-day research expedition in the area of Mt. Hekla. The purpose of the project was to investigate the vegetation of several lava fields in the region to compare with lava fields on Surtsey.

Hekla has been Iceland's most active volcano since the end of the Ice Age, with the average of two eruptions each century since Iceland was settled at the end of the ninth century. A total of 15 eruptions have been recorded from Hekla in historic times and five to eight additional eruptions from surrounding craters.

The frequent volcanic activity in this area has resulted in large numbers of lafa fields that vary in age. The ages of many of these, produced after the land was settled, are known. The ages of all lava fields formed after 1766 have, for example, been dated (eruptions: 1766-1768, 1845, 1878, 1913, 1947-1948, 1970). It has also been possible to date lava fields that were formed by the eruptions of 1300 and 1389-1390, as well as several others formed during the middle ages. Therefore, lava fields around Mt. Hekla are well suited for studying the manner in which life forms colonize new land, establish communities, and form successions.

The large number of lava fields in the area and their slight differences in age make it possible to compare communities at various levels of development where the most recent lava fields with the first levels of succession may be compared with the progressively more advanced communities in the older fields.

Many factors influence the establishment and continued survival of a community. Primarily the time available for life forms to settle an area, i.e., the age of the lava field, may seem to be the deciding factor. However, it is obvious that each lava field has its own special environment which determines what life forms develope there.

The following conditions are most likely to influence the settlement:

I. The type of lava field
   a. Character, i.e., surface texture and coarseness, pahoe-hoe or aa lava.
   b. Chemical substance.

II. The location of the lava
   a. Height above sea level.
   b. Slope and direction.
   c. Distance from sea.

III. Meteorological conditions.
   a. Prevailing temperature
   b. Precipitation (rainfall-snow cover).
   c. Wind.
   d. Light conditions.

IV. Influence of nearby communities
   a. Distance from communities
   b. composition of nearby communities.

V. Dispersal of substances onto the lava
   Substances, both organic and inorganic, may originate in nearby retions; and their dispersal is either by way of wind, water (rivers and brooks), or with animals (birds).

The lava fields investigated

The following lava fields were investigated: Skjólkvíahraun from 1970, Hekluhraun from 1947, Lambafitjahraun from 1913, Nýjahraun from 1878, Næfurholtshraun from 1845, and Sydra-Selshraun from 1389.

In the investigation major emphasis was laid on selecting lava fields of different ages. Generally, each field was studied at its lowest level; therefore, the ground level will vary somewhat from one field to the next. The lowest level was about 100 above sea level (the lava from 1389) and the highest, about 520 m. (the lava from 1913).

Three of the lava fields studied extended to the north and north-east of Mt. Hekla (lava from 1970, 1913, and 1878), and three were to the west and south-west of the mountain (lava from 1947, 1845, and 1389). The greatest distance between the areas investigated was ca. 30 km.

The ecology of the lava was strikingly different in the areas studied. A detailed study of the lava fields was not carried out, but in this preliminary investigation a few factors that are probably responsible for the variations in environment will be mentioned.

1. The topography of the lava fields was very dissimilar in spite of the fact that all were aa-lava types. Information on their chemical compounds will not be discussed here.

2. The differences in elevation (above sea level) of the various lava fields, as well as their location in relation to Mt. Hekla must play a major role in colonization of life forms. Meteorological studies were not performed in the regions, although it is

obvious that there are significant changes in climatic conditions (i.e., in temperature and precipitation), as height above sea level increases. It may also be expected that weather conditions in the northern and north-eastern region of Mt.Hekla are more severe than those in the western and south-western region.

3. There was an old well established vegetation at the lava borders in all the places that were investigated, except one (lava from 1878). Vegetated areas in the vicinity of the lava fields were not studied although they, clearly,differ somewhat in composition.

4. Surrounding Mt. Hekla are large barren areas of sand and pumice.

The vegetated areas are often badly eroded by winds, which pick up loose surface material and blow it away. Drifting and abrasion is very severe near Mt. Hekla, but it is not clear whether it varies between regions. It may be expected that the effects are rather similar in all of the lava fields.

As time of the investigation was limited, it was not possible to study the lava as extensively as desired. The major study was confined to the lava fields in one area only, for comparative purposes, a scant investigation of vegetation was also performed in the same fields at various elevations. The higher plants were mainly studied, while moss and lichen were collected only in the lava from 1970. Vegetation cover in the lava was measured and results are as follows:

Skjólkvíahraun from 1970

This lava field lies north of Mt. Hekla, and its north-westernmost part was investigated, i.e., north-east of Saudafell. The lava is about 300 m above sea level at its lowest level.

The lava is very coarse with many boulders, cavities and cracks. Snow often persists in the deep cavities during part of the summer.

Vegetation:

Small patches of moss and lichen were widely spread over the part of the lava that was investigated. The moss was most abundant in crevices, although it was also found in small clusters on the lava surface. On the lava surface the prevailing species was Racomitrium lanugiosum; Rac. canescens was also observed although it was mostly found in the crevices, where there was more moisture. The lichen Placopsis gelida was predominant on the surface while Peltigera sp. was common in crevices and clefts. The species Stereocaulon was also found in some places. Some samples of lichen and moss were collected, but the material has not been analyzed.

Vascular plants were found in one spot, in a deep and moist crevice. It seemed as if plant fragments had blown over the lava with some of them being deposited in the crevice. Four vascular plants were found among the plant fragments (see Table I). Apart from this, vascular plants were not observed anywhere in the lava, probably due to the fact that a suitable habitat for plants has not been established.

The plants found in the crevice can, therefore, hardly be considered representative for the lava in general.

The vegetation in the lava is still very sparse and has not attained 1% coverage.

2. Lava from 1947

The lava fields from the eruption in 1946 are extensive and cover about 40 km^2. The westernmost part of the lava ridge, abt. 270 m above sea level was studied. This lava ridge lies west of Mt. Hekla and has flowed to the west of the mountain, south of Melfell. This ridge lies ca. 1.6 km east of the old Naefurholtsfarm, which was abandoned during the eruption of Mt. Hekla in 1945.

The ridge's surface appears even and is without deep crevices or cavities. It is characterized by large rocks, relatively uniform in size. There were very few cliffs and no cinder.

Vegetation:

Vegetation in the lava was quite uniform, with the moss Racometrium lanugiosum predominating. Measurements of vegetation coverage gave the following results:

Species:	Coverage %
Bare	14.4
Rac.lan.	72.9
Rac. can.	5.1
Moss (other)	2.5
Stereocaulon sp.	5.1
	100.0

Vascular plants were not found in on the lava, but 7 species were found at the border of the lava from 1845 (see Table I).

3. Lambaritahraun from 1913

This lava field is situated ca. 15 km northeast of Mt. Hekla and was studied at 520 m above sea level, north of Landmannaleid which lies through it. A river that flows to the northwest in this area had to be crossed to get to the part of the lava which was studied.

The lava is rough and uneven, often with cavities and fissures.

Vegetation:

Racometrium lanugiosum is the dominant species. Stereocaulon sp. also has dense coverage in the area.

35 species of vascular plants were found (see Table), but their coverage was sparse. Measurements of vegetation coverage gave the following results:

Species	Coverage%
Bare	8.2
Racometrium lanug.	74.7
Racometrium canescens	1.6
Stereocaulon sp.	13.3
Festuca rubra	1.7
Carex bigelowii	0.4
Salix glauca	0.4
	100.0

4. New lava from 1878

This lava is 10 km northeast of Mt. Hekla and it was studied by Klofningar at abt. 480 m above sea level.

The lava surface is even and uniform and is similar to the surface of the lava from 1947, which was described earlier.

Vegetation:

Racometrium lanugiosum and Stereocaulon sp. are the dominant species. Racometrium can. also has some coverage. A total of 31 species of vascular plants was found (see Table I), but their coverage was very limited. Measurements of vegetation coverage gave the following results:

Species:	Coverage %:
Bare	8.0
Rac. lan.	45.0
Rac. can	10.1
Other moss	0.8
Stereocaulon sp.	32.0
Festuca vivipara	0.4
Poa alpina	0.8
Luzula spicata	0.4
Salix lanata	1.3
Cerastium alpinum	0.8
Saxifraga caespitosa	0.4
	100.0

5. Næfurholtshraun from 1845

This lava lies to the west of Mt. Hekla. Part of it is covered with lava from 1947. The western-most ridge, which is situated by the Næfurholt hayfield at 120 m above sea level, was studied all the way up to the bordér of the lava from 1947, ca. 2 km to the east at 270 m height.

The lava is very rough and uneven with crevices and deep cavities that are similar to the ones in the Skjólkvíahraun from 1970.

Vegetation:

Vascular plants are much more dominant here than in the lava fields previously described. Empretum nigrum

is the prevailing species in cavities, especially, farthest down in the lava. Herbs and grasses are also dominant. Up on the lava surface the moss Racometrium lanugiosum has large cover. Birch plants can be seen here and there in the lava as well as wuite a number of young plants. 43 vascular plants were found in this lava. Measurements of vegetation coverage gave the following results: a) 120 m above sea level:

Species:	Coverage:
Bare	10.4
Racometrium lan.	44.9
Racometrium can.	4.0
Hylocom. spl.	0.9
Stereoc. sp.	2.2
Festuca vivipara	1.3
Festuca rubra	0.4
Poa glauca	0.8
Luzula spicata	0.4
Juncus trifidus	0.4
Carex bigelowii	0.4
Salix herbaceae	0.9
Potentilla crantzii	0.4
Thalictrum alpinum	0.9
Polygnoum viviparum	0.4
Empetrum nigrum	29.5
Galium normanii	0.9
	100.0

b) 270 m above sea level:

Species:	Coverage %:
Bare	11.4
Racomentium lan.	68.3
Racometrium can.	0.4
Other moss	0.8
Stereodaulon sp.	1.6
Festuca vivipara	5.0

Festuca rubra	0.8
Poa glauca	0.8
Luzula spicata	1.3
Salix herbaceae	0.8
Empetrum nigrum	6.8
Vaccinium uluginosum	0.4
Galium normanii	0.4
Wilted grass	1.2
	100.0

6. Sydra-Selsundshraun from 1389

The lava is ca 15 km southwest of Mt. Hekla, with a border south of the farm at Selsund, and was investigated at abt. 100 m above sea level. The lava is very rough and uneven, alternating between deep crevasses and ridges similar to the lava fields from 1845 and 1970.

Vegetation:

In this lava the vascular plants have attained large coverage; the moss has retreated considerably, although it still dominates the highest points in the lava. There is a good deal of birch and in some places it forms scrubs. Empetrum, Arctostaphylos and Salix are also common. Grasses and herbs also are characteristic in the vegetation. The moss Hylocomium splendens, which is the most commonly found moss on the forest floor in Iceland, has some coverage in the area and forms a carpet in many places in the scrubs. Measurements of vegetation coverage gave the following results:

Species:	Coverage %:
Bare	3.7
Rac. lan.	19.8
Rac. can.	1.3
Hylocomiumspl.	4.3
Other moss	0.4

Stereocaulon sp.	o.4
Festuca vivipara	2.2
Festuca rubra	7.3
Agrostis tenuis	1.7
Kobresia myosuroides	2.1
Luzula multiflora	0.4
Carex biglowii	0.4
Salix herbaceae	0.8
Salix phylicifolia	6.2
Salix lanata	2.0
Betula pubescens	10.5
Polygonum viviparum	1.3
Cerastium cerastoides	0.9
Thalictrum alpinum	0.8
Rununc. acris	0.4
Parnassia palustris	0.4
Alchemilla alpina	6.3
Arctostaphylos uva ursi	4.8
Vaccinium uliginosum	1.3
Empetrum nigrum	15.7
Thymus arcticus	0.4
Taraxacum sp.	0.8
Arcin. norm	1.3
Hieracium sp	0.4
Wilted grass	1.7
	100.0