ORIENTATION AND NAVIGATION OF HARBOUR SEALS (phoca vitulina concolor) IN THEIR OVERLAND MIGRATIONS ON SABLE ISLAND

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ORIENTATION AND NAVIGATION OF HARBOUR SEALS (*Phoca vitulina concolor*) IN THEIR OVERLAND MIGRATIONS ON SABLE ISLAND

by

Deane Renouf ©

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ABSTRACT

During the spring and summer months on Sable Island, Nova Scotia, about 10% of the 1200 Harbour seals (Phoca vitulina) which are resident on the island at this time, regularly migrates between the sea and three inland lakes. This necessitates an overland journey of often ½ mile or more, one which is undertaken by adult seals, and by newly weaned pups which have been born on the lakes and move to the sea for the first time. The results of the investigations described in this thesis enabled the following conclusions to be drawn about the nature of the overland journeys, and the orienting abilities of these Harbour seals in guiding themselves to the lakes and back to sea.

(1) Both seabound and lakebound crossings were usually undertaken at sunrise and sunset. The peak number of crossings seemed to coincide with the pupping season in May and June, and the moult in late July.

(2) The approximate bearing of the shortest path between the lake and the sea is 204°, and the average bearing adopted by seabound adult seals was 202°. The lakebound adults did not necessarily cross on a bearing which was perpendicular to the coast; they did, however, tend to take the shortest path between the point where

they had hauled out on the coast, and the lake. The variability of the lakebound tracks did not differ from that of those heading toward the sea.

(3) The journeys of both adults and pups were not impaired by either visibility being reduced to less than 100 yards in fog which completely obscured all landmarks, or by a 100% cloud cover, which, for the human observer, made the sun impossible to locate.

(4) Many animals, both adult and newly weaned, having aborted their journeys, sometimes after having travelled more than 3/4 the way, were able to return to their exact departure point. Some did so when visibility was 1/4 mile or less.

(5) There was no clear relationship between wind direction and the courses adopted by seals either spontaneously crossing between lake and sea, or travelling after having been displaced.

(6) Zastruga, often prominent on the sandy plain separating the lakes from the sea, were not a necessary cue for the seals' orientation.

(7) Adults which were captured enroute to one of the lakes, and displaced 1500 yards to the east or west, either went to the sea upon release, or corrected for their displacement and continued their journey to the lake. This correction was made in the absence

of landmarks, and did not appear to be related to sun and wind conditions.

(8) The provenance of the sound of the surf did not appear to be related to the initial heading or to the bearing which a seal maintained during a spontaneous crossing. However, two adults which were relocated, and travelled to the lake upon release, may have been maintaining a bearing by listening to the sound of the surf. Weaners which were released at various points around Sable Island appeared to home on the sound of the surf when they were set free under unusually confined conditions.

The results of a T maze experiment, in which pups were given a choice between approaching and avoiding surf noise are discussed. The limitations imposed by field conditions are set forth, and suggestions for future research are made.

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Chapter 1

PINNIPED MIGRATION AND SABLE ISLAND

On Sable Island (43.55N: 59.55W), Nova Scotia, there are three inland lakes which during the spring and summer months accumulate a population of about 200 Harbour seals (*Phoca vitulina*). In order to get to the lakes, the seals must cross a flat stretch of sand, which involves an overland journey of often 1/2 mile or more. Nearly every day between May and September, one can see a number of seals crossing either to the lakes or back to the sea. This provides the observer with an excellent opportunity to study orientation and navigation in these seals, since the crossings are undertaken under varied weather conditions which are directly related to some of the cues available to the animals for guidance. For example, many animals travel when visibility is reduced by heavy insular fog to 150 yards or less, and under such conditions the seals could not be relying on landmarks to find their way to and from the lakes. Because the distance travelled is so short, and since seabound and lakebound journeys can be observed so often during the season, one can obtain a complete record of the orientation of a large number of animals.

Orientation and navigation cannot be so easily studied in other Pinnipeds, since their migrations occur at sea. The extent and precision of both their long distance migrations and their local movements indicates that these animals must be using an accurate navigational system. The best known, and probably the longest Phocid migration is that of the harp seal (*Pagophilus groenlandicus*) which regularly travels between Greenland and its breeding grounds in either the Gulf of St. Lawrence or on the Labrador Front (Sergeant, 1965). Some Otariid journeys are even more spectacular, for example, those undertaken by female and young fur seals (*Callorhinus ursinus*) which leave their rookeries on the Pribilof, Robben and Commander Islands during the spring and summer, some travelling as far South as the U.S. - Mexican border, and others reaching the shores of Japan at about 35°N (King, 1964).

It might not be unreasonable to assume that all seals which undertake lengthy migrations would home during the breeding season and hence be able to navigate with considerable accuracy. Oestrus occurs in most Pinnipeds only once a year (Anderson, 1969) and breeding sites are usually restricted to islands and sheltered uninhabited beaches (King, 1964). It is therefore important that animals which travel great distances from the breeding sites of the species be able to find an appropriate rookery during oestrus. It would seem that the ability to home to their native birth site would ensure this.

Homing has been verified in some Pinnipeds. *Callorhinus ursinus*, for example, returns to its site of birth for the breeding season. Though 70% of a year's production can be expected to die within three years (King, 1964), 20% (Norris, 1967) to 80% (Kenyon & Wilke, 1953) of the pups tagged on the Pribilofs manage to return to their island of birth within this period. About 90% of the adult females return to their native rookery each year (Norris, 1967).

Homing is also reported in Phocids. Though the Southern Elephant seal (Mirounga leonina) is credited with only local dispersal, 60% of the mature males and 77% of the mature females returned to within 4 km. of their birthsite on Macquarie Island for the spring breeding haul-out (Nicholls, 1970). Immature Mirounga tended to return to their birthsite during the autumn winter haul-out from March to August. The precision and regularity of such local movements can be taken to indicate that these seals, like those undertaking long migrations, must be relying upon some orientational mechanism.

Local movements are also reported in the grey seals, (Halichoerus grypus), which breed on the Farne Islands off the coast of Northumberland. Throughout the year they display a series of movements between the islands (Coulson & Hickling, 1964). Grey seal pups marked on these islands, and others born on the Orkneys have been recovered on the west coast of Norway (Hickling, Rasmussen & Smith, 1962). Coulson and Hickling (1964) suggested that pups which disperse after birth on the Farne Islands gradually return to the natal area when they are about three months old. After the pups become sexually mature at three years, they are said to return to their actual birth place (Hickling, Rasmussen & Smith, 1962). Grey seals in eastern Canadian waters also exhibit local movements. In spring, for example, more than 1000 of them find their way to the tiny French island of Miquelon, having presumably come from the Magdalen Islands in the Gulf of St. Lawrence (Mansfield, 1963).

Some very short distance movements which have been reported would appear to require accurate orientation. The Weddell seal (Leptonychotes weddelli), after travelling several miles under the ice, can somehow find its way back to a small breathing hole, a vital connection the animal maintains with oxygen. Such a feat is often performed in the darkness of the Antarctic winter when landmarks would not be visible (Kooyman, 1969). The ability to find so specific a point is also displayed by the female fur seal (C. ursinus) which leaves its pup on the rookery about a week after its birth and goes to sea to feed. It then returns only one day a week to suckle its pup (Harrison & King, 1965), and it is therefore crucial that it be able to locate the exact place of its departure.

Another short, but probably oriented journey is described in the report of mummified Crabeater seals (Lobodon carcinophagus) found inland in McMurdo Sound, Antarctica. Usually young seals, having penetrated the heads of inlets,get trapped there with the winter ice. Some go inland and die, while others manage to escape to the sea by travelling over the ice (Stirling & Kooyman, 1971).

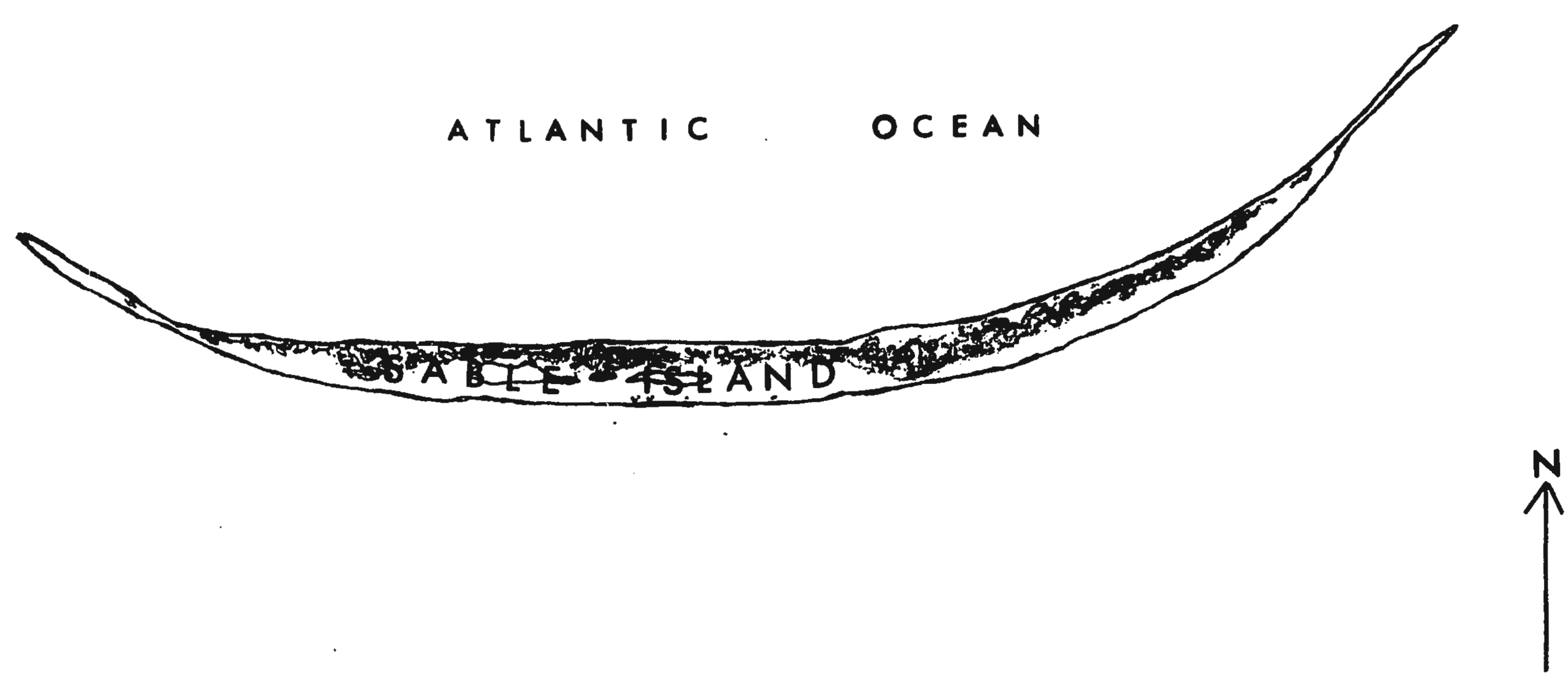
These authors speculate that the choice of direction might not be random.

Sable Island is one of the largest breeding grounds of both Grey seals and Harbour seals in the eastern Atlantic, but the local movements of Harbour seals away from the island, if any, have yet to be described. The number of Harbour seals hauled out on the beaches of Sable during the spring and summer diminishes almost completely during the winter, but it is not known whether the seals actually migrate away from the island, or just remain in the water off shore. However, the constant traffic of these animals to and from the inland lakes on Sable from May to September presents a compelling orientational problem in itself.

Sable Island is not much more than a sandbar 22 miles long, and at the centre, its widest part, about one mile wide. A continuous ridge of sand dunes runs East to West for almost the entire length of the island. This ridge varies in width and often reaches 80 feet in height (Map 1). The gross topography of the centre of the island is illustrated in Map 2. Here there are three shallow brackish lakes known as West, Middle and East Lake Wallace. Patterson (1824) reported that prior to 1881 these lakes were part of a fifteen mile long lagoon which opened to the sea on the South and was consequently used as a harbour for ships. However, for the duration of my research on the island in 1970 and 1971 there were three separate lakes closed to the sea on all sides.

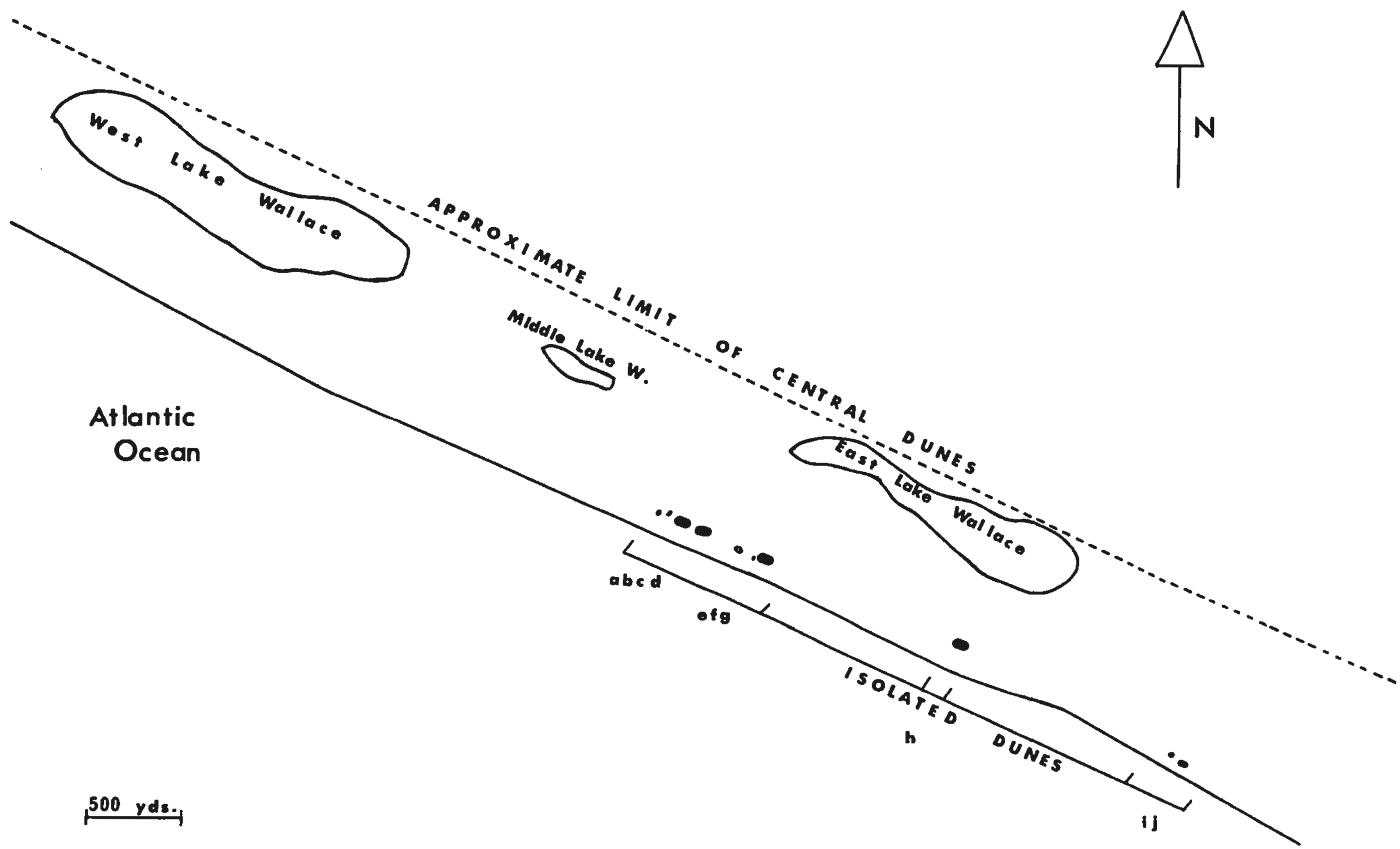
Map 1.

SABLE ISLAND.


ATLANTIC OCEAN
SABLE ISLAND
N

Map 2.

THE WALLACE LAKE SYSTEM ON SABLE ISLAND. The position of the shores of the three lakes changes with rainfall, wind direction, and wind speed, and the outlines shown on the map are therefore approximate.



West Lake Wallace
APPROXIMATE LIMIT OF CENTRAL DUNES
Middle Lake W.
East Lake Wallace
Atlantic Ocean
abcd
efg
ISOLATED DUNES
h
ij
N
500 yds.

The northern shore of the Wallace Lakes runs close to the southern limits of the central dunes. Separating the lakes from the sea to the South, and stretching for several miles to the East and West of the lakes is a flat sandy plain which varies from 500 to 1600 yards in width. The only prominent landmarks are a series of ten isolated dunes (marked A through J on Map 2) on the south coast opposite East Lake Wallace, and a small fifteen-foot-long shipwreck in the vicinity of West Lake Wallace.

By the end of the first week in May, during the pupping season, about 1200 adult and subadult Harbour seals have gathered on the north and south coasts of the island (Boulva, 1971), and these numbers are maintained, or even slightly increased until early winter. At the height of the pupping season, the herds are small and widely dispersed around the coast, but in late July, when the adults begin to moult, larger herds of more than 500 individuals can be seen on the beaches. These herds seem to haul out at traditional places along the coast. One could, for instance, usually find a fairly large herd of 150 to 200 animals either about 150 yards East of just West of J dune, another slightly smaller herd due South of H dune, and third behind EFG dunes and a fourth on the coast opposite a point about half way along West Lake Wallace.

Some of the adults from these herds (and some which did not emerge from a herd, but hauled out independently on the coast) cross over to one or another of the Wallace Lakes, where the females amongst them give birth to their pups and nurse them. The largest assemblage of lakeshore animals is to be found at the south-east corner of East Lake Wallace, where as many as 82 adults have been seen hauled out at the peak time in the early afternoon. There are other smaller groups along the shore of this lake, the total population reaching about 100 adults in late July. Middle Lake Wallace is used by a small group of animals during the whelping season, but is empty of adult seals at the time of moult. West Wallace maintains a population of about 35 adults spread all along the southern shore of the lake. Except on rare occasions in Middle Wallace and West Wallace, neither the adults nor the pups ever haul out on the northern shores of the lakes.

In order to travel either from the sea to one of the three lakes, or from the Wallace Lakes back to the sea, the seals must cross over the sandy plain illustrated in Map 2. The expeditions of the adults across this plain are initially rather hesitant affairs. Although the seals sometimes journey alone, they usually cross in groups of three or four animals. Once, however, I witnessed fourteen travelling to East Lake Wallace together. One animal, most often a member of a pod hauled out on the lake or sea shores, will venture forth 75 yards or so, most likely to be followed by two or three others. The animal initiating the movement is not necessarily the one to lead the way across the sandy plain. In fact, the front position of the troop is usually held by each animal during the journey. At the start, one, two, or sometimes all of the troup will, upon no obvious stimulus, dash back to the herd with great speed, often to start out again minutes later, only to turn back a second time. This stopping and starting can sometimes last for twenty minutes or more, but once the animals have managed to get about 100 yards away from their departure point, they appear to have passed the 'zone of uncertainty' and are committed to completing their journey.

Occasionally, however, an animal will abort its journey after having travelled quite far. In an extreme case, a seal might get within 75 yards of its apparent goal, and for some unknown reason, turn around and go back very often to its exact point of initial departure. These sorts of tracks will be referred to as aborted attempts, as distinct from the hesitant stoppings and startings which occur at the beginning of a crossing.

It usually takes an adult about 30 minutes to cross between lake and sea. A seal will hump for about 15 or 20 yards, and then stop, look around, lay its head flat on the substrate a number of times, look around again, and go on for a minute or more, and then move off and repeat the whole process a few yards later. The turns in an animal's course are not necessarily associated with these 'resting' spots. Once the seals have finally reached the lakes or the sea, they will either stay hauled out on the shore for a time or they will go straight into the water.

Very little is known about the composition of the population of seals which migrates between the sea and the Wallace lakes: indeed, it is not known if it is the same groups of animals crossing back and forth each day. Certainly some of the seals colonize a particular lake for several weeks at a time, returning periodically to the sea. I have watched some of the females marked on East Lake Wallace leave their pups on the lake shore while they returned to the sea overnight. In at least one instance, I know of a marked animal which regularly commuted between the sea and Middle Lake Wallace.

At least 50 gravid females travel to the lakes and give birth. Their pups are nursed and weaned there and eventually form a pod of their own separate from the adults. Though I have witnessed hundreds of seals crossing the sandy plain, I have never seen a pup which was born on the sea coast of the island visit any one of the lakes.

In this thesis, I shall examine the nature of the orienting mechanism used by both adults and newly weaned harbour seals in finding their way across the sandy plain.

Chapter 2

THE CENSUS

As the seals cross between the sea and the Wallace Lakes they leave clear tracks in the sand indicating whether they have travelled inland or to the sea. Plate 1 shows a sea to lake track made by an adult Harbour seal. The indentations in the track marked in the photograph show where the seal used its foreflippers in propelling itself across the sand. The action of the foreflipper results in a pile up of sand on the posterior rim of these indentations, and by noting the orientation of the sandpile one could readily tell which way the animal had been travelling.

In order to obtain a general picture of when the adults crossed the sandy plain, where the crossings occurred and whether the number of crossings was affected by low visibility and other weather conditions, a census was taken of all the tracks during the summers of 1970 (Census period = June 26 to July 30, inclusive) and 1971 (Census period = May 13 to July 30, inclusive). In 1970 a count was made every day, once between 0340 and 1015 and again between 1545 and 2055, of all the tracks made between East Lake Wallace and the sea. I recorded the direction of the tracks (sea to lake or lake to sea), their location and whether the animals concerned had completed their journeys or turned back mid-course.

Plate 1.

SEA TO LAKE TRACK MADE BY AN ADULT HARBOUR SEAL. The indentations marked A and B show where the animal used its foreflippers in propelling itself across the sand.


A
B

In order to get a more complete description, the 1971 census data were collected in a different manner. This time, tracks made between the sea and all three lakes were included. The count was made only twice a week, but on these days it was taken approximately every three hours between 0500 and 2000. For both censuses, part of every track was erased after each count to ensure that a track would not be counted twice. (The census data can be found in Appendix A.).

The information about the weather conditions was obtained from the hourly reports of the Department of Transport Meteorological Station resident on Sable Island. Their observation tower was situated about 1/4 mile North of the westernmost point on the sandy plain.

In general the census showed that the crossings were made early in the morning close to sunrise, and in the evening near sunset, and not often in between these times (Figure 1). I have on occasion, however, seen animals journeying at night. As far as the pattern of activity over the whole summer is concerned (Figure 2), the number of crossings appeared to reach a peak in May and early June, and again in late July. Perhaps not coincidentally, harbour seals on Sable Island pup in May and early June (Boulva, 1971) and are said to mate immediately upon the termination of lactation late in June or early in July (Fisher, 1959). I observed various stages of moult in the harbour seals on the island by mid to late July.

Figure 1.

THE TIMES OF DAY THE SEALS USUALLY CROSSED THE SANDY PLAIN ACCORDING TO THE 1971 CENSUS. In general, the seals crossed in the morning and close to sunrise and in the evening near sunset, and not often in between these times.

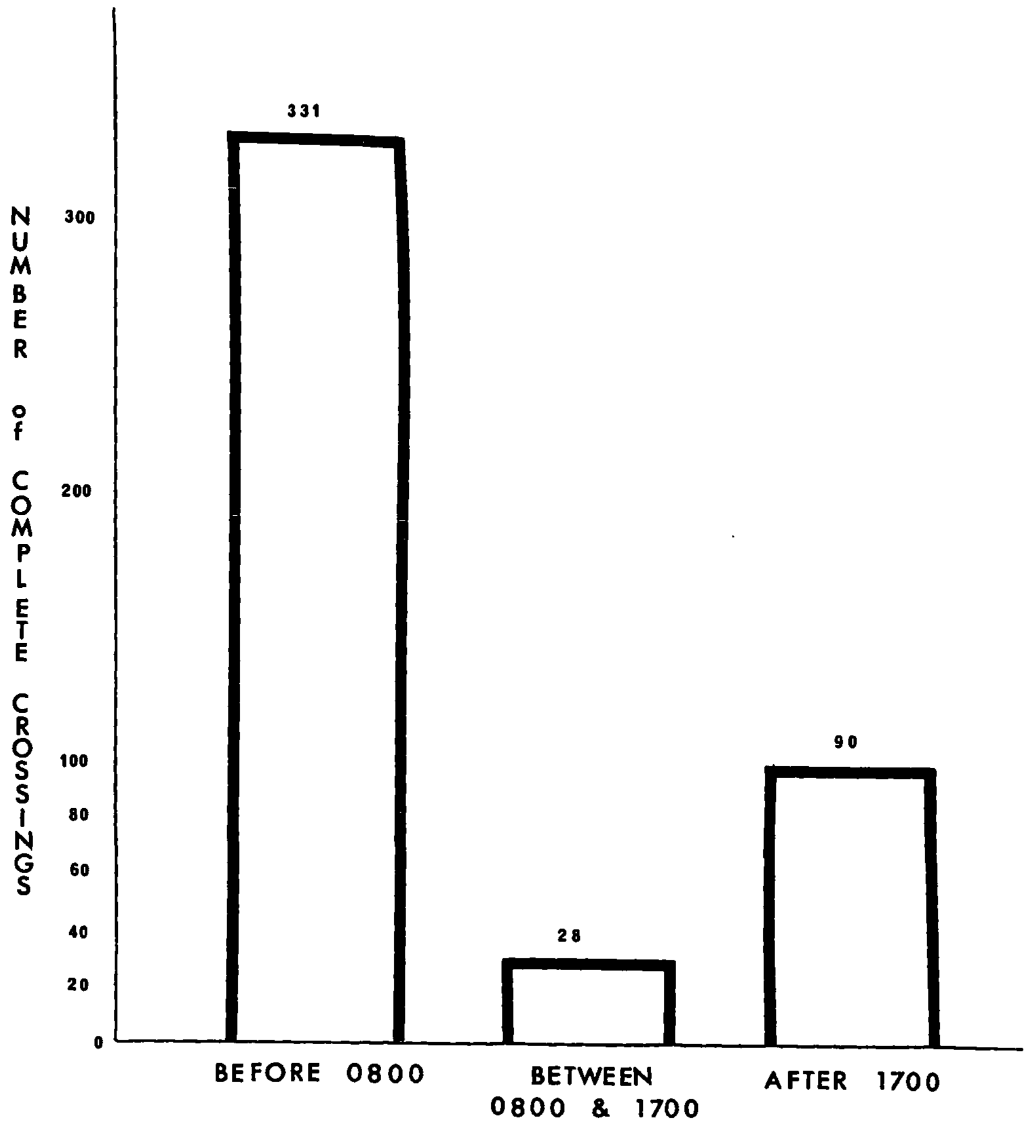
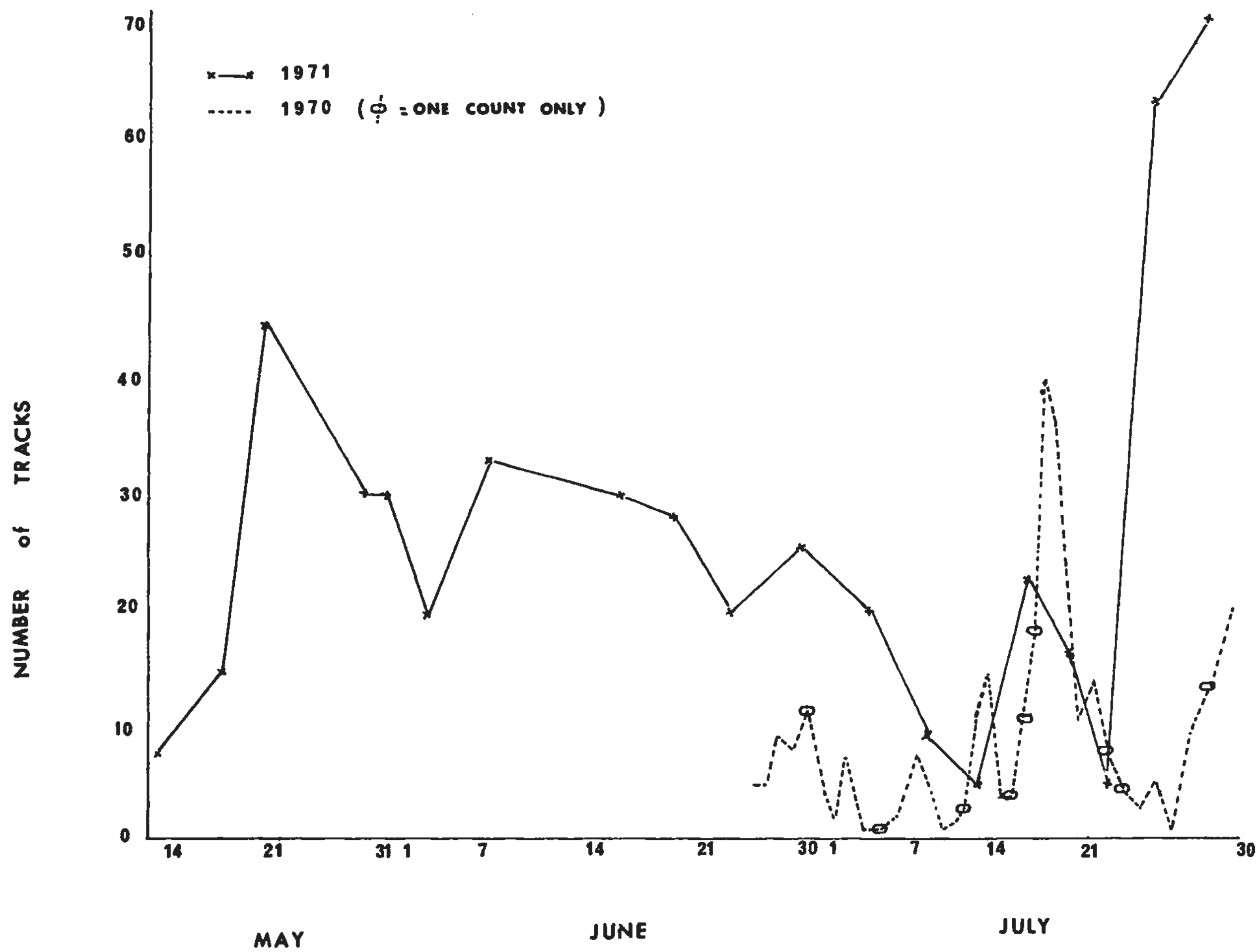

NUMBER of COMPLETE CROSSINGS
300
200
100
80
60
40
20
0
331
28
90
BEFORE 0800
BETWEEN 0800 & 1700
AFTER 1700

Figure 2.

THE TOTAL NUMBER OF TRACKS COUNTED ON EACH CENSUS DAY DURING THE SUMMERS OF 1970 AND 1971. The aborted attempts are not included in these totals.



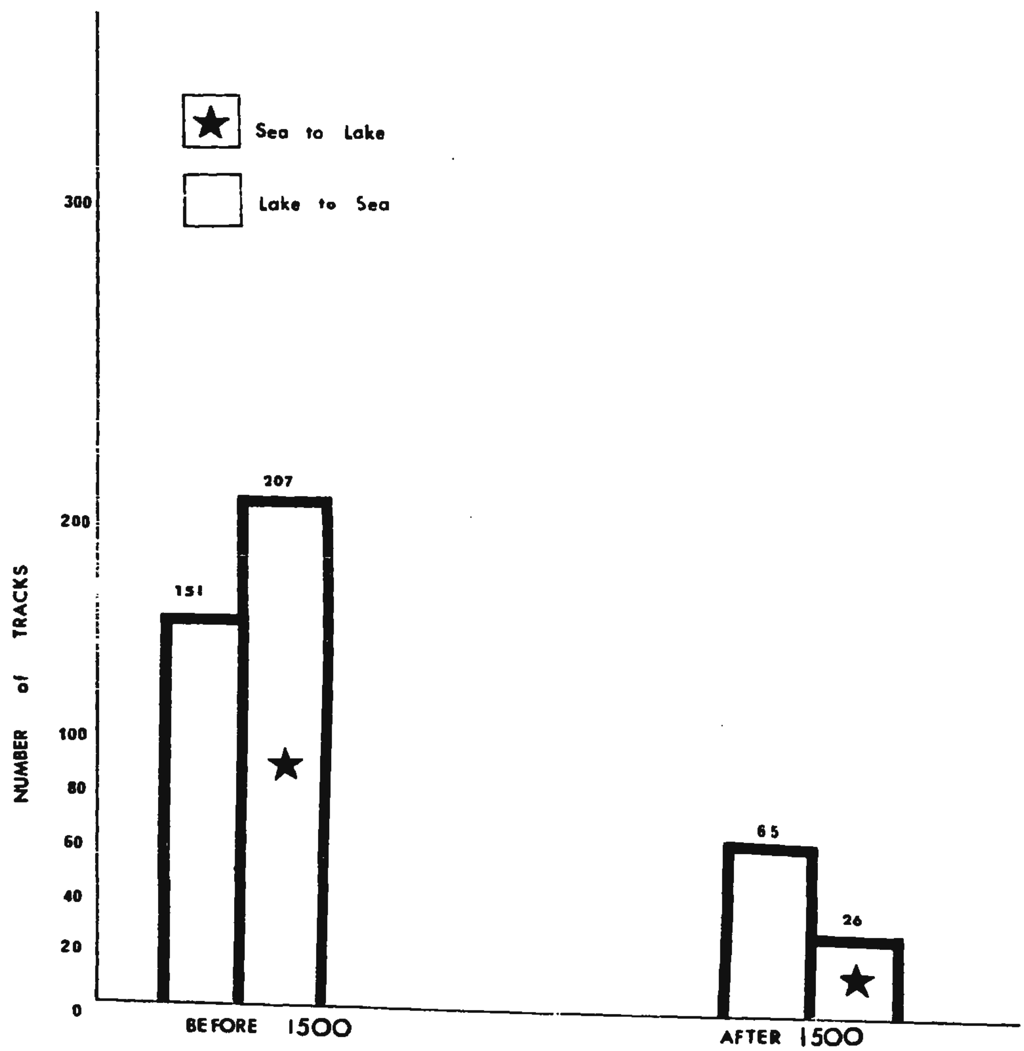
1971
1970 (= ONE COUNT ONLY)
NUMBER of TRACKS
70
60
50
40
30
20
10
0
14
21
31 1
7
14
21
30 1
7
14
21
30
MAY
JUNE
JULY

The diurnal traffic pattern (Fig. 3)* seems to correspond to some extent to the normal rhythm of the seals which remain on the coast. The latter begin to haul out just before sunrise, and the number of animals on shore increases linearly until about 1500. The herd then remains stable until sundown, when a much more rapid exodus to the sea begins. If the traffic across the sandy plain were an extension of the normal haul out pattern, one would expect that lake to sea crossings would occur most frequently at sundown when the coastal seals are leaving the beaches for the sea, and that there would be a movement in the opposite direction from sunrise until early afternoon when the coastal herds are forming on the beaches. As can be seen from Figure 3, there were significantly (x^2 = 8.76; DF = 1; $p \geq 0.01$) more sea to lake crossings during the time before 1500; from 1500 onward, the journeys were primarily toward the sea x^2 = 16.714; DF = 1; $p \geq 0.001$).

The seals travelling in the vicinity of West and Middle Lake Wallace did not appear to cross from specific points either on the sea coast or the shores of the lakes. Tracks were found all along the Stretch of sand separating these two lakes from the sea. In a small number of cases, animals travelling to Middle Lake Wallace would actually hump around the edge of the lake to enter it from its north shore. Between East Lake Wallace and the sea, however, there appeared to be two main crossing places, the most frequently used one in the vicinity of H dune, the other being that area of the sandy plain including dunes EF and G. Occasionally the seals

Figure 3.

Comparison of the number of seabound and lakebound tracks before 1500 and after that time. The diurnal traffic pattern seems to correspond to the normal rhythm of the seals which remain on the coast.



Sea to Lake
Lake to Sea
300
200
100
80
60
40
20
0
NUMBER of TRACKS
207
151
65
26
BEFORE 1500
AFTER 1500

would cross between these two sections of the sandy plain, and some of those animals which had hauled out about 1500 yards East of East Lake Wallace journeyed inland as far as the central dunes, missed the lake, and returned to their departure point on the sea coast. The relative number of tracks made in each of these areas is shown in Figure 4.

I analyzed the relation between frequency of crossing in 1971 and certain weather variables which, in light of the kinds of cues other experimenters have shown to be important in animal homing,could be related to the orientational mechanism the seals were using. It is not surprizing that some animals use familiar landmarks at some stage of their journey towards a goal (Matthews, 1955), but it has been shown conclusively with certain birds (Schmidt-Koenig, 1965), bees (Lockley, 1967) and various species of fish (Verwey, 1958) that orientation is often independent of terrestrial landmarks. These animals can take up a bearing by using the sun (or in the case of nocturnal migrants, the moon or the stars) as a compass[1]. It is said

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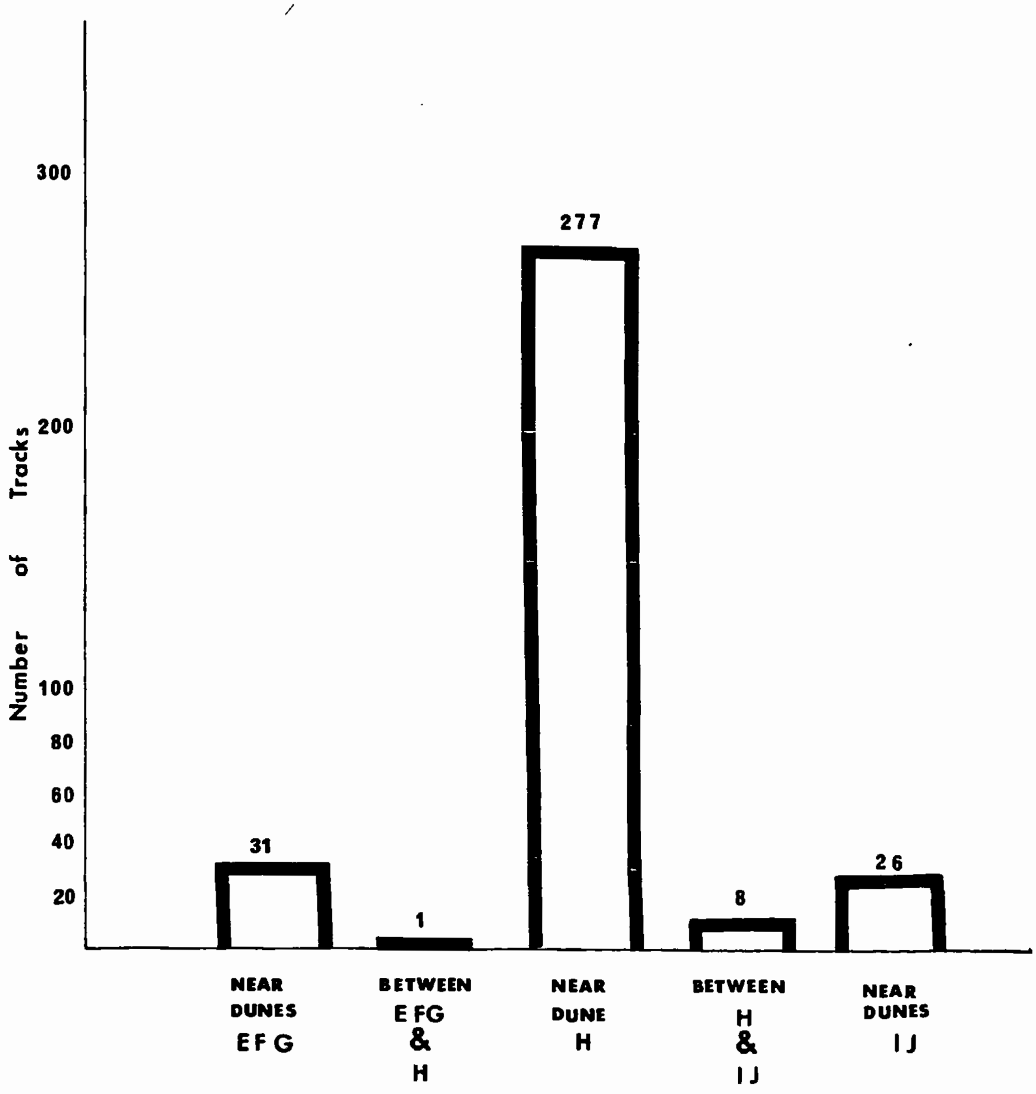
[1]Of course the ability to travel on a set bearing would not necessarily ensure that a migrant could reach its goal, for if the animal were displaced during migration, it would have to have some other system to compensate for the shift, and correct the course accordingly. The ability to evaluate present position and relate it to the position of home - without the use of landmarks - is navigation in the true sense of the word (Griffin, 1952).

Figure 4.

THE MAIN 'SEAL ROUTES' ON THE SANDY PLAIN. The number of completed crossings recorded in the 1971 census which were initiated in the vicinity of dunes EF and G, and in the vicinity of dune H, compared with the number initiated at other points in the East Lake Wallace area.



Number of Tracks
300
200
100
80
60
40
20
31
1
277
8
26
NEAR DUNES EFG
BETWEEN EFG & H
NEAR DUNE H
BETWEEN H & IJ
NEAR DUNES IJ

that salmon are able to find their native stream towards the end of their homeward migration by orienting on familiar olfactory cues (Lockley, 1967). A simple mechanism has been suggested for harp seal pups by Sergeant (1970) who proposed that these animals are orienting into the wind on their active northward movements.

Weather conditions can be related to the availability of these kinds of cues, and for this reason the census data for 1971 were analyzed according to certain weather variables. In a regression analysis, (1) wind direction, (2) wind speed, (3) horizontal visibility, (4) cloud cover, (5) temperature (6) presence of fog, and (7) presence of rain were used to predict the number of crossings, completed or aborted, to either West, Middle or East Lake Wallace. None of these predictors accounted for a significant amount of variance in the number of crossings in the 1971 census period. (See Appendix B.)

It should be pointed out here that very often horizontal visibility was reduced by dense insular fog, so thick that I often found myself completely disoriented and lost, heading unawares into one of the lakes. As can be seen from Figure 2, in 1971 the greatest number of crossings was made towards the end of July, and during this time, Sable Island was almost constantly enshrouded in dense fog, visibility typically being reduced to nearly zero. In light of this observation, and since horizontal visibility and the presence of fog accounted for almost no variance in the number of animals crossing the sandy plain during the census period, it might not be unreasonable to suggest that landmarks need not be visible for a seal to journey successfully between the lake and the sea.

Little else should be inferred from the census data. However, the relationship between the orientation of the seals' tracks and meteorological cues will be pursued in greater detail in the following chapters, in an effort to answer three questions about the nature of the seals' ability to cross the sandy plain:

(1) Nearly all of the inbound tracks recorded in the census were initiated at points on the coast in the approximate vicinity of one of the three lakes. Upon what cues are the seals relying in determining these appropriate departure points?

(2) What cues are used by the seals in initially ascertaining a suitable departure bearing when travelling inland or to the sea?

(3) Once the departure bearing has been decided upon, what cues allow the animal to maintain that bearing for the duration of its journey across the sandy plain?

Chapter 3.

THE ORIENTATION AND NAVIGATION OF ADULTS

The track a seal leaves in the sand during the journey between the sea and lake is a complete and accurate measure of the animal's orientational performance. These tracks were transcribed by using a hand compass to take a bearing of the successive changes in a track's direction, and then pacing out on foot the distances between these changes. In this way, every animal's track could be described numerically and easily drawn.

While a seal was crossing the sandy plain, I measured and recorded those meteorological variables which I felt may have enhanced or interfered with the animal's ability to find its way. They are as follows:

(1) HORIZONTAL VISIBILITY: Horizontal visibility in rain or fog was estimated as the distance (either paced out on foot or judged subjectively) at which it was possible to discern the presence of a large object, such as the LandRover or one of the isolated dunes.

(2) CLOUD COVER: The amount of sky covered by cloud was subjectively estimated and judgments of the cloud opacity were made according to whether the sun could be seen or approximately located in the sky.

(3) WIND: Wind direction was measured with a compass and wind speed was read with a hand anemometer.

In cases where these measurements were not made (which was true of most of the work completed in 1970) the necessary information was obtained from the hourly recordings of the resident Department of Transport Meteorological Station.

One possible cue which could have been used for orientation, regardless of horizontal visibility or cloud conditions, was the sound of the surf breaking on the south coast opposite the Wallace Lakes. It is almost always possible to hear the sound of the breakers wherever one stands on the sandy plain, unless it is masked by the noise of windblown sand. Normally the sound of the surf on the south coast of the island prevents one from hearing the breakers on the north coast, but occasionally, one can hear the surf on both shores simultaneously. More rarely, when there is a northerly wind, only the surf on the northern coast is audible.

When one is within about 50 yards of the sea the surf noise is completely diffuse and extends over at least a 180° sector. However, when one moves inland any further, the surf sound is, to the human ear, surprisingly directional in nature. In fact, at a given time there are usually two very specific points from where one would subjectively judge the surf noise is coming. Sometimes, however, a sound could have a diffuse range of 10 to perhaps 75 degrees.

The quality of the surf sound, again judged by the human ear, can be divided into four categories:

(1) A high frequency noise which is continuously audible,

(2) a high frequency noise which is heard intermittently,

(3) A low frequency continuous sound, and

(4) a low frequency intermittent sound.

Sometimes all four sounds appear to be coming from definite points on the coast, but more often the surf sound will appear to be coming from only two places. As one moves further inland, the positions of the sounds change, and there is a lesser change as one moves down the coast on a given latitude.

Two techniques were used in ascertaining the relationship between the environmental cues just described and the bearings adopted and maintained by the seals. Firstly, the tracks of 66 adults which were observed crossing the sandy plain during the summers of 1970 and 1971 were transcribed. When possible, the relevant weather data were recorded while the seal was in transit, though during 1970 I used the information in the Department of Transport's reports for that hour closest to the time of crossing. Once the seal had reached either the sea or the lake it was immediately tracked. At every turn in the track a number of simple psychophysical judgments were made of the apparent directions of the sounds of the surf, and the compass bearings of these judged directions were recorded along with the bearing of the track for that point.

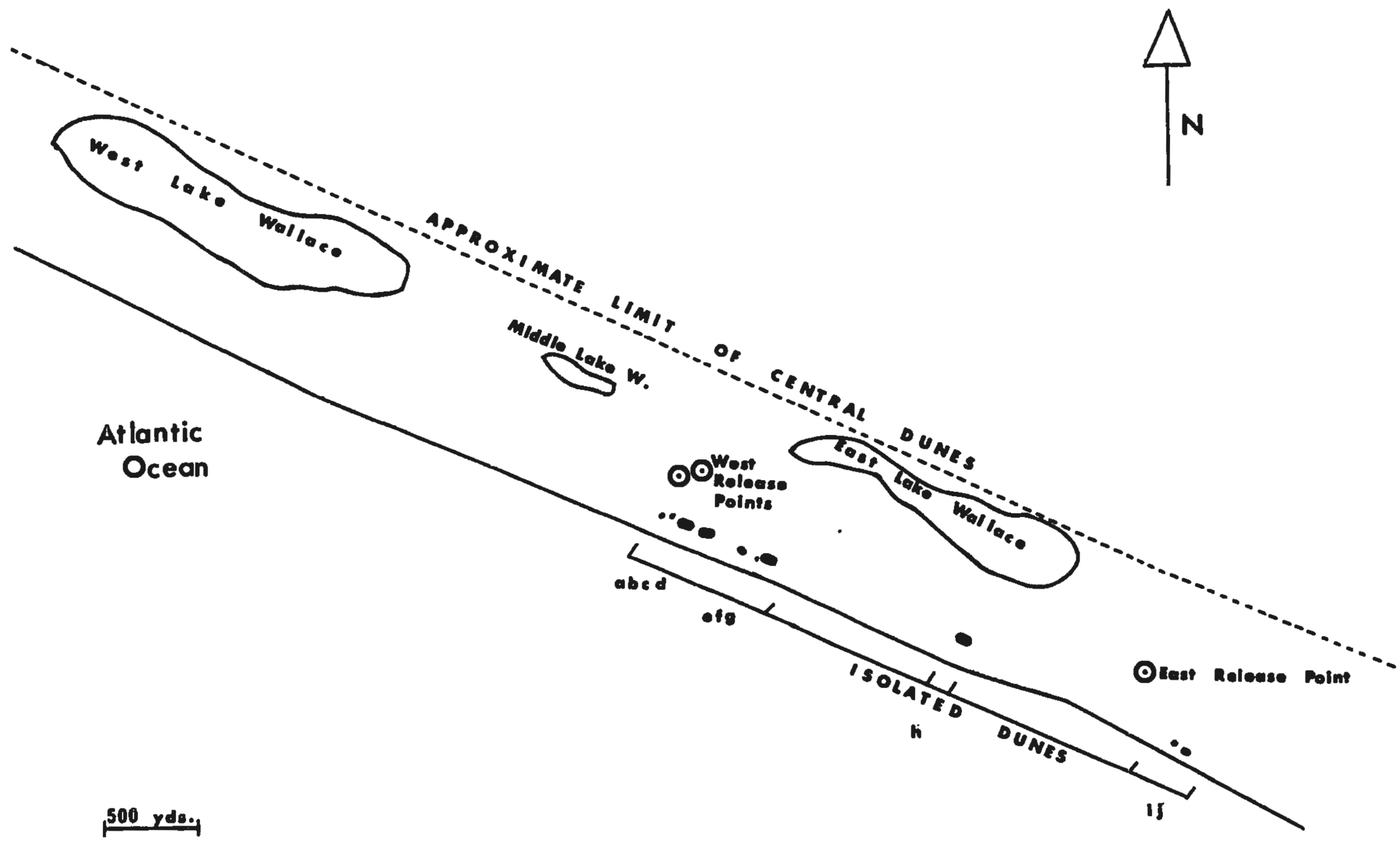
The second technique involved the capture and relocation of 16 adult seals. For this purpose a 6 foot long section of a discarded aluminum radio tower was covered with fishing net, which resulted in a reasonably portable cage which was capable of holding an adult seal securely (Plate 2). Each morning three of us lay in waiting hidden in the vicinity of the main seal route near H dune opposite East Lake Wallace. Once a seal had crossed half way or more over the sandy plain, we herded it into the cage, and two of us towed it on a sled behind the LandRover or tractor to one of two prearranged release points, 1000 yards east, and 1800 yards west of H dune (Map 3). Since the cage was open on all sides, the animals could see where they were going, given the natural limitationss of the amount of fog present at the time. However, the noise of the vehicle's demufflered exhaust, and of the corrugated iron sled scraping on the sand must have completely masked all other sounds. The cage was set down at the release point so that the seal faced North. Once the vehicle had been driven out of sight, the cage door was opened, and the remaining person quickly ran to hiding. When the seal had reached the sea or one of the Wallace Lakes, its track and the surf data were recorded. The meteorological data were gathered just prior to the animal's release. Meanwhile the third person stayed behind at H dune and recorded the spontaneous track of the captive, as well as the appropriate meteorological and surf sound information.

Plate 2.

CAGE FOR CAPTURING AND DISPLACING ADULT HARBOUR SEALS. A six foot long section of a discarded radio tower was covered with fishing net which resulted in a reasonably portable cage, capable of holding an adult seal securely.

Map 3.

ADULT RELEASE SITES. The western release point was adjusted by 100 yards half way through the experiment, since high winds caused the shallow west end of East Lake Wallace to move about 100 yards Southwest.


N
West Lake Wallace
APPROXIMATE LIMIT OF CENTRAL DUNES
Middle Lake W.
Atlantic Ocean
West Release Points
East Lake Wallace
abcd
efg
ISOLATED DUNES
h
East Release Point
ij
500 yds.

Results

(a) SPONTANEOUS CROSSINGS:

Of the 66 tracks we recorded, 33 represented sea to lake journeys, 18 were lake to sea tracks, and the remaining 15 were aborted attempts. For the following analyses, each attempt was divided into two separate tracks, one representing the lakebound leg of the track, the other being the seabound part. (The compass bearings and pace measures of all these tracks are listed in Appendix C.)

A mean direction was calculated for each track (see Appendix C). When these means were compared with a t test, significantly more variability was found between those tracks heading toward the lake than between those heading toward the sea ($p \leq 0.01$). That is, the average angles of attack adopted by lakebound seals fell within a much wider range than those adopted by animals travelling back to the sea (Figure 5). Because of this result, further analyses treated sea to lake and lake to sea tracks separately. This difference in the variances can be easily explained. The approximate bearing of the shortest path between the lake and the sea is about 204°, and the average bearing adopted by seabound seals was 202°. The bearing of the shortest route a seal might take to the lake would depend upon the starting point the animal chose on leaving the coast, the lake being a much smaller target than the sea. Since seals travelling inland start from widely varying points on the sea shore, it is not surprising that the bearing of the tracks they made varied as widely. This demonstrated ability of the seals to find the lakes by somehow relating their departure point on the sea coast to the location of their goal, is one of the principal facts which must be explained.

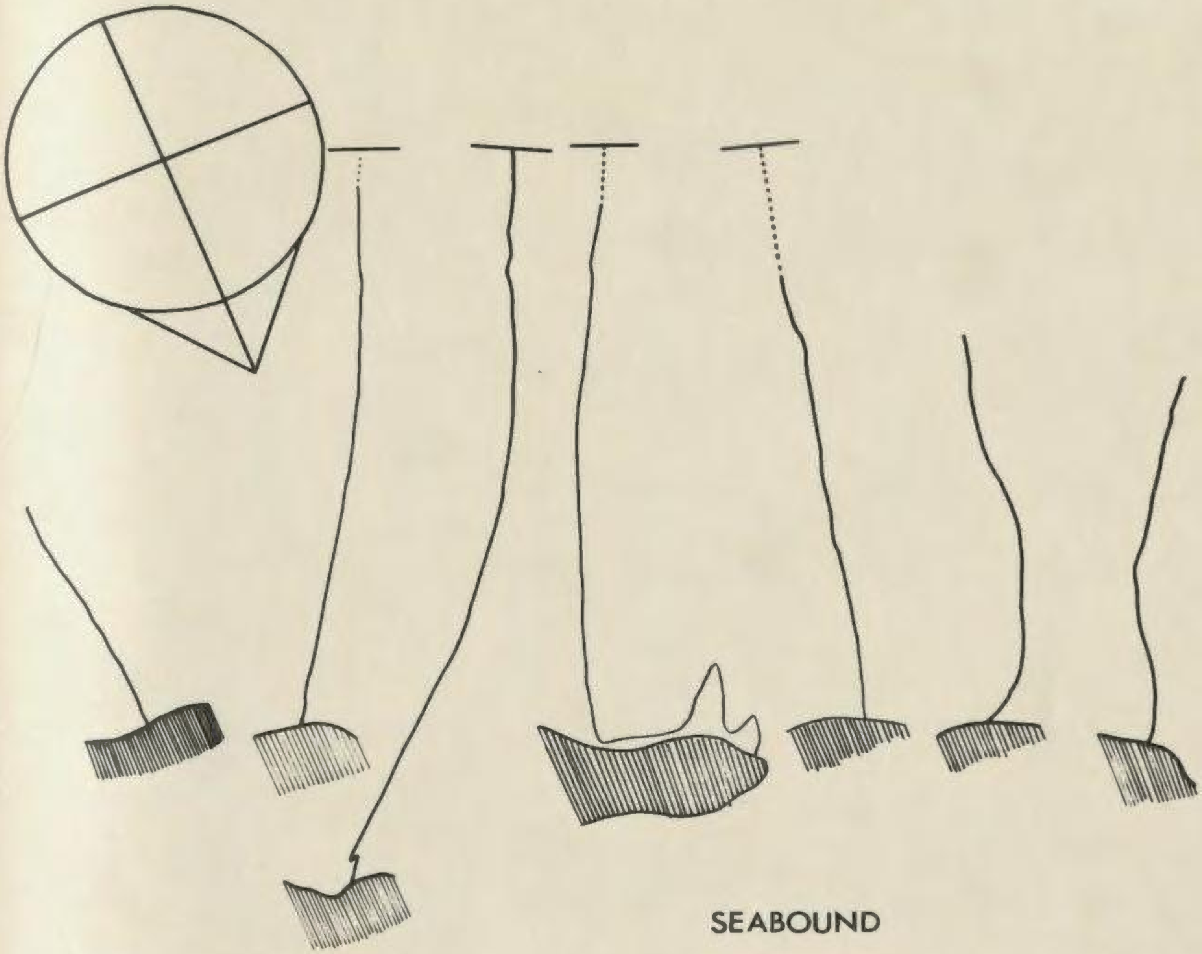
In order to determine the relationship between meteorological factors and the course bearings adopted by the seals, a regression analysis was performed, incorporating ten predictors of mean track bearing (Appendix D). Pearson product moment correlation coefficients were calculated to compare surf sound and track directions.

The Role of Visual Cues

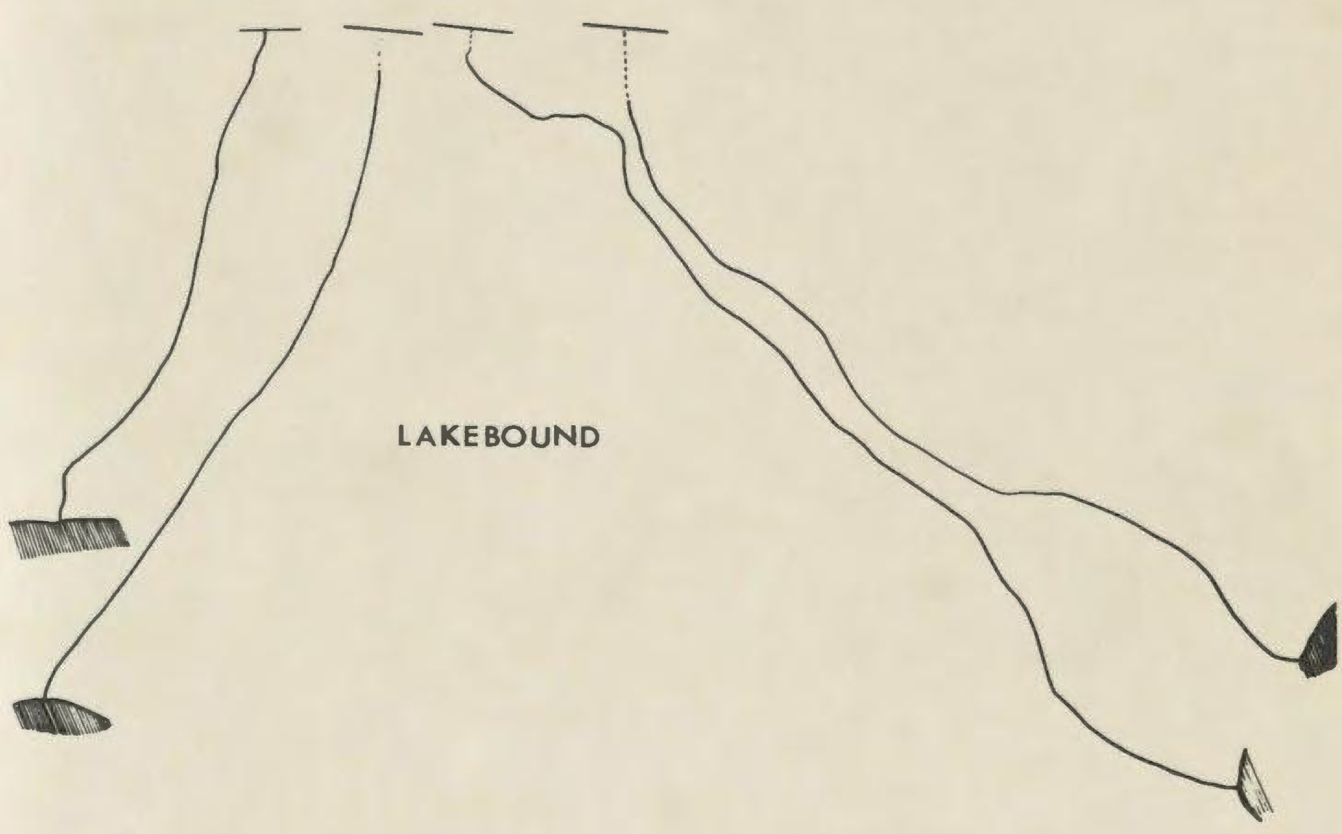
(a) The regression analysis showed that horizontal visibility accounted for a significant amount of the variance among track bearings ($F = 5.497$: $DF = 1.21$: $p < 0.02$) and that this was true only for lake to sea tracks. This meant that seabound animals adopted a different bearing during reduced visibility (visibility < 1/2 mile : $\overline{X} = 205.19°$) than they did in clear weather (visibility > 1/2 mile : $\overline{X} = 199.77°$). However, visibility accounted for only 18% of the variance among track bearings, and since the difference between the average course bearing adopted by animals travelling under each visibility condition is only 5.42° (even though this is a reliable difference, $p < 0.02$) it should not be concluded that landmarks are an important factor in the seals' orientation. To reinforce this

Figure 5.

SEABOUND AND LAKEBOUND TRACKS. Lakebound seals adopted diverse angles of attack, unlike seabound animals which generally took up a standard course bearing approximately representing the shortest route to the sea.



SEABOUND



LAKEBOUND

suggestion, the variance of each track was calculated and was used as a measure of its straightness (See Appendix C). These within track variances for lake to sea tracks do not differ from those of sea to lake tracks ($F = 0.039$: $DF = 1, 51$) and the tracks are equally straight under both good and poor visibility conditions (Sea to Lake $F = .413$, $DF = 1,33$: Lake to Sea $F = .019$, $DF = 1, 16$).

A further indication that vision is not important is the fact that some of the seals which moved inland from a point in the vicinity of IJ dunes, about 1500 yards East of East Lake Wallace, returned to the sea only after having reached the central dunes. If the animals were relying on visual information to reach the lake, one would think they would have recognized their mistake and aborted their journeys long before reaching the dunes.

Though I do not wish to conclude at this stage that the Harbour seals did guide themselves with landmarks if visibility allowed, it seems reasonable to assert that the animals can dispense with them and still find their way across the sandy plain without any obvious difficulty.

(b) Conceivably the use of the notable zastruga as a guide across the sandy plain (Plate 3) would not be hampered by poor visibility. Though I did not measure these sand ripples in any way, it was clear that their prominence and orientation changed with the wind direction and speed, and would therefore be an unreliable cue for the seals to choose their bearing. In any case, it is unlikely that the seals could have chosen a departure bearing by this cue regardless of the effect

Plate 3.

ZASTRUGA. These sand ripples were quite prominent and could have been used as an orienting cue. The direction and prominence of the zastruga changed with wind direction, and on occasion the sandy plain would be swept clean of them.

of the wind. The animals necessarily departed from a point where the sand was wet and hard packed, and zastruga do not form under such conditions. Only after the seals had moved far enough away from the sea or the lake to reach the dry sand would they have encountered the sand ripples. But even if it were postulated that the animals used zastruga to maintain a course bearing, they could not have always done so since the sandy plain was often swept clean by wind and rain.

(c) The regression analysis showed that track direction was unaffected by whether or not the sun were visible or obscured by a 10/10 (opacity and amount) cloud cover. Perhaps this should not be taken to mean that the seals were not using the sun, at least in part, to direct themselves across the sandy plain, since studies with other animals have shown that cloud cover is not always an effective control for the perception of the sun, since some light passes through even a very thick layer of cloud (Schmidt-Koenig, 1964). With a Pentax spotmeter I recorded a difference in brightness between the eastern and western sky one morning, even though horizontal visibility was about 150 yards, and the sun was completely obscured by a dense cloud cover and therefore impossible for me to locate in the sky. In addition, some seals crossed successfully at night, so any theory of celestial orientation might somehow have to consider the moon or the stars as possible referents.

The Role of Tactile Cues

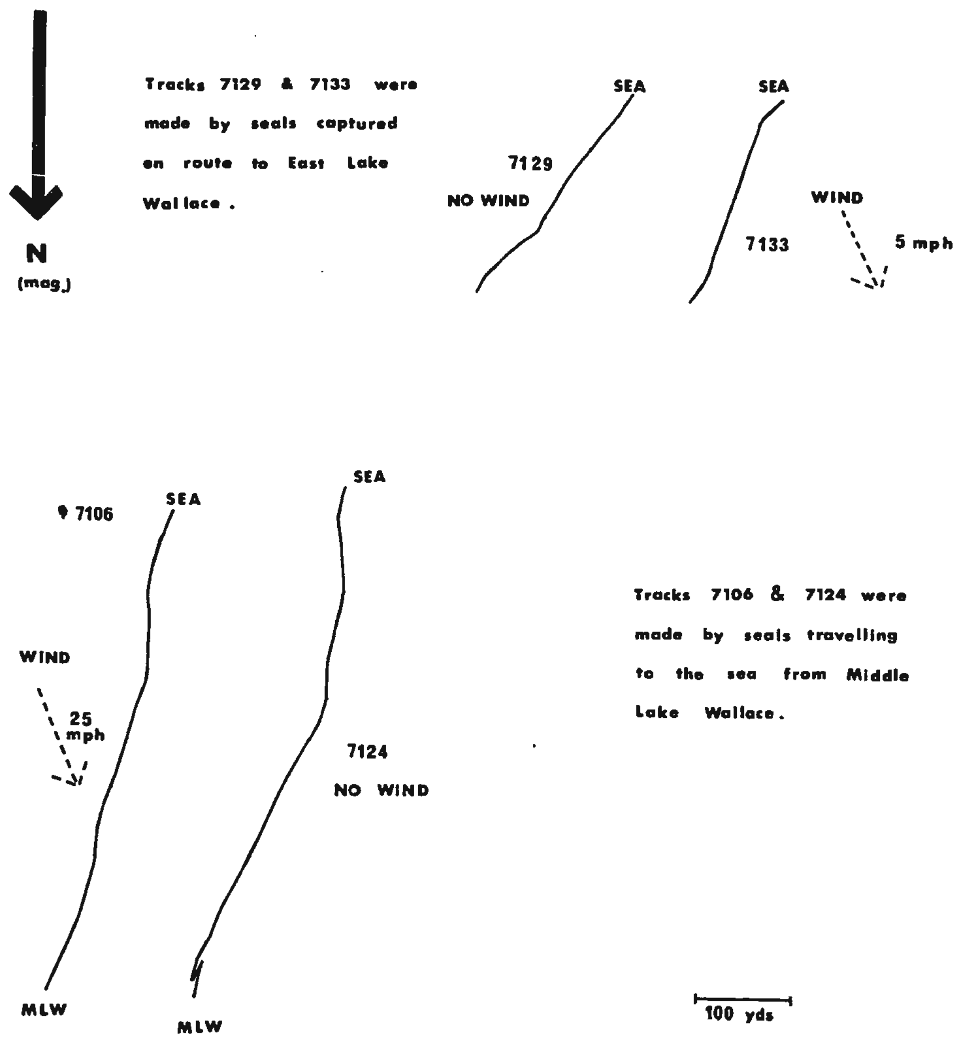
The wind could be used as a tactile cue for determining direction. However, the regression analysis showed that neither wind direction nor wind speed accounted for a significant amount of variance among the bearings taken up by seals in their journeys across the sandy plain, Furthermore, the correlation between wind direction and track direction was only -0.06 in the case of lakebound animals, and 0.10 for seabound ones. So it seems unlikely that the seals were choosing their bearing by the wind, or even by an olfactory cue carried by the wind. This conclusion is further reinforced by the fact that a number of seals successfully traversed the distance between lake and sea when there was no wind at all. Some of these tracks are shown in Figure 6.

The Role of Auditory Cues

Mohl, (1968) has shown that the harbour seal has a water adapted ear with some accomodation power for hearing in air, the best sensitivity in air being about 12 kc./s, and in water about 32 kc./s. He further showed that the seal has effective directional hearing in both media. It is therefore theoretically possible that the seals on Sable Island may have been obtaining directional information from the multifrequency sound of the surf beating on the South sea coast opposite the Wallace Lakes. This cue would certainly be available under all kinds

Figure 6.

ADULT TRACKS MADE WHEN THERE WAS NO WIND. These tracks were not appreciably different from those made when the wind was blowing.


N
(mag.)
Tracks 7129 & 7133 were made by seals captured on route to East Lake Wallace.
SEA
7129
NO WIND
SEA
7133
WIND
5 mph
7106
SEA
WIND
25 mph
MLW
SEA
7124
NO WIND
MLW
Tracks 7106 & 7124 were made by seals travelling to the sea from Middle Lake Wallace.
100 yds

of visibility sun and wind conditions, though the locations of the sounds would vary somewhat with the last (See page 24).

In order to determine if the seals were homing on the surf sound, or if the direction of the sounds was biasing the orientation of the seals, where possible a mean direction was calculated for (1) high frequency continuous, (2) high frequency intermittent, (3) low frequency continuous, and (4) low frequency intermittent surf noises (See page 25) and these means were then correlated with the relevant mean track directions. As can be seen from Table I, these correlations are very low. Furthermore, if the sea to lake and lake to sea tracks are combined and then broken down according to visibility, the resulting correlations are again consistently low, and provide no justification for believing that when visibility is poor the bearings of the seal's tracks are more highly correlated with the direction of the surf sound than when visibility is good.

A suggestion that surf sound is not important in the orientation of the adult seals is further reinforced by the fact that lakebound animals should not be able to select a bearing at the start of their journey by using surf sound, since the noise is diffuse and nondirectional when one is within about 50 yards of the coast. In 22 of the 39 cases where the seal's track was traceable right back to the water's edge, the departure bearing of the track (i.e. the compass bearing of the track from the water's edge to the first bend in the track) was within 10° of the mean bearing of the complete track. In

Table I

Pearson Product Moment Correlation Coefficients (r) Between Mean Track and Mean Surf For Spontaneous Adult Crossings

	High Continuous	Low Continuous	Low Intermittent	High Intermittent
Lake to Sea	r = .414 N = 11	r = -.246 N = 10	r = -.290 N = 6	r = -.191 N = 5
Sea to Lake	r = .038 N = 18	r = .070 N = 18	r = -.265 N = 13	r = -.006 N = 14

11 of these 22 cases, the departure bearing was within 5° of the mean bearing of the entire track. These observations suggest that many of the seals decide on their departure heading when they leave the water and subsequently maintain that heading right across the sandy plain.

Though the bearings adopted by the seals may not themselves have been related to a given surf noise, it is possible that the desired direction was determined at the start of the journey by some independent means, and then this direction maintained by listening to a surf noise and keeping a constant bearing to it. A correlation among means would not necessarily reflect this. To discover if surf sound were related only to the maintenance of a predetermined bearing, the direction of a track at each turn was correlated with the relevant surf sound direction recorded for that same point. The result was one, two, three or four intra-track correlation coefficients for each seal, depending on the number of surf sounds present at the time of crossing. These correlations are shown in Table II, and are again very low. It therefore appears as if surf sound is not a necessary factor in either the selection or maintenance of a bearing by adult seals.

(b) Displaced Adults

Eleven of the sixteen captive adults were successfully released at the dropping point East of H dune, and five at the point west of H

Table II

Intra Track Correlations With Surf (Pearson Product Moment r)
For Spontaneous Adult Crossings

Sealto Lake

Track Number	High Continuous	Low Continuous	Low Intermittent	High Intermittent
7102	r = .154 N = 14	r = -.041 N = 8		
7103	r = -.220 N = 17	r = -.274 N = 17		
7108	r = .162 N = 7	r = -.021 N = 8	r = .063 N = 6	r = .102 N = 8
7109	r = -.043 N = 15		r = .187 N = 15	
7112		r = -.267 N = 20		r = .190 N = 20
7113	r = .223 N = 25		r = -.045 N = 25	
7118		r = -.132 N = 9		r = .113 N = 9
7119	r = .216 N = 14	r = .014 N = 13		
7129	r = -.204 N = 9		r = .365 N = 7	r = 0.00 N = 1
7131			r = -.399 N = 12	r = .488 N = 12
7132			r = -.111 N = 14	r = .285 N = 14
7133	r = -.184 N = 9	r = -.130 N = 8	r = -.054 N = 4	r = -.087 N = 3
7134	r = -.084 N = 2	r = .024 N = 14		r = .204 N = 13
7135	r = -.351 N = 7	r = .443 N = 7		r = .167 N = 2
7136	r = .891* N=5 p <.05	r = .120 N==3		r = -.702 N = 4
7137		r = -.210 N = 10	r = .210 N = 2	r = .292 N = 10
7138		r = -.338 N = 9	r = -.230 N = 4	r = .657 N = 9
7151	r = .420 N = 9	r = -.110 N = 9		

	Track Number	High Continuous	Low Continuous	Low Intermittent	High Intermittent
Sea to Lake	7154	r = .229 N = 9	r = -.080 N = 9		
	7155	r = -.790 N = 4		r = -.306 N = 7	
	7157	r = -.006 N = 5	r = .367 N = 3	r = .646 N = 2	
	7159	r = 0.00 N = 1	r = 0.00 N = 1	r = -.110 N = 6	r = -.678 N = 5
	7160	r = 0.00 N = 1	r = 0.00 N = 1	r = -.110 N = 5	r = -.678 N = 5
	7161	r = -.359 N = 2	r = -.129 N = 8	r = .393 N = 4	r = -.667 N = 7
Lake to Sea	7101	r = .172 N = 10	r = .206 N = 9		
	7106	r = .076 N = 9	r = -.495 N = 10		
	7110	r = -.084 N = 6	r = -.349 N = 9	r = .104 N = 6	r = -.134 N = 8
	7111	r = .013 N = 8		r = .005 N = 8	
	7115		r = .110 N = 15		r = .164 N = 20
	7116	r = -.039 N = 2		r = .337 N = 18	
	7122	r = .028 N = 14	r = .270 N = 13		
	7124	r = -.365 N = 9	r = -.090 N = 7	r = -.049 N = 3	r = -.442 N = 5
	7125	r = 0.00 N = 1	r = -.329 N = 15	r = -.194 N = 11	r = -.123 N = 3
	7126	r = .289 N = 10	r = .116 N = 12	r = -.716* N = 9 p<.05	r = .416 N = 12
	7130	r = .395 N = 10	r = .115 N = 10		
	7117	r = -.048 N = 17	r = .526* N = 17 p<.05		
Attempts	7024	r = .229 N = 8	r = .329 N = 8		
	7026	r = .270 N = 4	r = .144 N = 4		
	7027	r = .067 N = 3	r = .144 N = 3		
	7107	r = .109 N = 9	r = .090 N = 6		
	7025	r = .068 N = 4	r = -.100 N = 3		

	Track Number	High Continuous	Low Continuous	Low Intermittent	High Intermittent
Attempts	7174		r = -.212 N = 13		r = .382 N = 13
	7190	r = .421 N = 8	r = .034 N = 3		
	7197	r = -.164 N = 9	r = -.521 N = 10		
	7114		r = .404 N = 17		r = .442 N = 17
	7120	r = .266 N = 11	r = .569 N = 7		

dune (Map 3). Seven animals went to the lake, and nine went to the sea. The tracks recorded before the animals were captured and after they were released are shown in Figures 7, 8 and 9. Although only seven of the sixteen seals maintained and completed their lakebound journeys after having been captured and displaced, eight of the nine animals which went to the sea upon release headed initially toward East Lake Wallace before changing to a southward course. The average bearing of these seaward courses did not differ from those of seals crossing spontaneously from the lake to the sea ($F = 1.245 : DF = 1, 25$). The only animal which was not captured in the vicinity of H dune was the one seal which did not initially head toward East Lake Wallace. This seal, captured near EFG dunes first headed Northeast from the eastern release site before taking up a bearing leading to the sea (See Figure 8).

These displaced adult tracks were examined in the same way as the 67 spontaneous crossings we recorded, and the data collected in this experiment can be found in Appendix E.

The Role of Visual Cues

(a) It appears as if relocated adults can dispense with landmarks when fixing their position, determining their departure bearing and holding a steady course across an unfamiliar stretch of sandy plain. Eight of the eleven seals dropped at the eastern release site travelled to the sea and did so under reduced visibility.

Figure 7.

TRACKS OF ADULTS AFTER HAVING BEEN DISPLACED TO THE EASTERN RELEASE SITE. The precapture tracks of all but one seal are also shown. The precapture track not illustrated here was made in the vicinity of EFG dunes, and is shown separately in Figure 8.

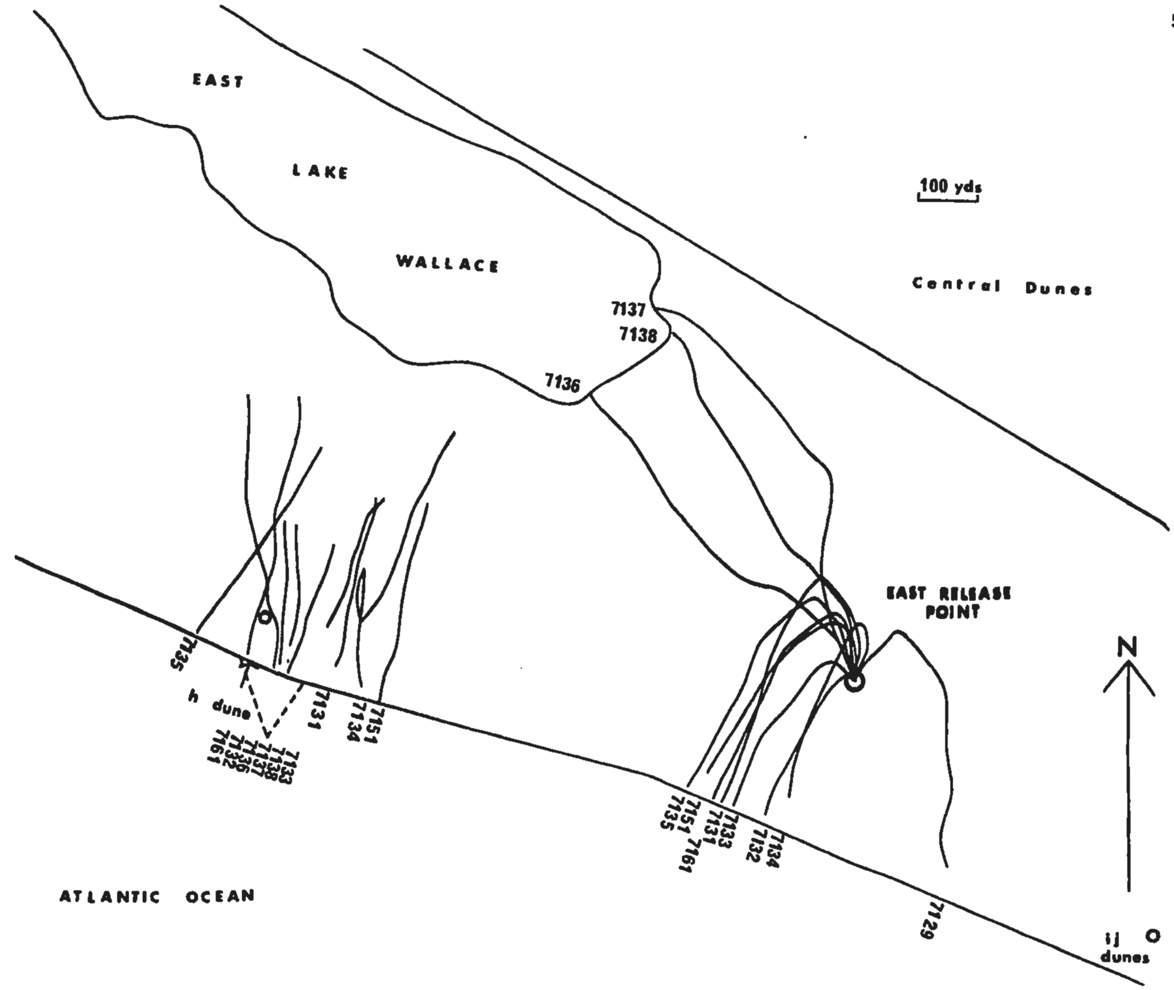

EAST
LAKE
WALLACE
100 yds
Central Dunes
7137
7138
7136
EAST RELEASE POINT
N
7135
h dune
7131
7134
7151
7133
7138
7137
7136
7132
7161
7135
7151
7161
7131
7133
7132
7134
7129
ATLANTIC OCEAN
ij
dunes

Figure 8.

TRACKS OF THE ONLY DISPLACED ADULT WHICH DID NOT INITIALLY HEAD TOWARD EAST LAKE WALLACE UPON RELEASE. This animal was the only seal which was not captured in the vicinity of H dune.

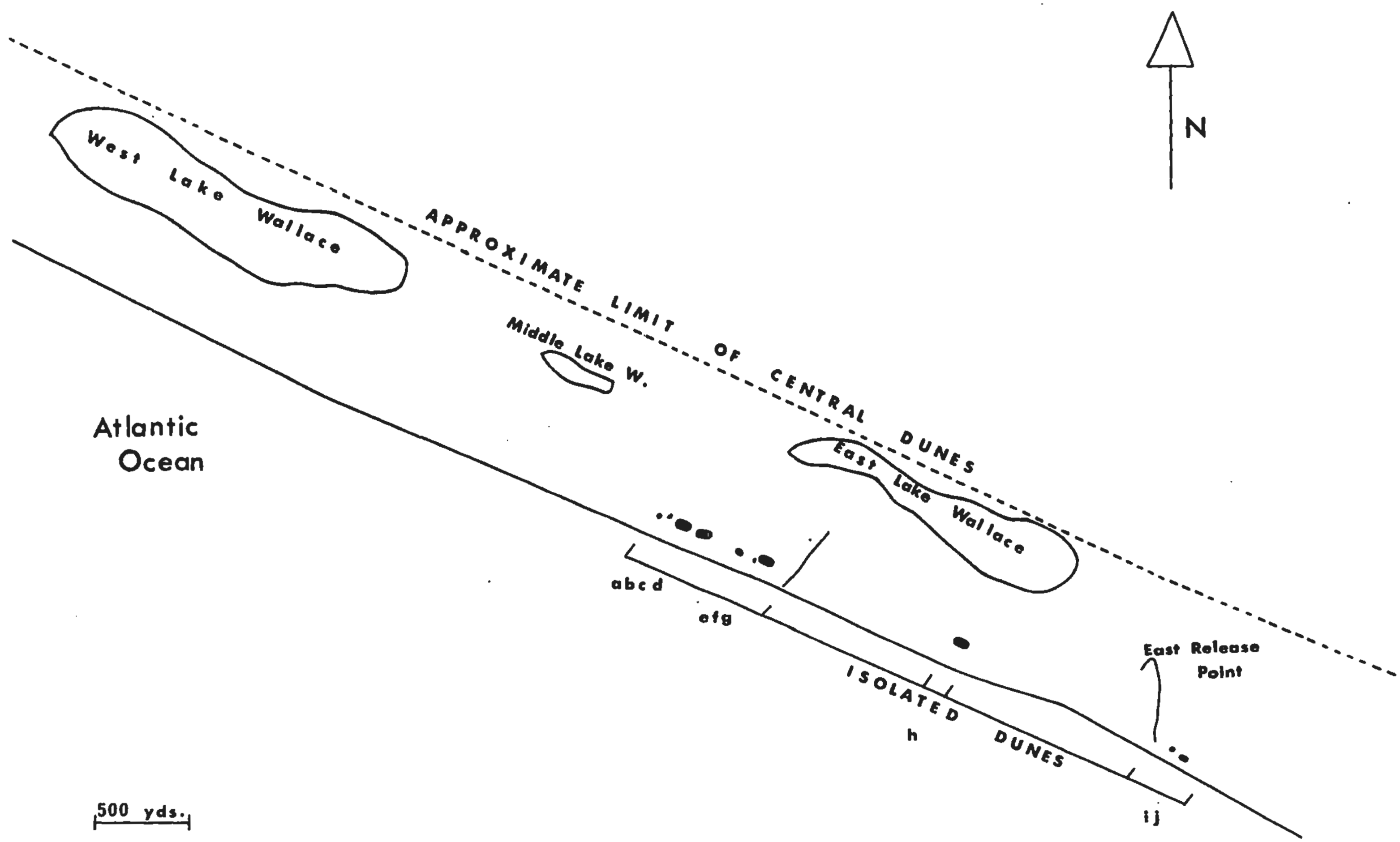
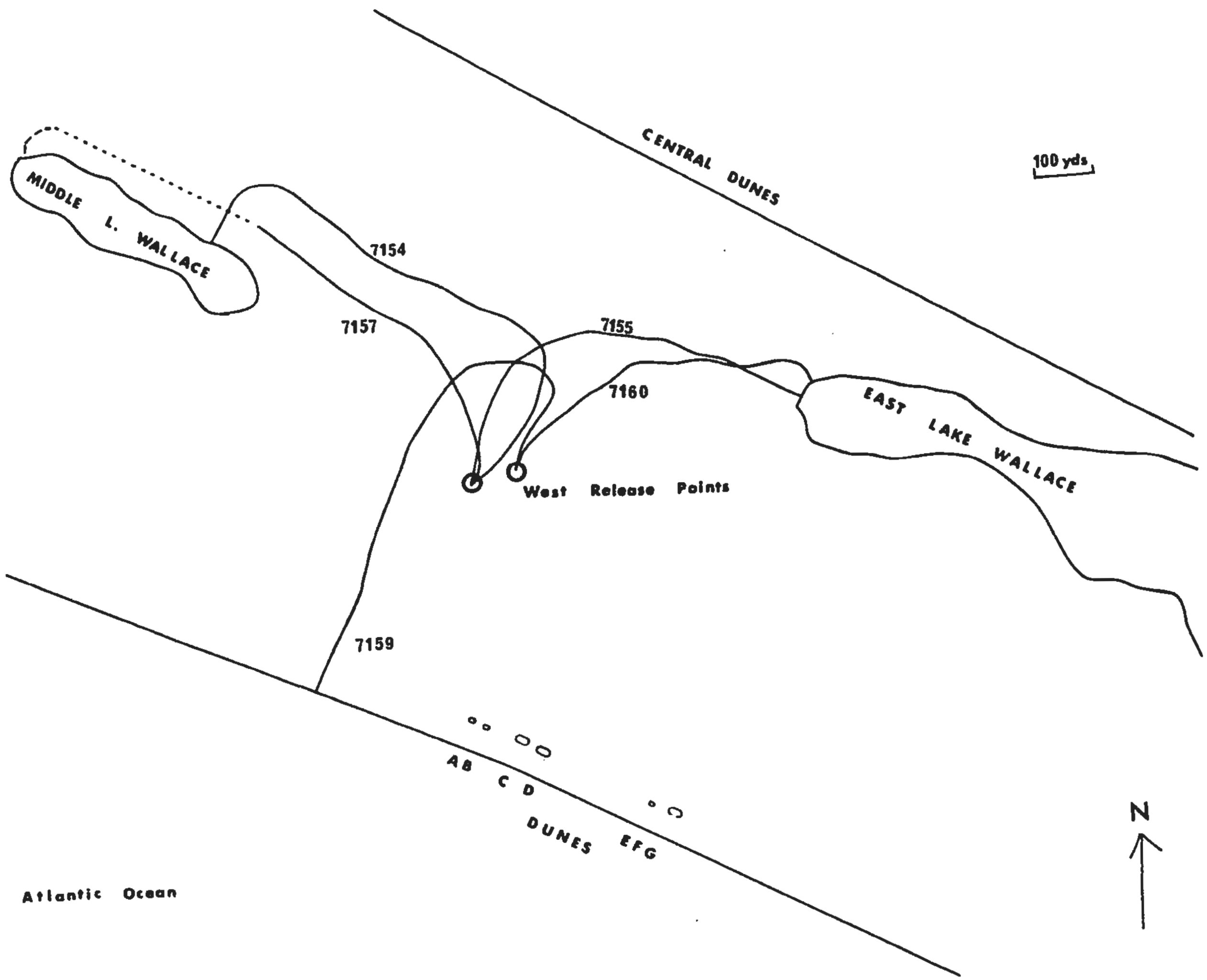

N
West Lake Wallace
APPROXIMATE LIMIT OF CENTRAL DUNES
Middle Lake W.
East Lake Wallace
Atlantic Ocean
abcd
efg
ISOLATED DUNES
h
ij
East Release Point
500 yds.

Figure 9.

ADULTS DISPLACED TO THE WESTERN RELEASE SITE. The precapture tracks of these animals were not appreciably different from those of the seals released at the eastern site.



CENTRAL DUNES
100 yds
MIDDLE L. WALLACE
7154
7157
7155
7160
EAST LAKE WALLACE
West Release Points
7159
AB C D
DUNES EFG
Atlantic Ocean
N

However, it was not sure that landmarks were not visible since the poorest visibility recorded was 1/4 mile, and under this condition, the central dunes could just be made out from the release point. On the other hand, the remaining three seals set free at this point travelled in extremely dense fog when we could be sure that no landmarks could be seen. These animals were the only ones to reach East Lake Wallace from the eastern release point, as can be seen from Figure 7.

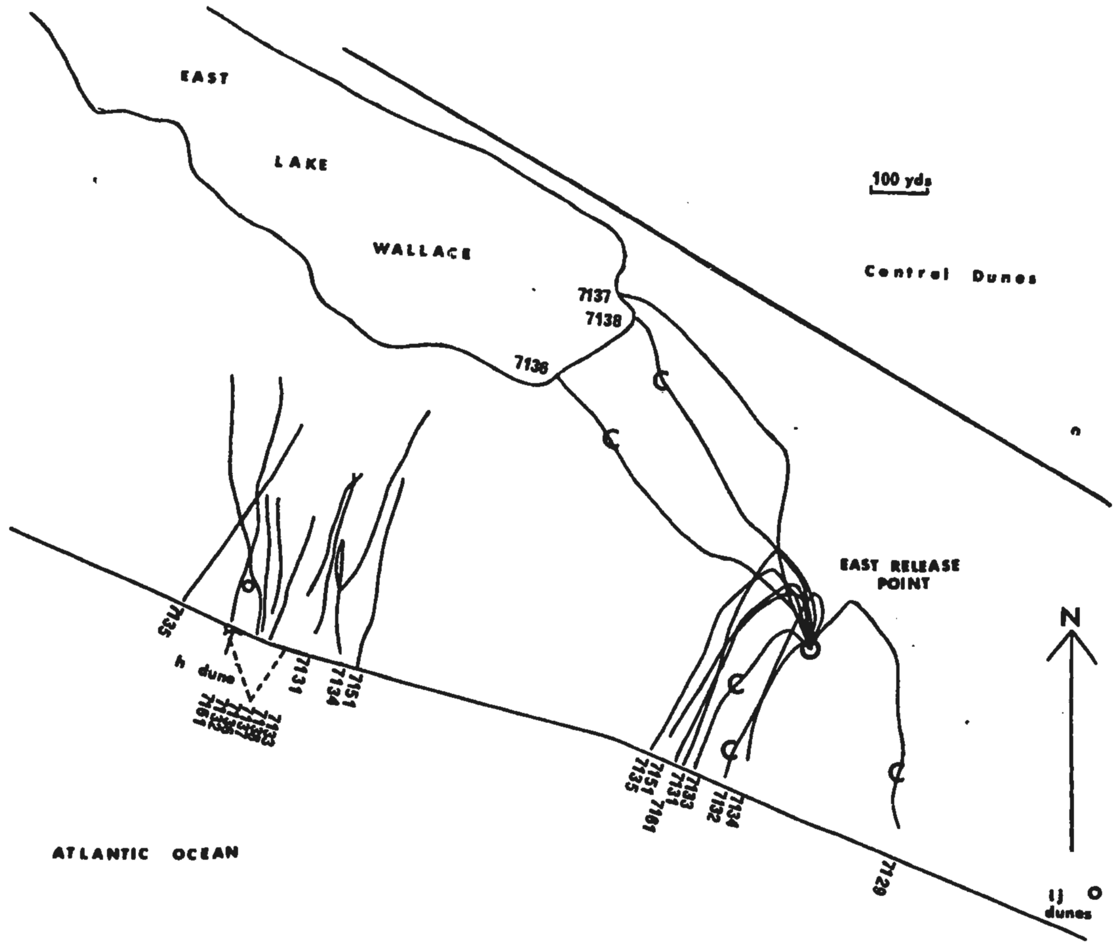
Unfortunately, when the animals were taken to the dropping point West of H dune were released, landmarks were visible. Four of the five seals travelled in clear weather. The remaining animal was set free when visibility was reduced to 500 yards, but even under these conditions, some of the isolated dunes could be seen from the release point.

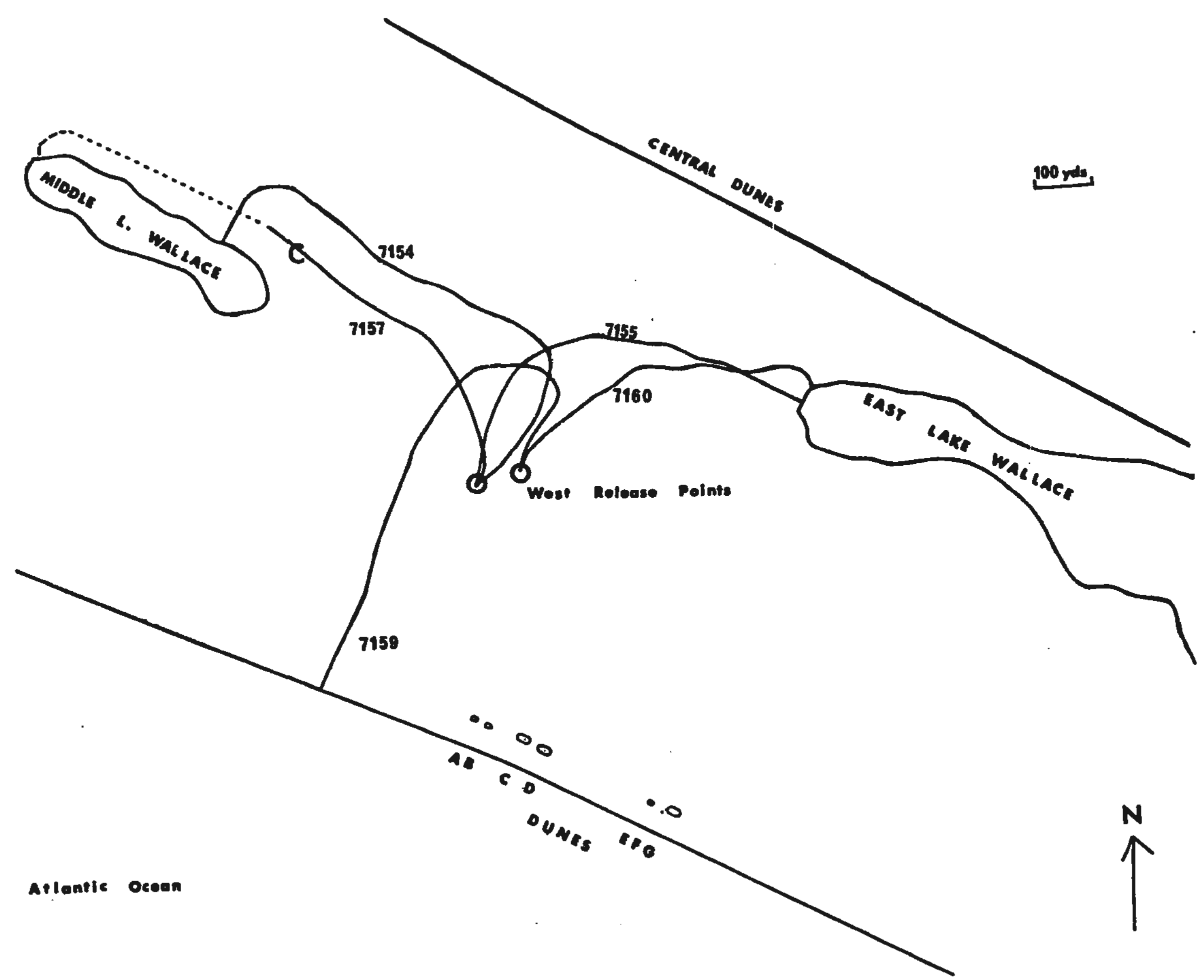
(b) It appears also that the sun might not be necessary cue in these seals' orientation, since six of the sixteen were released under a thick cloud layer which obscured the sun. Two of these animals travelled from the eastern release point to the lake, three went from there to the sea and the sixth went from the western release point to Middle Lake Wallace (Figure 10 a and b).

(c) The zastruga on the sandy plain could not have, by themselves informed a relocated animal about the location of its displacement. Whether or not the captives used the sand ripples to maintain their course bearings is unknown.

Figure 10 a and b.

RELOCATED ADULTS TRAVELLING UNDER DENSE CLOUD COVER. The tracks with a 'C' superimposed are those which were made when the sun was completely obscured by a thick cloud cover.


EAST
LAKE
WALLACE
100 yds
Central Dunes
7137
7138
7136
EAST RELEASE
POINT
N
7135
h dune
7131
7134
7151
7135
7151 7161
7133
7131
7132
7134
7129
ATLANTIC OCEAN
dunes


CENTRAL DUNES
100 yds
MIDDLE L. WALLACE
7154
7157
7155
7160
EAST LAKE WALLACE
West Release Points
7159
AB C D
DUNES EFG
N
Atlantic Ocean

The Role of Tactile Cues

It appears as if the wind did not affect the headings adopted by relocated adults, since the correlation between wind and track direction is only 0.04.

The Role of Auditory Cues

Mean surf sound bearings were calculated as before, and then correlated with the mean track direction of those seals which went to the sea upon release. None of these correlations proved to be significant (Table III).

The number of animals which travelled from the release point to the lakes was not sufficiently large to warrant the calculation of between-track correlation coefficients. Inspection of the means, however, (Table IV) reveals no sign that a correlation might exist between the mean track bearings of these animals and the directions of the various components of the surf sound.

Since a correlation among means would not necessarily demonstrate that the seals used the sound of the surf to maintain a constant bearing, intra-track correlations were calculated (See Page 39). None of these correlations were significant in the case of those seals which escaped to the sea after release. However, the tracks of two seals which went to the lake upon release were significantly correlated with high frequency continuous and low

Table III

Pearson Product Moment Correlation Coefficients (r) Between $\bar{X}$ Track and $\bar{X}$ Surf Bearings For Seabound Relocated Adults

	High Continuous	Low Continuous	Low Intermittent	High Intermittent
$\bar{X}$ TRACK	N = 7 r = .402	N = 9 r = .267	N = 6 r = .460	N = 8 r = .529

Table IV

Mean Track and Mean Surf Bearings for Those Relocated Adults Which Went to the Lake Upon Release

	$\bar{X}$ Track	High Continuous	Low Continuous	Low Intermittent	High Intermittent
7136	316.	194.	258.	210.	197.
7137	330.	282.	236.	215.	205.
7138	332.	196.	235.		202.
7154	309.	192.	243.		
7155	075.				
7157	328.	217.	261.	213.	
7160	076.	200.		211.	204.

Table V

Intra-Track Correlations With Surf For Each Of The Sixteen Relocated Adults

	High Continuous	Low Continuous	Low Intermittent	High Intermittent
7129		N = 4 r = -.148	N = 1 r = 0.00	N = 5 r = -.131
7131	N = 4 r = .533	N = 6 r = .275	N = 3 r = -.093	N = 4 r = .008
7132	N = 8 r = .518	N = 9 r = .083	N = 3 r = -.122	N = 4 r = .463
7133	N = 7 r = .659	N = 6 r = .808	N = 2 r = .414	
7134		N = 8 r = .283		N = 9 r = .063
7135		N = 7 r = .242	N = 3 r = .272	
7136	N = 23 r = -.271	N = 21 r = -.059	N = 1 r = 0.00	N = 4 r = -.026
7137	N = 31 r = 400* p<.05	N = 32 r = .622* p<.01	N = 3 r = -.047	N = 3 r = -.040
7138	N = 10 r = .242	N = 23 r = .137		N = 20 r = .388
7154	N = 17 r = -.523* p<.05	N = 17 r = -.872* p<.01		
7155			N = 5 r = .247	
7157	N = 9 r = .115	N = 3 r = .042		
7160	N = 8 r = .637		N = 3 r = .176	N = 7 r = -.006
7161	N = 4 r = .531	N = 7 r = -.189		
7151	N = 6 r = .278	N = 6 r = -.709		
7159	N = 4 r = -.024	N = 3 r = .111	N = 2 r = -.407	N = 1 r = 0.00

frequency continuous surf sound (Table V). Although all four correlations (.400, .622, -.523, and -.872) are statistically significant, only the last is convincingly high, accounting for 76% of the variance.

We cannot therefore conclude that animals which are displaced and hence are forced to fix their new position and relate it to the location of their goal, maintain the bearing they choose by keeping a constant angle to the surf sound. However, the possibility of surf sound orientation will be examined more fully in the following chapter.

Discussion

The three main facts about the sandy plain migration which have to be explained are:

(1) The seals leaving the lake take the shortest path to the sea, regardless of their departure point on the lake shore.

(2) Seals travelling inland head in the appropriate direction regardless of whether or not the departure point is exactly opposite one of the lakes[1].

(3) Seals interrupted while crossing towards East Lake Wallace and then transplanted to a point 650 yards East of this lake are able to fix their new position and arrive at the lake independently of landmarks.

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[1] Exceptions to this are discussed on Page 19.

The analyses have shown that the animals can find their way (1) when fog, or darkness, or both obscured all landmarks, (2) when the sun was hidden by a thick cloud cover, (3) in varying wind conditions, and that their bearings were chosen independently of the apparent direction of the surf sounds. The courses of the animals which cross spontaneously further do not appear to be maintained by reference to the apparent direction of the surf sound, though two of the four transplanted seals reaching the lakes may have been keeping their predetermined bearing constant by listening to a surf noise.

It appears as if each of these cues is not in itself a necessary condition for the seals to make their way across the sandy plain. There is no reason to assume, however, that the animals are able to rely upon only one cue. The seals could conceivably be using different cues under different conditions, or evan a combination of cues within one crossing, especially if they were not travelling over the sandy plain for the first time, and were familiar with the terrain. If this were the case, it is not surprising that the analyses reported here did not reveal the nature of the orientational mechanism. In most cases I was able to analyze only one cue and its relation to the courses selected and maintained by the seals, being forced to let the other, possibly relevant cues vary. Selecting tracks which were made under conditions which held all factors constant but one reduced the number of cases to a size which could not be dealt with statistically.

Chapter 4.

THE ORIENTATION OF WEANERS

Seals crossing the sandy plain for the first time might rely on a simpler mechanism than would experienced animals. As previously mentioned, the 50 or more pups born on the Wallace Lakes make their way to the sea independently of the adults. I have never found an inbound weaner[1] track, other than those forming the return half of an unsuccessful attempt to reach the sea. (The weaner in question bumped into one of the isolated dunes on the way to the sea, and returned to almost the exact same place it had started from on the lake shore.) Since I have never witnessed a young seal moving from the sea to one of the lakes, it is reasonable to assume that when these seals do venture toward the sea, they are doing so for the first time. The research described in this chapter was undertaken in the hope that these young animals might rely on a simpler guidance system than the adults, and therefore a single factor analysis with the young animals might reveal the nature of the environmental cues they were responding to. Though the pups may have been using an entirely different mechanism from the adults, it was hoped that some relation between the two might emerge. An added enticement was the fact that these small animals were more easily experimented with than the 250 lb. adults.

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[1]A weaner is a seal pup which has been recently weaned.

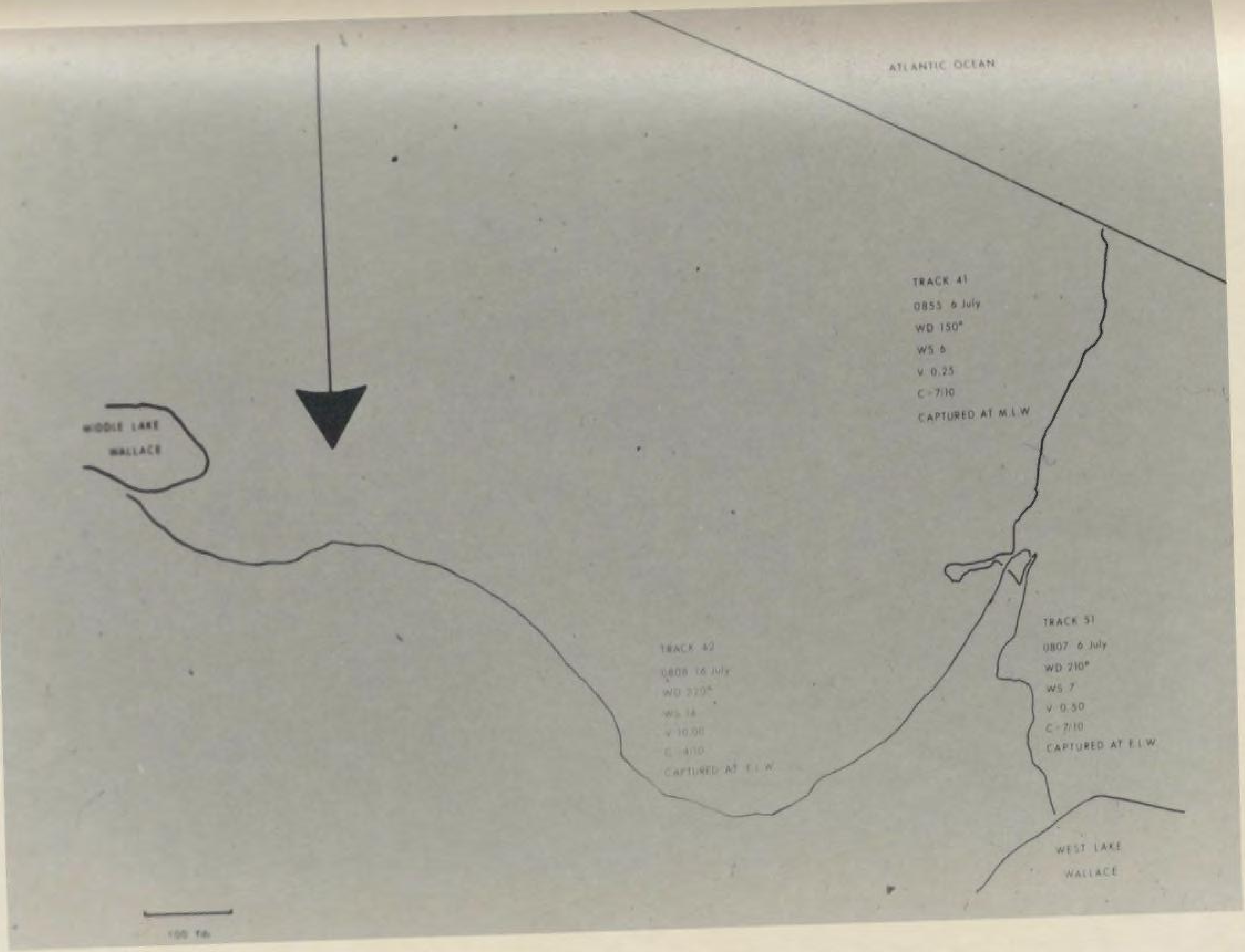
Unfortunately, of the more than 100 weaners which crossed from the Wallace Lakes to the sea during 1970 and 1971, only eight were actually observed in transit so very little can be said about the nature of the orienting mechanism used by the pups during a spontaneous crossing. Curiously enough, most of the weaner tracks found in the East Lake Wallace vicinity exited from the western most corner of the lake, rather than in the main adult seal route in the vicinity of H dune. Also, these young seals did not usually take the shortest route to the sea (which would be on a course of approximately 204°) as did the adults, but adopted an average bearing of 229°, ($F = 31.709$: $Df = 1, 24$: $p < 0.01$).

During 1970, in an attempt to discover a little more about the homing capacity of the young seals, eleven weaners were captured on either the shore of one of the lakes, or on the north or south coasts of the island. They were then taken by LandRover to one of three prearranged dropping points between the south coast and West, Middle and East Lake Wallace. The LandRover was driven out of sight, and the track of the weaner was plotted as soon as the animal had disappeared into the sea or one of the lakes. Figure 11 shows the tracks of the three weaners dropped between West Lake Wallace and the sea. These tracks are typical of all the releases.

Five of the eleven animals headed for the sea when they were released, and five went to one of the lakes. The eleventh moved about 20 yards in the direction of the sea and then went to sleep.

Figure 11

WEANERS RELEASED AT WEST LAKE WALLACE DURING 1970. These tracks are typical of all 10 successful releases. Track 41 was made when visibility was less than 200 yards.


ATLANTIC OCEAN
TRACK 41
0855 6 July
WD 150°
WS 6
V 0.25
C-7/10
CAPTURED AT M.L.W
MIDDLE LAKE
WALLACE
TRACK 42
0808 16 July
WD 220°
WS 14
V 10.00
C 4/10
CAPTURED AT E.L.W.
TRACK 51
0807 6 July
WD 210°
WS 7
V 0.50
C-7/10
CAPTURED AT E.L.W
WEST LAKE
WALLACE
100 Ft.

The tracks of the weaners are more erratic than those of the adults, as can be seen from Figure 11. But it was not possible to tell from such scant data whether this was due to the inexperience of the weaners, their unfamiliarity with the surroundings, or the traumata inevitably associated with being captured and taken for a ride on the floor of a LandRover.

It will be noted, however, that two of the tracks shown in Figure 11 were made when visibility was less than 1/2 mile. In the case of track 41, for instance, fog reduced visibility to less than 200 yards throughout the 30 minutes that this animal spent travelling from the dropping point to the lake. It is thus apparent that visual landmark cues for orientation can be dispensed with by weaners which have had no experience in crossing the sandy plain, in the same way as they can be by adults.

Unfortunately no surf sounds were recorded for these tracks, but of the eight spontaneous weaner crossings which we had observed, surf data are available for three. Table VI shows correlation coefficients between mean track and mean surf bearings (inter-track) as well as intra-track correlations for each animal. A correlation of .935 between mean low continuous surf sound and the mean track bearings was not significant statistically ($r = .950$ needed for $p < 0.05$) but this, in addition to the significant intra-track correlations for the two transplanted adults which escaped from the release site to East Lake Wallace (See Table V) suggested that it might be worth-

Table VI

Pearson Product Moment Correlation Coefficients (r) Between Track and Surf Bearings Of The Spontaneous Weaner Crossings:

A = intra-track; B = inter-track

		High Continuous	Low Continuous	Low Intermittent	High Intermittent
A.	1	N = 25 r = -.389	N = 26 r = -.166		
	2	N = 28 r = .165	N = 21 r = -.238		N = 20 r = .077
	3	N = 9 r = .030	N = 8 r = -.261	N = 2 r = .085	

	High Continuous	Low Continuous	Low Intermittent	High Intermittent
B.	N = 3 r = .754	N = 3 r = .935	N = 1 r = 0.00	N = 1 r = 0.00

while to pursue the possibility of surf sound orientation in the young animals. The following experiments were designed to test such a possibility.

EXPERIMENT I; RELOCATION

Subjects

The subjects were 16 harbour seal pups born on Sable Island in 1971. Eleven of the pups were male one was female, and the sex of the remaining five was unidentified. It is assumed that subjects 5 through 16, inclusive, were weaners, since they were captured between July 4 and July 23. The pupping season on Sable Island is in May and early June (Boulva, 1971) and harbour seals are usually weaned about three weeks after birth (Mansfield, 1963). Furthermore, when one approaches an unweaned animal which remains on the beach after the rest of the herd has been flushed into the sea, an adult (presumably the pup's mother) stays very close to the shore in the vicinity of the pup, sometimes hauling out and approaching the young animal despite the presence of a human. This did not occur when subjects 5 through 16 were captured. Similarly, subjects 1 and 2 did not appear to be attached to an adult upon capture on the 16 and 17 of June, respectively, so it is assumed that these were weaners as well, added to the fact that they were as large as one would expect a weaned animal to be. However, subjects 3 and 4 captured on June 26 and 27 were very small, and may have still been nursing.

Once they had been captured, with the exception of Subjects 1 and 2, the pups were kept in an enclosure which was erected with farm fencing and chicken wire on the edge of one of the small inland ponds found in the shelter of the central dunes (as distinct from the much larger Wallace Lakes). This enclosure is shown in Plate 4. Thirteen of these seals were used in Experiment II.

Table VII shows the date and location of the capture of each of the pups, and the dates on which they were used for the experiments.

Procedure

Map 4 shows five dropping points around Sable Island to which each subject was taken and there released.

Drop 1, labelled MOBIL on the map was close to the western limit of the central dunes about three miles East of the campsite of the Mobil oil workers on the island. The stake marking the drop was situated at a point where there was a break in the central dunes about 150 yards wide, leaving no barrier between the north and south coasts of the island. The stake was placed in the centre of this gap, exactly 250 yards from both sea coasts. Thus a pup should have been able to reach one shore as easily as the other.

Drop 2, labelled OLD MAIN on Map 4, was situated 250 yards from the south coast near the deserted remains of the Main Lifesaving

Plate 4.

WEANER ENCLOSURE. The pups used in Experiments I and II were detained in this enclosure until testing was completed.

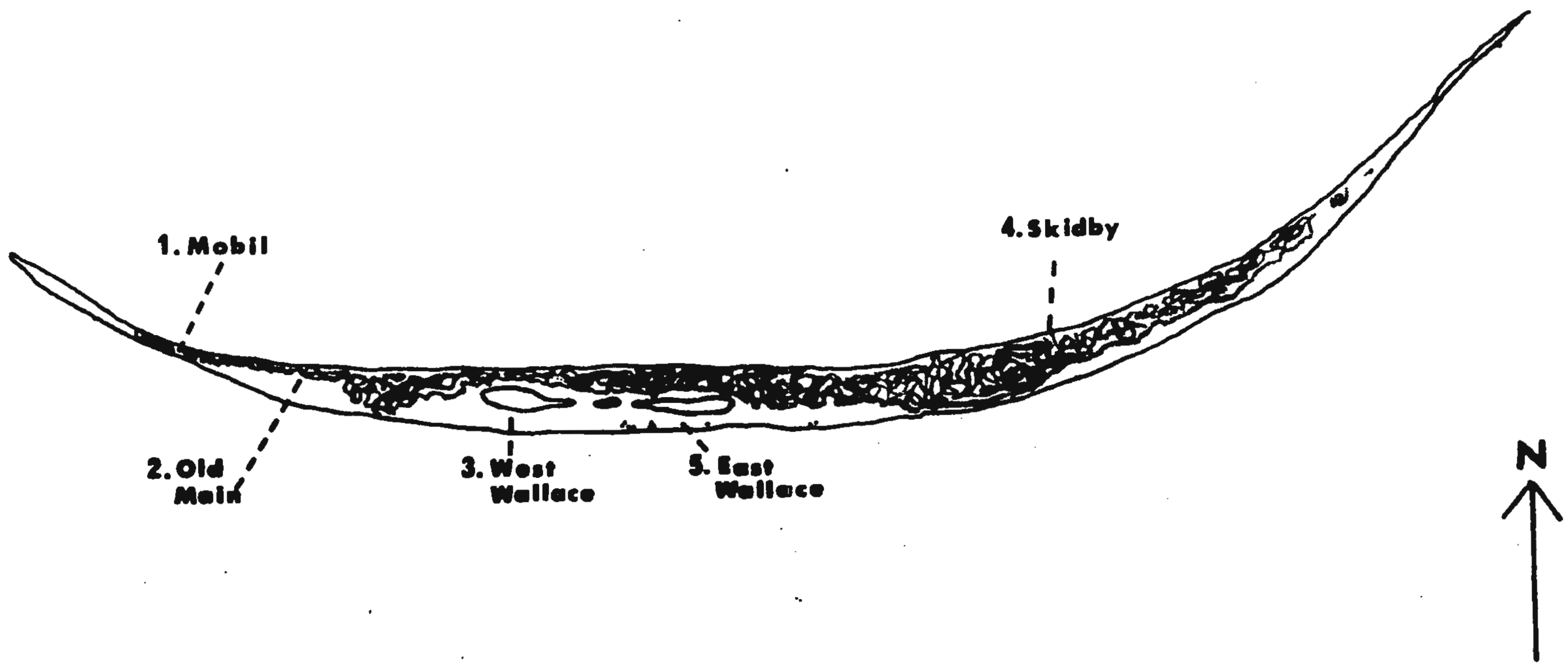
Table VII

The Date and Location of Each Subject's Capture, And The Date On Which It Was Used In Experiments I And II

Subject	Date of Capture	Location of Capture	Date Used in Experiment I	Date Used In Experiment II
1	June 16	North Coast	June 16	
2	June 17	Opposite East Lake Wallace	June 17	
3	June 26	On Middle Lake Wallace	June 26	July 8
4	June 27	On Middle Lake Wallace	June 27	
5	July 4	Opposite West Lake Wallace	July 4	July 14
6	July 5	South Coast, East of Lake Wallace	July 5	
7	July 6	Opposite Middle Lake Wallace	July 6	July 9
8	July 6	Between East Lake Wallace and Sea	July 7	July 8
9	July 7	On East Lake Wallace	July 11	
10	July 8	On West Lake Wallace	July 11	
11	July 11	Between East Lake Wallace and Sea	July 12	July 17
12	July 14	Opposite West Lake Wallace	July 14	July 17
13	July 14	Opposite East Lake Wallace	July 15	
14	July 17	Between East Lake Wallace and Sea	July 21	July 22
15	July 23	Opposite East Lake Wallace	July 23	July 24
16	July 23	South Coast, East of East Lake Wallace	July 24	

Map 4.

WEANER RELEASE POINTS. These were the release sites used for Experiment I undertaken in 1971.


1. Mobil
2. Old Main
3. West Wallace
5. East Wallace
4. Skidby
N

Station which are on the southern rim of the central dunes. The topography of this part of Sable Island is very much like the sandy plain area illustrated on Map 2, in so far as it consists of a stretch of flat featureless sand about 400 yards wide, bounded on the North by the central dunes and on the South by the sea.

Drop 3, called WEST WALLACE on Map 4, was located near the Western most part of West Lake Wallace, again 250 yards from the sea.

Drop 4, named SKIDBY (after a prominent shipwreck in the vicinity) was located on the north shore of the island and was different from the other dropping places. It was situated in a blowout[1] which was rather confined and had only three exits to the northern sea coast (Map 5). The stake marking the drop was 250 yards from the sea to the North, at the base of a long dune ridge fifty feet in height which formed part of the central dunes. The blowout was heavily littered with debris washed ashore from the many ship wrecks around the island, and there were five large isolated dunes (marked A through E on Map 5) which could have caused the seal to make a number of detours, though only dunes A, B, C, and D directly blocked an exit to the north coast. The central dunes effectively prevented a seal from getting to the south coast.

Drop 5, called EAST WALLACE, was located on the sandy plain, half way between dunes G and H, again 250 yards from the sea

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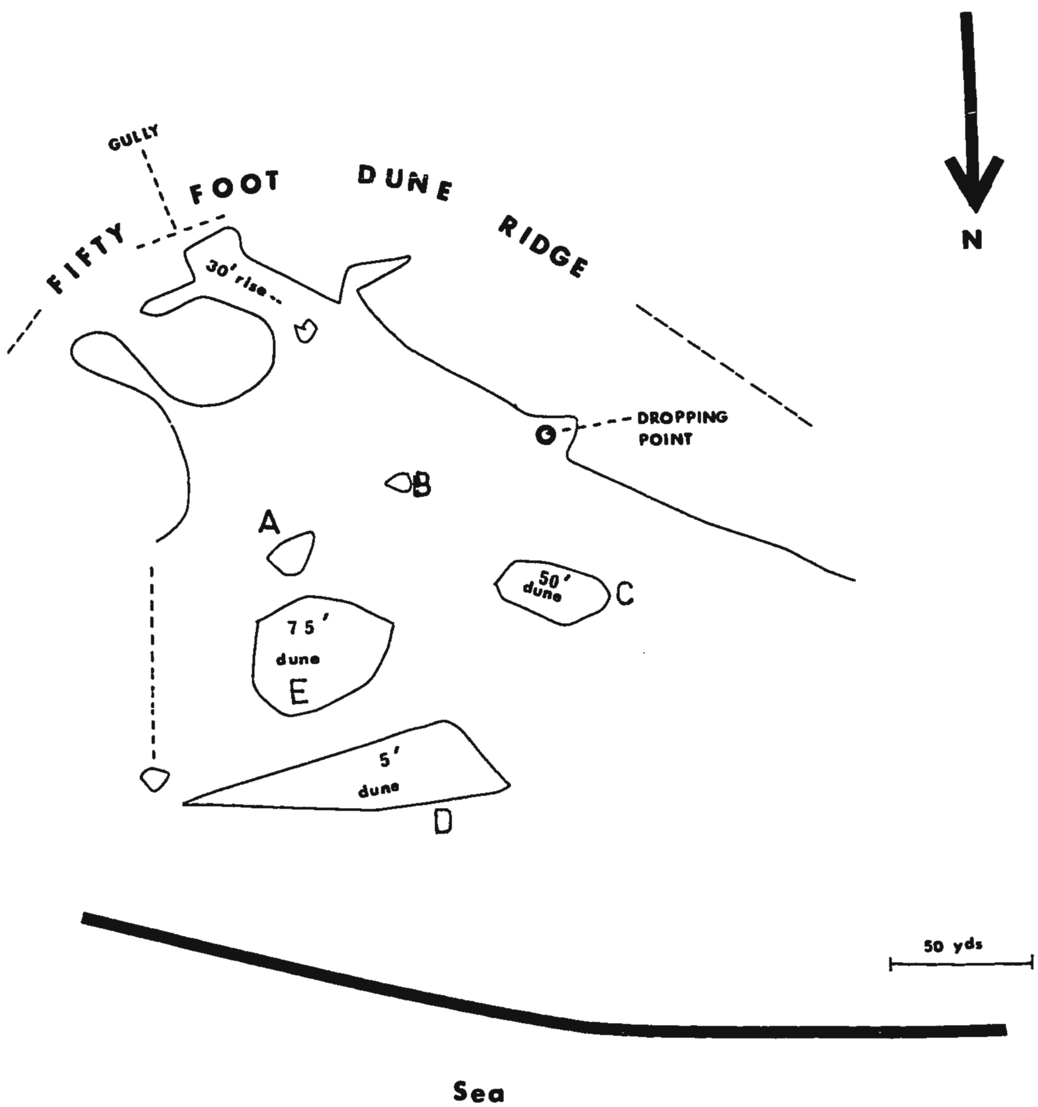
[1]A hollow swept out by wind between two hills of sand.

Map.5.

SKIDBY RELEASE SITE. The topography of this release point was different from the other four, in that it was situated in a rather confined blowout which had only three exits to the sea.


GULLY
FIFTY FOOT DUNE RIDGE
30' rise
DROPPING POINT
B
A
50' dune C
75' dune E
5' dune D
N
50 yds
Sea

to the South.

For all five dropping points, the sea was visible at seal level when one was within about 50 yards of the coast.

Each seal was transported by LandRover to the five places just described. The animal was carried in a net to the stake marking the dropping point, and there deposited, net open, while the LandRover was hastily driven out of view. The order in which a seal would experience the five releases, the direction (North, South, East or West) in which the seal was facing when released, and the direction (North, South, East or West) in which the vehicle retreated were all randomized.

The seal was permitted to travel away from the stake for five minutes, after which time it was recaptured to be taken to the next release site. Once the pup was secured in the LandRover, its track was plotted and the bearings of the surf sounds were calculated in the method described for the adults. Just before opening the net to free the seal, I made a subjective judgment of the horizontal visibility, and recorded the wind direction and speed with a compass and an anemometer. I also noted whether or not the sun were visible throughout the seal's wanderings, and the time the pup had been released.

Once the animal had been taken to all five dropping points, (usually about four hours later) it was returned to the enclosure described above, to be later tested in Experiment II. The data collected for each subject are tabulated in Appendix F.

EXPERIMENT II: T MAZE

Subjects

The logistic problems encountered in holding the seals captive during the interval between being tested in Experiments I and II prevented the use of all sixteen pups in both experiments. Subjects 1, 2 and 4 from the relocation study were not used in this second experiment.

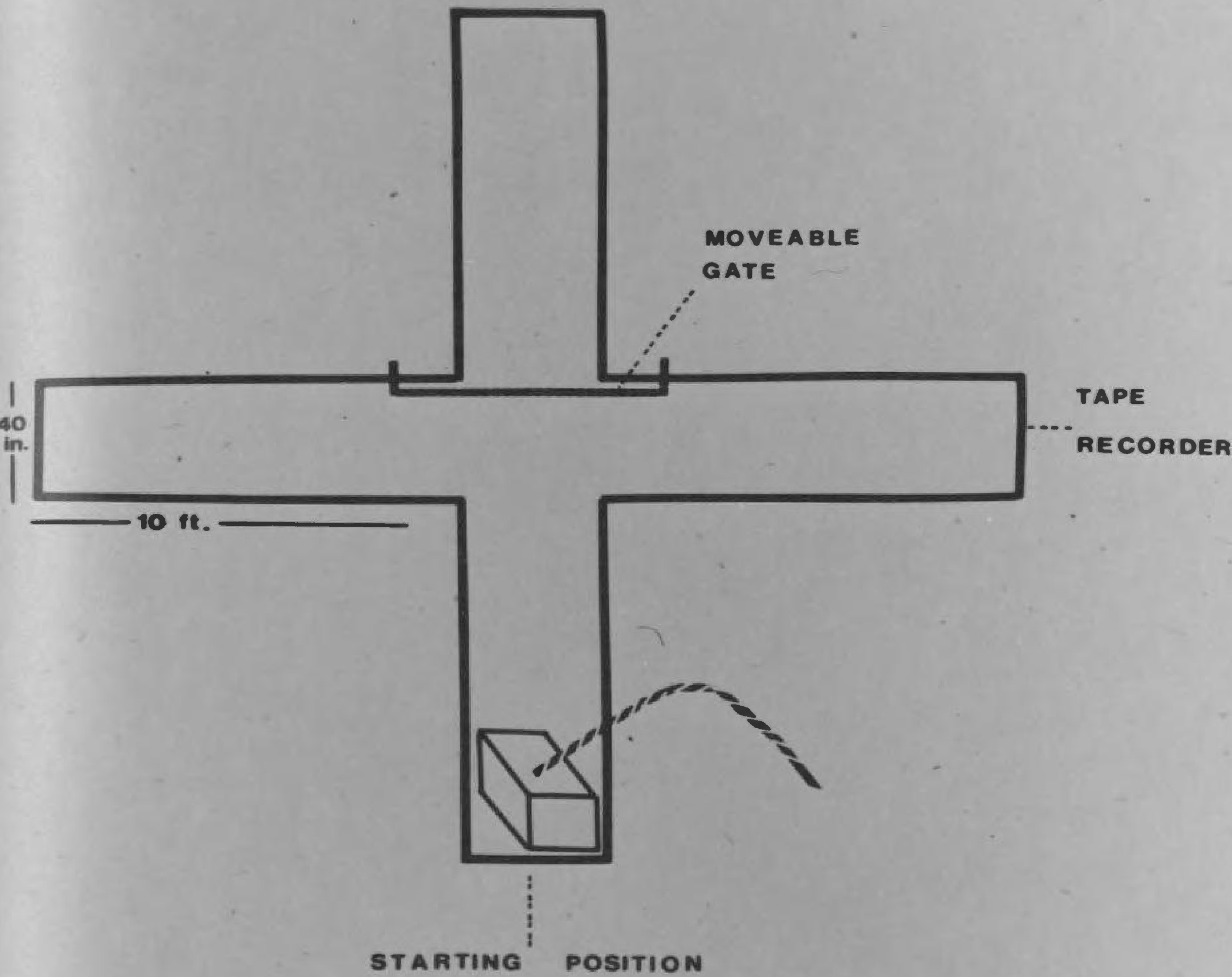
Apparatus

A nile green fibreglass maze was erected on the sandy plain half way between West and Middle Lake Wallace (Figure 12). Each of the four arms of the maze were 10 ft. long, 40 inches wide and 40 inches from the ground. It was used as an adjustable T maze. A portable 50 x 40 inch door was used to block the entrance to any one of the arms of the maze on a given trial, effectively leaving a three-armed T maze in which the seal was to be tested. The T was oriented differently on each consecutive trial, the starting position being either the North, South, East or West arm, with the door blocking that arm opposite the starting position.

I was able to make a reasonable recording of the surf sound with a Nagra IV-L taperecorder by standing within 30 yards of the

Figure 12.

T MAZE. This was the apparatus used in Experiment II. The portable door allowed the T to be oriented either North, South, East or West.



Adjustable T Maze

(40 inches high)

of the sea and pointing at right angles to the coast a 12 inch directional microphone (Electrovoice Cardiline Model 642) shielded from the wind by a foam rubber sleeve and a wire cage covered with nylon mesh (Figure 13). A continuous tape[1] was made of the surf sound which was recorded, so that it could be played for any length of time without interruption. During the experiment the sound was played with the Nagra's own amplifier coupled with an auxiliary amplifier.

An open bottomed box, large enough to cover a harbour seal pup was placed in the start position, with a rope attached to the top so that the box could be easily raised.

Procedure

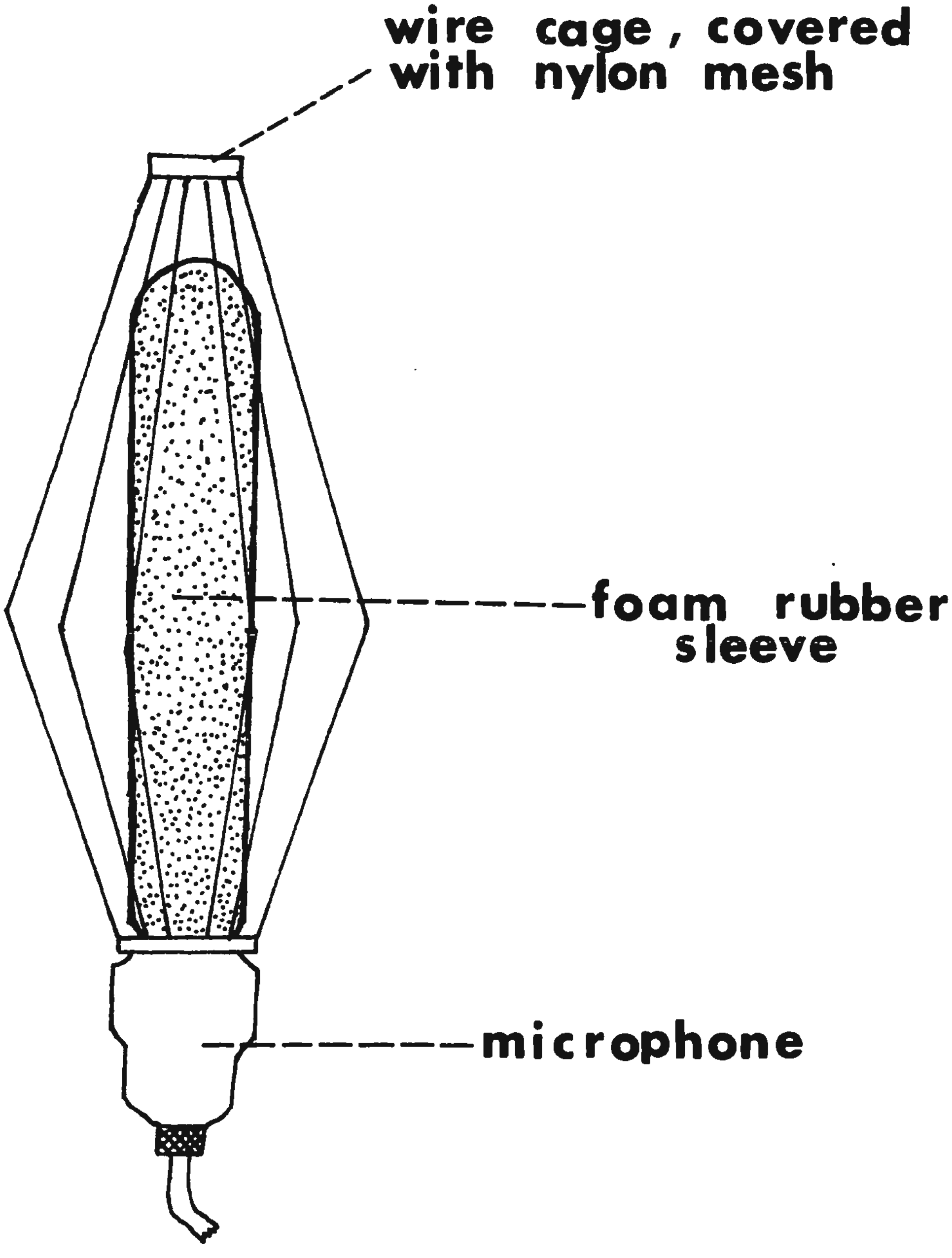
Each seal was given ten trials in the maze in which it faced a choice between going towards or away from surf sound. At the beginning of a session, the pup was detained under the start box, the total darkness of the box quietening the animal almost immediately. The tape recorder was turned on just outside the end of the arm either to the left or the right of the choice point. Natural surf could not usually be heard inside the maze (at least by the human ear) when the tape was being played.

After five minutes, the start box was lifted out of the maze and the seal was free to explore its quarters. The experimenter

[1]This was done by taking one piece of the tape on which the surf was recorded, and splicing the two ends together, thus making a loop just large enough to fit snugly around both reels on the tape recorder.

Figure 13.

MICROPHONE SHIELD. The sound of the surf was recorded with a 12 inch directional microphone which was shielded from the wind by a foam rubber sleeve, and a wire cage covered with nylon mesh.


wire cage, covered
with nylon mesh
foam rubber
sleeve
microphone

stood directly behind the starting arm of the maze and this effectively inspired the pup to head for the choice point since the presence of a human is usually sufficient to make a seal move quickly in the opposite direction. Once it had reached the choice point, the seal was faced with choosing to go either towards the artificial surf sound or away from it.

Once the decision had been made, and the seal had reached the end of either arm, the box was dropped over the animal, and this was to be the starting position for the next trial. The seal remained under the box on this second, and on all subsequent trials for three minutes, while the portable door was moved to block the appropriate arm of the maze. The tape recorder was carried to the arm either to the right or left of the new choice point, depending on an a priori decision of random order.

I recorded whether the animal had chosen to go toward the surf sound or away from it, and the latency between the raising of the start box and the completion of the choice, (which was defined as the moment when the seal's hind flippers had passed a mark indicating the half way point of the arm).

Results and Discussion: Experiment I.

A numerical analysis of the tracks made at the Skidby drop seemed inappropriate since the details of these tracks largely represented the avoidance or circumnavigation of various obstacles in the blowout (See Map 5). Therefore, these tracks were not included in any of the following statistical investigations, but will be considered in detail later.

Firstly I did a regression analysis to determine whether (1) time of release, (2) dropping place, (3) cloud cover, (4) horizontal visibility, (5) wind direction (6) wind speed, or (7) an interaction between wind direction and speed had a significant ($p < 0.05$) effect on the mean course bearings adopted by the pups after they had been released at the various dropping points. The results of this analysis can be found in Appendix G.

Both inter and intra-track correlations were calculated to establish the relationship between surf sound and the orientation of the weaners. In this analysis I computed, where possible, mean bearings for (1) high frequency continuous, (2) high frequency intermittent, (3) low frequency continuous, and (4) low frequency intermittent surf sound for each of a total of 64 tracks. These means were then correlated with the relevant mean track bearings. The results are shown in Table VIII.

In order to obtain intra-track correlations with surf, the tracks made by a given subject at East Lake Wallace, West Lake Wallace, Old Main and Mobil were collapsed into one. In the same way as with the analysis of the adult data, the bearing of the track at each turn was correlated with the relevant surf sound direction recorded for that same point. These correlations are shown in Table IX.

The Role of Visual Cues

(a) As can be seen from the outcome of the regression analysis, horiziontal visibility accounted for 14% of the variance ($p < 0.001$) among mean track bearings. This implies that the average bearing taken up by seals travelling when visibility was less than or equal to 250 yards (269.27°) was significantly different from that chosen by animals travelling when visibility was greater than 250 yards[1] (228.81°).

The weaners did not appear to be responding consistently to special topographical features of each release site, since a significant amount of variance was not accounted for by release site in the regression analysis. Even if they were relying on topographical cues when visibility permitted, it is nonetheless quite clear that the animals were well oriented when visual landmark cues had to have been dispensed with. The tracks made by animals released in dense fog (a sample of which are shown in Figure 14) do not indicate in any way that the weaners were disoriented.

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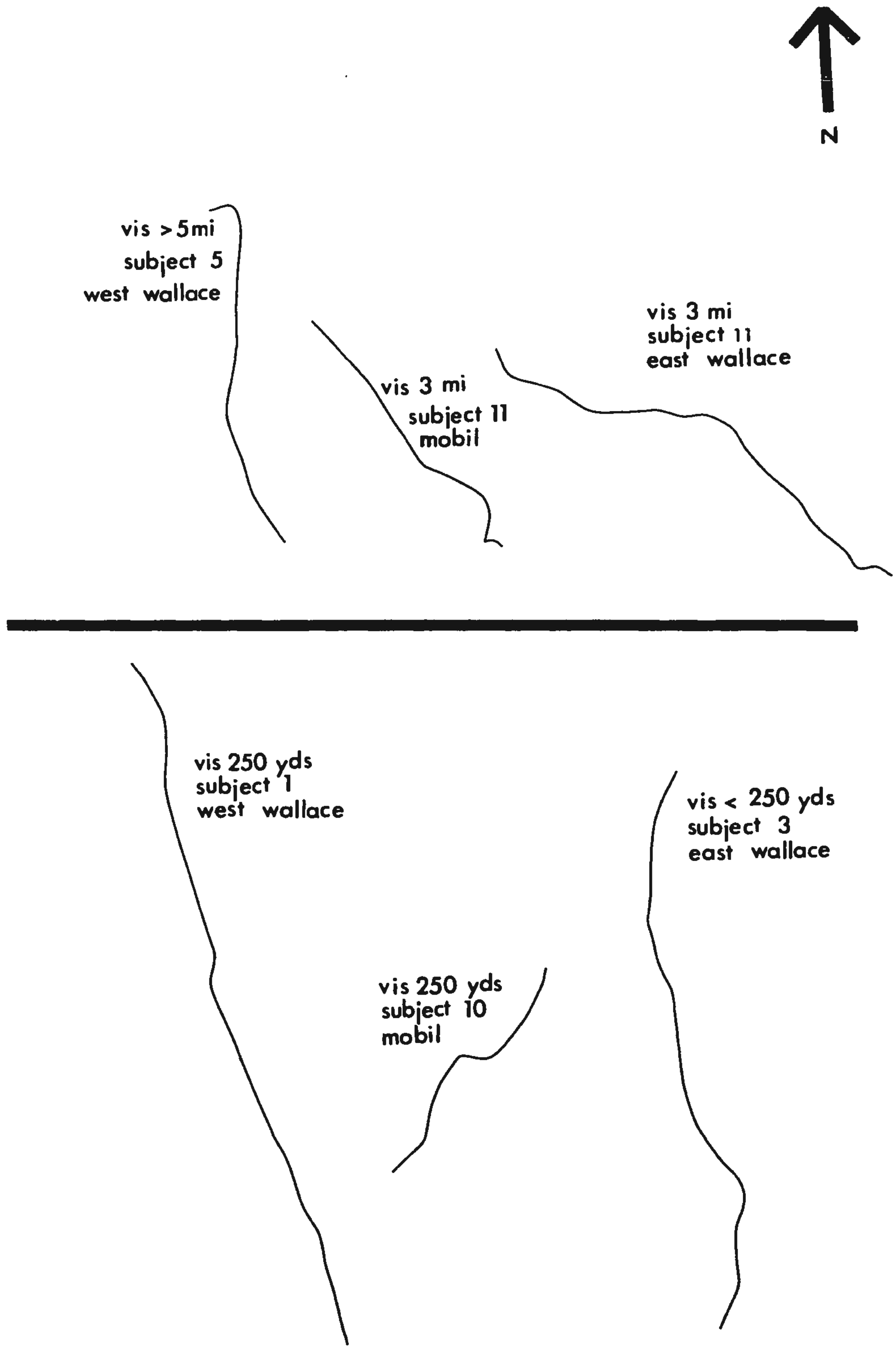
[1] This may have been an artifact since four of the thirteen seals journeying in minimal visibility were Northbound animals. The performance of these seals was necessarily represented by large numbers clustered around the 360 degree point of the compass, and so a high mean for that group including these animals would be expected.

Figure 14.

SAMPLE OF WEANERS RELEASED IN DENSE FOG. These tracks are as well oriented as examples of those made in clear weather.



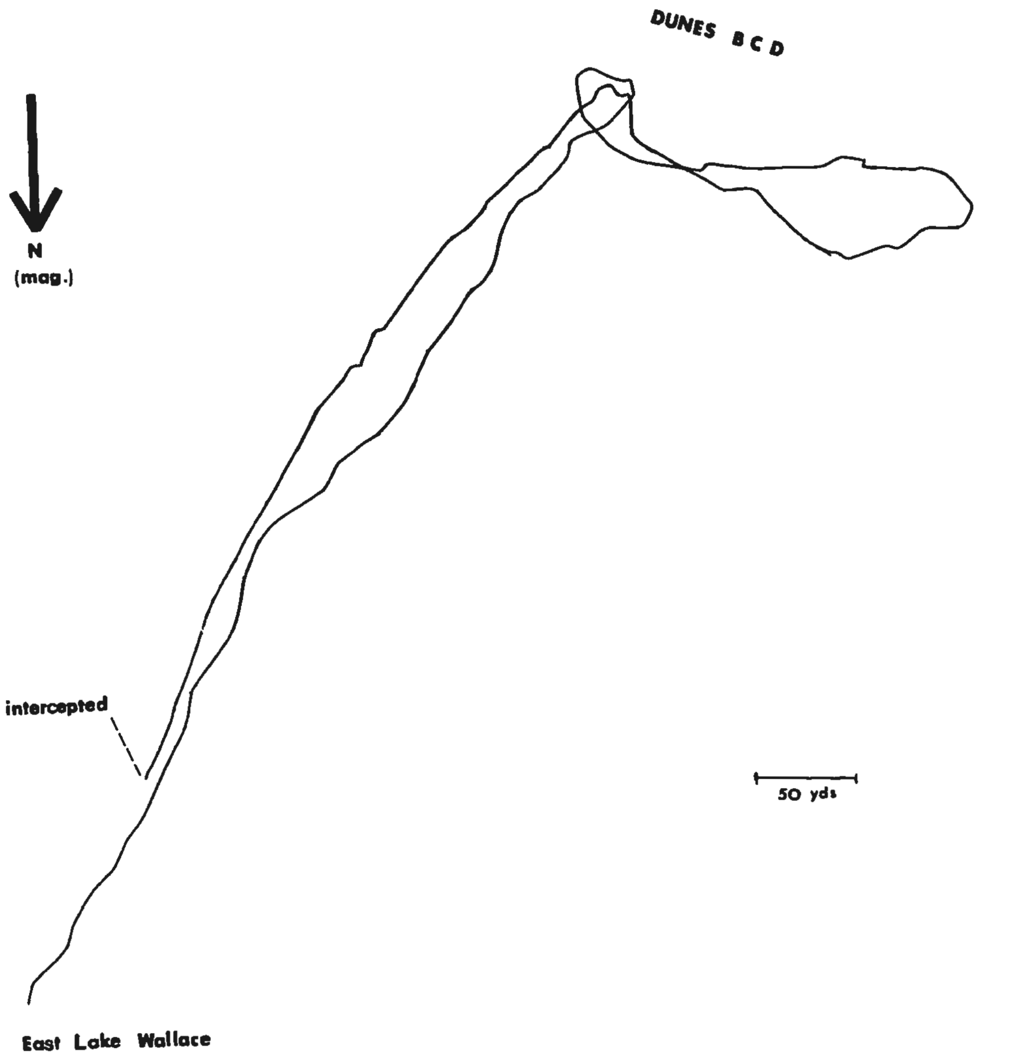
N
vis >5mi
subject 5
west wallace
vis 3 mi
subject 11
mobil
vis 3 mi
subject 11
east wallace
vis 250 yds
subject 1
west wallace
vis < 250 yds
subject 3
east wallace
vis 250 yds
subject 10
mobil

Field observations prior to this experiment tend to support the contention that landmarks are unnecessary cues for orientation. Some of the spontaneous weaner tracks recorded were made in dense fog, and did not suggest that these animals were hampered by the obscurity of landmarks. In fact, I observed one weaner which had started out from the west end of East Lake Wallace when visibility was less than 400 yards, head straight for the sea, only to be interrupted by encountering dunes BCD three quarters of the way (Figure 15). The seal then made an apparent search around the base of these dunes (presumably in an effort to circumnavigate them) which displaced the animal about 200 yards off course. The seal was nonetheless able to return to almost the exact departure point on East Lake Wallace before it was intercepted.

(b) As suggested for the adults, the zastruga on the sandy plain might serve as a visual cue for the weaners. Again, this would be an unreliable cue since the prominence and orientation of the sand ripples appeared to depend largely upon the wind conditions. Even if it were conceivable that an animal might maintain a bearing by keeping a constant angle to the zastruga, it is unlikely that the weaners which crossed spontaneously from the lakes could have used the sand ripples to select the appropriate bearing. The sand in the immediate neighbourhood of the lake shores was always wet and hardpacked, and therefore flat and unfeatured. The zastruga

Figure 15.

SPONTANEOUS WEANER TRACK WHEN VISIBILITY WAS LESS THAN 250 YARDS. In an effort to circumnavigate dunes BCD, this animal displaced itself 200 yards off course, but was still able to return to almost the exact departure point on East Lake Wallace before it was intercepted.



DUNES B C D
N
(mag.)
intercepted
50 yds
East Lake Wallace

appeared only when one had come upon the dry sand about 75 yards from the lake shore, therefore the weaners must have chosen their bearings independently of this cue.

(c) The regression analysis showed that conspicuity of the sun was not a significant predictor of the mean track bearings of the displaced weaners, therefore celestial orientation seems unlikely. As Figure 16 shows, animals released under a thick cloud cover do not appear to be disoriented when they are compared with those released under sunny skies. However, as previously mentioned in relation to the adult analyses, some sunlight can be detected even through an extremely dense cloud cover.

The Role of Tactile Cues:

The regression analysis revealed a significant interaction between wind direction and wind speed in predicting mean track bearing. The nature of this interaction is shown schematically in Figure 17. This result is extremely difficult to interpret, and is further confused by the fact that the correlation between track direction and wind direction is only 0.093 and between track and wind speed only 0.291. It should be remembered however, that this interaction, though statistically significant ($p < 0.01$) accounted for only 8% of the variance among mean bearings. For this reason I did not feel that this result was a very powerful one, although wind orientation has been suggested previously

Figure 16.

SAMPLE OF WEANERS RELEASED WHEN THE SUN WAS OBSCURED BY A THICK CLOUD COVER. These tracks are as well oriented as those made under sunny skies.

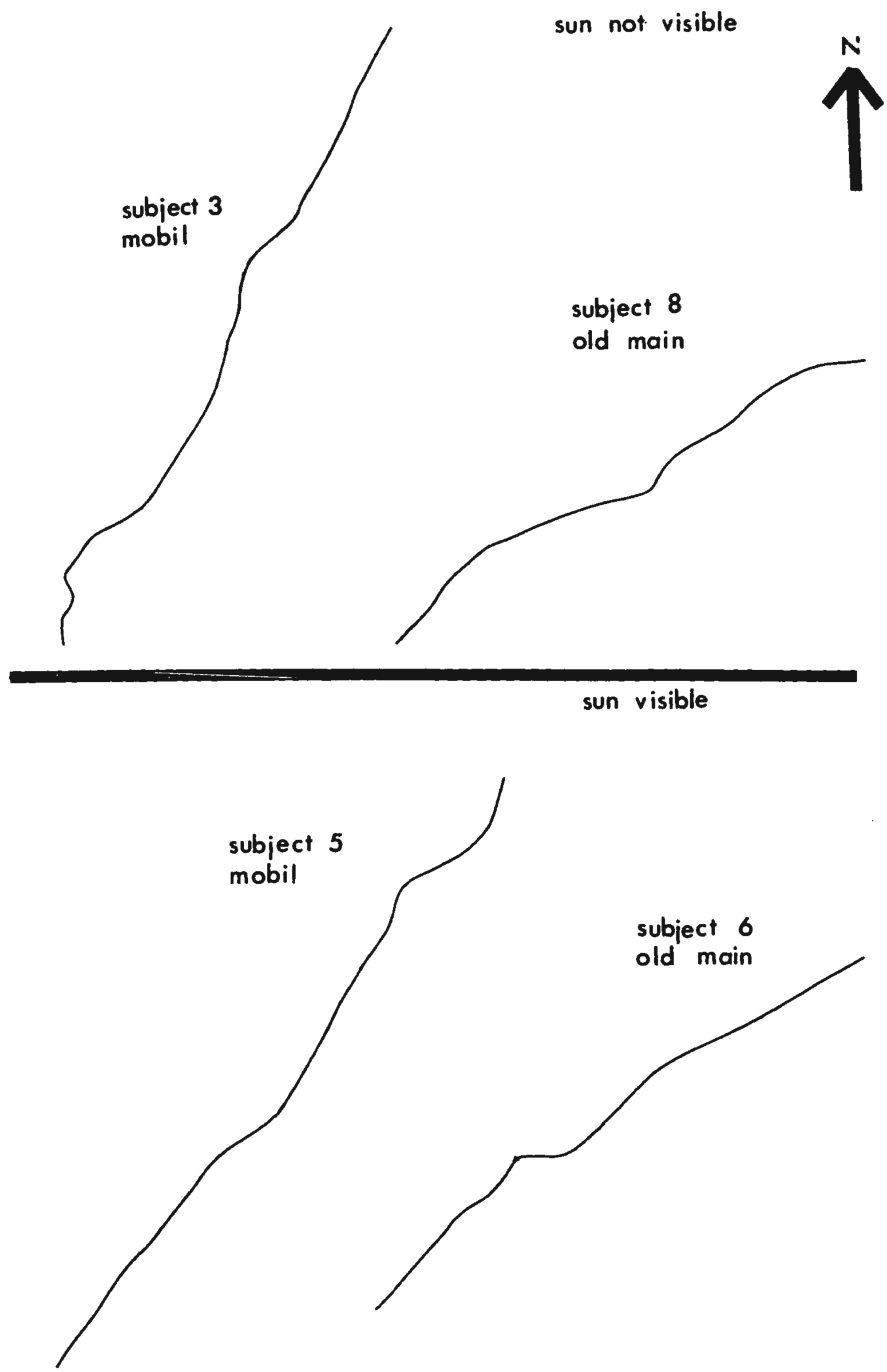
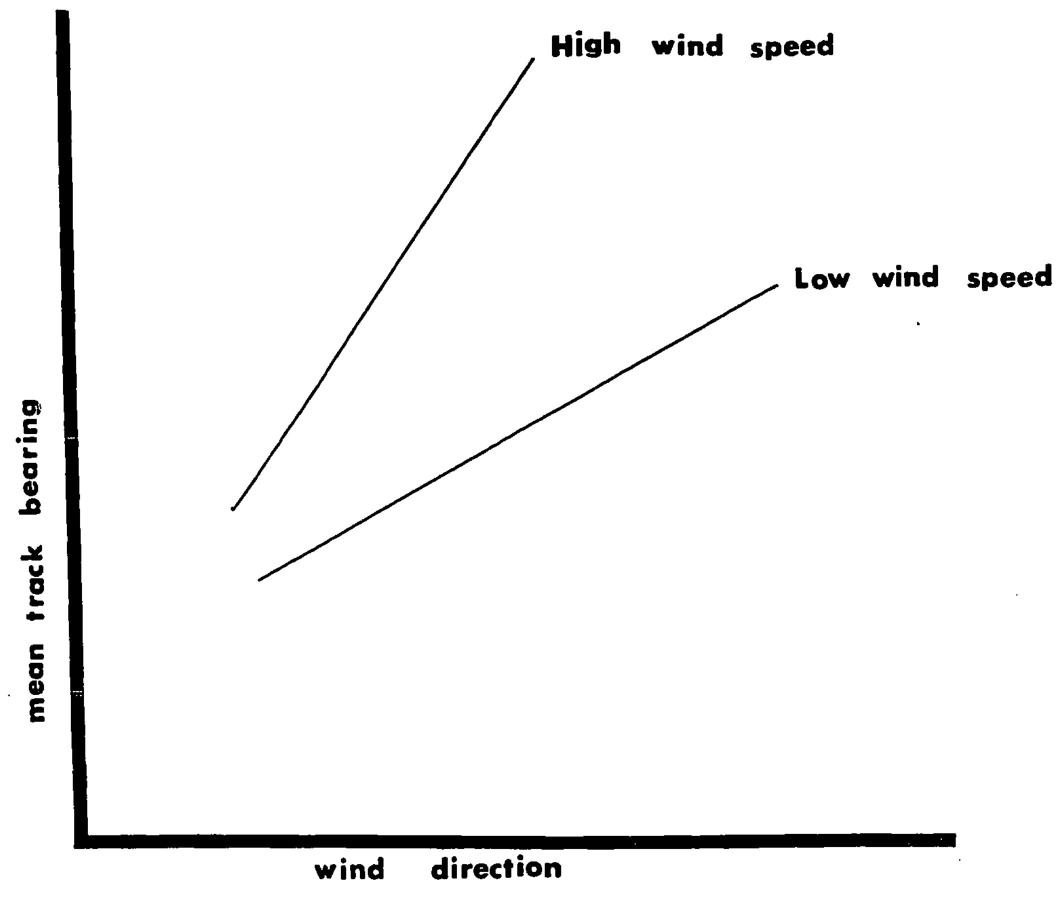

sun not visible
N
subject 3
mobil
subject 8
old main
sun visible
subject 5
mobil
subject 6
old main

Figure 17.

SCHEMATIC REPRESENTATION OF THE INTERACTION BETWEEN WIND DIRECTION AND WIND SPEED IN PREDICTING MEAN COURSE BEARINGS OF THE RELOCATED WEANERS. This interaction accounted for only 8% of the variance among average track bearings in a regression analysis.


High wind speed
Low wind speed
mean track bearing
wind direction

for young harp seals (Sergeant, 1970). Reinforcing my belief that wind was at least not necessary for the orientation of the relocated pups is the fact that three of subject 14's releases were made when there was no wind at all. Figure 18 shows this seal's five releases, and it can be seen from the figure that this animal did not appear to be disoriented.

The Role of Auditory Cues

It is possible that surf sound was serving as an orienting cue for the relocated weaners, though the statistical analysis does not clearly demonstrate this. The inter-track correlations between mean track and mean surf bearings are shown in Table VIII. Though the correlations between mean track and high continuous, high intermittent and low continuous surf bearings are significant, they are low and account respectively for only 8%, 29% and 11% of the variance.

Since horizontal visibility accounted for a significant amount of variance among track bearings, the data were partitioned according to whether visibility at the time of release were greater than 250 yards, or less than or equal to 250 yards. The inter-track correlations are shown in Table IX. When visibility was less than or equal to 250 yards, there was a significant ($p \leq 0.01$) positive correlation between track bearing and high

Figure 18.

POST-RELEASE TRACKS OF SUBJECT 14. Three of these four tracks were made when there was no wind at all.

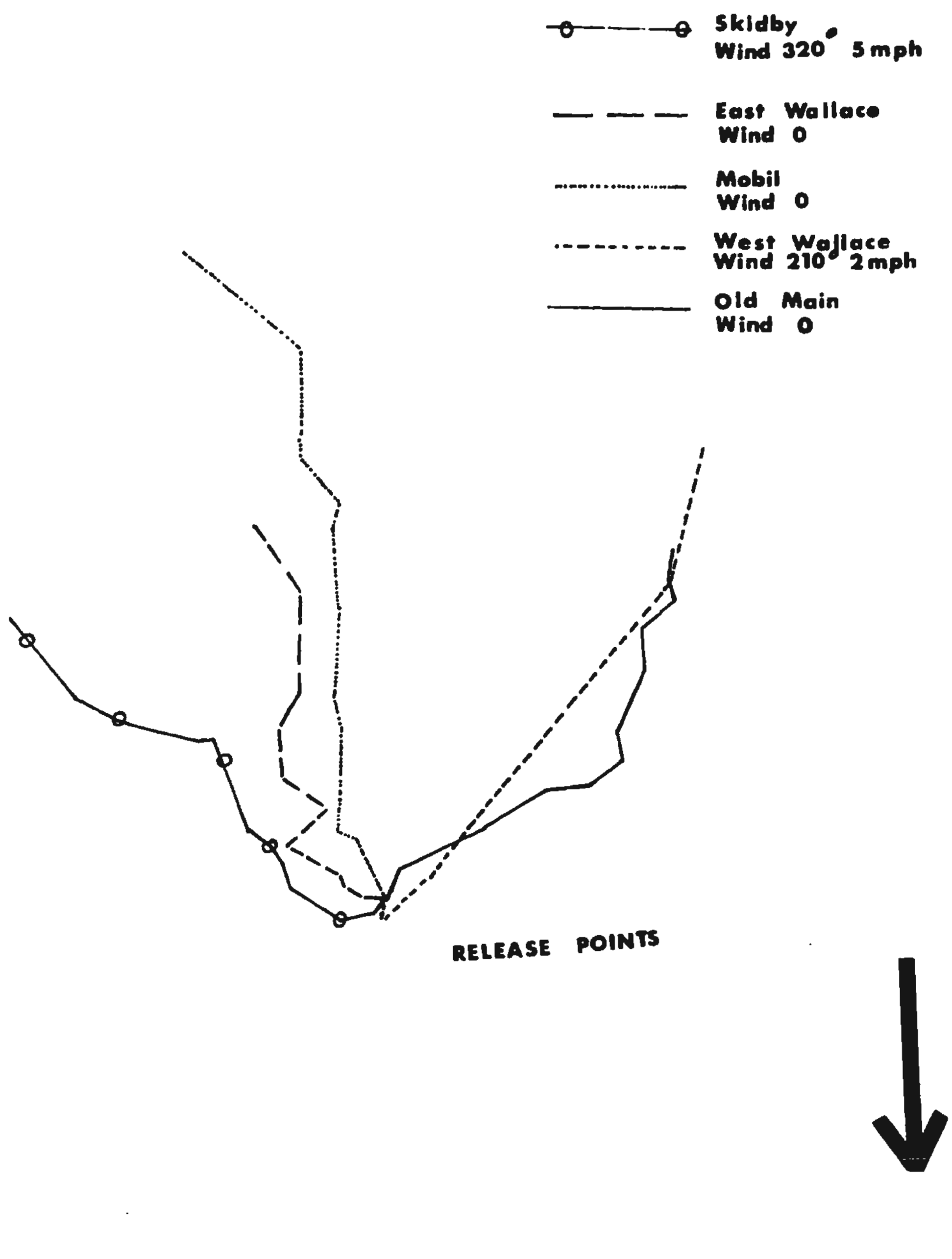

Skidby
Wind 320° 5 mph
East Wallace
Wind 0
Mobil
Wind 0
West Wallace
Wind 210° 2 mph
Old Main
Wind 0
RELEASE POINTS

Table VIII

Pearson Product Moment Correlation Coefficients (r) Between $\bar{X}$ Track Bearings and $\bar{X}$ Surf Bearings For Relocated Weaners

$\bar{X}$ TRACK	
N = 50 r = .2852* $p < .05$	High Continuous
N = 22 r = .5360* $p < .02$	High Intermittent
N = 55 r = .3297* $p < .02$	Low Continuous
N = 17 r = .4091	Low Intermittent

Table IX

Pearson Product Moment Correlation Coefficients (r) Between $\bar{X}$ Track Bearings And $\bar{X}$ Surf Bearings For Relocated Weaners, According To Whether Visibility Was Less Than Or Equal To 250 Yards, or Greater Than 250 Yards.

	High Continuous	High Intermittent	Low Continuous	Low Intermittent
Visibility < 250 Yds.	N = 8 r = -.9002* p < 0.01	N = 6 r = .9316* p $\leq$ 0.01	N = 12 r = -.0993	N = 3 r = .2779
Visibility > 250 Yds.	N = 42 r = .4147* p $\leq$ 0.01	N = 16 r = .5033* p $\leq$ 0.05	N = 43 r = .2562	N = 14 r = .6854* p $\leq$ = 0.01

continuous surf, and a significant ($p \leq 0.01$) positive correlation between track and high intermittent surf. However, the number of cases in the former was only 8, and only 6 in the latter, so these correlations, though high, are not necessarily persuasive. When visibility was greater than 250 yards, track bearing was significantly correlated with high continuous surf (N=42 : r=.4147 : $p \leq 0.01$), low intermittent surf (N=14 : 4=.6854 : $p \leq 0.01$), and high intermittent surf (N=16 : r=.5033 : $p \leq .05$). Though the number of subjects is greater in these significant correlations than it was in those instances when visibility was less than or equal to 250 yards, the correlations are still not convincingly large.

Whatever the case, it appears as if visibility were not having a consistent effect on the relationship between track and surf bearings. Perhaps this is not surprising when one considers that visibility accounted for only 14% of the variance among track bearings in the regression analysis, even though this had proven to be a statistically significant effect.

High correlations among means would not necessarily reflect the use of surf sounds as an orienting cue if the animals were only maintaining a bearing with the sound, having preselected it by some independent means. As explained previously, significantly high intra-track correlations with surf suggest at least the maintenance of a course bearing by way of surf sound. These correlations are shown in Table X. The orientation of eight of the sixteen is significantly correlated with some component of the surf sound, and as in the case of the means analysis, partitioning according to visibility does not have any consistent effect. Furthermore, as the Table indicates, those correlations that are statistically significant are not convincingly large. It is therefore difficult to conclude from either the inter- or intra-track analyses that the weaners were somehow orienting themselves in relation to the surf sound.

However, the most convincing evidence that the young harbour seals may have been responding to surf noise when they were released can be seen in the nonstatistical analysis of the Skidby tracks (Figures 19 through 34). Map 5 illustrating the topography of the Skidby drop shows that at the southeast corner of the central dune ridge, due South of dune E, there is a thirty foot rise which drops abruptly into a twenty foot deep gully. On most occasions the surf from the south shore could be heard clearly in the Skidby blowout, and very often the sound seemed to be coming directly over this rise. (In addition to this sound, there was occasionally another from the south shore, and one or more sounds coming from the north coast). In the case of subjects 1, 2, 7, 14 and 16, the sound of the south shore surf could be clearly heard in the direction of the hill described above. These five seals moved straight

Table X

Intra-Track Correlations With Surf (Pearson Produce Moment r) For Each Of The Sixteen Relocated Weaners, According To Whether Visibility Was Greater Than 250 Yards Or Less Than Or Equal To 250 Yards.

Subject	High Continuous	Low Continuous	High Intermittent	Low Intermittent	Subject	High Continuous	Low Continuous	High Intermittent	Low Intermittent
1	r = .648 N = 9	r = .097 N = 21	r = .203 N = 25	r = .084 N = 7	1		r = .317 N = 25	r = .021 N = 25	
2	r = .550* N = 34 p< .001		r = .673* N = 34 p< .001		2				
3					3	r = .357* N = 56 p< .007	r = .301* N = 56 p< .02		
4		r = -.534 N = 22 p< .01	r = -.356 N = 22		4				
5	r = .377 N = 9	r = .423* N = 32 p< .02	r = .026 N = 12		5				
6	r = .486* N = 32 p< .005	r = .437 N = 32 p < .01			6				
7	r = .158 N = 40	r = -.202 N = 39			7				
8	r = .064 N = 43	r = -.026 N = 43			8				
9	r = .593* N = 19 p < .007	r = -.314 N = 19			9	r = .675 N = 5	r = .007 N = 5		

Subject	High Continuous	Low Continuous	High Intermittent	Low Intermittent
10	r = -.268 N = 4	r = .135 N = 6	r = -.100 N = 2	
11	r = -.095 N = 19 p < .05	r = .421* N = 25	r = .187 N = 8	r = -.095 N = 19
12	r = .444 N = 15	r = .162 N = 25	r = .303 N = 15	r = -.782 N = 4
13	r = -.066 N = 49	r = .121 N = 4	r = -.120 N = 4	r = .332 N = 10
14	r = .521* N = 30 p < .01	r = -.603* N = 34 p< .001	r = -.626 N = 7	
15	r = .523* N = 22 p < .02	r = -.505 N = 5		r = -.335 N = 13
16	r = .400 N = 4	r = -.005 N = 10	r = -.090 N = 7	

Visibility $\geq$ 250 Yards

Subject	High Continuous	Low Continuous	High Intermittent	Low Intermittent
10	r = .268 N = 17	r = .139 N = 9	r = .118 N = 6	r = -.086 N = 11
11				
12				
13				
14				
15				
16		r = .019 N = 30	r = .231 N = 30	

Visibility $\leq$ 250 Yards

Figure 19.

SKIDBY RELEASE. Subject 1.

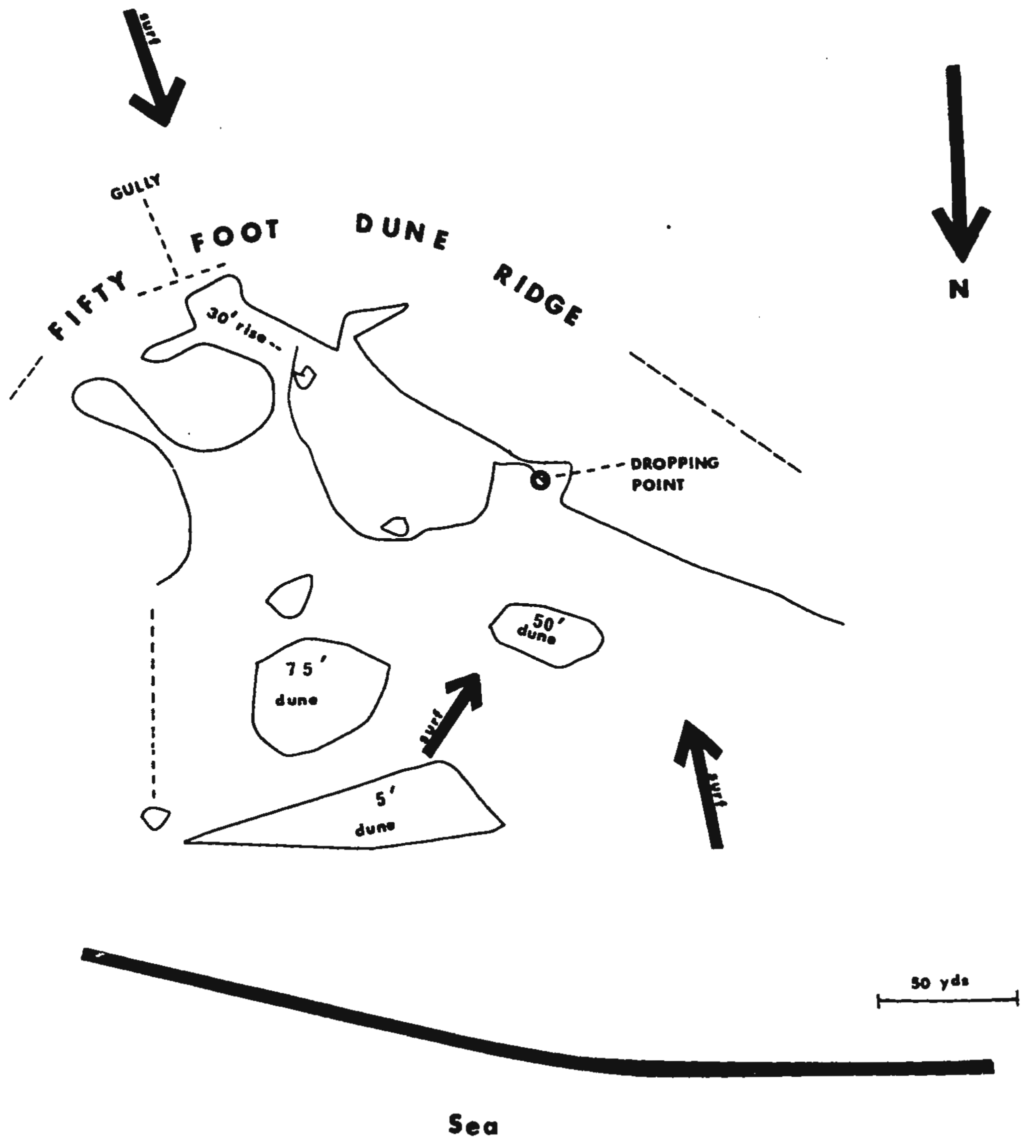
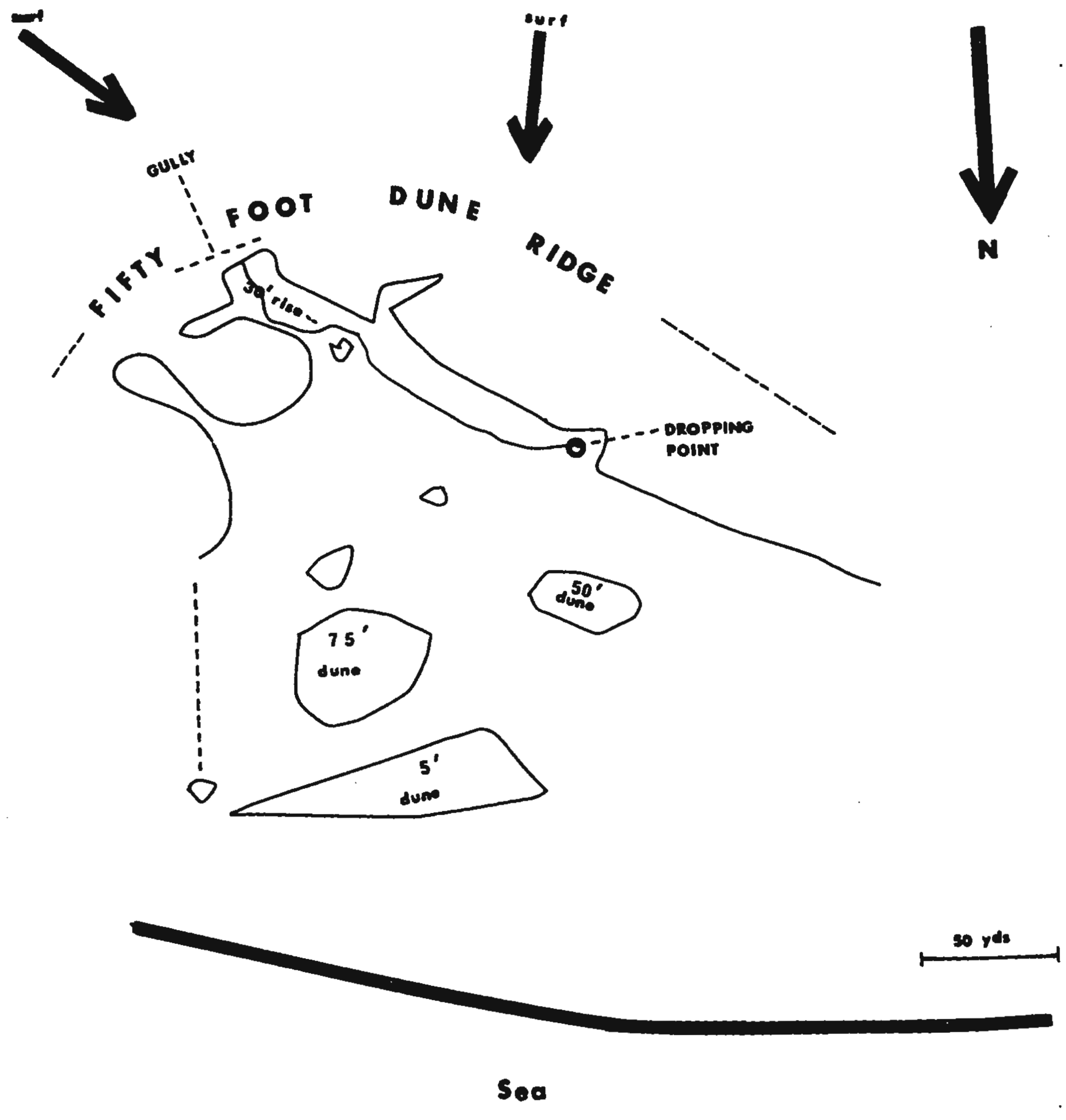

surf
GULLY
FIFTY FOOT DUNE RIDGE
30' rise
DROPPING POINT
N
50' dune
75' dune
surf
5' dune
surf
50 yds
Sea

Figure 20.

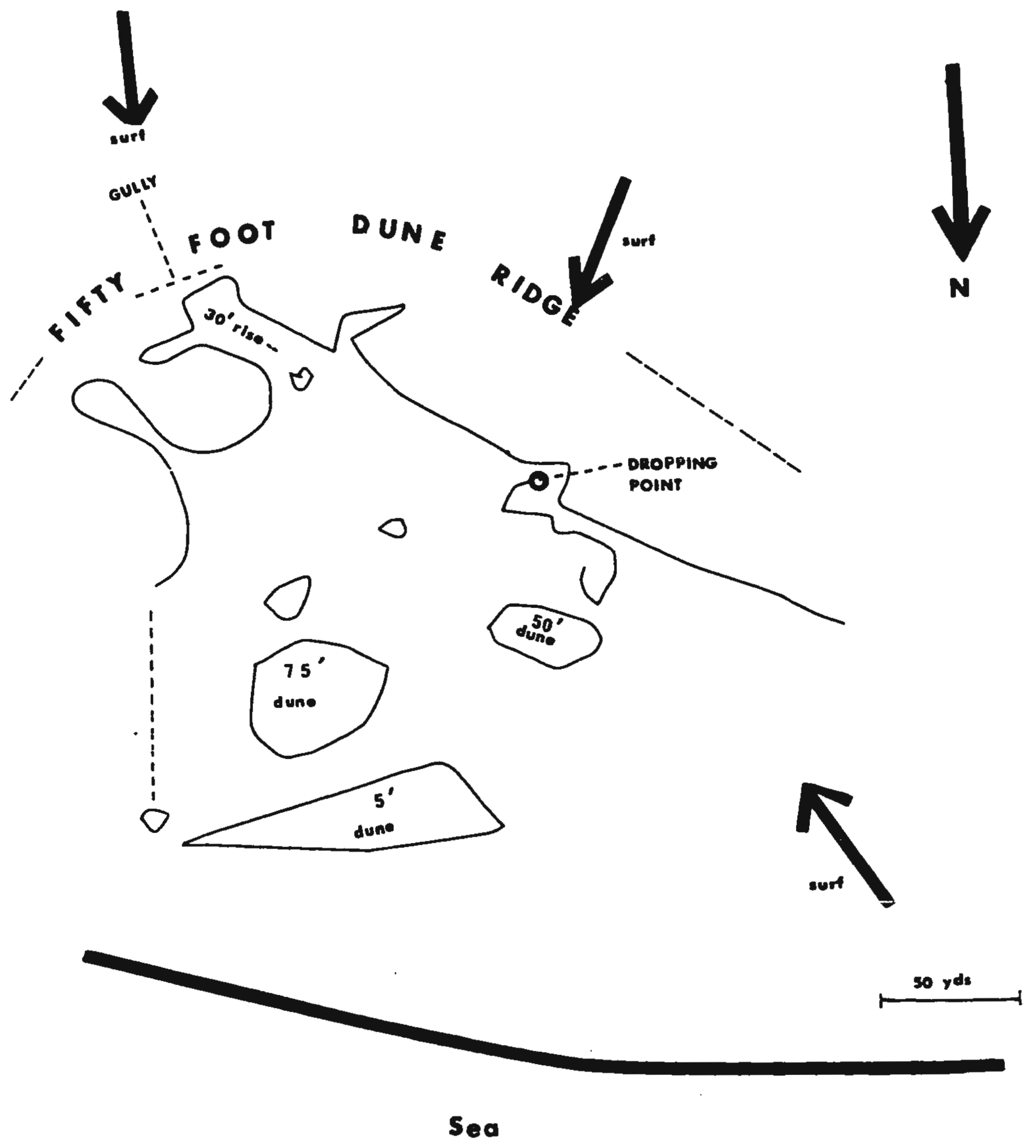
SKIDBY RELEASE. Subject 2.



surf
surf
N
GULLY
FIFTY FOOT DUNE RIDGE
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
50 yds
Sea

Figure 21.

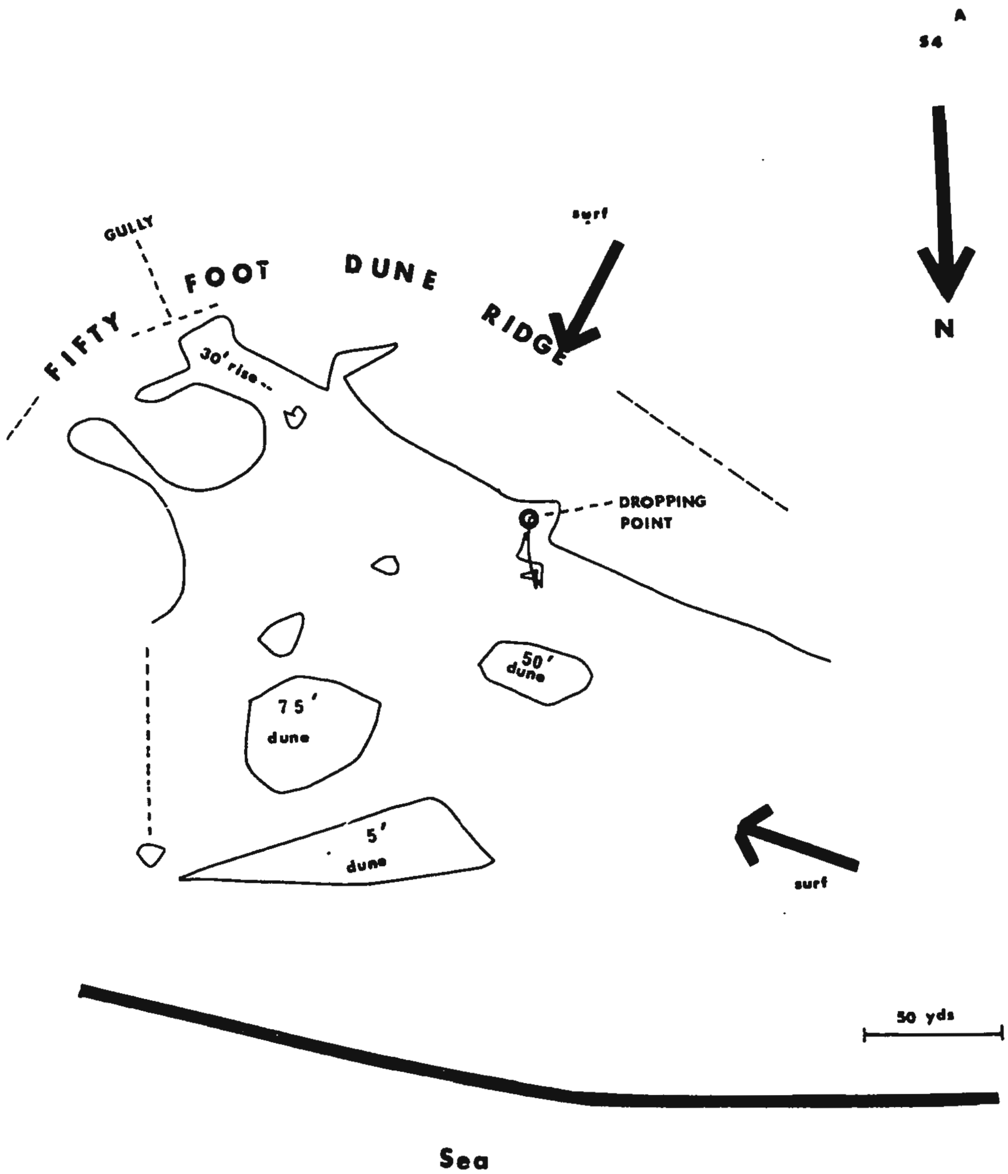
SKIDBY RELEASE. Subject 3.



surf
GULLY
FIFTY FOOT DUNE RIDGE
surf
N
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
surf
50 yds
Sea

Figure 22.

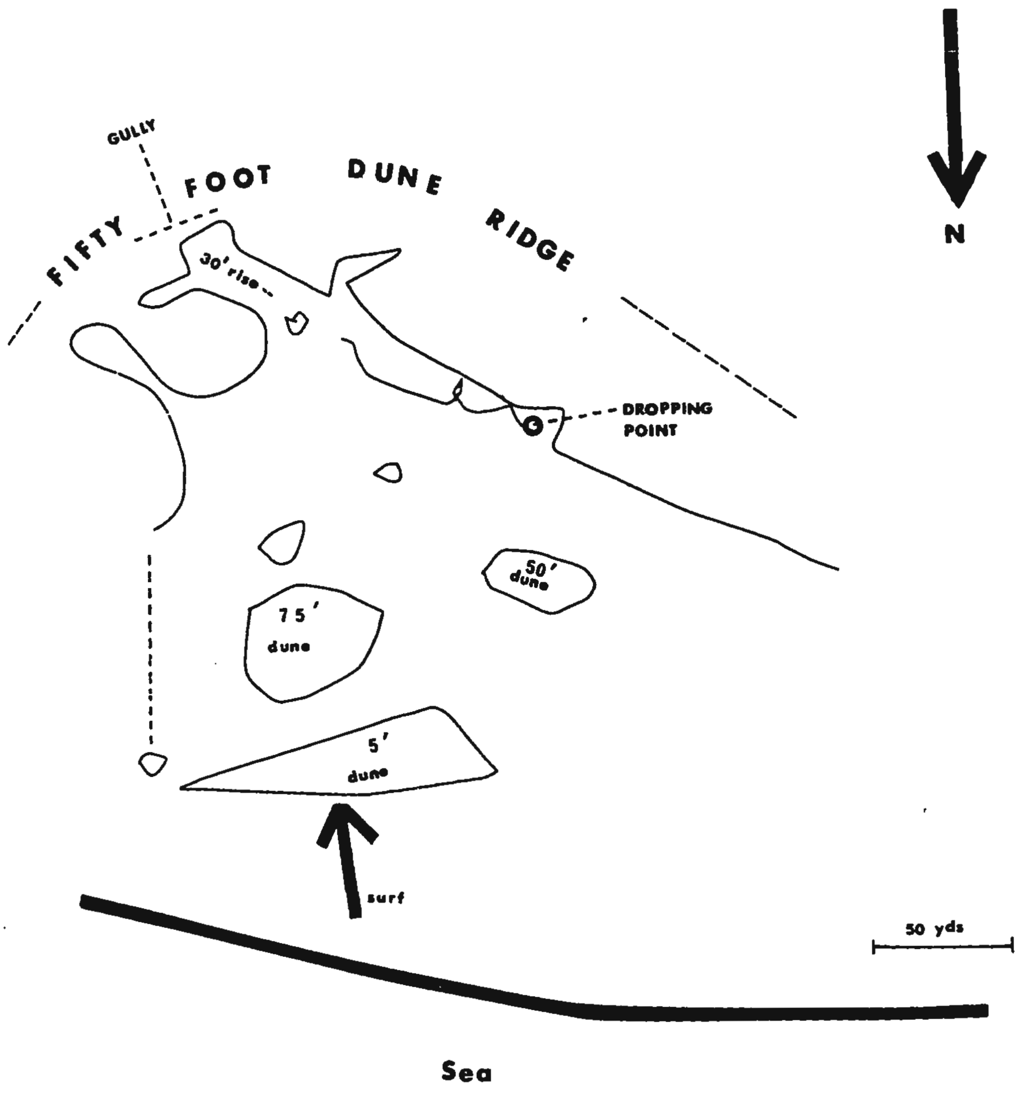
SKIDBY RELEASE. Subject 4.



S4
A
GULLY
FIFTY FOOT DUNE RIDGE
surf
N
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
surf
50 yds
Sea

Figure 23.

SKIDBY RELEASE. Subject 5.



GULLY
FIFTY FOOT DUNE RIDGE
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
surf
N
50 yds
Sea

Figure 24.

SKIDBY RELEASE. Subject 6.

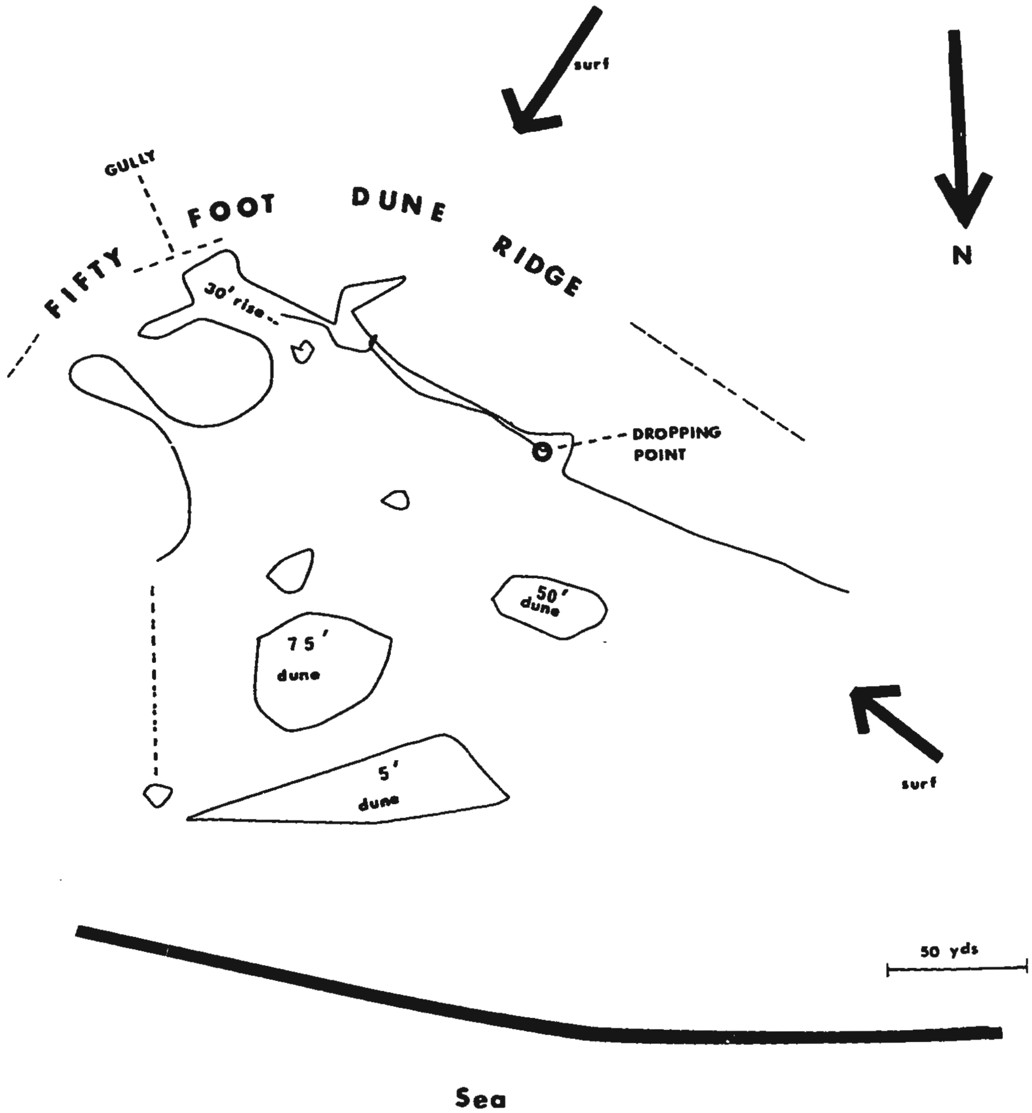
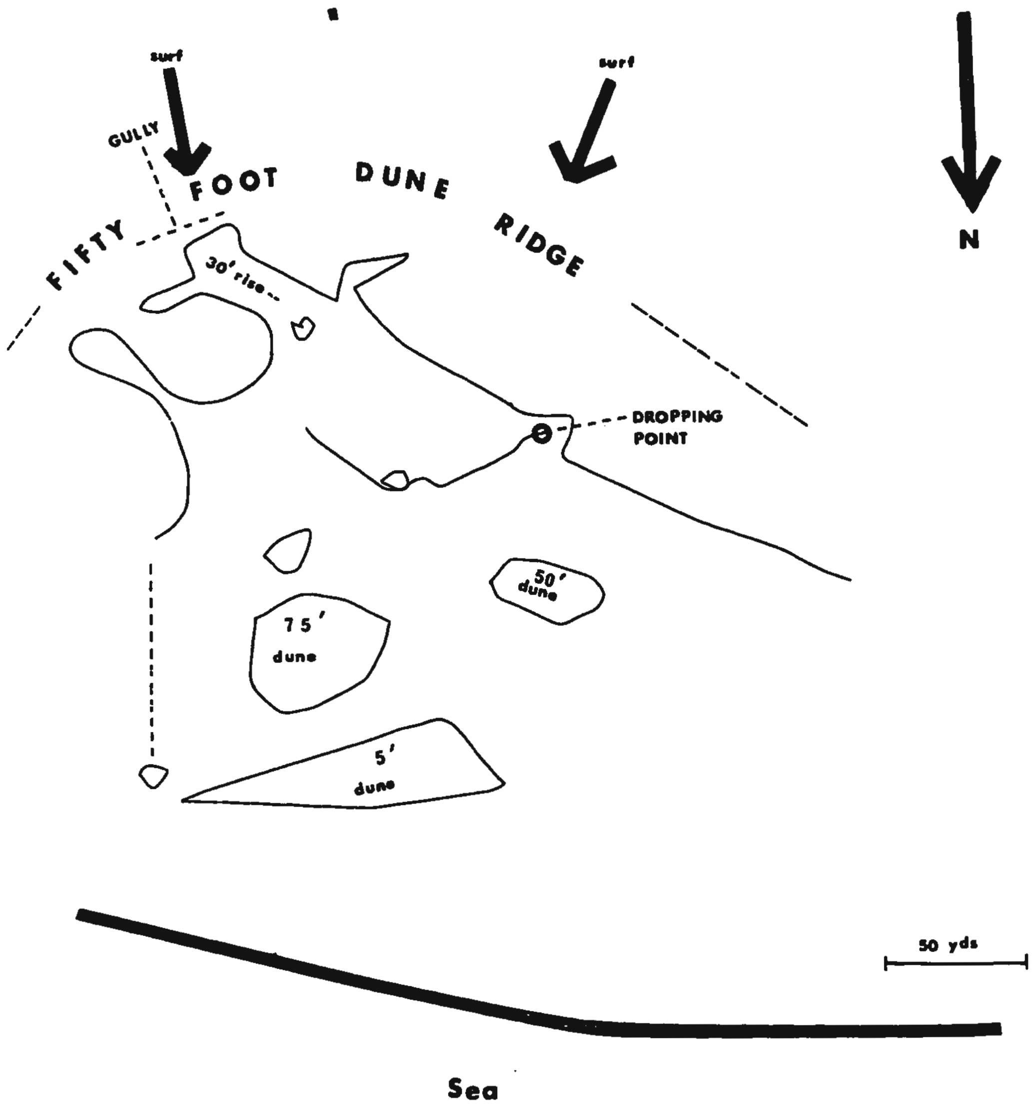

surf
GULLY
FIFTY FOOT DUNE RIDGE
N
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
surf
50 yds
Sea

Figure 25.

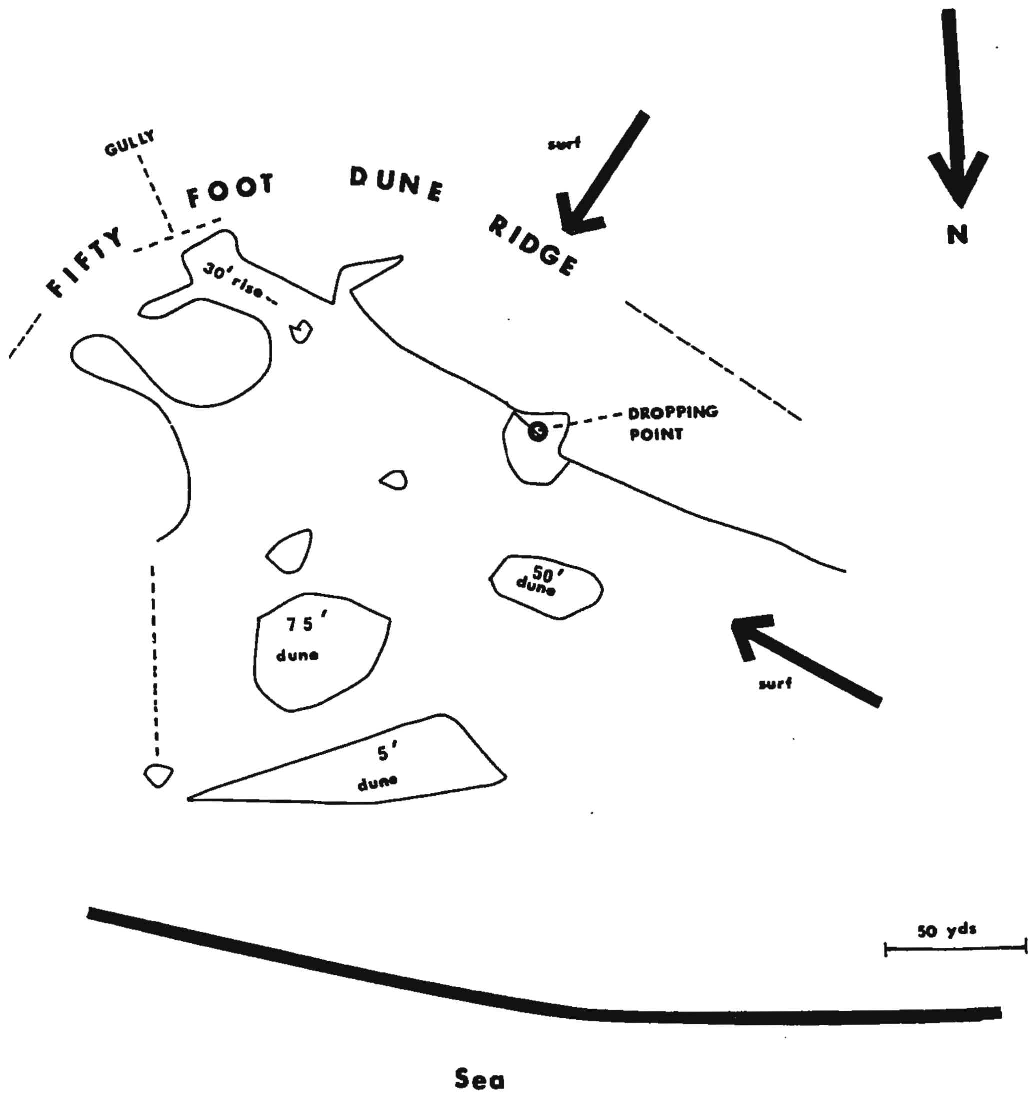
SKIDBY RELEASE. Subject 7.



surf
surf
GULLY
FIFTY FOOT DUNE RIDGE
N
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
50 yds
Sea

Figure 26.

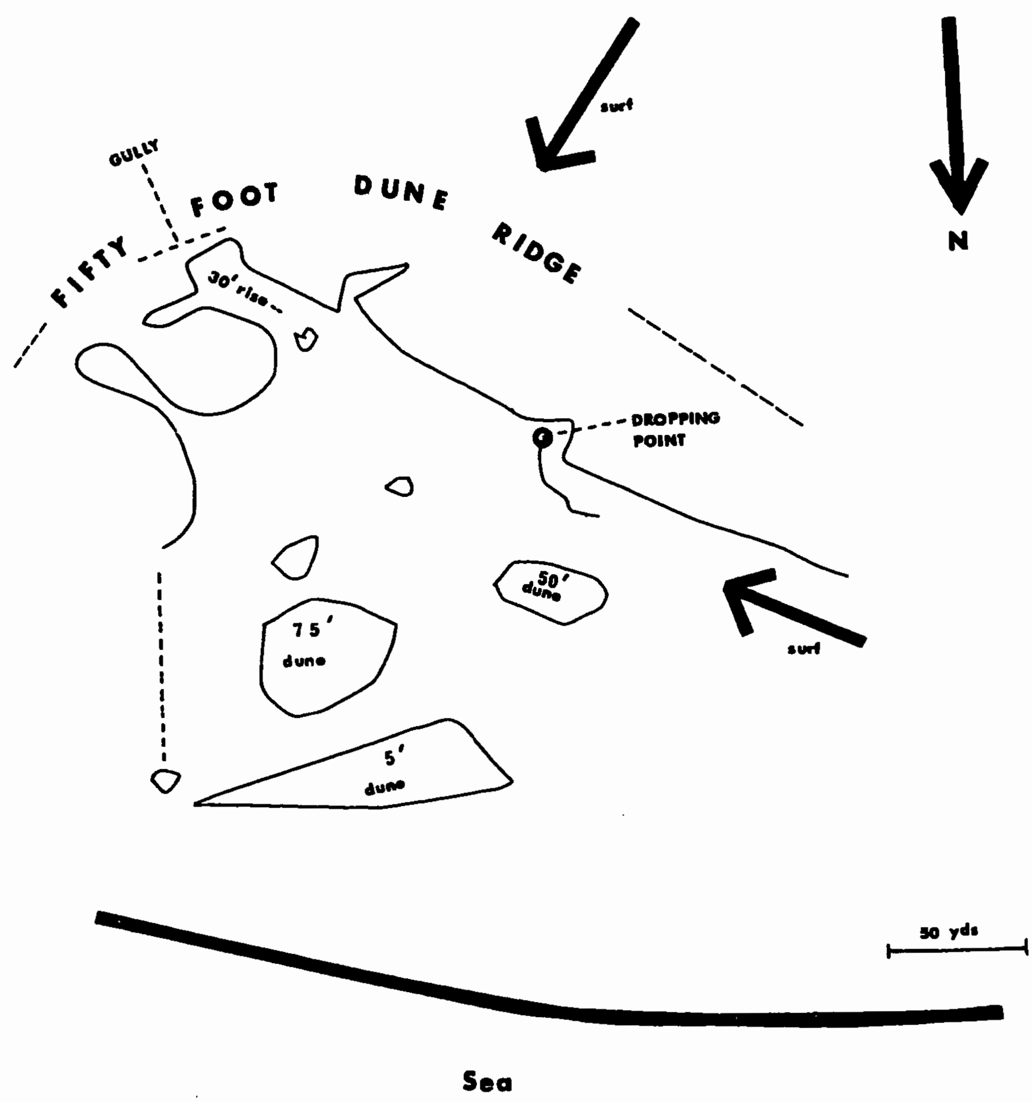
SKIDBY RELEASE. Subject 8.



GULLY
FIFTY FOOT DUNE RIDGE
surf
N
30' rise
DROPPING POINT
50' dune
75' dune
surf
5' dune
50 yds
Sea

Figure 27.

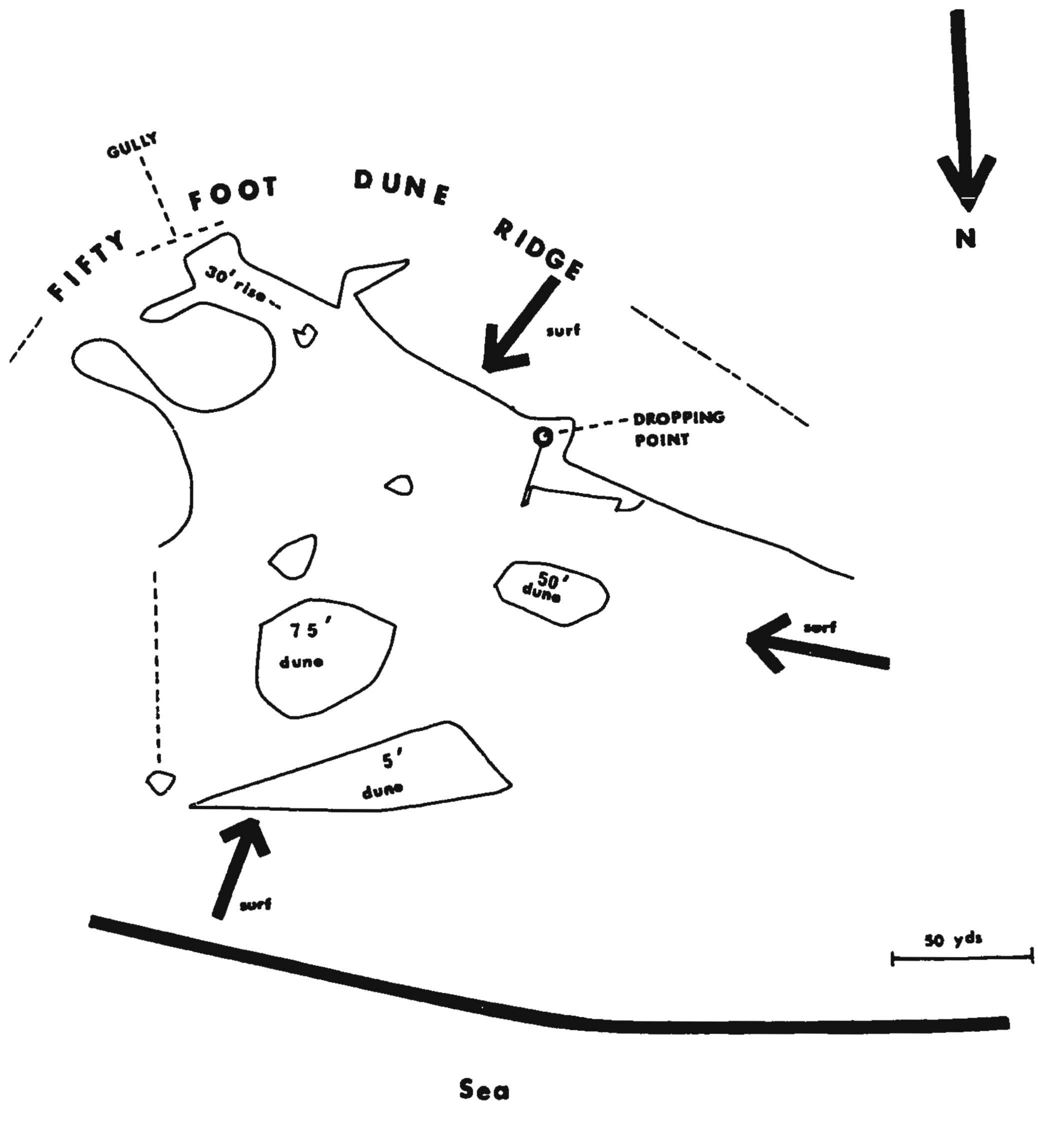
SKIDBY RELEASE. Subject 9.



surf
GULLY
FIFTY FOOT DUNE RIDGE
N
30' rise
DROPPING POINT
50' dune
surf
75' dune
5' dune
50 yds
Sea

Figure 28.

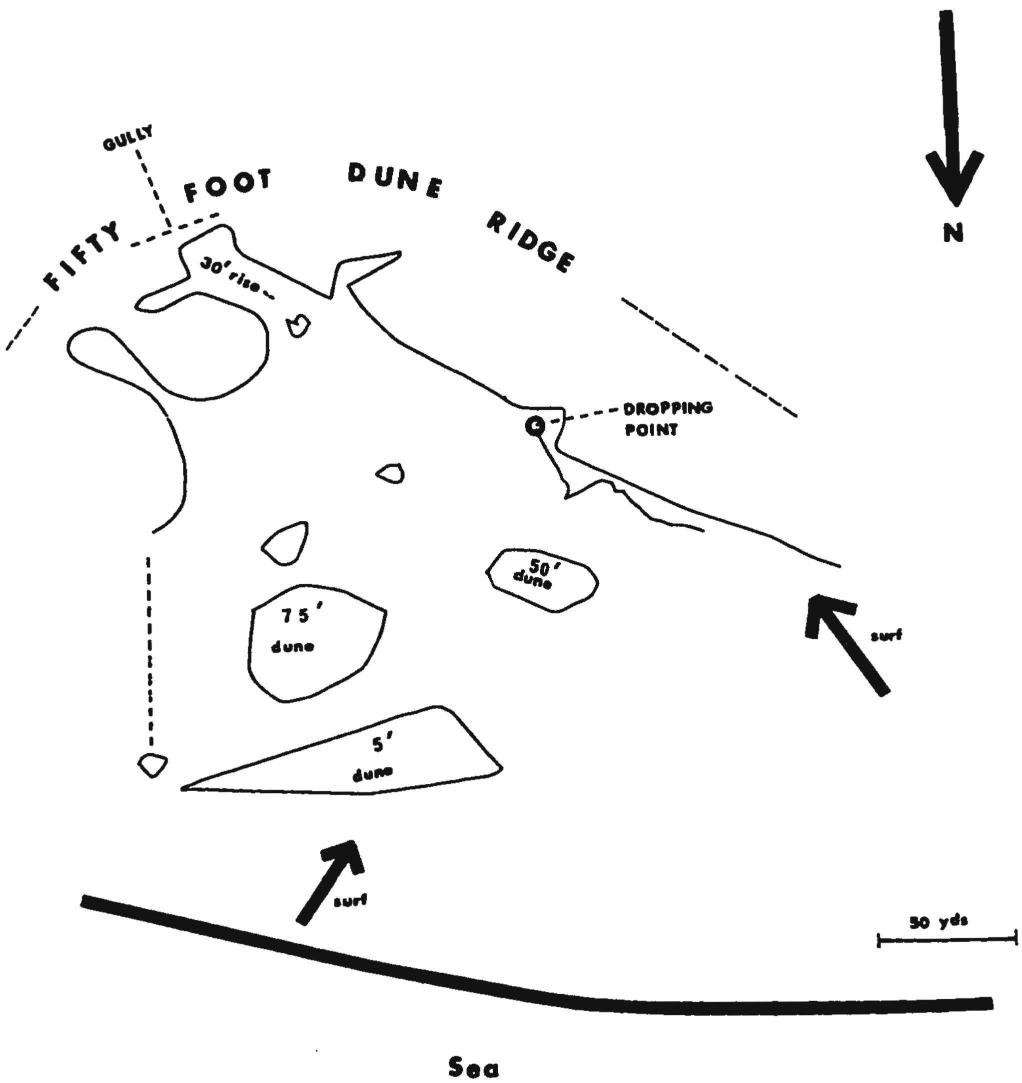
SKIDBY RELEASE. Subject 10.



N
GULLY
FIFTY FOOT DUNE RIDGE
30' rise
surf
DROPPING POINT
50' dune
75' dune
surf
5' dune
surf
50 yds
Sea

Figure 29.

SKIDBY RELEASE. Subject 11.



GULLY
FIFTY FOOT DUNE RIDGE
30' rise
DROPPING POINT
50' dune
75' dune
5' dune
surf
surf
N
50 yds
Sea

Figure 30.

SKIDBY RELEASE. Subject 12.

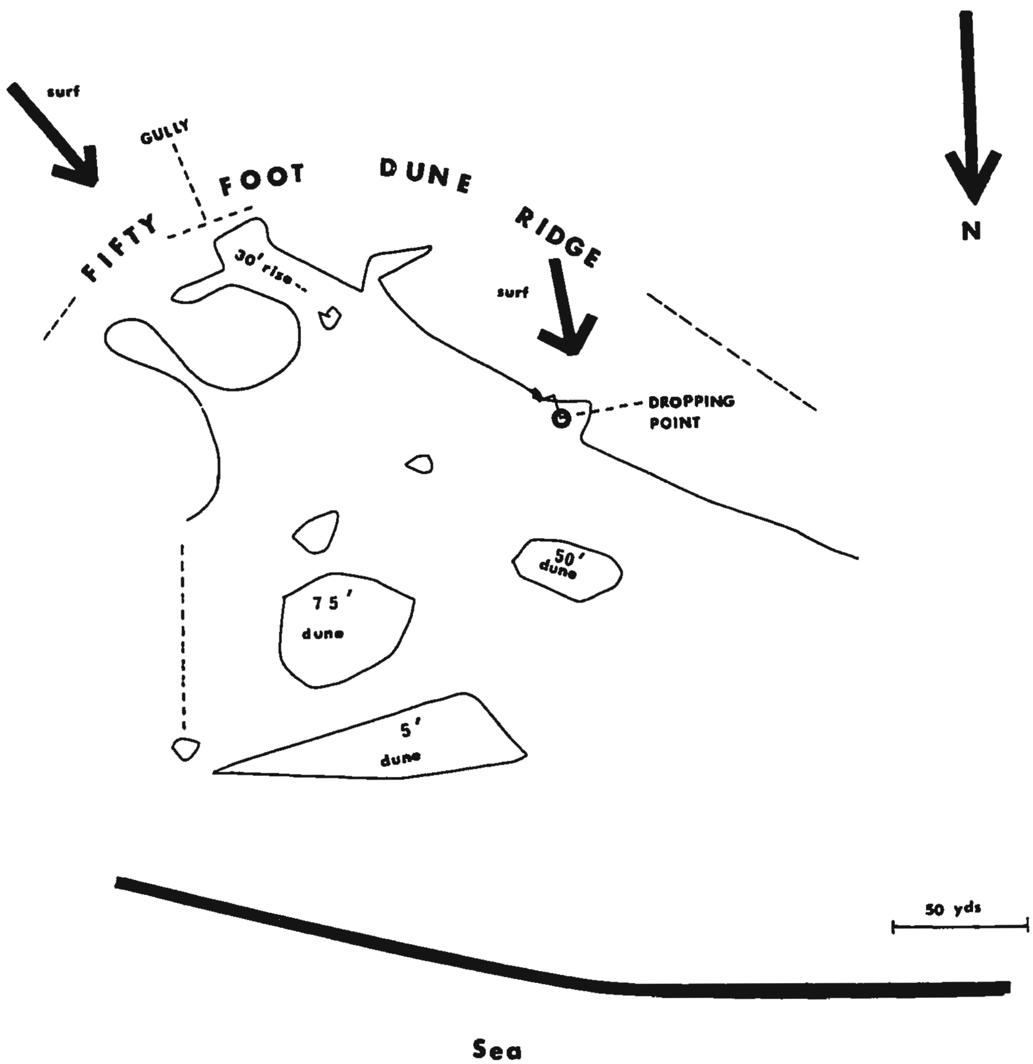

surf
GULLY
FIFTY FOOT DUNE RIDGE
30' rise
surf
DROPPING POINT
N
50' dune
75' dune
5' dune
50 yds
Sea

Figure 31.

SKIDBY RELEASE. Subject 13.

A S13

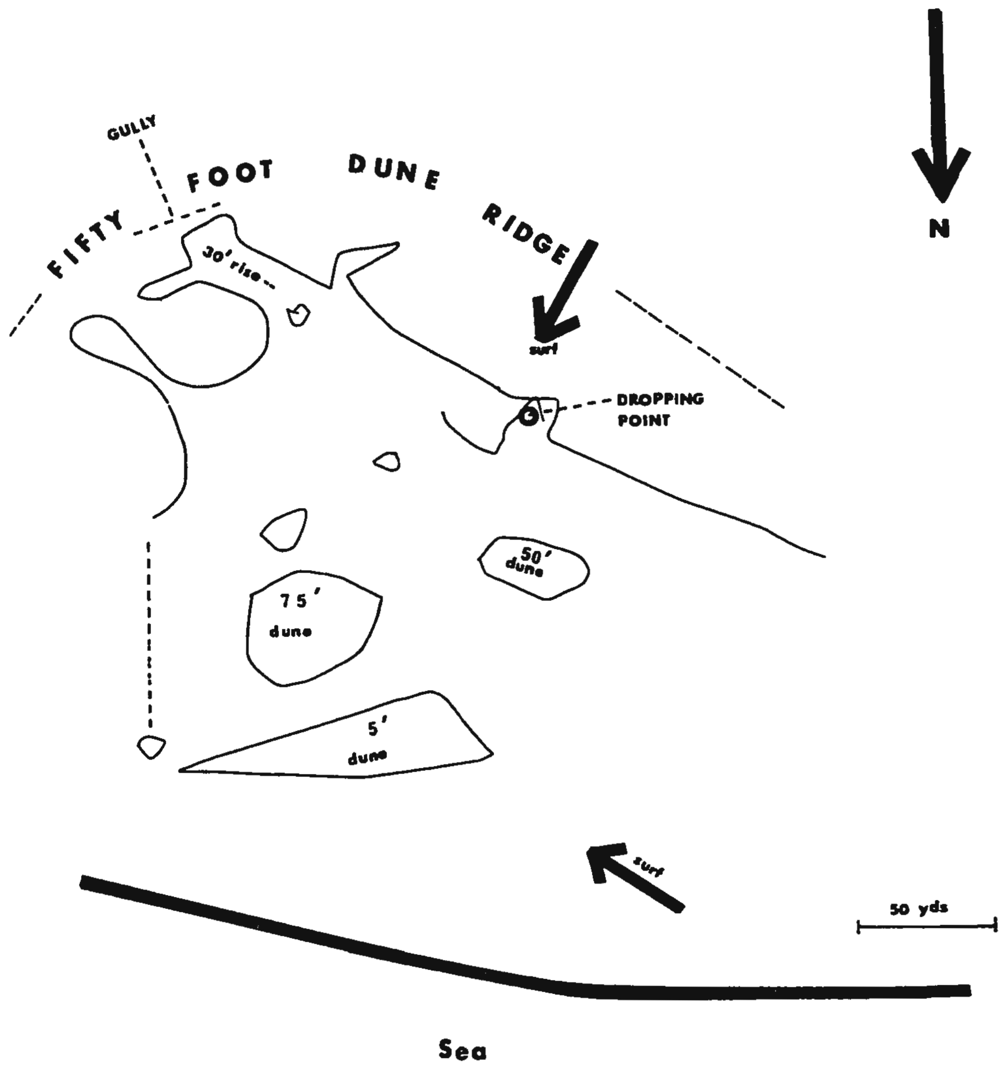
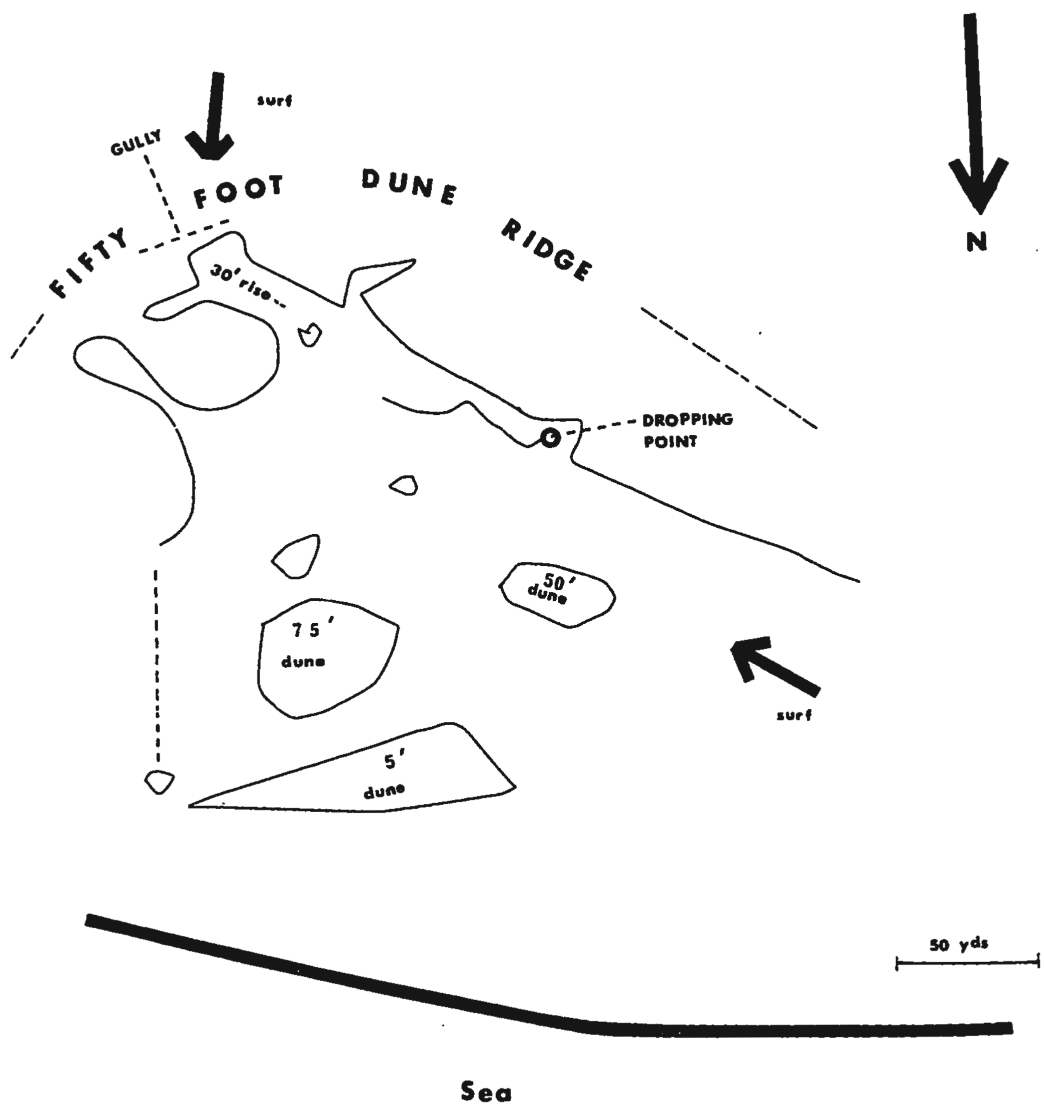

N
GULLY
FIFTY FOOT DUNE RIDGE
30' rise
surf
DROPPING POINT
50' dune
75' dune
5' dune
surf
50 yds
Sea

Figure 32.

SKIDBY RELEASE. Subject 14.



surf
GULLY
FIFTY FOOT DUNE RIDGE
N
30' rise
DROPPING POINT
50' dune
75' dune
surf
5' dune
50 yds
Sea

Figure 33.

SKIDBY RELEASE. Subject 15.

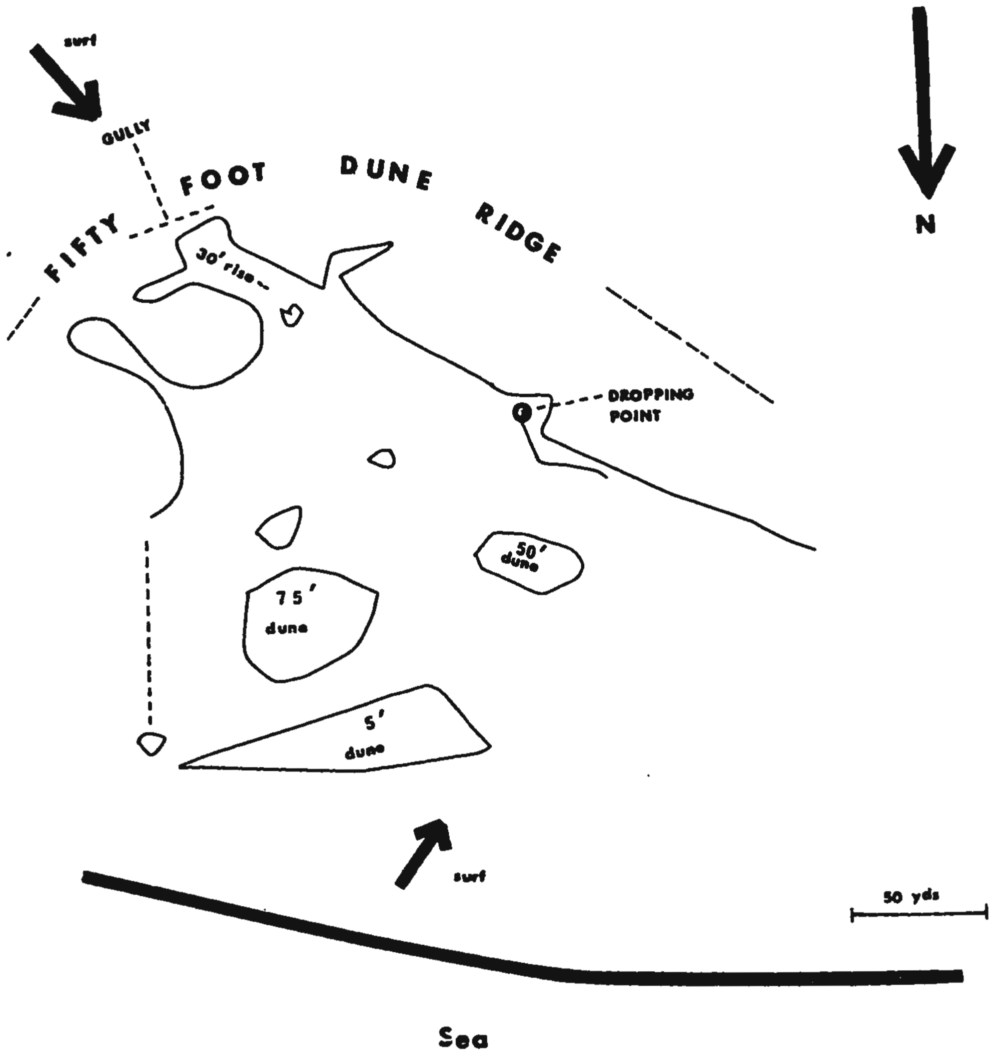
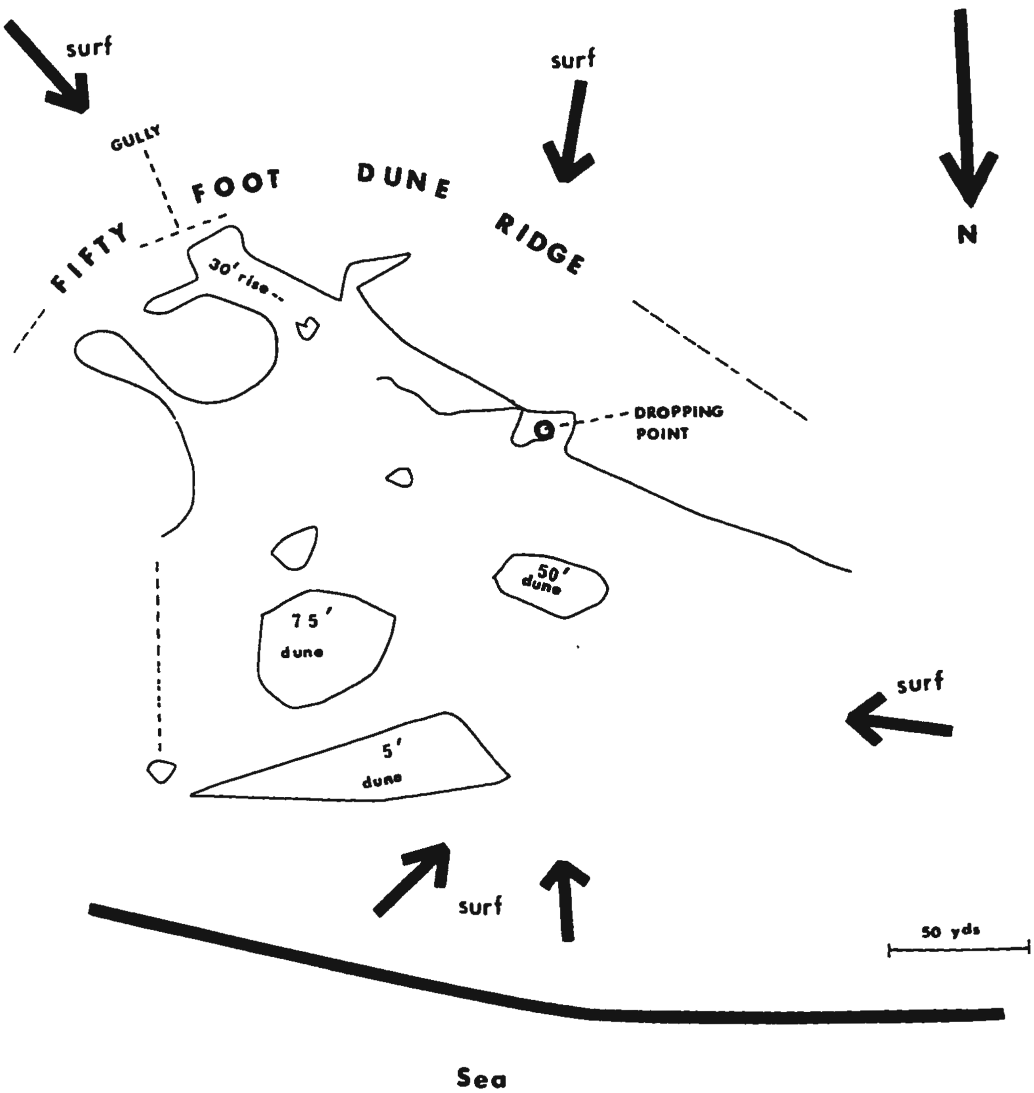

surf
GULLY
FIFTY FOOT DUNE RIDGE
30' rise
N
DROPPING POINT
50' dune
75' dune
5' dune
surf
50 yds
Sea

Figure 34.

SKIDBY RELEASE. Subject 16.


surf
surf
GULLY
FIFTY FOOT DUNE RIDGE
N
30' rise
DROPPING POINT
50' dune
75' dune
surf
5' dune
surf
50 yds
Sea

toward the sound, and Subject 2 actually managed to climb the hill and tumble into the gully behind it. Subject 1 also climbed the hill, but was recaptured just before it reached the top. These tracks are shown in Figures 19, 20, 25, 32 and 34.

When Subject 6 (Figure 24) was released the south shore surf appeared to be coming from a point about half way between the hill and gully described above, and the dropping point. This animal headed in the direction of the hill and tried to climb the thirty foot high dune ridge in the direction of the point where the surf sound was coming from. Subject 12 (Figure 30) almost immediately after being released also started to climb the ridge of central dunes towards the south shore surf sound.

Subjects 3, 4, 8, 9, 10, 11, 13 and 15 all went toward the north coast of the island upon release (Figures 21, 22, 26, 27, 28, 29, 31 and 33). In all these cases surf sound was audible from the north shore. The only seal whose orientation is difficult to relate to surf sound is subject 5 (Figure 23) which headed in the direction of the hill and gully, even though south shore surf was inaudible at the time the animal was tracked.

It should also be mentioned here that very rarely did a seal go toward the north coast at the Mobil dropping point, even though there was unimpeded access to both north and south shores (Map 4). The only time that the north shore surf was audible at this drop was during the release of Subject 11, which was one of the few seals to go toward the north shore. Subjects 3 and 4 similarly went on a northward course at this release site, though surf sound was coming form the South. However, these two seals were northbound on all five releases.

The performance of those weaners tested in the T maze experiment provides a rather tenuous indication that some seals do respond to the sound of the surf. The results of this experiment are presented in the section which follows.

Results and Discussion: Experiment II

The logistic difficulties encountered in running seals in the maze resulted in only 8 complete ten trial sessions. The performance of these eight animals is shown in Table XI with the binomial probability that the number of responses toward or away from the surf was random. If $p \leq 0.05$ is taken as the probability of random error which is tolerable, then it can be asserted that the performances of only Subjects 5 and 7 were affected by the presence of the artificial surf sound. Subject 5 approached the surf noise 8 out of 10 times, and Subject 7 approached it 9 out of 10 times. However, these results are confounded by the fact that subject 5 was the only animal whose behaviour at the Skidby release site appeared to be unaffected by the sound of the surf, (See page 105)

Table XI

Results of the Maze Experiment

Subject	Total Number of Approaches	Total Number of Avoidances	Binomial Probability
3	3	7	.1171
5	8	2	.0439
7	9	1	.0097
8	7	3	.1171
11	6	4	.2050
12	4	6	.2050
14	7	3	.1171
15	3	7	.1171

Learning may have interfered with the seals performance in the maze. It was assumed that the desire to escape largely motivated the seals in this experiment. It is perhaps not unreasonable to expect that if a tendency to approach or avoid surf sound goes unrewarded (that is the animal is not permitted to escape) the animal is bound to make a number of responses which are inconsistent with this tendency, in an effort to find its way out of the maze. For this reason, and since subject 5's behaviour is difficult to explain, the outcome of the T maze experiment should be interpreted cautiously.

Chapter 5

DISCUSSION AND SUMMARY

The migration of harbour seals across the sandy plain presents a number of problems which any comprehensive theory about the nature of the mechanism must explain. Firstly, the seals are able to select an appropriate departure point, adopt a bearing, and maintain that bearing during the journey across the sandy plain.

The impressiveness of such a feat is realized when one considers an animal travelling to Middle Lake Wallace when visibility is reduced. Middle Wallace stretches East to West for about 475 yards, and is about 75 yards wide. It is a minute target in relation to the entire expanse of the sandy plain; in fog I have often had considerable difficulty locating it. Figure 35 shows the track of an animal crossing to this lake when visibility was about 200 yards in fog. The track was appropriately aimed at the lake, and the amount of variance from the average course is small enough to indicate that the animal was not lost in any way. The two indicated changes in direction (see Figure) within about 40 yards of the lakeshore suggest that at least this animal may have been relying on cues of the lake itself only toward the very end of its journey. It appears almost as if the seal was, at point A unaware of the proximity of the lake, and started to head back toward the sea, only to make another about face and head straight into the lake. This suggests that the animal had only just then detected the lake's presence. Whatever the case, cues of the lake itself could not have played any further part in this animal's orientation since any visual information would have been hidden in fog, and olfactory cues obscured since the wind was coming from the West at 11 m.p.h.

For seabound seals, the choice of an appropriate departure point would not be difficult, since a southward course[1] from any point on the southern shores of the lakes would lead to the sea. However, a northward course from any point on the sea coast would certainly not ensure that a seal would reach one of the lakes. Nonetheless, in the case of East Lake Wallace, most seabound <u>and</u> lakebound departures were made in the vicinity of H dune and EFG dunes. This suggests that the seals crossing in the vicinity of H and EFG were using these dunes as landmarks marking an appropriate place to start. If this were the case, one might expect, at least for lakebound seals, that the

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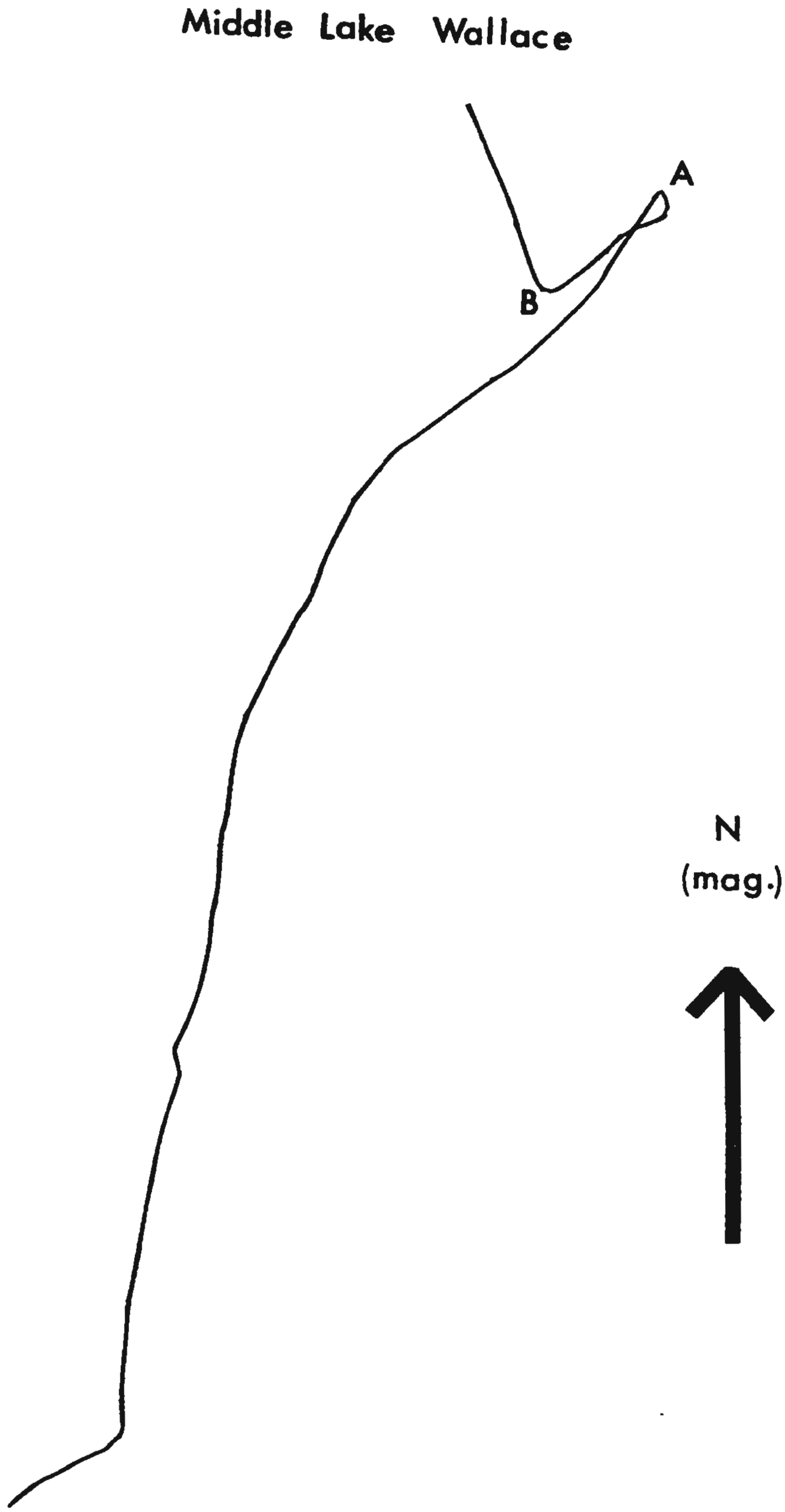
[1]The seals did not in fact take up <u>any</u> southward course, but consistently took up an average bearing approximating the shortest path to the sea.

Figure 35.

ADULT TRAVELLING TO MIDDLE LAKE WALLACE. Visibility was reduced to about 200 yards in fog, and the animal did not appear to be aware of the presence of the lake until the last 40 yards of its journey inland.


Middle Lake Wallace
A
B
N
(mag.)

clustering of tracks in the vicinity of the isolated dunes would break down when fog obscured landmarks. This expectation is not confirmed in the census data.

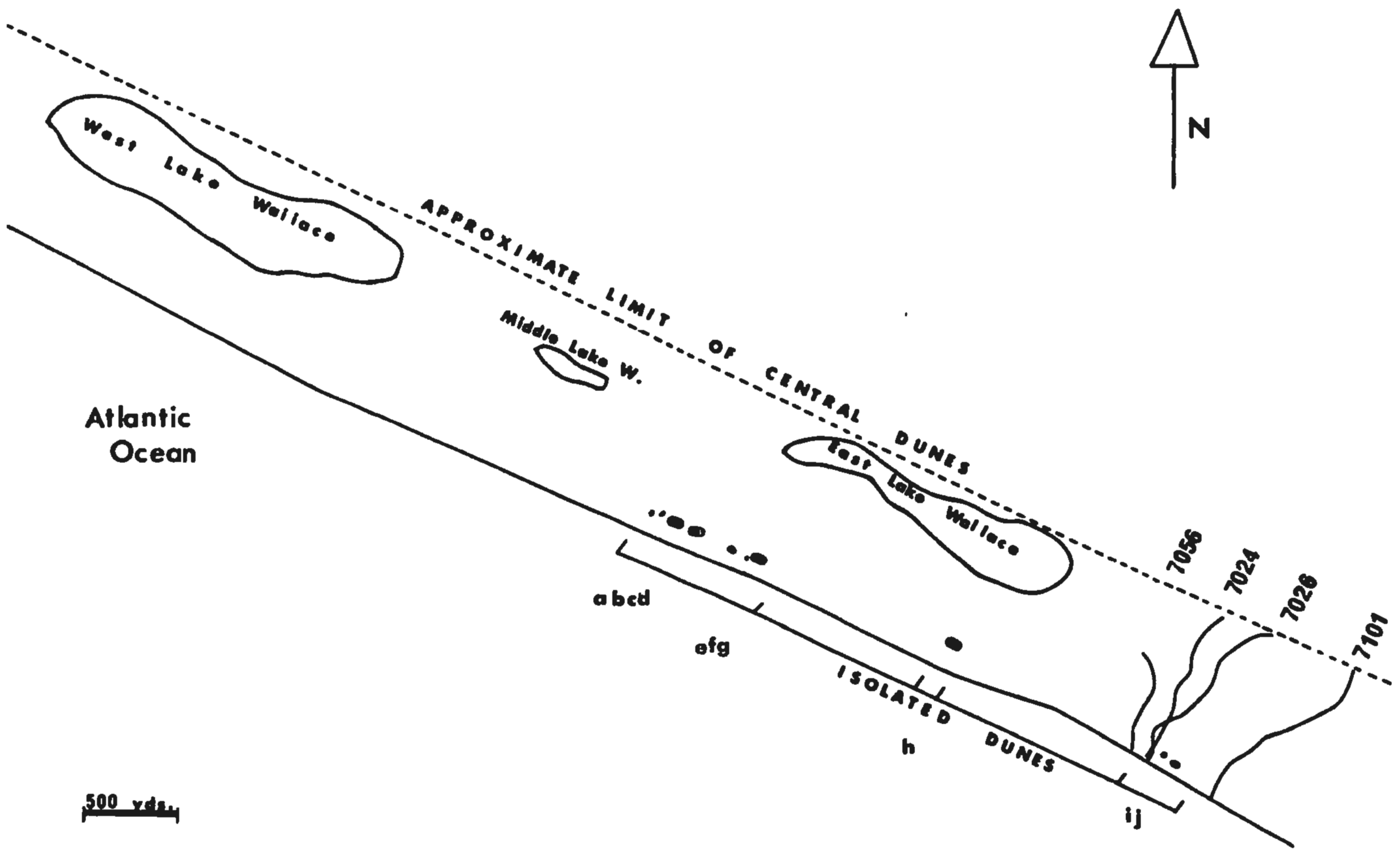
The choice of a suitable departure point can be crucial, as witnessed by the fate of most of the animals which tried to move inland from a point about 1500 yards East of East Lake Wallace. Most of these seals which I observed, missed the lake, and on reaching the central dunes headed back to the point where they had left the coast.

There is no obvious explanation for such tracks. Though their starting place is marked by I&J dunes, it is unlikely that the seals which did not reach the lake mistook I&J dunes for some of the other isolated dunes. Figure 36 shows that if some of the seals had started out in the vicinity of H dune, and others EFG dunes, the courses that in the true case took them to the central dunes, would have taken them to East Lake Wallace. Though this might seem to be a plausible explanation of such tracks found in 1970 when I&J were not very different in appearance from the other isolated dunes, in 1971 I&J had eroded to less than 1/4 of the original size and would have been difficult to mistake for H or EFG.

A 1961 map of Sable Island (Mansfield, 1967) shows that East Lake Wallace once extended eastward as far as I&J dunes. It

Figure 36.

ADULTS CROSSING IN THE VICINITY OF I&J DUNES. If these seals had started out near H dune, inbound legs only or near EFG, they would have reached East Lake Wallace instead of missing the lake and bumping into the central dunes.


N
West Lake Wallace
APPROXIMATE LIMIT OF CENTRAL DUNES
Middle Lake W.
East Lake Wallace
Atlantic Ocean
7056
7024
7026
7101
abcd
efg
h
ISOLATED DUNES
ij
500 yds.

might, then, be suggested that the animals which crossed near this dune were seals which had successfully reached the lake when part of it lay opposite I&J. This is probably not the case, since there were so many attempts made in this area. East Wallace does not extend as far as I&J in a 1966 map of the island, and one would think that the urge to cross so far East of the lake would have been extinguished in the five years between 1966 and 1971. Still, in 1971 more than 100 cases were observed[1], though most of these did not go as far inland as the seals which we had observed and tracked.

By whatever means the seals choose an appropriate place to begin their travèls, this choice is not the most crucial element in what is required to reach the lakes or the sea. Although many seals did not find East Lake Wallace because they had chosen a departure point 1500 yards East of the lake, some animals starting in the vicinity of I&J dunes travelled on a northwest course taking them directly to East Wallace. Clearly, the bearing adopted and maintained by a seal could compensate for an inefficient starting place on the sandy plain.

The observations concerning the bearings taken up by the harbour seals are threefold:

[1]Unfortunately most of these were not recorded since most of them were casually observed on days when the census had not been taken.

(1) The bearing of the shortest path between the lake and the sea is approximately perpendicular to the coast and has a bearing of 204°. The average bearing adopted by seabound adults was about 202°, but weaners spontaneously heading for the sea, and lakebound adults do not take up a course perpendicular to the coast.

(2) Lakebound adults which are captured and displaced 1000 yards either change plans and adopt a bearing taking them directly to the sea, or complete their lakebound journeys by correcting their courses for the displacement they have experienced.

(3) When weaners are released at various points along the south coast of the island they usually take up a course leading toward the sea to the South, even if accesssto the northern sea coast is equally possible. Weaners released on the north coast, however, do not necessarily travel on a course taking them northward to the sea.

Various investigations described in the previous chapters were undertaken in order to discover the nature of the mechanism which enabled the seals to adopt and maintain these headings which generally took them to one of the lakes or the sea. Each of six sources of directional information were eliminated one at a time, and the results suggested that each of these were at least unnecessary for successful orientation in both adults and weaners.

Some of them may have been sufficient for the seals' orientation and it was proposed that the relationship of the seals performance to some of these cues be examined in greater detail before they be eliminated. One thing is certain: adults do not need landmarks to reach the sea or the lakes if they are crossing spontaneously, or to find the lakes if they are displaced 1000 yards off course, and weaners do not need landmarks to find the sea on a spontaneous crossing or after being captured and released in unfamiliar surroundings.

The other cues which were examined, (1) visibility of the sun, (2) wind, (3) zastruga on the sandy plain, and (4) surf sound cannot be eliminated as confidently.

(1) The orientation of both adults and pups was not disrupted by a 10/10 cloud cover which at least prevented a human from locating the sun. However some light manages to get through an extremely thick cloud cover, and even such a small amount may have given the animals some of the information they needed to traverse the short distance between the Wallace Lakes and the sea. As has proven the case with other migrants, the only sure test of a sun compass is the recycling of the animal's biological clock. Perhaps this test should be performed before it can be confidently asserted that the sun is not a necessary cue in the orientation of adults and pups.

(2) Wind direction was not significantly correlated with adult or pup track bearings, which suggests that wind is not a

necessary cue for the selection of a particular bearing. This does not exclude the possibility that this bearing once established was maintained by keeping a constant angle to the wind. Examples of both adult and weaner tracks made under conditions when there was no wind indicate, however, that it is also an unnecessary source of information for the maintenance of a course. The possibility that the animals were responding to the wind when other cues were lacking should not be eliminated without further test, especially since another investigator has suggested that weaned harp seals orient with the wind on their northward migrations (Sergeant, 1970).

(3) Since there are no zastruga within the immediate vicinity of the lakes or the sea, it is unlikely that the seals could have chosen a departure bearing relative to the orientation of these sand ripples. In fact, they would probably be an unreliable cue for the adoption of a course direction from any point on the sandy plain, since their orientation seems to be dependent upon the wind conditions. However, it has not been shown that the seals could not have been maintaining a preselected bearing by keeping a constant angle to the zastruga.

(4) In the absence of landmarks, it would seem that the most reliable cue, at least for southbound seals, would be the sound of the surf beating on the south coast, since it is always

present, and consistently audible in the southern sector of the sandy plain. Whether enough information could be derived from the surf sounds to allow the relocated adults to assess their displacement and correct their courses accordingly seems unlikely since the apparent direction of the sound of the surf does not seem to vary systematically with longitude. However, it seems plausible to suggest that a seal could at least maintain a bearing by keeping a constant angle to the surf sound, and further a seal departing spontaneously from a point other than the sea coast could select a bearing by this cue.

However, the measurements which were taken showed that, in the case of adults it was unrelated to the selection and maintenance of a course bearing, except in the case of two displaced adults which appeared to be keeping a constant angle to the surf sound during their journey to East Lake Wallace.

Since I suggested that the orientation of the weaners might be dependent on a much less complex mechanism than that of the experienced adults, I felt that surf sound orientation, in its simplicity might be the method used by the young animals. The statistical results neither confirmed nor rejected this hypothesis, but the description of the performance of the weaners at the Skidby drop, if anything, tended to support this contention. It is possible, however, that the characteristics of this dropping place forced the seals to behave differently than they did at the other four release sites. The Skidby blowout, unlike the wide open expanses of the other sites, reduced the weaners' choice of direction considerably since it contained only three obvious exits. The landscape and horizon cues of the blowout were clearly different from anything the weaners had experienced before. It is possible that such conditions somehow compelled the young animals to home on the surf sound, something they did not appear to be doing at East Wallace, West Wallace, Mobil or Old Main. Nonetheless, the behaviour of the weaners at the Skidby release does suggest that the surf sound may, under as yet undefined conditions, be one, possibly sufficient cue for the young seals' orientation. The fact that surf sound orientation was not indicated in the other data (with the exception of some significant intra-track correlations) could mean either that the seals were not responding to the surf sound, or that I was not measuring the direction of the sounds accurately enough.

The most difficult problem to cope with in an investigation of this nature is the probable versatility of the animals in switching from one method of orientation to another, depending on the cues available at the time of crossing. If the seals were using more than one system, or a system composed of more than one factor, single variable analysis, like the one I was forced to perform, could at best be expected to reveal what cues are unnecessary for orientation. My hopes of skirting this problem by studying the orientation of the weaners, which I felt might, in their inexperience, rely on a simple perhaps single factor mechanism, resulted in the suggestion that surf sound could possibly be a sufficient cue for their purposes.

Whatever the case, there are many more investigations which could easily be undertaken withtthe seals on Sable Island. The possibility of a magnetic compass could be effectively tested by attaching appropriately placed and sized bar magnets to the seals in an effort to disorient them. Recycling of diurnal rythms of the animals could be done easily. A more accurate breakdown of the components of the surf sound could prove to be extremely valuable, especially for the investigation of weaner orientation. Obviously, some method of simultaneously testing those cues considered to be important, or testing them one at a time with all others held in control would be more than desirable.

Perhaps the most valuable result of the investigations described in the previous chapters is the discovery that adult seals, when captured and relocated, can compensate for such displacement and still reach their goal. They can correct their bearing without relying on landmarks, or any other apparent local cues. This is navigation in the true sense of the word, possibly representative of the kind of performance seals display in their long distance migrations which must require navigation of some kind. The behaviour of the seals on Sable Island, being on land and over such short distances, is amenable to experimentation, and a complete record of the animal's performance can be easily obtained.

Finally, there are many questions, peripheral to the actual orientational mechanism, which would be worthy of investigation. The inevitable question one finds oneself asking about the Sable Island migrations overland is 'Why do the seals go to the lakes in the first place'? What motivated the pups to leave the lakes shortly after weaning, and how do they 'know' where they are going if they have never seen the sea? Does the same population of seals migrate between the lakes and the sea each summer, and were those that migrate there, born on the lakes? Perhaps the historical origins of this overland travel coincide with the gradual separation of the Wallace Lagoon from the sea.

It seems clear that Sable Island is capable of sustaining the interest of those concerned with animal behaviour for many years to come.

APPENDICES

1. The compass bearings given in these Appendices are magnetic bearings.

2. The pace measures of the tracks listed in Appendix C, E and F are indexed by the Letter R, J, B, W or D. These letters refer to the pace widths of the people who helped with this project. The different widths are as follows:

   I R Pace = 30 inches
   I J Pace = 36 inches
   I B Pace = 34 inches
   I W Pace = 34 inches
   I D Pace = 33 inches

3. Arithmetic means were calculated for each track in Appendix C, E and F by multiplying each bearing in a track by the corresponding number of paces, adding all of these products, and dividing by the total number of paces in the track. Sections of a track which represented some upset in normal travel, such as the avoidance of debris, the movement of a weaner which had been travelling for a time in a deep tire rut, or the first reading of each track in the relocation experiment (Appendix F), were not included in the calculation of means and variances.

4. The mean bearings of the tracks of the relocated adults (Appendix E) were based upon the last 275 yards of the track, in order to avoid the bias imposed by the initial bend in all the tracks.

5. The inbound leg of the aborted attempts (Appendix C) is that leg of the track which represents travel in the direction of the Wallace Lakes; the outbound leg refers to seabound movement.

APPENDIX A.

Census Data For 1970 and 1971, With The Corresponding Meteorological Information For The 1971 Count.

Date	East Lake Wallace				
1970	S → L	L → S	Attempts	Direction Undetermined	Total
26 June	1	4	3	0	8
27	1	4	0	0	5
28	3	5	0	0	8
29	0	7	0	0	7
30*	3	10	2	0	15
1 July	0	5	1	0	6
2	2	0	0	0	2
3	0	7	6	0	13
4	1	0	0	0	1
5*	0	1	0	0	1
6	0	2	17	0	19
7	0	7	1	0	8
8	3	2	3	0	8
9	0	1	2	0	3
10	1	1	4	0	6
11*	1	2	3	1	7
12	0	10	1	0	11
13	7	8	1	0	16
14	0	4	6	0	10
15*	1	3	3	0	7
16*	10	1	≥7	0	>18
17*	11	7	40	13	71
18	34	5	25	12	76
19	19	17	>20	32	>88
20	2	8	25	0	35
21	0	13	12	0	25

Date	East Lake Wallace				
1970	S → L	L → S	Attempts	Direction Undetermined	Total
22*July	1	6	1	0	8
23*	5	0	6	0	11
24	0	3	0	0	3
25	3	3	0	0	6
26	0	1	17	0	18
27	5	3	7	0	15
28*	0	13	38	0	51
30	18	6	10	0	34

* Only One Count Made on This Day

S→L = Sea To Lake Tracks

L→S = Lake To Sea Tracks

Date	East Lake Wallace				Middle Lake Wallace				West Lake Wallace				Total
1971	S→L	L→S	Att.[2]	Total	S→L	L→S	Att.	Total	S→L	L→S	Att.	Total	
13 May	1	3		4	0	0		0	3	0		3	7
17 May	5	4		9	1	0		1	2	2		4	14
20 May	16	3		19	17	8		25	0	0		0	44
28 May	12	10		22	0	1		1	1	4		5	28
31 May	9	10		19	2	0		2	2	4		6	27
4 June	7	5		12	0	1		1	2	3		5	18
8 June	7	8		15	5	3		8	3	5		8	31
16 June	3	13		16	5	1		6	2	3		5	27
19 June	3	6		9	1	3		4	4	8		12	25
24 June	3	5		8	0	4		4	3	2		5	17
28 June	2	6	4	12	1	3	10	14	4	10	10	24	50
5 July	2	5	1	8	1	4	2	7	5	1	0	6	21
8 July	3	3	5	11	0	2	1	3	0	1	0	1	15
13 July	1	4	8	13	0	0	0	0	0	0	0	0	13
16 July	11	4	14	29	0	3	6	9	0	2	2	4	42
20 July	6	5	35	46	0	1	0	1	0	2	0	2	49
23 July	2	3	14	19	0	0	0	0	0	0	0	0	19
27 July	43	15	43	101	0	1	0	1	0	5	12	17	119
30 July	44	24	36	104	0	0	0	0	0	1	0	1	105

S→L = Sea To Lake Tracks
L→S = Lake To Sea Tracks
Att. = Attempts

[1]Attempts were included in the count only from 28 June onwards, since wet, sand prior to this time, prevented safe travel near the shores.

KEY FOR METEROLOGICAL SYMBOLS

F	fog
R	rain
R-	light rain
R--	very light rain
W -	showers
T	thunder
L	drizzle

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F^{O}	Direction	M.P.H.
13 May	0300	2,8	1/2	L--F	42	146	3
	0400	2,8	2	F	42	123	7
	0500	10	4	R--F	42	147	6
	0600	10	5	R--F	43	194	7
	0700	10	3	R--F	43	192	7
	0800	10	5	F	43	231	7
	0900	10	5	F	44	182	8
	1000	10	3/4	L--F	45	181	9
	1100	1,9	1/2	L--F	46	152	14
	1200	1,9	1/2	F	48	182	14
	1300	1,9	1/2	F	48	187	13
	1400	1,9	1/2	F	46	203	17
	1500	3,7	3/8	F	47	201	18
	1600	1,9	1/2	F	45	202	13
	1700	10	10	F	46	198	15
	1800	10	10	F	46	195	17
	1900	2,8	10	F	47	197	17
	2000	2,4,5	10	F	47	200	17
	2100	1,5,5	8	F	47	196	18
17 May	0300	9	10		44	125	9
	0400	2,9	10		44	123	13
	0500	4,1	10		44	128	12
	0600	10	10		45	127	13
	0700	1,9	10		46	129	13
	0800	1,9	10		47	119	15
	0900	10	10		47	118	12
	1000	2,9	10		47	122	14
	1100	8,2	2	R-F	47	122	10
	1200	10	3/4	R-F	47	124	12
	1300	10	1/2	R-F	47	121	12
	1400	10	1/2	R-F	48	122	14
	1500	10	1/2	R-F	48	112	14
	1600	10	1/2	R-F	48	112	15
	1700	10	1/2	R-F	48	114	16
	1800	10	1/2	R-F	48	120	15
	1900	10	1/2	R-F	48	132	15
	2000	2 W,6,4	3/4	R-F	48	118	19
	2100	2,4,6	5/8	R-F	48	111	20

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F°	Direction	M.P.H.
20 May	0300	10	1/4	F	46	077	8
	0400	10	1/4	F	46	041	10
	0500	10	1/8	F	46	062	11
	0600	10	1/4	F	46	067	12
	0700	10	1/4	F	46	059	15
	0800	10	1/4	L-F	46	067	15
	0900	6,3	5/8	F	48	053	17
	1000	6,4	5/8	F	47	067	11
	1100	4,6	3/4	F	50	079	17
	1200	3,6	1 1/2	F	53	081	15
	1300	6,3,2,1	5	F	53	080	17
	1400	10	6	F	51	073	13
	1500	3,2,3	5	F	50	078	17
	1600	7,2	1/2	F	49	063	13
	1700	9	1/2	F	47	052	12
	1800	9	1/2	F	46	059	12
	1900	10	1/2	F	46	058	14
	2000	10	1/4	F	47	069	16
	2100	2,8	4	F	46	072	15
28 May	0300	1	3	F	45	140	5
	0400	1,1	3	F	45	123	5
	0500	1,3	1	F	46	137	9
	0600	1,1,7	1	F	48	139	9
	0700	1,9	2	F	49	116	7
	0800	1,6,3	2	TR-F	51	117	14
	0900	1,9	1 1/2	TRF	49	129	12
	1000	7,3	3	F	53	117	22
	1100	1,3,8	1 1/2	F	53	116	21
	1200	10	1/2	F	51	122	21
	1300	10	1/2	R-F	51	131	16
	1400	10	1/2	R--F	53	172	23
	1500	7,3	1/2	F	50	219	20
	1600	10	1/2	F	48	236	23
	1700	4,6	1 1/2	F	49	252	24
	1800	3,7	1	F	48	253	26
	1900	8,2	5/8	F	47	257	19
	2000	10	1/4	F	46	253	20
	2100	2,8	2	F	47	249	17

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F^{o}	Direction	M.P.H.
31 May	0300	10	1/4	F	52	188	20
	0400	10	1/8	F	51	193	20
	0500	10	1/8	F	51	191	20
	0600	10	1/8	F	52	194	21
	0700	10	1/8	F	53	181	16
	0800	10	1/8	R-F	52	188	22
	0900	10	1/8	R-F	53	188	20
	1000	10	1/8	F	52	190	18
	1100	10	1/4	RF	53	182	22
	1200	10	1/4	R-F	55	188	24
	1300	10	1/4	R-F	54	208	24
	1400	10	1/4	F	55	204	22
	1500	10	1/2	R-F	52	202	18
	1600	10	1	R-F	52	194	14
	1700	10	1	RF	53	202	14
	1800	10	1/4	F	53	182	12
	1900	10	1/8	F	52	192	12
	2000	10	1/8	F	50	186	10
	2100	10	1/8	F	50	197	11
4 June	0300	1,9	3	F	50	202	15
	0400	8,2	10	R--	50	200	18
	0500	4,6	10	R-	51	203	19
	0600	7,2	10		52	200	22
	0700	4,1,2,3	6	F	53	197	22
	0800	6,7	10		53	191	23
	0900	4,8	10		53	199	25
	1000	10	6	R-F	53	207	25
	1100	3,7	3/4	L-F	53	210	25
	1200	10	1/2	F	53	202	24
	1300	10	3/8	F	53	207	23
	1400	7,3	3/4	F	53	218	18
	1500	8,2	1/2	F	52	222	16
	1600	10	1/4	F	51	222	14
	1700	10	1/4	F	50	220	21
	1800	10	1/4	F	50	221	20
	1900	10	1/8	F	49	220	20
	2000	10	1/8	F	48	218	17
	2100	10	1/8	F	48	220	18

Date	Time	Amount of each Layer($\frac{X}{10}$)	Visibility (Miles)	Weather and Obstructions To Vision	Temperature F^{o}	Direction	M.P.H.
8 June	0300	3	10		50	182	10
	0400	5,1	10		50	188	8
	0500	8,1	1/4	F	50	210	5
	0600	9	1/4	F	51	211	5
	0700	9,1	1/4	F	51	210	6
	0800	9	1/4	F	53	192	5
	0900	9	1/2	F	53	164	8
	1000	10	3/8	F	55	138	10
	1100	10	1/4	F	54	132	12
	1200	10	1/2	F	54	188	8
	1300	10	1/2	F	54	207	8
	1400	10	1/2	F	54	228	8
	1500	7,3	2	F	56	242	5
	1600	4,6	2	F	58	244	2
	1700	10	2	F	57	003	3
	1800	10	1	F	53	072	6
	1900	10	3/4	F	52	152	5
	2000	10	1/8	R-F	51	192	6
	2100	10	1/8	F	51	132	3
16 June	0300	1	10		46	231	7
	0400	2	10		47	220	6
	0500	1,4	10		48	222	9
	0600	8	10		49	224	10
	0700	6	10		51	212	12
	0800	3	10		52	210	16
	0900	2	10		53	221	13
	1000	1	10		55	218	14
	1100	1	10		55	226	14
	1200	1	10		56	214	12
	1300	1	10		55	226	16
	1400	1	10		57	218	14
	1500	1	10		56	214	17
	1600		10		54	237	18
	1700	1	10		54	226	15
	1800	1	10		53	226	15
	1900	1	10		51	226	15
	2000	1	10		50	217	13
	2100	1	10		50	211	12

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F^{o}	Direction	M.P.H.
19 June	0300	2	10		51	230	13
	0400	4	10		51	231	14
	0500	4	10		52	231	14
	0600	1,2	10		53	228	13
	0700	2	10		54	229	12
	0800	4	10		56	235	16
	0900	5	10		58	223	17
	1000	1	10		59	211	18
	1100	4	10		60	217	19
	1200	5	10		61	220	18
	1300	5	10		61	221	18
	1400	5	10		59	221	20
	1500	7	10		60	223	19
	1600	6	10		58	226	22
	1700	7	10		58	227	23
	1800	4	10		56	216	20
	1900	6	8		55	223	23
	2000	0	8		54	232	19
	2100	0	8		55	230	24

Date	Time	Amount of each Layer($\frac{X}{10}$)	Visibility (miles	Weather and Obstructions To Vision	Temperature F^{o}	Direction	M.P.H.
24 June	0300	8,2	5/8	R-F	57	132	15
	0400	8,2	3/4	R-F	58	152	12
	0500	10	1/2	R-F	58	159	15
	0600	10	1/4	F	58	202	18
	0700	10	1/4	F	56	232	16
	0800	10	1/4	F	55	224	18
	0900	10	1/4	F	56	242	13
	1000	10	1/4	F	55	232	15
	1100	10	1/2	F	56	234	17
	1200	10	3/4	F	56	238	17
	1300	3,7	1	F	55	240	15
	1400	10	1 1/2	R-F	57	243	13
	1500	10	1	R-F	53	229	12
	1600	10	1/4	R-F	54	221	8
	1700	10	1/4	R-F	55	180	4
	1800	10	3/8	R-F	54	160	5
	1900	10	3/8	R-F	54	161	9
	2000	1,9	1/1/2	R-F	55		0
	2100	3,7	3/4	F	53	301	5
28 June	0300	10	10	R--	53	340	13
	0400	8,2	10	RW-	50	312	18
	0500	4,1	10		50	275	10
	0600	1	10		52	290	15
	0700	1	10		54	303	18
	0800	1	10		56	294	16
	0900	1,1	10		55	302	23
	1000	2	10		56	313	24
	1100	3,3	10		56	328	25
	1200	4	10		57	331	16
	1300	1,2	10		57	324	20
	1400	2,3	10		58	322	22
	1500	3,7	10		55	360	18
	1600	1,3	10		55	354	15
	1700	5,3	10		54	323	12
	1800	1,8	10		52	023	18
	1900	5,4	10		51	358	22
	2000	8,1	10		51	359	20
	2100	8	10		51	360	11

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (Miles)	Weather and Obstructions To Vision	Temperature F°	Direction	M.P.H
1 July	0300	10	1/8	F	55	242	21
	0400	10	1/8	F	55	246	20
	0500	10	1/8	F	55	262	17
	0600	10	1/8	F	55	242	17
	0700	10	1/8	F	55	231	18
	0800	10	1/4	F	56	231	18
	0900	10	1/4	F	56	228	20
	1000	10	1/2	F	57	234	18
	1100	10	3/8	F	57	242	20
	1200	10	1/2	F	58	232	18
	1300	10	1/2	F	58	235	17
	1400	10	3/8	F	58	243	19
	1500	10	3/8	F	58	241	23
	1600	10	3/8	F	58	230	23
	1700	10	1/4	F	57	232	21
	1800	10	1/4	F	58	236	24
	1900	10	1/4	F	57	233	23
	2000	10	1/4	F	57	234	22
	2100	10	1/8	F	58	226	26
5 July	0300	5,4	7		54	164	11
	0400	2,2	7		53	170	9
	0500	3,1	10		53	164	8
	0600	6,1	10		55	211	8
	0700	5,1	10		56	220	12
	0800	7,1	10		57	212	8
	0900	3,4	10		60	219	12
	1000	2,7	10		61	228	13
	1100	1,8	10		59	235	15
	1200	6	10		61	232	15
	1300	5,1	10		61	233	16
	1400	4,1	10		61	227	17
	1500	10	10		61	226	16
	1600	10	10		60	225	19
	1700	2,7	10		60	227	20
	1800	2,5	10		60	223	17
	1900	4,3	10		58	218	19
	2000	2,1	10		57	220	17
	2100	5,2	10		57	211	21

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F°	Direction	M.P.H.
8 July	0300	10	1/8	F	51	240	14
	0400	10	1/8	F	55	245	16
	0500	6	0	F	55	233	17
	0600	2	2 1/2	F	56	242	20
	0700	10	1/8	F	56	255	19
	0800	10	1/8	F	57	248	18
	0900	10	1/4	F	57	240	16
	1000	10	1/4	F	58	242	16
	1100	2,8	1/2	F	59	238	14
	1200	1,1	3	F	63	242	18
	1300	1	8		63	251	16
	1400	1	10		63	262	19
	1500	1,1,1	10		62	241	13
	1600	1,1,1	10		64	258	15
	1700	1,1	10		62	274	18
	1800	1	10		62	267	12
	1900	1	10		60	261	11
	2000	1,1	10		57	243	9
	2100	1	10		57	242	11
13 July	0300	0	10		56	301	14
	0400	0	10		56	303	14
	0500	0	10		56	300	15
	0600	0	10		57	310	15
	0700	0	10		58	312	13
	0800	1	10		58	311	15
	0900	1	10		59	314	14
	1000	1	10		59	320	15
	1100	2	10		60	322	12
	1200	2	10		61	321	11
	1300	2	10		61	307	12
	1400	1	10		62	287	14
	1500	1	10		62	294	13
	1600	1	10		62	297	10
	1700	2	10		63	285	10
	1800	2	10		60	254	10
	1900	4,2	10		58	247	8
	2000	1,2	10		57	240	5
	2100	2,4	10		53	224	5

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F^o	Direction	M.P.H.
16 July	0300	0	5	F	57	231	15
	0400	1	5	F	56	223	14
	0500	0	3	F	57	216	17
	0600	1	2	F	58	220	15
	0700	1	3	F	60	225	15
	0800	1	4	F	61	212	11
	0900	1	10		63	220	13
	1000	3	10		63	212	11
	1100	2	10		63	213	12
	1200	1,2	10		64	216	11
	1300	1	10		65	194	10
	1400	1,3	10		65	183	10
	1500	1,2	10		65	184	11
	1600	1,2	10		66	170	10
	1700	1,2	10		64	151	11
	1800	6,3	5	F	63	153	10
	1900	10,1	4	F	62	152	5
	2000	7,4	5	F	62	127	9
	2100	9,3	5	F	61	144	6
20 July	0300	2,8	5	F	60	143	15
	0400	10	4	F	61	153	19
	0500	10	1/8	F	62	159	17
	0600	10	1/8	F	64	185	16
	0700	10	1/8	F	64	192	22
	0800	10	1/4	F	65	192	24
	0900	8,2	1/4	F	65	196	23
	1000	4,3,1	2 1/2	F	68	194	25
	1100	10,1	1 1/2	F	67	198	26
	1200	1,9,1	1	RF	66	202	27
	1300	9,2	1 1/2	R--F	66	203	28
	1400	10	1 1/2	F	66	208	27
	1500	10	1 1/2	F	66	221	23
	1600	10	1 1/4	F	65	218	22
	1700	10	1	F	64	208	23
	1800	10	1/2	F	63	213	22
	1900	10	1/4	F	63	217	19
	2000	10	1/8	F	63	221	15
	2100	10	1/8	F	61	215	16

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F^{0}	Direction	M.P.H.
23 July	0300	10	8		61	123	9
	0400	10	7	R--	61	132	12
	0500	1,9	1	R-F	61	113	9
	0600	1,1,9	1	RF	61	126	9
	0700	1,6,5	1	R-F	62	104	11
	0800	1,6,4	2	F	63	120	12
	0900	3,9	3	F	62	102	14
	1000	10	4	F	63	101	14
	1100	10	6	F	65	090	12
	1200	2,8	4	F	62	050	8
	1300	10	5/8	F	64	032	12
	1400	10	5/8	F	63	020	12
	1500	10	1/2	F	64	032	9
	1600	10	3/8	F	62	013	7
	1700	10	1/2	F	62	340	7
	1800	10	3/8	F	62		0
	1900	5,5	3/4	F	62	241	5
	2000	3,7	1 1/2	F	61	226	5
	2100	3,7	1 1/4	F	61	231	5
27 July	0300	1,6,7	3	F	62	164	11
	0400	10	5	F	62	148	11
	0500	10	1/4	F	62	159	10
	0600	10	1/4	F	62	148	11
	0700	5,5	1/2	F	62	140	12
	0800	10	1/2	F	63	132	14
	0900	7,7	3/4	F	65	142	16
	1000	9,4	1 1/2	F	66	144	14
	1100	6,4	1	F	68	152	15
	1200	1,6,3	2 1/2	F	66	151	14
	1300	3,7	5/8	F	67	150	17
	1400	3,5	3/4	F	68	151	17
	1500	5,5	5/8	F	66	153	15
	1600	7,3	5/8	R--F	65	150	16
	1700	7,3	3/4	F	65	152	11
	1800	10	1/2	F	64	152	16
	1900	10	3/8	F	64	153	13
	2000	10	1/8	F	63	158	14
	2100	3,7	1/8	F	64	151	13

Date	Time	Amount of each Layer ($\frac{X}{10}$)	Visibility (miles)	Weather and Obstructions To Vision	Temperature F^{o}	Direction	M.P.H.
30 July	0300	10	2	F	64	173	11
	0400	5,5	3/4	F	64	180	12
	0500	10	1/4	F	64	178	13
	0600	10	1/4	F	64	180	15
	0700	10	1/4	F	65	182	14
	0800	10	1/8	F	65	197	15
	0900	10	1/4	F	66	210	12
	1000	4,3	1/2	F	67	210	10
	1100	5,5	2 1/2	F	68	240	10
	1200	3,7	5/8	F	71	216	12
	1300	1,9	2	F	70	210	10
	1400	1,9	1	F	71	202	15
	1500	2,8	5/8	F	69	201	14
	1600	5,5	1/2	F	69	204	14
	1700	2,8	3/4	F	68	212	15
	1800	3,7	3/4	F	67	210	15
	1900	10	1/2	F	67	210	13
	2000	10	0	F	66	211	12
	2100	10	0	F	66	202	15

APPENDIX B
Regression Analysis I
Census, 1971

FULL MODEL CAST TO DETERMINE THE AMOUNT OF VARIANCE IN THE 1971 CENSUS DATA ACCOUNTED FOR BY SEVEN METEROLOGICAL VARIATES:

$$\begin{aligned}\text{CRITERION} = {} & a_0u + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + \\ & a_8X_8 + a_9X_9 + a_{10}X_{10} + a_{11}X_{11} + a_{12}X_{12} + a_{13}X_{18} + \\ & a_{14}X_{14} + a_{15}X_{15} + a_{16}X_{16} + a_{17}X_{17} + a_{18}X_{18} + a_{19}X_{19} + \\ & a_{20}X_{20} + a_{21}X_{21} + a_{22}X_{22} + a_{23}X_{23} + a_{24}X_{24} + a_{25}X_{25} + \\ & a_{26}X_{26} + a_{27}X_{27} + a_{28}X_{28} + a_{29}X_{29} + E_1.\end{aligned}$$

Where:

a_1X_1 = lakebound tracks

a_2X_2 = seabound tracks

a_3X_3 = lakeshore attempts

a_4X_4 = seashore attempts

a_5X_5 = 1 if 10/10 cloud cover when track was made; 0 otherwise

a_6X_6 = visibility when track was made

a_7X_7 = 1 if raining when track was made; 0 otherwise

a_8X_8 = 1 if foggy when track was made; 0 otherwise

a_9X_9 = Temperature when track was made

$a_{10}X_{10}$ = wind direction when track was made

$a_{11}X_{11}$ = wind speed when track was made

$a_{12}X_{12}$ = 1 if track in vicinity of East Lake Wallace; 0 otherwise

$a_{13}X_{13}$ = 1 if track in vicinity of West Lake Wallace; 0 otherwise

$a_{14}X_{14}$ = 1 if track in vicinity of Middle Lake Wallace; 0 otherwise

$a_{15}x_{15}$ = 1 if attempts were being recorded at the time track was observed; 0 otherwise

$a_{16}x_{16} = a_3x_3 * a_{15}x_{15}$: recorded lakeshore attempts

$a_{17}x_{17} = a_4x_4 * a_{15}x_{15}$: recorded sea shore attempts

$a_{18}x_{18} = a_1x_1 * a_{12}x_{12}$: lakebound tracks to East Lake Wallace

$a_{19}x_{19} = a_2x_2 * a_{12}x_{12}$: seabound tracks from East Lake Wallace

$a_{20}x_{20} = a_{16}x_{16} * a_{12}x_{12}$: Recorded lakeshore attempts on East Lake Wallace

$a_{21}x_{21} = a_{17}x_{17} * a_{12}x_{12}$: Recorded seashore attempts opposite East Lake Wallace

$a_{22}x_{22} = a_1x_1 * a_{13}x_{13}$: lakebound tracks to West Lake Wallace

$a_{23}x_{23} = a_2x_2 * a_{13}x_{13}$: seabound tracks from West Lake Wallace

$a_{24}x_{24} + a_{16}x_{16} * a_{13}x_{13}$: Recorded lakeshore attempts on West Lake Wallace

$a_{25}x_{25} = a_{17}x_{17} * a_{13}x_{13}$: Recorded seashore attempts opposite West Lake Wallace

$a_{26}x_{26} = a_1x_1 * a_{14}x_{14}$: lakebound tracks to Middle Lake Wallace

$a_{27}x_{27} = a_2\ x_2 * a_{14}x_{14}$: seabound tracks from Middle Lake Wallace

$a_{28}x_{28} = a_{16}x_{16} * a_{14}x_{14}$: Recorded lakeshore attempts on Middle Lake Wallace

$a_{29}x_{29} = a_{17}x_{17} * a_{14}x_{14}$: Recorded seashore attempts opposite Middle Lake Wallace

Model Number	Predictor Variables	Criterion Variables
1	a_5x_5	$a_{18}x_{18}$
2	a_5x_5	$a_{19}x_{19}$
3	a_5x_5	$a_{20}x_{20}$
4	a_5x_5	$a_{21}x_{21}$
5	a_5x_5	$a_{22}x_{22}$
6	a_5x_5	$a_{23}x_{23}$
7	a_5x_5	$a_{24}x_{24}$
8	a_5x_5	$a_{25}x_{25}$
9	a_5x_5	$a_{26}x_{26}$
10	a_5x_5	$a_{27}x_{27}$
11	a_5x_5	$a_{28}x_{28}$
12	a_5x_5	$a_{29}x_{29}$
13	a_6x_6	$a_{18}x_{18}$
14	a_6x_6	$a_{19}x_{19}$
15	a_6x_6	$a_{20}x_{20}$
16	a_6x_6	$a_{21}x_{21}$
17	a_6x_6	$a_{22}x_{22}$
18	a_6x_6	$a_{23}x_{23}$
19	a_6x_6	$a_{24}x_{24}$
20	a_6x_6	$a_{25}x_{25}$
21	a_6x_6	$a_{26}x_{26}$
22	a_6x_6	$a_{27}x_{27}$
23	a_6x_6	$a_{28}x_{28}$
24	a_6x_6	$a_{29}x_{29}$

Model Number	Predictor Variables	Criterion Variables
25	a_7X_7	$a_{18}X_{18}$
26	a_7X_7	$a_{19}X_{19}$
27	a_7X_7	$a_{20}X_{20}$
28	a_7X_7	$a_{21}X_{21}$
29	a_7X_7	$a_{22}X_{22}$
30	a_7X_7	$a_{23}X_{23}$
31	a_7X_7	$a_{24}X_{24}$
32	a_7X_7	$a_{25}X_{25}$
33	a_7X_7	$a_{26}X_{26}$
34	a_7X_7	$a_{27}X_{27}$
35	a_7X_7	$a_{28}X_{28}$
36	a_7X_7	$a_{29}X_{29}$
37	a_8X_8	$a_{18}X_{18}$
38	a_8X_8	$a_{19}X_{19}$
39	a_8X_8	$a_{20}X_{20}$
40	a_8X_8	$a_{21}X_{21}$
41	a_8X_8	$a_{22}X_{22}$
42	a_8X_8	$a_{23}X_{23}$
43	a_8X_8	$a_{24}X_{24}$
44	a_8X_8	$a_{25}X_{25}$
45	a_8X_8	$a_{26}X_{26}$
46	a_8X_8	$a_{27}X_{27}$
47	a_8X_8	$a_{28}X_{28}$
48	a_8X_8	$a_{29}X_{29}$

Model Number	Predictor Variables	Criterion Variables
49	$a_9 X_9$	$a_{18} X_{18}$
50	$a_9 X_9$	$a_{19} X_{19}$
51	$a_9 X_9$	$a_{20} X_{20}$
52	$a_9 X_9$	$a_{21} X_{21}$
53	$a_9 X_9$	$a_{22} X_{22}$
54	$a_9 X_9$	$a_{23} X_{23}$
55	$a_9 X_9$	$a_{24} X_{24}$
56	$a_9 X_9$	$a_{25} X_{25}$
57	$a_9 X_9$	$a_{26} X_{26}$
58	$a_9 X_9$	$a_{27} X_{27}$
59	$a_9 X_9$	$a_{28} X_{28}$
60	$a_9 X_9$	$a_{29} X_{29}$
61	$a_{10} X_{10}$	$a_{18} X_{18}$
62	$a_{10} X_{10}$	$a_{19} X_{19}$
63	$a_{10} X_{10}$	$a_{20} X_{20}$
64	$a_{10} X_{10}$	$a_{21} X_{21}$
65	$a_{10} X_{10}$	$a_{22} X_{22}$
66	$a_{10} X_{10}$	$a_{23} X_{23}$
67	$a_{10} X_{10}$	$a_{24} X_{24}$
68	$a_{10} X_{10}$	$a_{25} X_{25}$
69	$a_{10} X_{10}$	$a_{26} X_{26}$
70	$a_{10} X_{10}$	$a_{27} X_{27}$
71	$a_{10} X_{10}$	$a_{28} X_{28}$
72	$a_{10} X_{10}$	$a_{29} X_{29}$

Model Number	Predictor Variables	Criterion Variables
73	$a_{11}X_{11}$	$a_{18}X_{18}$
74	$a_{11}X_{11}$	$a_{19}X_{19}$
75	$a_{11}X_{11}$	$a_{20}X_{20}$
76	$a_{11}X_{11}$	$a_{21}X_{21}$
77	$a_{11}X_{11}$	$a_{22}X_{22}$
78	$a_{11}X_{11}$	$a_{23}X_{23}$
79	$a_{11}X_{11}$	$a_{24}X_{24}$
80	$a_{11}X_{11}$	$a_{25}X_{25}$
81	$a_{11}X_{11}$	$a_{26}X_{26}$
82	$a_{11}X_{11}$	$a_{27}X_{27}$
83	$a_{11}X_{11}$	$a_{28}X_{28}$
84	$a_{11}X_{11}$	$a_{29}X_{29}$

F Ratios Comparing The Amount Of Variance Accounted For (r^2) By Models 1 Through 84 With The Amount Of Variance Accounted For By Model 90 (A Built In Model Which Has $r^2 = 0$).

F Ratio	D.F. Num.	D.F. Den.	Full Model	r^2	Probability
0.9227	1	48	1	0.01886	0.34153
0.7584	1	48	2	0.01555	0.38815
0.9458	1	48	3	0.01932	0.33565
1.0257	1	48	4	0.02092	0.31621
0.1344	1	34	5	0.00394	0.71719
0.1144	1	34	6	0.00335	0.73730
0.5382	1	34	7	0.01558	0.46818
0.1339	1	34	8	0.00392	0.71663
0.3349	1	31	9	0.01069	0.56695
0.0606	1	31	10	0.00195	0.80717
0.1954	1	31	11	0.00626	0.66146
0.4475	1	31	12	0.01423	0.50849
1.4598	1	48	13	0.02951	0.23287
0.1247	1	48	14	0.00259	0.72548
0.6679	1	48	15	0.01372	0.41777
1.5566	1	48	16	0.03141	0.21818
0.9449	1	34	17	0.02704	0.33787
0.1649	1	34	18	0.00483	0.68723
0.2563	1	34	19	0.00748	0.61594
0.5803	1	34	20	0.01678	0.45144
0.0875	1	31	21	0.00282	0.76926
0.0039	1	31	22	0.00012	0.95079
0.6968	1	31	23	0.02198	0.41021
0.2370	1	31	24	0.00759	0.62978
0.0982	1	48	25	0.00204	0.75531
0.0417	1	48	26	0.00087	0.83894

F Ratio	D.F. Num.	D.F. Den.	Full Model	r^2	Probability
0.0457	1	48	27	0.00095	0.83165
0.0851	1	48	28	0.00177	0.77171
0.0543	1	34	29	0.00160	0.81708
0.2307	1	34	30	0.00674	0.63407
0.0814	1	34	31	0.00239	0.77710
0.1115	1	34	32	0.00327	0.74045
0.0157	1	31	33	0.00051	0.90102
0.3254	1	31	34	0.01039	0.57248
0.1744	1	31	35	0.00559	0.67910
0.0432	1	31	36	0.00139	0.83669
1.1825	1	48	37	0.02404	0.28225
0.0418	1	48	38	0.00087	0.83889
0.3697	1	48	39	0.00764	0.54596
0.2366	1	48	40	0.02511	0.27165
0.9043	1	34	41	0.02591	0.34833
0.2054	1	34	42	0.00600	0.65330
0.2080	1	34	43	0.00608	0.65123
0.6495	1	34	44	0.01875	0.42587
0.0306	1	31	45	0.00099	0.86226
0.0076	1	31	46	0.00025	0.93097
0.6438	1	31	47	0.02034	0.42844
0.1596	1	31	48	0.00512	0.69222
0.9370	1	48	49	0.01915	0.33787
0.2366	1	48	50	0.00490	0.62883
3.8637	1	48	51	0.07450	0.05514
3.2082	1	48	52	0.06265	0.07957
1.6741	1	34	53	0.04693	0.20442
0.1335	1	34	54	0.00391	0.71702
0.4965	1	34	55	0.01439	0.48580
0.1210	1	34	56	0.00355	0.73012

F Ratio	D.F. Num.	D.F. Den.	Full Model	r^2	Probability
1.1012	1	31	57	0.03430	0.30211
0.3107	1	31	58	0.00992	0.58119
0.0252	1	31	59	0.00081	0.87479
0.0000	1	31	60	0.00000	0.99540
0.1982	1	48	61	0.00411	0.65814
0.1950	1	48	62	0.00405	0.66075
0.0559	1	48	63	0.00116	0.81403
0.0177	1	48	64	0.00037	0.89479
0.7330	1	34	65	0.02110	0.39788
1.0499	1	34	66	0.02996	0.31273
0.0430	1	34	67	0.00126	0.83698
2.2183	1	34	68	0.06125	0.14560
0.4812	1	31	69	0.01529	0.49301
0.0325	1	31	70	0.00105	0.85802
0.7915	1	31	71	0.02490	0.38047
0.2250	1	31	72	0.00721	0.63857
0.0691	1	48	73	0.00144	0.79366
0.0038	1	48	74	0.00008	0.95083
0.0271	1	48	75	0.00056	0.86992
0.1997	1	48	76	0.00414	0.65689
0.0007	1	34	77	0.00002	0.97848
0.1786	1	34	78	0.00523	0.67521
0.0422	1	34	79	0.00124	0.83845
0.4826	1	34	80	0.01400	0.49194
0.2655	1	31	81	0.00849	0.60996
0.0182	1	31	82	0.00059	0.89349
0.0044	1	31	83	0.00014	0.94726
0.1782	1	31	84	0.00571	0.67586

APPENDIX C

Track, Surf and Meterological Data For Each Of The 67 Adults Observed Crossing The Sandy Plain.

TRACK 7001

Sea to Middle Lake Wallace (MLW)*: 0540 Hours: Sun Visible: Visibility 170 Yards in Fog: Wind *ca.* 15 mph from 244°: No Surf Data Recorded: Track Traced From MLW to Sea:

Bearings°	Paces[J]
347	38
009	8
058	17
050	12
080	23
142	26
248	12
286	30
264	17
238	17
340	17
004	11
320	3
284	5
324	12
348	20
322	3
296	4
286	32
273	36
267	17
240	24
336	110
300	4
224	18
206	38
248	24
284	20
310	23
258	9
359	26
227	8
170	46
182	28

TRACK 7001 (Continued)

Bearings°	Paces[J]
130	14
168	9
322	63
282	14
251	23
224	28
200	53
176	31
086	68
237	47
220	20
212	83
207	59
205	42
188	45
194	60
202	14
194	21
185	31
175	56
183	20
162	21
182	22
202	32

$\overline{X}$ Track Bearing = 019.00° Track Variance = 318.405

Though this seal travelled northward from the sea to Middle Lake Wallace, its track was traced southward from Middle Lake Wallace to the sea. For this reason, the track bearings shown here are southern readings. This backwards tracing is true of the tracks in this Appendix which are marked with an asterisk.

TRACK 7002

MLW to Sea: 0430 Hours: Sun Visible: Visibility 10 Miles Wind 020° 10 mph: No Surf Data Recorded: Track Traced from MLW to Sea:

Bearings°	Paces[J]
213	18
205	15
214	48
213	56
216	43
212	30
208	19
214	44
207	105
199	20
206	361
200	73
201	47

$\overline{X}$ Track Bearing = 208.13° Track Variance = 31.343

Track 7003

Sea to West Lake Wallace (WLW): 0550 Hours: Sun Not Visible: Visibility 1 to 2 Miles: Wind 2-3 mph from Southwest: No Surf Data Recorded: Track Traced from Sea to WLW:

Bearings°	Paces[J]
014	13
053	12
040	6
048	6
034	15
047	15
058	12
045	15
047	30
038	12
027	30
041	23
033	19
034	80
038	47
044	28
063	11
052	45
065	11
050	8
064	13
079	7
070	28
074	15
070	33
044	10
034	12
024	14
054	9
028	7

$\overline{X}$ Track Bearing = 045.55° Track Variance = 216.745

TRACK 7004

ELW to Sea: 0830 Hours: Sun Visible: Visibility 10 Miles: Wind <5 mph from 200°: No Surf Data Recorded: Track Traced from Lake to Sea

Bearings°	Paces[J]
217	15
214	20
073	10
227	62
240	8
227	18
223	29
232	32
225	50
238	12
228	8
227	19
222	9
226	12
228	10
225	47
218	7
227	10
216	14
220	21
212	7
220	8
211	21
213	18
207	28
216	11
204	97
195	23
204	35
137	2
188	16
211	5
236	11
175	4
204	11
172	8
212	37
198	52

$\overline{X}$ Track Bearing = 213.10° Track Variance = 429.346

TRACK 7005

WLW to Sea: 0545 Hours: Total Overcast:
Visibility < 1/2 Mile: Wind 13 mph from 020°:
No Surf Data: Track Traced from Lake to Sea

Bearings°	Paces^J
220	16
213	11
192	26
180	33
170	11
176	8
168	15
176	10
170	39
116	6
145	20
163	12
182	57
206	6
216	5
185	17
192	12
194	26
202	24
192	22
203	18
208	29
181	16
221	50
202	10
190	11
163	12
174	7
208	5

$\overline{X}$ Track Bearing = 188.66° Track Variance = 419.366

TRACK 7006

MLW to Sea: 0530 Hours: Sun Visible: Visibility 10 Miles: Wind 10 mph from 220°: Partial Surf Data Recorded: Track Traced from Lake to Sea

Bearings°	Paces[J]
High Surf 220° ;	Low Surf 272
234	3
218	10
207	9
180	23
061	22
094	8
148	3
160	5
High Surf 216° ;	Low Surf 280°
188	6
200	39
192	14
186	10
061	10
040	13
044	47
064	14
101	30
115	7
092	2
112	8
090	13
High Surf 209° ;	Low Surf 268°
110	5
183	3
194	4
183	6
188	40
204	17
196	26
192	5

TRACK 7006 (Continued)

Bearings°	Paces[J]
198	23
High Surf 224° ;	Low Surf 260°
212	13
200	81
200	57
201	51
206	19
209	67
206	52
204	17
209	67

$\overline{X}$ Track Bearing = 202.06° Track Variance = 41.767

TRACK 7008

Sea to East Lake Wallace (ELW): 0415 Hours: Sun Visible: Visibility 1-8 Miles in Mist: Wind 15 mph from 180°: No Surf Data Recorded: Track Traced from Sea to ELW:

Bearings°	Paces[J]
338	6
005	5
034	11
350	9
007	3
353	14
350	5
340	15
002	16
006	3
009	8
341	5
358	27
006	7
330	9
354	54
348	8
332	7
350	23
356	17
001	16
359	25
356	23
359	7
007	3
356	30
352	31
357	31
008	42

TRACK 7008 (Continued)

Bearings°	Paces[J]
018	28
013	28
010	21
359	16
020	8
008	15
350	11
252	4
279	13
298	5
320	5

$\overline{X}$ Track Bearing = 357.37°   Track Variance = 700.976

TRACK 7009

Sea to ELW:* 0530 Hours: Sun Visible: Visibility 10 Miles: Wind 15 mph from 270°: Partial Surf Data Recorded: Track Traced from Lake to Sea

Bearings°	Paces[J]
212	12
224	21
232	12
250	5
237	43
245	23
239	79
236	25
232	20
236	60
232	58
244	43
252	14
229	8
239	40
225	13
234	29
225	39
235	10
225	18
220	11
225	27
212	9
High Surf 226° ;	Low Surf 270°
220	20
216	54
205	10
222	10
208	28
213	12
205	18

$\overline{X}$ Track Bearing = 049.90° Track Variance = 125.924

TRACK 7010

Sea to East Lake Wallace (ELW)*: 0540 Hours:
Sun Visible: Visibility Clear in Slight Mist:
Wind 5 mph from 260°: Partial Surf Data Recorded:
Track Traced from ELW to Sea

Bearings°	Paces[J]
132	13
146	17
163	7
High Surf 214° ;	Low Surf 270°
148	3
169	11
160	16
170	6
162	17
174	15
181	20
163	15
153	16
144	38
139	14
144	16
136	62
112	22
High Surf 224° ;	Low Surf 263°
120	16
107	23
130	10
141	35
143	15
150	25
143	39
High Surf 216° ;	Low Surf 258°
164	23
156	14

TRACK 7010 (Continued)

Bearings°	Paces[J]
162	21
174	28
178	15
167	34
High Surf 206→236; Low Surf = 260°	
149	18
160	26
154	29
135	33
High Surf 215° ; Low Surf 255°	
152	19
168	27
160	58
High Surf 200° ; Low Surf 260°	
174	22
186	17
178	15
194	15
176	4
186	17
207	2
180	5
196	7
186	6
196	8

$\overline{X}$ Track Bearing = 334.88 Track Variance = 385.454

TRACK 7011

Sea to ELW*: 0615 Hours: Sun Visible: Visibility 3 Miles: Wind 10 mph from 250°: No Surf Data Recorded: Track Tracked From ELW to Sea.

Bearings°	Paces[J]
103	29
129	32
138	20
154	4
138	13
130	10
148	5
138	11
146	40
155	20
171	14
148	8
161	10
169	14
186	47
196	16
182	6
172	30
159	7
173	11
167	21
178	31
166	26
149	27
146	30
149	22
142	24
154	16
163	15
160	12
149	22
160	32
176	9
163	14

TRACK 7011 (Continued)

Bearings°	Paces[J]
171	5
163	9
157	6
174	8
155	11
164	9
155	63
142	17
168	12
155	11
164	11
168	10
170	40
162	17
164	10
164	11
172	5
162	13
181	14
192	18
200	15
188	17
148	10
138	8
148	16
140	4
115	7
097	8
122	6
114	8
099	22
146	10
154	18
142	15
150	26
164	26

$\overline{X}$ Track Bearing = 336.33° Track Variance = 429.329

TRACK 7012

ELW to Sea: 1757 Hours: Sun Possibly Visible: Visibility 10 Miles: Wind 17 mph from 140°: Partial Surf Data Recorded: Track Traced From ELW to Sea

Bearings°	Paces[J]
194	36
195	7
212	7
198	8
194	15
198	13
195	11
191	10
189	12
188	12
189	9
187	11
185	11
181	9
193	10
205	9
185	4
200	9
189	16
Surf 194°	
185	13
194	10
198	9
195	10
192	10
194	9
190	8
184	12
193	11
190	11
193	10
190	13
197	13

TRACK 7012 (Continued)

Bearings°	Paces[J]
201	7
196	15
170	11
177	16
182	11
185	19

$\overline{X}$ Track Bearing = 190.97° Track Variance = 51.090

TRACK 7013

Sea to ELW: 0708 Hours: Total Overcast: Visibility 2 1/2 Miles: Wind 5 mph from 190: Partial Surf Data Recorded: Track Traced From Sea to MLW

Bearings°		Paces[J]
042		26
049		13
035		5
050		30
011		5
040		23
046		15
High Surf 190°	;	Low Surf 223°
040		135
106		3
132		26
096		5
High Surf 186°	;	Low Surf 250°
040		4
016		58
003		30
High Surf 200°	;	Low Surf 273°
014		19
016		20
021		33
023		97
040		31
038		10
018		4
036		8
060		13

$\overline{X}$ Track Bearing = 036.13° Track Variance = 643.956

TRACK 7014/7015

ELW: Lake Shore Attempt: 1917 : Sun Visible: Visibility 10 Miles: Wind 18 mph from 230°: No Surf Data: Track Tracing Starts on Lakeshore With Outbound Leg:

Bearings°	J Paces
239	9
238	5
253	3
238	11
226	8
232	6
226	10
222	4
213	13
203	14
200	12
196	31
209	27
198	41
175	4
190	7
180	45
170	15
180	14
186	17
175	9
188	20
192	28
197	17
193	37
Erractic track of approximately 129~~0~~° for 163 paces	
164	23
155	3
224	8
112	4
069	9
050	7
035	28
021	26
018	19
002	16

TRACK 7014/7015 (Continued)

Bearings°	Paces
005	6
009	40
360	38
352	8
346	83
350	20
356	22
354	13
359	37
360	36
353	25
360	2
353	55
360	7
344	9
004	8
355	13

$\overline{X}$ Track Bearing Outbound = 194.77°

$\overline{X}$ Track Bearing Inbound = 002.53°

Track Variance Outbound = 314.793

Track Variance Inbound = 355.590

TRACK 7016/7017

ELW: Lakeshore Attempt: 2130 Hours: Moon Visible: Visibility 10 Miles: Wind 22 mph from 240°: No Surf Data: Track Tracing Starts on Lakeshore With Outbound Leg.

Bearings°	Paces[R]
207	9
194	19
191	33
181	26
195	15
192	27
208	10
195	19
190	7
198	18
224	12
241	6
226	8
218	15
210	7
206	17
208	5
214	32
210	25
206	6
218	31
210	16
220	13
213	21
218	8
224	9
214	22
293	10
288	4
317	3
324	12
348	19
352	7
010	14
010	8
080	11
338	5
009	14

TRACK 7016/7017 (Continued)

Bearings°	Paces[R]
031	17
041	28
036	39
048	17
031	38
038	14
032	26
040	16
032	31
020	8
030	10
023	11
028	30
035	4
022	47
038	10
030	6
340	4
040	20

$\overline{X}$ Track Bearing Outbound 206.02°

$\overline{X}$ Track Bearing Inbound 031.95°

Track Variance Outbound 164.589

Track Variance Inbound 187.032

TRACK 7019

Sea to MLW: 0643 Hours: Sun Visible: Visibility Clear: Wind From North East at 5 mph: No Surf Data Recorded: Track Traced from Sea to MLW:

Bearings°	Paces[J]
026	15
034	3
009	10
027	22
040	4
027	28
046	5
018	7
032	51
212	58
044	31
035	23
034	34
037	29
031	31
034	12
044	5
030	30
035	12
032	25
038	63
031	3
050	4
036	5
055	38
048	19
035	60
052	7
074	35
340	10
015	10
030	10
042	10
058	28

$\overline{X}$ Track Bearing = 040.04° Track Variance = 205.447

TRACK 7022/7023

ELW: Seashore Attempt: 0725 Hours: Sun Not Visible: Visibility <200 yards in Fog: Wind 14 mph from 180°: No Surf Data: Track Tracing Starts at the Turning Point of the Track and Records the Inbound Leg, and then Returns to the Turning Point and Traces the Outbound Leg.

Bearings°	Paces[J]
199	13
189	7
203	16
198	20
201	20
195	8
203	33
196	15
200	22
196	25
189	17
196	8
185	64
177	8
184	7
180	19
188	10
169	4
187	5
179	17
Return to Turning Point	
118	5
176	4
191	14
187	37
198	12
205	26
212	26
197	40
201	40
204	16
202	5
207	23
202	20
192	19
196	12

$\overline{X}$ Track Bearing Outbound 197.66°

$\overline{X}$ Track Bearing Inbound 012.06°

Track Variance Outbound 165.235
Track Variance Inbound 73.263

TRACK 7024/7025

ELW: Seashore Attempt: 0654 Hours: Sun Occasionally Visible: Visibility 200 yards: Wind 244° Partial Surf Data: Track Tracing Starts on Seashore with Outbound Leg.

Bearings		Paces[J]
037		14
041		32
048		18
061		19
058		26
075		10
038		17
026		31
045		17
054		7
046		19
051		14
057		13
048		6
056		26
Low Surf 270°	;	High Surf 235°
046		23
033		20
Low Surf 260°	;	High Surf 214°
022		11
031		24
018		5
Low Surf 264°	;	High Surf 230°
033		13
021		50
Low Surf 265°	;	High Surf 220°
018		9
032		10
042		7
038		6
042		12
042		18
037		15
052		5
028		13
Low Surf 260°	;	High Surf 230°
041		40
028		4

TRACK 7024/7025 (Continued)

Bearings°		Paces[J]
025		22
360		4
028		18
022		16
Low Surf 258°	;	High Surf 218°
005		14
342		5
Low Surf 250°	;	High Surf 218°
358		14
003		11
354		23
Low Surf 253°	;	High Surf 210°
016		28
354		13
348		7
308		10
281		12
235		23
249		13
221		5
189		8
206		13
224		12
Low Surf 243°	;	High Surf 213°
210		56
207		13
200		10
210		13
191		7
201		9
High Surf 215°		
194		22
204		18
212		15
203		16
213		15
206		13
212		7
210		17
204		35
195		3
220		8
207		61

TRACK 7024/7025 (Continued)

Bearings°		Paces[J]
Low Surf 256°	;	High Surf 206°
200		9
209		25
203		16
210		8
196		4
210		21
216		12
211		16
220		22
Low Surf 258°	;	High Surf 216°
216		20
220		7
233		6
219		25

$\bar{X}$ Track Bearing Outbound 210.69°

$\bar{X}$ Track Bearing Inbound 029.72°

Track Variance Outbound 111.882

Track Variance Inbound 622.727

TRACK 7026/7027

ELW: Seashore Attempt 0714 Hours: Sun Occasionally Visible: Visibility 200 Yards: Wind 244°: Partial Surf Data: Track Tracing Starts on Seashore with Outbound Leg.

Bearings°		Paces[J]
022		18
043		13
030		21
036		26
049		17
037		44
026		25
037		48
Low Surf 260°	;	High Surf 208°
028		20
037		58
Low Surf 260°	;	High Surf 218°
042		10
054		23
062		16
065		15
062		5
062		15
067		17
062		23
Low Surf 260°	;	High Surf 224°
049		16
059		6
050		51
042		8
049		11
061		22
046		33
057		19
Low Surf 267°	;	High Surf 225°
072		27
046		19
252		4
199		7
230		11
256		46
235		8
223		48
233		17

TRACK 7026/7027 (Continued)

Bearings°		Paces[J]
249		7
Low Surf 270°	;	High Surf 224°
227		26
220		27
231		13
227		15
210		44
224		29
212		16
229		11
Low Surf 249°	;	High Surf 216→230°
200		13
222		33
212		24
236		3
208		10
240		2
219		5
233		31
246		10
Low Surf 260°	;	High Surf 226→246°
228		38
236		10
255		3
228		22
213		11
202		22
208		3
233		5
202		5
194		6
229		6
204		21
212		11

$\overline{X}$ Track Bearing Outbound 224.87°

$\overline{X}$ Track Bearing Inbound 046.12°

Track Variance Outbound 213.701

Track Variance Inbound 167.068

TRACK 7028

Sea to MLW: 0550 Hours: Total Overcast: Visibility 1/2 mile: Wind 13 mph from 020°: No Surf Data Recorded: Track Traced From Sea to MLW.

Bearings°	Paces[J]
022	10
044	19
042	16
036	12
042	12
028	6
040	13
043	17
044	16
034	35
037	16
037	9
038	25
029	16
042	7
034	9
042	2
060	5
071	14
084	4
093	6
086	15
080	9
064	25
054	12
058	50
034	12
044	39
040	20
042	15
060	6
036	5
050	10
046	14
040	22
040	13

TRACK 7028 (Continued)

Bearings°	Paces[J]
020	13
354	2
067	2
095	35
100	14
085	5
064	3
040	6
044	12
331	17

$\overline{X}$ Track Bearing = 048.04

Track Variance = 545.340

TRACK 7029/7030

East Lake Wallace: Lakeshore Attempt: 1205 Hours: Sun Visible: Visibility 1 Mile : Wind 10 mph from 330°: No Surf Data: Track Tracing Starts on Lakeshore with Outbound Leg.

Bearings°	Paces[R]
182	20
176	10
183	9
175	39
182	4
175	24
173	9
184	11
165	18
187	5
173	26
164	18
175	8
163	12
170	18
166	7
168	25
178	39
187	12
015	13
024	28
015	17
012	21
021	5
005	14
010	26
005	43
360	12
006	10
360	71
352	55
334	10

$\bar{X}$ Track Bearing Outbound 174.20°

$\bar{X}$ Track Bearing Inbound 004.26°

Track Variance Outbound 42.487

Track Variance Inbound 113.472

TRACK 7031/7032

MLW: Seashore Attempt: 2010 Hours: 90% Overcast: Visibility 1/8 Mile: Wind 10 mph from 270°: No Surf Data: Track Tracing starts on seashore with inbound leg.

Bearings°	Paces[R]
045	8
050	19
060	43
073	21
079	9
094	25
114	7
089	6
075	5
081	20
055	13
049	11
027	23
021	7
065	5
048	13
237	4
225	6
198	5
182	7
213	6
189	6
209	2
190	6
209	5
225	16
198	5
149	4
191	13
170	4
190	7
152	4
182	3
196	12
206	22
250	12

$\bar{X}$ Track Bearing Inbound 062.90°
$\bar{X}$ Track Bearing Outbound 203.32°
Track Variance Inbound 477.314
Track Variance Outbound 535.115

TRACK 7039/7040

WLW: Seashore Attempt: 0545 Hours: Sun Visible: Visibility 1/2 Mile: Wind 15 mph from 170°: No Surf Data: Track Tracing Starts on Seashore With Inbound Leg.

Bearings°	Paces[R]
045	17
031	19
026	4
021	10
031	20
035	11
028	18
034	25
040	10
043	16
031	5
021	5
026	4
027	4
023	5
046	3
034	7
052	6
074	7
068	3
058	3
045	3
040	4
032	6
038	7
028	14
045	9
040	13
045	5
035	43
027	13
340	3
017	28
016	27
360	9
025	17
359	35
349	6
067	12

TRACK 7039/7040 (Continued)

Bearings°	Paces[R]
054	7
061	9
070	16
078	31
063	22
080	5
069	16
060	17
080	6
061	17
069	17
052	81
044	4
041	14
055	3
044	29
039	22
033	14
030	6
025	17
040	16
034	29
031	10
015	30
021	11
016	26
005	9
355	13
345	11
272	20
255	16
230	9
214	42
204	12
223	39
250	20
231	8
244	10
255	8
345	32
228	2
258	8
256	37

TRACK 7039/7040 (Continued)

Bearings°	Paces[R]
270	11
280	12
240	47
260	27
254	23
260	10
255	12
252	36
247	15
245	24
239	19
255	11
232	27
230	40
243	32
226	13
224	18
236	25
235	17
232	26
243	20
237	8
230	26
235	24
222	12
232	21
234	39
229	18
216	14
228	15
220	31
236	41
233	7
225	28
224	27
245	24
180	11

$\overline{X}$ Track Bearing Inbound = 060.50°
$\overline{X}$ Track Bearing Outbound = 216.99°

Track Variance Inbound = 572.414
Track Variance Outbound = 449.761

TRACK 7054/7055

ELW: Lakeshore Attempt: 0445 Hours: Total Overcast Visibility 1/8 Mile: Wind 18 mph from 240°: No Surf Data: Track Tracing Starts on Lakeshore With Inbound Leg

Bearing°	Paces[R]
212	17
196	31
180	22
250	8
236	66
251	50
213	7
120	1
030	9
048	4
024	3
042	60
064	14
036	45
060	24
099	7

$\bar{X}$ Track Bearing Inbound = 046.84°

$\bar{X}$ Track Bearing Outbound = 225.16°

Track Variance Inbound = 260.431

Track Variance Outbound = 603.398

TRACK 7056/7057

ELW: Seashore Attempt: 0725 Hours: Sun Visible: Visibility ca. 1/4 Mile: Wind 16 mph from 170°: No Surf Data: Track Tracing Starts on Seashore with Inbound Leg.

Bearings°	Paces[R]
200	13
220	10
186	13
234	13
206	16
186	98
159	7
194	10
211	8
196	9
206	35
214	21
204	13
186	20
212	12
216	10
172	15
120	35
156	8
136	5
158	13
022	11
062	28
049	9
088	11
060	10
080	8
074	11
055	74
068	11
061	5
096	20
210	6
261	9
281	6
055	11
077	18
176	4

TRACK 7056/7057 (Continued)

Bearings°	Paces[R]
155	10
163	33
146	11
165	35
157	19
150	54
141	5
161	28
070	33
023	31
020	15
036	13
028	11
003	14
026	9
034	10
003	8
002	22
023	38
348	13
022	35
321	73
338	15
352	12
002	31
040	20
072	44

$\overline{X}$ Track Bearing Inbound = 017.06°

$\overline{X}$ Track Bearing Outbound = 195.72°

Track Variance Inbound = 239.477

Track Variance Outbound = 1197.310

TRACK 7058

ELW To Sea:* 1655 Hours: Sun Visible: Visibility 10 Miles: Wind 15 mph from 020°. No Surf Data: Track Traced From Sea to Lake

Bearings°	Paces[R]
030	21
066	15
076	15
065	37
066	17
047	38
032	23
057	9
032	15
016	19
036	10
017	4
030	29
044	14
034	44
030	20
008	12
018	10
003	6
022	12
032	15
022	6
040	7
025	5
035	21
020	23
040	4
025	10
044	6
030	6
038	14
023	3
041	29
046	29
046	9
053	7

TRACK 7058 (Continued)

Bearings°	Paces[R]
026	6
032	25
032	5
016	12
036	14
001	11
020	12
011	19
028	13
014	25
038	8

$\overline{X}$ Track Bearing = 215.03° Track Variance = 276.051

TRACK 7060

ELW: Lakeshore Attempt*: 0510 Hours: Complete Overcast: Visibility 8 Miles: Wind 21 mph from 100°: No Surf Data: Inbound Leg Only: Track Traced from Lake Toward Sea

Bearings°	Paces[R]
250	67
156	59
188	33
208	23
214	21
231	27
216	14
212	15
226	23
040	7
220	11
240	77

$\overline{X}$ Track Bearing = 016.62° Track Variance = 2463.066

TRACK 7061

ELW: Lakeshore Attempt: 1750 Hours: Total Overcast: Visibility 1/4 Mile: Wind 5 mph from 060°: Nor Surf Data: Inbound Leg Only: Track Traced from Lake Toward Sea

Bearings°	Paces^R
195	18
187	17
200	46
200	25
200	16
203	8
208	20
200	26
206	12
198	13
204	29
211	97
207	20
210	71
203	37
217	19
207	30
200	15
204	13
216	3
206	6
198	4
192	6
200	12
188	7
198	25

$\overline{X}$ Track Bearing = 026.08° Track Variance = 31.888

TRACK 7101

ELW To Sea: 1854 Hours: Sun Not Visible: Visibility 250 Yards: Wind 5 mph from 100°: Partial Surf Data Recorded: Track Traced From Lake to Sea

TRACK		SURF BEARINGS$^{\circ}$			
Bearings$^{\circ}$	Paces	High Continuous	High Intermittent	Low Continuous	Low Intermittent
260	5	140			
220	17	140			200
200	29	130			200
180	17				
200	22	130			200
210	20				
190	12				
200	58	140			210
210	41	140			200
200	26				
170	4				
200	31				
205	9	150			210
190	24	130			180
170	20				
180	13				
170	31	130			210
180	178	130			210
200	16				
190	13				
200	8				
180	25				
190	24				
180	15				
210	62				

$\overline{X}$ Track Bearing = 192.47°

TRACK 7102

SEA TO MLW*: 0540 Hours; Sun Visible; Visibility 10 Miles; Wind 5 mph from 145°; Partial Surf Data Recorded: Track Traced From Lake to Sea

Bearings°	Paces[J]
338	24
262	40
240	10
268	27
High Continuous Surf 167°	
230	15
217	9
High Surf 160°	
180	15
180	14
High Surf 160° ; Low Surf 248°	
199	26
129	17
High Surf 163°	
203	49
High Surf 161°	
210	17
High Surf 149°	
171	38
High Surf 148°	
144	64
212	2
High Surf 152° ; Low Surf 203°	
155	16
High Surf 137° ; Low Surf 199°	
177	19
High Surf 155° ; Low Surf 205°	
189	23
High Surf 159° ; Low Surf 198°	
199	72
High Surf 159° ; Low Surf 190°	
193	24
201	11
183	8
High Surf 149° ; Low Surf 189°	
201	45
High Surf 148° ; Low Surf 184°	

TRACK 7102 (Continued)

Bearings°	Paces[J]
211	52
203	19
225	11

$\overline{X}$ Track Bearing = 022.47° Track Variance = 1736.582

TRACK 7103

Sea to WLW: 0535 Hours: Sun Visible: Visibility 10 Miles: Wind 5 mph from 145°: Partial Surf Data: Track Traced From Sea to WLW

Bearings	Paces[R]
014	15
110	13
016	16
004	25
354	12
351	34
High Surf 145° ;	Low Surf 189°
003	8
346	5
High Surf 138° ;	Low Surf 204°
341	45
High Surf 138° ;	Low Surf 192°
325	6
307	10
324	11
High Surf 142 ;	Low Surf 178°
360	42
High Surf 143° ;	Low Surf 192°
352	15
343	12
High Surf 145° ;	Low Surf 185°
349	15
350	31
High Surf 138° ;	Low Surf 180°
355	57
High Surf 143° ;	Low Surf 180°
350	79
High Surf 150° ;	Low Surf 182°
347	12
338	5
High Surf 145° ;	Low Surf 180°
342	12
334	10
345	31
High Surf 152° ;	Low Surf 180°
325	27
312	6

TRACK 7103 (Continued)

Bearings		Paces[R]
336		11
High Surf 150°	;	Low Surf 195°
325		41
High Surf 148°	;	Low Surf 200°
312		25
High Surf 159°	;	Low Surf 190°
330		29
325		7
330		7
322		10
325		30
High Surf 144	;	Low Surf 195°
330		35
High Surf 153°	;	Low Surf 202°
325		19
330		29
340		14
High Surf 158°	;	Low Surf 180°
336		22
310		35
326		20

$\overline{X}$ Track Bearing = 340.28° Track Variance = 267.315

TRACK 7106

MLW To Sea: 0602 Hours: Sun Visible:
Visibility > 3 Miles: Wind 25 mph from 135°:
Partial Surf Data Recorded: Track Traced
From MLW to Sea

Bearings°		Paces[R]
Surf:	186°; 156°	
205		90
Surf:	160°; 185°	
197		22
Surf:	155°; 185°	
194		81
Surf:	156°; 184°	
183		13
190		29
Surf:	154°; 182°	
196		24
207		24
Surf:	183°	
201		40
197		73
Surf:	186°; 161°	
198		29
Surf:	186°; 167°	
202		16
185		15
180		42
Surf:	160°; 200°	
172		25
Surf:	160°; 200°	
188		27
206		36
204		45

$\overline{X}$ Track Bearing = 196.13° Track Variance = 80.364

TRACK 7107/7197

ELW: Seashore Attempt: 0649 Hours: Sun Visible: Visibility 3 Miles: Wind 25 mph from 135°: Partial Surf Data: Track Tracing Starts at Turning Point of Track and Records the Inbound Leg, and Then Returns to the Turning Point and Traces the Outbound Leg

Bearings°	Paces[R]
Surf: 160° : 210°	
180	15
190	30
Surf 160° : 200°	
185	73
Surf 120° : 200°	
170	100
Surf 130° : 190°	
190°	62
Surf 140° : 190°	
210	11
190	10
Surf 160° : 220°	
150	46
Surf 140° : 190°	
185	101
Surf 130° : 180°	
180	32
185	43
Surf: 180°	
180	42
Surf 150° : 200°	
195°	139
Surf 163° : 183°	
227	22
Surf 170° : 198°	
230	100
Surf 164° : 187	
223°	87
Surf 160° : 179°	
238	19
241	48
Surf: 192°	
246	28
Surf 192°	
254	72

TRACK 7107/7197 (Continued)

Bearings	Paces[R]
Surf 170° : 194°	
226	12
248	12
254	39
Surf 180° : 194°	
232	181
Surf 176° → 223°	
223°	200

$\overline{X}$ Track Bearing Inbound 052.74°

$\overline{X}$ Track Bearing Outbound 183.04°

Track Variance Inbound 111.019

Track Variance Outbound 144.453

TRACK 7108

Sea to ELW: 0610 Hours: Sun Not Visible: Visibility 10 Miles
Wind 10 mph from 260°: Partial Surf Data Recorded: Track Traced
From Sea to ELW

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
043	20				
031	9				
047	11				
041	32	262			212
027	13				
045	13		238	194	
028	7				
013	6				
039	5	255			230
030	41	253			230
010	38	256			215
020	13				
035	13	250			218
012	7				
028	59	258			227
035	28				
043	29		220	258	
057	8				
042	42		223	258	
039	16				
042	46		222	262	
050	33		224	265	

TRACK 7108 (Continued)

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
030	18				
044	17		230		
053	24		229	260	
050	28				
034	30		220	259	
045	27				
038	28				
028	103				

$\bar{X}$ Track Bearing = 035.64°

Track Variance = 111.586

TRACK 7109

Sea to MLW: 050 Hours: Sun Visible: Visibility Clear: Wind From West at 6 mph: Track Traced From Sea to MLW

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
358	18				
357	16	240			184
348	25	260			202
358	37	256			190
352	43	258			195
356	33	264			190
360	16	254			194
354	12	263			198
358	47	258			188
004	16	257			206
358	88	266			190
350	17	265			196
354	42	262			192
358	40	280			214
351	78	265			194
357	17	263			188
346	25				
338	11				
358	13				
352	8				
320	2				

$\overline{X}$ Track Bearing = 354.65°

Track Variance = 24.902

TRACK 7110

WLW To Sea: 0900 Hours: Sun Visible: Visibility 10 Miles:
Wind 20 mph from 240°: Track Traced from Lake to Sea

Track Bearings°	Track Paces[R]	Surf Bearings° High Continuous	Surf Bearings° High Intermittent	Surf Bearings° Low Continuous	Surf Bearings° Low Intermittent
211	11				
232	29	228			222
210	12	212			
204	23	248			208
197	12	240			214
210	20	250			208
194	25		198	244	
201	30		206	236	
186	25		223	255	
194	95		219	260	
125	23		220	255	
165	6		196	265	
150	31				
178	40		230	253	194
190	75		201	256	
209	13				
211	74				
198	16				
205	22				
230	21				
198	14				

$\bar{X}$ Track Bearing = 194.94 Track Variance = 484.357

TRACK 7111

MLW to Sea: 1906 Hours: Sun Visible: Visibility 10 Miles: Wind 10 mph from 265°: Track Traced From Lake to Sea

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
202	17	255			204
203	37	240			190
191	11	225			185
214	17	230			191
218	43	225			185
210	30	235			187
230	11	230			192
208	45	242			210

$\overline{X}$ Track Bearing = 209.71

Track Variance = 68.520

TRACK 7112

Sea to MLW: 0555 Hours: Total Overcast: Visibility 200 Yards: Wind 11 mph from 262° Track Traced From Sea to MLW: Partial Surf Data

Track		Surf Bearings°			
Bearings	Paces[W]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
048	4				
063	14				
035	6				
060	5		275	170	
005	12				
002	31		254	227	
014	9		258	220	
006	9		262	225	
012	19		260	222	
010	11				
012	31		268	220	
002	7		269	226	
017	33		264	218	
007	18		272	220	
002	18		270	224	
013	12		268	220	
010	29		266	220	
025	22		270	226	
026	21		260	228	
024	40		270	222	
040	16		271	234	
052	29		271	230	
058	15		262	223	
047	24		268	224	
044	26		257	224	
032	37				
096	2		260	220	

TRACK 7112 (Continued)

Track		Surf Bearings°			
Bearings°	Paces[W]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
186	4		264	224	
241	9		258	226	
249	7		260	226	
223	14		262	228	
230	16		263	228	
272	3		260	220	
338	69				

$\overline{X}$ Track Bearing = 024.79°

Track Variance = 316.560

TRACK 7113

Sea to ELW: 1905 Hours: Sun Not Visible: Visibility< 500 Yards:
Wind 8 mph from 230°: Track Traced From Sea to ELW

Track		Surf Bearings°			
Bearings°	Paces^{R}	High Continuous	High Intermittent	Low Continuous	Low Intermittent
016	9				
350	13				
009	34				
352	31	246			140→235
356	24	258			214
354	29	255			192
360	10	262			191
350	7	189			263
003	25	189			269
340	58	187			256
348	24	180			252
345	21	180			213
327	12	171			252
004	48	165			266
356	56	178			261
001	10	186			258
359	89	180			252
004	18	172			252
334	32	176			255
340	17	159			247
346	8	168			248
336	18	162			244
342	67	162			247
354	48	168			248
003	29	165			246
352	41	172			241
353	49	167			241
350	37	175			245

$\bar{X}$ Track Bearing = 352.41°　　Track Variance = 92.886

TRACK 7115/7174

WLW: Lakeshore Attempt: 1928 Hours: No Cloud: Visibility 10 Miles: Wind 250° at 13 mph: Track Tracing Starts on Lakeshore With Outbound Leg

Track		Surf Bearings°			
Bearings°	Paces[W]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
174	14		196	234	
191	14		204	241	
199	17		202	234	
180	3		210	250	
199	6		204	250	
220	2		210	246	
191	3		207	254	
220	6		210	251	
203	6		205	254	
219	10		206	252	
233	5		210	254	
223	9		210	257	
225	9		204	250	
215	27		212	250	
224	21		213	253	
234	23		206	246	
254	25		206	248	
Bearings°	Paces[B]				
324	6		186	238	
340	5		184	244	

TRACK 7114/7174 (Continued)

Track		Surf Bearings			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
360	11		176	236	
008	9		182	236	
016	22		188	228	
026	14		190	230	
008	40		200	242	
010	13		186	228	
358	15		184	234	
004	16		188	240	
272	2		180	234	
336	6		180	234	
350	23		184	238	

$\bar{X}$ Track Bearing Outbound 217.03°

$\bar{X}$ Track Bearing Inbound 002.23°

Track Variance Outbound = 472.069

Track Variance Inbound = 274.518

TRACK 7115

WLW To Sea: 1928 Hours: Sun Visible: Visibility 10 Miles: Wind 13 mph from 250°: Track Traced from Lake to Sea

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
190	8		208		
185	22		206	245	
199	22		198	255	
194	20		210	263	
188	7		188	225	
206	10		195	231	
208	71		205	246	
211	9		198	237	
220	37		196	262	
210	37		199	254	
203	35		207		
235	20		218	250	
220	21		222	251	
095	4		190	237	
054	8		210	258	
165	7		207	175	
204	42		206	256	
192	35		220	182	
158	28		170	230	
182	26		178	238	
199	15				
190	22				
202	31				
216	133				

$\overline{X}$ Track Bearing 201.18° Track Variance = 574.015

TRACK 7116

ELW To Sea: 0650 Hours: Sun Visible: Visibility ≥ 5 Miles: Wind <5 mph from 090°: Track Traced From Lake To Sea

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
192	17	136			203
202	10				207
188	17	141			200
180	24				199
174	10				204
188	19				203
188	13				208
192	54				208
180	16				208
188	24				208
200	22				212
220	24				211
215	14				215
200	14				214
222	62				202
224	118				220
214	28				200
206	54				191
195	44				
184	23				
175	30				

$\overline{X}$ Track Bearing 203.23° Track Variance 283.658

TRACK7117

WLW To Sea: 1958 Hours: Sun Visible: Visibility 10 Miles:
Wind 10 mph from 236°: Track Traced From Lake to Sea

Track		Surf Bearings°			
Bearings°	Paces[W]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
240	7	265		216	
216	9	268		206	
228	10	264		216	
200	20	266		206	
224	23	264		202	
207	12	256		204	
218	7	256		210	
205	16	260		210	
220	18	252		218	
214	30	260		210	
218	22	260		214	
210	11	264		202	
214	11	266		202	
204	24	264		208	
217	55	270		216	
206	42	270		202	
214	112	280		212	

$\overline{X}$ Track Bearing = 213.61°

Track Variance = 50.435

TRACK 7118

Sea To ELW*: 1945 Hours: Sun Not Visible: Visibility 10 Miles:
Wind 10 mph from 265°: Track Traced From ELW To Sea

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
214	12		216	248	
229	6		215	250	
200	49		216	253	
213	90		210	263	
216	16		202	252	
211	85		211	256	
209	38		210	255	
214	50		211	252	
211	208		208	258	
230	16				
240	18				
248	60				
258	8				
251	30				
236	30				

$\overline{X}$ Track Bearing = 039.70°

Track Variance = 194.950

TRACK 7119

Sea To WLW*: 1926 Hours: Sun Visible: Visibility > 5 Miles:
Wind 10 mph from 244° : Track Traced From WLW To Sea

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
212	16	212		257	
204	28	206		248	
232	5	200		254	
204	20	204		252	
216	17	204		249	
212	44	216		262	
216	22	207		275	
208	13	202		254	
216	30	213		244	
225	35	207		270	
209	52	206		265	
210	70	198		264	
201	54	204		270	
174	5	200			
192	20				

$\overline{X}$ Track Bearing = 029.51

Track Variance = 72.807

TRACK 7120/7190

WLW: Lakeshore Attempt: 2008 Hours: Moon Visible: Visibility 5 Miles: Wind 5 mph from 168°: Track Tracing Starts on Lakeshore With Inbound Leg

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
194	13	200		272	
176	20	190			
194	31	194		262	
200	18	204			
182	117	190			
195	67	182		248	
195	60	220; 226			
198	20	200			
061	7	184			
012	44	206			
358	44	194			
007	73	182		260	
010	63	190		266	
360	12	192		254	
014	27	204		335	
040	23	214		344	
002	21	186			
338	23	188		230	
358	24	180		256	

$\bar{X}$ Track Bearing Inbound = 009.81°　　Track Variance Inbound = 53.049

$\bar{X}$ Track Bearing Outbound = 187.74°　　Track Variance Outbound = 205.583

TRACK 7122

MLW To Sea: 2045 Hours: Moon Visible: Visibility 10 Miles:
Wind 2 mph from 254° Track Traced From Lake To Sea

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
196	20	224		240	
204	27	214		254	
200	51	214		250	
213	22	226		252	
214	25	220		255	
210	62	216		246	
204	127	210		248	
212	29	217		248	
200	14	209		256	
194	20	202		250	
202	14	218		261	
196	45	212		256	
192	10	234		202	
176	17	216			
188	17				
194	56				

$\bar{X}$ Track Bearing = 203.35

Track Variance = 94.151

TRACK 7124

MLW To Sea: 0550 Hours: Sun Not Visible: Visibility 5 Miles:
Wind 070 at 2 mph: Track Traced From Lake To Sea

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
194	35		258		
025	17	244	264		
193	25	276	272		
204	19	196		270	
210	10	200		270	
192	16	190			275
205	31	186			226
206	66	179		265	
210	22	176		274	
202	47				272
208	84	155		273	
200	32			278	
179	37			278	
193	75	190			
176	78				
195	32				

$\overline{X}$ Track Bearing = 191.84°

Track Variance = 895.170

TRACK 7125

ELW To Sea: 1920 Hours: Sun Visible: Visibility 10: Wind < 5 mph from 016°: Track Traced From Lake To Sea

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
191	10			051	
180	47			051	
186	100			071; 031	
200	11			061; 086	
192	51			065; 041	239
203	14			061	219
195	29			061; 040	233
183	30			060; 027	234
200	30			062; 027	224
202	75			058; 026	188
230	17			058; 025	210; 235
204	34		262	022; 060	204
211	63		260	024; 057	210
202	37		266	048	235; 200
189	11				
187	45	255		045	178 → 236
194	34				

$\overline{X}$ Track Bearing = 195.61 Track Variance = 115.673

TRACK 7126

ELW To Sea: 1835 Hours: Sun Not Visible: Visibility 10 Miles:
Wind < 2 mph from 170°: Track Traced From Lake To Sea

Track		Surf Bearings°			
Bearings°	Paces^R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
245	10		185		242
213	8	208	186	250	239
198	15	205		238	
226	7	210		247	246
203	23	188		246	
201	51		210	254	248
209	58		188	267	258
203	20	210	185	272	
201	90	154	182	270	
203	40	152	166	238	273
187	7	188	165	248	270
198	52	188 →216	160	245	272
191	14	184	148	238	268

$\overline{X}$ Track Bearing = 203.28°

Track Variance = 75.996

TRACK 7130

ELW To Sea: 2005 Hours: No Moon Visible: Visibility 1/8 Mile:
Wind < 5 mph from 231°: Track Traced From ELW To Sea

Track		Surf Bearings°			
Bearings°	Paces[D]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
206	11	195		255	
219	17	195		235	
205	85	205		234	
206	123	202		231	
188	23	190		237	
148	25	188		246	
182	31	170→212		235	
201	62	172→197		244	
205	85	230→168		276	
206	63	194→222		276	

$\overline{X}$ Track Bearing = 200.54° Track Variance = 187.323

(The remaining 16 spontaneous adult tracks are the precapture tracks of the relocated adults. These tracks can be found in Appendix E.)

APPENDIX D

Regression Analysis II

Adult Spontaneous Crossings

II: Criterion = Adult Mean Track Bearings; Spontaneous Crossings

PROGRAM A: LAKE TO SEA TRACKS

Full Model (Model 1.) Cast To Determine The Amount of Variance Among Mean Track Bearings Accounted For By Ten Predictors:

$$Y_1 = a_0 u + a_2 X_2 + a_3 X_3 + a_4 X_4 + a_5 X_5 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + E_1$$

Where :

Y_1 = Seabound Mean Track Bearings

$a_2 X_2$ = Time of Departure for Each Track in the Criterion Vector

$a_3 X_3$ = 1 if Track was Made When Visibility Was $\leq$ 1/2 Mile: 0 Otherwise

$a_4 X_4$ = 1 if Track was Made When Sun Visible: 0 Otherwise

$a_5 X_5$ = Wind Direction Prevailing for Each Track in the Criterion Vector

$a_6 X_6$ = Wind Speed Prevailing for Each Track in the Criterion Vector

$a_7 X_7$ = 1 if Track Was Made Between Sea and Middle Wallace: 0 Otherwise

$a_8 X_8$ = 1 if Track was Made Between Sea and East Wallace: 0 Otherwise

$a_9 X_9$ = 1 if Track was Made Between Sea and West Wallace: 0 Otherwise

$a_{10} X_{10}$ = 1 if Track was Made East of East Wallace: 0 Otherwise

Models Placing Restrictions on Model 1 (Notation As Above)

MODEL 2 $Y_1 = a_0 u + a_3 x_3 + a_4 x_4 + a_5 x_5 + a_6 x_6 + a_7 x_7 + a_8 x_8 + a_9 x_9 + a_{10} x_{10} + E_1$

MODEL 3 $Y_1 = a_0 u + a_2 x_2 + a_4 x_4 + a_5 x_5 + a_6 x_6 + a_7 x_7 + a_8 x_8 + a_9 x_9 + a_{10} x_{10} + E_1$

MODEL 4 $Y_1 = a_0 u + a_2 x_2 + a_3 x_3 + a_5 x_5 + a_6 x_6 + a_7 x_7 + a_8 x_8 + a_9 x_9 + a_{10} x_{10} + E_1$

MODEL 5 $Y_1 = a_0 u + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_6 x_6 + a_7 x_7 + a_8 x_8 + a_9 x_9 + a_{10} x_{10} + E_1$

MODEL 6 $Y_1 = a_0 u + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5 + a_7 x_7 + a_8 x_8 + a_9 x_9 + a_{10} x_{10} + E_1$

MODEL 7 $Y_1 = a_0 u + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5 + a_6 x_6 + E_1$

MODEL 8 $Y_1 = a_0 u + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5 + a_6 x_6 + a_7 x_7 + a_8 x_8 + a_9 x_9 + a_{10} x_{10} + a_{11} x_{11} + E_1$

Where:

$a_{11} x_{11} = a_5 x_5 * a_6 x_6$

F Ratios Comparing Model 1 With Its Various Restricted Models, And Comparing Model 1 And Model 8 With Model 90 (A Built In Model Which has $r^2 = 0$).

F Ratio	D.F. Num.	D.F. Den.	Model	r^2	Model	r^2	Probability
1.3924	7	21	1	0.31701	90	0.0	0.25996
1.1636	8	20	8	0.31761	90	0.0	0.36721
1.0280	1	21	1	0.31701	2	0.28358	0.32216
5.4967	1	21	1	0.31701	3	0.13824	0.02896
2.8769	1	21	1	0.31701	4	0.22344	0.10463
2.1742	3	21	1	0.31701	7	0.10487	0.12123
0.5077	1	21	1	0.31701	5	0.30050	0.48395
0.9598	1	21	1	0.31701	6	0.28579	0.33836
0.0176	1	20	8	0.31761	1	0.31701	0.89561

PROGRAM B: SEA TO LAKE TRACKS

Criterion Vector (Y_1) = Lakebound Mean Track Bearings

Models 1 to 8 = Same As In Program A

F Ratios Comparing Model 1 With Its Various Restricted Models, And Comparing Model 1 and 8 With Model 90 (A Built In Model Which Has $r^2 = 0$).

F Ratio	D.F. Num.	D.F. Den.	Full Model	r^2	Restricted Model	r^2	Probability
1.1315	7	28	1	0.22049	90	0.0	0.37211
1.0286	8	27	8	0.23359	90	0.0	0.43924
0.0150	1	28	1	0.22049	2	0.22008	0.90324
0.0780	1	28	1	0.22049	3	0.21832	0.78199
1.1251	1	28	1	0.20049	4	0.18917	0.29787
0.6789	3	28	1	0.22049	7	0.16380	0.57230
0.2801	1	28	1	0.22049	5	0.21270	0.60078
1.7174	1	28	1	0.22049	6	0.17268	0.20066
0.4612	1	27	8	0.23359	1	0.22049	0.50281

APPENDIX E

Adult Relocation: Precapture and Post Release Tracks, With Relevant Meterological And Surf Sound Information.

TRACK 7129

<u>Precapture Track</u>: 0540 Hours: Sun Not Visible: Visibility 1 Mile In Rain: No Wind: Seal Moving Toward East Lake Wallace (ELW): Track Traced From Seashore To Interception Point

Track		Surf Bearings°			
Bearings°	Paces[R]	Low Continuous	Low Intermittent	High Continuous	High Intermittent
031	15	204			158
042	40	150→196			
053	42	140			172
024	18	145			166
043	7	148			186
033	20	145			176
029	43	145			188→166
039	100	145			180
034	25	184			144→200

$\bar{X}$ Track Bearing = 037.94°

Track Variance = 61.322

TRACK 7129 (Continued)

Post Release Track: 0658 Hours: Sun Not Visible: Visibility 1 Mile: Wind < 5 mph from 140°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
020	22	190			150
036	8	135			162
052	13	135		156	
041	36			160	130
030	27	128		166	
060	12	130		166	
109	13	126			170
138	61	124			166
145	33			123	156
160	28	135		177	158
180	73		144	186	
184	21		146	176	
171	58		175		140
178	49		140	170	
190	6				
200	35				
222	4				
180	52				

$\overline{X}$ Track Bearings = 170.75°

Track Variance = 357.568

TRACK 7131

Precapture Track: 0602 Hours: Sun Not Visible: Visibility 2 Miles In Fog: Wind < 5 mph from 200°: Seal Moving Toward ELW: Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
207	30		190→204		238→270
200	20		174→215		243→275
215	10		190→216		246→270
194	101		165→221		246→270
170	10		160→208		230→274
198	56		158→212		218→272
180	46		155→235		250→282
189	38		148→246		250→270
203	7		148→236		244→290
195	17		155→267		220→290
274	9		164→267		200→288
194	10		150→276		184→290

$\overline{X}$ Track Bearing = 015.89° Track Variance = 236.548

TRACK 7131 (Continued)

Post Release Track: 0644 Hours: Sun Not Visible: Visibility 1/2 Mile: Wind 180°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
018	11	251;176;214;263		243	
004	4	195→212		253	
013	8	169→199		248	
026	12	161→216			258
360	30	154		249	215
348	48	147		255	180
332	34	177		245	
315	19	183		240	215
334	24			248	196
324	25			241	203
308	9	170		250	187
265	8	193→212		244	
243	11	206		226→248	
235	10	186		255	220
226	16	194		247	
216	24	183		250	
210	64	174		250	
200	40	185		256	
210	42	171		253	206
190	20			266	197
187	55		166;185	261	
206	41	200	181	256	
202	54	238	175	273	221
191	54	206	196	264	
204	60	235→170		278	208
206	32				

$\bar{X}$ Track Bearing = 203.12°

Track Variance = 106.082

TRACK 7132

Precapture Track: 0755 Hours: Sun Not Visible: Visibility 2 Miles: Wind < 5 mph from 220°: Seal Moving Toward ELW; Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
167	25		182→216		250→284
188	46		171→228		260
174	16		164→220		260
181	125		166→232		270
176	33		180→240		252→275
164	85		154→232		267→280
156	56		174→253		272
186	34		164→243		260→277
175	20		175→240		173;284
156	12		177→230		174;283
146	7		165→220		284
159	31		162→210		283
176	12		180→246		158; 273
188	68		158→252		283

$\overline{X}$ Track Bearing = 354.14°

Track Variance = 136.446

TRACK 7132 (Continued)

Post Release Track: 0817 Hours: Sun Not Visible: Visibility <1/4 Mile: Wind From 185°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
348	4	169→200	215	263	
306	5	265	218		
282	12	260	211		
262	21	203	247	260	
226	37	235	202	270	
214	20	206→243			
200	21	215		276	
214	15	178→218		264	232
204	49	188	235	263	
211	17	189→299	223	272	
206	18	186→215		277	
216	44	191→234	220	273	
210	25	184→238		270	
197	82			278	168

$\overline{X}$ Track Bearing = 208.08

Track Variance = 86.697

TRACK 7133

Precapture Track: 0555 Hours: Sun Not Visible: Visibility 1/2 Mile In Fog: Wind 5 mph From 147°: Seal Moving Toward ELW: Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
225	37	170→220		162→268	
187	5	177→208		160→274	
200	24	172→205		158→270	
193	32	173→208		168→283	
198	67	174→216	200;190	162	
201	21	208	214	248	170
189	10	156→203		273	181
203	19	168→212		279	204
214	23	153	197		174

$\bar{X}$ Track Bearing = 023.33°

Track Variance = 122.187

TRACK 7133 (Continued)

Post Release Track: 0643 Hours: Sun Not Visible: Visibility 1 Mile: Wind < 5 mph From 168°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
334	2	180	155	231	
314	5	191	155	260	
302	13	215;188		274	
322	24	213		278	
270	16	223	188	280;135	
244	16	200	154	286	
226	19	174		274;150	
220	30	191	195	275	
216	43	186		266	151
216	75	174→146		271	
202	32	139→188			203
206	48	138→190			208
200	43	120→246;156		212	

$\overline{X}$ Track Bearing = 213.20°

Track Variance = 113.066

TRACK 7134

Precapture Track: 1000 Hours: Sun Visible: Visibility 2 Miles In Fog; Wind 5 mph From 170°: Seal Moving to ELW: Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
223	38	174		153	
219	25		187	152	
204	65		180→207	156	
213	24		193	152	
201	49		187	145	
196	42	180		139	
200	79		174→189	145	
207	54		166→180	142	
216	75		168→191	156	
025	13		162→180;208	150	
006	17		165→186; 210	148	
350	11		164→205	156	
358	31		157→205	138	
355	15		180→223	149	
014	47		178→200	146	
182	11		177→187; 210	144	
188	12		178;201	143	
180	17		180;203	146	
185	77		180;210	142	
185	73				
188	10		148→226	130	
170	38		136→226		

$\overline{X}$ Track Bearing = 018.82°

Track Variance = 199.296

TRACK 7134 (Continued)

Post Release: 1025 Hours: Sun Visible: Visibility *ca*. 2 Miles
Wind 5 mph From 158°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
020	11		206;148	256	
022	5		160→210	128	152
018	16		169;206	141	
015	43		171→208	144	
360	18		170→220	135	
332	23		170→210	128	
308	10		171→185	137	
255	7		178→212	148	
205	24		170→214	145	
208	80		171→210	144	
239	8				
201	69		173→190	148	
210	14		146→204	140	
193	25		151→204	132	
208	34		164→227	140	
190	10		160→220	143	
200	38		140→208		
190	35		146→225	125	

$\overline{X}$ Track Bearing = 202.75 Track Variance = 73.301

TRACK 7135

Precapture Track: 0612 Hours: Sun Visible: Visibility 10 Miles: Wind <5 mph From 040°: Seal Moving To ELW; Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
204	26	147		203	
190	9	141		186	
208	9	140		270	
215	52	136		205	
203	31	132		203	
210	31	140	205	268	
215	31	134	200	219	

$\overline{X}$ Track Bearing = 029.17

Track Variance = 42.525

TRACK 7135 (Continued)

Post Release Track: 0644 Hours: Sun Visible: Visibility 1-5 Miles In Fog: Wind < 5 mph From 035°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces^{R}	High Continuous	High Intermittent	Low Continuous	Low Intermittent
348	13			122	055
335	11		060	105	199
349	51		064	118	174
341	14		066	115;178	
336	39		067	126	185
323	22		070	132	193
316	36		061	145;192	
276	12		070	127;190	
257	8		065	130;192	
240	22		061	122	192
231	40		052	120;180	
235	12		072	118;182	
220	45		020;058	168;115	
214	18		042	186;108	
205	38			118;183	
200	70			114;166	215
218	32			182;125	237
208	35			118;182	160;204
205	61			198;134;160	
202	22		140	180→212	
214	69		130→145	172→219	

$\bar{X}$ Track Bearing = 211.96° Track Variance = 94.127

TRACK 7136

Precapture Track: 0550 Hours: Sun Not Visible: Visibility 3/4 Mile: Wind 12 mph From 193°: Seal Moving Toward ELW: Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
182	41	180→230	220	252	
176	44	164→230		254	
182	61	164→220	200→230	266	
197	8	162→199;250	207		
184	51	170→240	214→228		

$\overline{X}$ Track Bearing = 001.80

Track Variance = 17.460

TRACK 7136 (Continued)

Post Release Track: 0635 Hours: Sun Not Visible: Visibility 150 Yards: Wind 180°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
014	6	174→206		258	
345	17	170→216		262	
328	5	163→234		246	
332	7	164→216		262	
320	45	176→221		270	
314	60	163→226		270	
308	19	162→208		266	210
302	11	174→222		256	
308	14	176	214	270	
298	25	174→220		251	
283	30	180→224			
302	35	186→218	196	268	
308	11	170→204	184	244	
298	27	187→226		259	
320	100	202→232		262	
322	100	184→230		272	
336	26	170→216		257	
320	14	172→204		250	
314	21	170→208		247	
320	34	182→210		260	
308	12	190→219		254	
318	40	182→212		245	
326	22	198→170	194	238	

$\overline{X}$ Track Bearing = 312.04°

Track Variance= 174.570

TRACK 7137

Precapture Track: 0550: No Sun Visible: Visibility 550 Yards In Fog: Wind 8 mph From 230°: Seal Moving To ELW: Track Traced From Interception Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
183	20		195	246;260	
178	66		180;206	251	
172	24		175→213	260	
183	5		170→202	260	
163	8		170→216	257	
174	36		172→220	258	228
185	23		178→206	260	230
154	2		180→210	266	
188	8		182→217	268	
196	47		176→228	256	

$\overline{X}$ Track Bearing = 001.16°

Track Variance = 82.764

TRACK 7137 (Continued)

Post Release Track: 0614 Hours: Sun Visible: Visibility 200 Yards In Fog: Wind 8 mph From 233°: Eastern Release Point

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
344	15	186→220		238	
328	41	215		255	
338	13	205→221		267	
355	6	208		253→268	
333	17	203→225		245→265	
346	49	198→227		248	
338	24	201→229		248	
346	40	206→233		248→261	
016	7	211	203	240→257	
358	20		205;205→221	243	
011	88	198→204	206	240	
005	27	184→202		240	
002	19	194→212		232	
004	16	194→211		243	
344	20	205		238	230
331	40	190		227	193
319	22	196		232	
315	42	196		215→231	
329	26	197		220→233	
336	22	200→206		217→228	
312	43	204→220		240→255	
320	43	198		229→255	
330	39	198		218→240	
311	62	199		216	

TRACK 7137 (Continued)

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
303	8	196		222	
290	29	193→204		208→230	
314	27	193		227	
330	37	194		220	
308	12	192→210		226	
290	20	202		228	
282	17	186→204		210→230	
270	29	189		208	221

$\overline{X}$ Track Bearing = 330.41

Track Variance = 629.862

TRACK 7138

Precapture Track: 0525 Hours: Sun Not Visible: Visibility 1/4 Mile: Wind < 5 mph From 263°: Seal Moving Toward ELW: Track Traced From Interception Point To Sea

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
203	27		208	252	
194	14		170→213	260	248
200	83		186→211	262	238
204	21		186→234	260	
198	26		180→220	260	
179	6		180→204	264	
188	17		190→218	270	268
198	15		197→222	272	266
204	12		190→222	266	

$\bar{X}$ Surf Bearing = 018.72°

Track Variance = 27.921

TRACK 7138 (Continued)

Post Release Track: 0605 Hours: Sun Not Visible: Visibility 300 Yards: Wind < 5 mph From 245°: Eastern Release Site

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
007	29			250;210	
340	15	210		250	
348	18	208	226	254	
352	38	198→210	208	240→250	
348	12	208	206	240→250	
340	41		208	240→250	
322	27		214	232→250	
316	44		188→206	236→248	
330	9		196→213	235→248	
310	66		192→206	230→254	
318	14		188→212	236→240	
330	100		188→212	231→243	
332	60		198→210	226→239	
324	37		190→199	224→234	
320	18	188→206		220→231	
328	92	192	196	224→244	
322	14	180	204	216→226	
336	18	180	204	220→232	
342	41	188	203	218→230	
354	57	190	202	232	
336	10		184→190	202→236	
330	14		196	208→228	
312	25		191→204	224→240	

$\overline{X}$ Track Bearing = 332.11 Track Variance = 201.615

TRACK 7151

Precapture Track: 0643 Hours: Sun Visible: Visibility 10 Miles
Wind 10 mph From 296°: Seal Moving Toward ELW: Track Traced From
Seashore To Interception Point

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
015	6	242		178→224	
007	33	248		170→220	
350	30	254		192→234	
008	52	262		216	
020	35	264		219	
028	7	264		222	
017	32	266		212	
031	69	262		222	
014	32	260		214	

$\bar{X}$ Track Bearing = 015.08

Track Variance = 146.250

TRACK 7151 (Continued)

Post Release Track: 0710 Hours: Sun Visible: Visibility 10 Miles:
Wind 10 mph from 296°: Eastern Release

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
046	2	252		202	
086	9	252		202	
052	9	260		184	
028	12	263		210	
358	32	256		202	
346	36	260		202	
330	50	255		208	
316	58	258		202	
300	27	260		206	
280	12	264		204	
256	19	266		208	
234	17	262		210	
222	70	263		214	
212	70	258		210	
206	156	263		220	
218	130	270		196→234	

$\overline{X}$ Track Bearing = 215.80°

Track Variance = 120.452

TRACK 7154

Precapture Track: 0657 Hours: Sun Visible: Visibility 1 Mile: Wind 5 mph From 164°: Seal Moving To ELW: Track Traced From Seashore To Interception Point

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
024	23	200		200	
351	77	155		220	
011	86	170		220	
354	11	162		217	
002	73	168		217	
015	11	170		214	
006	78	166		216	
015	28	177		231	

$\overline{X}$ Track Bearing = 005. 01

Track Variance = 83.868

TRACK 7154 (Continued)

Post Release Track: 0745 Hours: Sun Visible: Visibility >2 Miles: Wind 6 mph from 160°: Western Release

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
056	4	186		220	
066	13	186		220	
032	155	156;188		216	
016	47	170;194		232	
356	43	194		242	
328	18	192		248	
314	50	194		246	
298	60	190		242	
288	60	200		244	
284	56	196		246	
294	209	188		250	
308	100	192		246	
310	78	188		260	
298	14	192		254	
270	56	196		252	
266	25	190		262	
204	103	194		258	

$\overline{X}$ Track Bearing = 308.88°

Track Variance = 2740.462

TRACK 7155

Precapture Track: 0652 Hours: Sun Visible: Visibility 10 Miles: Wind 11 mph from 006°: Seal Moving Toward ELW: Track Traced From Seashore To Interception Point.

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
004	69				160→250
358	22		250		190→220
007	46				202→224
014	62				190→236
017	33		216		190→210
009	53		214		190→215
015	58		240		190→210

$\overline{X}$ Track Bearing = 009.71°

Track Variance = 29.588

TRACK 7155 (Continued)

Post Release Track: 0742 Hours: Sun Visible: Visibility 10 Miles:
Wind 5 mph from 320°: Western Release

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
014	96				208→230
025	74				192→206
034	54				194→212
051	37				
064	28				226
074	109				
102	97				218
079	30				
095	22				
113	30				
124	16				
112	77				
120	117				

$\overline{X}$ Track Bearing = 075.18° Track Variance = 1476.290

TRACK 7157

Precapture Track: 0710 Hours: Sun Not Visible: Visibility 500 Yards In Fog: Wind 19 mph From 262°: Seal Moving Toward ELW: Track Traced From Seashore To Interception Point.

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
016	63	120→280			
020	38	278			198
360	20	276			220
024	70	266		210	
028	154	268		233	

$\overline{X}$ Track Bearing = 022.49°

Track Variance = 51.711

TRACK 7157 (Continued)

Post Release Track: 0806 Hours: Sun Not Visible: Visibility 450 Yards In Fog: Wind 21 mph from 254°: Western Release Site

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
030	25	227			
006	38	208		260	
350	41	216		268	
340	70	210		256	
330	122	218			
310	38	218			
294	46	214			
306	96	223			
318	86	215			

$\overline{X}$ Track Bearing = 327.57°

Track Variance = 537.070

TRACK 7159

Precaputre Track: 0710 Hours: Sun Visible: Visibility > 5 Miles: Wind 9 mph From 206°: Animal Moving Toward ELW: Track Traced From Seashore To Interception Point.

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
029	27		130→266		
040	19		226		172
015	49		252		164
032	38		213		178
023	32				210
014	63		250		190
023	96		237	208	

$\overline{X}$ Track Bearing = 022.59°

Track Variance = 54.711

TRACK 7159 (Continued)

Post Release Track: 0748 Hours: Sun Visible: Visibility 10 Miles
Wind 7 mph from 140°: Western Release.

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
002	13	188			
022	50	178;198			
040	65	180			214
012	25	210;226			
330	47	206;220			
286	21	194;222			
272	92	192			
233	85	186			220
216	76	274			238
204	218	208		236	
194	58	196		212	
206	179	166		212	

$\bar{X}$ Track Bearing = 209.12

Track Variance = 118.159

TRACK 7160

Precapture Track: Track and Meterological Data are the Same as for Track 7159

Post Release Track: 0857 Hours: Sun Visible: Visibility 5 Miles Wind 7 mph From 158°: Western Release Site.

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
004	11	194			
023	15	176			198
045	71	182			206 → 220
057	109	188			222
055	77		200		
074	25	198	220		
102	34		198		
087	81		208		
106	49		202		
084	55	222	192		
107	58	226	216		
158	28	210			

$\overline{X}$ Track Bearing = 076.41°

Track Variance = 921.870

TRACK 7161

Precapture Track: 0605 Hours: Sun Visible: Visibility > 4 Miles: Wind < 5 mph From 310°: Animal Moving Toward ELW: Track Traced From Capture Point To Seashore

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
170	17		260	226	
182	7		258	230→244	
196	130	256	192	240	
214	9	184→198	188	240→252	
184	18		202	244→256	
186	53		248	192→206;260	
201	61			170→222	
194	44		250	170→240	168

$\overline{X}$ Track Bearing = 013.23°

Track Variance = 76.674

TRACK 7161 (Continued)

Post Release Track: 0640 Hours: Sun Visible: Visibility > 4 Miles
Wind < 5 mph from 305°: Eastern Release Point.

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
344	21		230	200→250	
335	7		256	194→228	
008	6		250	206→244	
351	3			202→238	
007	8		246	196→232	
004	23			196→238	
348	10			192→228	
325	8		164	198→232	
308	11			196→226	
278	9		178	202→238	
262	8		198	200→236	
246	14			202→232	
238	28		200	186→246	
232	86		260	188→238	
218	12			190→232	
208	50	238		188→240	
207	7	244		186→232	
217	15	254		194→244	
210	54		250	200→250	
222	25	258		182→244	
212	55				

$\overline{X}$ Track Bearing = 220.61° Track Variance = 139.822

APPENDIX F

Track, Surf And Meteorological Data For Each
Of The Sixteen Relocated Harbour Seal Weaners.

SUBJECT 1: FIRST RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
189	3	154			182
232	7	150			188
203	2		154	193	
226	21	153			190
209	4	152			184
241	3	155	180		
225	6		191	151	
233	15		176	146	
190	29		180	150	
173	5		188	156	
151	5	150	186		
162	33		188	155	
145	53		153	194	
158	15		157	204	
200	4		152	202	
179	5		158		208
156	16		158	208	
170	7		146	200	165
183	22		166	208	150

$\bar{X}$ Track Bearing = 179.04°

Time Released = 1540
Cloud = 10/10 Sun Not Visible
Visibility = 10 Miles
Wind = 14 m.p.h. from 145°

SUBJECT 1: SECOND RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
194	3	150			182
147	4	153			190
163	35		166	144	
165	27		171	140	
152	11		174	143	
143	8		166	145	
150	6		170	146	
176	6		174	144	
120	49	138	166		
132	21		170	142	
164	21		171	140	
152	40		174	148	

$\overline{X}$ Track Bearing = 147.79°

Time Released = 1630
Cloud = 10/10 Sun Not Visible
Visibility = 3/4 Mile
Wind = 10 m.p.h. from 145°

SUBJECT 1: THIRD RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
147	12		171	145	
167	9		170	140	
180	5		172	148	
193	5		173	150	
168	29		170	148	
158	13		170	150	
188	8		165	146	
160	25		166	148	
142	3		165	144	
168	3		170	144	
148	8		170	143	
162	21		172	150	
152	6		172	153	
167	23		174	150	

$\overline{X}$ Track Bearing = 164.98

Time Released = 1730
Cloud = 10/10 Sun Not Visible
Visibility = < 200 Yards
Wind = 5 m.p.h. from 150°

SUBJECT 1: FOURTH RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
118	4		187	140	
160	20		168	140	
237	3		176	148	
177	6		174	147	
168	6		177	156	
185	15		184	154	
173	8		184	150	
182	20		182	150	
144	11		178	150	
170	53		168	144	
163	50		168	145	

$\overline{X}$ Track Bearing = 169.40°

Time Released = 1805
Cloud = 10/10 Sun Not Visible
Visibility = < 200 Yards
Wind = 10 m.p.h. from 104°

SUBJECT 1: FIFTH RELEASE: SKIDBY

Track		Surf Bearings°		
Bearings°	Paces[R]	North Shore Intermittent	South Shore Continuous	Intermittent
160	4		180	
180	6		178	
118	14	100	202	
143	4	043;100	178	
042	15	036	192	
072	12	030;085	171	
118	11			
105	4	028;080	196	
134	2	031;080	200	
088	8	015;082	190	
122	18	100;015	195	
145	5	059;002	178	204
166	15	[illegible];084	178	204
190	22	058	182	200
192	8	055;360	182	210
156	6	010;045	178	217
199	18	360;033	179	200
233	8			
203	5		196	
222	12		190	255

Time of Release = 1845
Cloud = 10/10 Sun Not Visible
Visibility = 1/2 Mile
Wind = 4 m.p.h. from 130°

SUBJECT 2: FIRST RELEASE: SKIDBY

Track		Surf Bearings°		
Bearings°	Paces[R]	High Continuous	Low Intermittent	North Shore
111	10	144	202	058
124	13	150	168	058
133	15	150	173	
177	4	162	202	
124	8	165	209	
150	31	164	200	
167	8	161	193	
158	11	160	199	
161	6	159	210	
220	4	156	211	
177	8	152	228	
138	13	149	233	
100	6	149	248	
125	6	143	258	
144	5	139	258	
130	4	143	245	
166	4	142	258	
192	10	147	240	
170	11	165	271	
185	9	174	274	

Time of Release = 1518
Cloud = 4/10 Sun Visible
Visibility = 10 Miles
Wind = 5 m.p.h. from 240°

SUBJECT 2: SECOND RELEASE: MOBIL

Track			Surf Bearings°		
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
173	4	139			222
200	7	142			219
222	7	137			222
225	8	137			232
200	32 In Car	141			229
202	19 Tracks	132			221
166	11 Here	144			227
205	23	138			222
185	8	139			211
183	7	135			223
195	4	139			230
212	42	139			226

$\overline{X}$ Track Bearing = 206.74°

Time Released = 1612
Cloud = 5/10 Sun Visible
Visibility = 10 Miles
Wind = 1 m.p.h. from 225°

SUBJECT 2: THIRD RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
200	3 In Car Tracks Here	143			240
251	5	143			243
210	22	143			223
201	4	133			225
202	7	131			231
208	13	136			231
198	24	133			230
188	14	131			228
202	17	132			227
215	20	128			229
205	10	132			231
213	12	133			232
221	18	129			229

$\overline{X}$ Track Bearing = 206.48°

Time Released = 1644
Cloud = 5/10 Sun Visible
Visibility = 10 Miles
Wind = 6 m.p.h. from 225°

SUBJECT 2: FOURTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
216	4	193			225
234	4	217			252
245	8	203			242
228	10	211			248
215	26	209			251

$\overline{X}$ Track Bearing = 224.29°

Time Released = 1806
Cloud = 5/10 Sun Visible
Visibility = 3 Miles
Wind = 5 m.p.h. from 240°

SUBJECT 2: FIFTH RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces^R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
247	5	208			262
230	16	218			244
216	6	224			246
229	17	204			242

$\overline{X}$ Track Bearing = 227.41°

Time Released = 1844
Cloud = 10/10 Sun Not Visible
Visibility = 3/8 Mile
Wind = 7 m.p.h. from 235°

SUBJECT 3: FIRST RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[W]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
022	7	208		260	
010	2	180		246	
357	10	198		250	
009	5	200		248	
016	7	200		252	
330	5	200		256	
315	8	198		250	
337	11	198		248	
348	10	180		248	
004	9	192		252	
350	7	190		256	
343	8	192		254	
328	2	184		244	
351	11	192		240	
004	35	190		238	

$\overline{X}$ Track Bearing = 352.85°

Time Released = 1351
Cloud = 10/10 No Sun Visible
Visibility = < 250 Yards
Wind = 13 m.p.h. from 220°

SUBJECT 3: SECOND RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
120	1	239	333		162
068	1	239	333		162
108	3	237	331		
088	4	228	333		166
052	12	222	332		163
352	4	212	312		168
300	20	212	321		165
012	6	212	308		168
290	9	223	317		162
320	19	235	015		179
018	11	225	026		185
060	10	217	053		273
036	3	214	074		257
062	5	223			255
155	5	218			259
182	7	218			259
223	6	233			257

Time Released = 1438
Cloud = 10/10 No Sun Visible
Visibility = 300 Yards
Wind = < 5 m.p.h. from 240°

SUBJECT 3: THIRD RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
360	2	215		261	
040	3	219		252	
008	3	214		252	
338	4	221		263	
036	12	222		266	
064	13	204		265	
032	30	214		266	
018	6	208		253	
002	5	214		260	
038	4	214		264	
002	9	214		268	
024	5	220		266	
048	16	220		268	
030	25	214		255	
026	22	217		250	

$\overline{X}$ Track Bearing = 390.59°

Time Released = 1545
Cloud = 10/10 No Sun Visible
Visibility = 150 Yards
Wind = 15 m.p.h. from 224°

SUBJECT 3: FOURTH RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
032	5	212		258	
014	4	200		266	
026	15	202		264	
034	16	201		266	
062	8	208		268	
052	7	203		257	
080	4	204		262	
042	6	220		267	
058	12	209		274	
041	27	222		273	
052	22	217		274	

$\overline{X}$ Track Bearing = 044.37°

Time Released = 1620
Cloud = 10/10 No Sun Visible
Visibility = 150 Yards
Wind = 16 m.p.h. from 222°

SUBJECT 3: FIFTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
054	8	203		252	
064	10	227		274	
036	4	212		264	
054	15	218		265	
088	4	220		262	
108	3	203		266	
084	9	213		261	
088	16	213		255	
104	8	219		265	
072	4	224		262	
091	6	217		262	
072	30	227		264	
090	13	215		264	
112	2	212		265	
082	11	213		265	

$\bar{X}$ Track Bearing = 078.19°

Time Released = 1651
Cloud = 10/10 No Sun Visible
Visibility = 150 Yards
Wind = 14 m.p.h. from 250°

SUBJECT 4: FIRST RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
042	15		231	275	
028	5		240	273	
042	6		240	271	
028	11		235	266	
038	18		242	278	
050	26		240	266	
030	8		245	270	

$\bar{X}$ Track Bearing = 039.51°

Time Released = 1400
Cloud = 0/10 Sun Visible
Visibility = 10 Miles
Wind = 16 m.p.h. from 270°

SUBJECT 4: SECOND RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
360	9		220	284	
330	8		252	290	
004	5		246	285	
020	19		242	282	
350	3		224	266	
360	7		229	270	
016	14		234	280	
008	11		234		

$\bar{X}$ Track Bearing = 006.60°

Time Released = 1429
Cloud = 0/10 Sun Visible
Visibilty = 10 Miles
Wind = 14 m.p.h. from 253°

SUBJECT 4: THIRD RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
320	5		254	287	
010	11		244	289	
322	13		233	282	
344	7		256	284	
320	5		252	285	
304	14		248	282	
330	7		244	283	
300	7		251	282	

$\overline{X}$ Track Bearing = 327.03°

Time Released = 1450
Cloud = 0/10 Sun Visible
Visibility = 10 Miles
Wind = 11 m.p.h. from 264°

SUBJECT 4: FOURTH RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
050	10		331	245	
350	11		322	245	
032	8		315	230	
180	3		306	250	
124	6		310	220	
200	1		305	228	
290	6		305	228	
020	4		310	230	
194	15				
210	15		304	241	

Time Released = 1530
Cloud = 0/10 Sun Visible
Visibility = 10 Miles
Wind = 8 m.p.h. from 315°

SUBJECT 4: FIFTH RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
306	6		240	266	

Time Released = 1607
Cloud = 0/10 Sun Visible
Visibility = 10 Miles
Wind = 13 m.p.h. from 252°

SUBJECT 5: FIRST RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
136	13		271	232	
173	2		275	229	
146	5		282	232	
187	5		283	239	
151	10		286	229	
131	10		281	228	
181	12		287	229	
175	9		288	228	
145	18		285	222	
172	31		274	233	
159	9		275	228	
178	11		268	224	

$\overline{X}$ Track Bearing = 163.19°

Time Released = 0952
Cloud = 10/10 Sun Visible
Visibility = > 5 Miles
Wind = 8 m.p.h. from 320°

SUBJECT 5: SECOND RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
166	4	255		223	
185	47	263		221	
164	18	259		211	
150	15	269		219	

$\bar{X}$ Track Bearing = 173.71

Time Released = 1023
Cloud = 8/10 Sun Visible
Visibility = > 5 Miles
Wind = 8 m.p.h. from 319°

SUBJECT 5: THIRD RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
140	13			226	
172	7			213	
187	8			238	
164	16			214	
170	20			223	
150	13			215	
164	28			210	

$\bar{X}$ Track Bearing = 165.93°

Time Released = 1045
Cloud = 8/10 Sun Visible
Visibility = > 5 Miles
Wind = 8 m.p.h. from 320°

SUBJECT 5: FOURTH RELEASE: SKIDBY

Track		Surf Bearings°
Bearings	Paces^R	North Shore
164	7	020
222	7	032
086	7	031
112	8	035
132	8	028
206	3	028
154	5	029
240	8	031
048	8	033
080	6	029
140	17	027
146	18	020
181	10	008
190	5	011
147	5	011

Time Released = 1114
Cloud = 8/10 Sun Visible
Visibility = > 5 Miles
Wind = 5 m.p.h. from 323°

SUBJECT 5: FIFTH RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
203	13			237	
225	10			230	
243	15			234	
201	10			237	
213	22	258		233	
210	24	265		241	
244	18	266		228	
216	11	270		227	
226	44	271		234	

$\overline{X}$ Track Bearing = 223.01°

Time Released = 1225
Cloud = 8/10 Sun Visible
Visiblity = $\geq$ 5 Miles
Wind = 7 m.p.h. from 285°

SUBJECT 6: FIRST RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
116	7		342	255	
154	19		343	233	
130	3		333	255	
153	11		322	242	
129	8		320	230	
170	2		322	234	
131	10		320	240	
138	11		319	250	
165	30		320	244	
250	5		348	232	
067	7		360	246	
131	13		004	234	
181	11		354	236	
135	17		328	260	

Time Released = 1630
Cloud = 1/10 Sun Visible
Visibility = 10 Miles
Wind = 8 m.p.h. from 270°

SUBJECT 6: SECOND RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces^{R}	High Continuous	High Intermittent	Low Continuous	Low Intermittent
244	15	208		256	
222	32	218		254	
238	23	209		284	
199	13	202		270	
220	16	192;206		278	
221	8	184→224		282	
232	15	203		282	
225	15	206		282	
244	21	220		282	

$\overline{X}$ Track Bearing = 226.80°

Time Released = 1715
Cloud = 8/10 Sun Visible
Visibility = > 3 Miles
Wind = 13 m.p.h. from 246°

SUBJECT 6: THIRD RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces^R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
205	5	198		271	
231	43	220		274	
244	16	222		270	
210	9	212		276	
228	11	203		254	
255	11	224		284	
234	19	212;242		284	
266	14	201;256		292	
223	15	198;283		288	

$\overline{X}$ Track Bearing = 235.91°

Time Released = 1801
Cloud = 3/10 Sun Visible
Visibility = 10 Miles
Wind = 15 m.p.h. from 240°

SUBJECT 6: FOURTH RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
238	36	215		292	
250	12	209		290	
232	12	234		291	
224	19	224		282	
261	11	215		287	
221	9	223		270	
233	7	215		277	
221	32	216		279	

$\bar{X}$ Track Bearing = 231.40°

Time Released = 1849
Cloud = 5/10 Sun Visible
Visibility = > 5 Miles
Wind = 13 m.p.h. from 230°

SUBJECT 6: FIFTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
204	14	204		264	
222	7	206		269	
215	8	206		260	
238	64	204		271	
228	40	208		279	
219	31	204		276	

$\overline{X}$ Track Bearing = 229.43°

Time Released = 1922
Cloud = 5/10 Sun Visible
Visibility = > 5 Miles
Wind = 10 m.p.h. from 244°

SUBJECT 7: FIRST RELEASE: OLD MAIN

Track		Surf Bearings			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
168	3	194		282	
200	4	178		276	
149	9	180		284	
128	4	176		282	
178	19	175		283	
145	3	175		278	
172	23	178		273	
198	3	179		284	
158	7	184		280	
178	8	176		286	
196	29	178		290	
210	5	158		284	
230	6	158		284	
198	33	158		284	
222	20	158		284	

$\overline{X}$ Track Bearing = 188.66°

Time Released = 1523
Cloud = 10/10 Sun Not Visible
Visibility = $\leq$ 4 Miles
Wind = 13 m.p.h. from 224°

SUBJECT 7: SECOND RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
082	9	220		148	
061	5	230		248	
091	18	182		240	
118	2	186		250	
087	16	190		252	
154	8	184		246	
112	5	190		240	
078	8	196		238	
116	8	185		220	
154	37	181		216	
178	7	216		234	

Time Released = 1617
Cloud = 10/10 Sun Visible
Visibility = 5 Miles
Wind = 2 m.p.h. from 136°

SUBJECT 7: THIRD RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
214	6	210		272	
180	21	202		273	
190	9	206		267	
204	11	200		265	
209	10	197		270	
198	14	200		265	
208	30	207		270	
206	64	206		270	

$\overline{X}$ Track Bearing = 201.38°

Time Released = 1654
Cloud = 5/10 Sun Visible
Visibility = 7 Miles
Wind = 8 m.p.h. from 205°

SUBJECT 7: FOURTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
184	34	185		268	
209	16	196		270	
198	9	201		257	
188	24	207		264	
196	15	205		260	
190	41	204		262	
200	23	144→264		220	

$\overline{X}$ Track Bearing = 195.06°

Time Released = 1735
Cloud = 3/10 Sun Visible
Visibility = 3 Miles
Wind = 17 m.p.h. from 212°

SUBJECT 7: FIFTH RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
186	5	202		266	
204	10	198		270	
189	7	198		274	
196	18	200		270	
187	7	194		260	
204	4	198		262	
190	9	198		264	
198	49	204		262	
202	17	200		268	
232	1	160→260			
192	16				

$\overline{X}$ Track Bearing = 196.48°

Time Released = 1808
Cloud = 3/10 Sun Visible
Visibility = < 5 Miles
Wind = 17 m.p.h. from 208°

SUBJECT 8: FIRST RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
029	7	234		242	
142	6	220		236;270	
230	3	218		236;267	
283	4	218		240;264	
251	18	234		242	
231	11	233		240;266	
264	9	234		238;273	
292	5	228		244;266	
254	10	230		240;266	
262	15	230		238;267	
240	6	234		237;270	
256	16	220		238;268	

$\bar{X}$ Track Bearing = 248.30°

Time Released = 0857
Cloud = 10/10 No Sun Visible
Visibility = 500 Yards
Wind = 13 m.p.h. from 248°

SUBJECT 8: SECOND RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
266	13	232		260	
248	5	240		224	
232	19 *	206;240		226	
245	4	234		217	
230	3	230		217	
240	5 *	232		216	
206	9	230		218	
258	21	235		220	
241	7	226		226	
253	8	216		230	
228	13	230		216	
210	6	220		218	
228	10	220		212	

$\overline{X}$ Track Bearing = 236.41°

Time Released = 0944
Cloud = 10/10 No Sun Visible
Visibility = 500 Yards
Wind = 12 m.p.h. from 258°

*In Car Tracks Here

SUBJECT 8: THIRD RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
243	5	230		206	
261	14	234		194	
274	7	224		194	
250	5	234		203	
273	19	227		200	
285	5	228		202	
270	14	224		214	
225	4	230		210	
268	31	230		213	
255	13	232		210	
286	3	234		210	
221	8	234		210	
251	17	224		207	

$\overline{X}$ Track Bearing = 261.64°

Time Released = 1020
Cloud = 10/10 Sun Visible
Visibility = 300 Yards
Wind = 13 m.p.h. from 250°

SUBJECT 8: FOURTH RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
056	11		059	238	346
013	16			236	328
347	8			230	319
296	10			232	316
250	14			244	314
338	14			240	324
360	7			250	319

Time Released = 1053
Cloud = 10/10 Sun Visible
Visibility = 3 Miles
Wind = < 5 m.p.h. from 340°

SUBJECT 8: FIFTH RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
266	10	218		272	
250	23	231		273	
234	24	240		271	
250	25	238		276	
234	38	231		276	
252	8	240		284	

$\bar{X}$ Track Bearing = 241.73

Time Released = 1126
Cloud = 10/10 Sun Visible
Visibility = 3/4 Mile
Wind = 10 m.p.h. from 240°

SUBJECT 9: FIRST RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces^R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
256	10	246		205	
313	8	244		215	
269	35	247		215	
264	14	247		205	

$\bar{X}$ Track Bearing = 273.95°

Time Released = 1055
Cloud = 10/10 No Sun Visible
Visibility = 300 Yards
Wind = 8 m.p.h. from 270°

SUBJECT 9: SECOND RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
034	7	334		237	45
013	13	333		235	
336	13	317		239	
026	6	312			
302	13	310		252	

Time Released = 1120
Cloud = 10/10 Sun Visible
Visibility = 1/2 Mile
Wind = 7 m.p.h. from 274°

SUBJECT 9: THIRD RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
255	4	284		200	
320	7	290		204	
356	8	291		226	
020	4	289		217	
312	19	296		217	

$\overline{X}$ Track Bearing = 329.89°

Time Released = 1153
Cloud = 10/10 Sun Visible
Visibility = 1/4 Mile
Wind = 8 m.p.h. from 255°

SUBJECT 9: FOURTH RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
268	5	274		225	
215	7	264		224	
190	4	255		228	
232	6 *	257		228	
223	10	262		224	
241	13 *	258		225	
194	1	256		222	
241	21	256		222	
222	11	260		227	
254	5	255		220	

$\overline{X}$ Track Bearing = 228.17°

Time Released = 1214
Cloud = 10/10 Sun Visible
Visibility = 300 Yards
Wind = 6 m.p.h. from 264°

*In Car Tracks Here

SUBJECT 9: FIFTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces^R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
283	2	270		210	
230	13	268		212	
238	27	269		207	
251	16	268		210	
243	11	269		209	

$\bar{X}$ Track Bearing = 240.37°

Time Released = 1311
Cloud = 10/10 Sun Visible
Visibility = 250 Yards
Wind = w m.p.h. from 230°

SUBJECT 10: FIRST RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
198	6	297		224	
218	20	291		218	
287	6	308		226	
213	14	294		222	
202	10	309		230	
221	11	303		208	

$\overline{X}$ Track Bearing = 221.56°

Time Released = 1424
Cloud = 10/10 Sun Visible
Visibility = 250 Yards
Wind = 10 m.p.h. from 231°

SUBJECT 10: SECOND RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
194	8	290		225	
233	3	296		228	
237	4	294		227	
267	10		298	222	
238	25		302	232	
190	7	304		223	

$\overline{X}$ Track Bearing = 236.67°

Time Released = 1447
Cloud = 10/10 No Sun Visible
Visibility = 500 Yards
Wind = 6 m.p.h. from 220°

SUBJECT 10: THIRD RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
040	18	232			042
273	3	236	320		042
220	8	234			044
301	39	239	302		064
048	5	244	302		
289	9	242	304		
224	6	226	304		

Time Released = 1552
Cloud = 10/10 No Sun Visible
Visibility = 1/4 Mile
Wind = 0

SUBJECT 10: FOURTH RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
242	7	273			218
223	9	276			220
161	4	276			212
229	14	276			205
211	4	276			204
237	5	278			193
167	4	275			212
204	7	276			200
177	9	274			200
209	13	283			200
186	8	302			212

$\overline{X}$ Track Bearing = 204.94°

Time Released = 1625
Cloud = 10/10 Sun Not Visible
Visibility = 150 Yards
Wind = < 5 m.p.h. from 260°

SUBJECT 10: FIFTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
228	17		190;224	282	
247	7		190;220		
212	15		196;235	275	
204	9		194;224	282	
250	9		196;234		
238	15		244		

$\overline{X}$ Track Bearing = 228.45°

Time Released = 1832
Cloud = 10/10 No Sun Visible
Visibility = 250 Yards
Wind = 1 m.p.h. from 248°

SUBJECT 11: FIRST RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces	High Continuous	High Intermittent	Low Continuous	Low Intermittent
330	2		020		
296	2		012		
010	6		009		
328	3		012		
042	1		016		
298	17		001	360→042	
328	26		018	255	
316	19		022		

$\overline{X}$ Track Bearing = 321.57°

Time Released = 1205
Cloud = 10/10 No Sun Visible
Visibility = 3 Miles
Wind = 10 m.p.h. from 360°

SUBJECT 11: SECOND RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
006	10		043		
360	10		053		
022	3		335		067
314	1		335		067
040	7		330		
272	18	305			
306	6	340			
008	5	358			
292	3		010		
346	17	024			
308	4		015		
336	4	316	037		
298	5	314	025;070		
318	10	023	043		
322	3	312	027		

Time Released = 1313
Cloud = 10/10 No Sun Visible
Visibility = 3 Miles
Wind = 9 m.p.h. from 350°

SUBJECT 11: THIRD RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
300	3			172	
260	3			035	
328	7			038	
302	7			026	
340	8			032	
312	16			034	
328	5			033	
296	7			032	
264	6			034	
290	5			032	
270	11			029	
300	10			040	
284	12			042	
240	10			046	

$\overline{X}$ Track Bearing = 293.70°

Time Released = 1353
Cloud = 10/10 No Sun Visible
Visibility = 3 Miles
Wind = 6 m.p.h. from 022°

SUBJECT 11: FOURTH RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
180	3	015			234
250	1	015			234
306	1	015			234
238	3	015			
192	3	015			
240	3	005			
252	12	009			
268	13	009		219	
360	6	009			196
228	6	012		214	
222	6	032		205	
240	4	018			208
220	9	030			217

$\overline{X}$ Track Bearing = 251.85°

Time Released = 1458
Cloud = 9/10 Sun Visible
Visibility = 4 Miles
Wind = 11 m.p.h. from 018°

SUBJECT 11: FIFTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[J]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
148	2	012		120	
180	1	012			
142	7	012			
190	8	012		100	
210	4	012		086;118	
182	20	012		087;115	
140	3			052;082;119	
168	2			052;078	

$\overline{X}$ Track Bearing = 176.22°

Time Released = 1533
Cloud = 1/10 Sun Visible
Visibility = 5 Miles
Wind = 5 m.p.h. from 011°

SUBJECT 12: FIRST RELEASE: EAST WALLACE:

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
162	6				
188	8		200	170	
218	8		202	168	
178	3 In Car Tracks Here		200	171	241
222	15		200	162	232
186	20		198	155	235
190	38		184	152	241
184	27		200	150	

$\overline{X}$ Track Bearings = 193.45°

Time Released = 1649
Cloud = 3/10
Visibility = 10 Miles
Wind = 12 m.p.h. from 190°

SUBJECT 12: SECOND RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
212	6	208		167	
192	13	208		160	
230	4	208		161	
188	17	200		164	
184	25	202		161	
192	33	204		145	
198	10		220 →	154	

$\overline{X}$ Track Bearing = 191.45°

Time Released = 1720
Cloud = 3/10 Sun Visible
Visibility = 10 Miles
Wind = 15 m.p.h. from 185°

SUBJECT 12: THIRD RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
162	13	210		169	
176	21	211	259	170	
166	17	206	244	161	
180	15		194	161	
174	15		193;246	165	

$\overline{X}$ Track Bearing = 173.94°

Time Released = 1752
Cloud = 3/10 Sun Visible
Visibility = 10 Miles
Wind = 13 m.p.h. from 173°

SUBJECT 12: FOURTH RELEASE: OLD MAIN

Track Bearings°	Paces[B]	Surf Bearings° High Continuous	High Intermittent	Low Continuous	Low Intermittent
188	6	222		168	
210	9	222	201	174	
220	22	227		178	
174	7	218		169	
204	22 In Car Track Here	246	200	167	
224	7	245	210	168	
195	15		204	163	

$\bar{X}$ Track Bearing = 207.35°

Time Released = 1822
Cloud = 4/10 Sun Visible
Visibility = 10 Miles
Wind = 13 m.p.h. from 180°

SUBJECT 12: FIFTH RELEASE: SKIDBY

Track		Surf Bearings°	
Bearings°	Paces[B]	Low Continuous	Lower Continuous
112	3	160	
186	9	161	214
100	7	149	197
142	3	155	169
214	4	154	178
356	4	150	182

Time Released = 1804
Cloud = 4/10 No Sun Visible
Visibility = 10 m.p.h.
Wind = 5 m.p.h. from 138°

SUBJECT 13: FIRST RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
140	7	286		227	
206	14	251		218	
228	4	262		235	
204	16	253		217	
222	7	264		224	
178	3	262		224	
208	30	267		226	
215	31	261		218	
206	18	270		217	
185	19			208→244	

$\overline{X}$ Track Bearing = 206.17°

Time Released = 1352
Cloud = 10/10 Sun Visible
Visibility = 1/2 Mile
Wind = 10 m.p.h. from 240°

SUBJECT 13: SECOND RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
141	4	258		217	
227	9	250		224	
233	16	260		227	
209	5	260;215		230	
231	34	262;210		230	
232	12	260;215		225	
181	5	260;220		218	
189	4	262;203		220	
227	18	261;206		220	
239	22	250;212		225	
224	24	272;204		198	
223	20	197→262		215	
238	8	194→264		212	
223	19	208→266		222	
236	8	188→270		212	
222	15	195→262		208	

$\overline{X}$ Track Bearing = 226.78°

Time Released = 1432
Cloud = 10/10 Sun Visible
Visibility = 1/2 Mile
Wind = 10 m.p.h. from 250°

SUBJECT 13: THIRD RELEASE: OLD MAIN

Track			Surf Bearings°			
Bearings°	Paces[R]		High Continuous	High Intermittent	Low Continuous	Low Intermittent
082	2		226;268		220	
185	6	In Car	256	214	234	
261	3	Tracks Here	264	216	230	
322	4		270	216	226	
224	6		268	226	220	
178	5		262		222	
236	4		212;272		218	
290	6		212;272		218	
258	7		218;264		236	
238	8		220;272		233	
222	5		204;276		224	
244	16		206;286;230			
225	9		212;280		224	

$\overline{X}$ Track Bearing = 237.70°

Time Released = 1515
Cloud = 10/10 No Sun Visible
Visibility = 500 Yards
Wind = 10 m.p.h. from 260°

SUBJECT 13: FOURTH RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[R]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
195	11		320	232	
075	6		322	230	
063	7		322	230	
079	5		322	244	
050	5		316	244	
011	3		316	250	
106	3		314	250	
043	4		314	246	
130	8		310	246	
153	20		312	252	
195	6		310	226	

Time Released = 1631
Cloud = 10/10 No Sun Visible
Visibility = 1/2 Mile
Wind = < 5 m.p.h. from 305°

SUBJECT 13: FIFTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces^R	High Continuous	High Intermittent	Low Continuous	Low Intermittent
221	3	253			219
202	9	256			223
238	5	250			220
225	23	254			219
205	7	252			212
192	5	252			210
171	8	250→220			207
193	8	256→220			208
233	79	260→222			206
285	4	262→190			215
228	22	216;262		210	

$\overline{X}$ Track Bearing = 223.84

Time Released = 1708
Cloud = 10/10 Sun Not Visible
Visibility = < 1/4 Mile
Wind = 10 m.p.h. from 255°

SUBJECT 14: FIRST RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
094	3	190		278	
118	3	189		276	
158	2	180		275	
120	9	190		284	
228	9	210		285	
124	9	180		284	
182	7	215		280	
210	6	196		280	
180	17	192		280	
148	12	200		280	

$\overline{X}$ Track Bearing = 166.05°

Time Released = 1145
Cloud = 10/10 No Sun Visible
Visibility = 1/2 Mile
Wind = 0

SUBJECT 14: SECOND RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
158	10	214	132	265	
114	4	218	130	297	
184	15	207	124	292	
172	9	208	114	292	
182	29	214	120	300	
142	8	210		302	
180	19	195	108	286	
130	24	195	127	296	

$\overline{X}$ Track Bearing = 164.06°

Time Released = 1238
Cloud = 10/10 Sun Visible
Visibility = < 1/4 Mile
Wind = 0

SUBJECT 14: THIRD RELEASE: WEST WALLACE

Track Bearings°	Paces[B]	Surf Bearings° High Continuous	High Intermittent	Low Continuous	Low Intermittent
310	3	158		226	
242	6	166		190	
220	33	154		197	
218	22	148		180	
220	13	156		186	
192	22	145		187	

$\bar{X}$ Track Bearing = 214.50°

Time Released = 1335
Cloud = 10/10 Sun Visible
Visibility = 1/2 Mile
Wind = 2 m.p.h. from 210°

SUBJECT 14: FOURTH RELEASE: OLD MAIN

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
202	5	145		225	
242	28	145		222	
262	5	150		228	
230	7	145		230	
176	5	132		225	
200	10	132		219	
184	5			216	
220	7			220	
178	4			212	
192	6			198 → 238	

$\overline{X}$ Track Bearing = 219.48

Time Released = 1406
Cloud = 10/10 Sun Not Visible
Visibility = 1/4 Mile
Wind = 0

SUBJECT 14: FIFTH RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
080	5		330		045
126	10		340		044
155	7		315		028
133	3		330		048;015
158	16		326		042
086	4		332		072;025
107	8		330		034
118	8		330		020
140	20		327		010

Time Released = 1550
Cloud = 10/10 Sun Visible
Visibility = 1/4 Mile
Wind = < 5 m.p.h. from 320°

SUBJECT 15: FIRST RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
036	6	160	060		
344	2	160	065		
026	4	158	064		
358	11	160	070		
040	2	168			
118	2	161			
306	31	170			
344	4	165			017

Time Released = 1017
Cloud = 10/10 No Sun Visible
Visibility = 8 Miles
Wind = 10 m.p.h. from 160°

SUBJECT 15: SECOND RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
190	5	180		210	
168	10	190	121		210
172	40	182	116		210
194	20	190	115	214	

$\bar{X}$ Track Bearing = 177.71°

Time Released = 1122
Cloud = 10/10 No sun visible.
Visibility = 8 Miles
Wind = 1 m.p.h. from 060°

SUBJECT 15: THIRD RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
266	6	135			180
114	3	145			190
204	6	130			180
180	4	130			193
220	2	140			185
194	25	133			192
166	2	132			185
202	9	133			190→230
192	12	131			185
202	18	128			190
192	11	128			180→210

$\overline{X}$ Track Bearing = 193.74°

Time Released = 1202
Cloud = 10/10 No Sun Visible
Visibility = 5 Miles
Wind = < 5 m.p.h. from 095°

SUBJECT 15: FOURTH RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
104	3	134			187
170	1	135			182
100	1	121			194
148	12	133			176
180	12	127			176

$\overline{X}$ Track Bearing = 161.77°

Time Released = 1259
Cloud = 10/10 Sun Visible
Visibility = 1/4 Mile
Wind = 8 m.p.h. from 065°

SUBJECT 15: FIFTH RELEASE: OLD MAIN

Bearings°	Paces[B]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
350	6	284	030;224	140	
214	12	295	350;212	135	
192	8		030;232	138	

$\overline{X}$ Track Bearing = 205.20°

Time Released = 1415
Cloud = 10/10 Sun Visible
Visibility = 1/2 Mile
Wind = 7 m.p.h. from 040°

SUBJECT 16: FIRST RELEASE: SKIDBY

Track		Surf Bearings°			
Bearings°	Paces[D]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
116	8		156;317	210	042
096	4		152;316	228	042
138	5		156;315	228	
237	15		157;316	220	032
118	13		076;321	205	048
122	16		166;078;319	232	
119	5		170;316	230	004
160	7		208;317	250	
161	6		217;084;313	242	008
146	4		315	230	
140	4		310	210	
188	5		308	208	
113	7		194;306	208	

Time Released = 1459
Cloud = 10/10 Sun Visible
Visibility = 3/4 Mile
Wind = < 5 m.p.h. from 250°

SUBJECT 16: SECOND RELEASE: OLD MAIN

Track			Surf Bearings°			
Bearings°	Paces[D]		High Continuous	High Intermittent	Low Continuous	Low Intermittent
029	6		224		268	
251	18		222		268	
241	30	In Car Track Here	225		274	
287	5			222	259	
260	4			217	263	
233	20			216	282	
237	13		208	243	284	
217	3			201;231	286	
225	10			188;230	280	
206	20			176;218	262	

$\overline{X}$ Track Bearing = 233.92°

Time Released = 1606
Cloud = 10/10 Sun Visible
Visibility = 1/4 Mile
Wind = 9 m.p.h. from 250°

SUBJECT 16: THIRD RELEASE: EAST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[D]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
218	4		215	250	
188	6		212	250	
227	7		213	248	
258	12		220	253	
235	11		210→232	255	
228	17		212→229	253	
202	9		190→220	257	
232	8		204→225	254	
214	5		185→230	266	
242	13		200→227	260	
222	6		192→215	270→260	
213	14		190→222	264→276	
229	21		184→213	252→290	

$\overline{X}$ Track Bearing = 227.03°

Time Released = 1649
Cloud = 10/10 Sun Visible
Visibility = 150 Yards
Wind = 10 m.p.h. from 220°

SUBJECT 16: FOURTH RELEASE: WEST WALLACE

Track		Surf Bearings°			
Bearings°	Paces[D]	High Continuous	High Intermittent	Low Continuous	Low Intermittent
240	38		202→215	270	
254	5		207→225	253→268	
238	17		178→228	252→280	
226	6		206→240	246→270	
243	26		194→226	259→270	
239	10		192→236	265	

$\overline{X}$ Track Bearing = 240.31°

Time Released = 1723
Cloud = 10/10 Sun Visible
Visibility = < 150 Yards
Wind = 8 m.p.h. from 245°

SUBJECT 16: FIFTH RELEASE: MOBIL

Track		Surf Bearings°			
Bearings°	Paces D	High Continuous	High Intermittent	Low Continuous	Low Intermittent
242	14		208→250	274→290	
224	25		185→270	285	
233	21		170→261	280→296	
213	11		158→280	294	
218	14		168→276	298	
192	9		148→261	284	
230	7		160→272	277	
219	12		145→278	295	
248	11		170→270	304	
237	7		168→282	304	
223	15		166→270	298	

$\overline{X}$ Track Bearing = 224.14°

Time Released = 1820
Cloud = 10/10 No Sun Visible
Visibility = 150 Yards
Wind = 8 m.p.h. from 220°

APPENDIX G

Regression Analysis III

Relocated Weaner Tracks; Experiment I.

III. Criterion= Mean Track Bearings Of Relocated Weaners

Full Model (Model 1.) Cast To Determine The Amount Of Variance Among Mean Track Bearings Accounted For By Ten Predictors:

$$Y_1 = a_0u + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8 + a_9X_9 + a_{10}X_{10} + E_1$$

Y_1= Mean Track Bearings

a_2X_2 = Time of Release For Each Track in the Criterion Vector

a_3X_3 = 1 if Track was Made When Visibility was $\leq$ 250 Yards; 0 Otherwise

a_4X_4 = 1 if Track was Made When Sun Were Visible; 0 Otherwise

a_5X_5 = Wind Direction Prevailing for Each Track in the Criterion Vector

a_6X_6 = Wind Spped Prevailing for Each Track in the Criterion Vector

a_7X_7 = 1 if Released at Mobil; 0 Otherwise

a_8X_8 = 1 if Released at Old Main; 0 Otherwise

a_9X_9 = 1 if Released at West Wallace; 0 Otherwise

$a_{10}X_{10}$ = 1 if Released at East Wallace: 0 Otherwise

Models Placing Restrictions on Model 1 (Notation As Above)

MODEL 2 $= Y_1 = a_o u + a_3 X_3 + a_4 X_4 + a_5 X_5 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + E_1$

MODEL 3 $= Y_1 = a_o u + a_2 X_2 + a_4 X_4 + a_5 X_5 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + E_1$

MODEL 4 $= Y_1 = a_o u + a_2 X_2 + a_3 X_3 + a_5 X_5 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + E_1$

MODEL 5 $= Y_1 = a_o u + a_2 X_2 + a_3 X_3 + a_4 X_4 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + E_1$

MODEL 6 $= Y_1 = a_o u + a_2 X_2 + a_3 X_3 + a_4 X_4 + a_5 X_5 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + E_1$

MODEL 7 $= Y_1 = a_o u + a_2 X_2 + a_3 X_3 + a_4 X_4 + a_5 X_5 + a_6 X_6 + E_1$

MODEL 8 $= Y_1 = a_o u + a_2 X_2 + a_3 X_3 + a_4 X_4 + a_5 X_5 + a_6 X_6 + a_7 X_7 + a_8 X_8 + a_9 X_9 + a_{10} X_{10} + a_{11} X_{11} + E_1$

Where:

$a_{11} X_{11} = a_5 X_5 * a_6 X_6$

F Ratios Comparing Model 1 With Its Various Restricted Models, And Comparing Model 1 and Model 8 With Model 90 (A Built In Model Which Has $r^2 = 0.$)

F Ratio	D.F. Num.	D.F. Den.	Full Model	r^2	Restricted Model	r^2	Probability
3.2023	7	53	1	0.29723	90	0.0	0.00666
3.9621	8	52	8	0.37871	90	0.0	0.00101
0.6117	1	53	1	0.29723	2	0.28912	0.43760
10.6332	1	53	1	0.29723	3	0.15624	0.00194
0.1153	1	53	1	0.29723	4	0.29571	0.73552
0.2017	3	53	1	0.29723	7	0.28921	0.89472
5.1927	1	53	1	0.29723	5	0.22838	0.02674
12.5729	1	53	1	0.29723	6	0.13052	0.00083
6.8192	1	52	8	0.37871	1	0.29723	0.01176

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