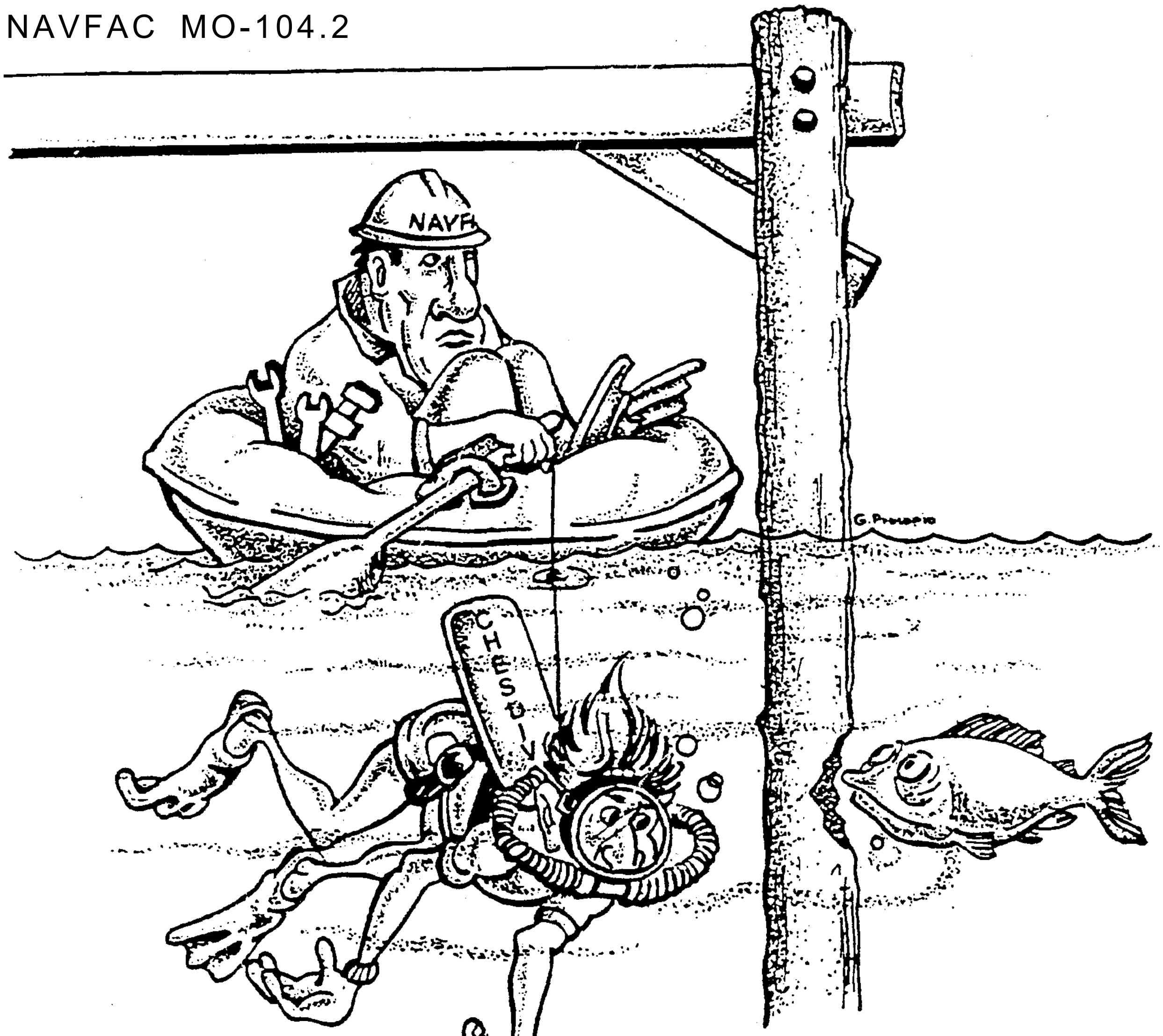
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, Virginia 22332-2300

APPROVED FOR PUBLIC RELEASE

SPECIALIZED UNDERWATER WATERFRONT FACILITIES INSPECTIONS

NAVFAC MO-104.2



OCTOBER 1987

SN 0525-LP-173-0167

Distribution: **Public Works Department,** Centers and **Offices**
Claimants and Shore Facilities Maintenance Support Activities
(2 copies each unless otherwise indicated)

SNDL	ACTIVITY
A3	CNO (60 cys)
A6	CMC (15 cys)
21A	FLECOMINCH
22A	FLECOM
23A	NAVFORCOM
23C	NAVRESFODET
24G	SUFORCOM
26B	NAVSRESFORDET
26U	SFORLANTREADSUPPGRU
26w	CARGOHANDPORTGRU
26Z	SHOREINTERMMAINTACT
26NN	LANTFLESCLSHIPENGTRATEAM
26VV	SUFORREP
26XX	OCEANU
39	CBREGIMDET
45H	ENGBCO
45J	HQB
51D1	EASTLANTCOM
51D2	WESTLANTCOM
B3	COLLEGE AM UNIVERSITY
B5	USCG (45 cys)
B8	COMUSMARDEZ (9 cys)
C20A	ONRDET
C20B	ONR
C20C	NRLDET (Chesapeake Beach, Orlando only)
C20G	NAVOCEANSYSCENDET
C20H	DAVTAYR&DCENDET
C28E	COMNAVBASDET
C31B	NAVSTADET
C31F	NAVFACDET
C31G	NAVSHIPREPFACDET
C34B	NAVSTA ROTA DET
C34C	NAVSUPPACT NAPLES DET
C40	NAVOCEANCOMDET (only Charleston, Gulfport, Newport, FPO Seattle FPO Miami)
C84D	NAVUSEAWARENGSTADET
E3A	LAB ONR
E3C	NORDA
E3D3	NAVCOASTSYSCEN

SNDL:	ACTIVITY
FA7	NAVSTA LANT
FA10	SUBASE LANT
FA13	NAVSUBSUPPFACLANT
FA23	NAVFAC LANT
FA32	CBU LANT
FB10	NAVSTA PAC
FB13	SUBASE PAC
FB28	COMNAVBASEPC
FB36	NAVFACPAC
FB41	CBU PAC
FB45	TRIREFFACPAC
FB48	NAVSUPPO EUR
FC1	FOCCEUR
FC3	COMNAVACT EUR
FC5	NAVSUPPACT EUR
FC7	NAVSTA EUR
FC12	NAVSUPPO EUR
FD1	COMNAVOCEANCOM
FD4	OCEANCEN
FF1	COMNAVDIST WASHINGTON DC
FF3	NAVSTA CNO
FF18	NAVTACSUPPACT
FF32	FLDSUPPACT
FF38	USNA (5 cys)
FF42	NAVPGSCOL (5 cys)
FF65	SNSPO
FKA1	SYSCOMHQS
FKA1C	COMNAVFACENGCOM (25 cys)
FKA1G	COMNAVSEASYSCOM
FKA8F2	NAVPRO
FKA8F5	SUBASE
FKN1	EFDs (25 cys)
FKN2	CBCs
FKN3	OICCs
FKN5	PWCs (10 cys)
FKN10	NAVSUPPFAC
FKN11	NAVCIVENGRLAB
FKP1B	WPNSTAs
FKP1J	NAVORDSTAs
FKP3A	NAVPRO

SNDL:	ACTIVITY
FKP5A	NAVSEACEN
FKP7	NAVSHIPYDs (10 cys)
FKQ6B	NAVCOASTSYSCEN
FKQ6C	NAVOCEANSYSCEN
FR15	NAVSUPPACT COMNAVRESFOR
FR18	NAVRESMAINTRAFAC
FT1	CNET
FT15	NAVU
FT18	CBU
FT20	NAVCONSTRACEN
FT24	FLETRACEN
FT28	NETC (5 cys),
FT31	NTC (5 cys)

HP U.S. Air Force,
Engineering and Services Center
Tyndall AFB, FL 32403
(10 copies)

HQ U.S. Army
Facilities Engineering Support Agency
Fort Belvoir, VA 22060-5516
(25 copies)

U.S. Army Office Chief of
Engineers Washington DC 20314
(DAEN-MPO) (10 copies)

Additional copies may be obtained from:

U.S. Navy Publications and Forms Center
5801 Tabor Avenue
Philadelphia, PA 19120

SNDL:	ACTIVITY
FT37	NAVSCOLCECOFF (5 cys)
FT38	NAVSUBTRACENPAC (5 cys)
FT39	NAVTECHTRACEN (5 cys)
FT55	NAVSCSCOL (5 cys)
FT60	EDTRASUPPCEN
FT78	NAVEDTRAPRODEVCEN
FT85	TRITRAFAC
V2	MARBKS
V12	CG MCDEC
V14	HQBN HQMC
V16	CG MCB (less Oahu)
V17	MARCORCAMP
V23	CG MCLB

ABSTRACT

Specialized inspection Guidelines developed from evaluation of shore facilities are presented herein for use by public works managers. Basic criteria for specialized inspection including responsibilities, desirable inspection frequency, recommended standards, test procedures, identification of defects, hazard assessment, and report preparation of records are discussed. In addition, use of information obtained during specialized inspection and interface with activity inspection programs are discussed.

FOREWORD

This Maintenance and Operations (MO) Manual contains information on specialized inspections which are administered by the Naval Facilities Engineering Command to supplement the activity inspection system. The manual provides guidelines for test and inspection of facility components that are not normally available through Activity Public Works Departments or Public Works Centers. Inspection results provide data for risk determination, justification of real property budget requests, accurate condition surveys, recording the total maintenance and repair resource requirements, evaluation of facility readiness for fleet support, identification of real property maintenance deficiencies, safety, and improved maintenance management.

The standards and methods presented are intended to accomplish the inspection, maintenance, and repair of waterfront structures and related facilities in the most efficient and cost effective manner. The procedures outlined have been developed from the best technical sources available in industry and the military services.

Recommendations or suggestions for modification, or additional information and instructions that will improve the publication and motivate its use, are invited and should be forwarded to the Commander, Naval Facilities Engineering Command (Attention: Code 100), 200 Stovall Street, Alexandria, VA 22332-2300. Telephone: Commercial (202) 325-8181, Autovon 221-8181.

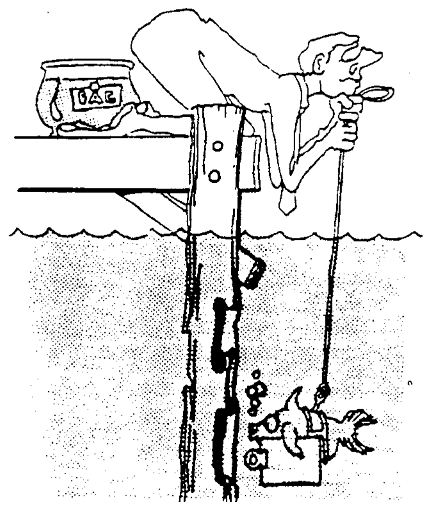
This publication has been reviewed and is approved for certification as an official publication of this Command in accordance with SECNAV Instruction 5600.16.

A.S. BRADFORD
ASSISTANT COMMANDER FOR
FACILITIES & TRANSPORTATION

CONTENTS

FIGURES

TABLES



UNDERWATER INSPECTION

1.1 INTRODUCTION. This chapter describes the portion of the specialized inspection program dealing with underwater structures of waterfront facilities. Inspection of waterfront facilities involves the application of special skills, equipment and techniques to examine underwater structures. The inspection requirements are similar to those for other structures, but the methods differ considerably. This program will recommend that the high mission priority facilities receive uniform inspections at intervals commensurate with facility age, construction, and location. As funding permits, baseline inspections will be conducted at every activity with waterfront facilities. The program is also available for use by activities conducting locally funded inspections.

1.1.1 Responsibility. Activities are responsible for the inspection and maintenance of facilities under their jurisdiction. They are also responsible for detailed underwater surveys and the design of all repair work identified by the underwater inspection report. MO-322 Volumes 1 and 2 provide guidance for the inspection of shore facilities. The Naval Facilities Engineering Command (NAVFACENGCOM) is assigned the responsibility for the centrally funded underwater waterfront inspection program and to support activities carrying out their facilities inspection responsibilities. The activity provides drawings, pile plans, logistics coordination, and other support needed to facilitate the inspection. The NAVFACENGCOM expertise for underwater inspections of waterfront facilities is Chesapeake Division (Code FPO-1) which is responsible for the performance of inspections and for providing assistance to the activity upon request.

1.1.2 Function. The objectives of the specialized underwater inspection program are to supplement activity inspections of waterfront facilities at-d to document underwater waterfront facility conditions Navy-wide. Specific program goals are:

a. Perform underwater inspections and assess the condition of waterfront facilities.

b. Provide recommendations to activities and claimants on inspected facilities with the following information sufficiently detailed for initial facilities project documentation:

1. Component or subcomponent condition assessment.
2. Recommended interim load or use restrictions.
3. Maintenance and repair (M&R) requirements.
4. Estimated M&R costs for planning and budgeting.

To meet these goals, the specialized inspection program will:

a. Establish criteria for underwater inspections.

b. Establish and maintain standards for underwater inspection procedures, techniques, equipment, data required and reports.

c. Correct, update, and expand the Naval Facilities Assets Data Base and establish a computerized inventory of facilities in the underwater inspection program.

1.1.3 Scope. About 1385 waterfront facilities are to be inspected under the initial specialized inspection program. They fall into the following facility category codes:

Type Facility	Category Code
Piers	151-10 to 80
Wharves	152-10 to 80
Seawalls, Bulkheads & Quaywalls	154-10 to 30
Fleet Landings	155-10
Small Craft Berthing	155-20
Aircraft Docking Facilities	159-10
Degaussing Range	159-21
Landing Craft Ramp	159-66
Fixed Moorings	163-10 to 30
Breakwater	164-10
Groins and Jetties	164-20
Drydock[1]	213-10
Recreational Piers	750-61
Outdoor Monuments/Memorials	760-20
R R Bridge & Trestle2	860-30

[1]Includes only the Trident Drydock at TRF Bangor
[2]Selected number based on a case by case identification

1.2 INSPECTION FUNDAMENTALS. Underwater structures are selected for inspection based on their use, age, lapsed time since last underwater inspection, and type of construction. Piers, wharfs, bulkheads, seawalls and mooring platforms which directly support fleet operational units receive the **highest priority** for inspection by Chesapeake Division, FPO-1, Naval Facilities, Engineering Command.

1.2.1 Frequency of Inspection. Under most conditions, the recommended frequency for underwater inspection is six years.[3] In historically polluted waters which are being radically cleaned, all wood structures should be inspected every three years. In cases of obvious overload or structural damage, an underwater inspection should be made soon after discovery of the incident. Specialized inspections are originally scheduled according to mission and condition priorities as discussed in paragraph 1.2. The frequency of re-inspection depends on the type and material of Construction, water conditions, and the condition assessment. The most important of these is the construction material wood, steel, or reinforced concrete.

1.2.1.1 Wood Structures. Wood structures are prone to a variety of problems. Besides local activity of biological infestation as shown in Figure 1-1 on wood marine structures, there may be structural damage due to overloading, impact, abrasion, and loosening connections. In areas where marine animal infestation is, or has been a problem, the frequency of inspection is increased.

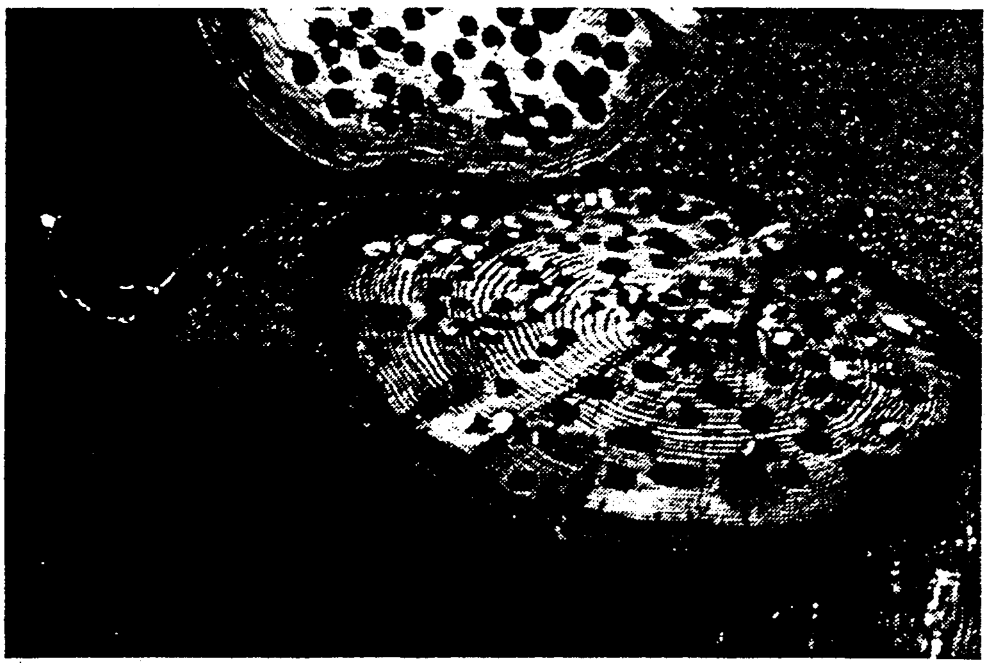


Figure I-I
Example of Marine Borer Attack

[3]NCEL is conducting research to better determine the rate of deterioration and optimum frequency for underwater structures.

1.2.1.2 Steel Structures. Steel Structures are prone to damage by corrosion as shown in Figure 1-2 and/or structural overloading. The age of the structure is the primary factor because the rate of deterioration due to corrosion is fairly constant. Steel quaywalls and bulkheads should be inspected more frequently when small holes or corrosion are discovered, especially at the mudline.

Figure I-2
Cleaning Reveals Extreme I-Beam Corrosion.

1.2.1.3 Concrete Structures. The factors affecting the deterioration of concrete structures are chemical effects, freeze-thaw cycling, overloading, mechanical damage, and age. Concrete in a saltwater environment deteriorates chemically with time. The surface spalling of concrete piles becomes significant to the structure/load bearing capability as the reinforcing steel becomes exposed and corrodes. Cracks due to overloading, impact, or installation are more significant; they allow saltwater direct access to the pile interior, therefore increasing deterioration.

1.2.2 Types of Underwater Investigations. The following are four types of underwater investigations. Chesapeake Division NAVFACENGCOM Code FPO-1 can provide assistance in scoping and conducting these types of inspections.

a. Routine Underwater Inspection.

1. Objective. To obtain data on general condition, to confirm and update drawings, and to make estimated cost of repairs for planning purposes.

2. Scope. The basic underwater inspection shall include a "swim-by" of all components of a facility and detailed examination of an engineered sample of components.

3. Funding. Routine underwater inspections will be conducted by the Chesapeake Division, Code FPO-1 and funded by Naval Facilities Engineering Command.

b. Underwater Engineering or Underwater Design Surveys.

1. Objective. To obtain data necessary for design, specifications, and detailed cost estimates.

2. Scope. -The underwater engineering and design surveys shall include necessary cleaning, detailed examination and measurements required for engineering repair or construction plans.

3. Funding. When an underwater engineering or design survey is required, it shall be initiated and funded by the cognizant activity or claimant.

C. Underwater Acceptance Inspection.

1. Objective. To confirm that repair or construction has been completed according to plans and specifications.

2. Scope. This underwater inspection shall include a detailed examination of all underwater components installed, repaired or replaced.

3. Funding. This service is available upon request from ROICC or activity on a reimbursable basis.

d. Underwater Research.

1. Objective. To obtain information for research projects such as the rate of deterioration.

2. Scope. Cleaning, detailed examination, and measurement of specified components is required.

3. Funding. This type of underwater investigation may be conducted in conjunction with other inspections when the additional work is funded.

1.2.3 Levels of Effort. The levels of effort for each type of inspection will vary and are divided into three categories:

Level I	General Inspection
Level II	Detailed Inspection
Level III	Highly Detailed Inspection

A cost effective inspection will utilize various levels of effort on different sections of the facility. This approach addresses numerous environmental conditions, construction methods, and structural designs along a structure's length, width, and depth. The typical routine underwater inspection will include 100% at Level I and a percentage of level II determined from engineered sampling and possibly from on-site changes resulting from observations made during the Level I effort. The Level III effort is normally a spot check only, unless problems are suspected in a particular structural member. Under all levels of effort, visual documentation (underwater television and/or photography) is included when possible to adequately document the findings representative of the facility condition.

1.2.3.1 Level I. The Level I effort is essentially a general inspection "swim-by" overview. It does not involve cleaning of structural elements which allows the inspection to be conducted rapidly. The Level I effort can confirm as-built structural plans and detect obvious major damage or deterioration due to overstress (collisions, ice), severe corrosion, or extensive biological growth and attack. The underwater inspector relies primarily on visual and/or tactile observations (depending on water clarity) to make condition assessments. These observations are made over the specified exterior surface area of the underwater structure whether it is a quaywall, bulkhead, seawall, pile or mooring. Although this is an overview, close attention should be given to confirming or providing information to update available facility drawings and condition evaluations.

1.2.3.2 Level II. Level II efforts are complete, detailed investigations of selected components or subcomponents directed toward detecting and describing damaged or deteriorated areas which may be hidden by surface biofouling (Figure I-2). Limited deterioration measurements are obtained. These data are sufficient for gross estimates of facility load capability. Level II inspections will often require cleaning of structural elements. Since cleaning is time consuming, it is generally restricted to areas that are critical or which may be typical of the entire structure. Simple instruments such as calipers and measuring scales are commonly used to take physical measurements (Figure I-3). Subjective judgements of structural integrity are occasionally made by probing wood with ice picks and by pounding concrete with hammers. A small percentage of more accurate measurements (Level III effort) taken with sophisticated-instruments may be required to statistically validate large numbers of simple measurements. Where the visual scrutiny, cleaning and/or simple measurements reveal extensive deterioration, a small sampling of detailed measurements will enable gross estimates to be made of the structure's integrity.

For example, on extensively corroded steel H-piles, a small percentage of piles receive ultrasonic thickness measurements to determine typical cross-section profiles. The cross-sections determined by these spot checks may be used to determine individual H-pile vertical load capability.

1.2.3.3 Level III. The Level III effort is a highly detailed and thorough investigation to detect the full extent of hidden or interior damage and the loss in material thickness (Figures 1-1 and 1-3). Recommendations for repairs are estimated based on the size of sample examined by a Level III effort. Detailed underwater engineering surveys or 100% Level III effort examination are required to obtain complete information for development of plans and specifications. Level III often rewires the use of Non-Destructive Testing (NDT) Techniques, but may also require the use of partially destructive techniques such as sample coring through concrete and wood structures, physical material sampling, or in Situ surface hardness testing. A Level III effort usually requires prior cleaning. The use of NDT techniques are generally limited to key structural areas, areas that may be suspect, or to structural members which may Se representative of the total structure.

Figure 1-3
Measurement of Steel Flange With Mechanical Calipers

1.2.4 Baseline Inspection. The initial inspection of a facility under the specialized inspection program is considered a "baseline inspection". The difference between the baseline inspection and follow-up periodic inspections is that the baseline includes significant pre-inspection efforts to obtain data documents and drawings. It also enables the activity to update and confirm current facility construction and configuration and to establish an accurate facility documentation. The activity should submit a copy of any underwater inspection obtained outside of the Special Inspection Program to CHESNAVFAVENGCOM. All this data will be recorded in a format suitable for entry into the data base. Once accurate drawings and data are on file, many of the documentation tasks need not be repeated in the follow-up inspections. This review and the perceived underwater condition are used to plan the inspection, i.e., determine the scope of the Levels I, II, and III inspection efforts required. Also, a Level I inspection will be used to confirm or update the available pile plans and drawings. Level II and possibly Level III inspections will enable these pile plans to be annotated as to the type inspection performed on each pile so that these drawings will then form a true "baseline" for the facility. These baseline drawings are included in the inspection report, and will be reused in subsequent inspections of the facility as the basis for the gradual building of a detailed condition history of the facility.

1.3 FACILITY INSPECTION. In order to achieve the objective of performing baseline inspections on every facility in the program, priorities are established as described in para. 1.2. Based on preliminary cost estimates for inspections, the highest priority facilities will be planned for accomplishment within available funding. Inspections may be sponsored and funded by the activity, claimant or NAVFACENGCOM. NAVFACENGCOM will coordinate contracts or Navy Underwater Construction Team (UCT) efforts for maximum efficiency. Concurrence will be obtained from the Public Works Offices (PWO's) or Staff Civil Engineers (SCE) at all the activities targeted for inspections. Mutually agreeable support arrangements are negotiated and the specific facilities to be inspected are identified. The NAVFACENGCOM Engineer-in-Charge (EIC) will coordinate inspections with the activity operations officers to best fit ship berthing schedules and activity requirements. In addition, the Engineer-in-Charge (EIC) is assigned the responsibility to manage, administer and coordinate all items related to underwater inspection performed from planning through on-site acceptance to review the final report.

1.3.1 Planning. During the initial planning period, facility data will be requested to supplement the data on hand. This data. which is required to perform inspection cost estimates and initiate A&E contracting, includes pile plans, plan views of bulkheads and quaywalls, typical cross sections, bathymetric charts, descriptions of structural materials, (sizes and shapes), water clarity, facility usage, last dredge date, control inspection records, previous underwater inspection or engineering studies; maintenance information, AIS, and repair history. It is necessary to start the information gathering process at an early stage of planning, since it is a time consuming process and is vital to cost estimating and preparation of the Scope of Work. To minimize cost and time, a site survey of the activity and facilities is conducted when funds and manpower are available prior to the planning effort. A site survey will accelerate the planning processes and a study of the facilities data will determine the level of inspection required.

1.3.2 Scope-of-Work. The scope-of-work is specifically tailored for each facility. The inspection procedure described in the scope-of-work, is determined by such factors as the type of material and construction of the facility, as well as its apparent condition. Sufficient flexibility is planned into the inspection so that procedures can be altered on site if significant differences exist between the findings and the expected condition. The inspection confirms or updates the as-built drawings and provides detailed measurements of the structural elements for assessment of the structural condition. The levels of effort, the number of measurements, and the extent of structural analysis are primary decisions that must be made in planning the inspection. The procedure at each facility is to first perform a Level I "swim-by" visual inspection from the splash zone to the mudline. Then, a portion of each facility is cleaned and inspected more closely; some sections visually and others with instruments. The extent and type of cleaning, visual examination, and structure measurements are dependent on function, use, M&R history, known biofouling and deterioration, water depth and temperature, and structure accessibility.

1.3.2.1 Detailed Inspections. The scope-of-work generally specifies the number of piles (bearing and batter) and the net surface area of bulkheads which are to be cleaned and inspected. It is desirable, to select the piles to be inspected so that all facility sections with expected similar physical conditions and/or similar degrading influences will be represented. Some areas, such as the perimeter piles where degradation is commonly high, warrant total representation. In parts of a facility where there are consistent degrading factors in a concentrated area such as chemical effluent discharges or stray electrical fields; a high percentage, if not all, of the piles should be inspected. When all components cannot be inspected, engineered sampling techniques shall be used.

1.3.2.2 On-Site Adjustments. Although each statement-of -work is prepared with sufficient detail to identify the quantity of piles or bulkheads to be cleaned and examined, the specific method of selecting samples may have to be determined or revised on-site. Areas to be photographed aredetermined on-site by the dive team leader with the Engineer-in-Charge (EIC). Procedures should be altered on-site if significant differences in inspection conditions are found.

1.3.2.3 Joint Efforts. For inspections which are performed by contract and in-house efforts, the statement of work is supplemented with an execution plan for the in-house work. These documents specify: the role of each; specific tasks for each; the equipment each will need; where responsibilities overlap and are separate; and their schedules.

1.4 GENERAL DIVING OPERATION. In accordance with SECNAVINST 12000.20, all commercial (A&E) diving operations are conducted in compliance with rigorous commercial safety standards. All Underwater Construction Team (UCT) diving operations follow Navy procedures. Where an inspection is performed as a joint A&E and UCT operation, the UCT will normally perform the majority of the visual inspecting, cleaning, and data measuring. The A&E, UCT leader and the EIC will review and agree on the type and quality of data required. The EIC will plan, coordinate and monitor the inspection and the following structural assessment and report. The A&E will perform the assessment and write the report with the EIC's guidance and approval. Most parts of the inspections are routine and performed by non-engineer divers who will note structural areas warranting closer and/or expert scrutiny. An engineer-diver is usually available on site to inspect and take measurements at critical or significantly deteriorated areas.

1.4.1 Personnel Qualifications. The subjective judgement of the diver is important because of the extensive reliance on visual examinations of structures. Only small percentages of structural members in critical areas are spot checked with cleaning and measurements. Accordingly, A&E's are required to have at least one engineer diver, preferably a licensed Professional Engineer with a degree in civil or structural engineering. All A&E divers shall be:

a. Trained and certified for scuba diving and surf ace air.

b. Skilled in the use of state-of-the art inspection equipment, including a broad range of viewing, cleaning, and measuring equipment.

All military divers and government civilian divers participating in underwater inspections shall be graduates of Navy dive schools and certified by the Navy for SCUBA diving.

1.4.2 General Inspection. The first in-water effort of each inspection is the Level I effort, which is a swim-by where divers visually examine structural elements from the splash zone to the mudline, observing the general conditions and noting damage and deterioration. The route of the divers in performing the Level I effort can greatly affect the cost and effectiveness of the inspection and is dependent on water clarity and depth. In very clear water it is most efficient for Level I inspections to be performed by two divers swimming transversely across pile bents at different elevations and spaced apart at the maximum distance which allows observance of each other. In turbid water, the divers are forced to swim down one pile and up an adjacent pile. This is a slower procedure. In this condition tactile sensing becomes important. During the swim-by, the structural elements above the water line, up to and including the underside of decking, are observed and their general physical condition documented. Depth soundings are made at each facility and are also recorded. Because of the wide range of conditions which can influence the rate of inspection, the Level I rate, as shown in Table I-I, will vary roughly from 300 to 600 piles per day or from 500 to 1500 lineal feet of bulkhead.

Table 1-1
Typical Performance Rates for Inspection Tasks[1]

INSPECTION TASK	PILES			BULKHEADS
Swim-By	300-600 Piles/Day			500-1500 LF/Day
Cleaning	30-70 Piles/Day			500-1500 LF/Day
Cleaning Sample Rate	3-15% of All Piles			50-300 LF Intervals [2]
	Wood	Steel	Concrete	
Measurements	50-200 Piles/Day	30-60 Piles/Day	30-70 Piles/Day	500-1500 LF/Day
Measurement Sample Rate	5-15% of All Piles	3-10% of All Piles	3-15% of All Piles	50-300 LF Intervals [2]

NOTES: 1. Wide range of rates encompasses the combined effects of many influencing factors as delineated in paragraph 1.4.3.2. The effect of each of these factors on an inspection can vary drastically and must be evaluated to determine a resultant rate for the specific conditions of each inspection.

2. Small areas are cleaned at one or two elevations spaced apart at random intervals.

1.4.3 Structure Cleaning. Decisions are made on site regarding the selection of specific structural elements (such as piles) and specific areas on those elements to be cleaned and measured. These decisions will be based on actual conditions of structures and the environment, especially biofouling. Since the cleaning costs represent a large portion of the inspection costs, it is important to minimize cleaning time by the use of special tools. The methods of cleaning commonly used include:

a. Chipping hammer and chisel.
b. Wire brush.
c. Hydraulic rotary brushes, grinders and scrapers.
d. High pressure water jets.
e. Cavitation erosion jet.
f. Sand blaster.

1.4.3.1 Locations. Surfaces cleaned for measurements are required to be free of any corrosion accumulation or biofouling. Bare surfaces are required for most measurements and bright metal surfaces are needed for other measurement methods such as pulse echo ultrasonic thickness measurement. Deeply pitted metal may even require extensive metal removal to allow accurate measurements to be taken. As shown in Figure I-4, priority locations on structures for cleaning are: (1) mean-low-water (MLW) areas; (2) mud zone areas; and (3) mid-structure zone (between MLW and mud zone). The areas to be cleaned on piles are specified as bards approximately ten inches high. The entire perimeter of wood and of steel piles are usually cleaned and at least half of the perimeter of concrete piles are cleaned. Weld areas are cleaned to bright metal. On bulkheads the areas to be cleaned are designated as one-half square foot sections at two or three elevations for each station. The stations are located at specified lineal intervals along bulkhead.

1.4.3.2 Cleaning Effort. Experience has shown that the rate of cleaning varies roughly between a minimum of 30 and a maximum of 70 piles per day or between 500 and 1500 lineal feet of bulkhead. These figures are tabulated in Table 1-1. The effort required for cleaning and measuring can vary widely between inspections because of influencing factors including the following:

a. Water visibility, temperature, depth, and current
b. Type facility (pier, quaywall, seawall, bulkhead)
C. Facility size and age
d. Facility usage (inspection interference)
e. Structure materials and coatings
f. Type construction (cross bracing, pile spacing, pile splices, cellular sheet pile, old repairs)
g. Marine growth (type and quantity)
h. Corrosion
i. Cathodic protection systems (working, overdriven)

Since the cleaning is time-consuming and expensive, determination of the number of structural elements to be cleaned is important. The number of structural elements cleaned for any facility will be based on experience judgments until a scientific method is developed. A general range of the extent of cleaning required per structure is listed in Table I-I.

1.4.4 Structure Measurements. Determination of the effective cross-sectional area of sane piles is required to ascertain a reasonable approximation of the facilities structural load bearing capacity. A variety of tools and instruments are utilized during both Level II and Level III efforts to obtain measurements of wood, concrete, and steel piles. Typical values for the number of measurements/cleaning per day are tabulated in Table 1-1.

1.4.4.1 Level II. During Level II efforts, measurements are commonly made with scales, calipers, feeler gauges, ice picks and hammers. Probing wood piles, cross braces, or bulkheads with an icepick is crude, but fast and inexpensive. Similarly, pounding concrete structures with a hammer is used to judge by feel and sound how solid or hard the structure is. On soft concrete, the amount that can be broken away from a structure by a given number of hammer blows is another crude measure of hardness, but it is

PIER-WHARF & BULKHEAD QUAY WALL TERMINOLOGY

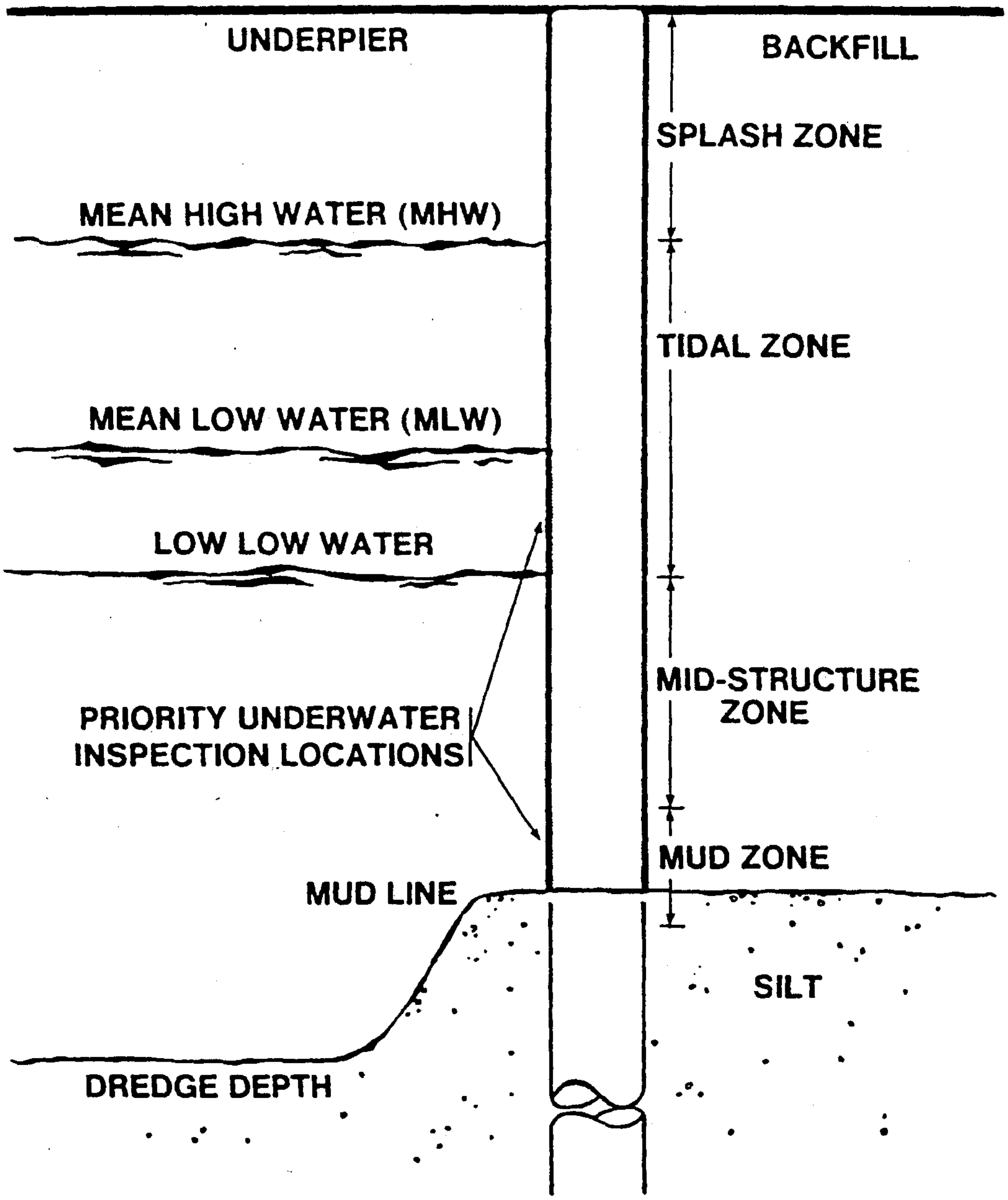


Figure 1-4
Pier/Wharf - Bulkhead/Quaywall Terminology

a destructive one. A newly developed underwater Schmidt hammer concrete hardness tester is becoming available to provide a better measure of surface compressive strength. The cross sections of steel H-piles can be measured more accurately than wood or concrete structures can with simple instruments.

1.4.4.2 Level III. Level III efforts are used when better data is desirable to perform structural assessments. A small sampling of more precise measurements are taken, where possible, with sophisticated instruments.

On steel H-piles and steel sheet piles, metal thickness measurements are made with a pulse echo ultrasonic thickness meter. Areas to be measured are cleaned so as to provide at least a square inch of smooth surface at each spot to allow the instrument's sensor to be held in direct firm contact with the metal. Many thickness measurements can be made rapidly once the cleaning has been done. Thickness measurements made with a pulse echo ultrasonic system will be made at a rate of 30 to 60 piles per day.

Measurements-in wood piles are performed with another type of ultrasonic transmission equipment. This system measures the undamaged cross-sectional area of wood piles in increments of fourths. One diver moves the transmitter and receiver sensor assembly around and up and down the piles fairly rapidly, while a meter at the surface, which is wired to the sensor, indicates the undamaged pile area and its elevation. Only the largest pile growth has to be removed, making this type of measurement very efficient.

With the exception of the hardness test, using the underwater Schmidt hammer, no specific quantitative methods are available to determine the structural integrity of concrete piles. Therefore, evaluating the physical properties of concrete underwater is limited to experience judgments with the use of simple instruments. The number of measurements per day used for concrete piles is also in the range of the effort used for cleaning alone. The number of measurements per day on concrete bulkheads is similarly considered to be in the same range as for cleaning bulkheads of all materials.

1.4.5 Photo Documentation. Color photographs are taken during the inspection to document facility configuration, representative damage or deterioration, both typical and extraordinary marine biofouling, pile splices or joints, cross-bracing and previous repairs. Photographs should include samples of structural members at the mudline, tidal zone, and midway between both areas. Turbid water conditions can be overcame for close-up photos by the use of clear water boxes and wide angle and close-up lenses. Underwater television can be useful to document general observations and to have a real-time display available on the surface. Color TV is preferable to black-and-white because the colors provide more distinction between types of corrosion and biofouling than do the shades-of-gray. However the video image lacks the resolution and color rendition qualities of still photography. Color TV should be used to augment color still photography rather than to replace it. Both types of visual records are useful to the structural analyst, particularly one who may not be part of the dive team.

1.4.6 Data Collection. Since industry practices for obtaining and recording underwater data vary, the collection of data is standardized as much as possible. A full set of updated drawings of the facilities and other necessary data is required by the inspection team. These include pile plan layouts and cross sections of typical bents. Throughout the inspection, notes are taken of all observations by the EIC as well as by the inspecting team. The inspectors maintain a daily log of the inspection details. The log clearly documents the exact location of all observations minimally showing relative elevation along the pile, water depth relative to MLW, and location of each pile on the pier as well as all measurement data. Specific test and measurement data are recorded manually in formats which are standardized for easy input to a computer data base system for the underwater inspection program.

The statements-of-work for inspections include standard data recording sheets and coding directions which enable inspectors to record a summary of the inspection results in a form directly transferable into the computer data base. Data base summaries are required for evaluations of waterfront facilities to determine readiness to meet fleet requirements.

The data base system will enable the following types of summaries to be rapidly executed and updated.

a. Facility data categorized by:
   1. EFD, major claimant or-activity
   2. Type material(s) or construction
   3. Age
   4. Geographic location

b. Set priority, frequency and date of future inspections based on most recent data.

C. Plan inspections so as to maximize utilization of available resources.

1.5 REPORTS. For each inspection performed, a report is prepared. The report describes the construction and physical condition of each facility inspected, the inspection procedure followed, structural assessments, maintenance and repair recommendations, and budget estimates of repair costs. Table I-2 is a typical report outline and format. The report provides sufficient technical detail to support structural assessments and recommendations.

1.5.1 Plans. The inspection report will provide significant information to update the latest facility drawing descriptions. These updates may be required to correct facility size, water depth, number of piles, and pile arrangement. The pile plans included in the report may be the only accurate record of the piles supporting a structure.

1.5.2 Assessment. Specialized inspection reports will provide a general assessment of conditions and will recommend downgrading, as appropriate, until recommended complete engineering investigations, structural analysis, design review, and detailed condition evaluation are conducted. The specialized inspection reports provide information for structural assessments based on damaged or deteriorated structural support elements of a facility. The vertical load capability of individual piles in a pier will be calculated and may be projected on a statistical basis to estimate a vertical load capacity of a section of a pier.

1.5.3 Condition Evaluation. The activity Commanding Officer has the responsibility to report the overall condition evaluation and to request an engineering structural analysis when required. Information in the specialized inspection report may not be adequate to determine the rating factor for the Activity's shore base readiness report. The specialized underwater inspection does not attempt to analyze lateral forces on the structure; however, if there is any doubt of the structural integrity, a recommendation will be made that a complete engineering investigation be made. The complete investigation should include both vertical and lateral load capability of the overall structure. If the activity does not have a qualified engineer to make a full structural analysis, an Engineering Service Request (ESR) should be forwarded to the geographical Naval Facilities Engineering Command Field Division requesting assistance. In addition to the defect descriptions in the underwater inspection report, the activity should provide other data such as ships to be berthed, wind, currents, waves and seismic conditions.

Table 1-2
UNDERWATER (U/W) INSPECTION REPORT OUTLINE

Report Cover (Government Furnished)
Title Page
Executive Summary (light blue paper)
Executive Summary Table (light blue paper)
Table of Contents
List of Figures
List of Photographs

Section	1.	Introduction
	1.1	Project Task Description
	1.2	Report Content
	1.3	etc.
Section	2.	Activity Description (Information that will effect inspection, repair, or rate of deterioration taken from Base Station Master Plan)
	2.1	Activity Location
	2.2	Existing Waterfront Facilities at Activity
	2.3	Climate
	2.4	Topography, Hydrology, Oceanographic Date
	2.5	etc.
Section	3.	Inspection Procedure
	3.1	Level(s) of Effort
	3.2	Inspection Pattern/Procedure
	3.3	Equipment
	3.4	etc.
Section	4.	Facilities Inspected
	4.1	Type Facility and Number
	4.1.1	Description
	4.1.2	Observed Inspected Condition
	4.1.3	Structural Condition Assessment
	4.1.4	Recommendations
	4.1.5	Conclusions
	4.2	Repeat as Necessary
Appendices		
	A	Field Notes
	B	Backup Data for Cost Estimates (gross)
	C	Backup Computations of Structural Analysis (sample)
	D	Measured Data (thickness measurements, etc.)
	E	Bibliography or any References