Ron

CHUGACH NAVIGATION

W.W. Mitchell
Cooperative Park Studies Unit
University of Alaska, Fairbanks

The Chugach Eskimos of Prince William Sound relied primarily on the bidarka, or kayak for transportation. Hunting and trading parties would often travel long distances in an area that is known for its changeable weather and often dangerous sea conditions. In order to deal with these hazards the Chugach developed a sophisticated system of sea routes, portages, and cognitive and social structures that allowed them to travel with a remarkable degree of safety and predictability and which, in turn, became one of the most important integrating forces in their culture.

One of the central nodes of the travel system was the Weatherman, a specialist whose job was to determine if the weather would hold long enough for the party to reach their destination (a period of from two to five days) and to set the course, taking into consideration the relevant wind, current, and swell factors. The Weatherman was one of the most important members of the community, and the lives of many men could depend on him. Unfortunately we know very little about who the weathermen were or how they operated. One of the only references to the Weatherman is in Birket-Smith (1953:116) who states that

> On hunting excursions there was always a "Weather Prophet" who was not a shaman but an old man of great experience. He was called La'tcuxta, i.e. "sky person" and used to advise the chief, who would then tell the hunters what to do.

Aside from this brief quote, nearly all that we know about the weathermen was collected during the ANCSA 14(h)(1) survey in 1978 and 1979 through interviews with many of the older residents of the area. The last known Weatherman was Makarka Chemowitsky, who died in the 1940s. Makarka was the chief of Angik village on Hawkins Island, was the main informant for Birket-Smith and de Laguna during the Danish-American Expedition of 1933, and was one of the best known characters in local history. While no one today can predict the weather as well as Makarka did, there are several people still alive who are familiar with the principles of the system and have seen it in use.

Because of tricky currents, dangerous coasts, and variable sea conditions, bidarka travel almost always followed fixed, well defined routes. One of the basic principles of the travel system was to maintain a variety of sea routes and portages so that travellers could usually pick a reasonably safe one under almost any given conditions. A good example of this can be found on Hinchinbrook Island.

During the latter part of the nineteenth century, and possibly earlier, one of the main sea otter hunting areas of the region was found off Hook Point on the outer shore of Hinchinbrook Island. The otters were harvested by large cooperative hunts involving up to 20 bidarkas (50 men). Hunters from various parts of the sound would gather at Boswell Bay on the eastern end of the island, compare scouting reports and plan their strategy while the Weatherman would go off alone or with a few apprentices to study the signs.

First, he would lie on his back, often for hours at a time, studying the speed, direction, and shape of the clouds. The Weatherman knew that the winds in the lower atmosphere carry today's weather, but it is the winds in the upper atmosphere that determine the movements of large storm systems. Next he would take his bidarka offshore and study the size and direction of the swells. This was often very complicated. Storm systems can send large swells great distances. Determining which swells were important and which were not took a great deal of experience. One of the most important things he noted was the rate of change of the swell pattern over time. This would allow him to intuit the direction and magnitude of storm movements. Finally he would note more familiar signs such as the amount of dew, the color of sunrise and sunset, the behavior of birds and insects and unusual tidal activity. Then he would decide if the weather would hold long enough for them to reach their destination. / If the weather would be good, they would cross Strawberry Point on a short portage (to avoid dangerous breakers off the tip of the point) then paddle to Hook Point and reassemble for the hunt. If the weather was going to be bad, they would portage along a trail from Boswell Bay to Hook Point.

In all there were three maintained portages on Hinchinbrook, and others on Montague and Hawkins Islands. Most of the trails had shelters at convenient locations, and all were designed so that the energy expended in portaging was as close as possible to that involved in paddling.

While the Chugach made occasional trips to Kodiak Island, the Kenai Peninsula, Turnagain Arm, and Yakutat, the longest regular trip they made was for seal and otter hunting at Middleton Island, 60 nm (nautical miles) south of Hinchinbrook Entrance. The successful sailing of this route was quite an accomplishment, requiring accurate weather predictions and careful navigation. Middleton Island is low, about 100 feet high, and the maximum distance at which it is visible is about 10 to 12 nm in good weather. The currents in the area are strong, and must be well understood to avoid being thrown off course. If the island were missed by more than 10 miles, it probably would not be found.

When a trip to Middleton was planned, the party would assemble at Nuchek in Port Etches and go through the usual preparations and weather predictions. The trip would take about 40 hours in good weather, and the men would rest by lashing their bidarkas together. There is a strong south running current coming out of Hinchinbrook Entrance which could help them for about half of the trip. Once past the halfway mark, however, the current begins to set southwest at one to two-and-a-half knots. In order to reach their target, it was necessary to aim for a spot about 10 nm to the east of the island. The hunting at Middleton Island was good, but it had one distinct disadvantage-- once they got there they could not get back, because the currents were too strong. To get back home, they had to paddle 60 miles east to Kayak Island, then north around the sound, making the total length of the trip about 250 miles (Fig. 1).

The major legs of the voyage to and from Middleton would be done at night in clear weather. We have not been able to determine the exact nature of the navigation method used, but it seems similar to that used by the Polynesians (Lewis 1975). Each leg of the route would be marked by following a series of stars as they appeared on the horizon. When the wind was strong, they would apply a correction factor to account for the additional drift.

II

While I was conducting an interview with a man who had been on the last bidarka expedition to Middleton around 1915, I began to feel that there was a great deal more to the travel system than was apparent on the surface. "What would happen if you got caught on the open sea in bad weather", I asked. "They didn't get caught", he replied,"because of the Weatherman." He added later that only a few people ever drowned in their bidarkas, and they

VALDEZ
WRANGELL MOUNTAINS
CHITINA
WHITTIER
CORDOVA — MCCARTHY
ANCHORAGE
Anchorage
CHUGACH NATIONAL FOREST
CHUGACH MOUNTAINS
KENAI NATIONAL MOOSE RANGE
KENAI PENINSULA
SEWARD
Prince William Sound
Knight Island
Hinchinbrook Island
Montague Island
Cape Hinchinbrook
Cape Cleare
Orca Bay
Granite Range
Robinson Mountains
Bering Glacier
Bering Lake
Miles Glacier
Cape Suckling
Kayak Island
Cape St Elias
Middleton I
Mt Wrangell 14163
Mt Sanford 16237
Mount Drum 12010
Mount Blackburn 16523
Hawgtie Pk 8504
Mount Marcus Baker 13176
Mt Susitna 4396
Nutzotin Mts
GULF OF ALASKA

were usually young men of little experience who did not listen to the Weatherman. After living in Prince William Sound for a summer I came to appreciate the violent and erratic nature of the weather and I attempted to visualize the proceedures the weathermen used, but without much success. I decided that the most important thing was to try to understand the problems the weathermen were having to deal with. I looked up meteorological summaries for the area with infomation on average precipitation and wind values, but I found them to be practically worthless because of the large variances involved. What was needed was a more dynamic picture of what the conditions in Prince William Sound were like, so I decided to construct a Monte Carlo simulation of the winds and currents of the area.

The idea behind the simulation was very simple. What would happen if you cast a bidarka adrift somewhere in the sound? Where would it go, and what are the probabilities that it would encounter potentially dangerous conditions? The course of a drifting vessel naturally depends on the speed and direction of the winds and currents in the area. The dangerous conditions that might be encountered would be to run aground, or get caught in high seas or fog. Performing a simulation of this type helps to quantify the hazards confronted by the Weatherman. The null hypothesis is that the Chugach could not predict the weather, and thus the timiming of voyages was essentially random.

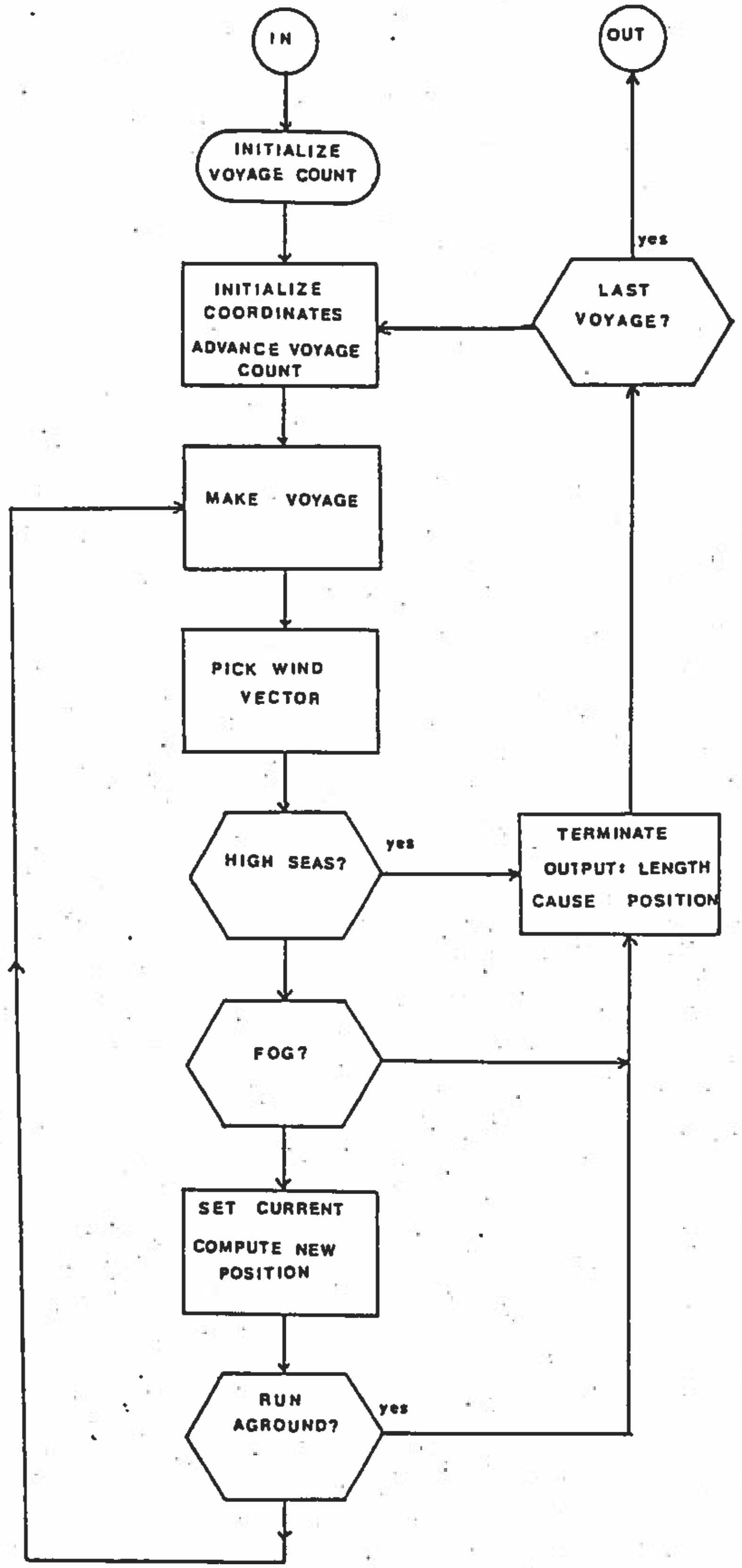
The simulation involved the following steps. (1) Initialize the coordinates of the craft to the selected starting point. (2) Select at random the wind speed and direction for that leg of the journey from a table of wind probabilities for that month. (3) Set the current speed and direction, depending on the craft's location. (4) Determine if high seas or fog have been encountered. (5) Compute the new position. (6) Determine if the vessel has been run aground. (7) If high seas, fog or land have been encountered, terminate the voyage and return to the starting point, otherwise advance the date and continue from step two (Fig. 2).

The program to conduct the simulation was written in FORTRAN IV and run on the UACN Honeywell System 66 computer. A total of about 10,000 voyages were simulated, using different starting points, wind data from different months, and different drift rates. Originally the length of each cycle was set at one day, but since the bidarkas had the unfortunate habit of sailing through islands (because land check isn't made until the end of the cycle), it was necessary to reduce the cycle time to six hours.

The wind data for the simulation was taken from the <u>Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska</u>, Vol 1 (Brower, et al 1977). In the Atlas, wind observations from Middleton Island and other locations are summarized by months, giving the probabilities

FIGURE 2

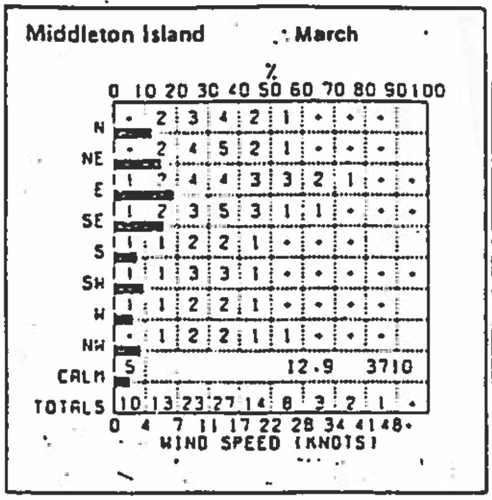
BIDARKA I FLOW CHART

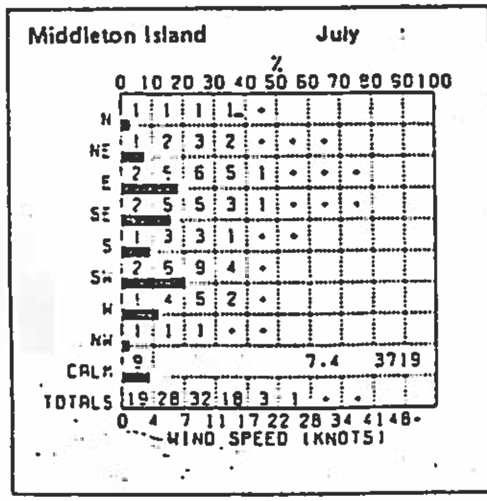


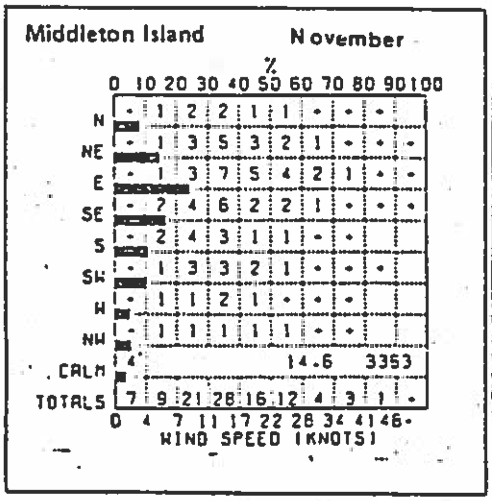
of winds occuring in 9 force ranges and 8 directions (Fig. 2). The data in each table are compiled from three to five thousand observations and can be taken to be reliable for the past five to ten years. For the purposes of the simulation the wind probabilities were arranged into two side-by-side 1x100 arrays, with the directions (in radians) in one and the magnitudes (in knots) in the other. If there was a four percent chance of a wind out of the northeast at 17 knots, then the vector would be entered four times into the arrays. To select a vector, a random number, M, between 1 and 100 would be generated and then the Mth member of the arrays would be read (see program in appendix A).

Two of the chief hazards of travel in this area, high seas and fog, are functions of the wind speed. If the wind speed is greater than 20 knots, then bidarka travel becomes difficult and dangerous. The occurrence of fog depends on a number of meterological factors, but overall if the wind speed in less than 5 knots, then the chance of fog is about 17%. If the wind speed is greater than 5 knots, the chance of fog is about 5%.

There are several possible problems with the wind data. The first is shallow time depth. The data were compiled over a relatively short time span. While they should be reasonably accurate for a period extending back about to the turn of the century, they may not apply for earlier times. From historical records it appears that the weather in the







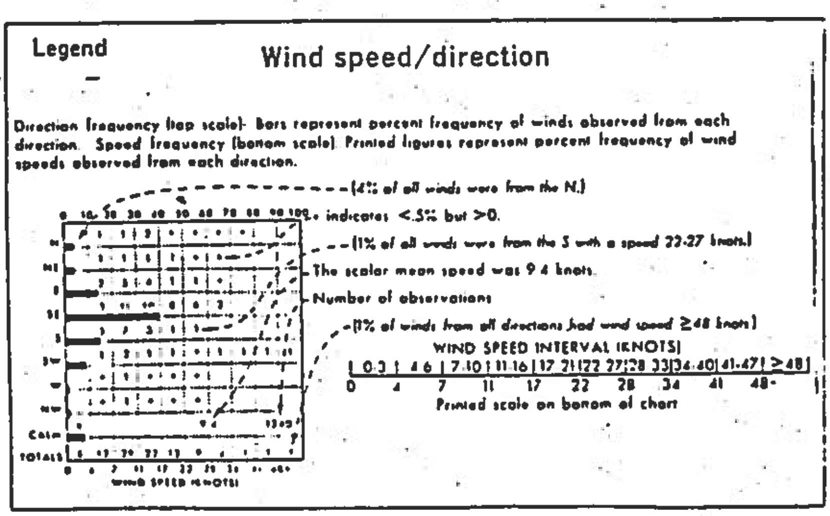


Figure 3 (From Brower et al, 1977)

area was more severe at the time of first contact than it is now. In this case the results of the simulation may not be accurate. The simulation does not deal with problems caused by dangerously large swells from distant storms, or with waves caused by current or current/swell interactions. These can occasionally produce spectacular and extremely dangerous conditions, but there is not sufficient data to include them in the simulation.

It can be argued that the temporal autocorrelation of meteorological processes produces a sequence that is not random from day to day. In fact the original selection of one day as the cycle time was a deliberate attempt to provide a middle value for this parameter. The reduction of the cycle time to six hours may have produced an amount of autocorrelation which is artifically low, but work done on similar simulations, such as that by Levison, Ward, and Webb (1976) in Polynesia seems to indicate that as long as the number of runs is sufficiently great, then accuracy should not be unduly affected.

The current data was taken from the U.S Coast Pilot (1979) and was cross checked with local residents . Because of the large amount of tanker traffic in the area, the data on Hinchinbrook Entrance and Middleton Island is quite reliable. There is a current running out of the entrance at one to two knots, depending on the tide. South of the entrance the Alaska Current parallels the coast, varying somewhat in location and intensity with the seasons. At Middleton Island the current sets southwest at 1 to 2.5 knots. Between Middleton and Kayak Islands, very little data is available, because most boats travel north or south of this line. According to general current charts for the region, this route is near the edge of the current. If this is true, it could complicate navigation by requiring a bow shaped route around the current, which would be too strong to paddle against. We will need more information in order to clarify this problem.

The simulation assumes that the bidarka moves with the water it is in. Because a bidarka is small and low, it would not act like a sail. The speed and direction of a wind induced drift current depends on the direction and magnitude of the wind, the eddy viscosity of the water, and the latitude. Because of the Coriolis effect, a drift current will not move in the same direction as the wind. In the northern hemisphere the current at the surface will tend to drift 45 degrees to the right of the wind in open water. This is part of a phenomenon known in oceanography as the Ekman Spiral. The velocity of the current is proportional to the wind speed and the latitude and is generally 1/20 to 1/30 of that of the wind (Fairbridge 1966:587). This is confirmed by observations of navy survival rafts which drifted at 2% of the wind speed in fair weather and 5% in a gale (Lee 1965:93). In shallow water, bottom drag can reduce these values, and coast lines can redirect the energy of the currents in various ways, but overall these should not be serious problems in this area.

To compute the new position of the bidarka, the wind is rotated 225 degrees, then scaled to 3% of the wind speed times the number of hours in the cycle. Thus if there was a north wind at 10 knots, the craft would drift southwest 1.8 nm in six hours. The actual computation involves converting from polar to rectangular coordinates, plotting the new position, then adding the current vector in a similar manner (except there is no 45 degree offset).

At the end of every cycle the program checks to see if the bidarka has run aground. This was accomplished by dividing the nautical charts for the area into a series of 1 nm squares. If a square contained land it was given a value of 1, otherwise it was given a 0. The data were arranged in a 49x80 array, and the craft's position was checked against this.

The results of each voyage were output onto a file, listing the number of the voyage, how long it lasted, the reason for its termination, and its final position. An upper limit of 30 cycles was placed on each voyage to avoid indefinitely long trips. During the early stages of the simulation the voyages were run in sets of 200; later they were run in sets of 1000. The starting points for the drifts were Hinchinbrook Entrance and Middleton Island.

Since the results were very similar, only the first will be discussed.

The results were quite surprising. The main path of the drifts was south, then southwest, as was expected (Fig. 4). The prevailing currents were by far the most dominant influence in the direction of travel. What was not expected was the large differences in the rates of termination and the reasons for termination for different months (Fig. 5). During July, over 59% of the voyages terminated within two days, and 78% failed within four days. In March 85.6% failed in one day, and 97.5% in two days. In November 90.5% failed in one day and 99% failed in two days.

During July 76.5% of the voyages terminated due to fog, 34% due to high seas, 14% ran aground, and 11% went longer than 30 cycles. In March 71% ran into high seas, 19% encountered fog, and 10% ran aground. In November 82% got caught in high seas, 6% encountered fog, and 12% ran aground (Fig. 6).

The steepness of the curves and the variations from month to month were much greater than we anticipated. The simulation in general tends to make Prince William Sound look like a fairly horrific place to sail. Well, is this a reasonable picture of the situation? I would say yes, but with a few qualifications. The question returns to the temporal autocorrelation of meteorological processes. A common period for weather cycles in the area, such as the

FIGURE 4a
BIDARKA I DRIFTS AFTER ONE DAY- JULY

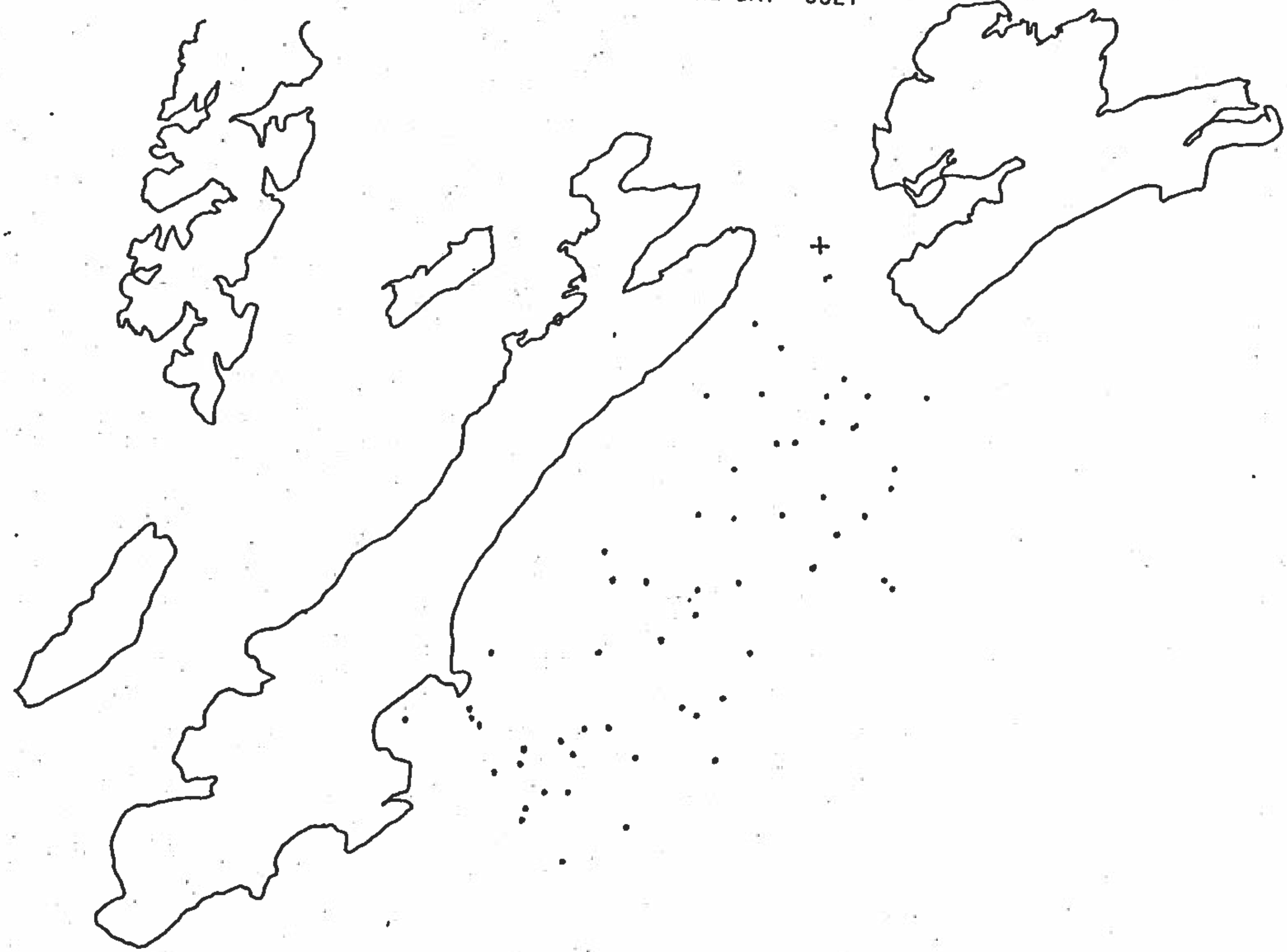


FIGURE 4b
BIDARKA I DRIFTS AFTER TWO DAYS- JULY

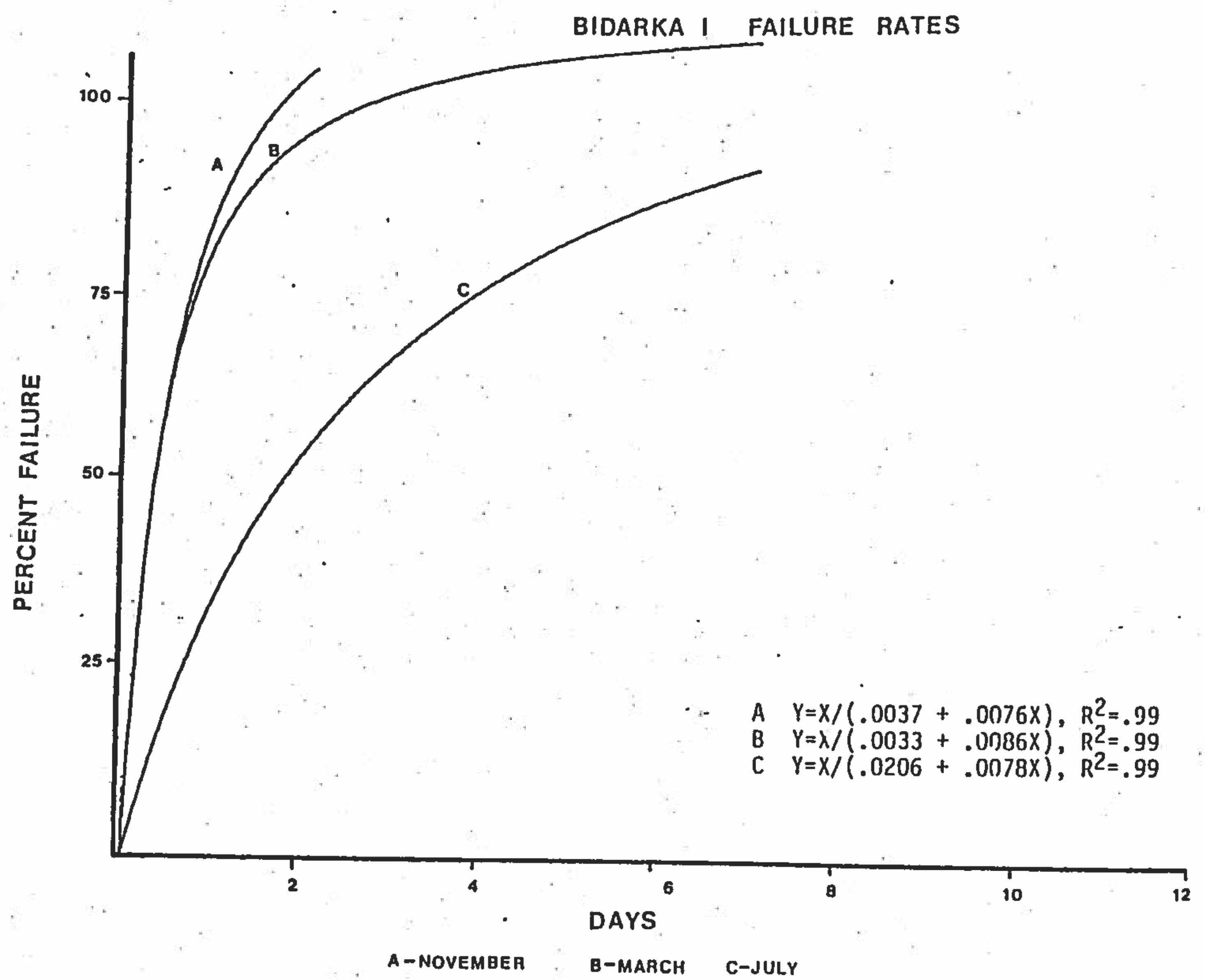

BIDARKA I FAILURE RATES
PERCENT FAILURE
100
75
50
25
A
B
C
A Y=X/(.0037 + .0076X), R2=.99
B Y=X/(.0033 + .0086X), R2=.99
C Y=X/(.0206 + .0078X), R2=.99
2
4
6
8
10
12
DAYS
A-NOVEMBER
B-MARCH
C-JULY

FIGURE 6

REASONS FOR TERMINATION

MONTH	HIGH SEAS	FOG	LAND	OUT OF TIME
JULY	17%	70.5%	7%	5.5%
NOVEMBER	82%	6%	12%	0
MARCH	71%	19%	10%	0

passing of a storm system, seems to be about three to five days. If bidarkas were indeed launched at random, then the simulation should give a good approximation of the rates and reasons for termination. However, if the time of launch was itself a probability funcion of the movements of weather systems, for example if trips were usually taken between storms, then the survival rates could rise considerably. The Chugach hunted year round, and were almost never caught in storms. This indicates that the accuracy of their weather predictions was probably on a par with those of modern weather forecasters.

The importance of accurate predictions to these people should not be underestimated. Most of their activities involved the use of bidarkas. The work of Birket-Smith (1953) and de Laguna (1965) shows that the Chugach culture was uniform over a fairly large area, and was quite stable through time. Most of this, I think, can be attributed to the regularity of travel within the area, which was made possible by the sophistication of the travel system.

APPENDIX A

```
10*#RUN #VECTRZ"C5";LAND"27";OUTPUT"06"
20 *
30 *  BIDARKA I
40 *  A PROGRAM TO SIMULATE THE RANDOM DRIFT OF
50 *  A BIDARKA IN PRINCE WILLIAM SOUND.
60 DIMENSION WINDR(100),WINDT(100),LAND(100,100)
70 REAL LAT,LONG,LATD,LONGD
80 *
90 *  INPUT WIND PROBABILITY TABLE
100 READ (5,20) ((WINDR(I),WINDT(I)),I=1,100)
110 20 FORMAT (1X,F3.0,1X,F4.2)
120 *  INPUT LAND ARRAY
130 READ (27,30) ((LAND(I,J),J=1,47),I=1,88)
140 *
150 *SET THE VOYAGE CYCLE COUNT, INITIALIZE POSITION
160 DO 1000 K=1,1000
170 *  COORDINATES OF STARTING POINT AND CRAFT ARE IN DECIMAL DEGREES
180 LATD=60.2833
190 LONGD=146.80
200 *
210 *  START THE VOYAGE
220 DO 99 L=1,30
230 *
240 *  PICK WIND SPEED AND DIRECTION
250 2 M=RANDT(99.)
260 IF (M.LT.1) GO TO 2
270 *
280 *  ROTATE AND ACCOUNT FOR CORIOLIS EFFECT
290 *  DIRECTIONS ARE IN RADIANS
300 T1=WINDT(M)+2.36
310 IF(T1.GT.6.28) GO TO 17
320 GO TO 15
330 17 T1=T1-6.28
340 *
350 *CALCULATE WAVE DANGER
360 15 IF(WINDR(M).GT.20.) GO TO 7
370 *
380 *  CALCULATE FOG DANGER
390 IF(WINDR(M).LE.5.) F=17.
400 IF(WINDR(M).GT.5.) F=5.
410 Q=RANDT (100.)
420 IF(Q.LE.F) GO TO 9
430 *
440 *  SCALE WIND DRIFT
450 R1=WINDR(M)*.18
460 *
```

```
* SET CURRENT SPEED AND DIRECTION
IF(LATD.LE.60.16) GO TO 13
R2=6.
T2=4.71
GO TO 5
13 R2=10.
T2=3.93
*  WARP FACTOR SIX MR. SCOTT!
*
*  MOVE BIDARKA
5 Y1=R1*SIN(T1)
Y2=R2*SIN(T2)
Y=(Y1+Y2)/60.
X1=R1*COS(T1)
X2=R2*COS(T2)
X=(X1+X2)/60.
LATD=LATD+Y
LONGD=LONGD-(X*2.)
*
*  HAS THE BIDARKA RUN AGROUND?
M1=INT((60.7-LATD)*60.)
N1=INT(((147.166-LONGD)*60.)*.5)
IF(M1.LT.1)GO TO 99
IF(N1.LT.1)GO TO 99
IF(LAND(M1,N1).EQ.1) GO TO 11
99 CONTINUE
*  TIME UP
LAT=DEG(LATD)
LONG=DEG(LONGD)
L1=0
WRITE(6,100) K,L,L1,LAT,LONG
GO TO 1000
*
*  VOYAGE TERMINATES DUE TO HIGH SEAS
7 LAT=DEG(LATD)
LONG=DEG(LONGD)
L1=1
WRITE (6,100) K,L,L1,LAT,LONG
GO TO 1000
*
*  VOYAGE TERMINATES DUE  TO FOG
9 LAT=DEG(LATD)
LONG=DEG(LONGD)
L1=2
WRITE (6,100) K,L,L1,LAT,LONG
GO TO 1000
*
*  VOYAGE TERMINATES DUE TO LANDING
11 LAT=DEG(LATD)
LONG=DEG(LONGD)
L1=3
WRITE (6,100) K,L,L1,LAT,LONG
GO TO 1000
30 FORMAT (4X,47I1)
```

```
100 FORMAT (I3,5X,I3,5X,I1,5X,F7.0,2X,F8.0)
1000 CONTINUE
STOP
END
*  FUNCTION TO CONVERT FROM DECIMAL DEGREES TO DEGREES.MINUTESSECOND
FUNCTION DEG(LAT1)
REAL LAT1,MIN,MINA
POS=INT(LAT1)
MINA=(LAT1-POS)*60
MIN=INT(MINA)
SEC=INT((MINA-MIN)*60)
DEG=(POS*10000)+(MIN*100)+SEC
RETURN
END
```