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HAWAII DEEP WATER CABLE PROGRAM

PHASE II

WIND CHARACTERISTICS AND GENERAL RELATIONSHIP
BETWEEN TRADE WIND SPEEDS AND WAVE HEIGHTS
IN THE
ALENUIHAHA CHANNEL

TK3351 Pacific Weather, Inc.
H35
PII Wind Characteristics and
1986a General Relationship
between Trade Wind Speeds
and Wave Heights in the
Alenuihaha Channel

States of America
Department of Energy

Final Report

HAWAII DEEP WATER CABLE PROGRAM

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WIND CHARACTERISTICS AND GENERAL RELATIONSHIP
BETWEEN TRADE WIND SPEEDS AND WAVE HEIGHTS
IN THE
ALENUIHAHA CHANNEL

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U. S. Department of Energy

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INTRODUCTION

FOR THE HAWAII DEEP WATER CABLE PROGRAM, HOURLY WIND SPEED AND DIRECTION DATA FROM PERTINENT LAND STATIONS, SPOT WIND AND WAVE OBSERVATIONS FROM DILLINGHAM TUGS AND AMERICAN HAWAII CRUISE SHIPS, AND HOURLY WIND AND WAVE DATA FROM NOAA BUOY 51005 (MARCH 1986 ONLY) WERE COLLECTED FOR THE PERIOD MARCH 1984-MARCH 1986.

THE COLLECTED DATA WERE SUMMARIZED, ANALYZED AND CORRELATED TO DETERMINE THE WIND SPEED AND DIRECTION CHARACTERISTICS IN THE ALENUIHAHA CHANNEL AND TO ALSO PROVIDE A GENERALIZED RELATIONSHIP BETWEEN WIND SPEEDS AND WAVE HEIGHTS UNDER TRADE WIND CONDITIONS IN THE ALENUIHAHA CHANNEL.

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SPEED AND DIRECTION AND HOURLY WIND SPEEDS
- ATTACHMENT B UPOLU 38, PERCENT FREQUENCY OF WIND
SPEED AND DIRECTION AND HOURLY WIND SPEEDS
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HAWAII DWCP FINAL REPORT: SUMMARY OF COLLECTED WIND AND WAVE DATA FOR THE
ALENUIHAHA CHANNEL DURING MARCH 1984 THROUGH MARCH 1986

I. Collected Data: For the period March 1984-March 1986, the following were collected (exceptions noted):

1. wind data: Upolu NWS; Upolu 38 (October 84, December 84-April, June 85-December 85); Constitution and Independence, American Hawaii cruise ships; Lihue and Kahului Airports, surface and gradient level; Dillingham tugs; and NOAA buoy 51005 (only for March 86).

2. seas and swell data: Constitution and Independence; Dillingham tugs; and NOAA buoy 51005 (only for March 86).

3. northwest surf data: Sunset Beach, Oahu (March and October 84 not available).

4. daily surface wind circulation pattern and strength for the Hawaiian Islands and North Central Pacific and any exceptional weather events affecting winds and waves in the Alenuihaha Channel.

II. Analysis of Winds over Hawaiian Islands (and Alenuihaha Channel), March 1984-March 1986.

The strength of the "dry" trade winds from March to October 1984 was not affected by the severe dry spell which was the most important weather condition in the Hawaiian Islands in 1984. The "drought", which started with the 1982-1983 El Nino, ended in November 1984 following return of the "wet" trade winds through November 1984 and following winter (1984-1985) rains.

After only three years since the severe El Nino/Southern Oscillation episode (ENSO) of 1982-1983 which distorted weather patterns world-wide, another ENSO, much milder, developed during the 1985-1986 winter. The result of this last ENSO episode in the Hawaiian Islands was light wind speeds during the winter months of November 1985-February 1986 highlighted by a pronounced drop in the frequency of trade winds during this period.

Lihue Airport is used as the representative wind station for the Hawaiian Islands because it is the only long-term wind station that has a good exposure to trade winds. Great emphasis is placed on occurrence and persistence of trade winds in the Hawaiian Islands because the broad scale trade winds are the dominant winds in the Islands making up at least 73% of the winds at Lihue Airport and about 84% of the winds in the Alenuihaha Channel.

Table 1 lists the monthly frequency of trade winds and average wind speed at Lihue Airport during January 1984-March 1986. The following are concluded from the data in the table:

1. Trade winds are the dominant winds in the Hawaiian Islands. Higher-than-normal frequency of trade winds is related to higher-than-normal wind speeds. Conversely, lower-than-normal frequency of trade winds is related to lower-than-normal wind speeds. The following months recorded significantly higher trade winds and higher wind speeds than normal: February 84, April-May 84, November 84 and March 85. The following months recorded significantly lower frequency of trade winds and lower wind speeds than normal: October 84, January 85, November 85, and February 86.

Table 1. Monthly Frequency of Trade Winds, Average Wind Speeds and Their Departures from Normal, Jan 1984- Mar 1986, at Lihue Airport, the Representative Station.

Year	Month	Normal % Trades	Approximate Actual % Trades	Difference % Act. - Normal Trades	Adjusted Normal Wind Speed (mph)	Actual Wind Speed (mph)	DIFF. Actual - Normal Wind Speed (mph)
1984	Jan	42	52	+ 10	12.0	13.0	+ 1.0
	Feb	55	80	+ 25	12.7	14.5	+ 1.8
	Mar	61	65	+ 4	13.4	12.8	- 0.6
	Apr	74	90	+ 16	14.2	17.8	+ 3.6
	May	86	100	+ 14	13.6	15.5	+ 1.9
	Jun	91	100	+ 9	14.1	16.9	+ 2.8
	Jul	95	97	+ 2	14.6	14.2	- 0.4
	Aug	94	100	+ 6	14.2	14.1	- 0.1
	Sep	83	77	- 6	12.8	11.9	- 0.9
	Oct	71	52	- 19	12.6	10.8	- 1.8
	Nov	64	90	+ 26	13.3	16.0	+ 2.7
	Dec	57	52	- 5	12.9	14.2	+ 1.3
1985	Jan	42	23	- 19	12.0	10.7	- 1.3
	Feb	55	50	- 5	12.7	13.3	+ 0.6
	Mar	61	100	+ 39	13.4	21.7	+ 8.3
	Apr	74	83	+ 9	14.2	15.1	+ 0.9
	May	86	90	+ 4	13.6	16.5	+ 2.9
	Jun	91	96	+ 5	14.1	13.4	- 0.7
	Jul	95	100	+ 5	14.6	15.8	+ 1.2
	Aug	94	93	- 1	14.2	15.1	+ 0.9
	Sep	83	80	- 3	12.8	12.8	0
	Oct	71	80	+ 9	12.6	13.4	+ 0.8
	Nov	64	33	- 31	13.3	11.5	- 1.8
	Dec	57	41	- 16	12.9	12.8	- 0.1
1986	Jan	42	48	+ 6	12.0	12.2	+ 0.2
	Feb	55	7	- 48	12.7	11.6	- 1.1
	Mar	61	68	+ 7	13.4	15.7	+ 2.3

2. March 1985, with 100% trade winds, would vie strongly for the title of the windiest month of record.

3. Trade winds are very persistent during summer months but are reduced to near-50% frequency during the winter months.

4. Directly related to the high frequency of trade winds, the average monthly wind speeds are strongest for the summer months. The average monthly wind speeds are weakest in winter and fall months where the frequency of trade winds are lowest during winter and weaker trade winds prevail during the transitional months of September and October.

5. Not seen in the monthly average wind speeds, the strongest daily trade winds occur not during the persistent trade wind summer months but during winter and spring months when very strong high pressure cells pass from the west to east north of the Islands. The passage of these strong highs is not a common occurrence so the average monthly wind speeds for the winter months are lower than those for the summer months.

6. Although the computation of the percent frequency of actual monthly trade winds is approximated, the comparison of the number of "+" and "-" values of the difference between actual and normal percentage of monthly trade winds shows that there were 17 months of "+" trade winds and only 10 months of "-" trade winds during this period. The difference between actual and normal monthly wind speeds shows that there were 16 months of "+" speeds and only 10 months of "-" speeds. These comparisons conclude that trade winds and higher than normal winds speeds were the dominant features of the winds during these 27 months.

III. Prevailing Wind Type and Speed in Alenuihaha Channel, March 1984-March 1986.

The summary of the prevailing daily wind type and speed in the Alenuihaha Channel is presented in table 2. This summary was developed using all the collected data plus knowledge of winds in the Islands by the analyst.

Only two types of winds are acknowledged in this summary: trade winds (T) and southerly winds (S). This simplifies the presentation and also shows the true picture of the important wind types in the channel. Trade winds made up about 84% of the winds and southerly winds made up about 95% of the remaining 16% of the winds in the channel. The reason for a higher percentage of trade winds in Hawaiian waters as compared to trade winds over land in the state is that weak trade winds remain trade winds over the waters but turn to other types of winds over land. This reduces the percentage of trade winds over land.

For this summarization, the wind speeds are broken down into 4 categories: light speeds (L) -- 1-10 knots, moderate speeds (M) -- 11-20 knots, high speeds (H) -- 21-30 knots, and very high speeds (VH) -- 31-40 knots.

Looking through table 2, it is readily seen that trade winds and moderate wind speeds are the predominant wind type and wind speed strength. The persistence of trade winds day after day is very evident. Trade winds occurred 84% of the time while southerly winds occurred 16% of the time. Moderate wind speeds occurred most often: 50% of the time under trade winds and 7% under southerly winds for a total of 57% of the time.

High wind speeds occur 28% of the time and very high wind speeds occur 3%

Table 2.

Prevailing Wind Type and Speed in Alenuihaha Channel (direction and speed),
 March 1984 - March 1986.

T = trade winds (NNE-E)

S = south winds (SW-SE)

Variable in forecasts

L = light: 1-10 kts

M = moderate: 11-20 kts

H = high: 21-30 kts

VH = Very high: 31-40 kts

1984:

DAY	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	DAY
1	SL	TH	TH	TM	TM	TM	TM	TM	TM	TM	1
2	SM	↑	↑	TM	↑	TH	↑	↑	↑	SL	2
3	↓	↑	TH	TH	↑	↑	↑	TM	↓	TM	3
4	SM	↑	TM	TM	↑	↑	↑	TL	TM	TH	4
5	SL	↓	↑	↑	↑	↓	↓	TM	TH	TM	5
6	TL	↓	↑	↑	↑	TH	↑	↑	↑	TH	6
7	↑	TH	↑	↑	↑	TM	↑	↓	TH	↓	7
8	↑	TVH	↑	↓	↑	↑	↑	TM	TM	TH	8
9	↓	TH	↓	TM	↑	↑	↑	TH	TM	TVH	9
10	↓	↑	TM	TH	↑	↑	↑	TH	TH	↓	10
11	TL	TH	TH	TH	↓	↓	↓	TM	TM	TVH	11
12	TM	TM	TM	TM	TM	↓	↓	TH	↑	TM	12
13	↑	TM	TM	↑	TH	TM	↑	TM	↓	SM	13
14	↑	TH	TH	↓	TH	TH	↑	↑	TM	SM	14
15	↓	↑	TM	TM	TM	TH	↑	↓	TH	TM	15
16	↓	↓	↑	TH	↑	TM	↑	TM	↑	↑	16
17	↓	TH	TM	TM	↑	↑	↑	SM	↑	TM	17
18	TM	TM	TH	↑	↑	↑	↑	SL	↑	TH	18
19	TH	↑	↑	↓	↑	↑	↑	TM	↑	TH	19
20	TM	↓	TH	TM	↑	↑	↑	↑	↑	TVH	20
21	TM	TM	TM	TH	↑	↑	↑	↑	↓	TM	21
22	TH	TH	TH	↑	↓	↑	↑	↑	↓	TM	22
23	↑	TM	TM	TH	TH	↑	↑	↑	TH	SL	23
24	↓	TL	TM	TM	TM	↑	↑	↑	TM	SL	24
25	TH	SL	TH	↑	↑	↑	↑	↑	SL	TM	25
26	TM	TM	TM	↑	↑	↑	↑	↓	↑	↑	26
27	TH	TM	↑	↓	↓	↑	↑	↓	↑	↑	27
28	↑	TH	↑	TM	↓	↑	↑	TM	SL	↑	28
29	↑	↑	↑	TH	TH	↑	↑	SL	TM	↓	29
30	↓	TH	↓	TM	TM	↑	TM	TM	TM	TM	30
31	TH	↑	TM	↑	TM	TM	↑	TM	↑	SL	31
TL	7	1	0	0	0	0	0	1	0	0	
TM	10	9	21	22	27	24	30	25	13	15	
TH	8	18	10	9	4	7	0	2	13	6	
VH	0	1	0	0	0	0	0	0	0	4	
SM	0	0	0	0	0	0	0	0	0	0	
SL	0	0	0	0	0	0	0	0	0	0	
TL	0	0	0	0	0	0	0	0	0	0	
TVH	0	0	0	0	0	0	0	0	0	0	
SM	0	0	0	0	0	0	0	0	0	0	
SL	0	0	0	0	0	0	0	0	0	0	
TL	0	0	0	0	0	0	0	0	0	0	
TVH	0	0	0	0	0	0	0	0	0	0	

of the time under trade wind conditions. Light wind speeds occur 3% of the time under trade winds and 9% of the time under southerly wind conditions.

IV. Wind and Waves Through the Alenuihaha Channel Under Trade Wind Conditions.

Before discussing the data and results of this section, it has to be cautioned that there are definite limitations to the data collected and method of analysis. On the other hand, this is the only generalized wind speed profile through the channel from Maui to Hawaii and it does provide useful comparative information on the wind and waves through the channel.

The Alenuihaha Channel was divided into 3 zones between Maui and Hawaii: the first third of the way from Maui to Hawaii was called zone 1, the middle third of the channel was called zone 2, and the last third of the way to Hawaii was called zone 3.

Because of the excellent cooperation of the Mate on the Constitution, wind and wave observations in the 3 zones were obtained during the ship's crossing of the channel from Maui to Hawaii on 27 nights in 1984. (see table 3)

Because of the coarseness of the data and method of analysis, the absolute values of the data should not be used. But the comparison of the wind speeds and wave heights in the 3 zones can be informative. The data shows that the winds and wave heights are about the same in all three zones. There is a very slight increase in the wind speeds and waves heights in the middle of the channel. One would expect that the middle of the channel would have the higher wind speeds and greater wave heights than the borders of the channel.

Table 3. Wind and Wave Observations in Three Zones in Alenuihaha Channel by U.S. Constitution Under Trade Wind Conditions, 1984, 2100 - 2300 Hours. (Zone #1: MAUI SIDE, Zone #2: MIDDLE, Zone #3: HAWAII SIDE)

1984 Mo/Day	ZONE #1				ZONE #2				ZONE #3			
	Wind Dir (°)	Wind Speed (Kts)	Seas (ft)	Swell (ft)	Wind Dir	Wind Speed	Seas	Swell	Wind Dir	Wind Speed	Seas	Swell
2/19	69	38	10	12	63	38	10	9	60	30	7	8
3/18	75	22	4	7	70	25	4	7	77	26	5	7
4/22	(65 34)	(5 10)			60	35	4	10	70	33	6	10
4/29	85	35	5	12	90	40	8	12	90	35	8	12
5/6	75	22	4	8	70	18	4	8	70	15	4	8
5/13	70	25	4	10	70	25	6	10	70	27	6	10
5/20	85	30	6	8	90	32	8	8	90	30	8	8
6/3	90	40	12	12	90	40	15	15	60	40	12	12
6/10	80	35	4	8	90	35	4	8	90	35	4	8
6/17	75	25	4	8	80	28	5	10	85	25	4	8
6/23	90	22	4	8	90	25	4	8	90	25	4	8
7/1	80	20	4	6	80	23	4	6	80	23	4	6
7/8	85	25	4	4	85	25	4	6	85	20	4	6
7/15	90	20	4	4	90	20	4	4	90	20	4	4
7/22	90	20	4	4	90	20	4	4	90	20	4	4
7/29	70	25	3	6	75	30	4	6	75	30	4	6
9/2	85	24	2	6	90	22	2	6	90	22	2	6
9/9	70	28	3	6	70	30	4	6	70	30	4	6
9/16	80	15	3	3	80	15	3	3	80	15	3	4
9/23	80	25	3	6	80	25	3	6	80	25	3	6
9/30	50	25	4	3	50	25	4	3	50	22	4	3
10/7	78	32	4	4	62	28	4	4	70	34	4	4
10/14	(75 24)	(2 4)			70	23	2	3	80	25	2	4
10/21	65	20	2	2	60	13	2	2	(65 17)		2	2
10/27	80	18	2	2	85	17	2	2	(85 18)	(2 2)		
11/11	55	27	6	6	70	31	6	6	(65 29)	(6 6)		
11/18	70	42	8	8	75	38	8	8	(75 40)	(8 8)		
average		26.6	4.4	6.1		26.9	4.9	6.2		26.3	4.7	6.1
notes:	no observations were available in a few zones and averaged data were calculated for these zones. data identified by brackets (xx).											

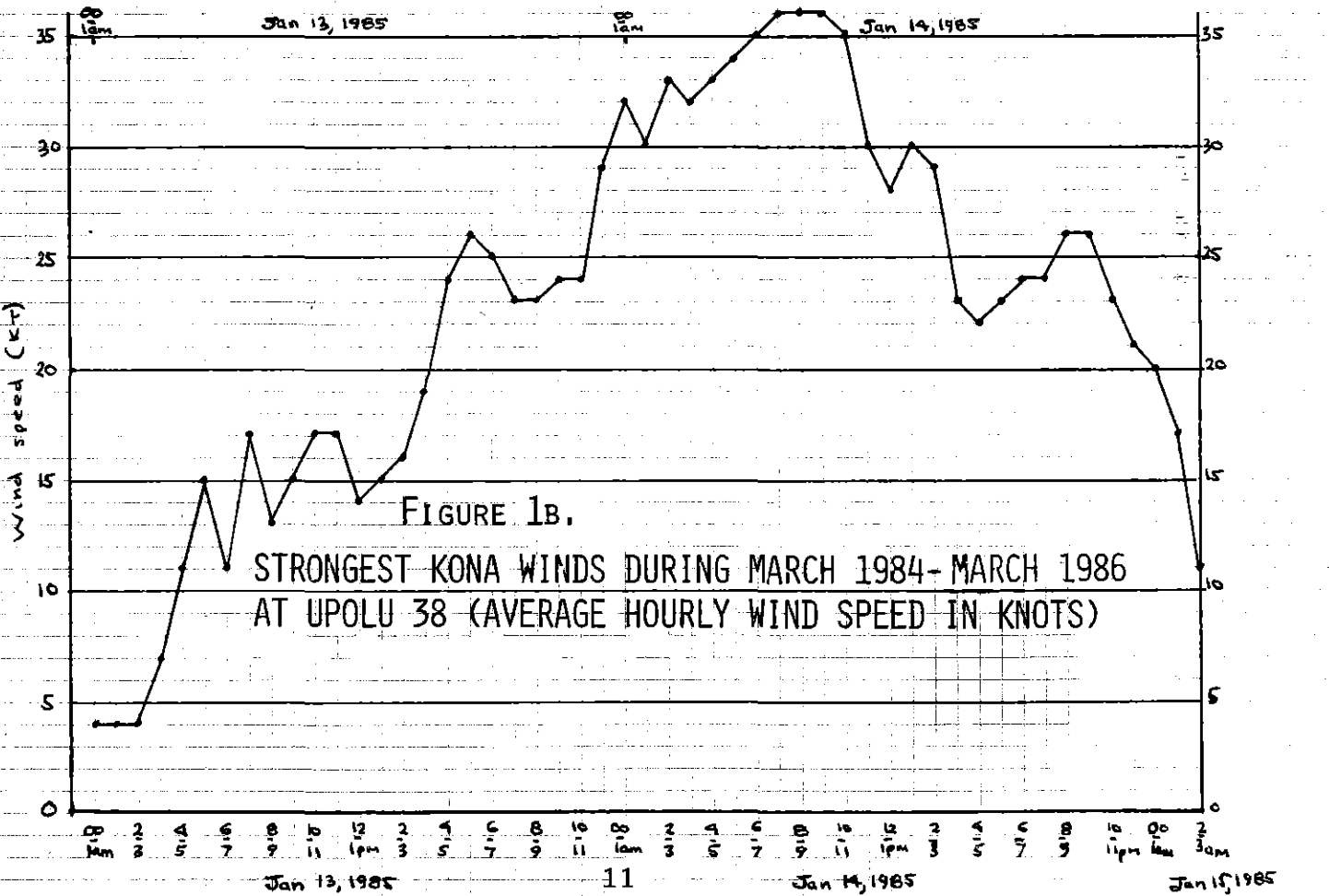
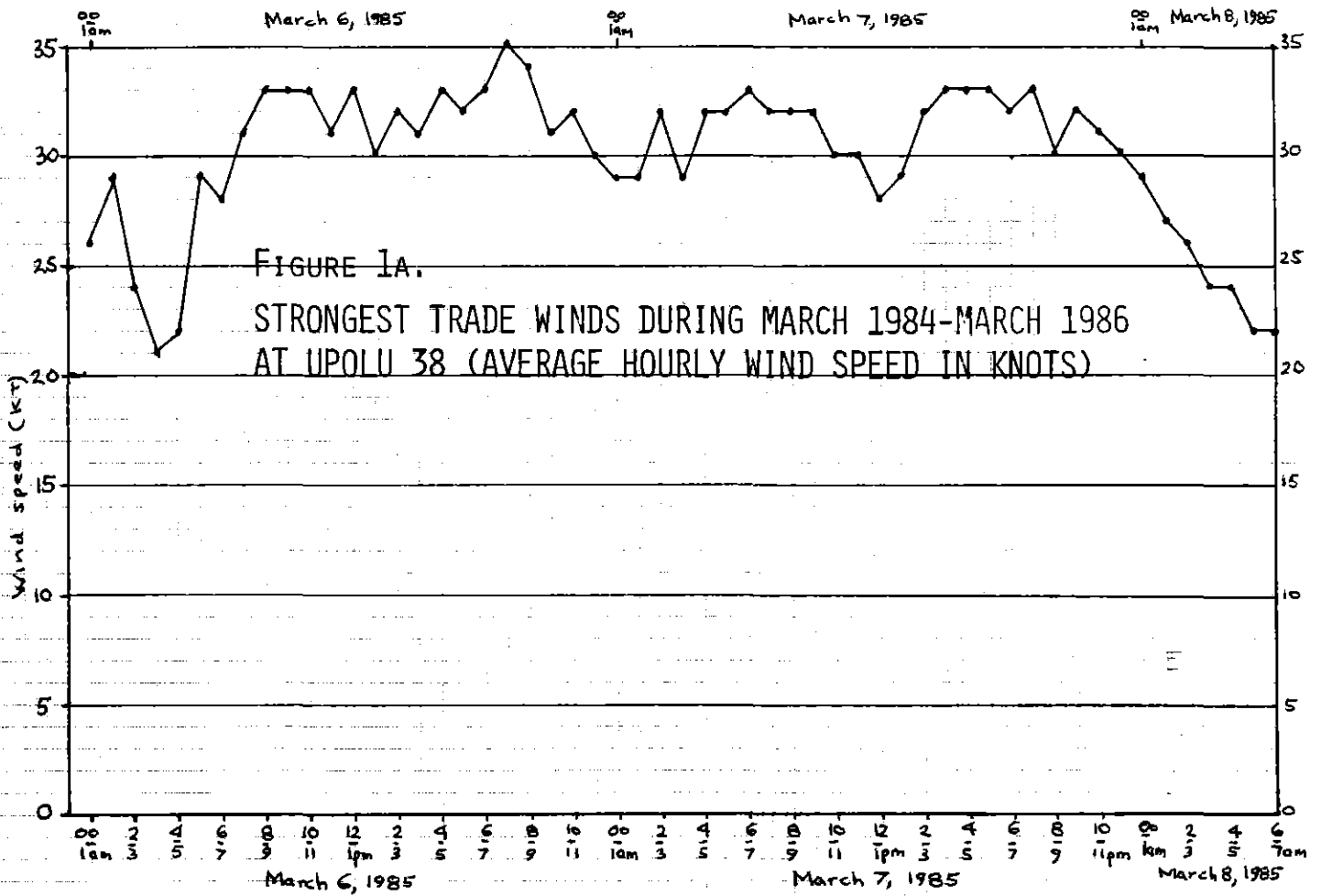
V. Summary of Winds at Upolu Point, March 1984-March 1986.

Located only a few hundred yards from the Alenuihaha Channel at Upolu Point, this National Weather Service wind station is automatically queried every hour and the data are available for operational use at the Honolulu office of the NWS. The uncorrected wind speeds from this station gives the impression that the winds are not as strong as expected at Upolu Point which is not the case. The wind speed from this station has significant error because of the wind sensor's location behind a building and ridge (in respect to the prevailing trade winds). The wind speeds from this station cannot be used directly to determine the wind speeds in the Alenuihaha Channel.

Another wind station, Upolu 38, was established a mile away in a well-exposed location to correlate with Upolu NWS. These correlations are presented in later sections and it will be shown how the adjusted Upolu NWS winds can be used on a real-time basis during any project operation.

It will later be shown that the winds at Upolu 38 can be used to represent the winds in the Alenuihaha Channel so it would be very informative to view some important characteristics of the winds at Upolu 38. The first graph, figure 1a, shows the average hourly wind speeds during the period of strongest trade winds, March 6-8, 1985. This was an exceptionally windy period with the speeds persistently above 30 knots for most of the time. The peak hourly average wind speed was 35 knots.

The second graph, figure 1b, shows the average hourly wind speeds during the period of strongest Kona winds, January 13-January 15, 1985. The strong Kona winds do not persist as long as strong trade winds at any one location.



The period of wind speeds above 30 knots lasted half a day on the 14th. The peak average wind speed of 36 knots persisted for three hours.

Figure 2 shows the average hourly wind speeds for a windy month (March 1985), moderately wind month (April 1985) and a light wind month (January 1985). The average wind speed for the windy month was about 25 knots, about 16 knots for the moderately windy month, and about 10 knots for the light wind month. The windy month shows little diurnal variation of the wind speed while the light-wind months shows a more pronounced diurnal wind speed variation. The stronger wind speed during the daylight hours and weaker wind speeds during the dark hours can be mainly caused by the greater turbulence of the winds from heating of the land surface by the sun.

The unadjusted monthly summaries of the frequency of wind speed and direction and average hourly wind speeds at Upolu NWS and Upolu 38 are presented in attachments A and B. respectively. The average hourly wind speeds for Upolu NWS are not correct for the hours when only few data were recorded: hour 1-2, 7-8, 13-14, and 19-20.

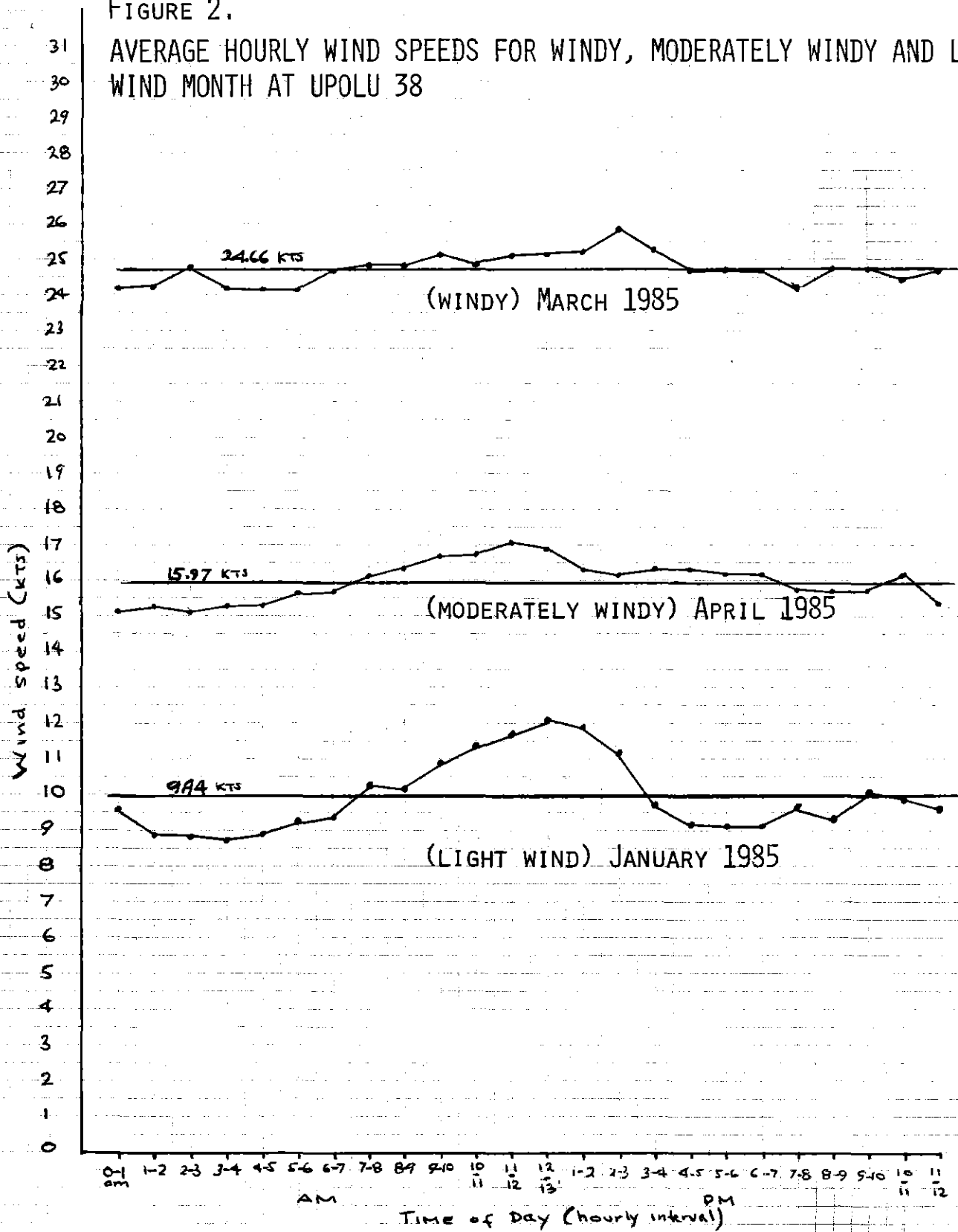
For comparison purposes, the monthly average wind speeds at Upolu NWS and Upolu 38 are listed in table 4. From the table, it is obvious that the measured wind speeds at Upolu NWS are lower than at Upolu 38. This erroneous relationship is mainly caused by the low wind speed recordings at Upolu NWS. The true condition is that at the same height at the two locations, the winds are stronger at Upolu NWS than at Upolu 38.

VI. Correlations of All the Collected Data.

The purpose of correlating the data is to determine the wind speeds and

FIGURE 2.

AVERAGE HOURLY WIND SPEEDS FOR WINDY, MODERATELY WINDY AND LIGHT WIND MONTH AT UPOLU 38



wave heights in the Alenuihaha Channel based on the data collected. Use of the linear regression line and correlation coefficient is a simple and effective method to graphically and quantitatively show the relationship between two variables that are related to each other by more than chance. Correlation coefficient values close to 1.0 show high relationship between the two variables while values below 0.3 mean weak or no relationship between the two variables. It has to be expected that correlating data taken from field measurements as opposed to laboratory measurements will produce lower correlation coefficients although the two variables can be better related than the correlation coefficients will show.

By a stroke of good fortune, the NWS installed a test NOAA buoy in the Alenuihaha Channel in late December 1985. There appeared to be problems in the data during the first few months. The wind and wave data from the buoy, NOAA buoy 51005, for March 1986 are submitted together with the other data for March 1986 (attachment C). Its percent frequency of wind speed and direction for the month is presented in attachment D. It will later be shown that the data from this buoy can be used as the standard in representing the winds and waves in the Alenuihaha Channel.

Table 5 lists all the possible correlations between pairs of data collected. Errors in most of the data collected reduce the correlation coefficients. The following discussion of the correlations between important variables is presented in a block-building manner leading to the best estimate of the winds and waves in the Alenuihaha Channel determined from the data collected:

1. Upolu 38 vs Upolu NWS: Each month's hourly data were correlated with

TABLE 5. CORRELATION COEFFICIENTS OF RELATED PAIRS OF VARIABLES FROM COLLECTED DATA.

<u>FIRST VARIABLE</u>		<u>SECOND VARIABLE</u>	<u>CORR. COEF.</u>	<u># DATA</u>
DILLINGHAM TUGS:				
WIND SPEED	VS	SEAS	0.62	195
WIND SPEED		SWELL	.45	196
WIND SPEED		UPOLU NWS 1-MIN SPEED	.50	176
WIND SPEED		UPOLU 38 1-HR SPEED	.66	47
WIND SPEED		UPOLU NWS PEAK GUST	.60	176
SEAS		SWELL	.45	195
UPOLU NWS:				
1-MIN SPEED		TUG SEAS	.48	175
1-MIN SPEED		TUG SWELL	.26	176
PEAK GUST		TUG SEAS	.51	175
PEAK GUST		TUG SWELL	.39	176
1-MIN SPEED		CONSTITUTION WIND SPEED	.57	66
1-MIN SPEED		INDEPENDENCE WIND SPEED	.59	68
PEAK GUST		CONSTITUTION WIND SPEED	.69	68
PEAK GUST		INDEPENDENCE WIND SPEED	.70	68
1-MIN SPEED		CONSTITUTION SEAS	.44	66
1-MIN SPEED		INDEPENDENCE SEAS	.25	68
PEAK GUST		CONSTITUTION SEAS	.44	55
PEAK GUST		INDEPENDENCE SEAS	.44	68
1-MIN SPEED		CONSTITUTION SWELL	.42	64
1-MIN SPEED		INDEPENDENCE SWELL	.41	48
PEAK GUST		CONSTITUTION SWELL	.43	61
PEAK GUST		INDEPENDENCE SWELL	.47	48
CONSTITUTION:				
WIND SPEED		SEAS	.58	72
WIND SPEED		SWELL	.52	66
SEAS		SWELL	.48	64
INDEPENDENCE:				
WIND SPEED		SEAS	.61	72
WIND SPEED		SWELL	.47	51
SEAS		SWELL	.43	51

TABLE 5 CONTINUED.

CORRELATION COEFFICIENTS IN RELATING UPOLU 38 1-HR AVERAGE WIND SPEED WITH THE FOLLOWING VARIABLES:

<u>YR/MONTH</u>	<u>UPOLU NWS 1-MIN SPEED</u>	<u>UPOLU NWS PEAK GUST</u>	<u># DATA</u>
1984 OCT	0.85	0.90	153
Nov	-	-	0
DEC	.87	.94	76
1985 JAN	.76	.79	359
FEB	.84	.89	278
MAR	.57	.64	566
APR	.63	.70	456
MAY	-	-	0
JUN	.87	.90	411
JUL	.82	.89	349
AUG	.65	.79	489
SEP	.88	.91	511
OCT	.88	.92	433
Nov	.85	.86	216
DEC	.83	.95	27
AVERAGE	.79	.85	

<u>VARIABLE</u>	<u>CORRELATION COEFFICIENT</u>	<u># DATA</u>
TUG SEAS	0.57	47
TUG SWELL	.63	47
CONSTITUTION WIND SPEED	.69	25
INDEPENDENCE WIND SPEED	.63	17
CONSTITUTION SEAS	.09	25
INDEPENDENCE SEAS	.52	17
CONSTITUTION SWELL	.73	23
INDEPENDENCE SWELL	.52	17

CORRELATION COEFFICIENTS IN RELATING NOAA BUOY 51005, MARCH 1986 DATA:

BUOY AVE. SPEED VS UPOLU NWS 1-MIN SPD	0.75	547
BUOY AVE. SPEED VS UPOLU NWS PEAK GUST	.86	551
BUOY PEAK GUST VS UPOLU NWS PEAK GUST	.85	551
BUOY AVE. SPEED VS BUOY WAVE HEIGHT	.79	551

each other: Upolu 38's 1-hour average wind speed compared with Upolu NWS's 1-minute sustained wind speed and with Upolu NWS's peak gust. The average correlation coefficients between Upolu 38's 1-hour average speed and Upolu NWS's peak gust and 1-minute sustained speed were .85 and .79, respectively. These correlation coefficients are high for wind speed data which indicates that the collected wind speed measurements are related to the general wind speed for the Upolu area (and for the Alenuihaha Channel). This also means that either one of the wind station's data can be substituted for the other.

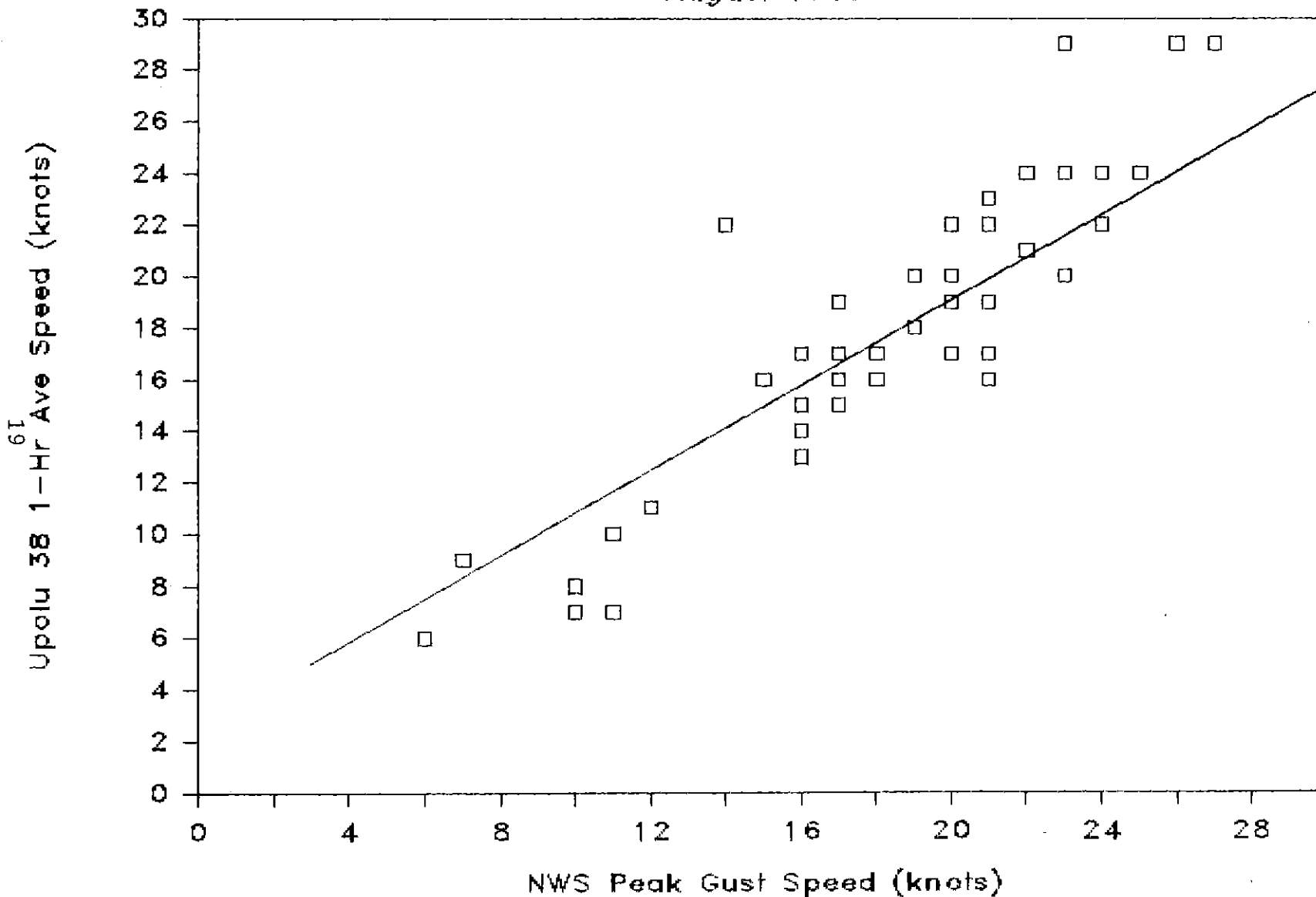
Because of the greater error in Upolu NWS's 1-minute sustained wind speed than in its peak gust speed, the correlation coefficient was higher in the relationship between Upolu 38's 1-hour average wind speed and Upolu NWS's peak gust than with its 1-minute sustained speed.

A graphic example of the correlation between Upolu 38's 1-hour average wind speed and Upolu NWS peak gust is seen in figure 3. There are more than 10 times the data points in the correlation than seen in the graph. The reason that only 40 points are seen on this graph is that most of the 489 points are overplotted and not seen as more than one point at each grid point. Most of the overplotted points are close to the regression line which is the sloping straight line relating the speeds of the two variables to each other. In the figure, a peak gust of 9 knots at Upolu NWS is related to about 10 knots 1-hour sustained speed at Upolu 38. At the higher wind speeds, a peak gust of 27 knots at Upolu NWS is related to about 25 knots 1-hour sustained speed at Upolu 38. Even with the known errors in the wind data, this relationship is still valuable and can be used to justify a useful almost 1:1 relationship between Upolu NWS's peak gust and Upolu 38 1-hour average wind speed.

FIGURE 3.

NWS Gust vs Upolu 38 1-Hr Ave Spd

August 1985



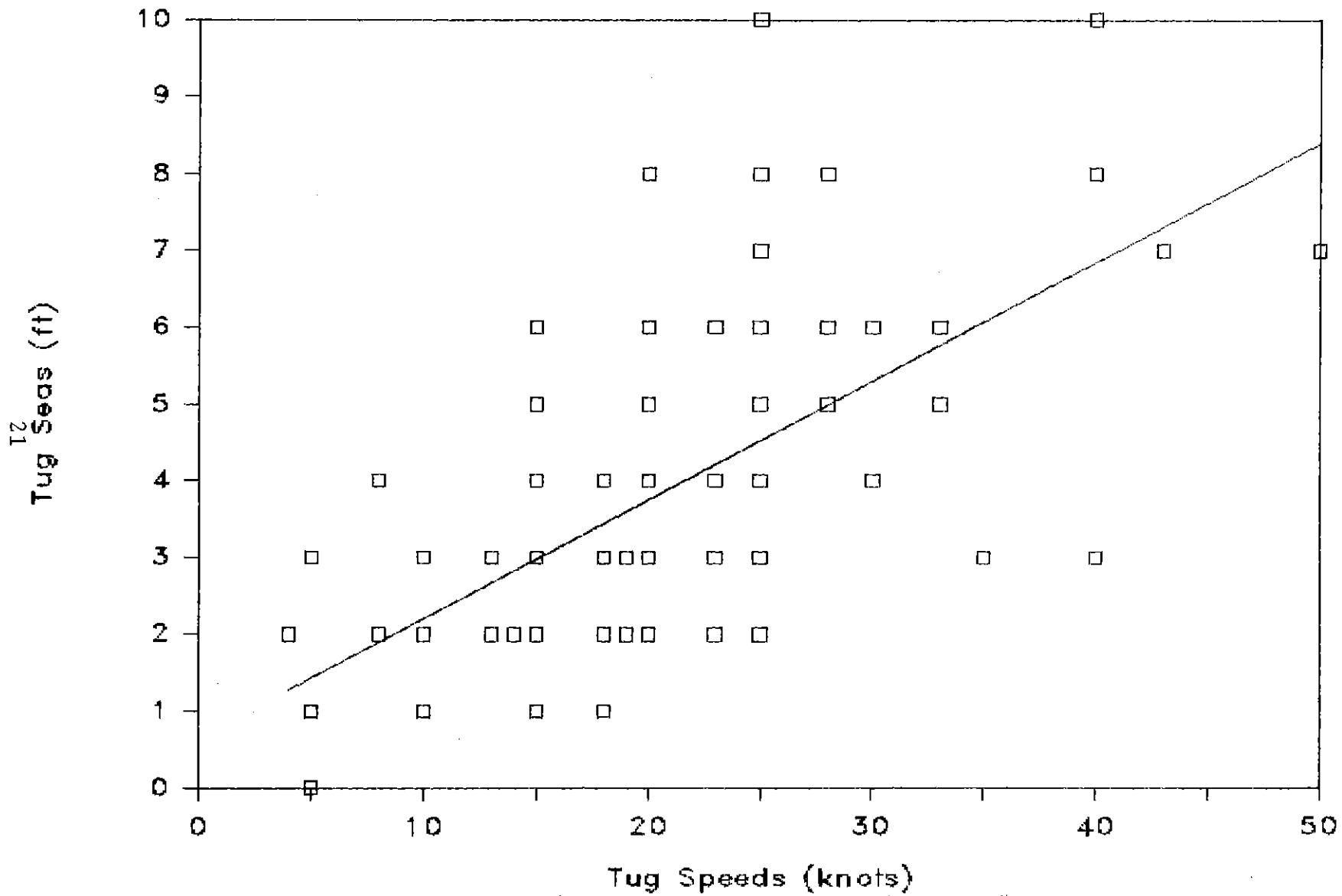
N = 489

CORRELATION COEFFICIENT = 0.79

2. Tug Wind Speeds vs Tug Sea Heights: The estimated sustained wind speed and sea heights observed by the Dillingham tugs' Mates during the tugs crossing of the Alenuihaha Channel under trade wind conditions were correlated. Using 195 data points, the correlation coefficient was 0.62 which implies moderate relationship between the local strength of the trade winds and the locally generated seas in the relatively short and narrow Alenuihaha Channel. Considering the errors in estimating the wind speeds and wave heights and the knowledge that the sea heights are also dependent on trade winds upwind of the channel, the moderate relationship between the strength of the trade winds in the channel and the local waves in the channel shown by the data is very encouraging. There is a good chance that the relationship between the strength of the trade winds and the local seas has a higher relationship than shown by this correlation coefficient.

Figure 4 shows the graphical relationship between strength of the trade winds and wave heights estimated by the tugs. The graph shows significant scattering of the data points away from the linear regression line. It is not as bad as seen in the chart because there is overplotting of the data points as evidenced by only about 50 points printed on the graph whereas there were 195 data points used to derive the correlation coefficient. Most of the overplotted points are closer to the regression line. The regression line shows that a wind speed of 10 knots is related to a wave height of about 2 feet and a wind speed of 28 knots is related to a wave height of 5 feet. Because of the errors mentioned earlier, this wind speed to wave height relationship has errors but it does show that wave heights are not as high as the NWS standard forecasts for wave heights in the channel: 12 feet with 25 knot speed and 15 feet with 30 knot speed.

FIGURE 4.
Tug Speeds vs Tug Seas



N = 195

CORRELATION COEFFICIENT = 45

It would be worthwhile to see how Upolu 38's wind speeds relate to tug wind speeds because it was earlier seen that Upolu 38 can be confidently used to represent the wind speed at Upolu Point and in the Alenuihaha Channel. Figure 5 shows the graphical relationship between Upolu 38's 1-hour wind speeds and tug's wind speeds. The correlation coefficient was only 0.66 with 47 data points which indicates that tug wind speed error contributed to this lower correlation.

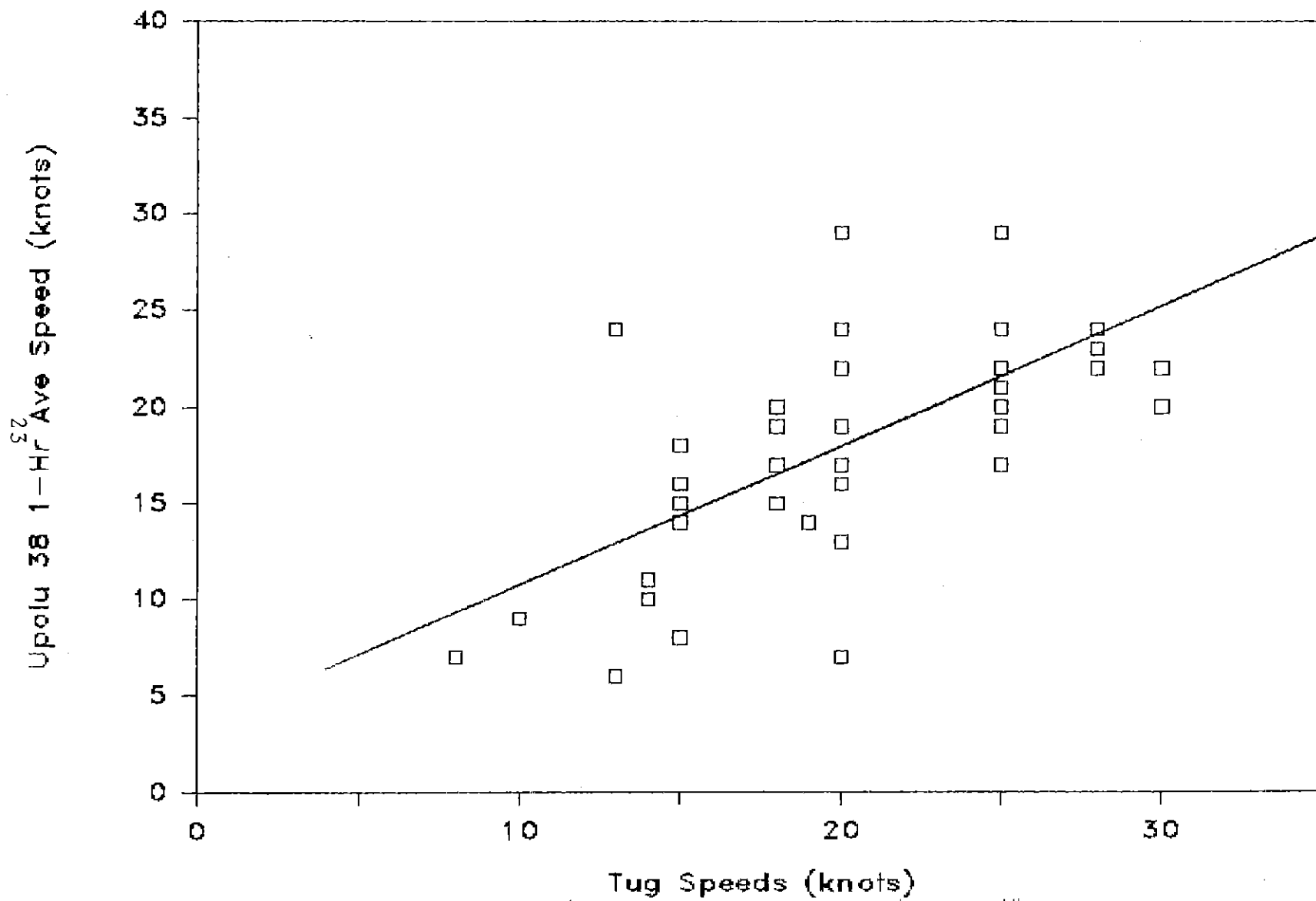
The main purpose of this discussion on the tug's winds and waves relationship is to lay the foundation for a better relationship between wind speeds and wave heights in the Alenuihaha Channel.

3. NOAA Buoy 51005's Average Wind Speed vs Significant Wave Height, March 1986: For an easy visualization of the wind speeds and wave heights in the Alenuihaha Channel, the buoy's wind speeds and wave heights are plotted together on the same graph. Figure 6a shows the wind speeds and wave heights for the entire month. Figure 6b shows the wind speeds and wave heights for March 4-5, a period of low wind speeds and wave heights. Figure 6c shows the wind speeds and wave heights for March 14-15, a period of strong wind speeds and high wave heights. In the figures, the top line graph is the wind speed and the bottom line graph is the wave height.

The following are the important facts seen in the figures: 1. low wind speeds relate to low wave heights while high wind speeds relate to high wave heights. 2. wind speed peaks precede wave height peaks. 3. even under low wind speeds, there is an underlying significant wave height varying between 3 to 5 feet which means that the wave heights do not drop to zero or close to

FIGURE 5.

Tug Speeds vs Upolu 38 1-Hr Ave Speed



N = 47

CORRELATION COEFFICIENT = 0.66

FIGURE 6A.

NOAA Buoy 51005

Wind Speeds vs. Wave Heights, MARCH 1986

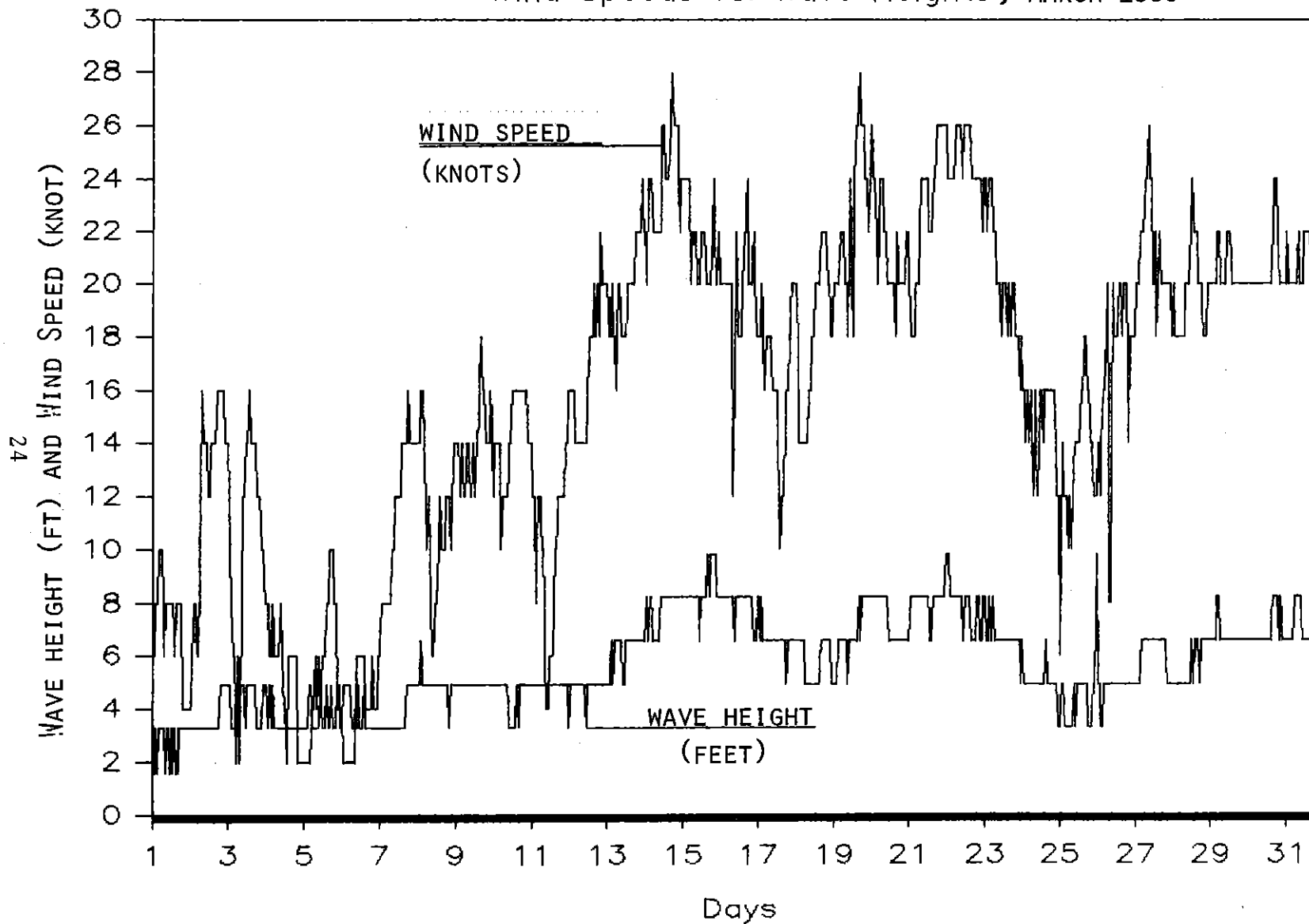
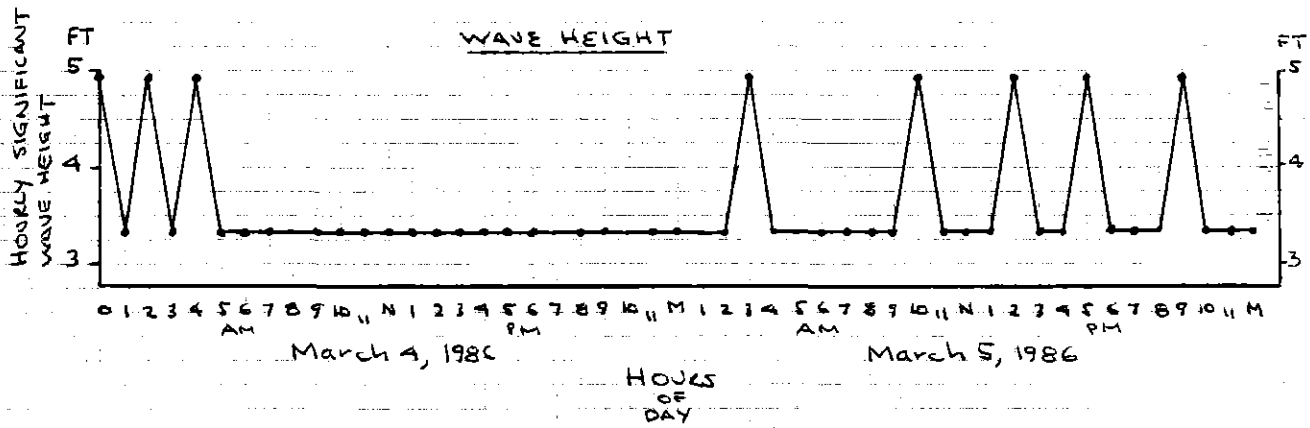
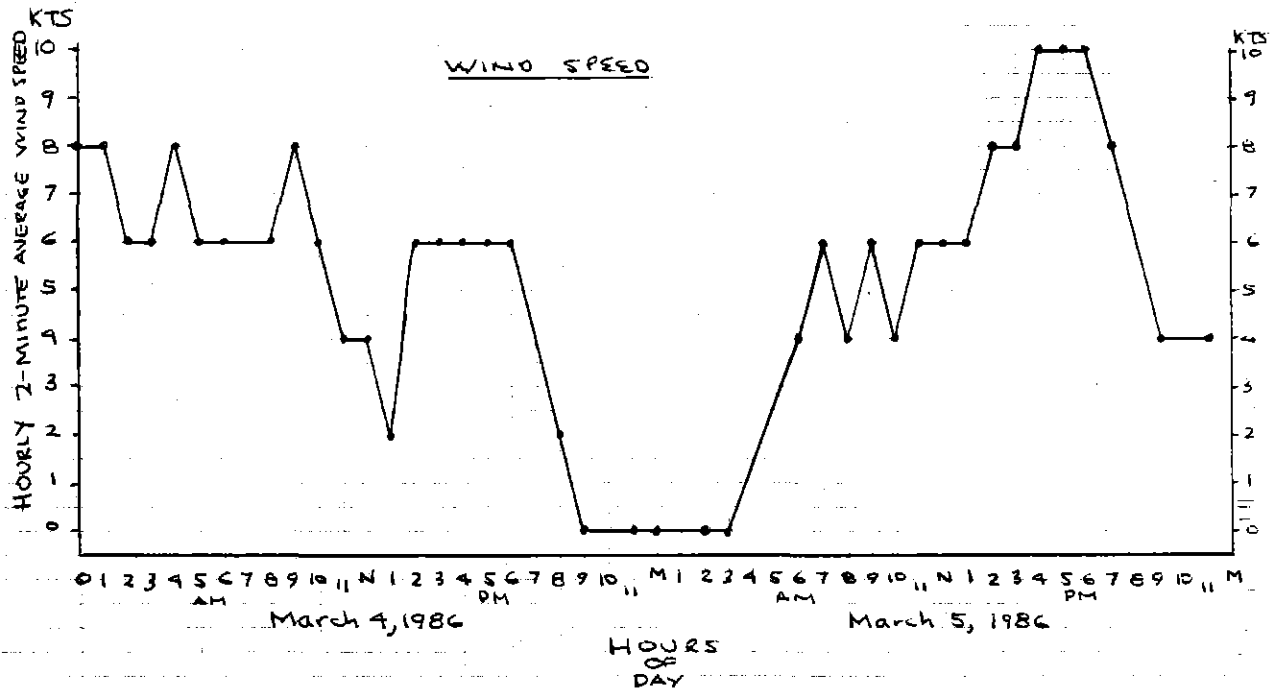
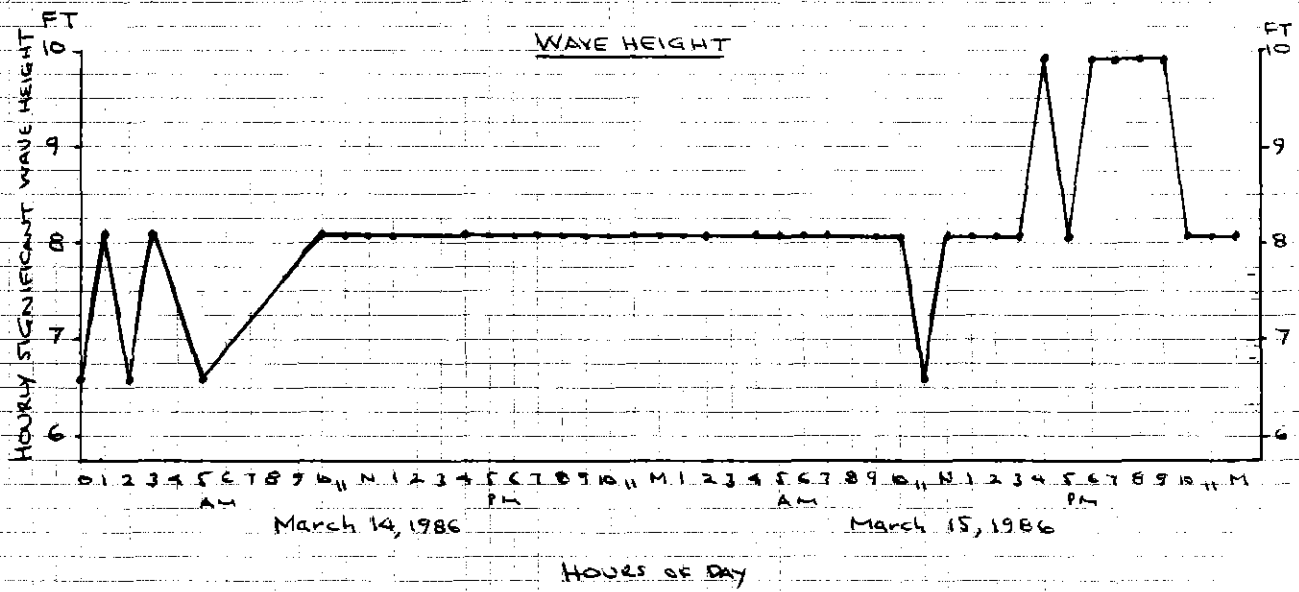
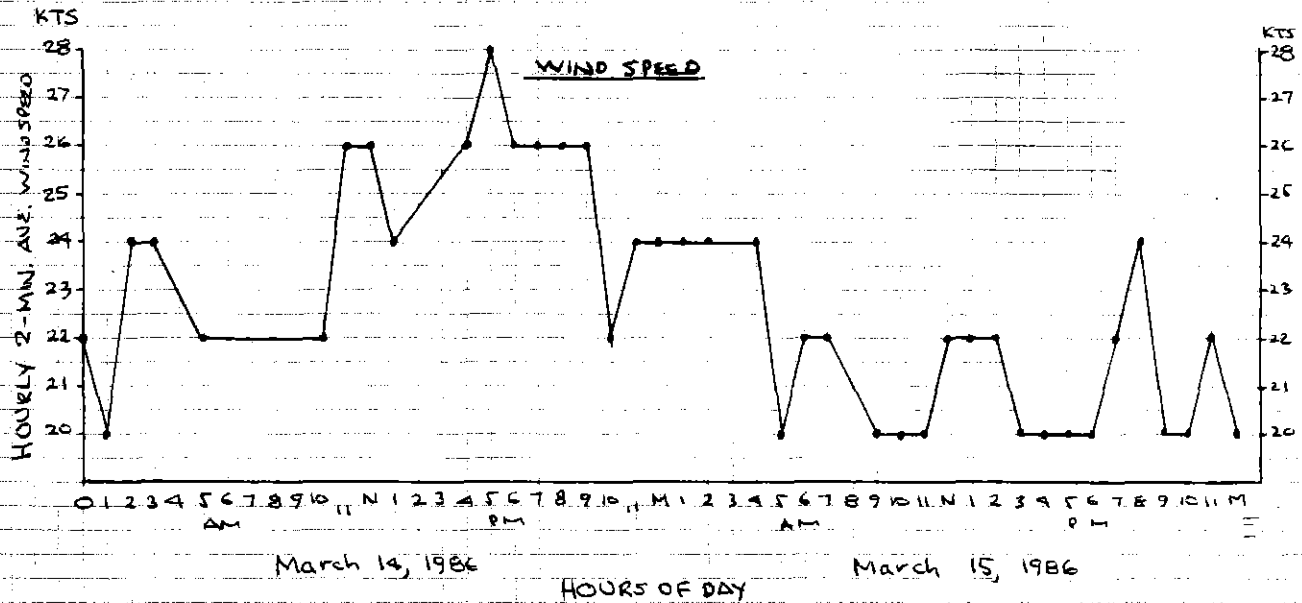


FIGURE 6B. WIND SPEED AND WAVE HEIGHT AT NOAA BUOY 51005 DURING LIGHT WIND SPEEDS ON MARCH 4 AND 5, 1986.



Relationship between wind speed and wave height under light wind speed condition (SOUTHWEST wind direction) at NOAA buoy 51005 in Aleutian Channel during March 4-5, 1986.

FIGURE 6C. WIND SPEED AND WAVE HEIGHT AT NOAA BUOY 51005 DURING STRONG TRADE WINDS ON MARCH 14 AND 15, 1986.



Relationship between wind speed and wave height under strong trade wind condition (NORTHEAST WIND DIRECTION) at NOAA buoy 51005 in Alenuihaha Channel during March 14-15, 1986.

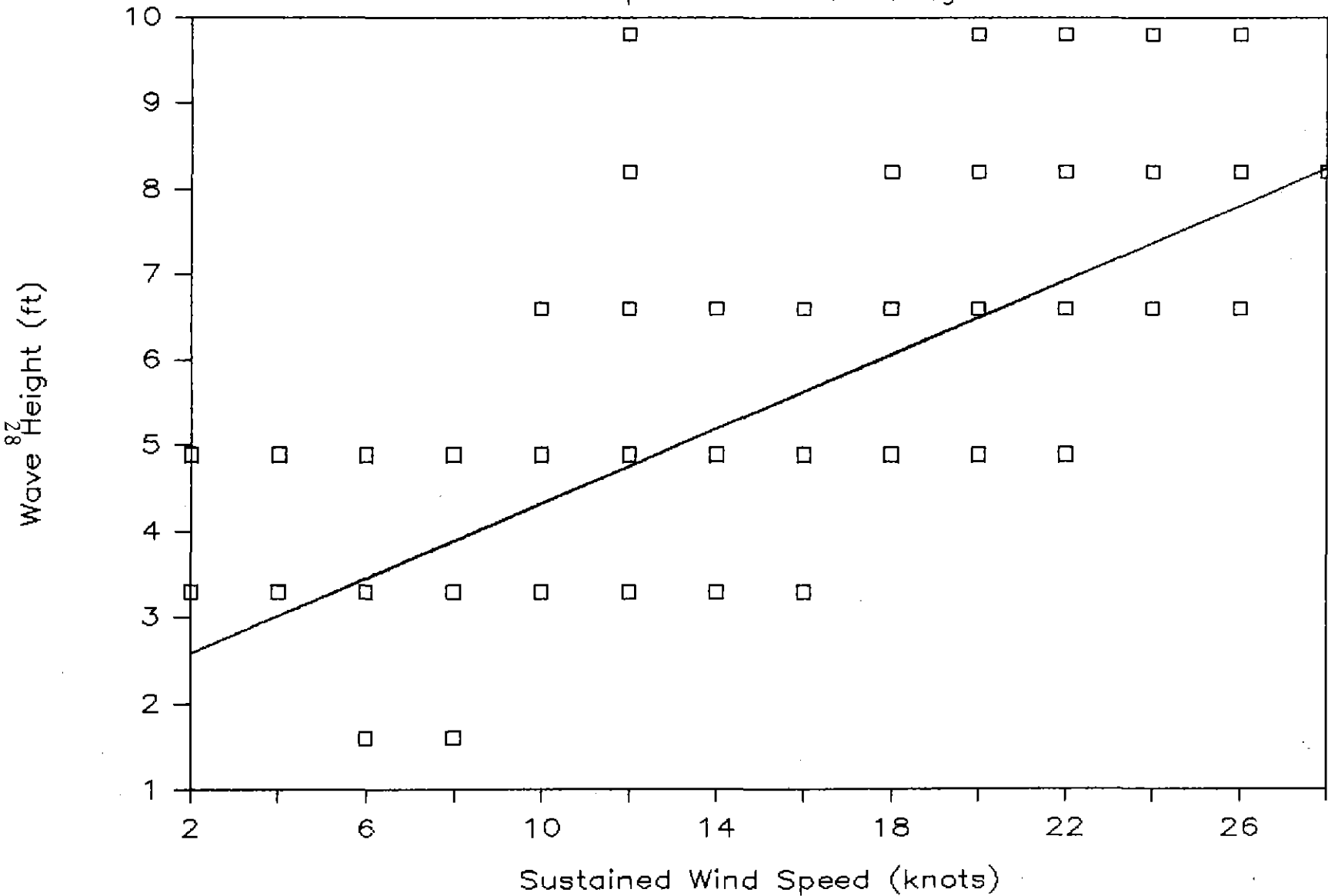
zero height when the wind speeds are light. 4. under strong wind speeds between 20 to 28 knots, wave heights varied between 6.6 to 9.8 feet.

For March 1986 data, the buoy's hourly 2-minute average wind speeds and significant wave heights were correlated for a verification of the tugs' wind speed to wave height relationship as derived in the earlier section because the errors in the buoy's measured data is significantly less than the estimated values from the tugs.

With 551 data points, the correlation coefficient for the relationship between 2-minute average wind speed and significant wave height was 0.79, a significant improvement from the 0.62 correlation coefficient in the tugs' wind speed vs wave height correlation. This high correlation coefficient between the buoy's wind speed and wave height implies that about 62% of the variation in the height of the waves is directly caused by variation in the wind speeds in the Alenuihaha Channel. This is a very important finding because it is proof that the cause of variation in the wave heights in the channel is due mainly to variations in the wind speeds in the channel. This also means that if the wind speeds in the channel is known then the wave heights can also be known. It then can be stated with confidence that if the trade winds are light over the North Central Pacific and in the Alenuihaha Channel, the wave heights in the channel would also be low. On the other hand, if the trade winds are strong over the North Central Pacific and in the Alenuihaha Channel, the wave heights in the channel would also be high.

Figure 7 shows the graphical relationship of the NOAA buoy 51005's wind speeds and wave height for March 1986. Although the data is for only one month, the graph can represent the relationship between wind speeds and wave

FIGURE 7.
NOAA Buoy 51005
Wind Speeds vs. Wave Heights



N = 551 LINEAR REGRESSION EQUATION: $Y(\text{WAVE HT}) = .2173442 X(\text{WIND SPEED}) + 2.151069$
CORRELATION COEFFICIENT = 0.79

heights under trade wind conditions throughout the year. Again, the scatter of the data points around the regression line is better than seen in the graph because of the overplotting of 551 data points on 42 points. The regression line shows that a wind speed of 10 knots is related to a wave height of about 4 feet while a wind speed of 28 knots is related to a wave height of about 8 feet.

4. Comparison of the Tug's Wind Speed/Wave Height Relationship and the NOAA Buoy 51005's Wind Speed/Wave Height Relationship: For a 10-knot trade wind speed, the tug's related wave height was only 2 feet while the buoy's related wave height was 4 feet. For a 28-knot trade wind speed, the tug's related wave height was only 5 feet while the buoy's related wave height was 8 feet. There are 2 main reasons for this discrepancy in the related wave heights from the tugs and the buoy. The first reason is that the estimated wind speeds by the tugs may be on the high side. The second reason is that the human's estimate of the height of the seas and the buoy's measurement of the significant wave height are not the same. The tug observes the sea and swell separately while the buoy's significant wave height is from the measurement of the total wave present. It was seen earlier that there is a 3 to 5 feet underlying wave height under light wind speed conditions. If 3 feet of this underlying wave height is added to the tug's seas height, the relationship between tug wind speed and wave height will be close to the relationship between buoy wind speed and wave height.

This problem of the difference in the related wave heights from the two sources is not as great as it appears. The tugs contributed greatly to the understanding of the wind speeds and wave heights in the channel. In the

first and only other definitive study of the wind speed and wave height relationship in the major channels, the analyst in 1973 with the cooperation of the Dillingham tugs, was able to find and publish for the first time the relationship between trade wind speeds and wave heights in all the major channels in the Hawaiian Islands. This earlier study, which used the tugs' wind speeds related to the gradient wind speeds over the state, concluded that for the Alenuihaha Channel, a 15-knot wind speed related to a wave height of 3 to 4 feet while a 30-knot wind speed related to a wave height of 8 to 11 feet.

It is seen that the wind speed to wave height relationship in the earlier study and in the NOAA buoy 51005 data are basically similar. This shows that the derived relationship of wind speed and significant wave height from the buoy data is fundamentally correct. Therefore, the relationship as shown in figure 7 between 2-minute wind speeds and significant wave heights at the buoy is accepted and believed to be the trade wind speed and wave height relationship in the Alenuihaha Channel for the project.

5. Correlating the Wind Speeds at Upolu NWS and NOAA buoy 51005: A permanent source of wind speeds in the Alenuihaha Channel other than from NOAA buoy 51005 has to be found because the buoy's life is uncertain as it was deployed for testing and not as a permanent station.

The Upolu NWS wind station is a permanent station. Its wind speed can be used as a good estimate of the winds in the Alenuihaha Channel if its errors are taken into account. The correlation of March 1966 Upolu NWS's peak gust and 1-minute sustained wind speed data with NOAA buoy 51005 2-minute wind speed data showed that both types of Upolu NWS's wind speed data correlated

well with the buoy's wind speed data. Because of errors in the Upolu NWS 1-minute wind speed data as explained earlier, the peak gust data correlated higher (0.86 correlation coefficient) than the 1-minute sustained wind speed (0.75 correlation coefficient) with the buoy's wind speed. See figures 8 and 9 for the graphical relationships between the two types of wind speeds at Upolu NWS and the wind speeds at the buoy. Again, the scatter of the data points around the regression line is not as bad as seen in the graphs because most of the data points around the regression line are overplotted on the graphs.

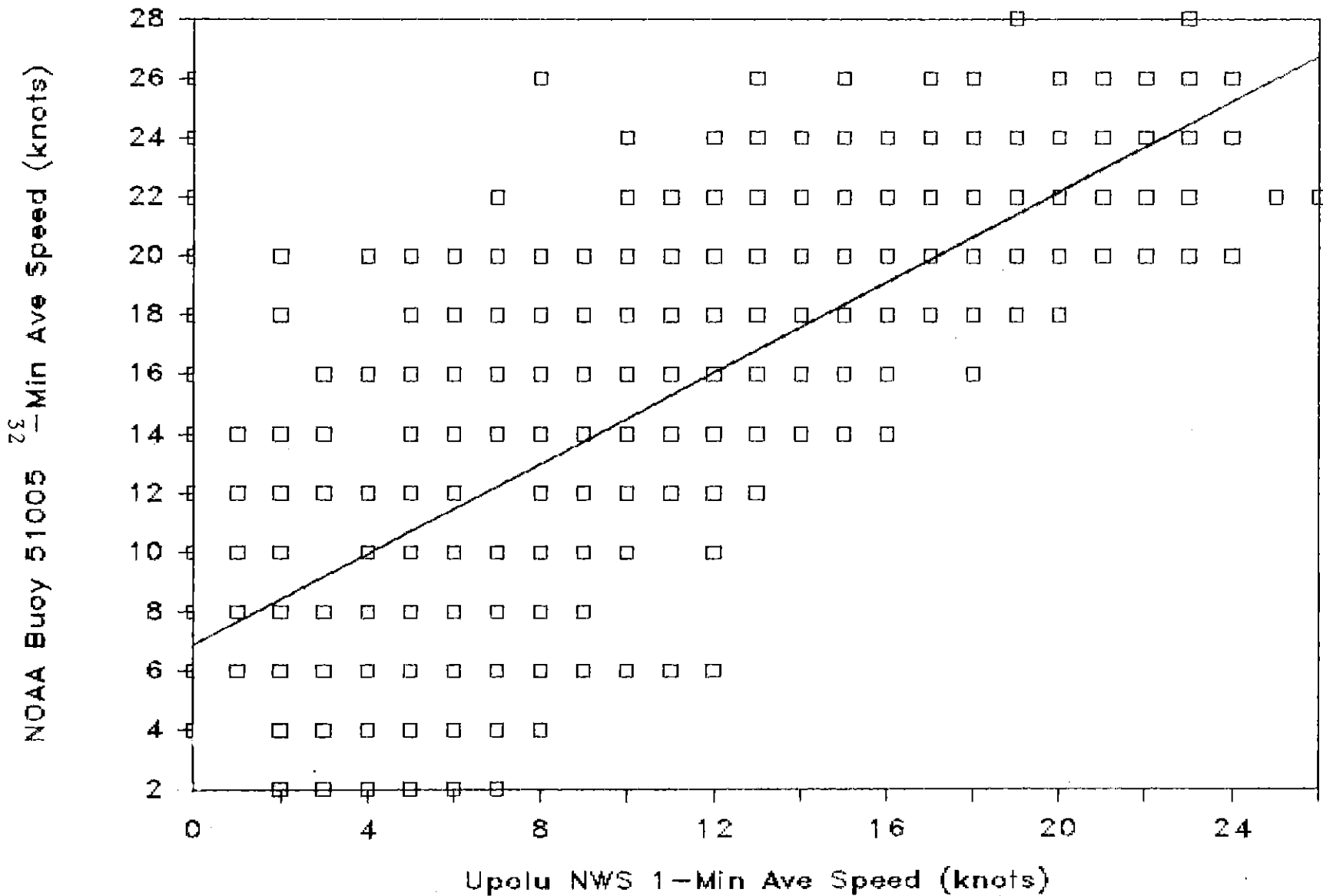
In the two graphs, the regression lines show that a 10-knot 1-minute sustained wind speed and a 10-knot peak gust at Upolu NWS relate to a 14.5 knot and a 11-knot sustained wind speed at the buoy, respectively. A 26-knot sustained wind speed and a 26-knot peak gust at Upolu NWS relate to a 27-knot and a 23-knot sustained wind speed at the buoy, respectively.

The errors in the wind speeds from Upolu NWS are greater at the lower end of the speeds. The lower wind speeds at Upolu NWS are affected more than the higher wind speeds by the reduction of the wind speeds by the building and ridge upwind (in respect to the trade wind direction). This is why the peak gusts of this station relate better to other variables than the sustained wind speeds.

The high correlation coefficients show that the wind speeds at Upolu NWS and at the buoy are well related and about three-fourths of the variation in the wind speeds at the buoy can be explained with the variations in the wind speeds at Upolu NWS. This is a high correlation for wind speeds in the field which leads to a high degree of confidence to use the adjusted Upolu NWS's

FIGURE 8.

Upolu NWS Ave Spd vs NOAA Buoy Ave Spd

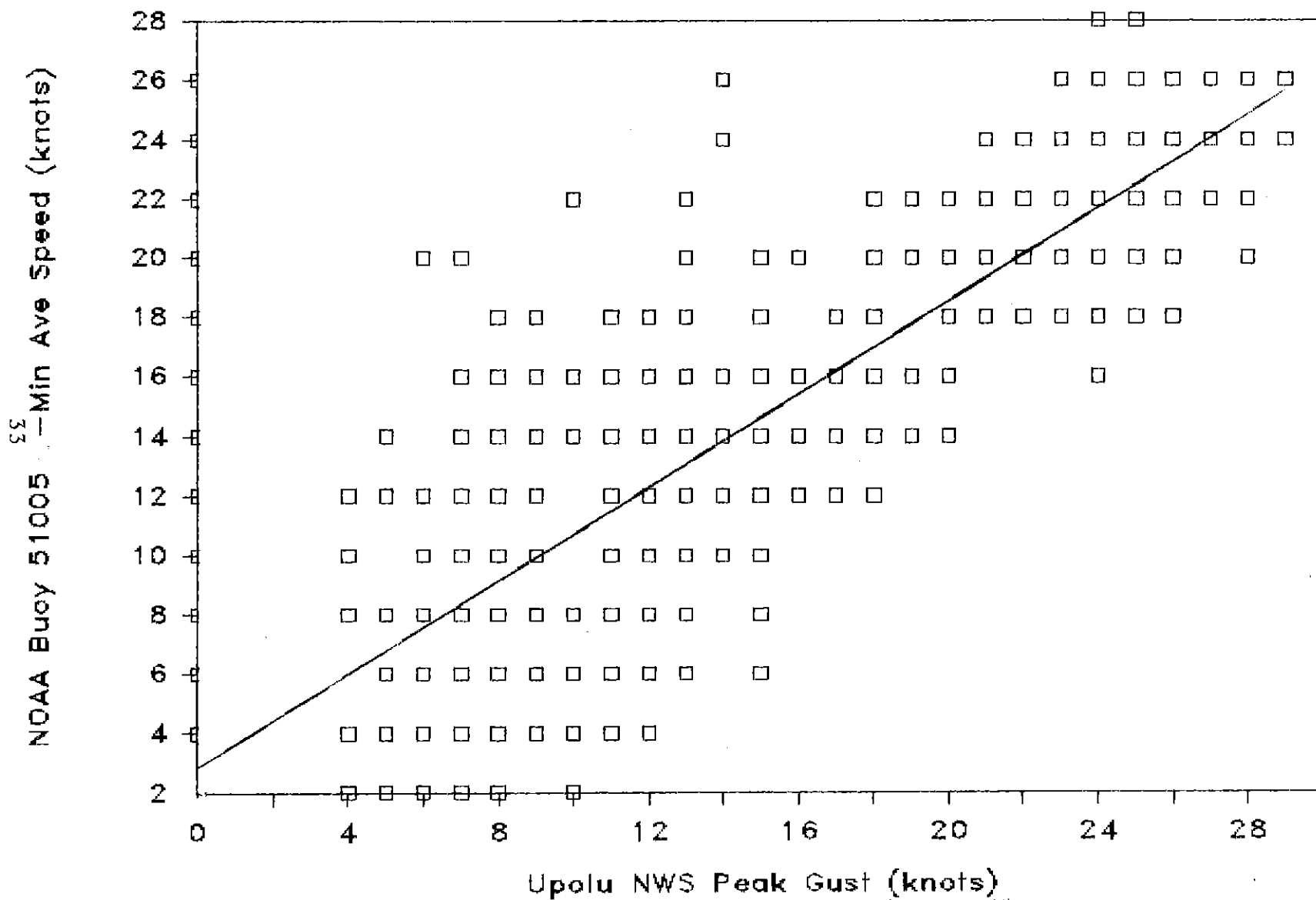


N = 547 CORRELATION COEFFICIENT = 0.75

LINEAR REGRESSION EQUATION: $Y(\text{BUOY WIND SPEED}) = .7637414 X(\text{UPOLU NWS WIND SPD}) + 6.886374$

FIGURE 9.

Upolu NWS Gust vs NOAA Buoy Ave Spd



N = 551 CORRELATION COEFFICIENT = 0.86

LINEAR REGRESSION EQUATION: $Y(\text{BUOY WIND SPD}) = .784136 X(\text{UPOLU NWS PEAK GUST}) + 2.866269$

wind speeds for the buoy wind speeds and wind speeds in the Alenuihaha Channel.

It was earlier seen that Upolu 38's 1-hour average wind speed related very highly with Upolu NWS's hourly peak gust. (see figure 3) This is a fortuitous relationship because waves are generated by winds pushing on the ocean surface over long periods of time and the 1-hour average wind speed at Upolu 38 is a much better value than the hourly 1-minute average wind speed or the hourly peak gust to relate to wave height generation in the Alenuihaha Channel.

It is not mere chance that the regression lines show that the peak gust at Upolu NWS relates about the same to the hourly average wind speed at Upolu 38 and to the hourly 2-minute sustained wind speed at NOAA buoy 51005. For a 10-knot peak gust at Upolu NWS, the related hourly average speed at Upolu 38 and the 2-minute speed at the buoy both were 11 knots, while for a 24-knot peak gust at Upolu NWS, the related hourly average speed at Upolu 38 and the 2-minute speed at the buoy both were 22 knots.

For the project's future operational purposes, the best available means to estimate the wind speeds in the Alenuihaha Channel is the NOAA buoy 51005's wind data which is available at the Honolulu office of the NWS. The future status of the buoy in the channel is not known so the backup data source is the Upolu NWS wind data which is also available at the Honolulu office of the NWS. In using the Upolu NWS wind data, it is suggested that the following regression equations relating Upolu NWS winds to buoy winds be used to relate the 1-minute and peak gusts to the expected hourly average wind speed in the Alenuihaha Channel:

(1). Upolu NWS 1-minute speed (x) vs NOAA buoy 51005 2-minute speed (y): y = .7637414 x + 6.886374

(2). Upolu NWS peak gust (x) vs NOAA buoy 51005 2-minute speed (y): y = .9231754 x + 4.239043

Alenuihaha Channel is substituted for the NOAA buoy 51005 (y) in the equations. Equation (2) is the favored equation but both equations can be used to determine the wind speed in the Alenuihaha Channel if wind speed data are not available from NOAA buoy 51005.

March 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	3.57
NE	3	0	0	0	0	0	3	7.50
E	31	25	10	1	0	0	68	10.82
SE	10	0	0	0	0	0	10	4.02
S	7	1	0	0	0	0	7	5.56
SW	5	2	0	0	0	0	8	8.85
W	2	0	0	0	0	0	3	6.53
NW	0	0	0	0	0	0	0	2.00
VAR	0	0	0	0	0	0	0	0.00
%	60	29	10	2	0	0		

Days of Data: 31
 Total Hours Available Data: 519
 Average Wind Speed: 9.39

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	7.69
1- 2	8.30
2- 3	7.07
3- 4	8.10
4- 5	8.31
5- 6	7.96
6- 7	8.50
7- 8	8.19
8- 9	10.33
9-10	7.92
10-11	10.74
11-12	11.44
12-13	11.78
13-14	11.89
14-15	11.40
15-16	11.82
16-17	11.36
17-18	10.27
18-19	10.37
19-20	9.42
20-21	8.08
21-22	8.55
22-23	8.60
23-24	7.76

note: percent frequency error of +/- 1% due to rounding

April 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	0	0	0	0	0	0	0	0.00
NE	0	0	1	3	1	0	5	22.79
E	21	32	26	10	1	0	90	14.33
SE	2	0	0	0	0	0	2	3.70
S	1	0	0	0	0	0	1	1.80
SW	1	0	0	0	0	0	1	3.00
W	1	0	0	0	0	0	1	7.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	26	32	27	13	2	0		

Days of Data: 30
Total Hours Available Data: 529
Average Wind Speed: 14.19

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	13.12
1- 2	12.67
2- 3	13.08
3- 4	11.68
4- 5	12.12
5- 6	12.31
6- 7	12.46
7- 8	11.88
8- 9	15.33
9-10	15.00
10-11	15.05
11-12	16.57
12-13	15.81
13-14	15.19
14-15	15.31
15-16	15.90
16-17	15.15
17-18	15.00
18-19	15.42
19-20	14.85
20-21	14.27
21-22	13.86
22-23	15.12
23-24	14.44

note: percent frequency error of +/- 1% due to rounding

May 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	0	0	0	0	0	0	0	11.50
NE	0	1	0	0	0	0	1	13.17
E	42	36	16	2	0	0	97	11.40
SE	1	0	0	0	0	0	1	3.86
S	0	0	0	0	0	0	0	3.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	44	37	16	2	0	0		

Days of Data: 31
Total Hours Available Data: 584
Average Wind Speed: 11.31

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	9.33
1- 2	8.96
2- 3	6.50
3- 4	8.55
4- 5	9.30
5- 6	8.93
6- 7	8.67
7- 8	8.93
8- 9	11.64
9-10	13.44
10-11	14.17
11-12	13.56
12-13	13.68
13-14	14.29
14-15	13.11
15-16	13.81
16-17	13.60
17-18	12.83
18-19	12.45
19-20	11.31
20-21	10.33
21-22	11.72
22-23	11.36
23-24	10.97

note: percent frequency error of +/- 1% due to rounding

June 1984

UFOLL NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	0	0	0	0	1	16.33
E	35	45	19	1	0	0	99	12.19
SE	0	0	0	0	0	0	0	0.00
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	35	45	19	1	0	0		

Days of Data: 30
Total Hours Available Data: 564
Average Wind Speed: 12.21

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	11.48
1- 2	11.23
2- 3	10.13
3- 4	10.37
4- 5	10.62
5- 6	9.64
6- 7	9.46
7- 8	10.29
8- 9	12.00
9-10	12.85
10-11	14.00
11-12	14.48
12-13	14.62
13-14	15.30
14-15	14.71
15-16	14.63
16-17	12.50
17-18	13.21
18-19	13.00
19-20	11.90
20-21	11.92
21-22	13.14
22-23	11.68
23-24	11.93

note: percent frequency error of +/- 1% due to rounding

July 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVE SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	0	0	0	0	1	14.00
E	45	39	12	1	0	0	98	10.95
SE	1	0	0	0	0	0	1	3.29
S	0	0	0	0	0	0	0	6.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	47	40	12	1	0	0		

Days of Data: 31
Total Hours Available Data: 541
Average Wind Speed: 10.86

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	10.13
1- 2	9.18
2- 3	10.10
3- 4	9.11
4- 5	8.14
5- 6	7.61
6- 7	7.57
7- 8	7.31
8- 9	10.92
9-10	11.11
10-11	12.89
11-12	13.92
12-13	14.10
13-14	14.12
14-15	13.82
15-16	13.61
16-17	13.00
17-18	12.73
18-19	12.14
19-20	11.17
20-21	11.27
21-22	10.58
22-23	10.07
23-24	10.07

note: percent frequency error of +/- 1% due to rounding

August 1984

WPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVE SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	0	0	0	0	1	14.67
E	35	44	15	2	0	0	96	11.67
SE	3	0	0	0	0	0	3	3.82
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	6.00
W	0	0	0	0	0	0	0	8.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	38	44	16	2	0	0		

Days of Data: 31
Total Hours Available Data: 434
Average Wind Speed: 11.46

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	9.75
1- 2	9.47
2- 3	9.73
3- 4	9.53
4- 5	7.88
5- 6	9.60
6- 7	8.58
7- 8	9.35
8- 9	11.40
9-10	13.33
10-11	14.12
11-12	14.57
12-13	14.60
13-14	13.45
14-15	13.44
15-16	13.87
16-17	13.76
17-18	12.70
18-19	11.73
19-20	12.58
20-21	11.54
21-22	10.72
22-23	11.60
23-24	9.88

note: percent frequency error of +/- 1% due to rounding

September 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	1	0	0	0	0	1	11.40
E	56	33	3	0	0	0	92	8.87
SE	6	0	0	0	0	0	7	3.53
S	0	0	0	0	0	0	0	3.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	63	34	3	0	0	0		

Days of Data: 30
Total Hours Available Data: 545
Average Wind Speed: 8.55

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	5.90
1- 2	7.00
2- 3	4.39
3- 4	4.86
4- 5	5.61
5- 6	5.79
6- 7	5.39
7- 8	7.38
8- 9	9.68
9-10	12.44
10-11	13.04
11-12	13.20
12-13	14.25
13-14	12.80
14-15	12.53
15-16	11.96
16-17	11.26
17-18	10.14
18-19	9.87
19-20	8.59
20-21	8.09
21-22	7.50
22-23	7.11
23-24	5.70

note: percent frequency error of +/- 1% due to rounding

October 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	1	0	0	0	0	0	2	6.71
E	44	31	10	1	0	0	86	10.38
SE	8	0	0	0	0	0	8	3.23
S	3	0	0	0	0	0	3	2.00
SW	1	0	0	0	0	0	1	5.00
W	1	0	0	0	0	0	1	5.00
NW	0	0	0	0	0	0	0	1.00
VAR	0	0	0	0	0	0	0	0.00
%	58	31	10	1	0	0		

Days of Data: 31
Total Hours Available Data: 441
Average Wind Speed: 9.46

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	7.54
1- 2	5.50
2- 3	7.57
3- 4	7.50
4- 5	6.77
5- 6	6.00
6- 7	5.83
7- 8	10.00
8- 9	9.54
9-10	13.13
10-11	11.50
11-12	12.36
12-13	13.22
13-14	11.00
14-15	11.26
15-16	12.05
16-17	11.09
17-18	10.60
18-19	10.26
19-20	12.00
20-21	8.52
21-22	9.15
22-23	8.70
23-24	9.35

note: percent frequency error of +/- 1% due to rounding

November 1984

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	0	0	0	0	0	0	0	2.75
NE	0	0	0	0	0	0	1	11.33
E	22	38	24	5	0	0	89	13.55
SE	3	0	0	0	0	0	3	4.47
S	2	0	0	0	0	0	2	1.93
SW	1	0	0	0	0	0	1	5.20
W	3	0	0	0	0	0	3	4.20
NW	0	0	0	0	0	0	0	3.00
VAR	0	0	0	0	0	0	0	0.00
%	32	38	24	5	0	0		

Days of Data: 30
Total Hours Available Data: 500
Average Wind Speed: 12.62

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	11.96
1- 2	13.00
2- 3	12.22
3- 4	10.92
4- 5	9.33
5- 6	10.32
6- 7	10.87
7- 8	11.50
8- 9	11.96
9-10	14.50
10-11	14.95
11-12	15.25
12-13	14.39
13-14	13.33
14-15	14.17
15-16	13.85
16-17	12.88
17-18	11.73
18-19	12.69
19-20	14.60
20-21	13.19
21-22	13.08
22-23	12.77
23-24	12.00

note: percent frequency error of +/- 1% due to rounding

December 1984

UFOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVE SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	1	1	1	0	0	4	13.57
NE	3	2	1	0	0	0	6	10.45
E	23	18	19	7	2	0	69	13.39
SE	14	0	0	0	0	0	14	4.91
S	5	0	0	0	0	0	5	3.67
SW	1	0	0	0	0	0	1	2.50
W	0	0	0	0	0	0	0	0.00
NW	1	0	0	0	0	0	1	2.25
VAR	0	0	0	0	0	0	0	0.00
%	47	22	21	8	2	0		

Days of Data: 31
Total Hours Available Data: 502
Average Wind Speed: 11.55

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	10.82
1- 2	7.17
2- 3	10.38
3- 4	10.39
4- 5	11.07
5- 6	10.93
6- 7	10.52
7- 8	10.40
8- 9	11.50
9-10	12.65
10-11	11.79
11-12	13.11
12-13	13.40
13-14	11.00
14-15	14.28
15-16	14.61
16-17	12.11
17-18	12.52
18-19	11.40
19-20	10.20
20-21	11.12
21-22	10.38
22-23	11.11
23-24	11.15

note: percent frequency error of +/- 1% due to rounding

January 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	2.14
NE	2	1	1	0	0	0	4	10.06
E	22	9	5	1	0	0	37	9.99
SE	18	0	0	0	0	0	18	4.69
S	21	0	0	0	0	0	21	3.67
SW	7	2	0	0	0	0	8	7.69
W	7	1	1	0	0	0	10	8.78
NW	1	0	0	0	0	0	1	2.25
VAR	0	0	0	0	0	0	0	0.00
%	78	13	7	2	0	0		

Days of Data: 31
Total Hours Available Data: 430
Average Wind Speed: 7.33

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	6.80
1- 2	11.00
2- 3	6.67
3- 4	6.30
4- 5	6.19
5- 6	5.23
6- 7	5.79
7- 8	4.00
8- 9	7.50
9-10	8.87
10-11	8.56
11-12	8.05
12-13	10.45
13-14	12.00
14-15	9.00
15-16	9.04
16-17	9.05
17-18	6.67
18-19	6.00
19-20	8.50
20-21	6.71
21-22	7.30
22-23	7.48
23-24	7.70

note: percent frequency error of +/- 1% due to rounding

February 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	2.88
NE	4	0	0	0	0	0	4	8.37
E	37	28	12	2	0	0	79	10.90
SE	6	0	0	0	0	0	6	3.87
S	3	0	0	0	0	0	3	2.11
SW	2	0	0	0	0	0	3	7.83
W	2	0	0	0	0	0	2	4.18
NW	1	0	0	0	0	0	1	2.25
VAR	0	0	0	0	0	0	0	0.00
%	57	28	12	2	0	0		

Days of Data: 28
Total Hours Available Data: 448
Average Wind Speed: 9.75

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	8.33
1- 2	8.00
2- 3	6.22
3- 4	8.30
4- 5	7.58
5- 6	8.13
6- 7	7.91
7- 8	0.00
8- 9	10.59
9-10	11.61
10-11	10.33
11-12	12.50
12-13	12.94
13-14	0.00
14-15	10.90
15-16	10.88
16-17	11.78
17-18	10.95
18-19	10.59
19-20	0.00
20-21	9.78
21-22	9.68
22-23	9.39
23-24	8.48

note: percent frequency error of +/- 1% due to rounding

March 1985

UPDLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	1	1	0	0	3	21.44
E	9	26	35	22	4	0	96	17.19
SE	1	0	0	0	0	0	1	9.67
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	10	26	36	23	5	0		

Days of Data: 31
Total Hours Available Data: 575
Average Wind Speed: 17.23

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	16.50
1- 2	19.50
2- 3	15.50
3- 4	15.17
4- 5	14.17
5- 6	15.31
6- 7	14.73
7- 8	23.00
8- 9	16.61
9-10	17.93
10-11	18.78
11-12	18.96
12-13	18.54
13-14	22.00
14-15	18.93
15-16	18.23
16-17	18.41
17-18	19.65
18-19	17.90
19-20	15.00
20-21	18.83
21-22	18.28
22-23	15.53
23-24	17.03

note: percent frequency error of +/- 1% due to rounding

April 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

DIR	WIND SPEED (KNOTS)						SPEED		
	AVG	0-10	11-15	16-20	21-25	26-30		>30	(%)
N	0	0	0	0	0	0	0	1	8.33
NE	3	2	3	0	0	0	0	8	12.22
E	30	35	19	2	0	0	0	86	12.19
SE	5	0	0	0	0	0	0	5	5.08
S	0	0	0	0	0	0	0	0	1.00
SW	0	0	0	0	0	0	0	0	1.00
W	0	0	0	0	0	0	0	0	1.00
NW	0	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0	0.00
%	39	37	21	3	0	0			

Days of Data: 30
Total Hours Available Data: 456
Average Wind Speed: 11.79

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	11.24
1- 2	19.50
2- 3	10.52
3- 4	9.85
4- 5	10.64
5- 6	10.12
6- 7	10.00
7- 8	9.00
8- 9	11.39
9-10	11.00
10-11	13.27
11-12	13.68
12-13	14.21
13-14	12.50
14-15	14.10
15-16	13.76
16-17	13.39
17-18	12.12
18-19	12.65
19-20	17.50
20-21	10.67
21-22	11.27
22-23	11.04
23-24	11.35

note: percent frequency error of +/- 1% due to rounding

May 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	3	1	0	0	0	0	4	6.38
NE	1	1	0	0	0	0	3	10.57
E	18	31	30	10	1	0	91	14.70
SE	0	0	0	0	0	0	0	6.00
S	1	0	0	0	0	0	1	3.17
SW	1	0	0	0	0	0	1	5.00
W	1	0	0	0	0	0	1	6.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	26	32	31	10	1	0		

Days of Data: 31
Total Hours Available Data: 548
Average Wind Speed: 14.00

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	12.50
1- 2	11.50
2- 3	12.31
3- 4	11.63
4- 5	11.40
5- 6	12.07
6- 7	12.07
7- 8	14.00
8- 9	14.32
9-10	15.32
10-11	15.21
11-12	16.91
12-13	17.00
13-14	0.00
14-15	15.86
15-16	15.82
16-17	15.41
17-18	14.23
18-19	14.50
19-20	18.33
20-21	13.62
21-22	14.48
22-23	13.93
23-24	12.96

June 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

DIR	WIND SPEED (KNOTS)						AVG	SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	1.00
NE	1	1	1	0	0	0	3	13.73
E	30	38	21	3	0	0	92	12.55
SE	4	0	0	0	0	0	4	4.00
S	1	0	0	0	0	0	1	1.83
SW	0	0	0	0	0	0	0	1.50
W	0	0	0	0	0	0	0	5.50
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	36	39	21	3	0	0		

Days of Data: 30
Total Hours Available Data: 549
Average Wind Speed: 12.08

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	10.70
1- 2	14.00
2- 3	9.92
3- 4	9.43
4- 5	8.52
5- 6	9.76
6- 7	9.93
7- 8	8.00
8- 9	12.88
9-10	12.48
10-11	14.43
11-12	14.79
12-13	15.50
13-14	16.00
14-15	15.37
15-16	14.33
16-17	14.17
17-18	13.40
18-19	13.13
19-20	9.50
20-21	11.33
21-22	11.70
22-23	10.83
23-24	10.93

note: percent frequency error of +/- 1% due to rounding

July 1985 UPOLU NWS
 PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	0	0	0	0	1	16.75
E	21	42	28	6	0	0	97	13.73
SE	1	0	0	0	0	0	1	3.75
S	0	0	0	0	0	0	0	2.00
SW	0	0	0	0	0	0	0	2.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	13.50
%	23	42	29	6	0	0		

Days of Data: 31
 Total Hours Available Data: 454
 Average Wind Speed: 13.62

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	11.29
1- 2	8.00
2- 3	10.72
3- 4	10.92
4- 5	11.80
5- 6	10.54
6- 7	11.88
7- 8	18.00
8- 9	13.82
9-10	16.00
10-11	15.29
11-12	16.42
12-13	16.33
13-14	10.00
14-15	15.85
15-16	15.78
16-17	16.78
17-18	16.16
18-19	14.00
19-20	15.00
20-21	12.74
21-22	13.57
22-23	12.59
23-24	12.00

note: percent frequency error of +/- 1% due to rounding

August 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	1	0	1	17.43
NE	1	1	0	0	0	0	2	9.75
E	28	38	18	7	1	0	92	13.11
SE	3	0	0	0	0	0	3	3.06
S	1	0	0	0	0	0	1	3.00
SW	0	0	0	0	0	0	0	2.00
W	0	0	0	0	0	0	0	5.00
NW	0	0	0	0	0	0	0	0.04
VAR	0	0	0	0	0	0	0	0.00
%	34	38	19	7	1	0		

Days of Data: 31
Total Hours Available Data: 505
Average Wind Speed: 12.85

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	11.22
1- 2	11.50
2- 3	10.37
3- 4	11.73
4- 5	11.48
5- 6	10.27
6- 7	10.46
7- 8	2.00
8- 9	13.74
9-10	14.26
10-11	14.46
11-12	15.30
12-13	14.15
13-14	20.50
14-15	14.38
15-16	14.46
16-17	15.10
17-18	14.25
18-19	13.26
19-20	15.00
20-21	12.22
21-22	12.43
22-23	11.82
23-24	11.96

note: percent frequency error of +/- 1% due to rounding

September 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

WIND SPEED (KNOTS)							DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	1	0	0	0	0	0	1	1.57
NE	3	1	0	0	0	0	5	8.32
E	35	30	10	2	0	0	77	10.94
SE	8	0	0	0	0	0	8	4.13
S	7	0	0	0	0	0	7	3.51
SW	0	0	0	0	0	0	0	10.00
W	2	0	0	0	0	0	3	5.07
NW	0	0	0	0	0	0	0	1.33
VAR	0	0	0	0	0	0	0	0.00
%	57	31	10	2	0	0		

Days of Data: 30
Total Hours Available Data: 533
Average Wind Speed: 9.56

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	8.89
1- 2	0.00
2- 3	7.55
3- 4	6.76
4- 5	7.11
5- 6	8.22
6- 7	7.21
7- 8	10.00
8- 9	8.60
9-10	10.52
10-11	10.93
11-12	12.53
12-13	11.71
13-14	0.00
14-15	12.08
15-16	11.54
16-17	10.89
17-18	10.90
18-19	10.63
19-20	21.00
20-21	9.75
21-22	8.93
22-23	8.83
23-24	8.25

note: percent frequency error of +/- 1% due to rounding

October 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.40
NE	1	0	2	1	0	0	5	15.04
E	30	37	18	1	0	0	86	11.80
SE	7	0	0	0	0	0	7	4.32
S	2	0	0	0	0	0	2	1.71
SW	0	0	0	0	0	0	0	1.33
W	0	0	0	0	0	0	0	3.00
NW	0	0	0	0	0	0	0	0.07
VAR	0	0	0	0	0	0	0	0.00
%	41	38	19	2	0	0		

Days of Data: 31
Total Hours Available Data: 533
Average Wind Speed: 11.23

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	10.07
1- 2	11.00
2- 3	9.71
3- 4	9.28
4- 5	9.00
5- 6	10.46
6- 7	9.64
7- 8	9.67
8- 9	12.05
9-10	12.10
10-11	13.67
11-12	13.65
12-13	12.82
13-14	12.50
14-15	13.44
15-16	12.57
16-17	12.70
17-18	11.00
18-19	11.68
19-20	9.00
20-21	11.54
21-22	11.04
22-23	9.93
23-24	10.07

note: percent frequency error of +/- 1% due to rounding

November 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	1	0	1	0	0	0	2	11.73
NE	6	3	1	1	0	0	10	10.19
E	28	8	0	0	0	0	36	7.73
SE	21	0	0	0	0	0	21	4.75
S	17	0	0	0	0	0	17	4.19
SW	8	1	0	0	0	0	9	6.89
W	4	1	0	0	0	0	5	5.81
NW	0	0	0	0	0	0	0	5.33
VAR	0	0	0	0	0	0	0	4.00
%	84	14	1	1	0	0		

Days of Data: 30
Total Hours Available Data: 527
Average Wind Speed: 6.82

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	5.48
1- 2	6.00
2- 3	4.54
3- 4	5.24
4- 5	5.15
5- 6	5.48
6- 7	5.71
7- 8	0.00
8- 9	6.04
9-10	8.30
10-11	8.37
11-12	9.00
12-13	9.95
13-14	11.50
14-15	8.46
15-16	8.62
16-17	8.54
17-18	5.82
18-19	6.00
19-20	5.50
20-21	6.59
21-22	6.70
22-23	6.96
23-24	6.14

note: percent frequency error of +/- 1% due to rounding

December 1985

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	0	0	0	0	0	0	0	3.67
NE	2	1	0	1	0	0	5	12.35
E	26	17	8	6	1	0	58	12.16
SE	12	0	0	0	0	0	12	4.75
S	11	0	0	0	0	0	11	4.33
SW	6	3	0	0	0	0	10	8.43
W	3	1	0	0	0	0	3	7.05
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	61	23	8	7	1	0		

Days of Data: 31
Total Hours Available Data: 548
Average Wind Speed: 9.92

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	8.76
1- 2	0.00
2- 3	8.17
3- 4	8.03
4- 5	8.97
5- 6	8.70
6- 7	8.76
7- 8	0.00
8- 9	9.30
9-10	11.42
10-11	11.00
11-12	11.33
12-13	12.79
13-14	10.00
14-15	12.10
15-16	10.90
16-17	10.76
17-18	9.95
18-19	10.00
19-20	0.00
20-21	10.27
21-22	9.87
22-23	8.97
23-24	9.66

note: percent frequency error of +/- 1% due to rounding

January 1986

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	2	7.75
NE	4	4	6	1	0	0	15	14.38
E	27	13	9	2	1	0	52	10.82
SE	11	0	0	0	0	0	11	5.18
S	13	0	0	0	0	0	13	4.16
SW	4	0	0	0	0	0	4	4.78
W	3	0	0	0	0	0	3	5.00
NW	0	0	0	0	0	0	0	1.00
VAR	0	0	0	0	0	0	0	3.00
%	63	18	15	3	1	0		

Days of Data: 31
Total Hours Available Data: 472
Average Wind Speed: 9.48

AVERAGE HOURLY WIND SPEEDS

Speed
Hour (knots)

0- 1 8.88
1- 2 6.00
2- 3 8.36
3- 4 7.62
4- 5 9.32
5- 6 8.76
6- 7 8.87
7- 8 0.00
8- 9 9.35
9-10 9.68
10-11 11.04
11-12 10.88
12-13 10.25
13-14 0.00
14-15 11.86
15-16 9.96
16-17 11.00
17-18 9.58
18-19 9.59
19-20 11.00
20-21 9.29
21-22 9.21
22-23 8.80
23-24 8.13

note: percent frequency error of +/- 1% due to rounding

February 1986

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR	AVG
	0-10	11-15	16-20	21-25	26-30	>30	(%)	SPEED
N	0	0	0	0	0	0	0	1.40
NE	3	1	0	0	0	0	4	6.44
E	13	5	0	0	0	0	18	6.92
SE	16	0	0	0	0	0	16	4.35
S	15	1	1	0	0	0	17	5.47
SW	19	9	3	0	0	0	31	9.70
W	7	4	2	0	0	0	13	10.03
NW	1	0	0	0	0	0	1	0.56
VAR	0	0	0	0	0	0	0	2.00
%	74	20	5	0	0	0		

Days of Data: 28
Total Hours Available Data: 449
Average Wind Speed: 7.64

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	5.89
1- 2	4.50
2- 3	6.19
3- 4	6.81
4- 5	6.65
5- 6	7.81
6- 7	7.00
7- 8	0.00
8- 9	6.00
9-10	8.47
10-11	8.55
11-12	9.00
12-13	9.42
13-14	11.50
14-15	9.71
15-16	10.50
16-17	9.32
17-18	9.10
18-19	7.43
19-20	10.00
20-21	7.12
21-22	6.56
22-23	6.50
23-24	6.57

note: percent frequency error of +/- 1% due to rounding

March 1986

UPOLU NWS
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	10.60
NE	2	3	6	3	0	0	14	16.47
E	23	20	15	6	0	0	64	12.87
SE	6	0	0	0	0	0	6	5.43
S	8	0	0	0	0	0	8	3.96
SW	4	1	0	0	0	0	5	6.60
W	1	0	0	0	0	0	1	6.75
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	45	24	21	9	0	0		

Days of Data: 31
Total Hours Available Data: 547
Average Wind Speed: 11.86

AVERAGE HOURLY WIND SPEEDS

Hour-	Speed (knots)
0- 1	10.90
1- 2	13.00
2- 3	10.62
3- 4	9.30
4- 5	10.46
5- 6	9.15
6- 7	9.97
7- 8	14.00
8- 9	10.91
9-10	11.64
10-11	11.66
11-12	12.83
12-13	14.35
13-14	14.50
14-15	13.87
15-16	12.93
16-17	13.68
17-18	12.00
18-19	13.30
19-20	10.00
20-21	13.21
21-22	11.90
22-23	13.18
23-24	12.04

October 1984

UFOLL 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	2.00
NE	1	0	0	0	0	0	1	12.67
E	11	22	25	7	0	0	65	15.07
SE	19	3	0	0	0	0	22	7.13
S	3	0	0	0	0	0	3	3.67
SW	2	0	0	0	0	0	2	4.67
W	1	0	0	0	0	0	1	4.33
NW	0	0	0	0	0	0	0	4.00
VAR	3	1	1	0	0	0	5	11.13
%	40	26	25	7	1	0		

Days of Data: 31
Total Hours Available Data: 306
Average Wind Speed: 12.36

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	9.31
1- 2	9.46
2- 3	9.38
3- 4	8.62
4- 5	8.62
5- 6	8.69
6- 7	9.31
7- 8	9.33
8- 9	11.67
9-10	14.42
10-11	16.75
11-12	17.00
12-13	16.83
13-14	17.00
14-15	17.50
15-16	16.58
16-17	15.92
17-18	14.92
18-19	13.57
19-20	11.86
20-21	11.79
21-22	10.57
22-23	10.23
23-24	9.69

note: percent frequency error of +/- 1% due to rounding

December 1984

UPDLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

DIR	WIND SPEED (KNOTS)						AVG	SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	2	1	0	0	0	4	11.25
NE	0	2	6	18	2	0	28	21.47
E	0	4	6	6	24	14	53	26.90
SE	3	3	0	0	0	0	6	9.17
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	10	0	0	0	0	0	10	4.00
%	14	10	13	24	26	14		

Days of Data: 31
Total Hours Available Data: 109
Average Wind Speed: 21.54

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	21.20
1- 2	21.40
2- 3	20.60
3- 4	17.50
4- 5	18.00
5- 6	20.67
6- 7	20.67
7- 8	17.33
8- 9	17.00
9-10	17.67
10-11	19.20
11-12	22.40
12-13	23.20
13-14	23.20
14-15	23.50
15-16	21.83
16-17	22.20
17-18	23.60
18-19	25.80
19-20	24.20
20-21	23.60
21-22	22.20
22-23	20.60
23-24	21.00

note: percent frequency error of +/- 1% due to rounding

January 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	3	3	2	0	0	0	8	11.78
E	12	4	2	2	0	0	21	11.66
SE	8	1	0	0	0	0	9	7.95
S	1	0	0	0	0	0	2	10.00
SW	1	4	3	2	1	1	14	19.05
W	7	2	1	1	0	0	11	10.83
NW	0	0	0	0	0	0	0	6.50
VAR	35	0	0	0	0	0	35	5.26
%	68	16	7	5	2	2		

Days of Data: 31
Total Hours Available Data: 608
Average Wind Speed: 9.94

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	9.52
1- 2	8.92
2- 3	8.84
3- 4	8.68
4- 5	8.96
5- 6	9.28
6- 7	9.40
7- 8	10.28
8- 9	10.16
9-10	10.96
10-11	11.44
11-12	11.68
12-13	12.04
13-14	11.96
14-15	11.12
15-16	9.68
16-17	9.15
17-18	9.08
18-19	9.08
19-20	9.62
20-21	9.35
21-22	10.04
22-23	9.92
23-24	9.54

note: percent frequency error of +/- 1% due to rounding

February 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	4	1	6	3	1	0	16	16.61
E	14	10	16	11	8	0	59	16.92
SE	1	0	0	0	0	0	1	6.00
S	0	0	0	0	0	0	0	0.00
SW	1	0	0	0	0	0	2	11.10
W	2	0	0	0	0	0	2	7.78
NW	2	0	0	0	0	0	2	6.50
VAR	18	0	0	0	0	0	18	4.39
%	43	11	23	14	8	0		

Days of Data: 28
Total Hours Available Data: 430
Average Wind Speed: 13.96

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	12.06
1- 2	11.28
2- 3	11.44
3- 4	10.72
4- 5	10.50
5- 6	11.72
6- 7	12.00
7- 8	12.11
8- 9	12.71
9-10	13.94
10-11	15.00
11-12	15.76
12-13	16.65
13-14	17.50
14-15	17.56
15-16	16.42
16-17	15.89
17-18	15.42
18-19	15.06
19-20	14.78
20-21	14.78
21-22	14.56
22-23	13.50
23-24	13.50

note: percent frequency error of +/- 1% due to rounding

March 1985

UPOLU 36 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	3	5	9	4	21	25.95
E	1	4	15	24	24	10	79	24.38
SE	0	0	0	0	0	0	0	0.00
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	1	4	19	29	33	14		

Days of Data: 31
Total Hours Available Data: 731
Average Wind Speed: 24.66

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	24.19
1- 2	24.23
2- 3	24.84
3- 4	24.19
4- 5	24.16
5- 6	24.16
6- 7	24.65
7- 8	24.90
8- 9	24.87
9-10	25.07
10-11	24.80
11-12	25.07
12-13	25.10
13-14	25.17
14-15	25.89
15-16	25.31
16-17	24.63
17-18	24.67
18-19	24.58
19-20	24.13
20-21	24.74
21-22	24.71
22-23	24.48
23-24	23.65

note: percent frequency error of +/- 1% due to rounding

April 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

DIR	WIND SPEED (KNOTS)						AVG	SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	6.50
NE	4	3	6	3	0	0	16	15.18
E	13	18	31	18	1	0	81	16.49
SE	3	0	0	0	0	0	3	7.61
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	20	21	37	21	1	0		

Days of Data: 30
Total Hours Available Data: 720
Average Wind Speed: 15.97

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	15.10
1- 2	15.27
2- 3	15.03
3- 4	15.33
4- 5	15.33
5- 6	15.60
6- 7	15.63
7- 8	16.07
8- 9	16.43
9-10	16.70
10-11	16.73
11-12	17.03
12-13	16.90
13-14	16.30
14-15	16.17
15-16	16.37
16-17	16.33
17-18	16.17
18-19	16.17
19-20	15.70
20-21	15.70
21-22	15.67
22-23	16.10
23-24	15.43

note: percent frequency error of +/- 1% due to rounding

June 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

DIR	WIND SPEED (KNOTS)						AVG	SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	2	6	18	7	2	0	34	18.17
E	14	17	22	5	1	0	60	14.99
SE	4	0	0	0	0	0	4	5.65
S	1	0	0	0	0	0	1	1.67
SW	1	0	0	0	0	0	1	4.33
W	0	0	0	0	0	0	0	6.00
NW	0	0	0	0	0	0	0	6.00
VAR	0	0	0	0	0	0	0	0.00
%	22	22	40	12	3	0		

Days of Data: 30
Total Hours Available Data: 539
Average Wind Speed: 15.52

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	12.91
1- 2	12.50
2- 3	13.00
3- 4	12.23
4- 5	12.45
5- 6	12.91
6- 7	12.86
7- 8	14.45
8- 9	15.86
9-10	17.59
10-11	18.59
11-12	19.14
12-13	18.95
13-14	19.04
14-15	18.83
15-16	18.17
16-17	18.09
17-18	17.48
18-19	16.26
19-20	14.74
20-21	13.91
21-22	13.96
22-23	14.22
23-24	13.91

note: percent frequency error of +/- 1% due to rounding

July 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	1	0	0	0	1	19.00
E	7	21	46	21	4	0	99	17.75
SE	0	0	0	0	0	0	0	11.00
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	7	21	47	21	4	0		

Days of Data: 31
Total Hours Available Data: 603
Average Wind Speed: 17.76

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	15.64
1- 2	15.04
2- 3	15.24
3- 4	14.80
4- 5	15.16
5- 6	15.24
6- 7	15.52
7- 8	17.44
8- 9	19.32
9-10	19.76
10-11	20.64
11-12	21.00
12-13	21.32
13-14	20.80
14-15	19.84
15-16	20.08
16-17	19.65
17-18	18.62
18-19	17.85
19-20	16.92
20-21	17.12
21-22	16.88
22-23	16.24
23-24	16.08

note: percent frequency error of +/- 1% due to rounding

August 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	26.67
NE	1	0	0	0	0	0	1	9.90
E	9	18	38	22	8	0	95	17.99
SE	1	0	0	0	0	0	2	6.00
S	0	0	0	0	0	0	0	4.67
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	81.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	6.00
%	12	18	38	22	8	0		

Days of Data: 31
Total Hours Available Data: 712
Average Wind Speed: 17.76

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	16.53
1- 2	15.83
2- 3	14.87
3- 4	17.07
4- 5	16.53
5- 6	14.67
6- 7	13.76
7- 8	15.07
8- 9	17.23
9-10	18.28
10-11	19.41
11-12	20.00
12-13	20.41
13-14	20.69
14-15	20.28
15-16	21.97
16-17	19.33
17-18	18.60
18-19	17.90
19-20	17.90
20-21	17.77
21-22	17.53
22-23	17.77
23-24	17.30

note: percent frequency error of +/- 1% due to rounding

September 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	3.50
NE	3	1	1	1	0	0	5	10.09
E	13	21	29	12	1	0	76	14.90
SE	6	0	0	0	0	0	6	3.84
S	7	0	0	0	0	0	7	3.38
SW	0	0	0	0	0	0	0	5.50
W	3	0	0	0	0	0	3	4.76
NW	1	0	0	0	0	0	1	3.83
VAR	0	0	1	0	0	0	2	14.57
%	34	22	31	12	1	0		

Days of Data: 30
Total Hours Available Data: 676
Average Wind Speed: 13.31

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	12.04
1- 2	11.54
2- 3	11.57
3- 4	11.00
4- 5	10.75
5- 6	11.07
6- 7	11.14
7- 8	11.46
8- 9	12.79
9-10	14.89
10-11	16.04
11-12	16.89
12-13	16.61
13-14	16.00
14-15	15.89
15-16	14.79
16-17	14.79
17-18	13.76
18-19	13.10
19-20	13.10
20-21	13.10
21-22	12.55
22-23	12.18
23-24	12.37

note: percent frequency error of +/- 1% due to rounding

October 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	0	0	0	0	0	1	3.25
NE	1	0	2	1	0	0	5	15.96
E	14	17	43	9	1	0	83	15.82
SE	8	0	0	0	0	0	8	6.53
S	3	0	0	0	0	0	3	4.00
SW	0	0	0	0	0	0	0	3.00
W	0	0	0	0	0	0	0	5.00
NW	0	0	0	0	0	0	0	3.50
VAR	0	0	0	0	0	0	0	0.00
%	27	17	45	11	1	0		

Days of Data: 31
Total Hours Available Data: 609
Average Wind Speed: 14.61

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	12.88
1- 2	13.04
2- 3	13.28
3- 4	12.72
4- 5	12.92
5- 6	13.68
6- 7	13.12
7- 8	13.48
8- 9	14.84
9-10	16.80
10-11	17.48
11-12	17.28
12-13	17.16
13-14	17.00
14-15	16.28
15-16	16.12
16-17	15.77
17-18	15.15
18-19	14.36
19-20	13.85
20-21	14.23
21-22	13.38
22-23	12.88
23-24	13.08

note: percent frequency error of +/- 1% due to rounding

November 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

WIND SPEED (KNOTS)

	0-10	11-15	16-20	21-25	26-30	>30	DIR (%)	AVG SPEED
N	0	0	0	0	0	0	0	0.00
NE	6	5	1	0	1	0	12	12.08
E	20	7	2	0	0	0	31	9.78
SE	22	0	0	0	0	0	22	6.23
S	15	2	0	0	0	0	17	7.08
SW	6	5	2	0	0	0	14	11.72
W	3	0	0	0	0	0	3	6.10
NW	1	0	0	0	0	0	1	3.50
VAR	0	0	0	0	0	0	0	0.00
%	72	20	6	0	1	0		

Days of Data: 30
Total Hours Available Data: 288
Average Wind Speed: 9.01

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	7.91
1- 2	7.00
2- 3	6.42
3- 4	6.83
4- 5	7.25
5- 6	7.18
6- 7	7.18
7- 8	6.75
8- 9	8.92
9-10	9.50
10-11	9.92
11-12	10.83
12-13	11.08
13-14	11.17
14-15	11.38
15-16	11.62
16-17	9.77
17-18	8.83
18-19	8.83
19-20	10.00
20-21	10.08
21-22	9.75
22-23	8.67
23-24	8.42

note: percent frequency error of +/- 1% due to rounding

December 1985

UPOLU 38 FT
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	0	0	0	0	0	0	0	0.00
NE	0	0	0	0	15	0	15	29.60
E	0	0	21	18	44	3	85	25.24
SE	0	0	0	0	0	0	0	0.00
S	0	0	0	0	0	0	0	0.00
SW	0	0	0	0	0	0	0	0.00
W	0	0	0	0	0	0	0	0.00
NW	0	0	0	0	0	0	0	0.00
VAR	0	0	0	0	0	0	0	0.00
%	0	0	21	18	59	3		

Days of Data: 31
Total Hours Available Data: 34
Average Wind Speed: 25.88

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	23.00
1- 2	26.00
2- 3	25.00
3- 4	26.00
4- 5	26.00
5- 6	25.00
6- 7	25.00
7- 8	23.50
8- 9	24.50
9-10	25.00
10-11	30.00
11-12	32.00
12-13	30.00
13-14	30.00
14-15	30.00
15-16	30.00
16-17	28.00
17-18	28.00
18-19	27.00
19-20	27.00
20-21	26.00
21-22	23.00
22-23	20.00
23-24	21.00

note: percent frequency error of +/- 1% due to rounding

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

NOAA Buoy
51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES	HT (ft)
1/0	280° 8	180° 13	230 4/7							
1	270 6	200 10	-					230° 6/3	11	1.6'
2	230 9	210 10	190 4/6	265 9	-			220° 8/10	8	3.3
3	240 9	180 10	190 3/6					230 8/10	11	1.6
4	290 7	230 8	190 4/6					200 10/12	8	3.2
5	280 7	210 8	-							
6	260 5	250 5	260 9/12							
7	290 3	220 4	-					240 6/8	10	3.2
8	20 4	180 8	240 4/11	250 4	215 6			250 8/10	7	1.6
9	10 5	180 12	200 8/10					240 4	11	3.3
10	30 5	210 12	180 7/11							
11	80 6	180 13	190 4/12					180 8/10	8	1.6
12	50 13	200 10	240 6/11					160 8/10	8	3.3
13	60 7	60 8	-					180 8/10	11	1.6
14	10 15	10 8	210 4/10	160 2	20 40			220 6/8	11	3.2
15	20 12	50 9	240 2/9					220 8/10	11	1.6
16	340 3	10 9	230 3/8							
17	40 3	40 7	240 9/7					180 8/10	8	3.2
18	340 4	30 6	230 3/8				NW 10	190 8/10	13	3.3
19	20 5	20 6	-					200 4/6	13	3.3
20	250 4	10 7	-		340 7			230 6	11	3.3
21	CALM	70 5	160 3/5					250 4/6	13	3.3
22	240 5	160 5	160 2/5					240 4/6	10	3.2
23	240 4	150 4	180 3/5							
2/0	250 5	340 9	190 3/5					240 4/6	13	3.3
1	280 5	-	-					230 6/8	11	3.3
2	270 5	-	200 4/5	285 1	-			250 8/10	13	3.2
3	CALM	-	230 3/6					280 8/10	11	3.3
4	270 4	360 9	230 2/7					300 6/8	10	3.3
5	270 6	360 8	360 7/11					40 6/8	11	3.3
6	270 7	50 4	20 10/16					30 12/16	11	3.3
7	280 6	100 4	-					30 16/18	11	3.2
8	280 7	CALM	20 8/16	15 10	10 50			30 14/18	10	3.3
9	340 7	20 13	60 10/12					50 14/18	13	3.3
10	20 11	30 12	60 10/11							
11	60 9	30 14	70 10/12					40 12/16	13	3.3
12	90 9	30 12	70 13/14					50 12/14	13	3.3
13	90 9	30 10	-					50 14/16	13	3.3
14	90 10	20 10	60 10/15	40 3	-			50 14/16	13	3.3
15	80 8	30 12	80 16/16							
16	120 8	30 13	80 12/15							
17	130 8	40 13	70 14/16					50 16/18	14	3.3
18	140 7	30 9	70 13/17					50 16/20	14	3.3
19	150 9	50 6	-					50 16/20	14	4.0
20	190 5	20 8	100 9/13	190 5	20 8			60 16/18	17	4.9
21	240 4	360 10	110 9/13					60 16/18	14	4.7
22	270 8	110 4	110 8/12					60 14/18	14	4.7
23	270 7	100 4	110 9/11							

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

J. Foss

51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	SWAYS
3/0	250 7	120 4	140 5/11					80 14/16	14 4.9
1	240 8	-	-					70 10/14	14 4.9
2	230 7	150 4	150 7/10	215 12	-			70 8/10	14 3.3
3	220 7	150 5	170 4/7					60 5/8	14 3.3
4	200 9	-	170 3/7					40 6	14 3.3
5	220 9	150 5	190 2/5					CALM	14 3.3
6	180 3	160 5	190 4/6						
7	240 6	220 6	-					290 2/4	14 4.9
8	250 16	170 12	230 8/10	255 25	-			270 4/6	14 4.0
9	240 19/28	190 11	250 13/14					330 12/14	-
10	240 21/29	180 16	240 16/17						
11	240 20/29	180 15/25	240 15/19					250 14/16	14 3.3
12	240 21/31	190 18/25	-					240 14/18	14 4.9
13	250 25/30	220 19	-					260 16/8	11 4.0
14	230 25/32	210 17/23	240 13/20	260 27	-			270 14/18	14 4.0
15	240 25/31	170 20	240 12/19					260 14/18	14 4.0
16	240 18/24	180 17/24	230 10/19					260 14/16	14 4.0
17	230 18	170 16	230 8/20					250 14/16	14 4.0
18	230 21/27	190 14	240 12/15					230 12/14	14 3.3
19	230 16	180 12	-						
20	270 4	180 10	200 4/7	215 16	-				
21	240 4	130 8	180 4/7					240 0/2	13 3.3
22	230 6	160 7	180 0/6					240 10/12	14 4.0
23	260 5	150 6	180 4/7					230 8/10	14 4.9
4/0	280 7	150 7	180 4/6					220 8/10	14 4.9
1	260 8	150 4	-					210 8/10	13 3.3
2	290 7	210 7	190 8/8	190 8	-			210 6/8	14 4.9
3	250 11	210 4	180 3/8					210 6/8	13 3.3
4	290 8	240 4	190 3/5				VAR 5	180 8/10	13 4.9
5	280 8	CALM	170 3/7					190 6/10	13 3.3
6	280 9	260 3	180 3/7					190 6/8	13 3.3
7	280 8	180 5	-						
8	270 6	170 10	180 3/7	225 14	185 5			170 6/8	11 3.3
9	70 4	190 12	180 5/8					170 8/10	13 3.3
10	190 4	180 10	250 4/9					170 6/10	11 3.3
11	170 12	180 9	250 7/10					190 4/6	13 3.3
12	230 15	170 6	280 6/9					180 4/6	13 3.3
13	190 14	40 7	-					200 2/4	13 3.3
14	230 16	170 8	-	250 19	195 6			200 6/8	13 3.3
15	190 13	20 5	50 1/11					210 6/8	13 3.3
16	230 14/20	250 10	80 1/6					230 6/8	13 3.3
17	240 13/20	190 10	80 2/5					250 6/8	13 3.3
18	230 8	230 4	110 0/5					250 6/8	13 3.3
19	220 8	210 7	-						
20	240 8	200 7	150 3/4	215 100	205 8			280 2/4	13 3.3
21	230 7	140 4	160 2/4					CALM	12 3.3
22	240 9	150 4	160 3/5						
23	240 12	150 3	150 3/7					CALM	11 3.3

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH (wind direction in degrees or compass points)

51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
5/0	240 11	CALM	160 6/8					CALM	13 3.3
1	230 13	140 4	-						
2	240 10	180 3	170 5/7	230 21	-			CALM	13 3.3
3	230 11	140 3	190 7/7					CALM	11 4.0
4	230 9	170 6	150 7/0						
5	240 10	170 4	170 5/8						
6	240 13	180 4	180 6/7					160 4/6	13 3.3
7	250 13	160 8	-					80 6/8	11 3.3
8	220 9	170 8	200 7/7	245 18	205 15			170 4/6	17 3.3
9	200 6	190 8	240 5/10					180 6/8	11 3.3
10	260 13	190 16	240 5/12					190 4/8	17 4.0
11	200 12	180 14	240 7/13					200 6/8	11 3.3
12	210 13	180 16/22	250 9/12					220 6/8	17 3.3
13	190 17	210 15/24	-					230 6/8	17 3.3
14	210 14	190 17/23	240 7/13	225 14	195 28			240 8/10	17 4.0
15	200 13	190 17/23	240 9/15					230 8/10	11 3.3
16	190 12	190 18/23	250 6/11					230 10/14	17 3.3
17	220 12	180 16/24	240 5/13					240 10/12	17 4.0
18	200 10	190 13	240 4/9					240 10/12	17 3.3
19	220 13	200 11	-					240 8/10	17 3.3
20	230 13	180 11	190 3/4	230 18	210 220				
21	230 7	180 12	180 4/5					260 4/6	14 4.0
22	230 8	170 12	150 6/7						
23	240 7	170 12	160 3/7					270 4/6	17 3.3
6/0	240 7	150 8	160 3/5						
1	250 7	170 10	-					CALM	17 4.0
2	230 8	170 9	180 2/5	245 19	-			CALM	14 4.0
3	220 9	180 8	150 4/6					300 2/6	14 4.0
4	220 7	260 4	150 5/6						
5	220 6	260 5	160 4/7						
6	240 7	170 3	140 5/6					CALM	14 3.3
7	240 7	170 3	-					110 2/2	14 3.3
8	240 6	CALM	-	-	205 12				
9	220 10	260 4	90 4/9					100 6/8	14 3.3
10	200 9	170 8	80 4/9					100 6/8	14 4.0
11	230 9/20	170 11	80 10/11					90 6/8	14 3.3
12	220 16/20	170 8	-						
13	230 16/22	180 11	-					90 6/8	14 3.3
14	160 16/22	250 11	-	245 17	220 8			90 6/8	14 4.0
15	210 16/26	30 10	70 5/9					80 4/6	14 3.3
16	220 17/23	350 9	70 5/8						
17	220 13	360 9	100 3/6					50 4/6	14 3.3
18	220 11	20 7	110 3/4					40 4/6	14 3.3
19	220 13	290 6	150 6/6					50 6/8	14 3.3
20	230 17	300 6	150 6/7	250 14	65 3			60 4/6	14 3.3
21	230 13	300 6	150 7/7					60 4	13 3.3
22	210 9	90 5	150 7/8					30 4/6	14 3.3
23	CALM	110 5	110 5/8					30 6/8	14 3.3

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
7/0	270 4	120 4	140 6/7					-	
1	270 6	-	-					50 8/0	13 3.3
2	280 5	140 5	110 6/7	235 7				60 8/0	14 3.3
3	240 7	140 5	110 3/8					60 8/0	13 3.3
4	260 6	150 5	110 5/7					40 8/0	13 3.3
5	240 5	150 5	110 6/8						
6	260 5	150 5	110 4/8					40 8/0	14 3.3
7	270 6	140 5	-						
8	260 7	110 3	-	-	15 8			50 10/2	12 3.3
9	280 7	360 5	70 12/15						
10	100 7	320 9	80 13/17					50 12/4	13 3.3
11	100 7	30 15	80 13/18					50 12/4	11 3.3
12	110 9	30 16	80 12/18					50 12/4	13 3.3
13	130 7	40 14	-					60 12/16	13 3.3
14	110 9	20 14	70 15/18	135 9	30 9			60 14/16	13 3.3
15	90 8	30 11	80 12/18						
16	100 8	20 15	80 10/16					70 14/18	14 3.3
17	100 7	360 14	-					60 14/18	14 4.0
18	80 6	30 11	90 5/11					50 16/20	13 4.0
19	60 7	50 6	70 8/13					60 14/18	14 4.0
20	60 7	50 5	70 14/17	100 4	85 17			60 14/16	12 4.0
21	60 6	40 8	70 13/16					60 14/16	13 4.0
22	300 4	30 5	70 14/17					60 14/20	14 4.0
23	260 5	30 9	90 10/18					30 14/18	14 4.0
8/0	250 5	80 6	70 15/19					30 14/18	14 4.0
1	260 8	190 5	-						
2	270 7	150 4	120 5/15	140 6	-			40 16/20	14 6.6
3	250 6	CALM	110 7/13					50 16/18	14 4.9
4	260 6	130 5	120 5/8					50 14/16	14 4.9
5	260 6	140 5	150 5/8					60 12/16	14 4.9
6	250 6	160 5	150 6/8					70 10/12	14 4.0
7	250 7	140 5	-					60 12/14	14 4.0
8	240 5	160 4	90 2/6					60 10/12	14 4.9
9	110 5	180 3	60 4/6					40 6/8	14 4.0
10	150 8	350 4	30 2/6					50 6/8	14 4.0
11	150 14	360 8	350 1/4					40 8/0	14 4.9
12	170 15	360 8	-					30 8/10	14 4.9
13	180 14	30 10	-					40 10/2	14 4.9
14	190 12	10 10	70 10/12					50 12/14	13 4.9
15	110 7	20 10	80 9/14					50 10/12	13 4.9
16	50 10	40 10	-						
17	100 7	20 11	80 6/14						
18	110 11	20 7	80 8/13					60 12/14	8 4.0
19	250 6	360 7	80 10/11						
20	320 5	30 7	80 6/12					60 12/14	14 3.3
21	280 6	60 5	80 8/13					60 10/12	9 4.9
22	290 7	350 6	60 11/13					50 12/16	9 4.9
23	290 6	340 8	60 13/14					50 14/16	9 4.0

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
9/0	250 5	330 8	60 13/14				LOW STRATUS	40 14/16	14 4.9
1	280 7	-	-						
2	280 6	-	50 11/15					40 14/16	13 4.9
3	280 4	-	80 6/16					30 12/14	13 4.9
4	270 9	20 8	50 14/16					30 14/16	14 4.9
5	270 7	40 5	100 2/16					80 12/16	14 4.9
6	270 8	30 5	70 11/14					30 12/16	9 4.9
7	280 7	40 3	30 14/17					30 14/16	13 4.9
8	270 7	30 5	90 3/17					40 14/16	9 4.9
9	30 8	360 6	70 9/17					30 2/14	14 4.9
10	70 6	30 8	70 11/13					40 12/16	9 4.9
11	40 8	20 8	90 15/17					40 14/16	10 4.9
12	70 9	30 12	70 12/17					40 12/14	9 4.9
13	110 9	30 14	-					60 14/16	8 4.9
14	110 7	20 13	80 11/16					50 14/16	13 4.9
15	90 7	40 12	70 12/16					40 16/18	14 4.9
16	100 7	30 14	-					40 18/20	13 4.9
17	100 6	30 9	70 13/18					50 16/20	13 4.9
18	70 6	20 11	80 10/18					50 16/20	12 4.9
19	50 5	20 11	80 11/16					60 14/18	13 4.9
20	300 5	20 12	100 9/16					50 14/18	13 4.9
21	290 7	20 10	90 9/16						
22	280 6	10 9	80 10/15					50 16/18	13 4.9
23	270 5	30 7	70 13/15					40 15/20	9 4.9
10/0	260 6	70 5	90 5/14				ENE 23	40 12/16	13 4.9
1	240 6	-	-					40 14/16	9 4.9
2	260 7	130 4	120 6/18					40 14/16	13 4.9
3	280 8	140 5	120 5/18					50 14/16	9 4.9
4	270 8	140 4	120 6/18					80 14/16	13 4.9
5	280 9	150 3	120 7/19					80 10/12	8 4.9
6	270 9	160 3	110 5/18					80 12/14	13 4.9
7	270 9	160 3	-					80 12/14	13 4.9
8	280 9	130 4	-						
9	260 5	20 3	90 10/13					70 12/14	12 4.9
10	10 6	10 5	70 10/13					60 14/16	10 3.3
11	20 5	340 6	90 13/16					50 14/18	9 3.3
12	110 7	330 8	90 16/17					50 16/20	8 3.3
13	110 10	20 10	-					60 16/18	10 3.3
14	80 8	60 7	80 12/19					60 16/18	9 3.3
15	90 8	20 10	90 11/19					50 16/20	9 4.9
16	110 8	50 11	80 12/17					50 16/18	14 3.3
17	90 8	20 10	80 11/17					50 16/18	13 4.9
18	60 9	40 7	70 14/17					40 16/18	13 4.9
19	30 7	320 7	-					40 16/18	17 4.9
20	60 6	90 5	90 8/15					40 16/20	14 4.9
21	290 6	100 8	100 4/12					40 16/20	13 4.9
22	280 7	150 3	80 9/13					50 14/18	14 4.9
23	270 8	150 5	90 9/15					50 14/18	13 4.9

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

FOSS CONSULTANTS S1005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
11/0	240 6	130 5	120 6/8				150° 1200 knots	60 14/16	17 4.0
1	240 7	160 4	-					60 12/16	13 4.0
2	270 7	160 5	180 3/9					80 12/16	9 4.0
3	270 7	150 5	200 2/5				240 7	50 8/10	- 4.0
4	280 8	160 4	260 0/4					20 12/14	14 4.0
5	280 9	160 5	180 1/7					20 12/16	14 4.0
6	270 8	160 5	200 0/5					20 12/14	14 4.0
7	240 7	150 5	-					20 10/12	14 4.0
8	270 9	CALM	110 1/6					10 10/2	14 4.0
9	310 3	360 6	70 4/6					20 6/8	14 4.0
10	60 7	10 8	100 3/11					60 4/6	12 4.0
11	60 8	20 12	70 8/10					50 4/6	14 4.0
12	60 9	350 12	70 12/13					60 8	14 4.0
13	60 11	10 11	-			NE 10		80 6/8	13 4.0
14	60 10	40 16	70 11/15					60 6/8	9 4.0
15	70 10	50 15	70 10/14					50 10/12	14 4.0
16	70 11	20 15	80 12/14					40 10/12	14 4.0
17	50 16/21	20 10	100 10/14					30 12/14	14 4.0
18	30 13	20 9	80 10/13					20 12/14	14 4.0
19	20 14	10 9	-					30 12/16	13 4.0
20	360 9	20 8	80 9/15					30 12/18	13 4.0
21	20 11	360 10	70 13/15					40 12/16	14 4.0
22	10 8	360 7	70 10/16					40 14/16	8 4.0
23	360 5	40 5	70 10/16					40 14/16	-
12/0	320 6	40 4	60 13/16					40 16/18	13 3.3
1	350 10	360 6	60 13/16					40 16/20	13 4.0
2	350 7	50 5	60 7/15					40 16/18	14 4.0
3	310 6	20 3	60 12/15				NNE 6	40 14/18	14 4.0
4	290 5	70 4	60 13/15					40 14/16	14 4.0
5	360 6	60 4	70 13/14					50 14/16	13 4.0
6	40 15	40 3	100 2/15					50 14/16	13 4.0
7	40 16	30 3	-					50 14/18	13 4.0
8	40 16	50 6	90 9/13					50 14/16	8 4.0
9	40 18	360 9	90 11/15						
10	20 20	10 13	80 9/16					50 14/16	13 4.0
11	20 21/28	360 15	80 12/17					60 14/16	13 3.3
12	40 22	20 17	80 15/20					60 16/20	8 4.0
13	40 18	10 17	-					60 18/22	8 4.0
14	10 19/25	20 21	70 16/20						
15	20 20	30 19	70 15/20					50 18/22	8 4.0
16	30 22	30 19	60 18/21					50 20/24	8 4.0
17	30 20	30 16	-					50 18/22	9 4.0
18	40 20/23	30 15	70 17/22					50 20/22	9 4.0
19	30 16/24	20 22	-					50 18/24	9 4.0
20	30 19/25	30 17	70 18/20					50 22/26	8 4.0
21	40 22	20 18/22	80 12/21					50 20/24	4 4.0
22	40 24	30 19	70 15/19					50 20/24	8 4.0
23	40 21	20 20	50 8/20					60 20/24	5 4.0

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH (wind direction in degrees or compass points) 51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
13/0	50 19	30 18	90 7/23					50 20/24	8 4.9
1	40 20	40 12	-					60 18/22	8 4.9
2	40 18	40 10	90 12/23					70 18/22	8 4.9
3	50 19	60 11	70 17/22					60 20/24	8 6.6
4	40 19	40 17	100 9/23					60 18/22	8 4.9
5	50 20	50 16	80 18/23					50 18/24	8 6.6
6	40 20	40 15	80 18/24					60 16/20	7 6.6
7	30 20/29	40 15	-					60 20/24	8 6.6
8	40 23/28	60 17	-						
9	30 20/25	50 18	90 15/21					60 18/20	8 6.6
10	30 20/29	30 17	80 16/21					50 18/22	8 4.9
11	30 22/29	40 21	90 16/23					60 18/22	8 4.9
12	40 20/28	50 18	-					50 18/24	7 6.6
13	50 20/27	40 20/27	80 18/22					60 20/26	9 6.6
14	40 19/27	50 17	80 18/24						
15	50 20/26	50 19	70 19/23						
16	50 18/26	40 21	70 23/25						
17	50 20	40 17/22	80 21/24						
18	50 23/27	30 15	70 17/24						
19	60 24	40 14	-					50 22/26	8 6.6
20	50 20/26	40 13	80 19/26						
21	50 20	20 15	80 16/26						
22	60 19/25	20 15	90 14/25					60 24/28	5 6.6
23	50 20	20 12	80 20/23					50 22/28	7 6.6
14/0	40 19/25	40 12	90 21/26					60 22/28	8 6.6
1	50 17/23	40 18	-					50 20/26	7 8.2
2	60 18/23	60 15	80 22/28					50 24/28	7 6.6
3	50 20	60 16	90 19/28					60 24/28	7 8.2
4	60 21/26	50 17	80 21/26						
5	60 20	50 13	80 17/24					50 22/28	7 6.6
6	60 19	40 15	90 25/25						
7	60 20	50 16	-						
8	80 23	70 18	80 26/26						
9	70 20/28	60 13	90 16/27						
10	60 20/26	50 17/23	100 18/23					50 22/26	7 8.2
11	60 16/25	50 18/24	100 13/23					50 26/30	7 8.2
12	50 20	70 19	100 17/26					50 26/32	7 8.2
13	60 16/24	50 19/26	-					50 24/30	7 8.2
14	70 16/22	50 17/28	70 24/27	85 21	65 27				
15	70 17/24	50 19/26	80 21/28						
16	60 18	60 19/26	80 21/25					50 26/22	8 8.2
17	60 19	40 15/26	90 19/24					50 28/34	8 8.2
18	50 17	50 17	90 23/25					60 26/34	7 8.2
19	50 16	40 17	-					60 26/32	8 8.2
20	60 18	30 14	90 24/29	-	65 35			60 26/34	7 8.2
21	60 19	20 15	80 22/26					50 26/30	8 8.2
22	60 18	20 22	80 22/28					50 22/28	8 8.2
23	60 20	20 18	90 16/27					50 24/22	8 8.2

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

51005

day/time	Lihue				Kahului				Upolu				Lih 2M				Kahul 2M				Dilling				Am Hi C.				WINDS		CHANGES	
	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp	dir	sp				
15/0	60	19	20	15	100	16/23																			50	24/30	7	8.2				
1	60	20	40	20	-																				50	24/30	7	8.2				
2	60	18/25	40	20/30	80	22/26	70	23																	50	24/28	8	8.2				
3	60	18	40	18	80	20/26																										
4	60	19	40	15	90	19/28																			60	24/28	8	8.2				
5	60	16	40	16/25	90	12/26																			60	20/26	9	8.2				
6	70	16	70	8	80	23/26																			50	22/26	9	8.2				
7	70	18	100	7	-																				50	22/28	8	8.2				
8	70	19	70	11	-		75	19	95	18																						
9	50	22/28	200	7	90	15/25																			60	20/26	8	8.2				
10	60	18	340	9	80	14/22																			60	20/26	8	8.2				
11	70	21	140	6	90	11/21																			60	20/26	8	6.6				
12	60	19	60	18/27	-																				50	22/28	8	8.2				
13	60	17	60	22/29	-																				50	22/26	8	8.2				
14	60	19	40	20/28	80	17/19	80	22	85	9															50	22/26	9	8.2				
15	60	17	60	23/30	80	15/21																			50	20/26	8	8.2				
16	70	17	50	21/28	80	12/20																			60	20/24	9	9.8				
17	70	17	70	21/31	-																				60	20/24	9	8.2				
18	70	18	50	16/22	90	18/21																			60	20/24	9	9.8				
19	70	18	40	17	-																				60	22/28	9	9.8				
20	80	18	70	12	70	19/21	85	180	85	11															50	24/28	9	9.8				
21	80	20	80	13	70	18/23																			60	20/26	9	9.8				
22	70	20/26	50	12	90	10/28																			50	20/24	9	8.2				
23	80	19	40	8	80	17/21																			50	22/26	10	8.2				
16/0	70	16	100	5	80	10/22																			50	20/24	9	8.2				
1	60	15	-	-	-																				50	20/24	9	8.2				
2	70	14	-	-	100	6/22	-	-																	50	20/26	9	8.2				
3	70	13	-	-	90	5/15																			60	20/26	9	8.2				
4	70	13	60	3	150	2/13																			50	20/26	9	8.2				
5	80	17/22	130	4	150	2/7																										
6	100	21	250	3	100	6/15																										
7	90	15	120	5	-																				70	20/24	8	8.2				
8	90	15	100	7	100	4/11	95	180	-																70	12/16	9	8.2				
9	90	19	150	4	90	11/14																			50	16/18	9	6.6				
10	90	16	10	4	90	12/18																			70	22/26	9	8.2				
11	80	16	180	5	-																				70	18/24	9	8.2				
12	90	17	60	16	100	12/18																			60	18/22	9	8.2				
13	90	15	80	17	-																				70	18/22	9	8.2				
14	80	15	40	17/23	110	11/15	80	15	105	7															60	20/24	9	8.2				
15	80	14	70	19	110	14/22																			60	22/20	7	8.2				
16	90	14	-	-	-																				80	22/26	8	8.2				
17	90	12	80	12	-																				80	24/30	8	8.2				
18	90	11	50	18	100	11/20																			70	20/26	8	8.2				
19	90	13	80	13	-																				60	20/24	9	8.2				
20	90	15	110	10	80	15/18	-	-	105	12															80	20/26	9	8.2				
21	80	15	120	5	90	10/21																			80	22/30	8	6.6				
22	80	15	50	4	100	17/20																			70	20/26	9	8.2				
23	90	15	120	8	100	8/20																			60	18/22	9	8.2				

WINDS FOR HAWAII DEEP WATER CABLE PROJECT (speed in knots)

1986 MARCH

(wind direction in degrees or compass points)

J. Foss

SIGET

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
17/0	90 16	120 4	100 0/9					70 8/23	9 3.2
1	90 15	-	-					60 18/22	0 6.5
2	100 13	120 6	100 5/19	105 6	-			50 20/22	9 3.2
3	100 11	120 3	110 2/8					60 18/22	0 3.2
4	100 11	100 6	90 6/9					60 16/22	9 6.6
5	70 3	110 7	120 7/12					70 18/22	9 6.6
6	290 10	CALM	120 5/9					80 18/22	10 6.6
7	290 7	150 5	-					70 18/22	9 6.6
8	290 8	140 4	80 6/11	50 100	180 4				
9	270 7	180 3	80 14/14					60 16/20	9 6.6
10	40 8	170 4	100 8/17					70 16/20	3 6.6
11	80 8	170 4	80 10/17						
12	70 12	50 15	70 7/14				ENE 25	70 16/18	8 6.6
13	60 10	40 14	-					50 12/16	8 6.6
14	70 11	330 6	70 5/9	30 13	340 9			30 10/14	10 6.6
15	70 15	40 14	70 8/12					50 12/14	10 6.6
16	50 16	10 11	90 11/13						
17	50 15	20 12	70 10/14					50 14/18	10 6.6
18	50 14	30 12	80 14/15					50 16/20	10 4.9
19	50 14	30 11	-					60 15/20	10 6.6
20	40 11	20 8	80 17/20	40 15	60 15			50 13/20	8 6.6
21	40 12	20 11	90 15/21					60 20/24	10 6.6
22	30 14	20 12	100 16/21					60 20/26	10 6.6
23	30 15	30 15	100 8/22						
18/0	30 16	30 10	90 11/18					30 20/24	9 6.6
1	10 18/26	60 7	-					80 18/20	9 6.6
2	10 18/25	220 4	100 8/14	-	-			90 14/20	10 6.6
3	360 20	120 4	100 6/9					80 14/18	10 6.6
4	10 21/29	360 5	140 5/7						
5	350 12	40 6	120 7/8					70 14/16	9 6.6
6	360 11	60 8	100 6/8					60 14/18	10 4.9
7	360 21	90 8	-					60 14/18	9 4.9
8	10 17/23	40 6	-	-	45 16			20 16/20	0 4.9
9	360 12	50 10	-					30 16/20	9 4.9
10	20 20/30	30 15	70 14/24					40 18/22	10 4.9
11	20 20	30 15	80 13/20					50 18/22	9 4.9
12	20 20	10 14	-					40 20/24	10 4.9
13	10 22/28	10 10	-					40 20/24	9 4.9
14	20 20/27	10 13	80 13/20	20 17	-				
15	360 21/28	20 15	70 16/21						
16	360 21/28	10 17	60 19/21					40 22/26	10 6.6
17	10 19/26	20 14	60 19/21					40 22/26	9 6.6
18	360 17	30 16	60 18/21					40 22/26	9 6.6
19	10 14	10 11	-					50 22/26	9 6.6
20	360 11	20 11	60 17/21	15 24	30 210			40 20/24	9 6.6
21	360 11	20 12	60 16/21					40 20/24	9 6.6
22	350 12	20 12	60 19/22					50 18/22	9 6.6
23	20 20/27	20 11	60 16/22					50 18/22	8 4.9

WINDS FOR HAWAII DEEP WATER CABLE PROJECT

1986 MARCH

J. FOSS INDEPENDENCE 51005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WINDS
19/0	350 11	20 12	16 19/22					40 20/22	8 4.0
1	350 12	40 12	-					40 20/20	9 4.0
2	10 20	30 17	16 18/22	30 140	-			40 20/20	9 4.0
3	10 11/21	30 12	70 20/23				CALM	40 20/20	0 6.6
4	350 11	-	60 19/23					40 22/24	10 6.6
5	10 12	40 10	-					40 22/26	8 6.6
6	20 17	40 12	80 10/22					40 22/26	0 6.6
7	260 10	20 15	-					30 20/26	0 6.6
8	10 20/26	30 13	-	30 19	-				
9	30 23	30 11	-					40 18/22	0 4.0
10	40 23	20 10	30 19/22			ELY 25		30 24/28	0 6.6
11	30 18/28	30 13	50 14/21					30 22/26	0 6.6
12	30 21	30 11	50 19/21					40 18/20	9 6.6
13	40 20/27	40 16	-					30 24/30	0 6.6
14	30 21/29	40 14	-	20 20	35 190			30 26/32	0 6.6
15	40 22	20 14	50 18/24					40 26/32	6 6.6
16	30 22	20 17	70 23/25					40 28/32	9 8.2
17	30 18	20 15	60 18/26					40 26/30	9 6.6
18	30 22/30	40 17	60 22/24					40 26/32	6 8.2
19	30 20/28	20 19	-					40 26/32	6 8.2
20	20 24	40 14	70 23/25	-	-			40 24/32	9 8.2
21	30 19	40 15	70 14/24					40 24/30	6 8.2
22	30 19	50 12	70 22/24					40 22/28	6 8.2
23	360 9/24	50 11	60 18/26					40 24/28	6 8.2
20/0	30 16	20 12	50 15/24					30 26/30	7 8.2
1	10 14	30 10	-					30 24/28	9 8.2
2	30 16	50 12	50 20/23	20 220	-			30 24/30	8 8.2
3	360 10	40 12	-					30 22/28	8 8.2
4	30 21	40 16	60 21/23					30 20/24	9 8.2
5	30 21/27	40 15	30 21/24					40 24/30	8 8.2
6	50 20/27	30 12	50 21/24					30 24/28	8 8.2
7	40 22	10 17	-					40 24/28	0 8.2
8	40 18/30	20 17	60 14/24					30 22/28	0 8.2
9	30 20/27	20 20	30 12/20					30 22/26	9 8.2
10	50 20/25	30 16	80 8/20					30 20/24	8 8.2
11	50 20	30 16	60 17/20					30 20/24	9 6.6
12	30 16	40 19	100 15/20					30 20/24	0 6.6
13	20 16	30 18	-					30 20/24	9 6.6
14	20 16	20 17	80 13/20					30 20/22	7 6.6
15	50 20	10 16	60 17/26					40 18/24	8 6.6
16	30 20/25	30 15	60 20/24					40 20/26	0 6.6
17	50 21	20 13	70 19/24					30 20/24	9 6.6
18	50 20	40 9	70 23/24					50 20/24	8 6.6
19	40 20	40 15	-						
20	30 20/26	20 12	70 24/26					60 20/26	9 6.6
21	30 23/28	50 15	60 19/25					50 20/24	8 6.6
22	30 20/30	50 8	70 19/23					50 22/26	0 6.6
23	40 20/25	20 9	-						

WINDS FOR HAWAII DEEP WATER CABLE PROJECT

1986 MARCH

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	51005	
								WINDS	WAVES
21/0	40 19/26	20 8	70 15/18					50 20/24	9 6.6
1	30 18/15	50 10	-					50 18/22	8 8.2
2	30 18	60 13	60 17/22					50 18/22	8 8.2
3	40 20	40 12	100 8/17					40 18/22	8 8.2
4	30 16/28	40 12	90 14/18					40 20/24	8 8.2
5	30 20	40 12	-					40 20/24	9 8.2
6	50 20/27	50 18	90 10/19					40 20/26	8 8.2
7	40 20/27	40 16	-					40 24/30	9 8.2
8	40 19	40 14	70 24/27						
9	30 20	50 16	70 20/27					40 24/30	9 8.2
10	40 21	30 16	70 22/29					50 24/30	9 8.2
11	40 19	50 17	80 14/27					50 24/28	9 8.2
12	40 17/23	40 16	60 21/23					50 22/28	8 8.2
13	30 17	40 18	-					50 22/26	8 8.2
14	30 17/23	40 18	60 23/26					30 22/28	9 8.2
15	40 18	40 17	60 19/26					40 24/30	9 8.2
16	40 19/25	40 14	60 20/27					40 20/28	9 8.2
17	40 21	40 15	60 8/14					40 26/32	9 8.2
18	40 21/29	60 16	60 22/27					40 26/32	9 8.2
19	50 19/25	40 16	-					50 26/34	9 8.2
20	40 24/29	30 17	80 24/28					50 26/32	8 8.2
21	50 22/31	30 20	60 23/24					30 26/30	9 8.2
22	50 25/30	-	60 24/28						
23	50 22/28	20 18	50 20/26					40 26/32	8 9.2
22/0	50 22	20 16	60 20/26					30 24/30	8 9.8
1	60 20/28	20 20	-						
2	50 21	30 14	60 23/27					30 24/30	8 8.2
3	30 21	20 13	60 20/25					40 24/30	8 8.2
4	40 20	20 17	60 21/24					30 24/28	7 8.2
5	30 20	20 16	-					30 26/30	8 8.2
6	40 20	30 15	60 21/25					40 26/32	8 8.2
7	40 18/25	20 17	-					40 26/30	8 8.2
8	40 20	30 14	50 24/27					30 26/32	8 8.2
9	40 19	20 17	50 22/26					30 24/28	8 8.2
10	30 18	20 18	50 22/27					30 26/32	8 6.6
11	40 22	10 18	70 18/26					30 26/30	8 8.2
12	10 20/25	20 15	60 21/25						
13	40 22	30 18	-						
14	40 25	20 19	60 22/24						
15	40 23	20 17	-					40 24/28	6 6.6
16	30 22	40 17	60 20/27						
17	30 21	30 18	80 18/25						
18	40 20	40 15	80 17/25					50 24/30	6 6.6
19	30 21	40 16	-					40 24/28	8 8.2
20	40 17	40 14	80 12/25					50 24/30	6 8.2
21	20 14	30 12	70 15/25					50 24/28	6 6.6
22	30 17	30 13	80 18/25					50 22/28	7 8.2
23	30 15	30 11	70 16/22					50 24/28	7 8.2

WINDS FOR HAWAII DEEP WATER CABLE PROJECT

1986 MARCH

day/time	B. FORS			CONSTITUTION		5100'			
	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
23/0	30 17/25	30 12	80 20/23					50 24/30	7 8.2
1	60 19	-	-					40 22/26	8 6.6
2	60 18	-	60 18/23					50 24/29	8 6.6
3	70 19	-	80 18/23					50 24/30	8 5.2
4	50 20	50 16	90 12/26					50 24/30	8 6.6
5	60 17	40 14	80 13/24					50 22/28	3 2.2
6	60 17	40 16	90 15/24					60 22/28	3 5.2
7	50 17	50 15	-					50 20/24	8 6.6
8	50 15	50 17	90 21/23					50 20/24	8 6.6
9	50 15	60 15	70 14/22					50 20/24	8 6.6
10	50 18	40 19/24	60 20/25					40 18/24	8 6.6
11	60 16	50 17	60 20/24					50 20/22	8 6.6
12	70 18	50 19/26	60 18/22					50 20/24	8 6.6
13	60 17	40 19	-					50 20/26	8 6.6
14	60 15	40 18	70 20/22					40 18/22	8 6.6
15	70 16	40 15	60 19/22					40 20/26	8 6.6
16	60 16	50 18	70 18/24					50 18/24	8 6.6
17	60 14	50 14	70 18/23					40 20/26	8 6.6
18	60 14	60 9	60 18/21					50 20/24	9 6.6
19	60 14	60 11	-					50 18/22	8 6.6
20	60 14	50 11	70 13/20					40 18/22	8 6.6
21	50 16	30 14	60 14/20					50 18/22	8 6.6
22	40 11	40 12	80 11/20					40 16/20	8 6.6
23	50 14	40 15	70 14/17				50 20	40 18/22	8 4.0
24/0	70 14	20 14	80 9/15					40 16/20	8 6.6
1	40 13	-	-					40 16/20	8 4.9
2	50 13	50 4	90 7/11					40 14/18	8 4.9
3	60 12	150 4	80 5/10					40 16/18	8 4.9
4	10 7	110 6	100 5/15					60 14/16	7 4.9
5	60 10	120 5	100 5/10					60 16/20	8 4.9
6	70 11	140 6	110 1/8					60 14/16	8 4.9
7	70 11	190 3	-			NE 10-15		40 12/14	8 4.9
8	60 10	CALM	120 6/7					40 15/20	7 4.9
9	60 11	330 8	60 5/8					60 12/14	8 4.9
10	50 13	300 7	80 9/13			E 25-30			
11	50 14	70 5	100 13/17					60 16/18	3 4.9
12	50 12	40 12	80 12/16					60 16/20	8 4.9
13	50 12	90 12	80 11/16					60 14/18	5 4.9
14	20 14	50 9	-					60 16/18	8 4.9
15	10 14	50 7	90 15/17					60 16/20	8 6.6
16	30 15	-	90 13/19					80 16/20	9 4.9
17	20 14	30 10	90 10/17					70 16/18	9 4.9
18	360 11	250 5	100 8/14					70 16/20	9 4.9
19	350 8	150 3	-					80 16/20	9 4.9
20	10 7	70 4	110 9/8					80 16/20	8 4.9
21	360 11	100 9	160 2/7					70 14/18	9 4.9
22	360 9	230 3	140 6/7					60 12/16	8 4.9
23	350 7	190 3	120 6/9					50 12/14	8 3.3

WINDS FOR HAWAII DEEP WATER CABLE PROJECT

1986 MARCH

day/time					INDISPONDANCE		SIDOS		
	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
25/0	340 6	360 5	140 5/7					110 6/4	8 2.3
1	320 6	130 4	-					80 14/16	8 4.9
2	290 5	120 3	140 1/7					80 12/16	8 4.9
3	300 6	140 4	150 5/6					70 12/16	9 3.3
4	290 5	160 4	140 6/9					50 12/14	9 3.3
5	330 6	140 4	200 4/4					70 10/12	8 3.3
6	340 6	120 5	150 6/9					90 12/4	9 3.3
7	40 10	140 3	-					70 10/12	8 3.3
8	50 11	110 3	-					60 12/16	9 3.3
9	50 11	330 11	80 11/15					70 14/16	9 4.9
10	60 11	20 15	-					70 14/18	9 3.3
11	60 13	40 15	-					50 14/18	9 4.9
12	50 13	40 12	70 16/18					50 14/18	9 4.9
13	50 12	40 13	-					60 16/18	8 4.9
14	50 12	40 15	-					50 16/20	9 4.9
15	50 14	40 15	80 20/20					60 18/22	9 4.9
16	50 14	20 16	90 13/20						
17	50 14	40 15	-					60 16/20	9 4.9
18	50 13	50 14	100 3/13					60 16/20	8 3.3
19	50 13	40 11	-					60 14/18	9 3.3
20	50 12	50 10	90 5/10						
21	50 14	30 12	100 9/8					50 12/14	9 4.9
22	40 16	30 5	90 3/6					50 12/14	9 4.9
23	50 17	10 10	100 3/7					50 12/16	13 9.3
26/0	50 16	360 12	100 3/5					40 14/16	9 4.9
1	50 16	360 8	-					40 12/16	9 4.9
2	50 16	30 7	-					40 14/18	9 3.3
3	50 15	30 6	-				NNE 10	40 16/20	9 3.3
4	40 17	40 9	70 15/19					40 16/20	9 4.9
5	50 17	40 10	60 19/21					40 18/20	9 4.9
6	40 14	40 9	100 4/6					40 20/22	9 4.9
7	30 15	30 8	-					50 8/22	9 4.9
8	60 17	50 10	80 6/7						
9	60 19	30 15	80 11/22					60 20/24	10 4.9
10	60 19	20 16	60 9/13					60 18/22	9 4.9
11	60 19	40 16	80 18/22					60 18/22	9 4.9
12	50 20	40 16	-						
13	50 20	20 18	-					50 20/24	9 4.9
14	50 22	30 17	-					60 20/24	8 4.9
15	50 22	20 17	80 19/21					50 18/24	9 4.9
16	40 21	30 17	80 10/18					40 20/24	9 4.9
17	40 18	30 17	-					40 20/24	9 4.9
18	40 20	40 13	70 18/20					50 20/24	5 4.9
19	60 15	30 13	-					50 14/16	9 4.9
20	50 15	50 15	70 19/20					70 18/24	9 4.9
21	40 18	30 15	70 17/22					50 18/22	9 4.9
22	40 20	30 12	70 17/23					50 18/22	9 4.9
23	50 15	40 12	80 15/23						

WINDS FOR HAWAII DEEP WATER CABLE PROJECT

1986 MARCH

ST005

day/time	MIXIAL			Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS		WAVES	
	Lihue	Kahului	Upolu					WINDS	WAVES		
27/0	40 17	30 12	70 20/21			B. Pass		40 20/22	9	4.9	
1	50 19	30 10	-					50 20/24	6	4.9	
2	50 20	20 15	80 21/23					50 20/24	8	4.9	
3	40 21	50 15	40 15/23					50 22/23	6	4.9	
4	40 20	20 13	70 19/23					50 22/26	8	6.6	
5	40 22	40 12	70-21/26					60 22/26	6	6.6	
6	40 18	50 13	70 21/26			NE 35		60 24/32	8	6.6	
7	50 19	40 12	-			NE 30		70 24/32	7	6.6	
8	60 16/22	30 12	70 24/27					50 26/30	5	6.6	
9	50 17	40 10	80 20/26					60 24/30	6	6.6	
10	50 15	30 14	90 13/26			NE 25		50 24/30	6	6.6	
11	40 16	30 15	70 16/23					60 20/26	7	6.6	
12	40 14	50 15	90 14/22					70 22/24	6	6.6	
13	50 15	50 14	-					60 18/22	7	6.6	
14	40 15	40 19	100 14/21					60 20/24	7	6.6	
15	50 13	50 14/24	90 12/20					50 22/26	7	6.6	
16	40 13	60 13/21	-					70 20/24	6	6.6	
17	50 15	40 13	90 14/20					70 20/24	7	6.6	
18	50 17	40 10	90 10/16					60 20/24	7	6.6	
19	40 14	40 8	-					60 20/24	7	6.6	
20	60 15	40 10	100 12/16					50 20/24	7	4.9	
21	50 14	360 8	80 19/22					60 20/24	8	4.9	
22	60 13	30 10	70 18/21					60 20/24	7	4.9	
23	60 12	40 10	80 19/22					50 18/22	8	4.9	
28/0	60 11	360 10	80 17/20					60 20/24	7	4.9	
1	50 10	10 8	-					60 18/22	7	4.9	
2	280 6	30 10	100 10/15					70 18/22	8	4.9	
3	40 12	20 9	100 9/13					70 18/20	8	4.9	
4	60 12	10 8	110 11/12					70 18/22	7	4.9	
5	70 14	10 7	100 10/13					70 18/22	7	4.9	
6	70 15	40 7	100 7/13					70 18/22	8	4.9	
7	80 14	360 7	-								
8	80 16	40 14	80 10/16					50 20/24	7	4.9	
9	90 15	50 15	80 13/22								
10	70 15	40 19	90 17/22					60 20/24	7	4.9	
11	70 14	40 20	80 20/25					60 22/26	7	4.9	
12	80 14	40 20/26	90 22/25					60 24/30	5	6.6	
13	70 16	30 20/25	-					70 22/26	8	4.9	
14	60 15	50 20/25	80 20/25					60 22/26	8	6.6	
15	60 14	50 21/29	80 14/22					70 22/26	8	6.6	
16	60 15	70 21/28	80 19/21					70 20/24	8	6.6	
17	60 14	60 19/26	80 18/24					70 20/26	7	4.9	
18	60 15	70 18	-					70 20/26	8	6.6	
19	70 14	70 17	-					60 18/22	8	6.6	
20	80 16	60 13	100 15/23					80 18/24	8	6.6	
21	70 15	40 12	90 13/21								
22	60 16	40 13	100 17/21					80 20/22	7	6.6	
23	70 17	40 13	100 11/22					80 20/24	8	6.6	

WINDS FOR HAWAII DEEP WATER CABLE PROJECT

1986 MARCH

CONSTITUTION ST005

day/time	Lihue	Kahului	Upolu	Lih 2M	Kahul 2M	Dilling	Am Hi C.	WINDS	WAVES
29/0	70 19	30 10	110 14/21						
1	70 18	50 9	-						
2	70 17/23	40 9	90 8/16					70 20/22	8 6.6
3	70 16	80 11	-					70 20/26	8 6.6
4	60 17	-	-					70 22/26	8 8.2
5	60 16	30 9	100 7/10					70 22/26	8 8.2
6	70 16	40 12	90 8/13					70 20/26	8 6.6
7	70 17	50 13	-						
8	70 18	40 13	90 9/20					70 20/26	8 6.6
9	80 15	50 15	80 15/21					80 20/22	8 6.6
10	80 18	40 17	80 13/22					70 22/26	8 6.6
11	90 16	60 12	80 14/23					70 22/26	8 6.6
12	70 16	70 22	80 15/22					60 22/26	8 6.6
13	80 15	80 18/26	-					70 20/26	8 6.6
14	60 14	70 17/24	80 10/23	90 12	-				
15	70 15	80 14/28	80 7/19						
16	70 16	80 20	-						
17	60 16	60 18	100 10/18						
18	70 17	70 15	70 18/23						
19	60 16	60 13	-						
20	60 16	60 13	70 19/26	75 17	95 8				
21	60 18	40 13	70 20/25						
22	60 18	20 12	80 21/25						
23	70 16	20 11	70 18/26						
30/0	60 18	30 11	-						
1	60 14	-	-						
2	70 15	-	70 22/24	65 150	-				
3	80 17	-	80 20/24						
4	70 12	60 11	80 21/25						
5	70 13	40 10	80 18/25						
6	80 17	40 9	80 17/24						
7	70 14	40 14	-						
8	70 15	50 13	70 21/25	80 180	80 30				
9	60 16	70 19/26	90 15/25						
10	60 17	70 19/25	80 14/24						
11	70 17	70 19/29	70 20/25						
12	60 17	60 20/26	70 21/25						
13	60 17	70 24/28							
14	80 16	70 22/31		-	80 19			50 20/26	8 6.6
15	80 17	80 20/30						60 22/28	8 8.2
16	60 16	70 19/28						60 24/30	8 8.2
17	70 15	50 20/28						60 24/24	8 8.2
18	70 17/22	60 22						60 22/26	8 8.2
19	60 17	50 15						60 20/26	8 6.6
20	70 17/25	50 13		80 150	80 24			60 20/24	8 8.2
21	60 18	50 12						60 20/26	8 6.6
22	60 19	20 11						60 20/24	8 6.6
23	70 17	30 10					NE 25	70 20/24	8 6.6

March 1986

NOAA BUOY
PERCENT FREQUENCY OF WIND SPEED AND DIRECTION

	WIND SPEED (KNOTS)						DIR (%)	AVG SPEED
	0-10	11-15	16-20	21-25	26-30	>30		
N	1	1	0	0	0	0	1	9.64
NE	6	14	29	15	4	0	69	18.02
E	3	3	10	2	0	0	17	16.50
SE	0	0	0	0	0	0	0	0.00
S	3	0	0	0	0	0	3	6.23
SW	5	1	0	0	0	0	5	7.63
W	3	1	0	0	0	0	4	6.14
NW	1	0	0	0	0	0	1	6.00
VAR	0	0	0	0	0	0	0	0.00
%	20	19	39	17	4	0		

Days of Data: 31
Total Hours Available Data: 744
Average Wind Speed: 16.15

AVERAGE HOURLY WIND SPEEDS

Hour	Speed (knots)
0- 1	15.67
1- 2	15.42
2- 3	15.55
3- 4	15.42
4- 5	15.48
5- 6	15.16
6- 7	15.55
7- 8	15.23
8- 9	15.23
9-10	15.48
10-11	15.81
11-12	16.06
12-13	16.26
13-14	16.39
14-15	16.71
15-16	17.03
16-17	17.42
17-18	17.55
18-19	17.48
19-20	16.77
20-21	16.84
21-22	16.39
22-23	16.19
23-24	16.32