NDBCM W6222 - 2

U. S. DEPARTMENT OF COMMERCE ● NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

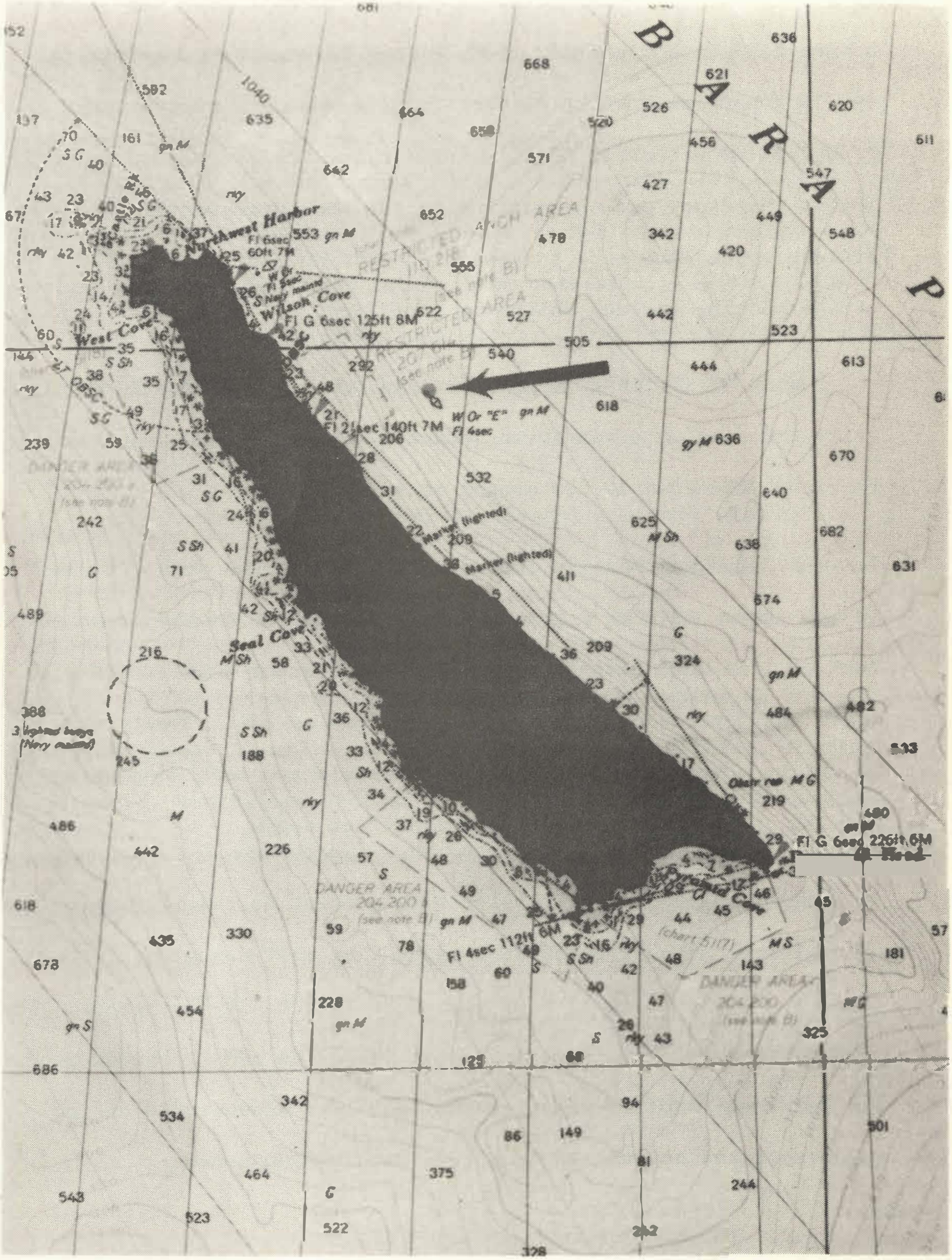
NATIONAL OCEAN SURVEY

NATIONAL DATA BUOY CENTER

[Patrick J. Hargreaves]

EXAMINATION OF SEA LANES MOORING E AFTER TWO YEARS ON STATION

EXAMINATION OF SEA LANES MOORING E
AFTER TWO YEARS ON STATION



NATIONAL DATA BUOY CENTER
JULY 1972
MISSISSIPPI TEST FACILITY
BAY ST. LOUIS, MISS. 39520

ABSTRACT

As part of the Sea Lanes Buoy Project, which extended from November 1969 to September 1970, a long term mooring materials test was performed on nylon mooring line. Buoy E was deployed in 3750 feet of water off San Clemente Island, California on March 25, 1970. This buoy and its mooring of one inch diameter double braided nylon line were to remain on station until April 1972 or the mooring failed, whichever came first.

On April 11, 1972, after 747 days on station, Buoy E and its entire mooring were retrieved intact. Line tension during the retrieval exceeded 10,000 pounds at several times.

The line was heavily fouled with slime in the euphotic zone (0-150 feet). Six to eight mussels were present on the upper 10 feet of line when brought aboard the USCG Cutter WALNUT (WLM-252). Below the light zone the line was as clean as new. Twenty-five to thirty colonies of hydroid approximately two feet long were present on the line to about the 1500 feet depth.

Seven significant fishbites were present on the mooring. These all occurred above the 650 foot mark. The most damaging of these bites reduced the strength of the nylon line to 18,700 pounds. The minimum rated break strength of this line when new is 25,000 pounds. For Sea Lanes applications, the maximum load encountered during deployment and on station is approximately 5000 pounds.

The metal hardware including mild steel shackles and swivel, high tensile strength 3/4 inch chain in the bottom chafe zone, and captive bronze thimbles showed little wear and no damage.

A great deal of barnacle and mussel growth was present on the $1\frac{1}{4}$ inch chain and shackle connected to the top end of the nylon line (15 feet below the buoy). The possibility of long term damage to the nylon from these marine organisms may be eliminated through the application of a thick (1/8 to 1/4 inch) coating of urethane over the entire thimble and top ten feet of the line.

The results of this test deployment indicate that nylon moorings of this type can be deployed significantly longer than two years in areas where fishbite does not become a serious menace.

The fishbite problem can be overcome by tubing on a continuous armor jacket of nylon (1/8 to 1/4 inch wall thickness) or other suitable synthetics such as those presently being examined at Woods Hole Oceanographic Institution for the National Data Buoy Center.

ACKNOWLEDGEMENTS

The materials survival test of the Sea Lanes Mooring E took place over a two year time span. As a result of the Sea Lanes Program, significant improvements in the state-of-the-art of deep water Aids to Navigation have been developed. Better understanding of the long term properties of nylon moorings, their design and survival is now available.

The author would like to thank the U. S. Coast Guard Office of Ocean Engineering (EOE), The Commander Eleventh Coast Guard District (o), the Officers and men of the USCGC WALNUT (WLM 252), Samson Cordance Works, and Woods Hole Oceanographic Institution's Buoy Engineering Section for their participation in and contributions to this test.

PATRICK J. HARTMAN

July 1972

TABLE OF CONTENTS

Section 1

INTRODUCTION

1.1 SEA LANES TEST PROGRAM

The Sea Lanes Buoy Project was an operational test of deep sea aids to navigations moorings jointly sponsored by the United States Coast Guard Offices of Aids to Navigation (WAN) and Ocean Engineering (EOE), the National Plan for Navigation Project and the National Data Buoy Project (National Data Buoy Center - NDBC - NOAA). The Project was initiated in December 1968 to examine the critical design and operational aspects of these moorings.

Test deployments took place between November 1969 and September 1970 in 600 fathoms of water off San Clemente Island, California.[1*]

1.2 LONG TERM MOORING MATERIALS TEST

At the beginning of this Project little quantitative knowledge existed on the long term effects of the ocean environment on nylon moorings. Substantial progress was made in this area during the detailed design phase and testing of the Sea Lanes moorings.[1]

To test the long term survival of these moorings and their components, Buoy E was deployed on 25 March 1970 and slated to be recovered in April 1972 after over two years on station. This buoy and its complete mooring were retrieved on 11 April 1972.

*Numbers refer to references at the end of this report.

1.3 AREAS REPORTED ON

The examination and analysis of Buoy E's mooring components have been completed. This report covers:

1. design and deployment of the mooring,
2. retrieval of the mooring,
3. examination of the mooring components, and
4. conclusions drawn from this experiment.

Section 2

DESIGN AND DEPLOYMENT OF THE MOORING

The mooring for Buoy E was designed to survive under the two worst cases encountered. The first is the maximum environment in which the winds, currents and seas mount to destroy the buoy and mooring system. The second is the case of minimum sea action in which a long nylon mooring could drag and chafe on the bottom.

2.1 MOORING COMPONENTS

The mooring components selected for this Sea Lanes Buoy are shown in Table 2.1-1. The nylon line was purchased under MIL-R-24050A (20 January 1967) with U. S. C. G. Addendum FS-4-67.

SHACKLES:** *	STOCK NUMBER:*
2 inch	CG 4030 236 8403 SK
1 1/2 inch	CG 4030 236 8401 SK
1 inch	CG 4030 236 8400 SK
SWIVEL: *	
2 inch	CG 4030 729 6089
MOORING LINE:	
1 inch diameter	2 in 1 double braided nylon 25,000 pound minimum rated break strength
CHAIN:*	
3/4 inch	CG 4010 729 5924
BRIDLE:	
1 1/2 inch X 26 feet	
SINKER:	
10,000 pound concrete (Approximately 5830 pounds in water)	

*Reference Coast Guard Civil Engineering Report No. 17D
CG-250-17D Mooring Components

**Reference Drawing No. BU-45-01 Swivels and Shackels

TABLE 2.1-1

MOORING COMPONENTS

2.2 CALCULATION OF MOORING LENGTH

One inch diameter, double braided, 2-in-1, nylon line by Samson Cordage Works was selected for the mooring of Buoy E. Three shots of 3/4 inch High Tensile Strength (HTS) steel chain weighing 4.92 pounds per foot made up the bottom chain. (Figure 2.4-2).

The design criteria for deep water aids to navigation moorings requires that the nylon line never chafes on the bottom, even after long periods of deployment. During the two years this mooring was on station permanent line elongation took place during the buoy/mooring launch, and time dependent nylon shrinkage and creep altered the overall length.

To compensate for these phenomena, the mooring line length calculations specified in Section 3.2.3.2, Mooring Length Calculations Using Graphical Techniques, of the Sea Lanes Test-Operations Report (Reference Number 1) were performed. One-half of the 3/4 inch chain was to be suspended above the bottom by the nylon mooring.

For a water depth of 3600 feet these calculations required a nylon mooring section of 3210 feet of new line measured at a tension of 200 D^2 pounds. The actual deployment site was 3750 feet deep, therefore the nylon line was cut to 3360 feet. This added length was equal to the increase in water depth as specified in Section 3.2.3.3, Desensitizing Buoy Mooring (Reference Number 1).

Examination of the 3/4 inch chain upon recovery (Section 4.2 of this report) shows that a minimum of 110 feet of the chain was suspended. This is very close to the design length of 135 feet.

2.3 DEPLOYMENT TECHNIQUE

The "WALNUT Faking Box Technique" used in the deployment of the Buoy E mooring is an original technique devised (with the aid of Samson Cordage Works Representatives), developed and implemented by the USCGC WALNUT personnel.

"In this technique the sinker is hung in the chain stopper, and the drop point is approached. The buoy is then hung over the side. (The buoy is not released to float away from the ship.) The ship maneuvers into position and the sinker is released from the chain stopper at the drop point. The mooring line runs freely from a faking box position at the ship's rail. The buoy is released after the sinker is on the bottom."[1]

During deployment, the sinker and mooring fall almost straignht to the bottom affected mainly by subsurface currents and hydrodynamic sinker drift. No line tension build up is encountered until all of the line has run from the faking box. When the line is all out of the box, the sinker stretches the nylon to close the gap between deployed mooring length and the ocean bottom. The mooring tension gradually builds to a maximum and then settles down to a steady state level.

2.4 DEPLOYED MOORING CONFIGURATION

Buoy E and its nylon mooring were deployed on 25 March 1970 in 3750 feet of water near San Clemente Island, (Figure 2.4-1). The deployed mooring configuration is shown in Figure 2.4-2, and its deployment data on Table 2.4-1.

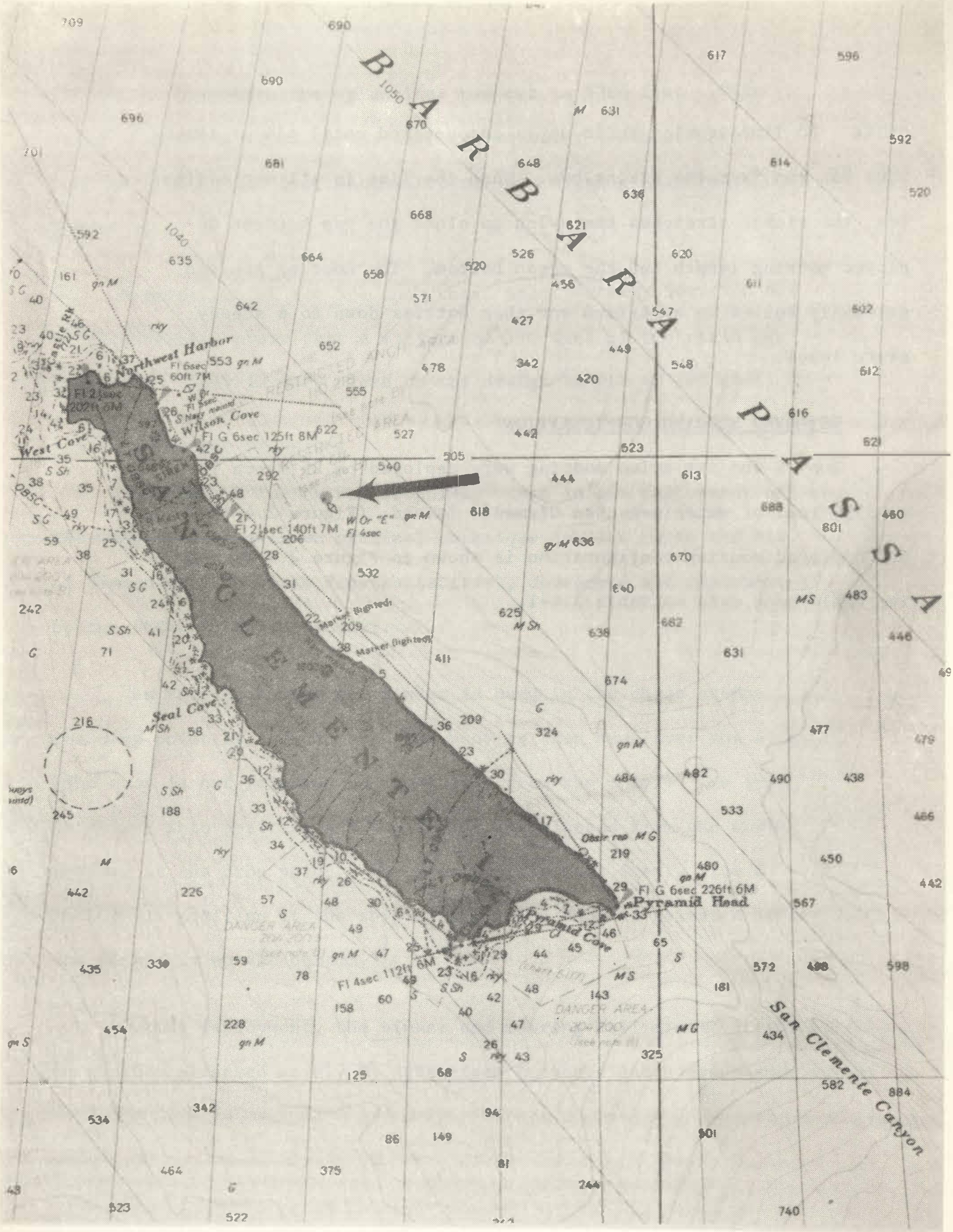


FIGURE 2.4-1 LOCATION OF BUOY E FROM CGS5101

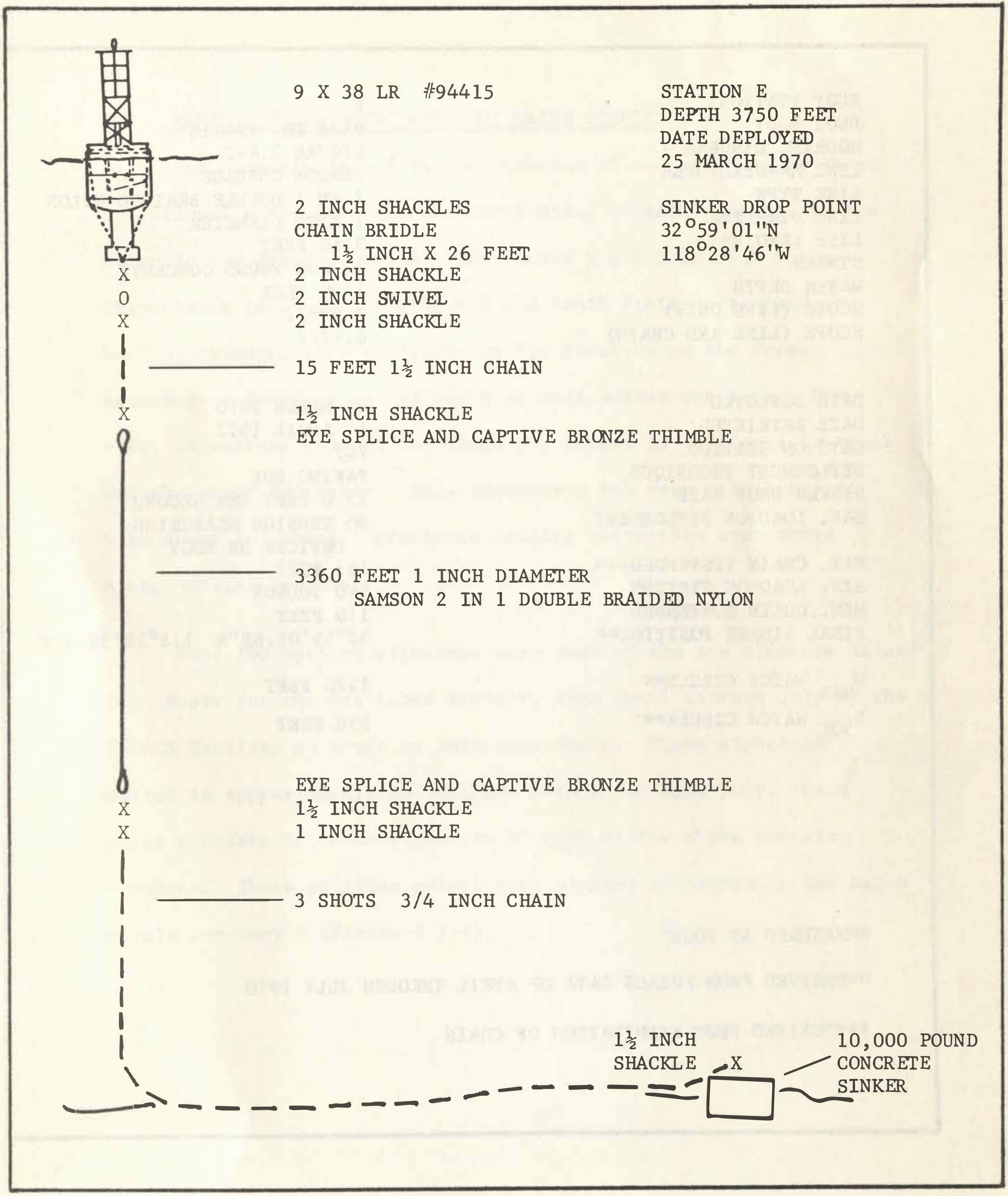


FIGURE 2.4-2 BUOY E DEPLOYED MOORING CONFIGURATION

BUOY STATION	E
BUOY BODY	9X38 LR #94415
MOORING DIAGRAM	FIGURE 2.4-2
LINE MANUFACTURER	SAMSON CORDAGE
LINE TYPE	2 IN 1 DOUBLE BRAIDED NYLON
LINE DIAMETER	1 INCH DIAMETER
LINE LENGTH*	3360 FEET
SINKER	10,000 POUND CONCRETE
WATER DEPTH	3750 FEET
SCOPE (LINE ONLY)	0.895/1
SCOPE (LINE AND CHAIN)	0.97/1
DATE DEPLOYED	25 MARCH 1970
DATE RETRIEVED	11 APRIL 1972
DAYS ON STATION	747
DEPLOYMENT TECHNIQUE	FAKING BOX
SINKER DROP RATE	13.6 FEET PER SECOND
MAX. LOAD ON DEPLOYMENT	NO TENSION MEASURING DEVICES ON BUOY
MAX. CHAIN SUSPENDED***	165 FEET
MIN. LOAD ON STATION	540 POUNDS
MIN. CHAIN SUSPENDED	110 FEET
FINAL SINKER POSITION**	32°59'01.88"N 118°28'39.9"W
D_{MAX} WATCH CIRCLE**	1530 FEET
$D_{50\%}$ WATCH CIRCLE**	550 FEET

*MEASURED AT $200D^2$

**DERIVED FROM FORACS DATA OF APRIL THROUGH JULY 1970

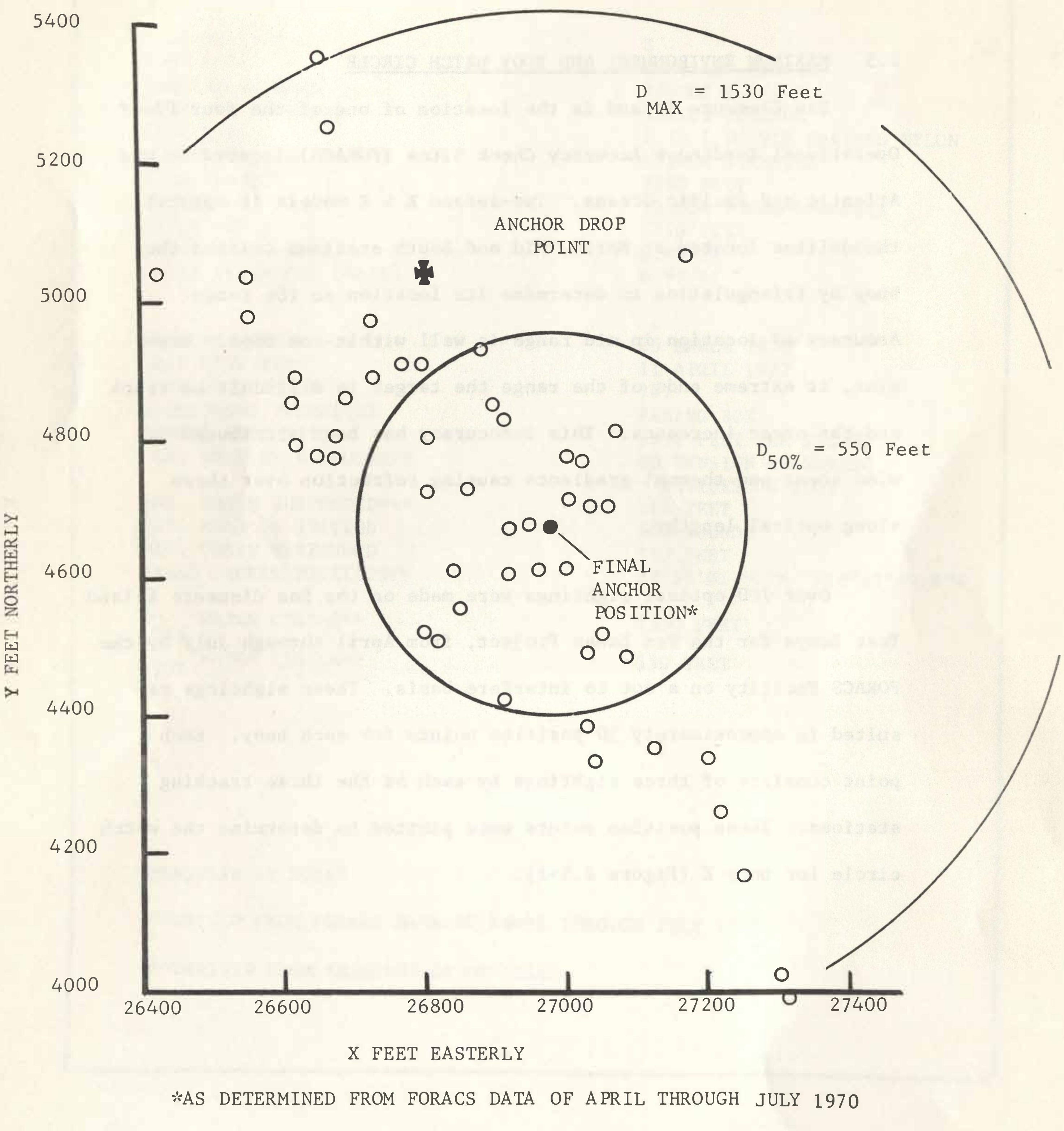
***DERIVED FROM EXAMINATION OF CHAIN

TABLE 2.4-1 Buoy E Deployment Data

2.5 MAXIMUM ENVIRONMENT AND BUOY WATCH CIRCLE

San Clemente Island is the location of one of the four Fleet Operational Readiness Accuracy Check Sites (FORACS) located in the Atlantic and Pacific Oceans. Two-second K & E Models IE optical theodolites located at North, Mid and South stations tracked the buoy by triangulation to determine its location on the range. Accuracy of location in mid range is well within one foot. However, at extreme ends of the range the target is difficult to track and the error increases. This inaccuracy has been attributed to wind shear and thermal gradients causing refraction over these along optical lengths.

Over 700 optical sightings were made on the San Clemente Island Test Buoys for the Sea Lanes Project, from April through July by the FORACS Facility on a not to interfere basis. These sightings resulted in approximately 50 position points for each buoy. Each point consists of three sightings by each of the three tracking stations. These position points were plotted to determine the watch circle for Buoy E (Figure 2.5-1).



*AS DETERMINED FROM FORACS DATA OF APRIL THROUGH JULY 1970

FIGURE 2.5-1 BUOY E LOCATIONS FROM FORACS DATA

Section 3

RETRIEVAL OF THE MOORING

On 11 April 1972, Buoy E and its entire mooring including bottom chain and concrete sinker were retrieved intact by the USCGC WALNUT.[9] Sinker breakout was successfully initiated by placing the top 15 feet of 1½ inch chain in the chain stopper and backing on the mooring with the ship. Recorded tensions in the line exceeded 10,000 pounds during retrieval. (Figure 3.2-1)

3.1 ENERGY STORED IN THE MOORING

A synthetic mooring acts much like a large rubber band when stretched. It stores a great deal of energy within its structure.

If one attempts to retrieve the mooring with sinker and ground tackle attached, this stored energy may be catastrophically released by line failure.

The following exert from "Review of Synthetic Fiber Ropes"[3] by Dr. Walter Paul, defines the energy in a mooring line.

> "Moorings which stretch under load therefore absorb mechanical energy which is equal to the work done by the external loads on the mooring. Since $E_{pot} = \int L\,dx$, the absorbed energy can be expressed by the area under of mooring load elongation curve.

The energy absorbed by the mooring can thus be expressed by the area under the load elongation curve.

$$E_{pot} = C_e \times L \times l \times s$$

Where:

E absorbed energy in (ft x lbs-wt, kilogram-wt x meter)

C_e shape factor of the curve. For a straight line, (Hooke's) as in wire ropes, $C_e = 1/2$. For fiber ropes C_e is approximately 1/3.

L load of the mooring (lbs-wt, kilogram-wt)

l initial length of the mooring (ft, meters)

s strain under load = $\Delta l/l$

The potential energy of a mooring at break is

$$E_{pot} = C_e \, BS \, l \, s_b$$

where BS is the breaking strength and s_b the strain at break. This potential energy is converted to the kinetic energy of the broken rope."[3]

The mooring on buoy E consists of 3360 feet of 1 inch diameter Samson 2 in 1 double braided nylon line. This line has an elongation at break strength (strain at break) of 17%. Its ultimate break strength is 28,500 pounds.

If the buoy E mooring line reaches its full break strength while dislodging a sanded in anchor, the energy released will be 5.4×10^6 foot-pounds.

When a line breaks, the energy released in each section of the line is proportional to its length. Thus, if the mooring parts just above the ground tackle all of the potential energy available will go toward accelerating the end of the line in the direction of the ship. Hydrodynamic drag will dissipate most of this energy very quickly.

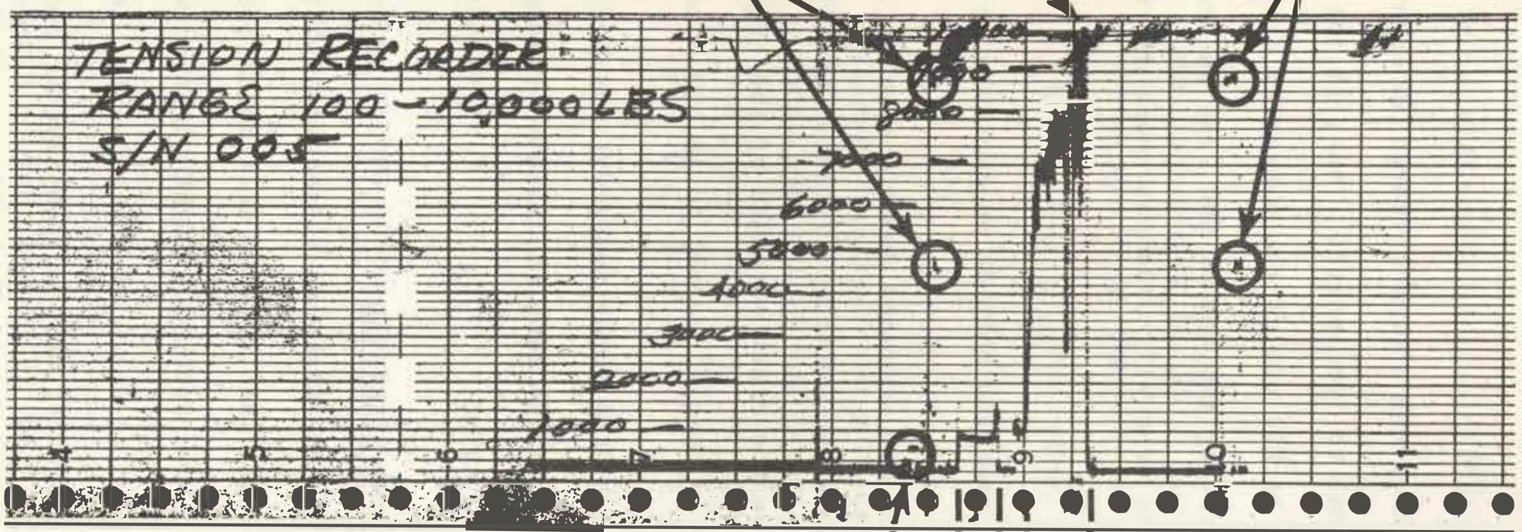
A line breaking near the ship or on deck can be very hazardous.

The nylon mooring had suffered seven fishbites from a depth of 100 to 650 feet below the surface. (Section 4.1.2) The most severe of these reduced the break strength of the line from 25,000 pounds (minimum rated by specification) to 18,700 pounds.

Retrieval of actual Sea Lanes Buoys will most likely be initiated by sliding a cutting mechanism down the line to the bottom thimble before retrieval of the nylon.

3.2 SINKER BREAKOUT AND RETRIEVAL

The WALNUT arrived San Clemente Island at 0710 PDT and prepared to lift buoy E and install the in-line, self-contained, recording tensiometer (NDBC-Swift Co. S/N005). Light variable winds and calm seas were encountered during the entire retrieval. At 0800 the buoy was replaced in the water and the tensiometer recorded the steady state mooring tension until 0840 (Figure 3.2-1).



COMPARISON: 11 APRIL TENSION AND SUSPENDED CHAIN

LOAD FOR 1/2 HR. RANGE 800#-900# FOR STRIKER	= 850#
15 FT. CHAIN (1 1/2")	= 294#
MOORING TENSION	= 556#
MINIMUM SUSPENDED CHAIN	= 541#

FIGURE 3.2-1 TENSION TRACES FROM BUOY E RETRIEVAL

Sinker breakout began at 0915 by backing on the mooring with the top 15 feet of chain in the ship's chain stopper. The WALNUT dragged the mooring and sinker toward shore until 1035. The tensiometer was then lifted aboard and retrieval of the first part of the mooring (Figure 4.1-2) began at 1115 using the hydraulic winch installed on the ship. This converted oceanographic winch consisted of a Vickers hydraulic motor on a Wheeler Manufacturing Company gear box. The towing and winching operations continued until the bottom chain and sinker were on board at 1655 PDT.

Section 4

EXAMINATION OF THE MOORING COMPONENTS

After its successful deployment of over two years, the nylon mooring line was examined for damage. Initial observations were recorded as the line came aboard the ship. The next day the entire length of line and chain was faked out in the buoy yard at Base Terminal Island for detailed analysis and selection of samples.

4.1 NYLON MOORING LINE AND HARDWARE

New one inch diameter double braided nylon line and 3/4 inch high tensile strength open link chain were deployed to moor buoy E on 25 March 1970. These components are shown in Figure 4.1-1 immediately before the sinker left the chain stopper at deployment.

4.1.1 MACROFOULING ON MOORING

MARINE FOULING

Figure 4.1-2 illustrates the results of two intervening years. The bottom five feet of 1½ inch chain connecting the buoy and nylon mooring hosts a thriving colony of mussels, acorn barnacles and hydroid. The connecting swivel, shackle and captive bronze thimble were completely covered. No significant damage was done to the metal parts, but the barnacles had grown inside the ears of the captive thimble and were in contact with the nylon line. This problem and the rust saturating the nylon from the shackle call

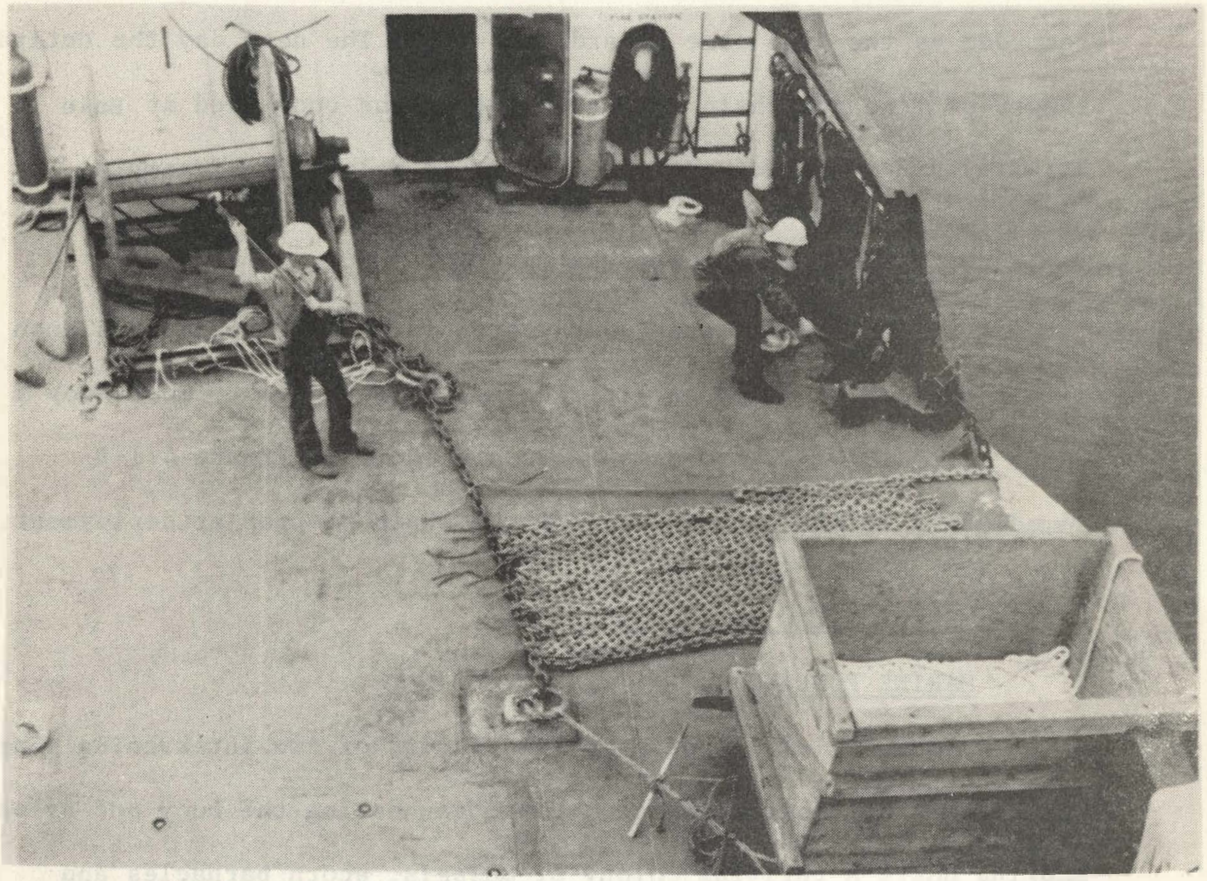


Figure 4.1-1 Buoy E mooring immediately before deployment. Nylon line, 3/4 inch chain, and 10,000 pound sinker are shown.

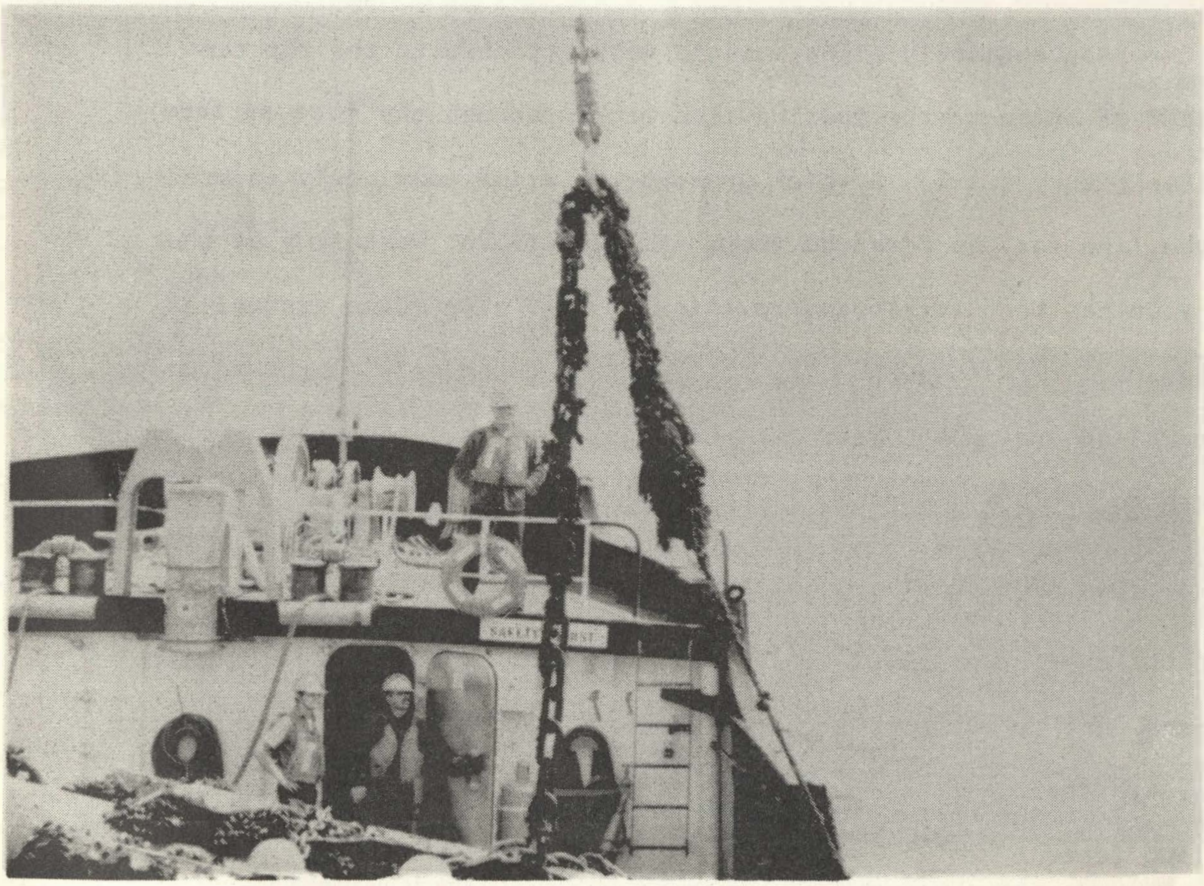


FIGURE 4.1-2 Two years of marine fouling on chain, shackle and captive thimble at top of the nylon line.

for a protective covering around the nylon and captive thimble. A dipped or painted on coating of urethane 1/8 to 1/4 inch thick would eliminate these hazards. This coating should extend ten feet down from the thimble.

Approximately eight mussels were attached to the top ten feet of nylon as the mooring line broke through the sea surface (See Figure 4.1-2). A thick green-brown slime completely covered the line for the first 60 feet. No significant weakening of the nylon has been attributed to this fouling. The slime gradually became less with depth. At the 200 foot depth only slight coverage remained and at 350 feet (end of light penetration zone) the fouling ceased.

The like new line found below the euphotic (light) zone is shown in Figure 4.1-3. Only a slight yellow tinge marked the line from here to the anchor chain. Several bands of light brown marine growth (hair) 18-24 inches long were found to a depth of approximately 1500 feet.

HARDWARE CORROSION

The swivel and shackle at the top of the mooring were covered with marine organisms and some red rust. Black corrosion deposits and red rust were found on the top captive bronze thimble. The bottom thimble had red rust, green copper corrosion and no fouling. None of these items had significant damage or wear.

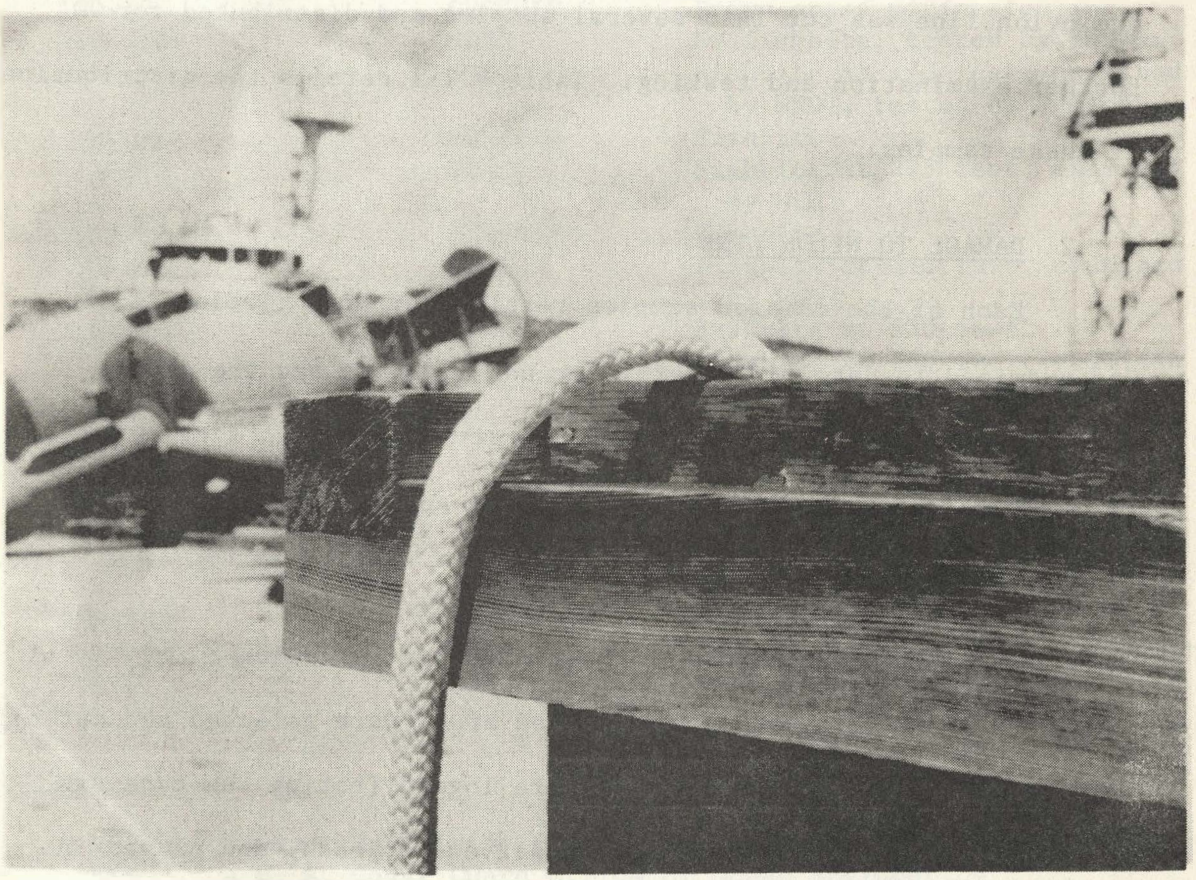


FIGURE 4.1-3 Like new nylon line from below the light zone on Buoy E.

DISTRIBUTION OF SAMPLES

After detailed inspection of the macrofouling was completed, the nylon line was cut into several samples and distributed for further examination and testing. Table 4.1-1 details the distribution of these samples.

4.1.2 DAMAGE TO NYLON LINE

Each of the damaged samples retained by NDBC (Table 4.1-1) was examined to determine whether or not fishbite was the cause. Of the nine damaged spots on the line, seven have been attributed to fishbite, one purely to capstan damage and the other to a strand of a long machine splice popping out.[2,5]

The method of examination employed was as follows:

1. Strands from damaged areas were selected and cut off.
2. These specimens were logged (noting the type of damage visually observed for each) and placed in labeled envelopes.
3. After being washed in clean tap water, the fibers were examined under a biological microscope at 50-100X for fiber damage characteristic of fishbite. (References 2, 4, 6 and 7).

This technique is graphically presented in a sequence of photographs beginning with Figure 4.1-4.

SAMPLE LOCATION	DISTRIBUTION	REMARKS	
feet below buoy			
0-30	NDBC	Top thimble, tested by Samson	#1
30-60	CHESDIV	No fishbite	
60-100	NDBC	Scuff at 80 feet	
100-120	CHESDIV	Brown grass marine fouling	
120-150	NDBC	No fishbite, tested by Samson	#4
150-180	NDBC	Fishbite at 170 feet, examined by WHOI, tested by Samson	#2
250-260	CHESDIV	Fishbite	
260-290	NDBC	Fishbite at 275 feet, examined by WHOI	
290-295	CHESDIV	Fishbite	
295-330	NDBC	Fishbite at 310 feet, examined by WHOI	
620-670	NDBC	Fishbite at 630 feet Fishbite at 650 feet, examined by WHOI, tested by Samson	#3
feet above 3/4 inch chain			
570-550	CHESDIV	No fishbite	
550-520	NDBC	Long machine splice at 530 feet	
30-0	EOE	Bottom thimble	

Legend:

- CHESDIV - Naval Facilities Engineering Command - Chesapeake Division
- EOE - U. S. Coast Guard Office of Ocean Engineering
- NDBC - National Data Buoy Center
- Samson - Samson Cordage Works
- WHOI - Woods Hole Oceanographic Institution

TABLE 4.1-1 Distribution of Buoy E Line Samples

FISHBITE DAMAGE AT 650 FEET BELOW BUOY

The most spectacular line damage occurred at 650 feet below the buoy. Two bite marks were found 10 inches apart. Strands were severed at points around the entire circumferance of the line. Most important, the neatly clipped strands came from both the outer cover and the inner core of the double braided line. (Figure 4.1-4) The fishbite had penetrated the cover, cutting even into the line's core. A total of 66% of the outer cover and 10% of the line's core had been damaged in this area. The ultimate strength of this damaged section was 19,000 pounds.

Scuff marks resulting from line slippage over the winch capstan during retrieval are also evident in Figure 4.1-4. These marks occurred at each of the damaged areas on the line. It has been theorized that the fishbite area acted as a line discontinuity which caused slippage over the capstan. Several samples of damaged fibers from the outer cover, inner core, and scuffed areas were selected, logged, and washed. Photomicrographs of the fibers were taken at 64X through a ZEISS Research Microscope (Model Number 4687531) located at the U. S. Coast Guard Academy. A Polaroid MP3 Land Camera with type 55, Hi Contrast-Positive/Negative film was used to produce the photomicrographs in this report.

Figures 4.1-5 and 4.1-6 exemplify the sharply angled, razor like cuts produced by fishbite on nylon lines. Very little defor-

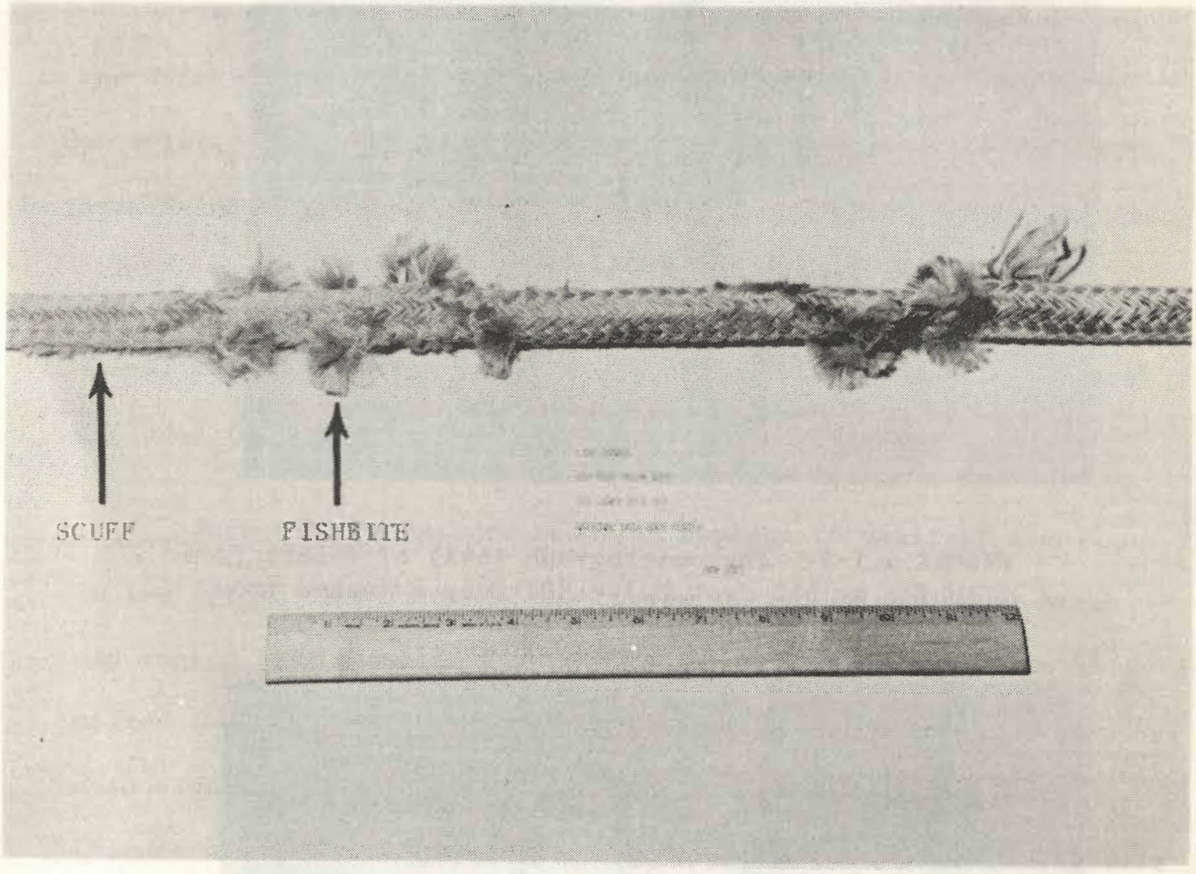


FIGURE 4.1-4   Fishbite at 650 feet below Buoy E. Outer cover and inner core of the line were damaged.

FIGURE 4.1-5 Photomicrograph (64X) of fibers from fishbite at 650 feet below SCI Buoy E (taken from outer cover strands)

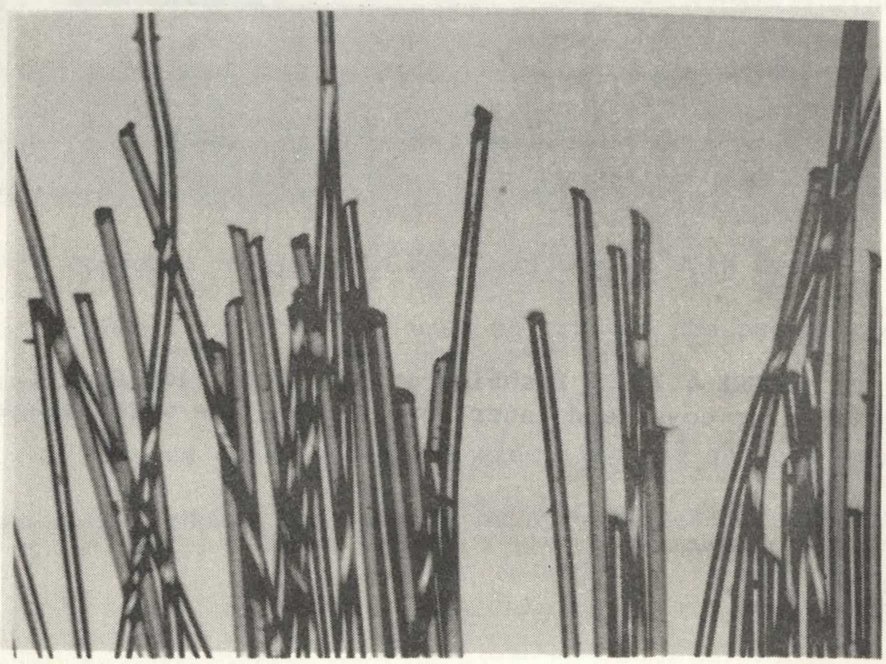


FIGURE 4.1-6 Fishbitten fibers from inner core of Buoy E mooring line 650 feet below buoy. (64X)

mation of the fiber ends is associated with fishbite. Fishbites from Woods Hole Oceanographic Institution moorings and the NDBC XERB-1 mooring have also exhibited this characteristic.[2,6]

In contrast, scuffed fibers (Figure 4.1-8) were taken from the damaged line 170 feet below buoy E (Figure 4.1-7). Scuffing on metal (capstan or deck edge) causes torn, deformed, fibers with hooked ends. (Figure 4.1-8)

Photomicrographs of nylon fibers cut with sissors (Figure 4.1-9) and sawed over metal under low tension (Figure 4.1-10) are included for comparison with fishbite and scuff damage.

Pure tensile failure of nylon appears to manifest itself in two forms. The first is the cupped (slightly deformed) break and ragged ends shown in Figure 4.1-11. Some ends appear to be melted (swollen) by the energy released during the break. The more elongated and tapered break observed on a WHOI mooring (Figure 4.1-12) took place at a fishbite while the anchor was being retrieved. Both types of end deformation have been produced in the laboratory. The interdependence among rate of loading, compressive stress, and fiber wetness which cause these two forms of deformation are not fully known at this time.

The above photomicrographs demonstrate the technique employed to discern between fishbite, handling damage, and tensile breaks.

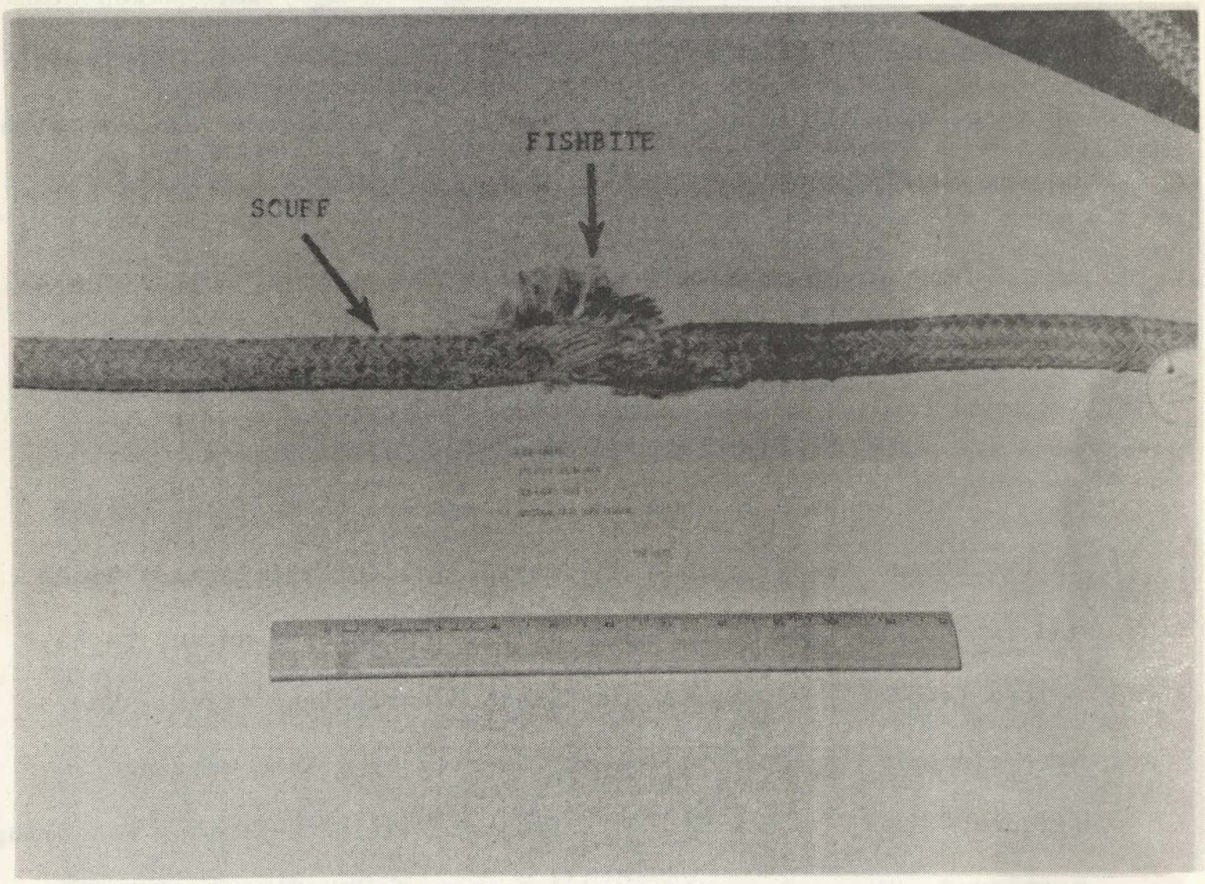


FIGURE 4.1-7 Overview of fishbite (right) and scuff (left) on line 170 feet below San Clemente Island Buoy E.

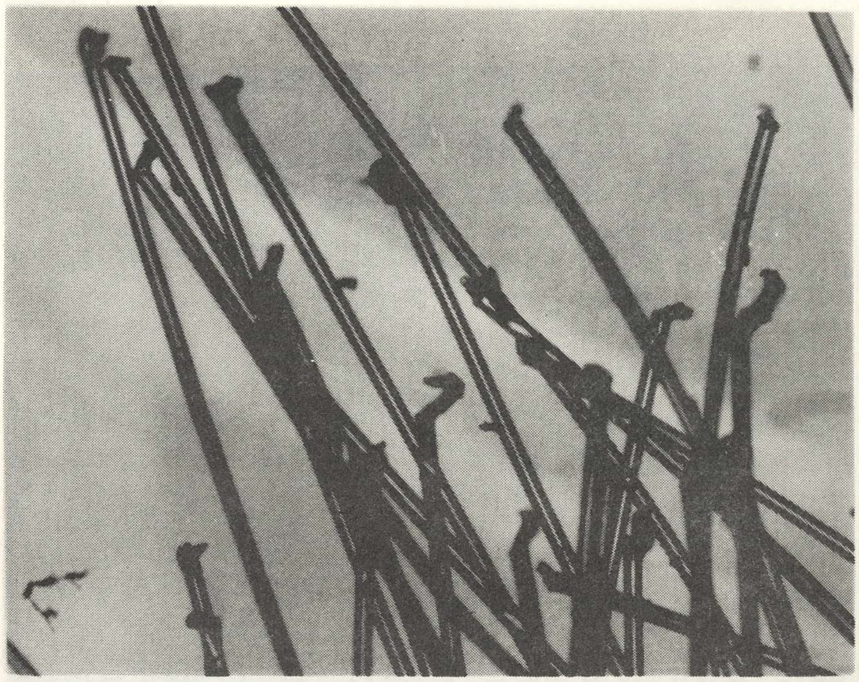


FIGURE 4.1-8 Fibers from outer cover of SCI Buoy E mooring (170 feet below buoy) showing scuff damage received over capstan during retrieval. (64X)

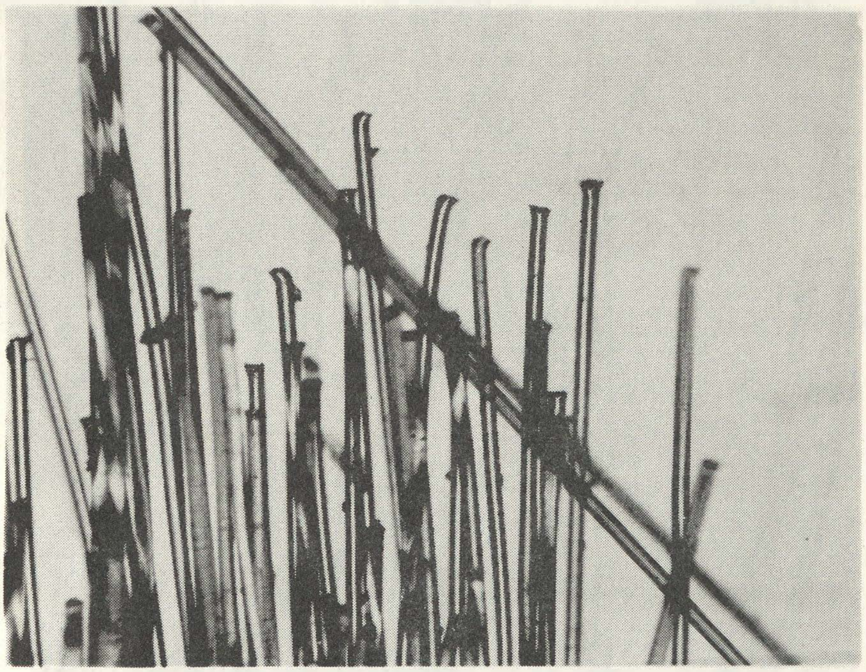


FIGURE 4.1-9 Test sample (530 feet above bottom chain) cut with sissors. (64X)

FIBER 4.1-10 Test sample (530 feet above bottom chain) sawed on metal under low tension. (64X)

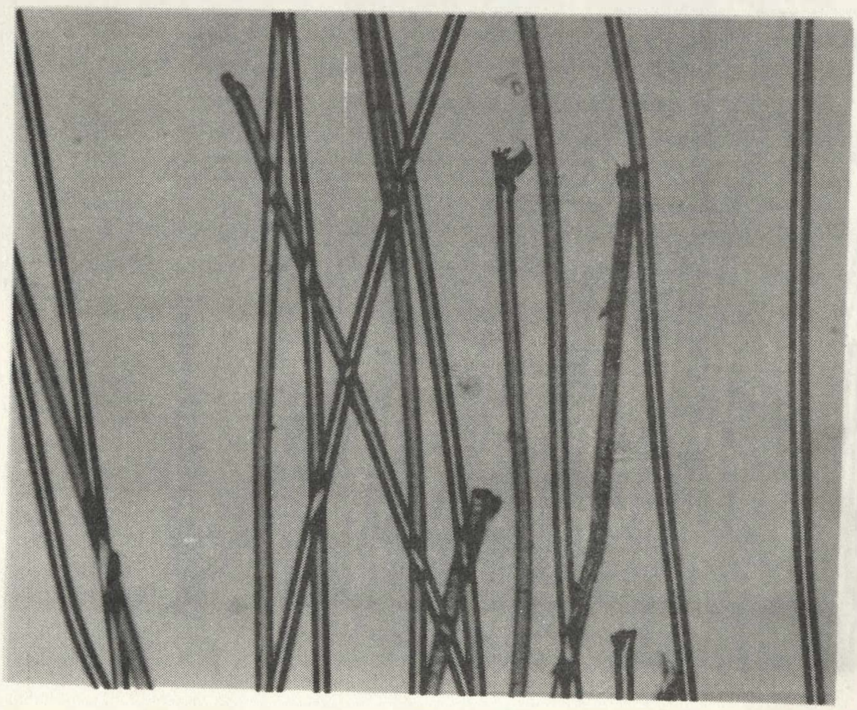


FIGURE 4.1-11 Test sample (530 feet above bottom chain) pure tensile break with dry line. (64X)

FIGURE 4.1-12 Tensile failure of Woods Hole Oceanographic Institution's mooring at Site D in 1969. The 5/8 inch diameter plaited nylon line broke at a fishbite while retrieving the mooring and anchor. (64X)

In review:

Fishbite	- Exhibit neatly clipped fiber ends having little deformation and cut angles ranging from perpendicular to the fiber axis to nearly parallel with it.
Scuff Marks	- Appear as highly deformed fibers and ends (hooked and ragged).
Tensile Breaks	- Produce both slightly deformed cupped ends and long drawn, tapered terminations.

RESULTS OF ULTIMATE BREAK STRENGTH TESTS

The Samson Cordage Works Research Laboratory in Shirley, Massachusetts, was contracted to perform load-elongation and ultimate break strength tests of whole and damaged sections of the mooring line.

The samples tested are listed below:

Sample Number	Location on Mooring
1	0-30 Feet-Top Thimble
2	150-180 Feet - Fishbite at 170 Feet
3	640-670 Feet - Fishbite at 650 Feet
4	120-150 Feet - Undamaged

Samples Number 1, 2 and 3 were tested dry. Sample 4 was soaked in cold tap water (53°F) for 20 hours before break testing. The tests were performed on a Young Testing Machine having a capacity of 300,000 pounds. This machine was calibrated to be accurate within ASTM and Federal Specifications on 28 April 1972.

The results of these tests are detailed below as experts[8] from the Samson Technical Report Number TR 17-72 of 12 June 1972.

Sample #1 -

Sample with original eye splice and captive thimble. An unburied splice put in other end for break test.

Break - 21,200# - cover break at throat of unburied eye - original thimble eye intact.

85% of MIL-R-2405A minimum strengths (25,000#)

Sample #2 -

Sample with fishbite damage (170 ft.) - 35% cover strands cut through - core, O. K.

Break - 18,700# - break at area of fishbite damage.

75% of MIL-R-2405A minimum strengths (25,000#)

Sample #3 -

Sample with fishbite damage (650 ft.). The area has two major bite marks 8" apart (29% cover strands cut at one and 27% cut at the other. Shared cuts in cover strands between marks bring the total to 66% of entire cover strands - 8 of the 24 strands remained), 10% of core strands cut at bite.

Break - 19,000# - Break at area of fishbite damage.

76% of MIL-R-2405A minimum strengths (25,000#)

Sample #4 - Two tests made: One dry with unburied splices and one wet with buried splices.

(A) Sample spliced with buried eyes (19 ft. sample Soaked in cold tap water (53°F) for 20 hours, then broken.

Break - 21,600# - Break on splice at cross over point

86% of MIL-R-2405A minimum strengths (25,000#)

(B) Sample with unburied eye splices tested dry.

Break - 26,700# - Cover break at throat of splice

107% of MIL-R-2405A minimum strengths (25,000#)

Experimental laboratory quality control tests performed at Samson in 1969, yielded an ultimate break strength of 30,000 pounds. Samson advertises a break strength of 28,500# for this size nylon line.

Fishbite damage reduced the strength of this one inch diameter line by approximately 25%.

The undamaged sections of line still exceeded the minimum Mil-Spec break strength after over two years of continuous deployment.

4.2 <u>3/4 INCH DIAMETER CHAIN</u>

As the three shots of 3/4 inch high tensile strength (HTS) chain were hauled aboard the recovery vessel, three distinct colored bands were observed, red rust at the top, white sand polished chain and then black chain before the sinker.

Subsequent examination indicated that these colored zones defined the lengths of chain continually suspended from the bottom, the chafe zone and the totally buried portion. (Figure 4.2-1)

The minimum suspended chain (Figure 4.2-2) was 110 feet. The 3/4 inch HTS chain weighs 4.92 pounds per foot. Therefore, the minimum line load on station was 541.2 pounds. The forty minute mooring tension test (Figure 3.2-1) shows a load at the buoy bridle of 850 pounds including 294 pounds of 1½ inch chain (15 feet). Subtracting the weight of 15 feet of top chain indicates that the mooring tension (556 pounds) was nearly at its minimum on this calm day before retrieval.

No significant wear was present anywhere on the chain. The 60-80 feet of chain which tangled into a ball appear to have remained continually buried in the bottom near the sinker. (Figure 4.2-3)

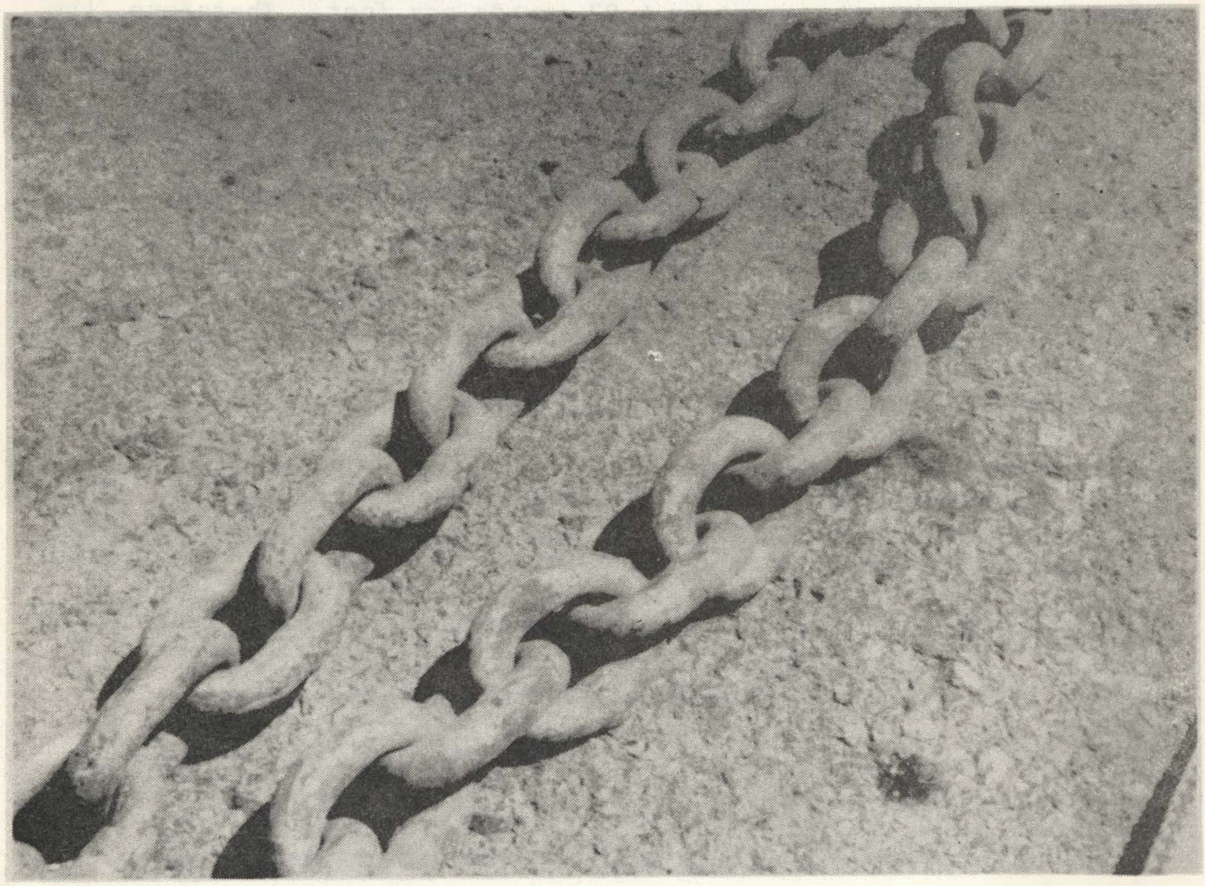


FIGURE 4.2-1 3/4 inch chain showing transition zone from continually suspended section (right) and chain in chafe zone (left).

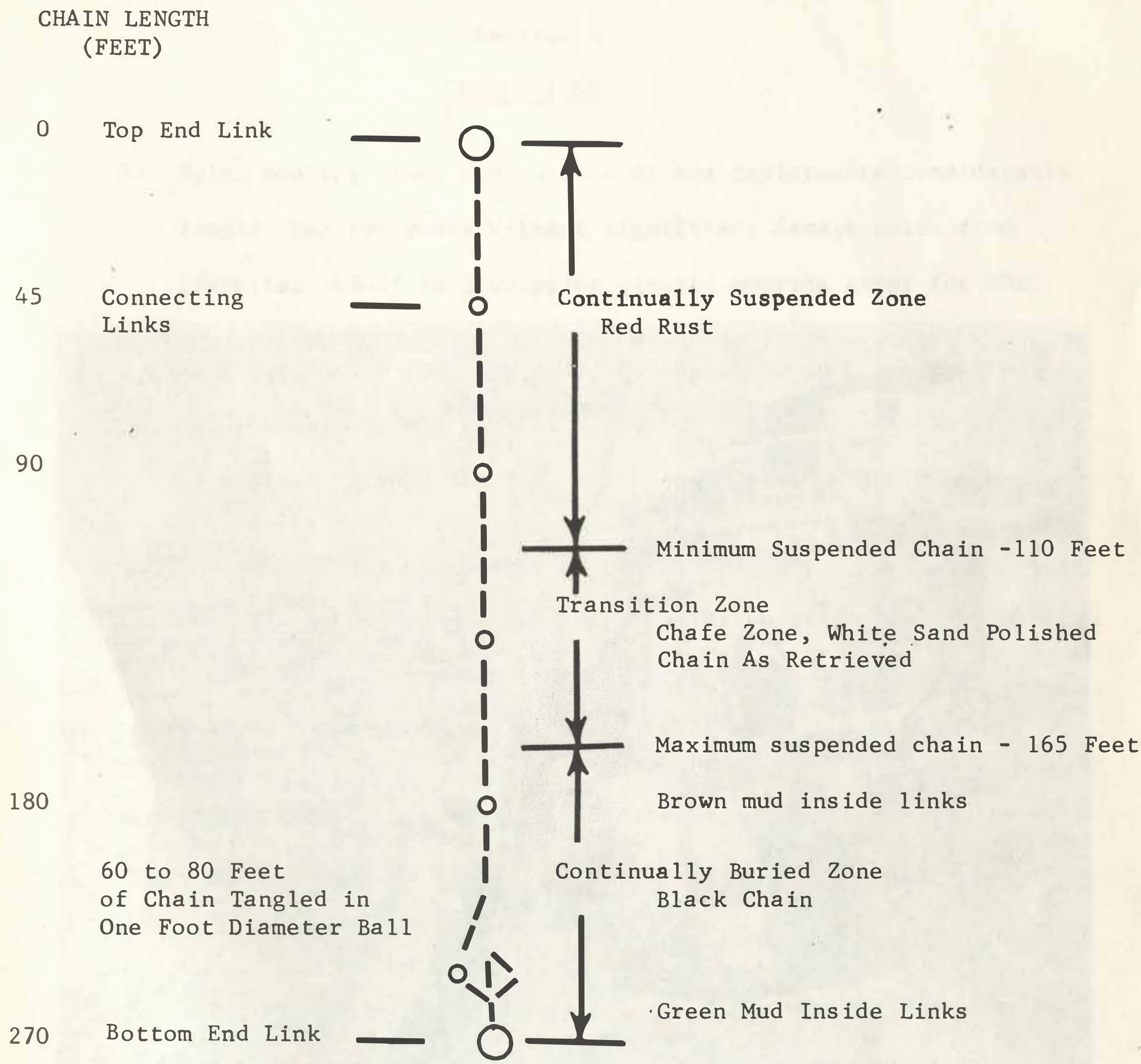


FIGURE 4.2-2 Condition of 3/4 Inch HTS Chain From Buoy E

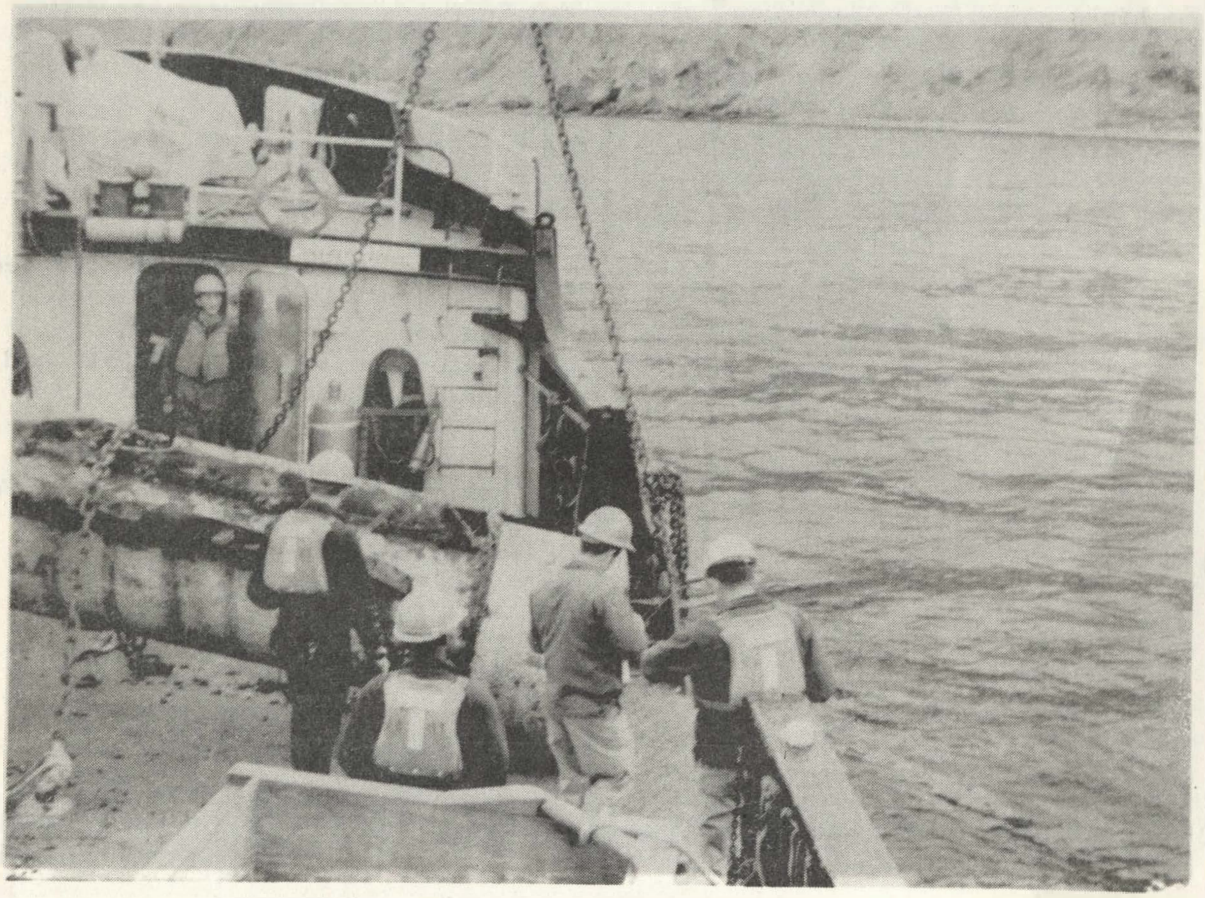


FIGURE 4.2-3   Entangled section of 3/4 inch chain at concrete sinker.

Section 5

CONCLUSIONS

1. Nylon mooring lines can survive at sea deployments considerably longer than two years without significant damage aside from fishbite. WHOI* is developing plastic mooring armor for NDBC.

2. Possible damage from the heavy barnacle and mussel growth at the top thimble and first few feet of nylon line may be protected against through the use of a coating of urethane.

3. Seven fishbites did occur during the two year deployment. These were all above the 650 foot depth. The worst reduced the minimum break strength from a Mil-Spec rating of 25,000 pounds to 18,700 pounds.

4. Fishbites can be distinguished from handling damage (scuff) by their cleanly cut fibers. Scuffed fibers appear highly deformed with ragged ends when viewed under a microscope.

5. Below the light zone, the nylon line appeared as clean as new. Its break strength was 26,700 pounds thus showing that it had deteriorated little. The minimum Mil-Spec of 25,000 pounds was still exceeded.

6. The 3/4 inch bottom chain suffered no significant visible degradation.

*Woods Hole Oceanographic Institution
Department of Ocean Engineering - Buoy Engineering Section

Section 6

REFERENCES

1. Hartman, Patrick J., "Sea Lanes Test - Operations Report", NDBCM W6222-1. Bay Saint Louis, MS: National Data Buoy Center, (NOAA), 133 pages, July 1971 (COM-71-01151).

2. Hartman, P. J., "Photographs Demonstrating the Difference Between Fishbite and Other Types of Line Damage", Report WBS 6221. Bay Saint Louis, MS: National Data Buoy Center, (NOAA), Unpublished Report, June 1972.

3. Paul, Walter, "Review of Synthetic Fiber Ropes". New London, Conn.: U. S. Coast Guard Academy, August 1970.

4. Stimson, P. B., "Synthetic-Fiber Deep-Sea Mooring Cables: Their Life Expectancy and Susceptibility to Biological Attack", Woods Hole Oceanographic Institution Contribution No. 1521, Deep-Sea Research, Vol. 12, pages 1 to 8. Pergamon Press Ltd. Great Britain, 1965.

5. Stimson, P. B., Conversation with P. J. Hartman regarding fishbites on Buoy E mooring, letter to NDBC Marine Systems Division to follow. Woods Hole, Mass.: Woods Hole Oceanographic Institution, 30 May 1972.

6. "Some Characteristics of "Fishbite" Damage on Deep-Sea Mooring Lines", Report Reference No. 65-22. Woods Hole, Mass: Woods Hole Oceanographic Institution, 1965.

7. Turner, Harry J. Jr., and Prindle, Bryce, "The Vertical Distribution of Fishbites on Deep-Sea Mooring Lines in the Vicinity of Bermuda", Report Reference No. 67-58. Woods Hole, Mass: Woods Hole Oceanographic Institution, 1967.

8. Samson Cordage Works, "3" Circ. Samson 2-in-1 Nylon Used By National Data Buoy Center Sea Lanes Test", Technical Report Number TR 17-72. Shirley, Massachusetts: Prepared under National Data Buoy Center Material Request No. 117628, 12 June 1972.

9. CO, USCGC WALNUT (WLM 252), letter 3260 to CCGD11, Subject: San Clemente Test Buoy "E" Recovery; comments concerning, dated 25 May 1972