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NRL Memorandum Report 3384

Argus Island Tower 1960 to 1976

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Shallow Water Surveillance Branch
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October 1976

NAVAL RESEARCH LABORATORY
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A history of Argus Island, a research tower located 24 miles off the southwest coast of Bermuda, is presented from its construction in 1960 to its demise in 1976. Presented in this report are descriptions of the tower, activities and experiments conducted, and steps undertaked to topple the tower.

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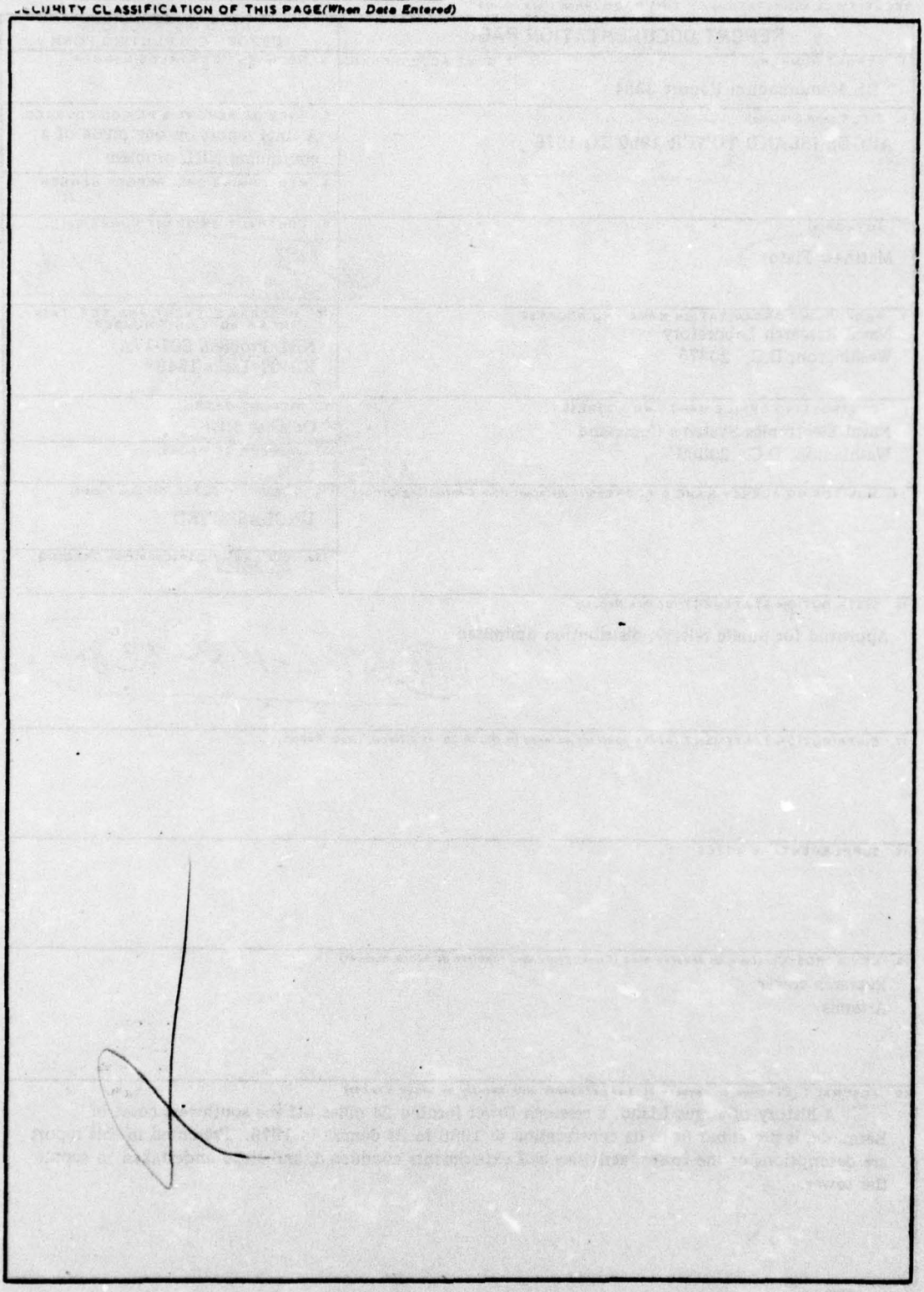

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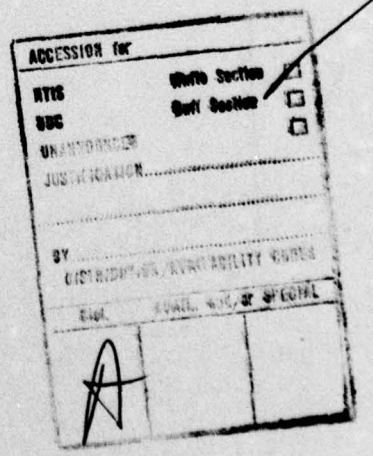

ARGUS ISLAND TOWER
1960 TO 1976

I. BACKGROUND

Argus Island Tower was a U.S. Navy Research Platform located on Plantagenet Bank approximately 24 miles off the South West Coast of Bermuda. Photographs of two sides of the facility are shown in Figures 1 and 2, respectively. Figure 3 is a sketch of the constructional elements of the tower. The location of Plantagenet Bank and its proximity to Bermuda is shown on the chart, Figure 4. This chart is a section of Hydrographic Chart No. 5723, Approaches to Bermuda Island. Figure 5 is a detailed chart showing the location of Argus Island Tower on Plantagenet Bank. The tower was constructed to be a terminal for underwater cables used with Project Artemis, an underwater acoustic research program initiated in the late fifties. Argus Island was designed, fabricated, and installed in 1960 by J. Ray McDermott & Co., Inc., New Orleans, La., for the Office of Naval Research (ONR).

II. DESCRIPTION OF THE TOWER

The tower is a four legged steel structure embedded in coral. There is extensive bracing between the legs of the structure. On top of the tower is a building containing two enclosed levels with fuel storage, helicopter platform, and a crane on the top deck. The enclosed areas include living quarters, diesel-generator room, housekeeping facilities, shops, and laboratory spaces.

A more complete description of the Argus Island structure can be found in Appendix I[1] in the section, "Description of Argus Island."

III. DESIGN CRITERIA

The original design of Argus Island was based on environmental conditions specified by the U.S. Navy. These design environmental conditions, which were established using the best data available at that time, included a design wave height of 70 feet.

Design criteria philosophy explanations and other studies can be found in Appendix I.[1]

Note: Manuscript submitted September 17, 1976.

IV. DAMAGES AND INSPECTIONS

During the first years of the platform's existence, waves approaching a height of 70 feet were observed at Argus Island. These large waves damaged the tower to some extent. Two underwater inspections were made on the tower, one in 1963 and the second in 1969. The primary inspections were both visual and ultrasonic. In Appendix I[1] Section II, Inspections of Structure 1963 and 1969, is a complete record of these inspections.

No analysis of the structure will be discussed in this report, however, it can be found in a J. Ray McDermott & Co., Inc., report, "Structural Study of Argus Island," 1970.

V. SAFETY

Underwater inspections were conducted on Argus Island during the fall of 1969 to determine the condition of the structure. The inspections included ultrasonic testing of all welds which revealed that five of the welds were cracked. After considerable discussion among technical personnel in a meeting of 9 December 1969 it was concluded that the structural integrity of Argus Island probably was imparied and steps should be taken to remove the resident field engineering service personnel. The results of this meeting were reported in a message.[2]

It was initially agreed when the sea and wind conditions exceeded specified levels personnel would not be allowed to remain on the tower. These levels were waves and swells of 10 feet or more and/or winds of 20 knots or more. These conditions were communicated to the Naval Research Laboratory (NRL) representatives in Bermuda in a message.[3] A request also was made at the same time for the Fleet Weather Center to provide weather information for the area to the NRL representatives in Bermuda and Washington, D.C.

The limitations of sea conditions were modified in a message[4] of 27 February 1970, whereas, when the waves and/or swells of 15 feet or more, winds of 30 knots or more are forecasted, the tower will be evacuated. These restrictions were based on an analysis performed by J. Ray McDermott & Co., which showed that if the structure contains one broken brace at the upper level the structure will be limited to a 30 to 40 foot wave in the presence of a 60 knot wind. This compares with the wave and wind force limitations on the original structure of 70 foot wave and 120 knot wind.

All support for experimental work in the Bermuda area involving the use of Argus Island was terminated on 30 June 1970. After the support personnel departed occasional visits were made to the tower by NRL personnel conducting inspections and maintenance. A helicopter or a work boat would be standing by while personnel were on the tower. No personnel remained the night.

Navigation lights were placed on the four corners to comply with U.S. Coast Guard regulations.

VI. FIELD ENGINEERING MAINTENANCE AND HOUSEKEEPING SERVICES

The field engineering maintenance and housekeeping services were contracted to the Dynelectron Co. during the years that the tower was manned. These services were provided for the overall operations, upkeep, security and records of Argus Island. Besides the scientific equipment, the operation equipment includes diesel generators, evaporators, air conditioners, a crane, pumps, plumbing system, and related electrical and electronic equipment in the audio to microwave frequency range.

A typical minimal staff that manned Argus Island consisted of the following:

One	supervisor, electronic technician.
Two	senior electronic technicians (both with broad qualifications including communications and digital circuits).
Two	diesel mechanics/diesel-electrical, welding, plumbing and crane operator.
Two	cook-baker stewards.
One	general helper/maintenance janitor.

The staff had been increased from time to time as the work load was increased. The personnel from Dynaelectron staggered their time between the tower and Bermuda. They normally worked three weeks on the tower and then worked one week ashore in Bermuda.

VII. TRANSPORTATION TO THE TOWER

The trips to the tower were made usually by a 100 foot work boat (R/V ERLINE after 1967) or a MAC III prior to the purchase of R/V ERLINE. Helicopter trips were made to the tower when the weather and seas were too bad for boat service. The helicopter operated from a squadron located in Bermuda.

The fuel for Argus Island diesel engines was JP 5 which is also the standard fuel for the Bermuda Naval Station and the work boat R/V ERLINE. Fuel was brought to the tower by ERLINE in 500 gallon rubber bags weighing approximately two tons when filled. The maximum load ERLINE carried was four bags in one trip. It took about one hour to empty the fuel from each bag after the bag was placed on top of the tower.

VIII. EXPERIMENTS CONDUCTED FROM THE TOWER

The majority of the experiments and the reason the tower was built relates to the Artemis underwater acoustic research program. Strings of hydrophone modules placed along the slope of the Bermuda rise were

brought up to one common terminus at Argus Island. The signals from these hydrophones were amplified, passed through a bulk delay, and then transmitted to terminal equipment at the Tudor Hill Laboratory. The majority of the transmissions to the Tudor Hill Laboratory was via a microwave link, however, especially prior to the installation of the microwave link, transmission of signals were via a 21 Quad cable.

In addition to acoustical measurements the following list of measurements were also conducted at Argus Island:

(a) Underwater optical measurements
(b) Ocean current measurements
(c) Wave height measurements
(d) Air contaminant measurements
(e) Structure deformation measurements

Many of the experiments were reported and can be found in an annotated bibliography by Hoyt and Cobb (see Appendix II).[5] Mr. Dale E. Tidrick, Publications Management Branch, Naval Oceanographic Office, prepared a list of NAVOCEANO reports concerning experiments conducted on Argus Island (see Appendix III).[6]

Argus Island was used during the Sea Lab I[7] experiment during a period in 1964. The crane of the tower raised and lowered the life support system and the transfer capsule between the surface and the support system. The tower was also used as a base of operations, communications, and housing for personnel associated with the project.

IX. ENVIRONMENTAL IMPACT STATEMENT

In July 1966 the project and the facilities of the underwater acoustic research program were transferred to Project 2407 and assigned to the Manager, Antisubmarine Warfare Project Office (MASWPO). The technical responsibility for Argus Island was transferred to NRL in April 1969. In late fall of 1969 an inspection and analysis was made of the tower to determine the structural conditions and to develop cost estimates for necessary maintenance and repairs. These studies had led to the conclusion that very extensive and expensive repairs would be required to make Argus Island suitable for continued use in the underwater acoustic research program. This, along with program considerations, had led to the conclusion that the facility would have completed its useful life insofar as the underwater acoustic research program is concerned by July 1970. Unless some other program could assume the complete responsibility for Argus Island, it was planned for the facility to be disposed during early FY 71 in the least costly manner consistent with the requirements of International Law.

Up to July 1970 many activities within the Navy had utilized the facility for programs which supported the underwater acoustic research work or for other experiments and research programs which required a platform located in the open ocean. A few of these programs expressed

concern over the prospects of Argus Island's removal and the loss to programs. An invitation by NRL to a meeting on 20 May 1970 was extended by a letter[8] to those concerned with the tower. The meeting was called to allow the participants an opportunity to discuss among themselves program requirements, Argus Island operation, and funding alternatives.

MASWSPO requested that the Judge Advocate General (JAG) by letter[9] to render an opinion or interpretation on whether the Argus Island structure should be removed down to the sea floor or to some specified depth below the sea surface. JAG replied in a letter[10] that there is apparently no specific codified international law requiring total or partial removal of a structure erected in high seas areas. The letter also stated that if the structure posed no present or potential threat to the reasonable high seas use of the area it could be left intact as long as it is properly equipped with the required warning devices and noted on appropriate navigational charts. If removed to some depth below the surface it should not interfere with fishing or navigation.

NRL in a letter[11] requested the Naval Facilities Engineering Command to provide procedures for the removal of Argus Island. Two procedures were submitted by letter.[12] The Atlantic Division, Naval Facilities Engineering Command in a letter[13] provided three schemes and their cost estimates for disposing of the tower:

1. Sever the upper portion of the tower, leaving no members above minus 90.0 ft. Estimated cost, $185,000.

2. Completely remove the tower to the mud line (minus 192 feet) and dispose of debris in deep water. Estimated cost, $858,000.

3. Sever the tower at the mud line and tip it over in place, leaving no portion above elevation minus 90.0 ft. Estimated cost, $260,000

NRL stated in a letter [14] of 15 October 1970 to all concerned with Argus Island that all support for experimental work in the Bermuda area involving the use of Argus Island was terminated on 30 June 1970. Scientific equipment of value has been removed and appropriate action taken to secure the structure. Navigation lights were placed on board at the four corners to comply with U.S. Coast Guard regulations. MASWSP tasked NRL to remove Argus Island platform during FY 72 in such a manner that it will not constitute a hazard to submerged navigation.

NRL requested the Chief of Naval Operations (CNO), by letter 7 Dec 1971, to arrange for fleet resources to dispose of Argus Island in a manner that meets the legal and environmental requirements.[15] A follow-up Naval Speed Letter[16] was sent to CNO, 6 March 1972, requesting information on status of action on the 7 Dec 1971 letter. CNO requested NRL to prepare an Environmental Impact Statement (EIS) on

19 April 1972.[17] A Candidate EIS[18] on Argus Island Disposal was submitted to Op 45 of CNO, 15 October 1972. The candidate EIS was defended before a Navy Review Panel, 20 November 1972. The Review Panel submitted their findings to the Director, Environmental Protection Division, Op 45,[19] 14 December 1975. The panel voted to require the filing of a Draft EIS, primarily due to the international implications of the proposed action. In addition, the following revisions to the Candidate EIS were suggested:

1. Insure, by proper distribution of the Draft EIS, that all possible interested Government agencies review the statement with the view that funding might be available to maintain the tower as a research facility. Accordingly, identify the estimated funds necessary to renovate and maintain the structure in the project description.

2. Revise the estimate of the expected fish kill using data collected at Cross Cay, Puerto Rico.

3. Identify the marine life present in the area in at least sufficient detail so that a determination can be made if the area is barren or abundant in species normal to the Bermuda area.

4. Some mention of operational constraints, i.e., submarine navigation over Platagenet Bank, should be mentioned for the record. Also, any subsequent provisions to identify the wreckage/or public information should be discussed.

Incorporating all of the Review Panel's suggestions and recommendations a Draft EIS[20] was prepared and submitted to Op 45, CNO, in March 1973. The Draft EIS was signed by the Deputy Secretary of the Navy, Joseph A. Grimes, Jr., on 19 April 1973 and disseminated to other Government agencies. Questions which were raised by several of these Government agencies concerning Argus Island disposal were replied to in accordance with EIS practice and resulted in a Final EIS[21] which was filed with the Council of Environmental Quality on 28 November 1973. Notification of this Final EIS appeared in the 13 December 1973 edition of the Federal Register. The mandatory 30-day waiting period was concluded on 11 January 1974, and since no adverse comments were received in regard to the disposal, a letter from CNO to NRL,[22] 1 February 1974, stating that requirements have been met and that NRL may proceed with demolishing of Argus Island.

X. ARGUS ISLAND TOWER DEMOLITION

Late January 1974 NAVELEX, PME 124 informally tasked Naval System Command, Ocean Engineering (SUPSALV) to dispose of Argus Island. Early February 1974, NRL supplied SUPSALV personnel with technical information, such as, construction drawings and a movie made of the erection of the tower. Mr. James W. Walker in a SUPSALV memorandum[23] of 21 March 1974 explained what he hoped would be a practical and

inexpensive plan to topple the tower. This plan would not require divers. Walker, in the memo suggests toppling the tower in the summer since the weather usually is better. NRL agreed that the weather usually is better in the summer than the winter but opted for other than the summer since one of the Bermuda Government's requests was not to endanger their summer fishing season.

One of the requirements set forth in the Final EIS is that all pollutants, especially chemicals and fuel oil, will be removed from the tower prior to demolishing. No Navy organization either in SUPSALV or at Bermuda appeared willing to undertake the task. NRL agreed to remove the pollutants. The major pollutants on the tower in late 1974 consisted of 1100 gallons of diesel fuel stored as follows: Three hundred gallons in a day tank and four hundred gallons in each of the two main tanks. A commitment was made to remove all the fuel oil on the tower even though it would be considered a minor oil spill according to a Navy contingency plan.(24)

The author, Matthew Flato, arrived in Bermuda late August 1974 to visit with LCDR Brown (the NRL-ONR-NUSC Representative in Bermuda) and inspect Argus Island to prepare a plan for the removal of pollutants. LCDR Brown and Mr. Flato visited Mr. McHugh, the U.S. Consul in Bermuda to brief him on the proposed removal of Argus Island. Mr. McHugh put LCDR Brown and Mr. Flato in touch with Mr. Gordon Groves, the Director of Agriculture and Fishing. At the meeting with Mr. Groves he was assisted by Mr. James Burnett-Herkes, Curator of the Government Aquarium. Mr. Burnett-Herkes was very helpful to the author by providing a list of the species of fish found in the Bermudian waters for the Final EIS.

The demolition of Argus Island was expected by the Bermudian Government, however, they still felt adamant that it should not be accomplished during the summer fishing months. Mr. Burnett-Herkes asked that as much as 50 feet of the legs be left standing in the coral. He felt that this would decrease the scarring of the sea floor and also provide a better habitat for fish.

Naval Sea Systems Command requested Service Atlantic (SERVLANT) at Norfolk, Va., by message(25) 17 September 1974 to undertake the task of demolishing Argus Island using Fleet assets. The message also requested SERVLANT to conduct an on site survey to confirm construction details, prepare a firm disposal plan within constraints of the Final EIS, and to advise Naval Sea Systems Command of the fundings required. SERVLANT in turn passed the task of demolishing Argus Island to SERVRON 8 by message(26) 27 September 1974.

SERVRON 8 requested in a message(27) 25 Nov 1974 Naval Weapons Test Center, China Lake, California, to review proposed plans to demolish the tower and provide technical advice with regards to size, placement, and sequencing of explosive charges.

A meeting was held 16 Jan 1975 at the headquarters of SERVRON 8 on methods for toppling Argus Island. Attendees were LCDR Charles S. Macklin, SERVRON 8; Mr. Carl C. Halsey, Naval Weapons Test Center; and Mr. Matthew Flato, NRL.

A preliminary plan for toppling the tower was devised. Since the outer jacket for each leg is 34 in. OD 0.500 inch steel with a 30 in. OD 0.625 steel pile within the jacket and grout placed in the piling during the construction phase, shape charges should be used to blow out the legs. Naval Weapons Test Center agreed to design, fabricate, and test shape charges at a West Coast facility.

In the plan the horizontal supports which would be vertical after toppling would be explosively sheared first using small charges. The north legs will be blown first in two places concurrently. The lowest charges are to be placed at the -160 to -170 ft. level. Next about one second later the south legs would be blown causing the tower to topple to the north. The reason that this direction was chosen is that it will topple toward the heavier side of the deck house and cranes. Also, there would be less likelihood of hanging up on the lower portion of the structure remaining on the sea floor when toppling in the northerly direction.

A plan for demolishing Argus Island was formulated in a 28 Jan 1975 message from COMSERVRON 8 to COMNAVSEASYSCOM, Washington, D.C.(28) The commencement of the disposal operation was scheduled for 21 April 75 and the estimated cost for the disposal is $45,000. This estimate includes Naval Weapons Test Center, China Lake effort. Naval Weapons Test Center would provide an on site visit, fabrication of shaped charges and firing systems, test target and charge assembly, and on site representation during the operation.

At a meeting at NAVELEX, PME-124 on 10 Feb 1974 approval was given to the SERVRON 8 plan and cost estimate in the message(28) of 28 Jan 1974. NAVELEX PME-124 originated a message(29) 18 February 1975 to interested parties that any activity having a continuing or future use for Argus Island must assume administrative and fiscal responsibility for the facility and must be prepared to dispose of the tower upon completion for the facility. Unless notification of an interested agency by 15 March 1975 the tower would be demolished.

A meeting was held by SERVRON 8 and NAVWPNCEN personnel at the Tudor Hill Laboratory in Bermuda on 20 February 1975 to inform the Bermuda Government officials present and the Navy representatives in Bermuda of the final plans to dispose of Argus Island. At this meeting it was stated that to topple the tower would require a series of smaller shots plus the near simultaneous detonation of a series of six large charges. The six large charges total approximately 1800 pounds of HE.

In a message from NAVWPNCEN,(30) China Lake, another recommended approach to topple the tower was put forth. NAVWPNCEN suggested

dismantling the uppermost portion of the tower to the water line and then toppling the tower from the 90 foot level.

COMNAVSEASYSCOM replied to NAVWPNCEN alternate approach to toppling the tower in place with a message(31) of 3 March 1975 that because headquarters funding constraints dictated that the most cost effective plan be implemented. The topple-in-place scheme was preferred. Admittedly, this plan will result in significant fish kill. However, past experience indicates repopulation will occur rapidly and the increased underwater structure should ultimately support greater marine life than at present.

In a message(32) on 19 March 1975 to NRL and SERVRON 8, the Bermuda representative takes responsibility for removal of environmental contaminants. The Naval Station Bermuda would assist the Bermuda representative in the removal phase. All ocean cables to the tower were identified and tagged prior to severing. The 21 Quad cables were observed sliding down inside the cable housing. Several smaller severed cables were still contained within the housing due to insulation swelling and old support lines, but will be cleared before demolition.

All environmental contaminants were removed from Argus Island and the fuel tanks refilled with sea water on 25 March 1975 as per message from the NRL Representative in Bermuda.(33) The Bermuda Representative also stated that the cables appeared to have cleared the housing and that personnel in Bermuda were unable to gain access into the tower legs.

A schedule of events from placing charges on the legs to inspecting the wreckage to insure no part of the tower extends above the 90 foot depth, was provided by message(34) by SERVRON 8, 4 Apr 75.

NAVWPNCEN designed and fabricated a shape charge which they tested on a replica of the tower's main legs off San Clemente Island, Calif. On 10 April 1975 the test was conducted, however, the charges failed to cut through the replica leg. SERVRON 8 in a message(35) explained the failure and advised all concerned that the time table proposed for the destruction was no longer valid and a final plan would be promulgated after a successful test shot by NAVWPNCEN.

NAVWPNCEN in a message(36) informed SERVRON 8 it would require three to four weeks additional time and more money to develop a specialized shape charge to cut the legs.

NAVSEASYSCOM, Sup Salv, contracted for a detailed failure mode analysis of the Argus Island structure and endorsed a demolition plan which provides for a significant reduction in the number of explosive charges but requires their placement at deeper depths and a toppling pull from a salvage ship.

In a message[37] NAVSEASYSCOM requested NAVWPNCEN to cost estimate a design and fabrication of a shaped charge capable of completely severing the main support legs at the 190 foot depth. The above message for all concerned concluded that the weather window for calendar year 75 was lost and a new window is tentatively planned for May-June 76.

NAVSEASYSCOM promulgated a demolition plan prepared for the disposal of Argus Island.[38] A meeting was planned by Sup Salv to discuss the detailed demolition plan of Argus Island 10 Sept 75. The meeting was held in conjunction with another discussing the utilization of the MK1 deep diving system which was hoped to be used in the Argus Island demolition.

NAVWPNCEN replied to NAVSEASYSCOM cost estimate request with a message[39] giving the cost-time breakdown for the design, fabrication, and testing of the required charges. At the 10 Sept 1975 meeting[40] to discuss the disposal of Argus Island, it was decided that the disposal plan [38] would be adhered to, commercially available shaped charges would be used, and the MK1 Mod 0 Deep Dive System and two ARS ships to conduct the operation would be utilized.

A working conference[41] was held at SERVRON 8 for the purpose of finalizing plans and to define any remaining problems associated with the disposal of the tower. Captain G.E. Jackobssen, Commander SERVRON 8, decided because of the limited qualifications of SERVRON 8's divers, not to use gas breathing diving systems. An operation order[42] was developed at the meeting and promulgated to all concerned. The operation plan described all of the operational functions and equipment to be used.

The task force commander, designated CTE 40.7.3.6 issued nineteen sitreps from the 27 April through 13 May 1976. The sitreps contained information regarding the weather and seas in the operating area, deployment intentions and executions of the propellant anchors, setting and detonation of the charges, and the status of the work following surveys.

Sitrep number 18, 131350Z May 76, reported that "Argus Island tower toppled satisfactorily at 130945Z." The final sitrep, 132350Z May 76, reported findings of a post toppling survey with the deep drone. The deck house remained attached to the upper section of the tower which separated from the lower major tower structure. The lower section toppled in the northeast direction and is resting on its side on the bottom. The deck house settled to the bottom and is resting upright on all four legs as it originally stood atop of the tower. The microwave antenna remained upright. Scuba divers set charges and subsequently trimmed the antenna tower to leave a 100 foot clearance to the surface.

MV ERLINE conducted a fine grid survey with an installed precision depth recorder and confirmed that no portion remained above the 100 ft

level.

In a message,[43] NAS Bermuda advised all concerned of the release it gave to the media.

The tower toppling sequence taken with a movie camera equipped with a telephoto lens by a photographer on an ARS is shown in Figs. 6 through 12.

The end of this story is summarized in the 12 June 1976 Notice to Mariners[44] "obstruction (covered 16 fms) for Argus Island height. Note: Light demolished."

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1. Appendix I "Structural Study of Argus Island - 1970" Chapters I and II J. Ray McDermott & Co., Inc.

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5. Appendix II - Annotated Bibliography of Research Reports Based on Experiments conducted at the Tudor Hill Laboratory, Bermuda, NUSC Technical Document 4761, 13 May 1974.

6. Appendix III - List of NAVOCEANO Reports.

7. Project Sea Lab Summary Report "An Experimental Eleven-Day Undersea Saturation Dive at 193 Feet" Sea Lab I Project Group; O'Neal, H.A., Bond, G.F., Lanphear, R.E. and Odum, T., June 14, 1965.

8. Letter NRL 8108-82:ATM:hap Ser 3085, 3 May 1970.

9. Letter MASWSPO ASW-240/213:LMT, 01674, 8 April 1970.

10. Letter JAG:102.2:MRD:lgc Ser 086, 24 April 1970.

11. NRL Ltr 8108-76:ATM:hap Ser 0308, 24 April 1970.

12. Letter FAC 04B4/MY:plp, 28 May 1970.

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16. Naval Speed Letter NRL 8108-45:ATM:hap 6 Mar 1972.

17. Letter CNO Op-453/mb Ser 377 p45, 19 Apr 1972.

18. Candidate, Environmental Impact Statement, Argus Island (Tower) Disposal.

19. Memorandum: Candidate EIS Review Panel to Op 45, 14 Dec 1972.

20. Draft, Environmental Impact Statement, Argus Island (Tower) Disposal.

21. Final, Environmental Impact Statement, Argus Island (Tower) disposal.

22. Letter CNO to NRL Ser 453/585 1 February 1974.

23. Memorandum - Walker, Ship OOC, 21 Feb 1974.

24. National Oil and Hazardous Substances Pollution, Contigency Plan, OPNAVINST 6240.3B, 11 Mar 1972.

25. Message NAVSEASYSCOM 171741Z Sept 74.

26. Message COMSERVLANT 272036Z, Sept 74.

27. Message COMSERVRON 8 251901Z Nov 74.

28. Message COMSERVRON 8 282002Z Jan 1974.

29. Message COMNAVELECSYSCOM 181709Z Feb 1975.

30. Message NAVWPNCEN 260034Z Feb 75.

31. Message COMNAVSEASYSCOM 031332Z Mar 75.

32. Message NRL Rep 041725Z Apr 75.

33. Message NRL Rep 261350Z March 75.

34. Message SERVRON 8 041725Z Apr 75.

35. Message SERVRON 8 232250Z Apr 75.

36. Message NAVWPNCEN 232001Z Apr 75.

37. Message NAVSEASYSCOM 26221Z Jun 75.

38. Argus Island Demolition Plan Capt. D.R. Saveker, USN (Ret) 23 June 1975 Alex Rynecki Ocean Engineers, Sausalito, Calif.

39. Message NAVNPNCEN 040010Z Sept 75.

40. Letter NAVSEASYSCOM, Minutes of 10 Sept meeting OOC/CAB/klb, 3920/1187 Ser 1125, 19 Sept 75.

41. Message SERVRON 8 252111Z Mar 76.

42. Operation Order - COMSERVRON Eight 2-76.

43. Message NAS Bermuda 132106Z May 76.

44. Notice to Mariners, June 12, 1976, Section 1, Items 26030 and 26040.

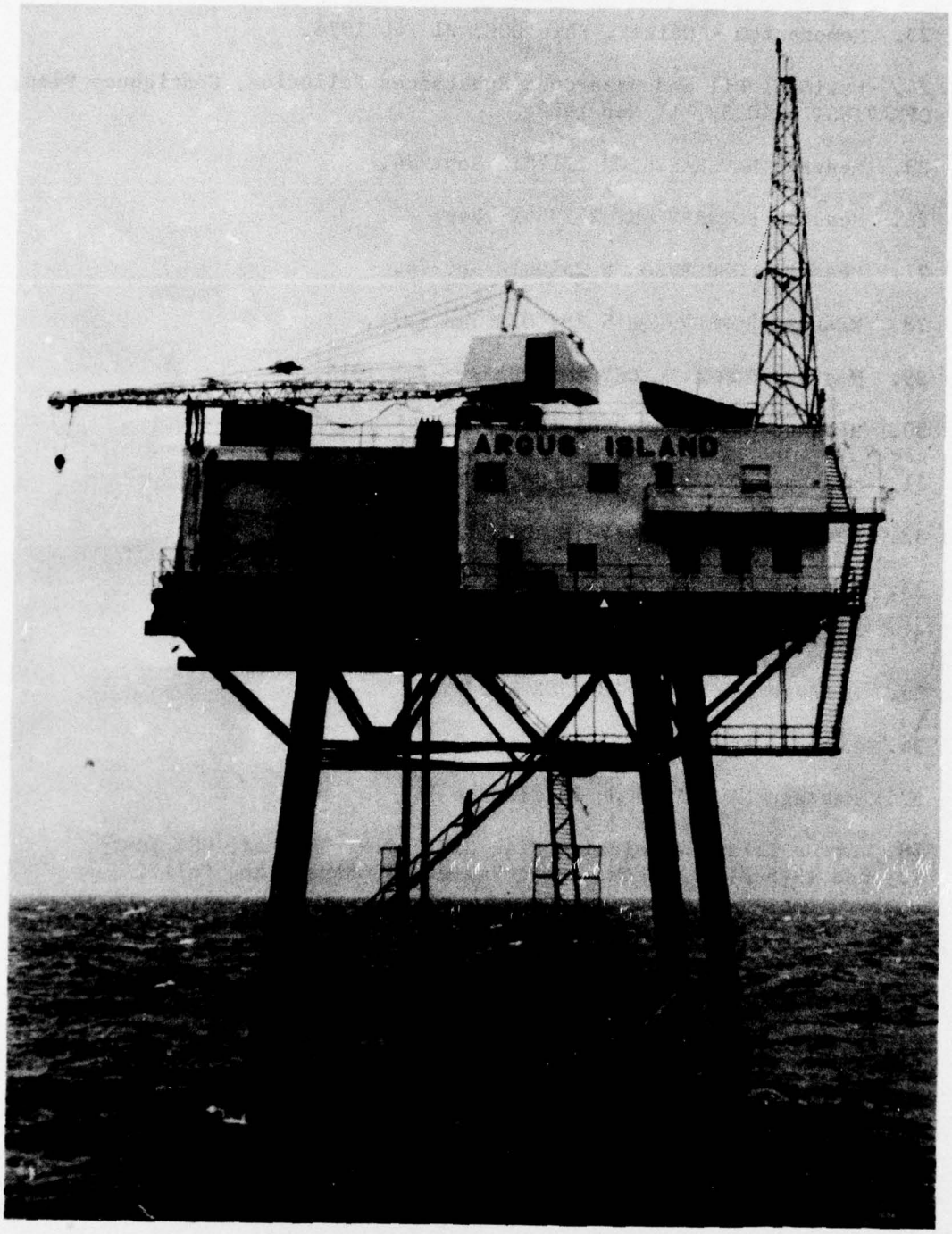

Fig. 1 — Photograph of Argus Island

Fig. 2 — Photograph of Argus Island

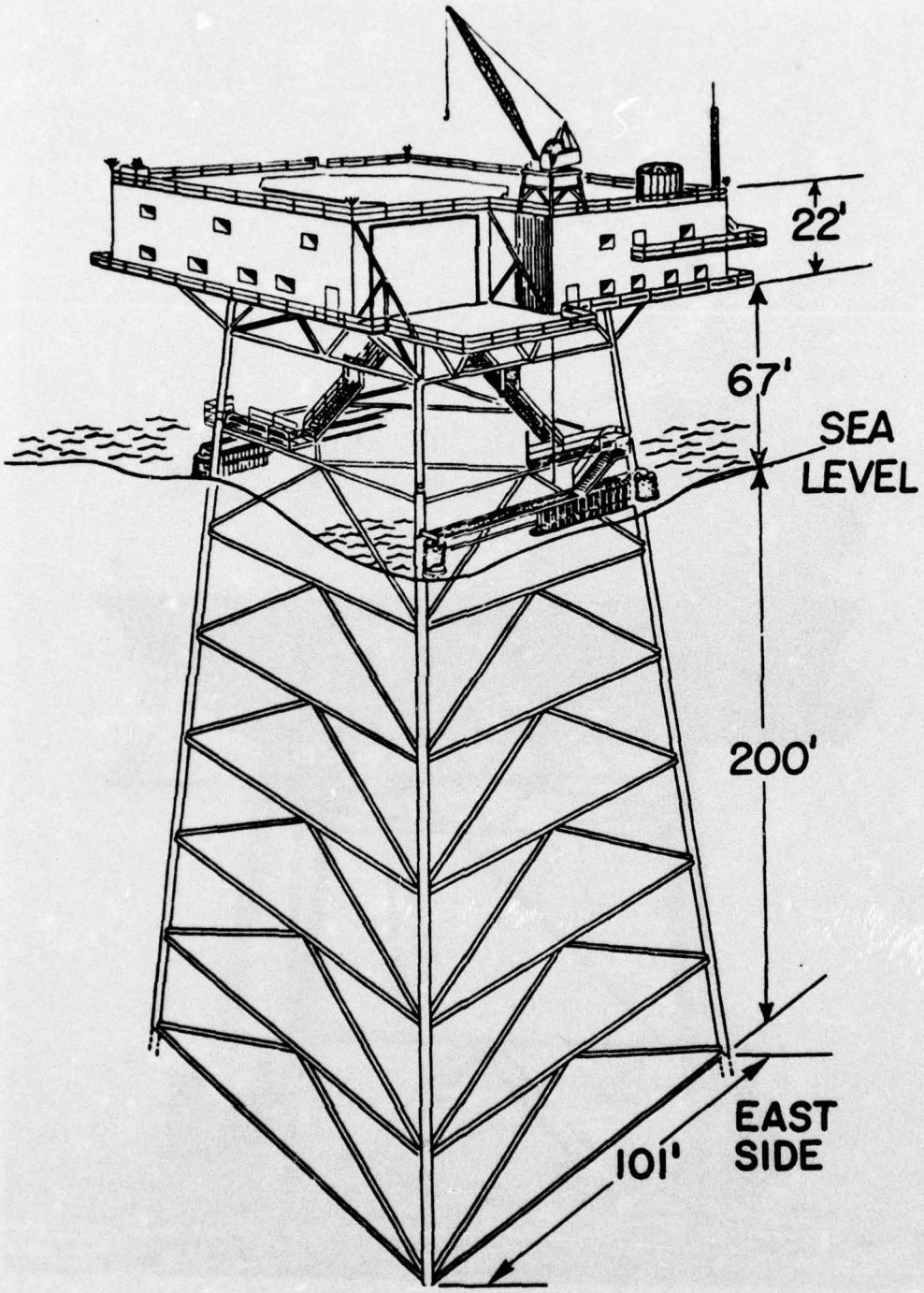

Fig. 3 — Sketch of tower

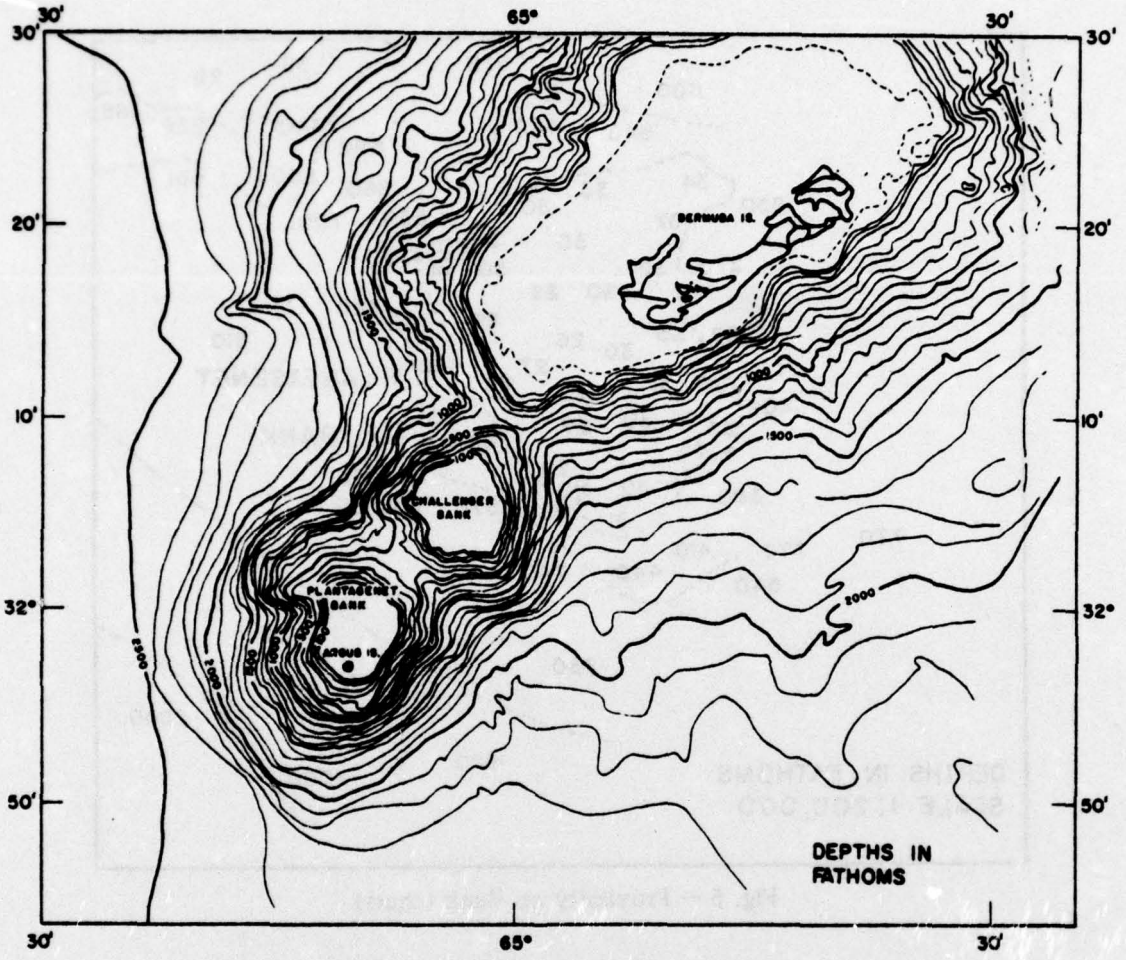

Fig. 4 — Proximity to Bermuda (chart)

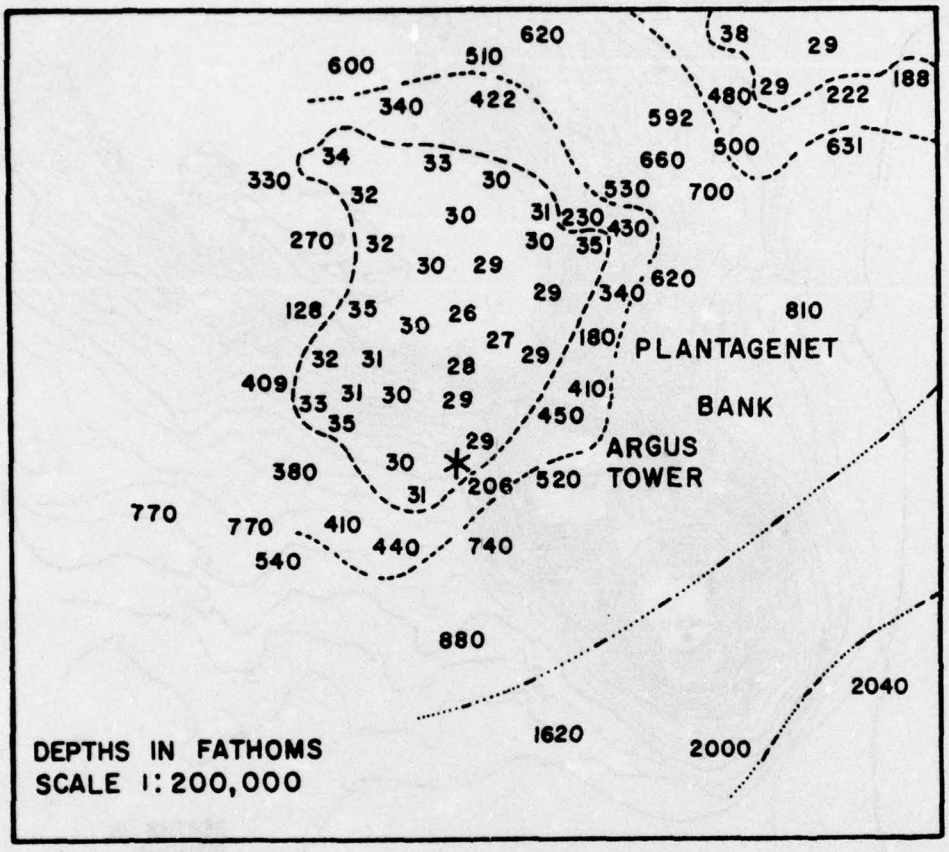

Fig. 5 — Proximity on Bank (chart)

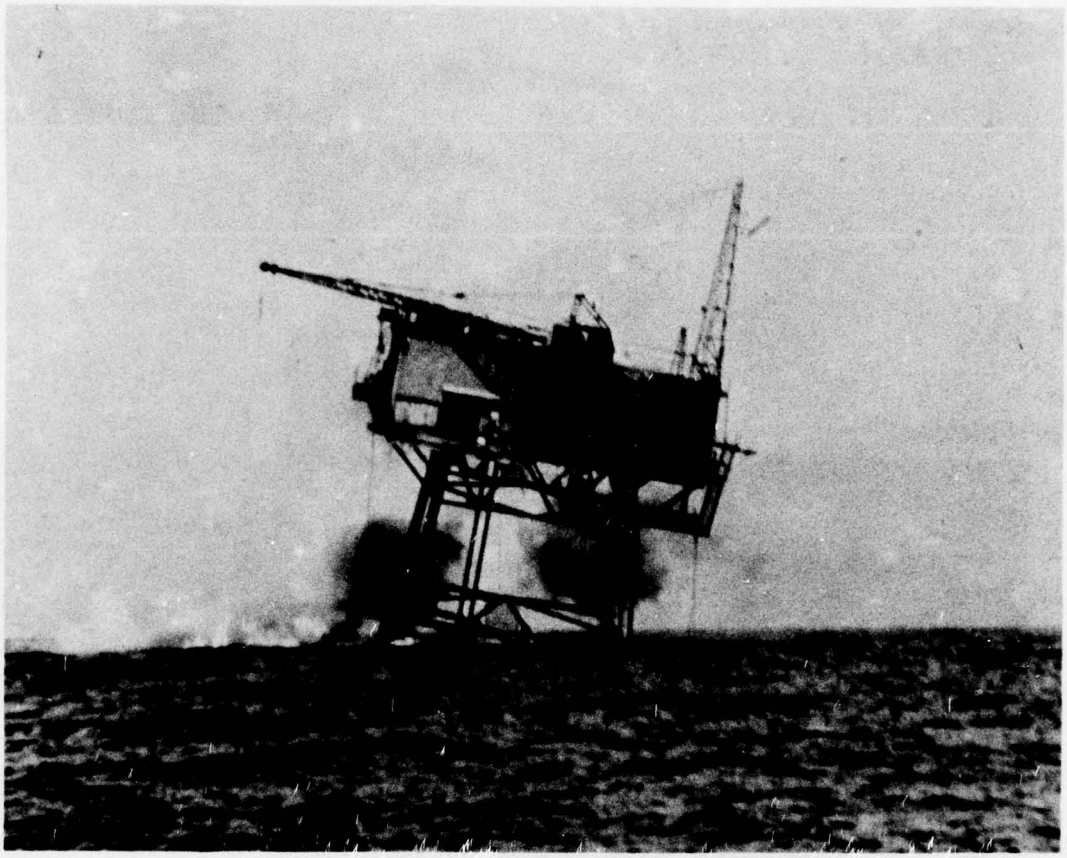

Fig. 6 — Tower toppling sequence (1)

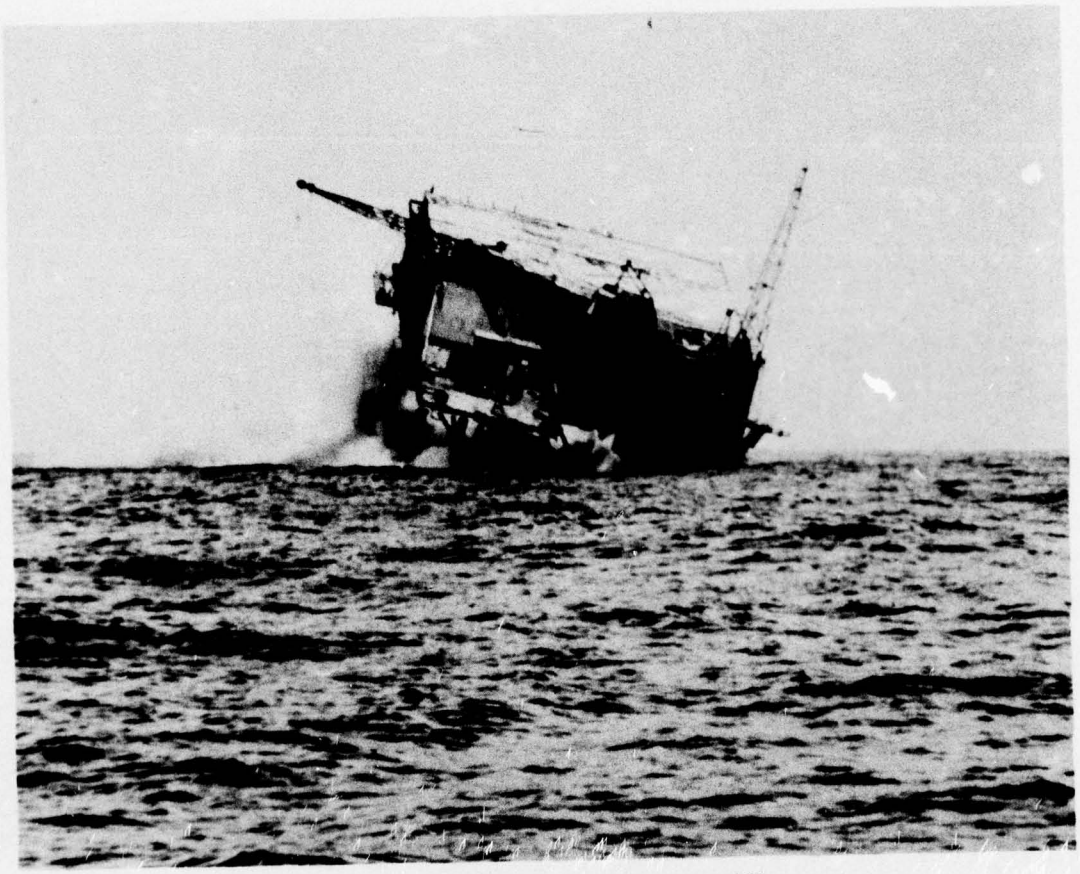

Fig. 7 — Tower toppling sequence (2)

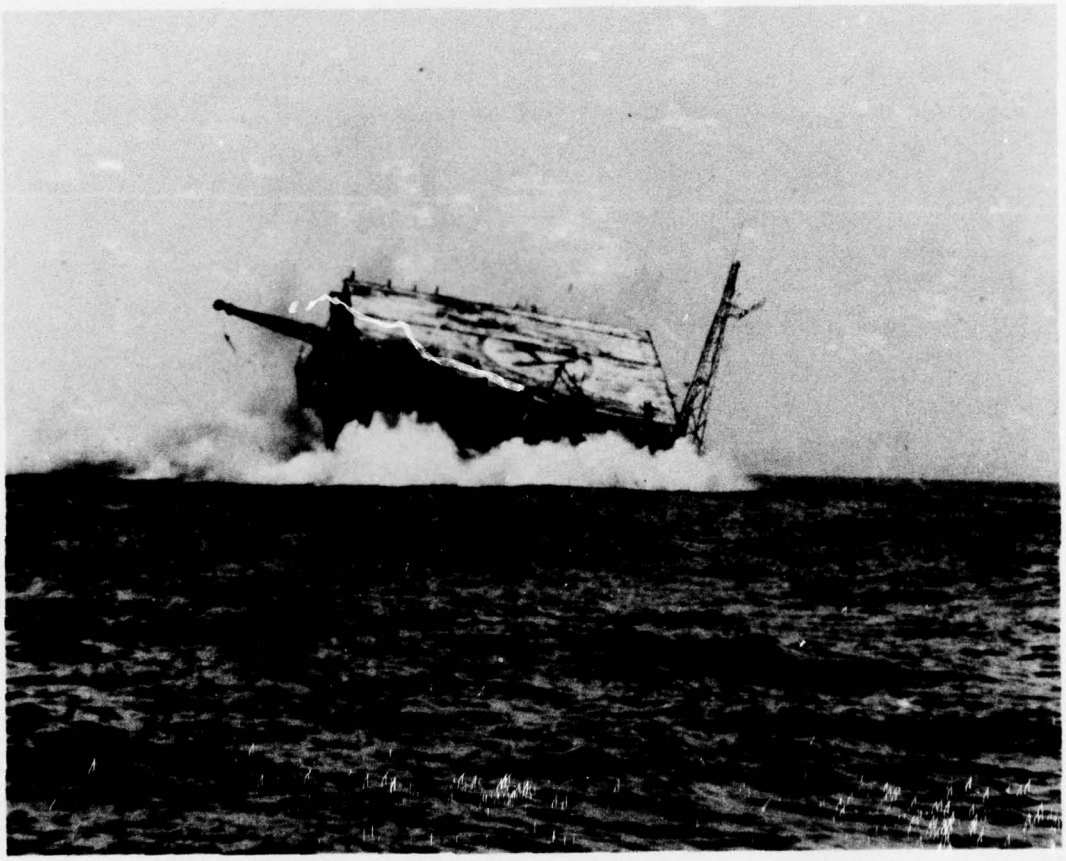

Fig. 8 — Tower toppling sequence (3)

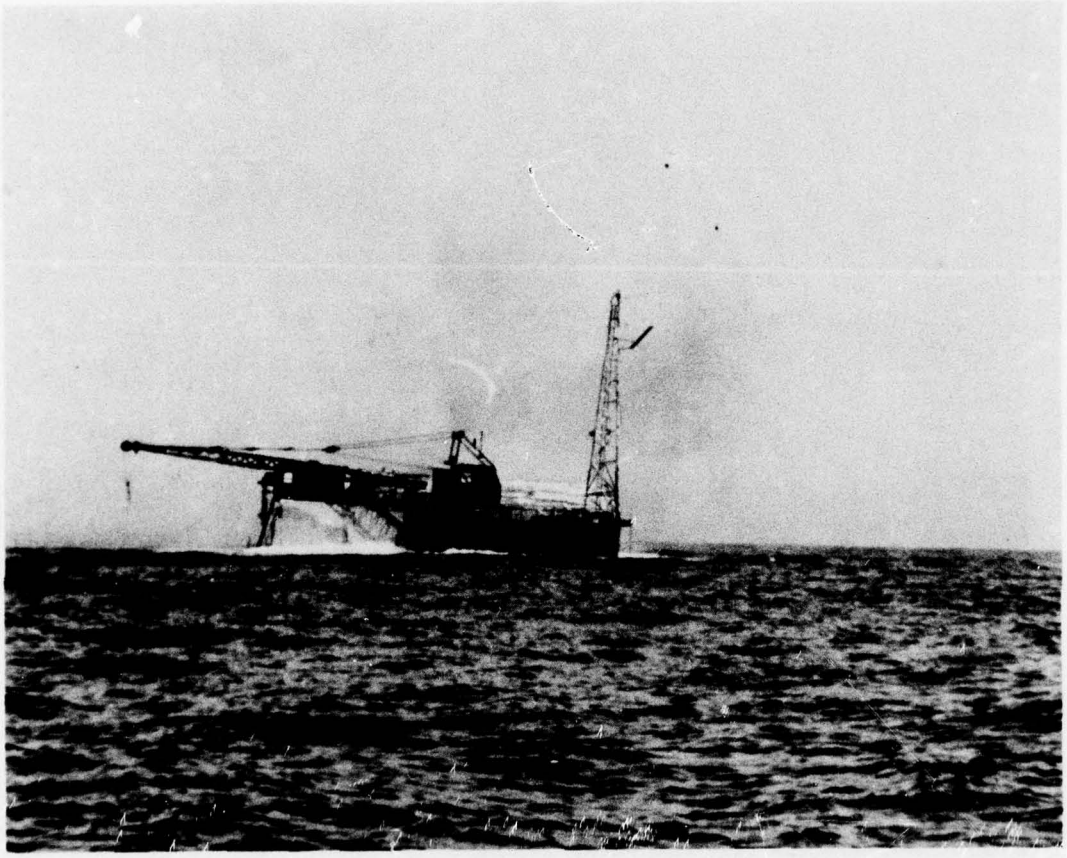

Fig. 9 — Tower toppling sequence (4)

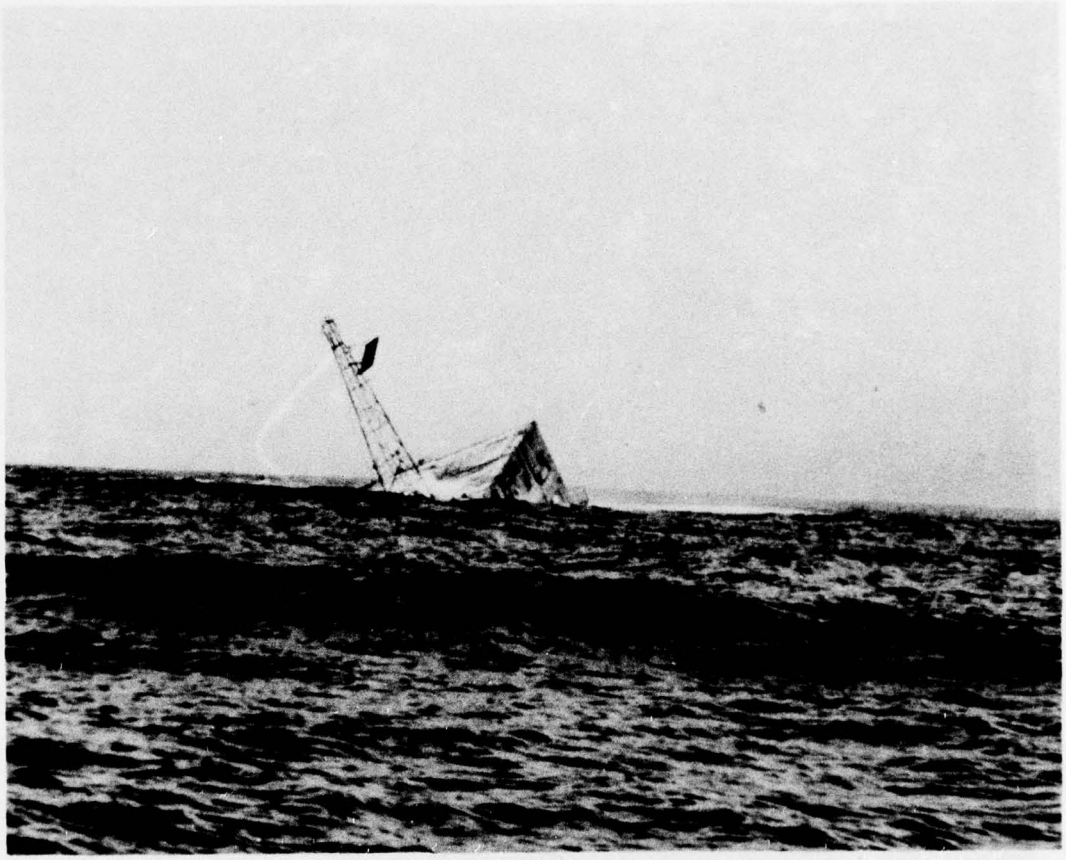

Fig. 10 — Tower toppling sequence (5)

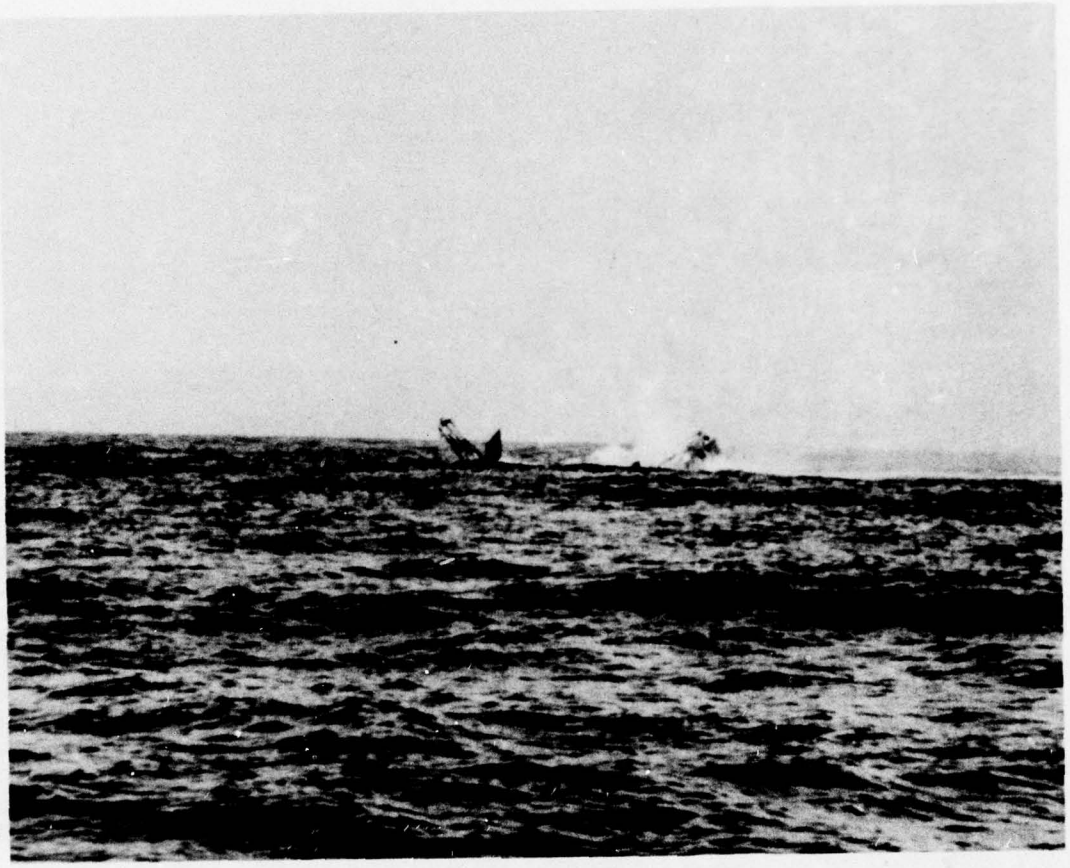

Fig. 11 — Tower toppling sequence (6)

APPENDIX I

I. INTRODUCTION

A. Description of Argus Island

Argus Island is a U.S. Navy Research Platform located in the Atlantic Ocean on Plantagenet Bank approximately 30 miles southwest of Bermuda. This platform was designed, fabricated and installed at its present location in 1960 by J. Ray McDermott & Co., Inc.

The structure is similar in basic configuration and concept to the many fixed platforms which have been installed in the ocean in temperate regions throughout the world for the exploitation of seabed resources. Drawing No. USN-4159-001-P, which is bound in this report, shows the general configuration of the structure.

The structure consists of four basic components, the jacket, the piles, the deck section and the deck house. These four components were prefabricated separately onshore, transported separately to the location, and there installed and assembled to form the complete structure.

The jacket is the lower portion of the structure, extending from the sea floor to approximately eighteen feet above the water line. Water depth at this location is approximately 192 feet. The jacket is a triangulated space frame fabricated from steel pipe members joined by welding. The battered legs of the jacket serve as templates for the installation of the piles. The triangulated web system in each face of the jacket serves to transfer the shear of wind and wave forces to the piles at the level of the sea floor. The overturning moment on the structure, which results from the application of wind and wave forces well above the sea floor, is resisted by axial tension in the piles on the weather side of the structure and axial compression in the piles on the leeward side of the structure. The jacket was transported to the location on the deck of a cargo barge. At the location the jacket was launched from the deck of the cargo barge to float, by its own buoyancy, in a horizontal position at surface. By controlled ballasting and with lifting assistance of a derrick barge, the jacket was brought to the vertical position and set on the sea floor at its final location.

Holes to receive the piles were drilled through the jacket legs into the coral bottom. Pile penetration into the coral bottom is 60 feet. The lower 45 feet of the pile is a steel

H section which is spliced into the 30 inch diameter steel pipe comprising the upper section of the pile. The piles were installed through the jacket legs into the predrilled holes in the coral bottom; and grout was placed through the interior of the pipe forming the upper section of the pile to completely fill the predrilled holes and bond the piles into the coral. Field welded connections attached the tops of the piles to the tops of the jacket legs; and grout was pumped into the annular space between the exterior of the pipe pile and the interior of the pipe jacket leg to bond the piles to the jacket legs. Final cut-off of the piles was made approximately 20 feet above the water line.

The deck section is that portion of the structure, extending from pile cut-off at 20 feet above the water line to 65 feet above the water line, which serves to support the deck house. The deck section consists of four 30 inch diameter steel pipe columns rigidly connected by seventeen foot deep trusses framed into the upper portions of the columns. The deck section was transported to the site on the deck of a cargo barge; and, after completion of pile installation, was lifted from the deck of the cargo barge by a derrick barge and set atop the piles extending above the jacket. The bottoms of the deck section columns were joined to the tops of the piles by field welding.

The deck house was prefabricated in two sections to stay within the 250 ton lifting capacity of the derrick barge used for its installation. The two sections of the deck house were lifted from their cargo barge, set atop the deck section, and joined together to complete the installation of the structure.

B. Design Criteria

The original design of Argus Island was based upon the design philosophy which has been the most widely used for fixed platforms located offshore. Under this philosophy, the environmental conditions of wind velocity and wave height which are to be used for design are established by experts in the fields of oceanography and meteorology. The proportions of the structure and the size of its members are then established to carry the dead loads, the live loads, and loads imposed by design evironmental conditions, based on the provisions of the Specification for Design, Fabrication and Erection of Structural Steel for Buildings of American Institute of Steel Construction, using normal allowable stresses for dead and live loads, and allowable stresses

increased by 1/3 for dead and live loads plus environmental loads. The sizes of all members within the jackets of most offshore structures are determined by the storm load condition at 1 1/3 normal allowable stresses. At this stress level, the factors of safety of compression members will range from 1.25 to 1.44, depending upon the slenderness ratio of the individual member.

Design environmental conditions are generally based upon the statistically predicted frequency with which weather of sufficient severity to cause the conditions could occur at the location of the platform. During the early 1960's, the magnitudes of design storms used for platforms located in the Gulf of Mexico ranged from a storm with predicted recurrence interval of 25 years to the maximum predictable storm. After Hurricane Hilda, 1964, and Hurricane Betsy, 1965, both maximum hurricanes, struck the eastern part of the Louisiana coast, almost all owners of platforms erected in the Gulf of Mexico have elected the maximum storm as the basis for design.

With this design philosophy, risk of property loss to some degree is always recognized and accepted. No risk of life is taken since all personnel are evacuated from the offshore platforms well in advance of the approach of a possibly severe storm.

The original design of Argus Island was based on environmental conditions specified by the U.S. Navy. These design environmental conditions, which were established using the best data available at that time, included a design wave height of 50 feet.

C. Previous Studies

During the first years of the platform's existence, waves approaching a height of 70 feet were observed at Argus Island. In 1963, a structural study of the platform was performed by J. Ray McDermott & Co., Inc. to assess the effect on the platform of waves of this magnitude. In this study, the structure was analyzed on an ultimate load basis for waves with heights of 50 feet, 60 feet, and 70 feet concurrent with a 119 mile-per-hour velocity wind. These ultimate capacity analyses indicated that, for a 70 foot high wave concurrent with 119 mile-per-hour velocity wind, the factors of safety of some members loaded in a combination of compression and bending would be less than one. The theoretical ultimate load capacity of each individual member which was used to calculate these factors of safety was the lowest possible load which might cause failure

in the member, with the magnitudes of all variable factors chosen so as to reduce the calculated ultimate load. In the actual structure, the scatter of these variable factors, such as the variation above specified minimum yield point for the steel used, would make it probable that the actual load capacities of the members were above the theoretical minimums calculated.

Following this study, a subsequent study was undertaken in 1963 to determine methods of increasing the ultimate load capacity of the platform. As a result of this study, certain modifications to the platform were made in 1963 to reduce the total wave load and to increase the ultimate capacity of certain critical members. Analysis of the platform on an ultimate load basis indicated that these modifications would permit the platform to withstand the forces imposed by 70 foot wave concurrent with a 95 mile-per-hour velocity wind with a minimum calculated factor of safety of 1.32, which is slightly lower than the factor of safety of a comparable member loaded to 1 1/3 allowable stress. This analysis included the effect of increased wave load from contemplated instrumentation which, at the present time, has not been added to the platform.

D. 1970 Structural Study

In 1963 and again in 1969 surveys and inspections of Argus Island were made by H. M. Tiedemann & Co., Inc. to determine the actual physical condition of the structure. The report of the 1969 survey indicated that further structural studies of the platform were desirable.

In 1970, J. Ray McDermott & Co., Inc. was retained under contract no. N62470-70-C-0940 to perform these studies. The scope of work of this contract follows:

1. Review and evaluate findings which were developed in the recent ultrasonic inspection of the structure. No on-site investigation shall be required.

2. Compare the new report findings with the findings that were developed in the 1963 inspection.

3. Using electronic computer methods to the greatest extent possible, analyze the structure for its condition as reported by H. M. Tiedemann and Co., Inc., following their 1969 inspection of the structure. From this

analysis, the height of wave to which the structure can be subjected without exceeding the allowable stresses of the American Institute of Steel Construction is to be determined.

4. Using electronic computer methods to the greatest extent possible, analyze the structure considering that one "K" Brace member between elevation (+) 15 feet and elevation (-) 20 feet has been completely severed. The maximum wave height which the tower can sustain without exceeding AISC allowable stresses for this condition is to be determined.

5. Employing the stiffnesses developed during the analyses of 3 and 4 above, the lowest natural frequency for the tower in the condition outlined in 3 is to be determined and the lowest natural frequency for the condition outlined in 4 is to be determined.

6. Using information developed in 1, 2 and 3 above, submit recommendations, comments and drawings covering any apparently necessary repairs or modifications to the structure.

7. Prepare a cost estimate to perform under contract the work covered in 6 above. In addition, submit an estimate of the fee required to prepare contract drawings and specifications for the work covered in 6 above.

8. Retain an oceanographic consultant to obtain four (4) wave loadings in the proper range of heights to accomplish the analyses of 3 and 4 above.

II. INSPECTIONS OF STRUCTURE - 1963 AND 1969

A. Description

H. M. Tiedemann & Co., Inc. of New York, New York was retained in 1963 by the Bureau of Yards and Docks under contract no. NBy-50647 and in 1969, by the Naval Facilities Engineering Command under contract no. N-62470-69-C-1207 to perform surveys and inspections, both below and above water, of the Argus Island structure.

These surveys and inspections included inspections of welded joints both visually and by ultrasonic methods, visual inspections covering marine growth, corrosion, general alignment of the structural members and local deformations of structural members, the condition of the grout surface where the legs and piles are grouted into the coral bottom, measurements to determine the alignment of the members and the relative locations of the joints, measurements of the thickness of the structural members by ultrasonic methods to determine the amount of corrosion that had occurred, and during the 1969 inspection, a survey of the auxillary or secondary members installed subsequent to the 1963 inspection in order to increase the ultimate load capacity of the platform.

B. Reported Results

1. Visual Inspection of Welds

In the report of the 1969 inspection, it was stated that no surface cracking was observed in any weld and that for the most part, the welds retain their original bead pattern with no excessive corrosion. These are substantially the same findings included in the report of the 1963 inspection.

2. Ultrasonic Inspection of Welds

The report covering the 1969 inspection states that no significant changes were noted in those welds which were reported to contain flaws following the 1963 inspection.

In the report of the 1969 inspection, five (5) other welds in the web members of the jacket were stated to contain cracks. These cracks were all reported to be approximately 1/4" in their depth dimension with length varying from 3 3/4" to 16 1/2".

No cracks of any type were reported following the 1963 inspection.

3. Inspection of Pin Joints

These pin joints join the secondary bracing members to the main jacket members. This secondary bracing system was installed during 1963, subsequent to the inspection of 1963, and therefore is not included in the report of that inspection. One of the pin joints located on the north face of the structure approximately at the water line was reported to be loose, with severe wear on the pin. An unsuccessful attempt was made to repair this joint by welding during the 1969 inspection.

4. Alignment Measurements

During the 1969 inspection, measurements were taken at the upper three levels of the jacket. Results reported following the 1969 inspection were the difference in the two diagonal measurements of the jacket at each of the three levels and the vertical and horizontal deviation of the mid-point of the horizontal member from a straight line joining the two legs into which the horizontal member frames.

Only the difference in the diagonal measurements of the jacket at these three levels could be compared with information from the 1963 report. Substantial differences exist at the first and third levels. At these two levels the reported difference between the measurements of the two diagonals is not only large, but has changed in direction from that reported in 1963. At level one, the net change between 1963 and 1969, is four and one-half inches (4 1/2"). At level three, the net change is four and one-quarter inches (4 1/4"). At level two, the net change is only one-half inch (1/2") with the same diagonal being reported as longer in 1969 as in 1963.

5. Visual Inspection at Base of Legs

The surface of the grout fixing the jacket legs and piles into the coral bottom was examined both in 1963 and 1969. No evidence of any foundation distress was reported following either inspection.

6. Ultrasonic Thickness Measurements

Ultrasonic thickness measurements were taken both in 1963 and 1969 to determine the degree of corrosion which has taken place. During the 1963 inspection, thickness measurements were taken at those locations below water which from visual inspection appeared to be corroded the most severely. It was reported that marine growth had prevented visual selection of the most severely corroded areas during the 1969 inspection; therefore, thickness measurements were taken at arbitrarily selected locations to permit comparison with inspections to be made in future periods.

The degree and extent of corrosion reported following the 1969 inspection is of no significance in so far as the present structural integrity of the platform is concerned.

Proper maintenance of the protective coating above water and continued maintenance and use of the cathodic protection system below water should prevent corrosion from compromising the structural integrity of the platform during the remainder of its useful life.

7. General Visual Inspection

The report of the general visual inspection of the structure in 1969 contained only one item of particular interest in so far as maintenance of the platform is concerned. The report states that numerous discarded lengths of loose wire, chain, and wire rope are hanging from the structure at all levels and that, in some cases, their movement has chafed the steel to a bright finish. While the mechanical wear of the steel members of the structure is probably insignificant, the continued chafing from the steel of corrosion products and the coating deposited by the cathodic protection will greatly accelerate the loss of metal at these locations from continued corrosion.

III. ANALYSIS OF STRUCTURE FOR WAVE LOADS

A. Description of Problem

As a guide to the limits of the sea state within which personnel could remain on the platform with safety, two determinations were made of the maximum wave which could be imposed on the structure without exceeding the allowable stresses of the American Institute of Steel Construction (A.I.S.C.). For one of these wave height determinations, the condition of the structure was based on the report of H. M. Tiedemann & Co., Inc. following their 1969 inspection. For the second wave height determination, it was assumed that one of the diagonal members of the jacket between elevation (+) 15 and elevation (-) 20 was completely severed.

B. Results of Analyses

Since there is no direct method to determine the wave height causing a specific stress level, the stresses in the members of the structure were determined for several wave loadings for each of the two assumed conditions of the structure. Plots were then made of the wave heights versus the ratios of calculated stress to A.I.S.C. allowable stress for the governing members of the structure.

Figure 1 shows these curves plotted for the condition of the structure as reported in 1969. The maximum wave height below which all members remain within the allowable stresses of the A.I.S.C. is approximately 61 ft.

Figure 2 shows the curves plotted for the assumed condition of the structure with one diagonal member severed. For this condition, the maximum wave height below which all members remain within the allowable stresses of the A.I.S.C. is approximately 53 ft.

Table 1 lists for the structure in the condition reported in 1969, the maximums of the stress ratios of the various types of members for wave heights ranging from 40 ft to 70 ft. The direction of wave advance for which the maximum stress ratio of each type of member occurs is also indicated.

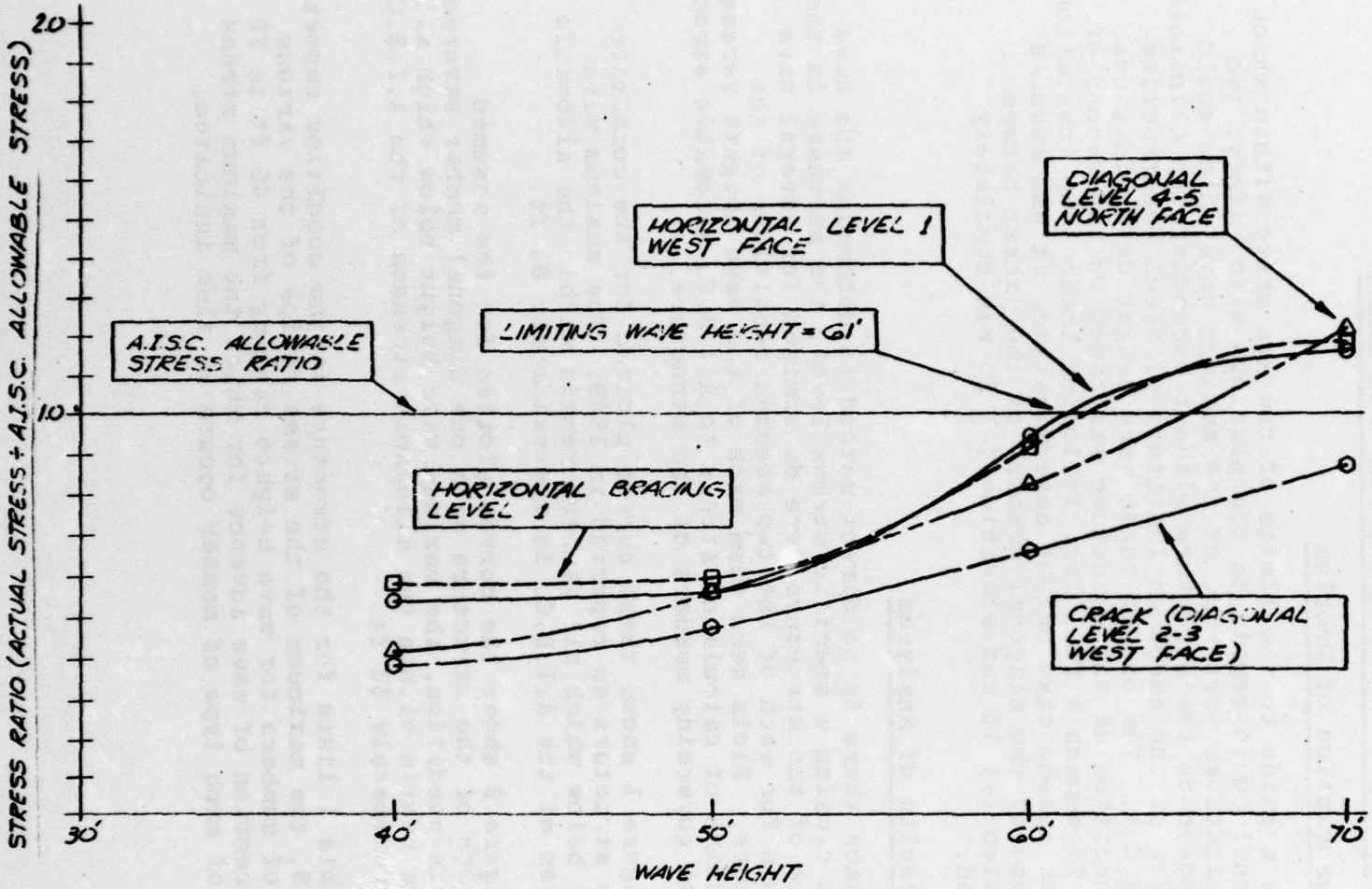

Fig. 1 — Plot of stress ratio vs. wave height for structural conditions as reported in 1969

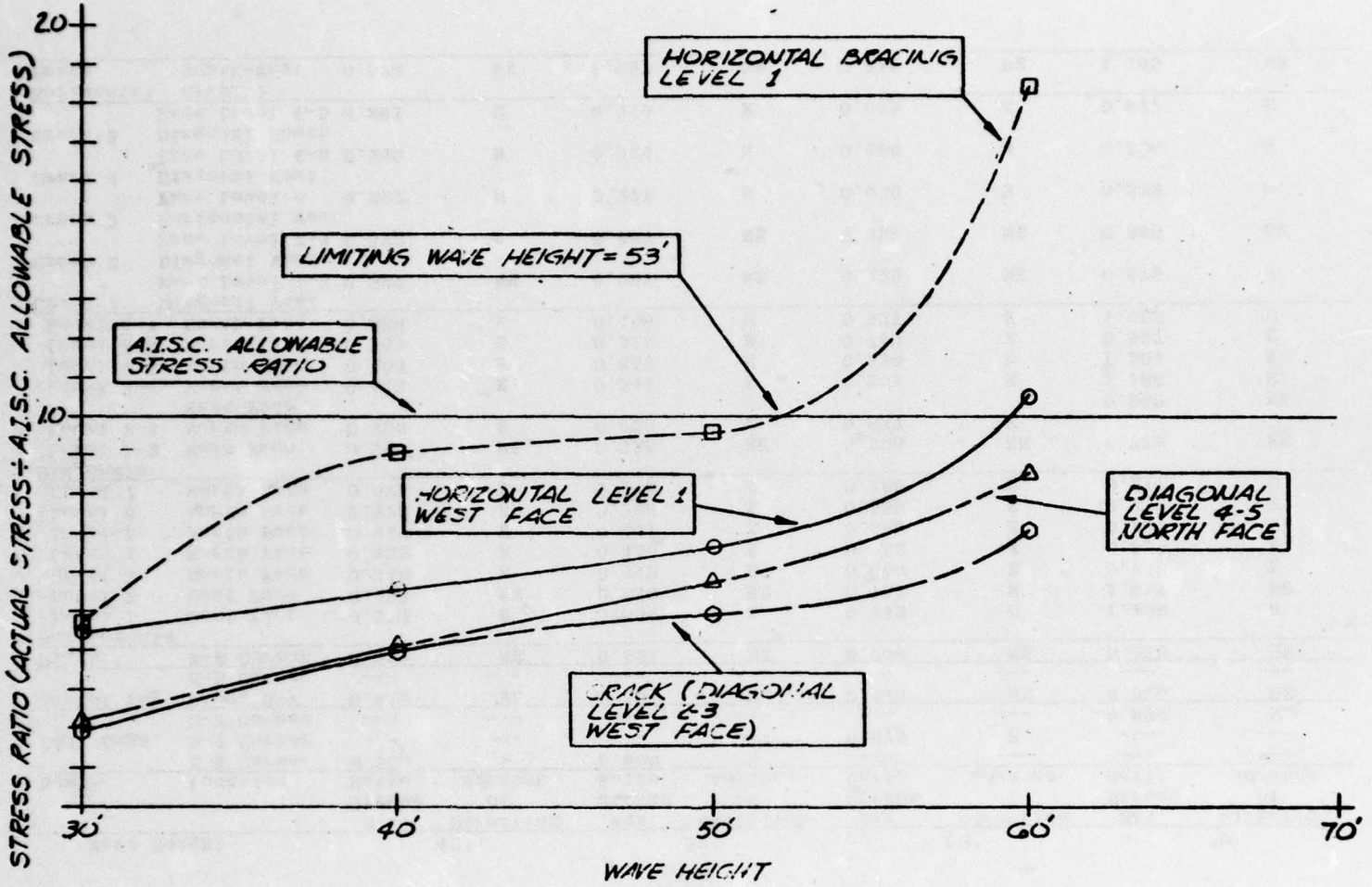

Fig. 2 — Plot of stress ratio vs. wave height with diagonal in east face between levels 1 and 2 assumed severed

Table 1

Wave Height		40'		50'		60'		70'	
Member	Location	Max. Stress Ratio	Direction of Advance	Max. Stress Ratio	Direction of Advance	Max. Stress Ratio	Direction of Advance	Max. Stress Ratio	Direction of Advance
	S-E Corner	0.583	N	0.600	N	---	---	---	---
Deck Legs	N-E Corner	---	---	---	---	0.675	N	---	---
	N-W Corner	---	---	---	---	---	---	0.880	N
Jacket Leg	Level 6-7	0.449	NE	0.593	NE	0.748	NE	0.915	NE
	N-E Corner	---	---	---	---	---	---	---	---
Piles	N-E Corner	0.484	NE	0.591	NE	0.758	NE	0.938	NE
Horizontals									
Level 1	West Face	0.532	E	0.556	E	0.942	E	1.159	E
Level 2	West Face	0.423	NE	0.539	NE	0.767	NE	1.017	NE
Level 3	North Face	0.340	E	0.449	E	0.649	E	0.850	E
Level 4	North Face	0.335	E	0.456	E	0.652	E	0.865	E
Level 5	North Face	0.319	E	0.441	E	0.630	E	0.837	E
Level 6	North Face	0.278	E	0.396	E	0.558	E	0.730	E
Level 7	North Face	0.075	E	0.118	E	0.166	E	0.217	E
Diagonals									
Level 1-2	West Face	0.295	NE	0.325	NE	0.496	NE	0.738	NE
Level 2-3	North Face West Face	0.356	E	0.425	E	0.637	E	0.890	NE
Level 3-4	North Face	0.413	E	0.541	E	0.804	E	1.166	E
Level 4-5	North Face	0.404	E	0.559	E	0.828	E	1.204	E
Level 5-6	North Face	0.363	E	0.516	E	0.743	E	0.997	E
Level 6-7	North Face	0.338	E	0.496	E	0.727	E	1.006	E
Crack 1	Diagonal East Face Level 1-2	0.262	NE	0.297	NE	0.428	NE	0.575	N
Crack 2	Diagonal West Face Level 2-3	0.372	N	0.463	NE	0.657	NE	0.865	NE
Crack 3	Horizontal West Face Level 4	0.207	N	0.271	N	0.400	N	0.538	N
Crack 4	Diagonal West Face Level 4-5	0.242	N	0.324	N	0.460	N	0.606	N
Crack 5	Diagonal South Face Level 4-5	0.261	E	0.359	E	0.515	E	0.677	E
Horizontal Brace	Level 1 South-West	0.574	NE	0.587	NE	0.915	NE	1.165	NE

APPENDIX II

162. ARGUS ISLAND TIDES. ("Unpublished Manuscript"), R. B. Elder. Naval Oceanographic Office Informal Manuscript Rept. No. O-68-62. 9 p. Dec 1962. UNCLASSIFIED. (NOO 38265).

This preliminary manuscript briefly outlines the extent of tides in the vicinity of Argus Island.

163. ARGUS ISLAND TIDES - II ("Unpublished manuscript"), R. B. Elder and C. F. Beckner. Naval Oceanographic Office IMR No. O-19-64. 16 p. May 1964. UNCLASSIFIED. (NOO 38265-II).

This report covers data on which the Oceanographic Prediction Division is currently conducting a research program aboard the Argus Island tower located on Plantagenet Bank approximately 22 miles southwest of Bermuda in 192 feet of water. The report provides basic tidal data referenced to Hampton Roads, Virginia, based on data obtained during 1963.

164. ARGUS WQC IN SITU MEASUREMENTS (U), D. D. Abraham and R. R. Rumpf. USL TM 2214-063-69. 4 p. 30 Dec 1969. CONFIDENTIAL. (2214-063-69).

(U) The purpose of the tests was to obtain an up-to-date calibration for the Argus AN/WQC-2 transducer. Specifically, these tests were to include measuring the transmitting response, the receiving response, and the vertical transmit beam pattern of the transducer.

165. BI-LEVEL OCEAN CURRENT MEASUREMENTS AT ARGUS ISLAND, A. B. Crumpler. Naval Oceanographic Office Informal Manuscript Rept. No. O-45-63. 18 p. Feb 1962. UNCLASSIFIED. (NOO 40182).

As a continuation of the study of the circulation pattern over Plantagenet Bank, bi-level (15 and 105 foot) current measurements were taken at Argus Island during the latter part of 1962. Analysis of the data shows that neither winds nor tidal influence were primary factors in determining direction of current flow during the observational period. However, tidal influence on current speed is apparent. Current direction at both levels was fairly constant. Direction at the lower level was about 40 degrees to the right of direction at upper level.

166. COMPARISON OF WEATHER DATA AT ARGUS ISLAND WITH WEATHER DATA ABOARD SHIPS OPERATING IN THE TRIDENT AREA (U), W. A. Von Winkle. USL TM 906.2-013-63. 4 p. 1 Mar 1963. CONFIDENTIAL. (906.2-013-63).

(U) During the period November 7 through November 14, 1962, the USS ROOKVILLE (EPCER-851) and the USS NEPTUNE (ARC-2) were operating in the Trident area. ROCKVILLE was conducting exercises in connection with the Fishbowl system evaluation, and the NEPTUNE was engaged in replacing the horizontal string of hydrophones connected to the Trident facility. The presence of these ships afforded an opportunity to compare weather data as observed at Argus Island with observations of the same parameters taken simultaneously aboard ship. This memorandum presents a brief analysis of some of the data obtained.

167. AN EVALUATION OF A COMPUTERIZED NUMERICAL WAVE PREDICTION MODEL FOR THE NORTH ATLANTIC OCEAN, D. C. Bunting and L. I. Moskowitz. Naval Oceanographic Office TR-209. v.p. Jul 1970. UNCLASSIFIED. (NOO 55510).

Procedures used to evaluate a computerized numerical wave prediction program are described. Statistical analyses were made using records from shipborne wave meters or a wave staff at five different locations in the North Atlantic and machine-made predictions of wave spectra for forecast intervals up to 36 hours. Comparisons are shown between two different sets of input data. The results of the evaluation indicate that automated numerical wave spectral predictions are feasible and that the forecasts are within a reasonable degree of accuracy for forecast intervals up to 36 hours.

168. IMPLANTMENT OF AN ACOUSTIC-ENVIRONMENTAL UNIT OFF ARGUS ISLAND, R. R. Rumpf. USL TM 2214-180-69. 4 p. 16 Jun 1969. UNCLASSIFIED. (2214-180-69).

On 22 April 1969, an Acoustic-Environmental Unit was emplanted at a range of 450 feet on a bearing of 353° from Argus Island in 192 feet of water. The following requirements generated the development of the Unit, which contains a hydrophone, projector, and thermistor. These are: 1) to correlate ambient noise with rainfall, 2) to aid in future acoustic navigation experiments, and 3) to provide a sensor for measuring water temperatures.

169. MARINE FOULING AND CORROSION OF INSTRUMENTATION AT ARGUS ISLAND, C. F. Beckner, Jr. Naval Oceanographic Office IM No. 0-55-65. 9 p. Jan 1966 (reprinted Nov 1966). UNCLASSIFIED. (NOO 48496).

This report describes the marine fouling and corrosion of instrumentation at Argus Island. Goose barnacles and green and brown algae were the predominant fouling organisms. These organisms generally attached to sensors in areas where antifouling coatings had become chipped or scratched. The severity of fouling indicated seasonal variation.

170. MICROMETEOROLOGICAL SITE EVALUATION OF AN OCEAN TOWER. PRELIMINARY MICROMETEOROLOGICAL SURVEY OF ARGUS ISLAND, C. W. Thornthwaite. C. W. Thornthwaite Associates Laboratory of Climatology. 28 p. 1962. UNCLASSIFIED. (THRNWAITE 44836).

The experience which we have gained during the observation program of 1962 has given us a new insight into the problems of making reliable micrometeorologic observations over a sea surface. Although it is beyond the scope of the present preliminary survey, we have become aware of the great difficulty in utilizing ships as observation platforms for climatic studies over the oceans.

171. OPTICAL PROPERTIES OF THE NORTH ATLANTIC OCEAN AT ARGUS ISLAND, R. E. Morrison. Naval Air Development Center Report No. NADC-AE-6723. 51 p. 5 Jan 1968. UNCLASSIFIED. (NADC 48540).

The attenuation coefficient, the relative irradiance, and the volume scattering function were measured at 5300 angstroms independently and nearly simultaneously as a function of depth and time of day. Volume scattering function data were extrapolated to extreme angles, and the total scattering coefficients were computed by machine integration for 81 samples. Assuming a radiance distribution function, the absorption coefficient was approximated from relative irradiance data. The experimentally determined coefficients are compared with each other to discover the degree of consistency with theoretical predictions. Attempts are made to correlate the vertical distributions of these coefficients with profiles of temperature and biological and particulate concentrations which were measured concurrently.

172. OPTICAL PROPERTIES OF SEA WATER OF THE NORTH ATLANTIC OCEAN AT ARGUS ISLAND AND BLOCK ISLAND SOUNDS AT LONG ISLAND, R. Morrison. 73 p. 17 Feb 1970. Naval Air Development Center Report No. NADC-AE-6918. 73 p. 17 Feb 1970. UNCLASSIFIED. (NADC 53827).

Attenuation, absorption, and scattering coefficients were obtained from nearly simultaneous optical measurements at sea.

The total scattering coefficients were computed for 159 samples from data obtained with two scattering meters, one of which was capable of measuring the volume scattering function at 0.2°. Depth profiles of the optical properties were compared for consistency, and overall agreement within a factor of two was observed. Consistent agreement between an increase in the turbidity and the top of the seasonal thermocline was demonstrated by data profiles from Argus Island. The light attenuation distributions at the coastal stations were influenced by the tidal cycle and fresh water run-off.

173. OPTICAL RANGING AND DETECTION (ORAD) MEASUREMENTS (U), L. M. Ott and J. L. Figgles. Naval Air Development Center, Aero-Electronic Tech. Dept Report No. NADC-AE-6625. 32 p. 6 Sep 1966. CONFIDENTIAL. (NADC 45537).

(U) Two-way air-to-underwater ranging measurements were made at the Argus Island test station, a tower located 30 mi southwest of Bermuda, to evaluate the feasibility of an optical ranging and detection (ORAD) system. The transmitter was a pulsed blue-green laser. Ranging measurements were made as a function of laser beam divergence using both black and white targets. Light reflected from the targets at an underwater depth of 175 ft was detected by a photomultiplier-tube receiver. These experiments have shown it is feasible to detect undersea objects by using an ORAD system.

174. PRELIMINARY REPORT ON ORADS TESTS AT ARGUS ISLAND (U), L. M. Ott and R. E. Morrison. Naval Air Development Center Tech Memo ADC-AEYA-2:LMO-REM. 7 p. 29 Sep 1965. CONFIDENTIAL. (NADC 43514).

(U) The objective of this project is to establish the feasibility of aerial detection of undersea objects by using an optical ranging and detection (ORAD) system. The system consists of a blue-green laser transmitter, receiver, optics, synchronizer, control unit, and power supply. Phase II ORAD system, developed by Kollsman Instrument Corporation, was taken to the Argus Island test station where an extensive sea test program was conducted. This program included oceanographic measurements in support of the ORAD measurements.

175. STATISTICAL FORMULAS FOR THE REDUCTION OF CODE 941 DATA ACCUMULATED ON THE ARGUS ISLAND TOWER, M. J. Goldstein. USL TM 907-155-66. 5 p. 29 Aug 1966. UNCLASSIFIED. (907-155-66).

The reduction of data accumulated on the Argus Island Tower was used to determine the relationship between variations in phase and amplitude of VLF electromagnetic waves passing through the air-sea interface and pressure variations from the collected data. This paper concerns itself with the mathematical formulas employed to compute the desired statistics of sample spaces derived from the accumulated data and containing infinite-valued samples.

176. VERTICAL WIND PROFILE NEAR BERMUDA, L. C. Huff. USL TM 2213-92-67. 4 p. n.d. UNCLASSIFIED. (2213-92-67).

ARGUS ISLAND tower, located at 31°57'N,65°11'W, has been used extensively by NAVOCEANO for air-sea interaction projects. One of the routine measurements is wind velocity at 157 feet above mean sea level. It was assumed that for established southerly wind patterns, the horizontal wind shear would be negligible as compared with the vertical wind shear and that one could obtain meaningful statistical comparisons between the ARGUS ISLAND reference anemometer and an anemometer mounted on a NOMAD moored 32°N,64°40'W. Comparison is made between ARGUS ISLAND and NOMAD wind speeds for averaging times from fifteen minutes to three months. The statistical relationship is determined between ARGUS ISLAND and NOMAD winds. Utilizing the statistically predicted wind profile, NOMAD wind speed is projected to 157 feet and compared with the 157-foot measured wind speed for averaging times from fifteen minutes to three months.

177. WAVE POWER SPECTRA FROM ARGUS ISLAND, SEPTEMBER 1962 ("Unpublished Manuscript"), S. M. Lazanoff. Naval Oceanographic Office IMR No. 0-46-64. 48 p. Dec 1964. UNCLASSIFIED. (NOO 42291).

This report presents wind and wave data obtained during the period 16-22 September 1962 at Argus Island Tower. The wave data are presented as power spectra. The series of power spectra represents data from relatively low sea states, in contrast to the high energy of the November 1961 wave spectra described in IMR No. 0-65-62.

178. WIND SPEED AND DIRECTION DISTRIBUTIONS AT ARGUS ISLAND OFF BERMUDA (U), A. J. Perrone, J. M. Gorman and F. G. Weigle. USL TM 911-04-65. 6 p. 15 Mar 1965. CONFIDENTIAL. (911-04-65).

(U) This memorandum is the fourth in a series relating to the results of an ambient measurement program carried on from March 1963 to the present time (1965).

WIND-SPEED AND WIND-DIRECTION DISTRIBUTIONS AT ARGUS ISLAND OFF BERMUDA (U), A. J. Perrone, J. M. Gorman and F. G. Weigle. USL Report No. 683. 22 p. 24 Aug 1965. (Reissued as Artemis Report No. 44.) Hudson Labs/USL Artemis Report No. 44. UNCLASSIFIED. (Hudson/USL 32839-44).

Argus Island wind information was systematically recorded and processed over a three-year period. The recording, processing, and analysis procedures used are described. Monthly mean wind speeds (with standard deviations) are compared with monthly median wind speeds and quartiles. Monthly distributions of wind speed are given, as well as yearly distributions. Cumulative distribution plots compare wind-speed occurrences over the three-year period. A time plot of daily mean and maximum wind speeds is given, and diurnal variations are discussed. The distributions of wind direction for each month are also shown.

APPENDIX III

NAVOCEANO REPORTS

INFORMAL

IOM 16-62 Comparison of Sea Surface Spectral Estimates, EDO 255 B versus ULCER I SONIC SCANNER; by P. S. DeLeonibus, Mar. 1962, 9p.

IM 19-62 Comparison of Wave Telemetering Buoy and Electronic Wave Staff Data; by R. L. Pickett, Mar. 1962, 10p.

IMR 0-28-62 Comparison of Sea Surface Spectral Estimates, EDO 255 B versus ARGUS ISLAND Resistance Wire Wave STaff; by R. Merrifield, May 1962, 8p.

IOM 0-35-62 Comparison of Hindcast to Observed Significant Wave Heights at ARGUS ISLAND November 20 to 30, 1961; by P. S. DeLeonibus, June 1962, 29p.

IMR 0-65-62 A Series of Wave Power Spectra; by R. L. Pickett, Nov. 1962, 111p.

IR 0-68-62 ARGUS ISLAND Tides; by R. B. Elder, Dec. 1962, 9p.

IMR 0-45-63 Bi-Level Ocean Current Measurements at ARGUS ISLAND; by A. B. Crumpler, Feb. 1962, 35p.

IMR 0-5-63 An Analysis of Ambient Light Recordings in the Ocean from ARGUS ISLAND Tower; by R. Merrifield, Jan. 1963, 26p.

IMR 0-19-64 ARGUS ISLAND Tides - II; by R. B. Elder and C. F. Beckner, Jr., May 1964, 16p.

IMR 0-20-64 ARGUS ISLAND Wave Recorder; by R. E. L. Pickett, May 1964, 11p.

IR 0-45-64 The Non-Gaussian Character of Gravity Wave Displacements; by R. E. L. Pickett, May 1965, 37p.

IMR 0-46-64 Wave Power Spectra from ARGUS ISLAND, September 1962; by S. M. Lazanoff, Dec. 1964, 48p.

IMR 0-4-65 Performance of a Shipboard Wave Height Sensor; by A. Moskios and P. S. Deleonibus, Mar. 1965, 50p.

IMR 0-50-65 Spatial Changes in Thermal Structure near ARGUS TOWER; by R. L. Pickett and C. F. Beckner, Jr., Dec. 1965, 16p.

IM 0-55-65 Marine Fouling and Corrosion of Instrumentation at ARGUS ISLAND: by C. F. Beckner, Jr., Jan. 1966, 9p.

IM 66-24 On Observation of Subtidal Internal Wave Velocities Near Bermuda; by R. L. Pickett and C. F. Beckner, Jr., Dec. 1966, 9p.

IR 67-36 The Use of the Kolmogorov-Smirnov Test to Determine the Existence of a Fully Developed Sea (Part I): The Mean Spectrum for a Fully Developed Sea Recorded at ARGUS ISLAND (Part II); by R. J. Manasseri, May 1967, 27p.

IR 67-60 Wind Mixing at ARGUS ISLAND; by E. L. Corton, Sept. 1967, 8p.

IR 67-78 Evaluation of Spectral Wave Hindcasts Using the Automated Wave Prediction Program of the Naval Oceanographic Office; by L. I. Moskowitz, Oct. 1967, 32p.

IR 69-54 Behavioral, Physical, and Acoustic Characteristics of Humpback Whales (Megaptera novaeangliae) at ARGUS ISLAND; by C. Levenson, May 1969, 13p.

IR 69-62 Test and Evaluation of a Spar-type Oceanographic Buoy; by A. N. Kalvaitis, July 1969, 25 p.

IMR 0-103-65 (CONFIDENTIAL) Preliminary Report on ARTEMIS Oceanographic Data for June 1964 (U); by L. J. Fisher, Oct. 1965, 35p.

SPECIAL PUBLICATIONS

SP-153 Manned Submersibles and Underwater Surveying; 1970, 156p.

TECHNICAL REPORTS

TR-131 Ocean Currents over Plantagenet Bank, Bermuda; by R. A. Pedrick, June 1962, 73p.

TR-144 A Study of Aeromagnetic Component Data, Plantagenet Bank; by G. A. Young and A. L. Kontis, Jan. 1964, 18p.

TR-209 An Evaluation of a Computerized Numerical Wave Prediction Model for the North Atlantic Ocean; by D. C. Bunting and L. I. Moskowitz, July 1970, 66p.

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Eddy Correlation Measurements of Momentum and Heat Flux at ARGUS ISLAND; by R. T. Field, Final Report, Contract N62306-2119, 19 p., 1967.

Disturbance of Airflow Around ARGUS ISLAND near Bermuda; by C. W. Thornthwaite, W. J. Superior and R. T. Field, Final Report, Contract N62306-1122, 1962.

SCIENTIFIC PAPERS

Momentum Flux Measurements at ARGUS ISLAND Tower; by P. S. DeLeonibus, in "Transactions of the American Geophysical Union," Vol. 46, No. 1, p.98, 1965.

Momentum Flux Observations from an Ocean Tower; by P. S. DeLeonibus, in "Nauka", p. 221, 1966. Presented at "Second International Oceanographic Congress", Moscow, USSR.

Observations of Wind and Wave Spectra' at ARGUS ISLAND Tower; by P. S. DeLeonibus, in "Transactions of the American Geophysical Union", Vol. 50, No. 4, p. 187, 1969.

Momentun Flux and Wave Spectra Observations from an Ocean Tower; by P. S. DeLeonibus, in "Journal of Geophysical Research", Vol. 76, No. 27, Pp. 6506-6527, 1971.

A Case Study of Duration-Limited Wave Spectra Observed at an Open Ocean Tower; by P. S. DeLeonibus and L. S. Simpson,

Results with a Deep Research Vehicle Transponder Navigation System at the U.S. Naval Oceanographic Office; by R. Merrifield and R. R. Delort, in "Proceedings of the Fourth National Marine Sciences Instrumentation Symposium, Marine Sciences Instrumentation, Vol. 4", pp. 337-346, Jan. 1968.

Airborne and Shipboard Wave Profiling in Support of the U. S. naval Oceanographic Office Program on Wave Research; by L. Moskowitz and D. B. Ross.