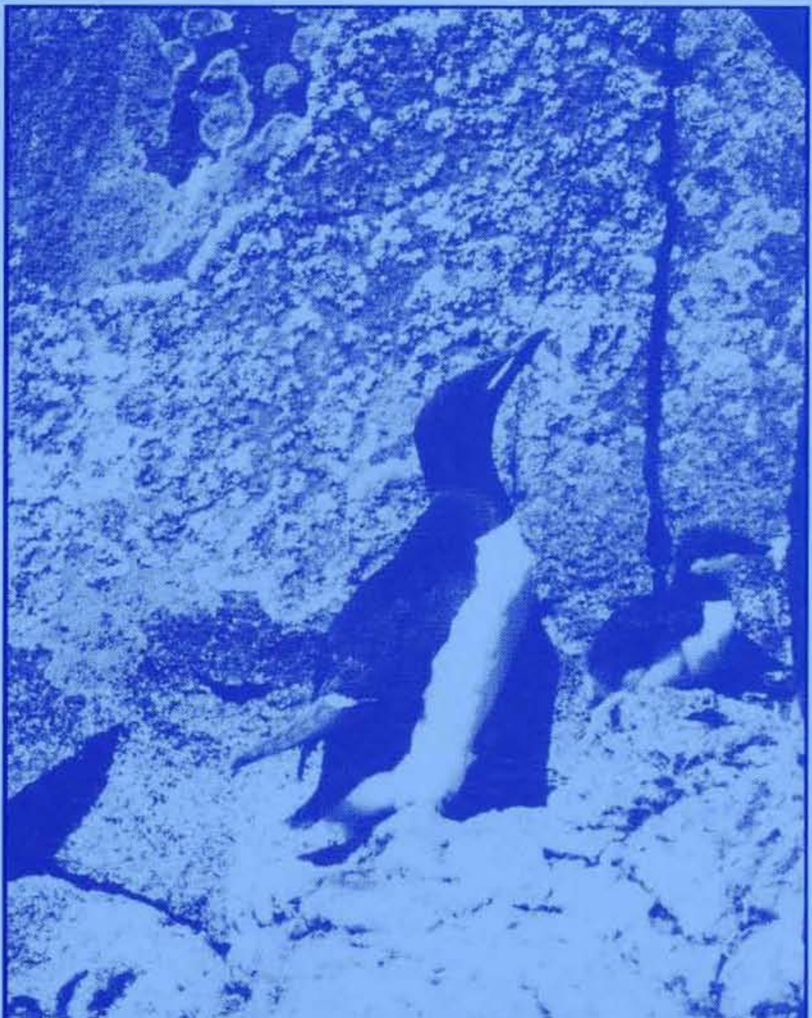
NORSK POLARINSTITUTT

RAPPORTSERIE

NR. 64 - OSLO 1990

OLOF OLSSON and GEIR WING GABRIELSEN:

EFFECTS OF HELICOPTERS ON A LARGE AND REMOTE COLONY OF BRÜNNICH'S GUILLEMOTS *(URIA LOMVIA)* IN SVALBARD



NORSK POLARINSTITUTT
RAPPORTSERIE
NR. 64 - OSLO 1990

OLOF OLSSON and GEIR WING GABRIELSEN:

EFFECTS OF HELICOPTERS ON A LARGE AND REMOTE COLONY OF BRÜNNICH'S GUILLEMOTS *(URIA LOMVIA)* IN SVALBARD

Olof Olsson
Department of Zoology
Stockholm University
S-106 91 Stockholm
Sweden

Geir Wing Gabrielsen
Norwegian Polar Research Institute
Rolfstangveien 12
N-1330 Oslo Lufthavn
Norway

Table of contents

1. INTRODUCTION

In 1987 Fjeld et al. (1988) performed a study on effects of helicopter noise on a small colony of Brünnich's Guillemots (1300 ind.) in Kongsfjorden (79° N), Svalbard. The results from this study indicated that non-breeding birds left the colony when the distance between the colony and the helicopter was 500 m to 6 km. For non-breeding birds all helicopter flights within 2 km from the colony seem to cause disturbance in the colony. One possible reason for little or no reaction of breeding birds upon provocations could be that they were habituated to helicopter traffic. The bird colony was only 10 km from the settlement of Ny-Ålesund and 4 km from the regularly used helicopter route from Longyarbyen.

One goal of the present study was to investigate the effects of helicopter provocations on a large and remote colony of Brünnich's Guillemots, preferably on birds which were not habituated to helicopter noise. Another object of this study was to investigate if the size of the colony could influence its vulnerability. Some observations (e.g. Knutsen et al. 1988) in Svalbard indicate that helicopter noise creates mass panic in large colonies.

For more detailed background information to this study, an overview is given by Fjeld et al. (1988).

2. STUDY AREA

The study was performed in Kovalskifjella, north of Hambergbukta in the south-western part of Storfjorden, Svalbard (77° 04'N, 17° 18'E). The colony is large, comprising about 90 000 individuals of Brünnich's Guillemots (Olsson unpubl.). The breeding cliffs rise about 250 m above sea level (m.a.s.l.) and the birds breed from about 130 m.a.s.l. to the top of the cliffs. The area where birds breed is about 600 m wide. Between the cliffs and the sea there is a beach which is about 700 m wide (Fig. 1 and 2).

The colony is situated about 20 km north of an area (Haketangen) where oil/gas drilling has been taking place since 1987. This has increased the traffic of helicopters to the area. But it has, according to the Governor of Svalbard, not affected the study area to any great extent.

3. METHODS

3.1 Biological observations

This study was done from 12 July until 11 August 1989. During this period, 15 helicopter provocations were made during three days; 25 July, provocation 1 to 6, 26 July, provocation 7 to 11 and 1 August provocation 12 to 15.

From the time that we arrived until the first provocation was made (14 days), we selected three ledges which were for behavioral observations. Two ledges were selected just below the top of the colony, and a third in the middle. On the two upper ledges, where the observation distance was short (5 to 10 m), we mapped which birds bred and which did not. On the third ledge, in the middle of the colony, the observation distance was very long (about 60 m), and it was impossible to map the breeding status among the birds on that ledge.

Our intention was to get a good documentation of the behaviour of the birds on the two upper ledges during the helicopter provocations. The third ledge should only be used as a reference, to control that the behaviour of the birds during the provocations was similar to the two upper ledges.

When the first helicopter provocations (1 to 4) were done, we did find that the behavioural reaction of the birds in the upper part of the colony was not representative to the birds in the entire colony. Therefore the two mapped ledges in this part of the colony were inconvenient as study plots. The reaction of the birds on the third ledge, in the middle of the colony, seems to represent the reaction in the entire colony.

Because of this miscalculation, we decided only to make registrations during the provocation on one of the two upper ledges, called "A" in the further reading, and on the ledge in the middle of the colony, called "B".

Ledge A was about one meter wide and the birds bred in many rows, the surrounding vertical cliffs formed a corner so that the ledge was quite unexposed. Ledge B did consist of an area with very narrow ledges, with only one row of breeding birds on each. It was also situated more exposedly than ledge A. The number of birds observed on ledge A was 25 to 42, on ledge B the number was 61 to 77 (except flight no. 1, 35 birds). The reason for the varying number is that the number of birds which were possible to separate easily on the pictures was varied (see below).

A sketch of the breeding cliffs with the positions of the ledges and the observation points (= camera positions) is given in Figure 1.

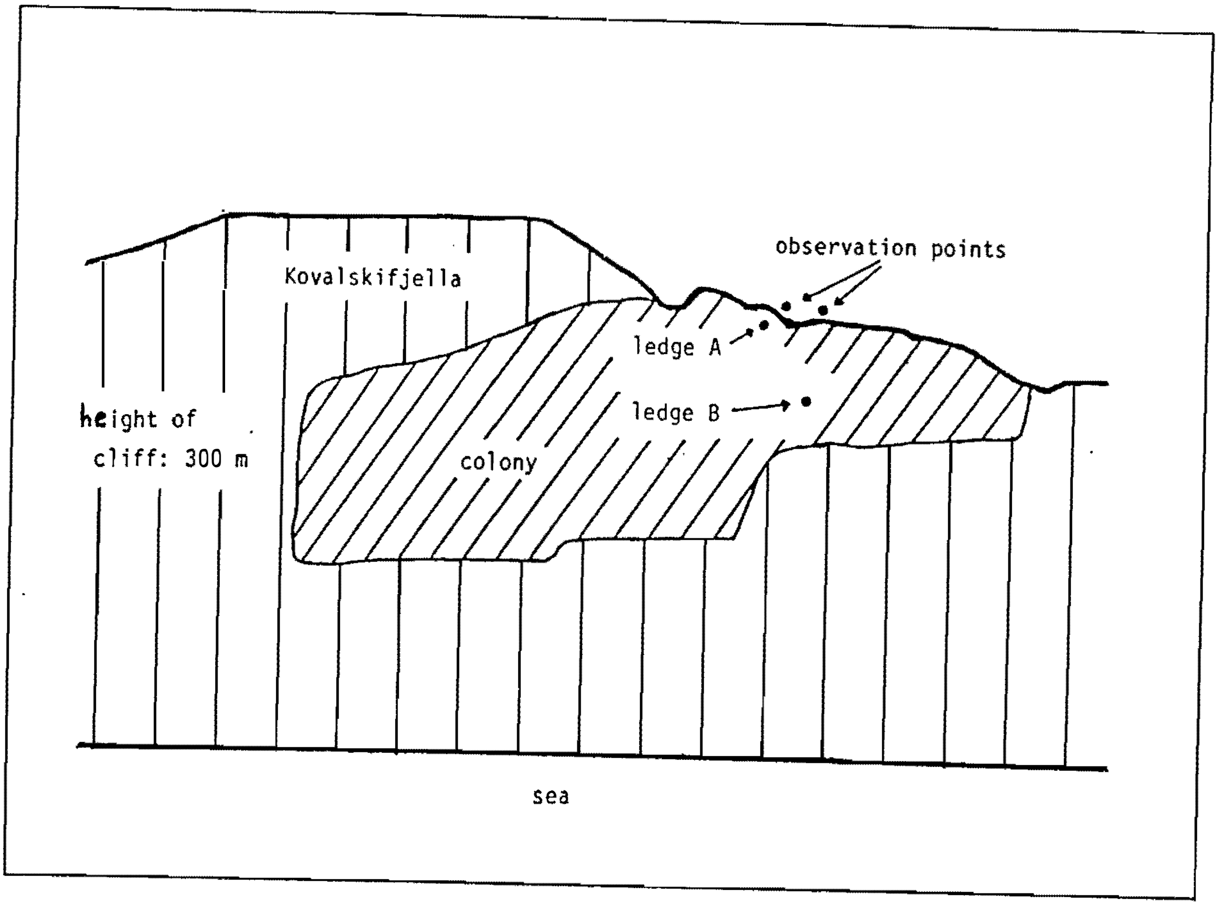


Figure 1. Sketch of the breeding cliffs in Kovalskifjella, with the position of the studied ledges (A and B) and the observation points (= camera positions).

The methods applied in this study were meant to be similar to the methods used by Fjeld et al. (1988) in the Kongsfjorden study. But because of the unexpected divergent behaviour of the birds on the ledges that we had mapped, we were forced to base our study primarily on ledge B, where the breeding status among the birds was not known. Despite the knowledge of the breeding status on ledge A, we present the registrations from this ledge as from ledge B, in order to keep the presentation uniform. Therefore, in this study, the birds which flew during the provocations are given as per cent of the total number of birds present on the ledge (breeders + non-breeders). In the Kongsfjorden study the birds which flew were given as per cent of the non-breeders.

However, when a bird flew it was possible to see if there was any egg or chick in the place where it sat. In this way, we were able to separate breeders from non-breeders.

During the helicopter provocations the two ledges, A and B, were registrated with photo cameras in fixed positions, from the top of the cliffs (Fig. 1). The distance between the cameras and ledge A and B, was 10 m and 60 m, respectively. When the helicopter advanced to the colony, pictures were taken with an interval of one per 10 sec. before maximum response. After maximum response, when the helicopter had passed, one picture per minute was taken. Pictures were taken at most 24 minutes after the provocation. In each picture it was possible to count birds present on the ledges throughout the provocation period, and the returning rate afterwards. At ledge A it was possible to observe "orienting response" (raised heads or standing) of the birds. The orienting response indicates that the birds try to locate the source of the disturbance. It is the first sign of stress. When the birds got more stressed they left the ledge. In the pictures from ledge B, birds flying was the only behavioural response possible to detect, since the distance to the ledge was long.

During the study in Kongsfjorden (Fjeld et al. 1988), the sound pressure levels (SPL) generated by the helicopter were quantified with microphones. The results showed that the behavioural response of the birds started at a certain SPL, not directly depending on the distance to the helicopter. During some circumstances, the SPL, and hence the behavioural response of the birds, could be the same when the distance between the helicopter and the colony differed as much as 500 m and 6 km.

In the present study we did not have the opportunity to measure the SPL, and therefore the distance to the helicopter was the only parameter used.

In order to determine the distance between the advancing helicopter and the ledge, when the birds left, we also filmed the course at ledge B during the provocation with a video camera. A clock on the video tape made it possible to determine how much time passed from the first birds leaving the ledge, to the helicopter passing the ledge. The distance could then be calculated by multiplying the time with the speed of the helicopter.

During the flights, we had radio communication with the helicopter pilot. He continuously gave us speed, altitude and position. The information was recorded on the video tape by holding the radio next to the microphone on the video camera, synchronously with the filming of the course on the ledge.

Because of the previously mentioned divergent behaviour of the birds in the upper parts of the colony, ledge B was not video taped during flight 1 to 4, and the distance to the helicopter when the first birds flew is not known from these provocations. Flights similar to these (10, 12, 13 and 14) were done later, and they were video taped.

The study area with helicopter flight routes is presented in Figure 2. Altitude, speed and direction of the helicopter in each flight are presented in Table 1.

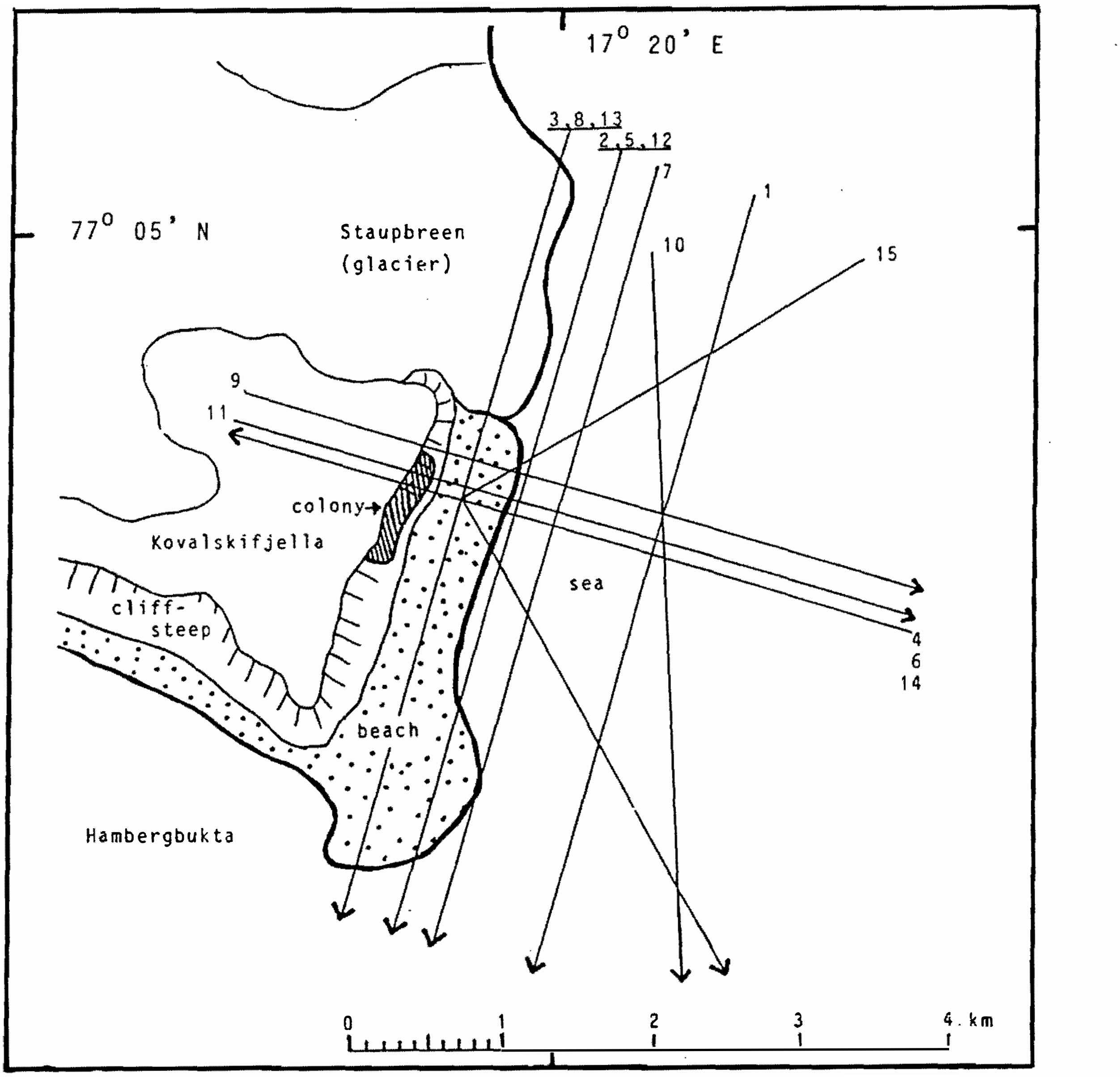


Figure 2. The study area with helicopter flight routes. The numbers correspond to the flight numbers in the text, tables and the appendix.

3.2 Helicopter types

All provocation flights except one were made by a three bladed AS 350 B1 (Ecureuil) helicopter, which was stationed on R/V Lance. One provocation, no. 10, was made by a two bladed Bell 212 helicopter from the Governor of Svalbard. This type of helicopter is bigger and makes significantly more noise, the sound has a lower frequency and it can be heard from a longer distance than the Ecureuil helicopter. The number of rotor blades of a helicopter is an important factor influencing the strength and frequency of the noise. An important difference between this study and the Kongsfjorden study is that Bell 212 helicopters were used in Kongsfjorden.

4. RESULTS

4.1 Descriptions of the flights and the response of the birds

The distance given below is the minimum distance between the helicopter and the ledges when flying parallel. The altitude is above sea level, and the speed was 110 knots when nothing else is given.

1. Helicopter flying parallel to the colony, distance 1700 m, altitude 300 m.

Ledge A: orienting response, and 5 % of the birds flew (probably for some other reason than disturbance from the helicopter).

Ledge B: no birds flew.

2. Helicopter flying parallel to the colony, distance 700 m, altitude 300 m.

Ledge A: orienting response, but no birds flew.

Ledge B: 22% of the birds flew, distance to the helicopter when first birds flew is unknown.

3. Helicopter flying parallel to the colony, distance 350 m, altitude 300 m.

Ledge A: no orienting response, and no birds flew.

Ledge B: 27% of the birds flew, distance to the helicopter when first birds flew is unknown.

4. Helicopter flying right towards and over the colony, altitude 300 m (50 m above the top of the colony).

Ledge A: orienting response, and 7% of the birds flew.

Ledge B: 45% of the birds flew, distance to the helicopter when first birds flew is unknown.

5. Helicopter flying parallel to the colony, distance 700 m, altitude 500 m.

Ledge A: no orienting response, and no birds flew.

Ledge B: 25 % of the birds flew, distance to the helicopter when first bird flew was 1.8 km.

6. Helicopter flying right towards and over the colony, altitude 500 m (250 m above the top of the colony).

Ledge A: orienting response, but no birds flew.

Ledge B: 31 % of the birds flew. Distance to the helicopter when first birds flew was 2 km. The birds continued to fly until the helicopter had passed the colony and was 300 m behind. Strongest reaction appeared from a distance of 1 km.

7. Helicopter flying parallel to the colony, distance 1 km, altitude 500 m.

Ledge A: no orienting response, and no birds flew.

Ledge B: no birds flew.

8. Helicopter flying parallel to the colony, distance 350 m, altitude 50 m, speed 80 knots (this flight was meant to resemble the route a helicopter would fly through fog to be able to navigate, if it does not have a radar on board).

Ledge A: orienting response, but no birds flew.

Ledge B: 41 % of the birds flew. Distance to the helicopter when first birds flew was 600 m, birds continued to leave the ledge until the helicopter had passed the colony (distance 250 m).

9. Helicopter flying over the colony from behind about 300 m beside the observed ledges, altitude 250 m (same height as the top of the colony).

Ledge A: orienting response, but no birds flew.

Ledge B: 37 % of the birds flew. First birds flew when the helicopter had passed the ledge with 200 m (60 m from the cliff steep), and they continued to leave the ledge until the helicopter was 400 m away (350 m from the cliff steep).

10. Helicopter (Bell 212) flying parallel to the colony, distance 1.7 km, altitude 300 m.

Ledge A: orienting response, but no birds flew.

Ledge B: no birds flew.

11. Helicopter flying over the colony from behind above the observed ledges, altitude 280 m (30 m above the top of the colony), speed 65 knots.

Ledge A: orienting response, and 24 % of the birds flew.

Ledge B: 32 % of the birds flew. First bird flew when the helicopter was straight above the colony and they continued to leave the ledge until the helicopter was

230 m away.

12. Helicopter flying parallel to the colony, distance 700 m, altitude 300 m.

Ledge A: orienting response, but no birds flew.

Ledge B: 22% of the birds flew. First birds flew when the helicopter was 1 km away, and they continued to leave the ledge until the helicopter had passed the ledge by 170 m.

13. Helicopter flying parallel to the colony, distance 350 m, altitude 300 m.

Ledge A: orienting response, but no birds flew.

Ledge B: 18 % of the birds flew. First birds left the ledge when the helicopter was 1.1 km away, and they continued to leave the ledge until the helicopter was right outside.

14. Helicopter flying right toward and over the colony, altitude 250 m (just above the top of the cliffs).

Ledge A: orienting response, and 16 % of the birds flew.

Ledge B: 62 % of the birds flew. First birds flew when the helicopter was 2.5 km away, then no birds flew until the helicopter was 1.2 km away, the birds continued to leave the ledge until it was 170 m behind the colony. This was the only provocation when it was possible to observe that breeding birds left the ledge. No loss of eggs or chicks was observed.

15. Helicopter flying 45 degrees towards the colony and turning over 90 degrees at a distance of 350 m and then flying away 45 degrees from the colony, altitude 230 m.

Ledge A: orienting response, and 19% of the birds flew.

Ledge B: 45 % of the birds flew. First birds flew when the helicopter was 2.3 km away, the birds continued to leave the ledge until the helicopter had turned over and was 450 m away from the colony.

In the appendix sketches are given of each flight, when birds flew from ledge B, with the distance between the helicopter and the ledge when the first birds flew. In Table 1 information of all flights, with all registrations, is listed.

Table 1. Provocation flights listed in chronological order. All registrations accounted.

	Flight data				Ledge A			Ledge B		
Fl. no.	Direc- tion	Min. dist.	Alti- tude	Speed	a) n	b) OR+F	c) F	a) n	c) F	First resp.
1	paral.	1700m	300m	110kn	42	38%	5%	35	0%	-
2	paral.	700	300	110	37	54	0	67	22	?
3	paral.	350	300	110	34	0	0	63	27	?
4	towar.	-	300	110	42	35	7	69	45	?
5	paral.	700	500	110	32	31	0	61	25	1800m
6	towar.	-	500m	110kn	26	34%	0%	67	31%	2000m
7	paral.	1000m	500	110	28	0	0	73	0	-
8	paral.	350	50	80	28	64	0	71	41	600
9	behind	-	250	110	25	72	0	71	37	-200
10	paral.	1700	300	110	30	20	0	72	0	-
11	behind	-	280m	65kn	25	64%	24%	76	32%	0m
12	paral.	700m	300	110	28	78	0	69	22	1000
13	paral.	350	300	110	30	60	0	68	18	1100
14	towar.	-	250	110	25	52	16	65	62	2500
15	tow.(45°)	350	230	110	27	56	19	77	48	2300

a) n = number of birds present on the ledge before provocation.
b) OR+F = birds showing the orienting response or flying from the ledge, % of a).
c) F = birds flying from the ledge, % of a).

There was a significant difference in the birds' response toward provocations on the two ledges studied. On ledge A, birds left the ledge only in 4 of 15 flights (in flight no. 1 the birds flew because of other factors), while on ledge B birds flew in 12 of 15 flights. Upon provocations, when birds flew from both ledges (flights no. 4, 11, 14 and 15), the relative number of birds flying from ledge A was lower than on ledge B.

In Table 2 the provocation flights are listed in turn, considering the number of birds which flew from ledge B. It is obvious that flights towards or from behind, over the colony, caused more stress than flights parallel to the colony. Birds also flew from the ledge at a longer distance when the helicopter advanced towards the colony. The maximum distance between the ledge and the helicopter when advancing, when birds flew, was 2.5 km (flight 14). The maximum distance when the helicopter advanced parallel was 1.8 km (flight 5). The results also indicate that flights at lower altitudes caused more stress than at higher ones.

Table 2. Provocation flights listed in turn considering the number of birds which flew from ledge B.

Flight no.	Birds flying (%)	Dist. first resp.	Direction	Altitude	Min. dist.
14	62	2500m	towards	250m	-
15	48	2300	tow.(45°)	230	-
4	45	?	towards	300	-
8	41	600	parallel	50	350m
9	37	-200	behind	250	-
11	32	0	behind	280	-
6	31	2000	towards	500	-
3	27	?	parallel	300	350
5	25	1800	parallel	500	700
12	22	1000	parallel	300	700
2	22	?	parallel	300	700
13	18	1100	parallel	300	350
1	0	-	parallel	300	1700
7	0	-	parallel	500	1000
10	0	-	parallel	300	1700

5. DISCUSSION

5.1 Responses to the provocations

The reason for the difference in behavioural response of the birds between ledge A and B is probably the appearance and the location of the ledges in the colony. Ledge A was quite broad, unexposed and situated just below the top of the cliff. Ledge B, on the other hand, was more exposed. It consists of some very narrow ledges and it was situated in the middle of the colony.

Stoneslides were frequently observed in the colony. It is possible that birds sitting in the lower parts of the colony (as the birds on ledge B) were aware of birds flying out above them, because this could indicate stoneslide. Therefore, flying out when birds above were flying could be an adaptable response. This could be one reason for the stronger reaction of birds on ledge B. It could also explain the mass panic behaviour in large colonies.

It is likely that the two ledges studied were very safe and insecure, respectively. The total reaction of the provocations in the entire colony was probably more like the reaction on ledge B, since most of the ledges in the colony look like ledge B.

In only one flight (no. 14) it was possible to confirm that breeding birds left the ledge during the provocations. But it is possible that some breeders also flew during some other provocations. However, it was a big difference in behaviour between breeders and non-breeders. The results from this study are similar to the results from the Kongsfjorden study, which indicate that the weak response among the breeders in Kongsfjorden was not due to habituation.

A comparison between the study of the small colony in Kongsfjorden and the large colony in this study shows that the stress caused by helicopter traffic did not seem to increase in large colonies. The relative number of birds leaving the ledges seems to be about the same in both colonies, when the provocations are comparable considering the distance of the helicopters to the colonies. The mass panic flight observed in large colonies does not depend so much on the fact that the relative number of birds leaving the ledges is higher as the fact that even when quite a small share of the birds leave the ledges in very large colonies, the amount of birds in the air outside the colony is overpowering to the observer. But because different types of helicopters were used in the two studies, the results are not directly comparable. It is possible that the stress would have been stronger if a Bell 212 helicopter had been used in this study. So the hypothesis that large colonies are more vulnerable can not be rejected. (It would also have been more realistic to use a Bell 212 in this study, since it is the helicopter type most commonly used in Svalbard.) The results from flight 10 are contradictory to the statement that the Bell 212 should cause more stress; no birds left the ledges despite that the flight was performed with a Bell 212. But the most likely reason for the poor reaction is that the direction of the helicopter was away from the colony and that the distance to the colony was long. This implies that the noise was relatively weak. A contributing reason could be that less than 20 minutes had passed since the previous provocation, and all birds may not have returned. The reason for this is that the helicopter appeared incidentally on some other mission in the area.

5.2 Habituation

The habituation effect during this study was investigated by comparing flights 1, 2 and 3 with flights 10, 12 and 13, respectively (Table 3). There was no clear trend of a lesser number of birds flying in the later flights. Therefore, this study could not confirm that Brünnich's Guillemots could be habituated to helicopter traffic. But it is still possible that more frequent traffic could create habituation. One can not exclude that the birds already were habituated, because the area already has some helicopter traffic in connection with oil/gas drilling on Haketangen.

Table 3. Habituation experiment; comparison between provocation flights which were identical. OR = orienting response, F = birds flying.

	Response of birds			Flight data			
Fl. no.	Ledge A OR+F(%)	Ledge A F (%)	Ledge B F (%)	Direction	Min. dist.	Altitude	Speed
1/10	38/20	5/0	0/0	paral.	1700m	300m	110kn
2/12	54/78	0/0	22/22	paral.	700	300	110
3/13	0/60	0/0	27/18	paral.	350	300	110

5.3 Return after provocation

In Table 4 the rate of return to the ledge after provocations is shown. Even when the ledge was recorded for more than 20 minutes (max 24 min.) after the provocation, the number of birds was less than before the provocation. This could be explained by some birds landing on other ledges. But in this case it is most likely that some birds which flew from other ledges should have landed on ledge B. Our conclusion is that in most cases it took more than 20 minutes before all birds had returned after a provocation. This is longer than in the Kongsfjorden study, where it took 5-10 minutes. May be this is caused by habituation in Kongsfjorden?

Table 4. Birds' rate of returning to ledge B after provocations.

Fl. no.	a) n	b)0 min	c) Max	d)2 min	4	6	8	10	12	14	16	18	20	22	24
1	35	no birds flying													
2	67	79	78	78	78	79	78	76							
3	63	81	73	73	73	80	80	80	80						
4	69	81	55	55	59	59	62	64	64	70					
5	61	80	75	75	74	75	79	82	84	89	90	92	93		
6	67	73	69	69	70	76	81	85	88	91	90	90	91	91	
7	73	no birds flying													
8	71	92	59	62	68	70	69	73	76	79	82	85	86	89	94
9	71	63	63	63	63	73	77	76	77						
10	72	no birds flying													
11	76	70	68	68	68										
12	69	86	78	81	88	86	87	87	93						
13	68	82	82	85	93	93									
14	65	80	38	38	42	45	49	55	57	60	62	69	71	71	
15	77	74	52	64	65	73	75	81	84	88	87	92	92		

a) Number of birds present on the ledge before provocation.
b) Minute 0, birds present immediately after the first birds flew, % of a).
c) Maximum response, % of a).
d) Minute 2, 4, 6...etc., birds present 2, 4, 6 ..etc., minutes after the first birds flew from the ledge, % of a).

5.4 Orienting response

The fact that birds on the relatively safe ledge A in all but two provocations exhibit orienting response (Table 1), indicates that helicopters could cause stress in colonies even if birds do not always leave the ledges. So, when deciding the minimum distance to aircrafts in areas with seabird colonies, one has to reckon with the possibility that the birds get stressed long before they leave the ledges.

5.5 Offspring loss and predation

This study, like the one in Kongsfjorden, was performed at the end of the breeding season when most of the breeding birds have chicks. Birds with chick are probably more motivated to remain on the ledges to protect their offspring than birds with egg because of their high investment at this stage of the season. Earlier in season a loss of offspring could be replaced by laying another egg. Therefore, it is possible that helicopter traffic could cause more losses of offspring earlier in the season. Another reason for believing that the vulnerability is greater in the brooding period is the fact that the egg is brooded at the feet of the adult. If the adult hastily leaves the ledge there is a big risk of the egg being lost. In this study no losses of eggs or chicks could be observed, even when the provocations were very strong. Nor could any increased predation from Glaucous Gulls (*Larus hyperboreus*) be observed in connection with the provocations.

5.6 Conclusions

The existing flying limit in the vicinity of seabird colonies in Svalbard is 500 m (Environmental Regulations for Svalbard, 14). Fjeld et al. (1988) suggest, in the light of the results of the Kongsfjorden study, that the limit should be increased to 2 km, and if helicopter traffic passes regularly over areas with large or many colonies, traffic should be directed to follow specific routes passing the colonies at a minimum of 6 km. The results from this study support the conclusion that the limit should be expanded, with the addition that the closest limit should be 3 km, to avoid stress in the colonies.

6. ACKNOWLEDGEMENTS

We would like to thank field assistants Georg Bangjord and Egil Soglo for their enthusiasm and great achievement. We also want to thank expedition leader Fridtjof Mehlum for the co-ordination of the helicopter flights and advices, helicopter pilot Jarl Andresen for his kind assistance and professional flying, captain and crew on R/V Lance for their kind assistance.

7. REFERENCES

Fjeld, P.E., Gabrielsen, G.W. & Ørbæk, J.B. 1988. Noise from helicopters and its effect on a colony of Brünnich's Guillemots (Uria lomvia) on Svalbard. In: Presterud, P. & Öritsland, N.A. (eds). - Norsk Polarinstitutt, Rapportserie no. 41 (Oslo).

Knutsen, L.Ø., Fjeld, P.E. & Olsson, O. 1988. Sjøfuglundersøkelser på Øst-Spitsbergen, Svalbard, med konsekvensvurdering av aktiviteten på Haketangen. In: Presterud, P. & Øritsland, N.A. (eds). - Norsk Polarinstitutt, Rapportserie no. 41 (Oslo).

Olsson, O. unpubl. Rapport från fältarbetet vid Kovalski- och Stellingfjellet 1989. Intern rapport, Norsk Polarinstitutt.

8. APPENDIX.

Description of all flight routes and reaction of the birds, when birds flew from ledge B. Flights no. 1, 7 and 10 are not described because no birds left ledge B during these flights (nos. 2, 3 and 4 are lacking because of error in the methods, see chapter 3.1).

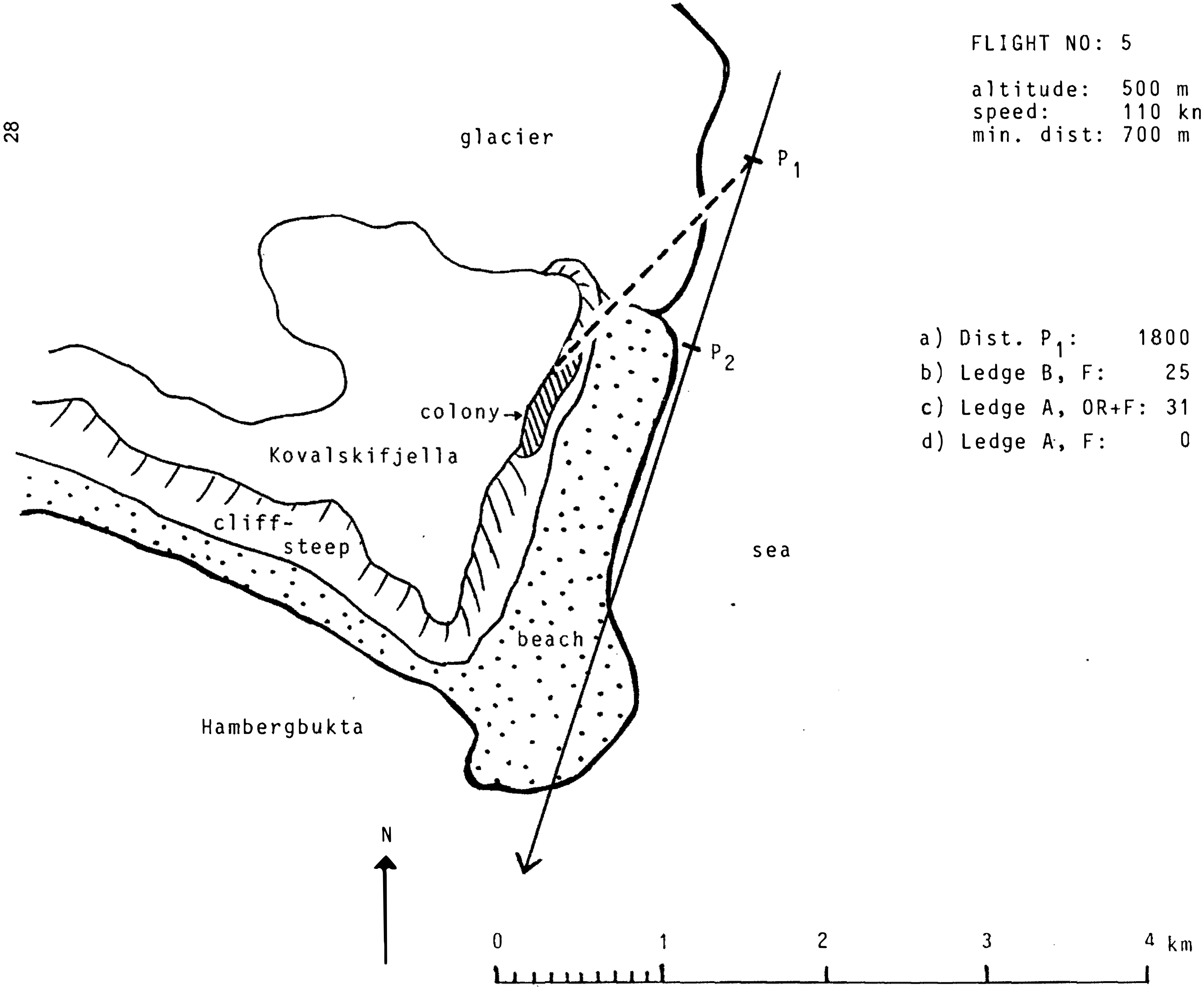
P_1 is the position of the helicopter when the first birds flew from ledge B. When the helicopter had passed P_2 no more birds left the ledge. Between P_1 and P_2 birds continuously left the ledge. Data of the flights and the maximum reaction of the birds on both ledges (A and B) are given.

a) Dist. P_1: = distance between the helicopter and ledge B when the first birds flew (dashed line indicates the distance, when the helicopter did not fly over the colony).

b) Ledge B, F: = maximum number of birds flying from ledge B.

c) Ledge A, OR+F: = maximum number of birds showing the orienting response or flying from ledge A.

d) Ledge A, F: = maximum number of birds flying from ledge A.



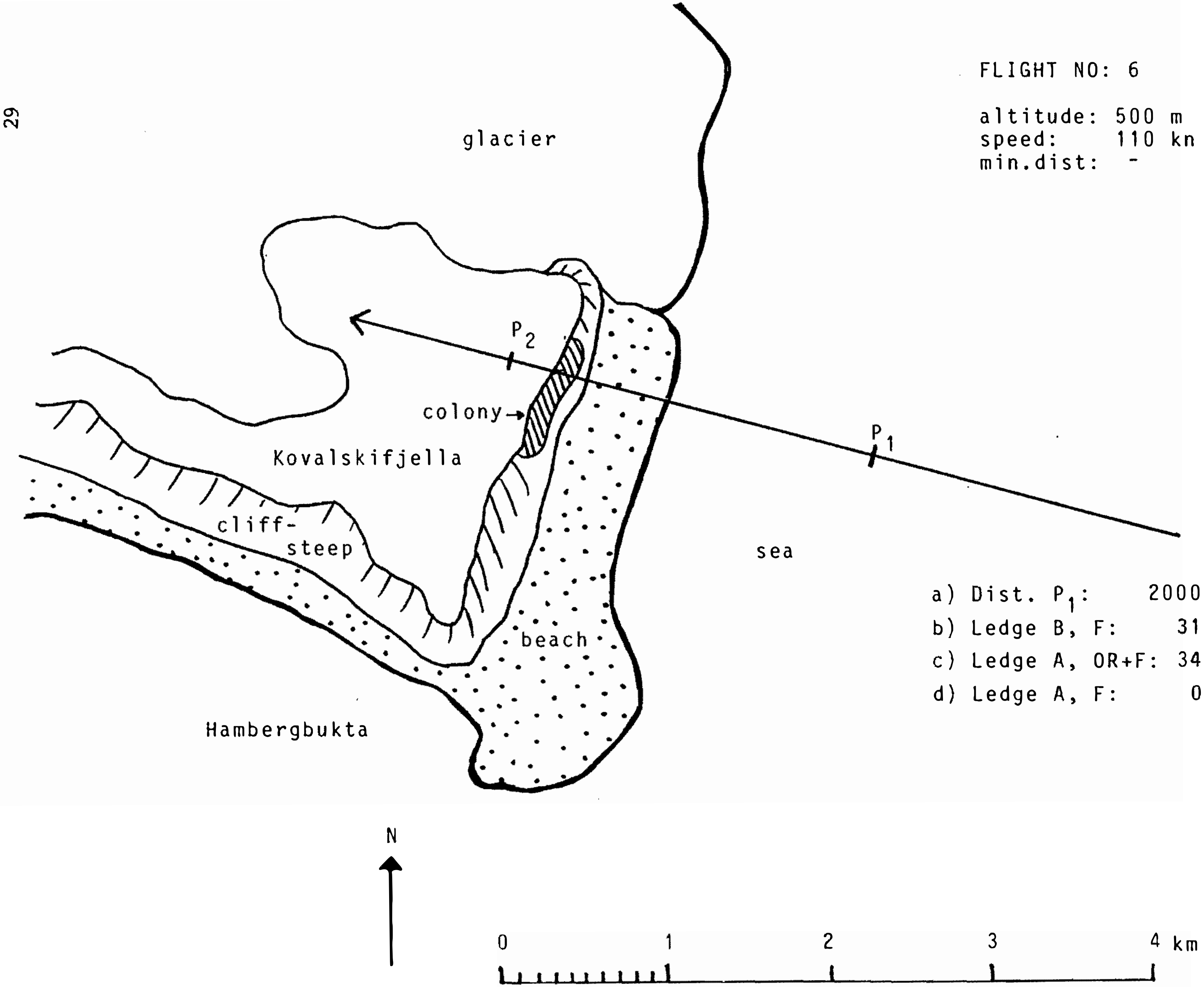
FLIGHT NO: 5

altitude: 500 m
speed: 110 kn
min. dist: 700 m

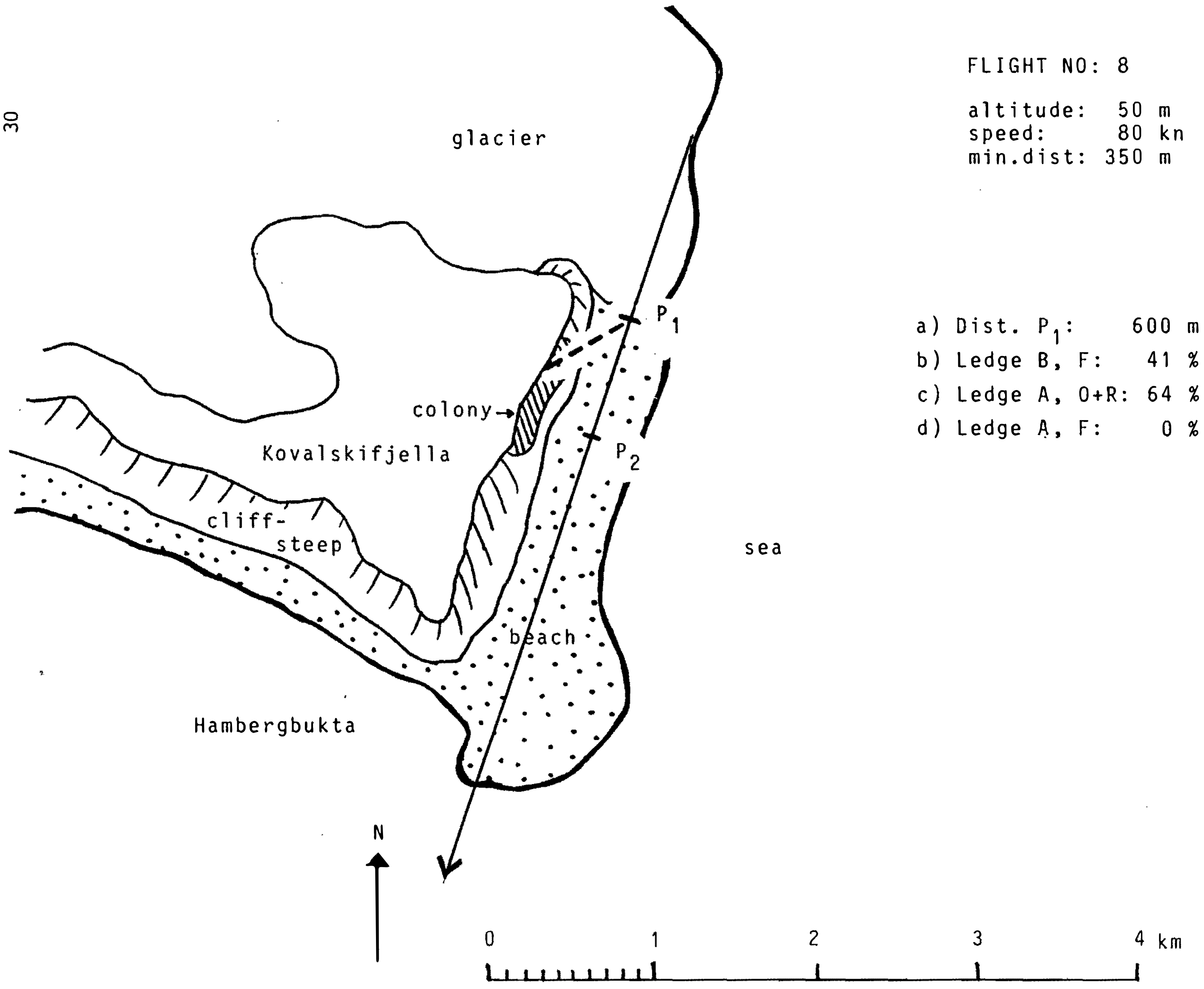
a) Dist. P_1: 1800 m
b) Ledge B, F: 25 %
c) Ledge A, OR+F: 31 %
d) Ledge A, F: 0 %

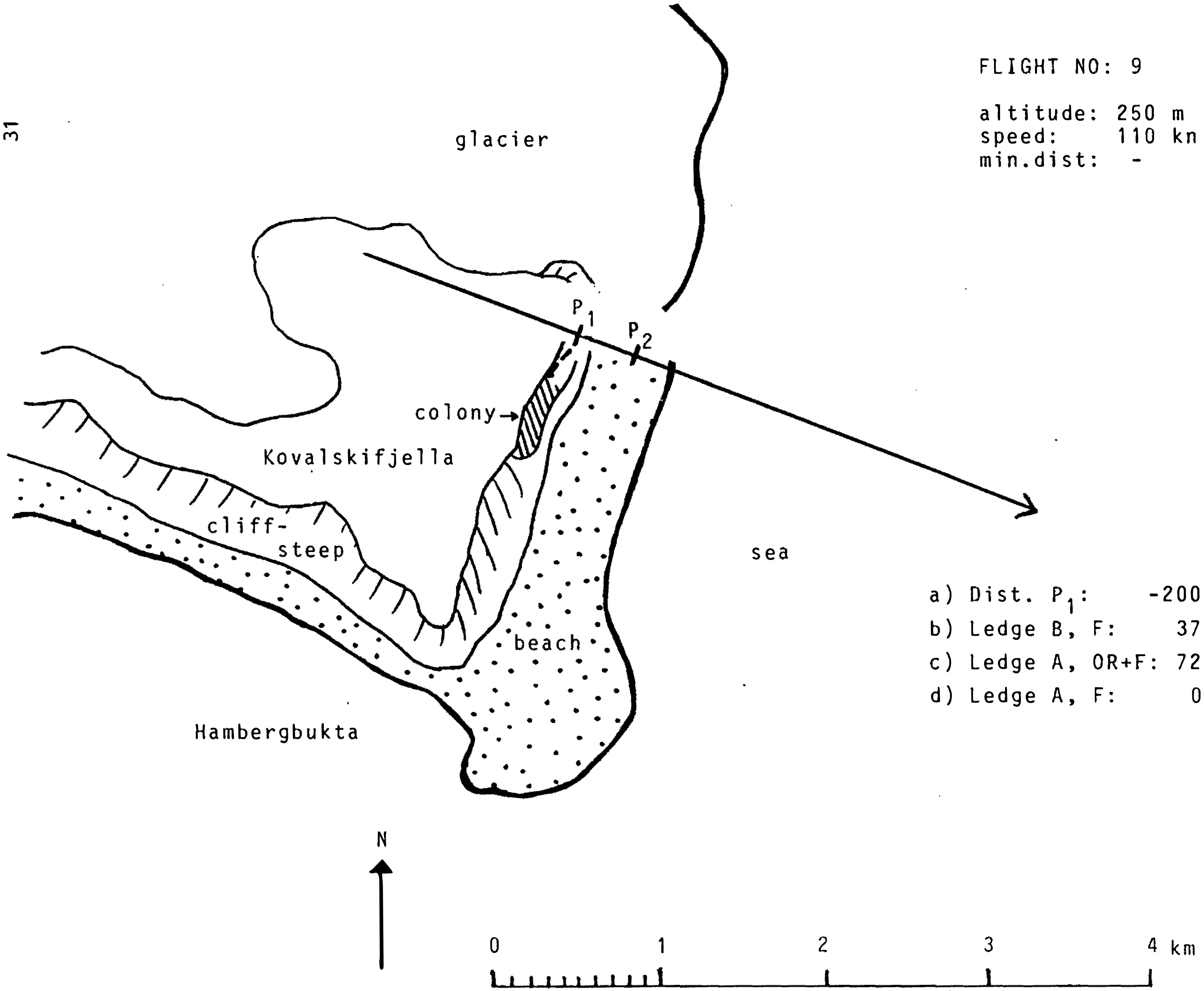
FLIGHT NO: 6

altitude: 500 m
speed: 110 kn
min.dist: -



a) Dist. P_1: 2000 m
b) Ledge B, F: 31 %
c) Ledge A, OR+F: 34 %
d) Ledge A, F: 0 %


FLIGHT NO: 8
altitude: 50 m
speed: 80 kn
min.dist: 350 m
a) Dist. P_1: 600 m
b) Ledge B, F: 41 %
c) Ledge A, O+R: 64 %
d) Ledge A, F: 0 %
glacier
colony
Kovalskifjella
cliff-
steep
beach
P_1
P_2
sea
Hambergbukta
N
0
1
2
3
4 km



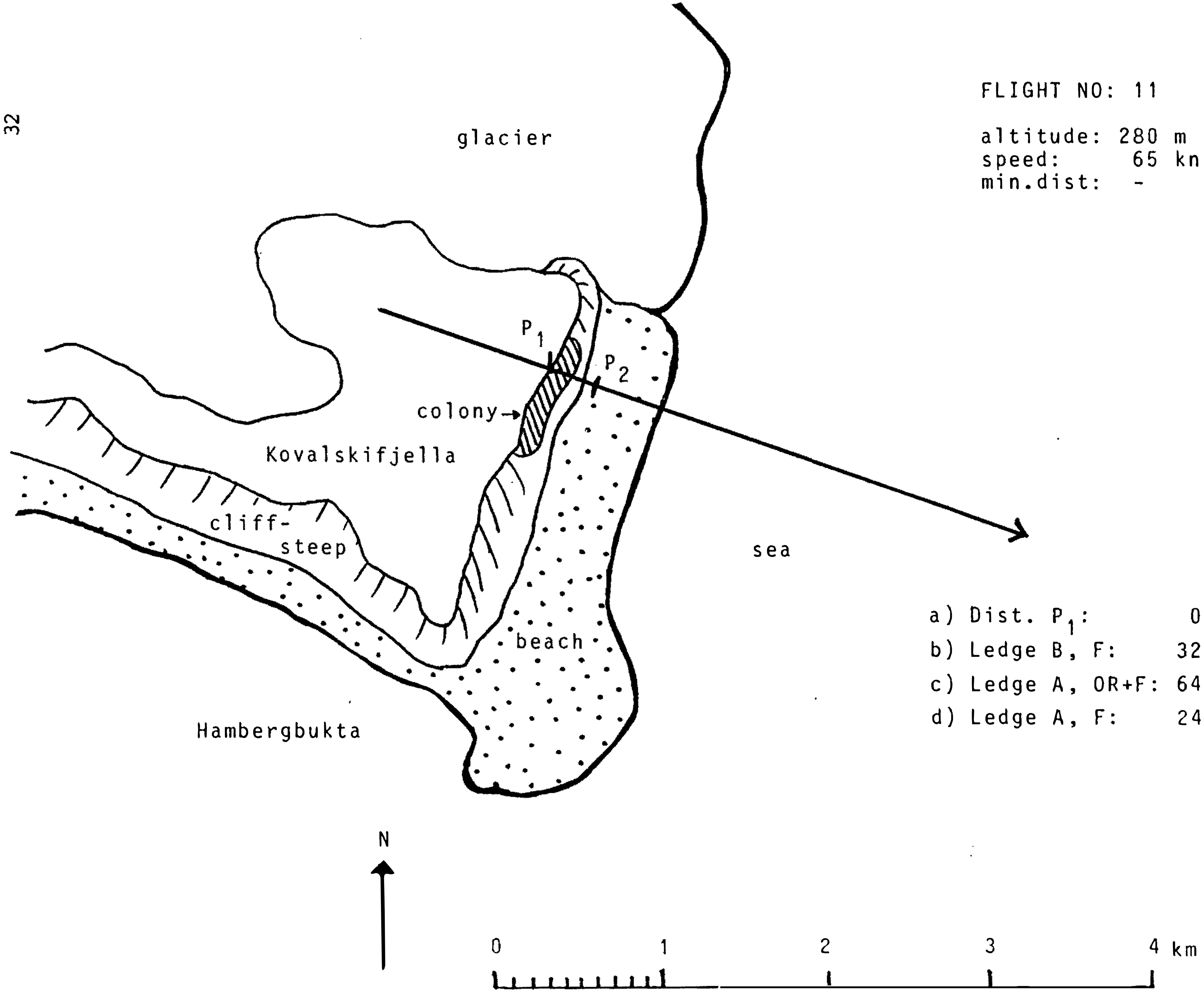
FLIGHT NO: 9

altitude: 250 m
speed: 110 kn
min.dist: -

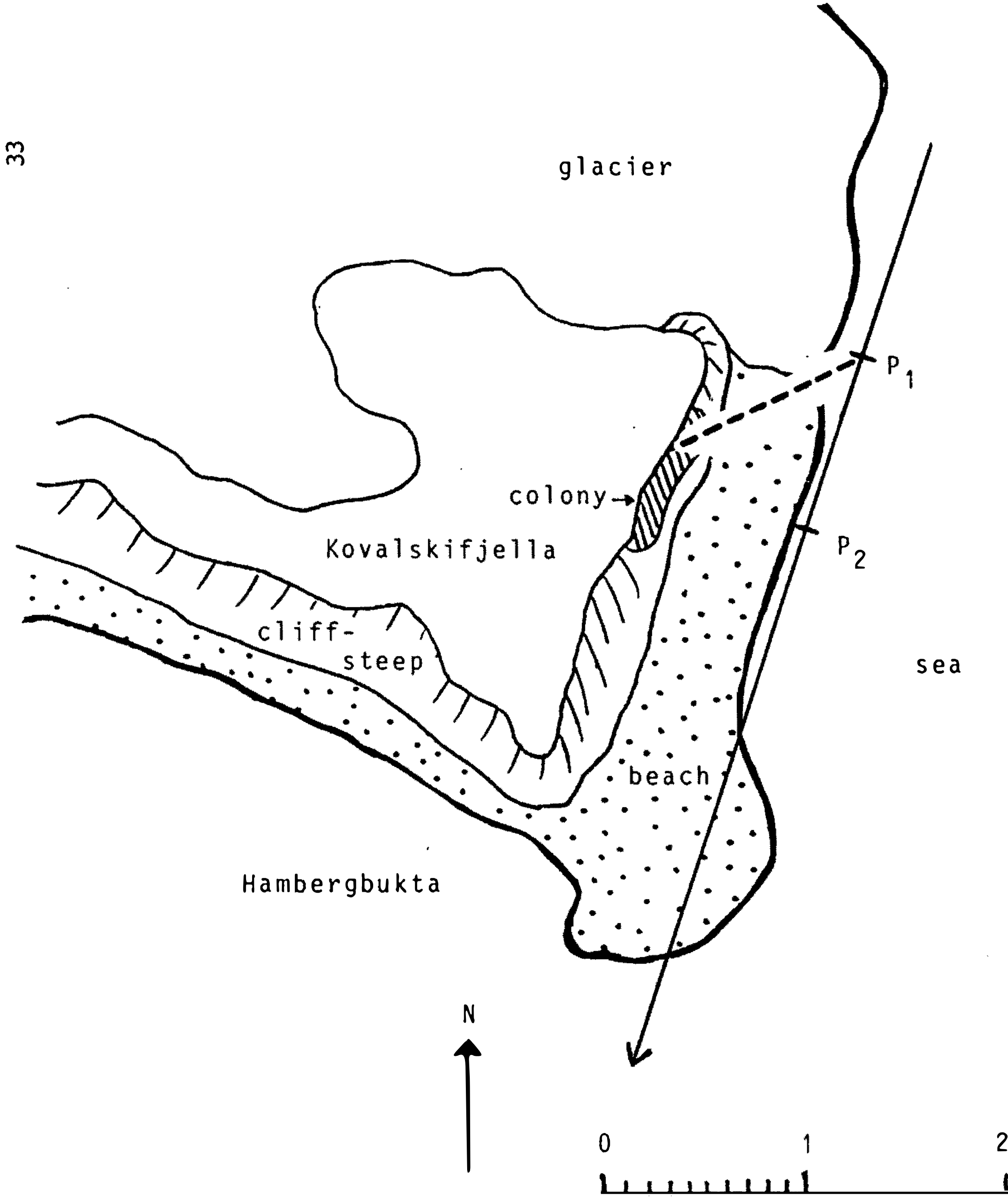
a) Dist. P_1: -200 m
b) Ledge B, F: 37 %
c) Ledge A, OR+F: 72 %
d) Ledge A, F: 0 %

FLIGHT NO: 11

altitude: 280 m
speed: 65 kn
min.dist: -



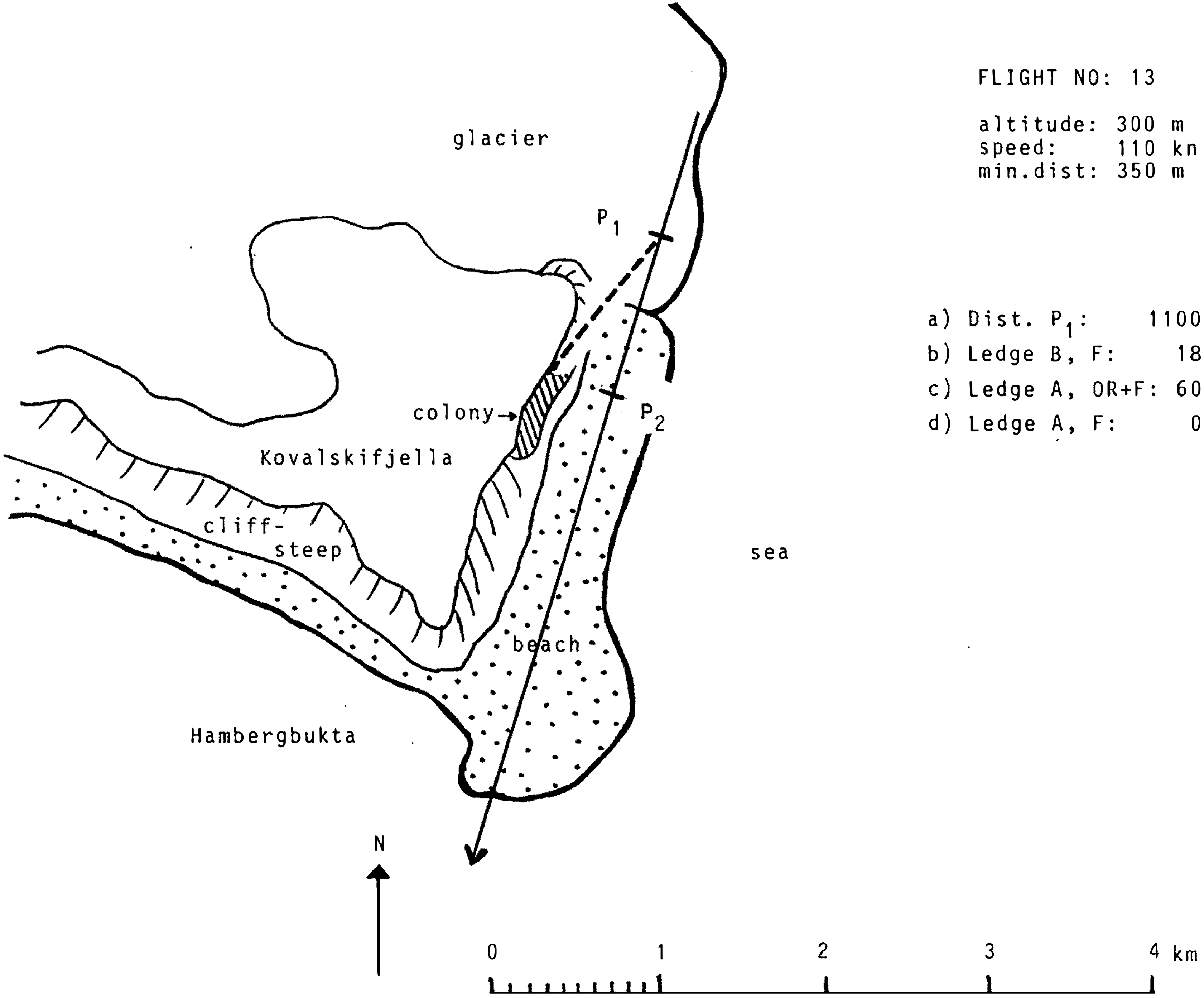
a) Dist. P_1: 0 m
b) Ledge B, F: 32 %
c) Ledge A, OR+F: 64 %
d) Ledge A, F: 24 %



FLIGHT NO: 12

altitude: 300 m
speed: 110 kn
min.dist: 700 m

a) Dist. P_1: 1000 m
b) Ledge B, F: 22 %
c) Ledge A, O+R: 78 %
d) Ledge A, F: 0 %



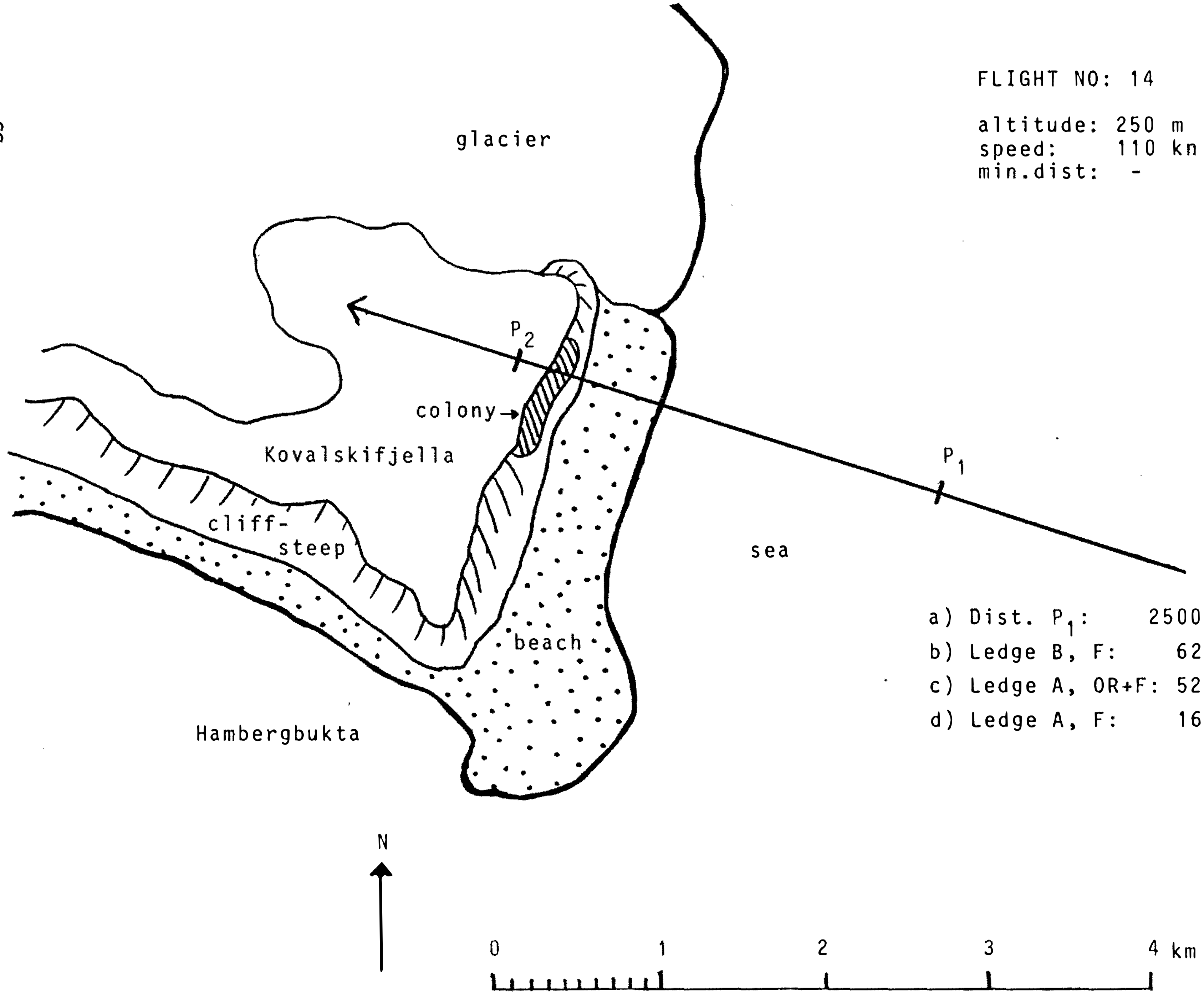
FLIGHT NO: 13

altitude: 300 m
speed: 110 kn
min.dist: 350 m

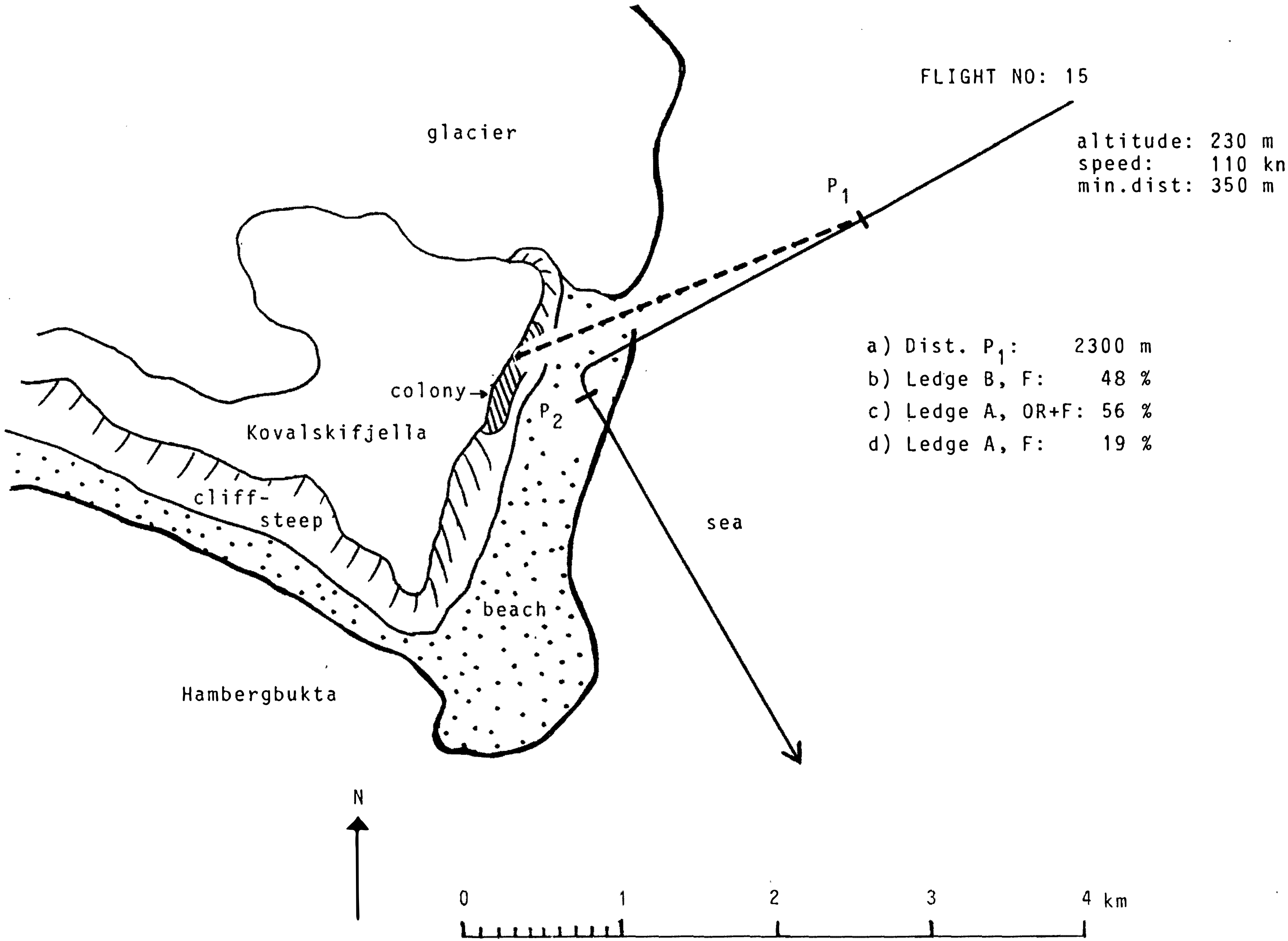
a) Dist. P_1: 1100 m
b) Ledge B, F: 18 %
c) Ledge A, OR+F: 60 %
d) Ledge A, F: 0 %

FLIGHT NO: 14

altitude: 250 m
speed: 110 kn
min.dist: -



a) Dist. P_1: 2500 m
b) Ledge B, F: 62 %
c) Ledge A, OR+F: 52 %
d) Ledge A, F: 16 %


FLIGHT NO: 15
altitude: 230 m
speed: 110 kn
min.dist: 350 m
glacier
P_1
a) Dist. P_1: 2300 m
b) Ledge B, F: 48 %
c) Ledge A, OR+F: 56 %
d) Ledge A, F: 19 %
colony
P_2
Kovalskifjella
cliff-
steep
sea
beach
Hambergbukta
N
0
1
2
3
4 km

GCS VEST HURTIGTRYKK