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·SUBSEA ENGINEERING · MARINE CIVIL CONSTRUCTION · COMMERCIAL DIVING SPECIALISTS·

Document Title:	**HCC Petone Wharf – Approach Structure** **– Pile Condition Survey & Reporting**
Document No.:	**UCL – 2021.01 – HCC Wharf Approach PCS&R001 – V2**
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Hutt City Council
Petone Wharf – Approach Structure
Pile Condition Survey & Reporting
January 2021

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Preface

Hutt City Council Wharves infrastructure and associated marine assets represents a major planning and engineering effort, and as such constitutes a massive investment of capital. For Companies and or Government Authorities to obtain the maximum working life and return on their initial investment from assets in a marine environment it is important that they be maintained to an acceptable and safe operational standard. To ensure the ongoing and safe operation of their asset it is necessary to complete infrastructure surveys, programmed maintenance, and subsequent to inspection findings; remedial works.

When marine civil works come into service, it is hoped that they are free of all significant faults. This of course depends on the rigour of the quality assurance of the numerous Parties involved in design, fabrication, construction, and installation.
Marine assets must be adequately maintained and indications of fault or weakness corrected before serious damage occurs.
To ensure a continuous working life for any asset, it is necessary to maintain an adequate inspection programme. Such a programme must be capable of detecting potential problems at an early stage. This allows the designers and engineers time to analyse the inspection information and suggest remedial action if required.

Experience has shown that the vast majority of all faults; damage / defects / deterioration found in marine assets and associated civil works have been done so visually. Visual information is of utmost importance both in programmed visual survey inspection, condition assessment, and general observations.
Throughout the progression of these survey inspections personnel observe and record data on numerous components in varying condition states.
The consequences of failure of what initially may only be a minor fault, especially sudden failure, can be catastrophic and very expensive, both in terms of repairs, lost business, and risks to health, safety and the environment.
Programmed survey inspections / condition assessment / asset audits are completed to ensure the continuing operational function and safe condition of marine assets are maintained. Providing the Asset Owner, its operators, and subsequently the users with an assurance of reliability and ensuring the integrity of the works.

Condition assessment is an important step in the life cycle management process of structures and other assets.
One of UCL's major facets of work and experience is in the inspections, condition assessment and reporting on numerous 'in-water' structures throughout New Zealand and Offshore. It is a facet of our work that we can derive immense satisfaction from; when being able to detect potential problems at an early stage, then work in partnership with Clients towards achieving common goals and economic solutions. Thus minimising risk and therefore maintaining the Clients valuable asset in safe and efficient working condition – "fit for purpose".

Asset Management

Asset management is a strategic, long-term approach which provides a foundation for improved operational performance and a sustainable business model.
The key benefits of Asset Management Planning are:

- Manage an asset throughout its lifetime and improve performance.
- Consider risks associated with costs and performance in all decisions.
- Help to improve organisational performance and achieve sustainable business objectives.
- Achieve tangible profits over time with optimised return on investment and / or growth.
- Be able to demonstrate to stakeholders, sensible utilisation of assets and associated risks and costs.
- Improve corporate reputation and credibility.

Asset Maintenance

“It needs to be recognised; to have an effective Asset Management Plan; you’re required to have an effective Asset Maintenance Programme”.

Over the past few decades, the desire of extending the useful service life of infrastructures has become of paramount significance. Where the ageing infrastructure is a serious problem faced by countries across the world, the premature deterioration has also emerged as the major problem that results in reduced service life of structures.
Structural elements are constantly subjected to multiple risk factors that result in deterioration over the course of their service lives.
Structural failure may be defined as the inability of a structure to serve its intended function with the desired levels of safety and serviceability.
Failure of a structure may be attributed to a number of independent and interrelated factors.

Asset condition assessments combine the processes of periodic inspection and testing and the assessment and interpretation of the resultant data to provide an indication of the current condition of a specific asset as to the determination of the requirement for remedial action.
Asset condition assessments determine the physical state of an asset that may affect the performance of the asset and the ability of the asset to provide the required level of service.

The benefits of knowing the current condition of an asset are:

- The ability to plan and manage the delivery of the required level of service of the asset.
- Avoiding premature asset failure by providing the option of cost effective remediation.
- Providing an accurate estimate of future expenditure that is required.
- Determination and refinement of maintenance and rehabilitation strategies.

Asset maintenance to be undertaken over the balance of structure service life is a major challenge to provide reliable and sustainable facility operation. Operating ageing facilities efficiently and safely requires an asset maintenance cycle to include inspection diagnosis, evaluation and implementation of remediation processes.
It is a critical part of asset management to determine the remaining lifecycle of an asset and the capability of the asset to meet the designed performance and level of service requirements.
In today’s environment, the preventative maintenance of ageing structures is much better than the cost of construction of new structures once original design lives have been exceeded. Asset Condition Assessment gathered information assists the determination of the remaining service life of an asset, the scheduling of remediation requirements that are required to reinstate the level of service that is provided by the asset to the desired standard.

Being unaware of the current condition of an asset may lead to the premature failure of the asset leaving limited options to the facility owner with replacement being the most expensive option. Unforeseen failure of an asset provides major consequences that constitute a risk to business operations or potential loss to the organisation. The benefits of knowing the current condition of an asset are the ability to plan and manage the delivery of the required level of service of the asset, avoiding premature asset failure providing the option of cost effective remediation, providing an accurate estimate of future expenditure that is required and the determination and refinement of maintenance and rehabilitation strategies.

Assessment of damaged or deteriorated structures should only be made by qualified and experienced people and the process of should always include the aspects of the condition of the structure including all visible, non-visible and potential damage and defects, a review of the past, current and future service functions / requirements.

With most damaged or deteriorated structures, the facility owner has a number of options which will effectively decide the appropriate remediation strategy that will meet the future service requirements of the structure. These options will include doing nothing, downgrading the capacity or functioning of the structure, preventing or reducing further damage without repair, improving, strengthening or refurbishing the structure, reconstructing all or part of the structure or demolishing the structure.

Proper remediation methodology begins with inspection and testing to identify the type and extent of defects and degradation mechanisms and the overall condition and quality of the structure. Remediation projects are prone to increasing in volume and costs once work has commenced – investing in comprehensive and accurate Asset Condition Assessments before remediation begins has proven cost effective in the long term.

Often there is limited information on “as built” with drawings and construction records being partial at best and more than often incorrect.
An understanding of structures is critical in being able to provide comprehensive reporting on all aspects of the construction envelope. Prior to diagnosing the causes of defects or failure within a structure it is important to understand that defects result from several factors: design, construction practices, materials, the environment, and loading applied to the structure.

The Asset Condition Assessment is intended to form the foundation for short-term maintenance strategies in which structural elements of the facility are prioritised aligned with the degree of deterioration and loss of function.

General and Overview

During 2 moderate rated earthquake events experienced in Wellington over the past month: 31st December 2020 (4.5 Magnitude) and 02nd January 2021 (4.2 Magnitude), a number of already deteriorated / weakened timber piles designed to support the Walkway Approach to the outer Petone Wharf failed in a catastrophic manner. These pile failures resulted in the partial collapse of several upper sections of the Approach Structure (e.g. Cap Beams, Stringer Beams, Walkway Deck).
Initial inspection observations find the structures condition and extent of the damage to be significant; and as common with damage in aging structures, there remains an extremely high risk of major loss if exposure to a further earthquake or major storm event were to occur prior to sufficient remedial works being completed to secure and make safe the structure before such a potential event.
Following brief discussions on the Project task objectives between personnel from Calibre Group, Hutt City Council (HCC), G.K. Shaw Ltd. (GKS) and Undersea Construction Ltd. (UCL) in respect to completing a Pile Condition Assessment Survey of the Petone Wharf Approach Structure timber piles; a Scope of Works was agreed to, as to was approval to proceed with the work.
The emphasis of the underwater inspection being to assess the condition of the timber piles: observing and reporting on any fault: defect / damage / deterioration – that has or could potentially have a detrimental effect on the existing or future service life of the pile and the safe operational working life of the wharf as a whole.

Constructed in 1908 Petone Wharf is built from heavy Australian Hardwood Timbers.
The Wharf is a timber structure, typical of its construction era, with its main structural members composed of rows of piles driven into the seabed, braced and connected with timber wale, diagonal, and cap beams and longitudinal stringer beams that support the upper timber / concrete deck.

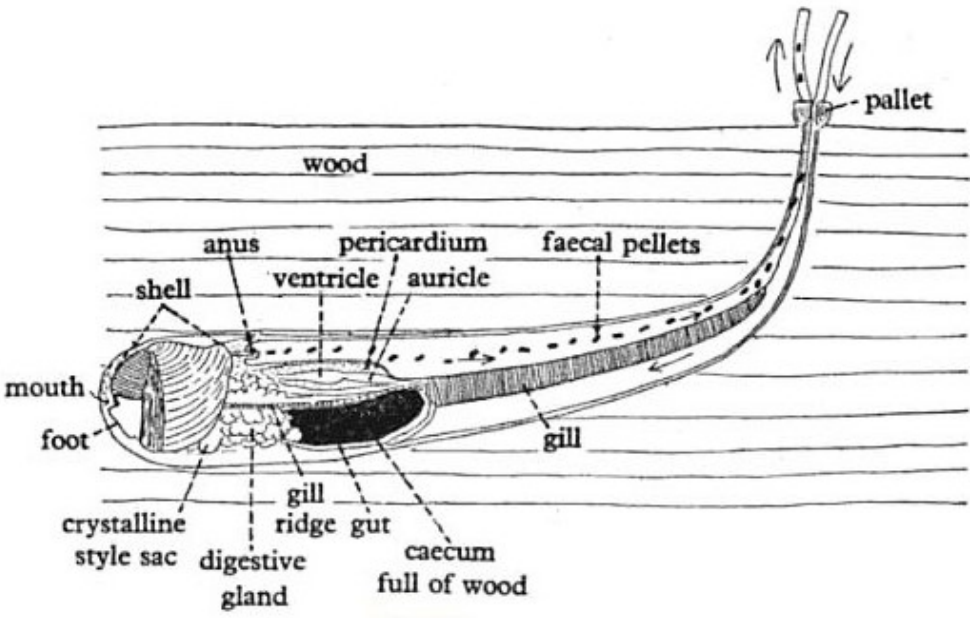
Hardwood timber piles, wales, and diagonal braces (submerged timber components) at Petone Wharf, as with a major percentage of water-borne timber structures internationally are attacked by marine borers.
At Petone Wharf the Molluscan Borer **Teredo** ('shipworm') is primarily responsible for greatest amount of damage to the timber piles; and while also present but causing damage to a far lesser extent the Crustacean Borer **Limnoria** ('gribble' or 'sea-louse').
The burrowing of molluscan (Teredo worm) and crustacean (Limnoria sea gribble) organisms that inhabit saline waters are responsible for the most severe damage of piles in marine environments.
Teredo borers enter through minute holes when young, destroying the host wood as they grow.
The borers are found throughout the oceans of the world. Salinity, temperature, current action, depth of water, pollution, pH value, dissolved oxygen, and sulphuretted hydrogen, all affect the presence or absence of borers.

Teredo 'shipworms' are marine bivalve molluscs: belonging to a group of saltwater clams with long soft worm-like bodies. The colour of the Teredo species that inhabits Wellington waters is milky white when the wood is opened to expose the clam. Teredo are notorious for working with extraordinary speed, excavating long cylindrical tunnels (and commonly eventually destroying) wood that is immersed in seawater. The wood is reduced to sawdust by the rotatory action (rasping) of the two shell valves, in which the adductor muscles fibres maintain a rhythmical contraction. The sawdust is shallowed by the animal and is largely retained in a relatively enormous caecum of the stomach; but a great deal of the material passes into the cavity of the digestive gland, where ingested by the epithelial cells. Unlike other typical clams, the shell covers only a small portion of the Teredo and used more like a drill bit to burrow a circular hole through wood. The tube-like home is capped at the opening of the burrow with a secreted calcareous cover, with protruding siphons that allow the animal to breathe, feed on plankton and excrete

wastes. It appears that the Teredo lives out its life within its tunnel home, continuing to extend its burrow.

Teredo (shipworm)

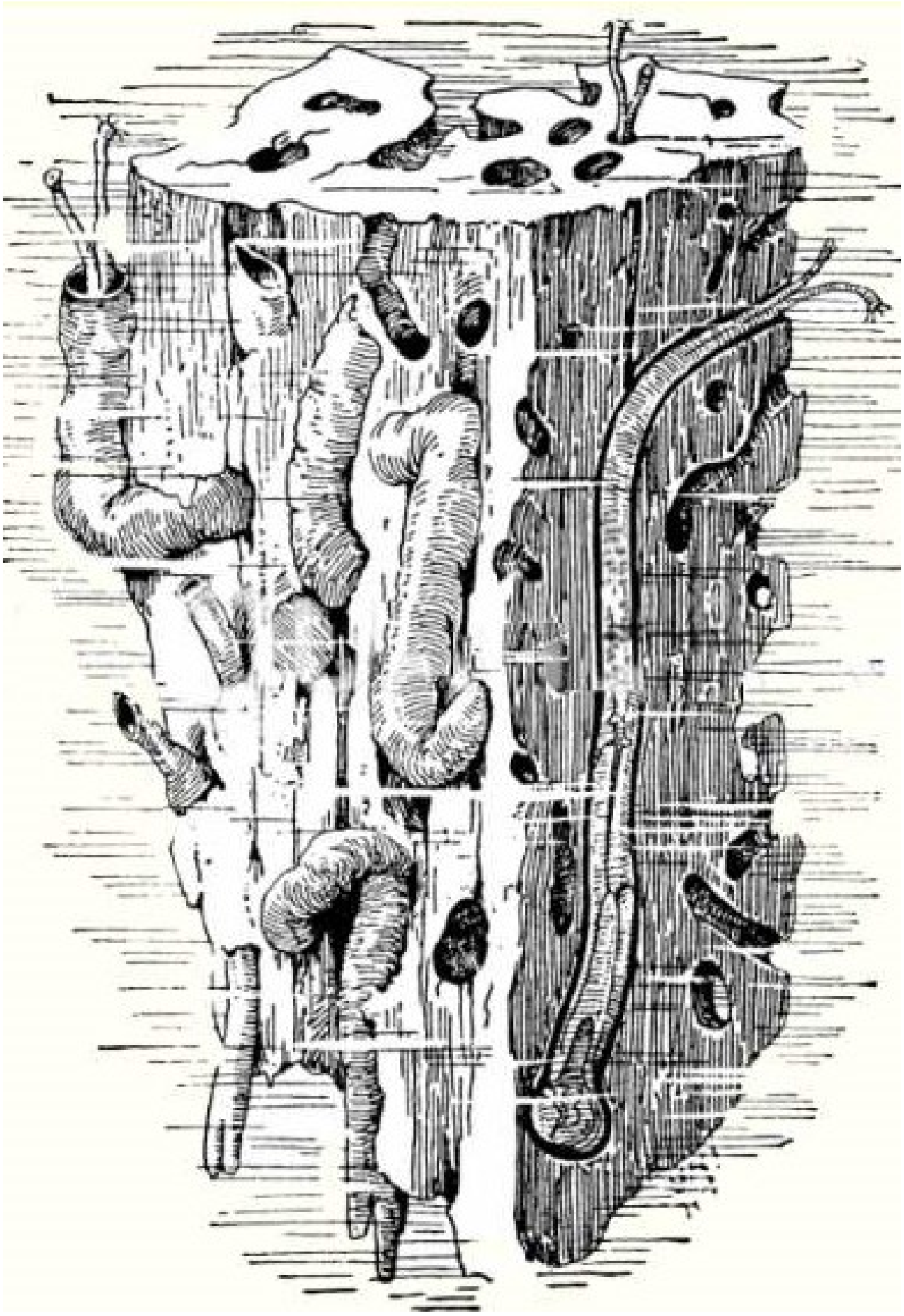
The secreted calcareous wall of the tunnel remains soft while wet, however rapidly hardens as the substance dries



Teredo boring into wood. Sawdust formed by the rotating movement of the shell enters the mouth, and faecal pellets of undigested wood are sent out via the exhalant chamber. The arrows indicate the direction of water current

Example (from Petone Wharf) of how the Molluscan Borer ‘Teredo’ damages the hardwood timber piles internal integrity by significantly reducing the piles strength and mass

Teredo worm actively destructing a timber pile



An illustration displaying Teredo infestation and destruction of submerged wood

Scope of Work

- Discuss Client objectives and then formulate a survey plan.
- Produce and submit UCL HS&E documentation for review by Client.
- Submit Worksafe NZ Notification of Work (Diving – Notifiable Work).
- Job specific and environmental analysis (JSEA), task methodology, site specific risk assessment, hazard analysis, and all proposed controls.
- Equipment preparation.
- Use drawings provided for reference to pile layout details.
- Hand clear sufficient marine growth from piles to allow accurate visual assessment.
- Complete visual condition assessment inspection survey of all timber piles; from upper inter-tidal zone to seabed.
- Log all data and any other observations relevant to the process.
- Photograph significant deterioration / damage as observed in timber piles.
- Compile and submit a report of all inspection findings.

Inspection Process

Working from the shoreline and wharf Divers carried out pile condition assessments of the Petone Wharf Approach Structure timber piles. Using hand-tools to clear sufficient amassed marine growth to complete accurate assessments; visually inspecting each pile, monitoring the inspection component general condition, and surveying for any evidence of loss or partial loss of function, damage, defects or deterioration.
Logging positions, and photographing evidence of all pile damage (of a significant nature), and then reporting findings / observations back to the Projects Client and other involved Parties.

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P. O. BOX 31081,
LOWER HUTT 5040
NEW ZEALAND.

DAILY RECORD OF INSPECTION OR NDT

DATES OF DIVES: 05, 12, 13, 15, 21 & 22nd January 2021
INSPECTION PERSONNEL: Wayne Angus, Rian Kriel
CLIENT: Hutt City Council c/- Calibre Group
LOCATION: Petone Wharf, Wellington Harbour
INSPECTION COMPONENT: Petone Wharf – Approach Structure – timber piles

TYPE OF DIVE:

SCUBA	SURFACE SUPPLY	MIXED GAS	OTHER
X			

DIVE DETAILS: (multiple dives to varying depths over the duration of the Survey)

	DIVE 1	DIVE 2	DIVE 3	DIVE 4
MAXIMUM DEPTH OF DIVE	Various	Various	Various	Various
BOTTOM TIME (minutes)	Various	Various	Various	Various

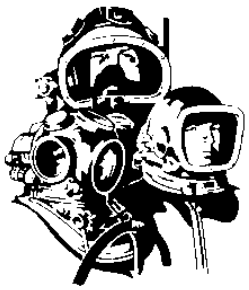
METHOD	CHECK	PARTICULARS / EQUIPMENT
CLEANING		
TECHNIQUES:	X	Hand-tools to clear amassed marine growth from piles
SAMPLING		
TYPE:		
VISUAL INSPECTION		
GENERAL SURVEY:	X	Visual assessment of timber piles; checking for evidence of damage / deterioration
STILL PHOTOGRAPHY:	X	Photograph damaged / deteriorated piles
VIDEO SURVEY:		
NDT		
POTENTIAL MEASUREMENT:		
DIMENSIONAL SURVEY:		
REMEDIAL GRINDING:		
M.P.I.:		
ULTRASONIC:		
OTHER:		

ANY OTHER REMARKS: Refer to this Report for result detail.

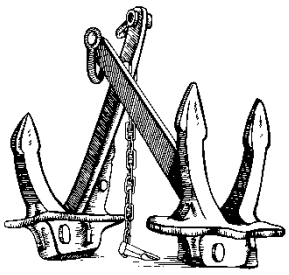
APPROVED

NAME OF SUPERVISOR: Wayne Angus
SIGNATURE: *W. T. Angus*
DATE: 23rd January 2021

NAME OF CLIENT'S REP: Tom Arthur
SIGNATURE:
DATE:



"To solve it easily, detect it early"



Pile Condition Ratings

Use of Condition Grading Standards

Each rating is based on the generic format below:

Condition	General Meaning
Satisfactory	Acceptable physical condition; previous repair / FRP jacket installed, or, minimal short term failure risk, however deterioration of timber is evident *Only minor work required (if any at all) to rehabilitate – e.g. small Epoxy Plug*
Fair	Moderate deterioration evident; failure unlikely in near short-term, but further progression of deterioration highly likely *Work required but Pile remains serviceable – e.g. continue to monitor / consider FRP jacket if further deterioration in short term is going to advance the pile rating to Poor*
Poor	Deterioration is entering advanced stage. Further loss of piles ability to maintain loadings is likely to result in pile failure within short-term *Work required within short-term if Pile is to remain serviceable.* *– e.g. FRP jacket / stump repair*
Very Poor	Failed or failure imminent / immediate safety risk *Significant work required urgently* *e.g. – Pile stumping and FRP jacket / renew Pile*

Table 1: Pile Condition Ratings

The assessment is based on current physical condition; as surveyed by Engineer / Surveyor Diver visual observations.

IMPORTANT NOTE: the inspection data contained within this documents following section provides Pile loss of section percentages; these figures account for external wastage. It's extremely important to recognise that these figures **do not** account for the additional internal loss of timber mass within the piles, resulting from Teredo worm hole boring.

Inspection Observations

IMPORTANT NOTE: the following Table 2 only covers Condition Assessment observations for the timber piles supporting the Wharf's Approach Structure; it does not include any of the piles that are part of the outer wharf structure.

Petone Wharf – Approach Structure – timber piles condition assessments

Bent	Pile / Row	Condition Rating	Existing Repair	Recommendation	Comment
6	C	Satisfactory			Satisfactory condition
	D	Satisfactory			Satisfactory condition
7	C	Fair		Consider future protective wrap	Timber weathered. Top-end splitting
	D	Fair		Consider future protective wrap	Timber weathered. Top-end splitting
8	C	Fair		Consider future protective wrap	Timber weathered. Top-end splitting
	D	Fair		Consider future protective wrap	Timber weathering. Top-end splitting
9	C	Fair		Consider future protective wrap	20% loss of section within tidal zone
	D	Fair		Consider future protective wrap	10% loss of section within tidal zone
10	C	Fair		FRP Jacket (3.0 metre length jacket cut in ½ to provide 2 jackets)	40% loss of section within tidal zone
	D	Fair		FRP Jacket (3.0 metre length jacket cut in ½ to provide 2 jackets)	15% loss of section within tidal zone
11	C	Fair		Epoxy capping to reduce further advances in deterioration. Consider future protective wrap	Moderate hollowing and decay in top-end
	D	Fair		Epoxy capping to reduce further advances in deterioration. Consider future protective wrap	15% loss of section within tidal zone. Top-end splitting with minor decay

12	C	Fair		Consider future protective wrap	20% loss of section within tidal zone
	D	Fair		Epoxy capping to reduce further advances in deterioration. Consider future protective wrap	10% loss of section within tidal zone. Moderate hollowing and decay in top-end
13	C	Fair		Consider future protective wrap	10% loss of section within tidal zone
	D	Fair		Epoxy capping to reduce further advances in deterioration. Consider future protective wrap	10% loss of section within tidal zone. Moderate hollowing and decay in top-end
14	C	Fair		Consider future protective wrap	15% loss of section within tidal zone
	D	Poor		Stump repair	60% loss of section within tidal zone. Severe hollowing
15	C	Poor		FRP Jacket	50% loss of section within tidal zone
	D	Fair		Consider future protective wrap	20% loss of section within tidal zone
16	C	Very Poor		Stump repair	Broken pile
	D	Very Poor		Stump repair	Broken pile
17	C	Poor		FRP Jacket	40% loss of section within tidal zone
	D	Satisfactory	FRP Jacket 2017 repair		Satisfactory condition
18	C	Poor		Stump repair	50% loss of section within tidal zone
	D	Poor		Stump repair	60% loss of section within tidal zone
19	C	Fair		Consider future protective wrap	20% loss of section at seabed
	D	Fair		Consider future protective wrap	10% loss of section at seabed
20	C	Fair		Consider future protective wrap	10% loss of section at seabed
	D	Fair		Consider future protective wrap	10% loss of section at seabed

21	C	Satisfactory	FRP Jacket 2017 repair		Satisfactory condition
	D	Fair		Consider future protective wrap	15% loss of section within tidal zone
22	C	Fair		Consider future protective wrap	15% loss of section within tidal zone
	D	Poor		Stump repair	60% loss of section at seabed
23	C	Very Poor		Stump repair	Broken pile
	D	Satisfactory	FRP Jacket 2018 repair		Satisfactory condition
24	C	Poor		FRP Jacket	35% loss of section within tidal zone
	D	Poor		FRP Jacket	50% loss of section within tidal zone
					NOTE: For the purpose of positional recognition; Bent 25 is the shoreward facing Bent of the Wharf Approach's Cart Stop section
25	C	Poor		Stump repair	40% loss of section within tidal zone. Severe hollowing
	D	Poor		Stump repair	60% loss of section within tidal zone
	F	Satisfactory	FRP Jacket 2018 repair	Install splitter bolts to top-end timber	Satisfactory condition.
26	C	Fair		Consider FRP Jacket – as wale & diagonal braces will require removal for 26F stump repair	20% loss of section – lower tidal zone
	D	Fair		Consider FRP Jacket – as wale & diagonal braces will require removal for 26F stump repair	20% loss of section – lower tidal zone
	F	Poor		Stump repair	60% loss of section – lower tidal zone
27	C	Very Poor		Stump repair	Broken pile – at seabed
	D	Very Poor		Stump repair	Broken pile – at seabed
	F	Satisfactory	FRP Jacket 2018 repair		Satisfactory condition

28	C	Very Poor		Stump repair	Broken pile – at seabed
	D	Very Poor		Stump repair	Broken pile – at seabed
29	C	Very Poor		Stump repair	Broken pile – at seabed
	D	Very Poor		Stump repair	Broken pile – at seabed
30	C	Poor		FRP Jacket	40% loss of section – lower tidal zone
	D	Poor		FRP Jacket	50% loss of section – lower tidal zone
31	C	Poor		FRP Jacket	40% loss of section – lower tidal zone to seabed
	D	Poor		Stump repair	60% loss of section – at seabed
32	C	Satisfactory	FRP Jacket 2018 repair		Satisfactory condition
	D	Fair		Review: wrap or possible stump repair	25% loss of section – lower tidal zone. Hammer test returned dull sound: indicates internal hollowing
33	C	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone to seabed
	D	Fair		Consider FRP Jacket	20% loss of section – lower tidal zone
34	C	Poor		FRP Jacket	35% loss of section – lower tidal zone to seabed
	D	Fair		Consider FRP Jacket	30% loss of section – lower tidal zone
35	C	Poor		FRP Jacket	40% loss of section – lower tidal zone
	D	Fair		Consider FRP Jacket	20% loss of section – lower tidal zone. Failed wale beams require removal
36	C	Poor		FRP Jacket	35% loss of section – lower tidal zone. Moderate hollowing
	D	Fair		Consider FRP Jacket	30% loss of section – lower tidal zone
37	C	Poor		FRP Jacket	45% loss of section – lower tidal zone to

					seabed
	D	Poor		FRP Jacket	35% loss of section – lower tidal zone
38	C	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone
	D	Poor		Review: wrap or stump repair	35% loss of section – above tidal zone. Moderate hollowing & decay
39	C	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone
	D	Fair		Consider FRP Jacket	30% loss of section – lower tidal zone
40	C	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone
	D	Fair		Consider FRP Jacket	20% loss of section – lower tidal zone
41	C	Fair		Consider FRP Jacket	20% loss of section – lower tidal zone
	D	Fair		Consider FRP Jacket	20% loss of section – lower tidal zone. Minor top-end decay
42	C	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone
	D	Poor		FRP Jacket	30% loss of section – lower tidal zone. Failed wale beams require removal
43	C	Poor		FRP Jacket	35% loss of section – lower tidal zone
	D	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone
44	C	Poor		FRP Jacket	40% loss of section – lower tidal zone. Top-end splitting
	D	Satisfactory	FRP Jacket 2018 repair		Satisfactory condition
45	C	Fair		Consider FRP Jacket	20% loss of section – lower tidal zone
	C1 (inner)	Fair		Consider FRP Jacket	25% loss of section – lower tidal zone
	D1 (inner)	Very Poor	Redundant	No repair	Broken pile – tidal zone
	D	Poor		Review: FRP Jacket	Moderate hollowing within tidal zone

46	C	Fair		Consider FRP Jacket	Satisfactory condition
	C1 (inner)	Very Poor	Redundant	No repair	Broken pile – tidal zone
	D1 (inner)	Poor		Review	50% loss of section – lower tidal zone. Moderate hollowing
	D	Fair		Consider FRP Jacket	Satisfactory condition
47	C	Fair		Requires epoxy plug – upper tidal zone. Consider FRP Jacket	Satisfactory condition
	C1 (inner)	Fair		Review	30% loss of section – at seabed. 40% loss of section – lower tidal zone
	D1 (inner)	Fair		Review	40% loss of section – 2M above seabed
	D	Fair		Consider FRP Jacket	Satisfactory condition

Table 2: Wharf Approach Section – Pile Condition Assessment Results

Photographic Gallery

Pile 10C: Fair Condition – 40% loss of section within tidal zone

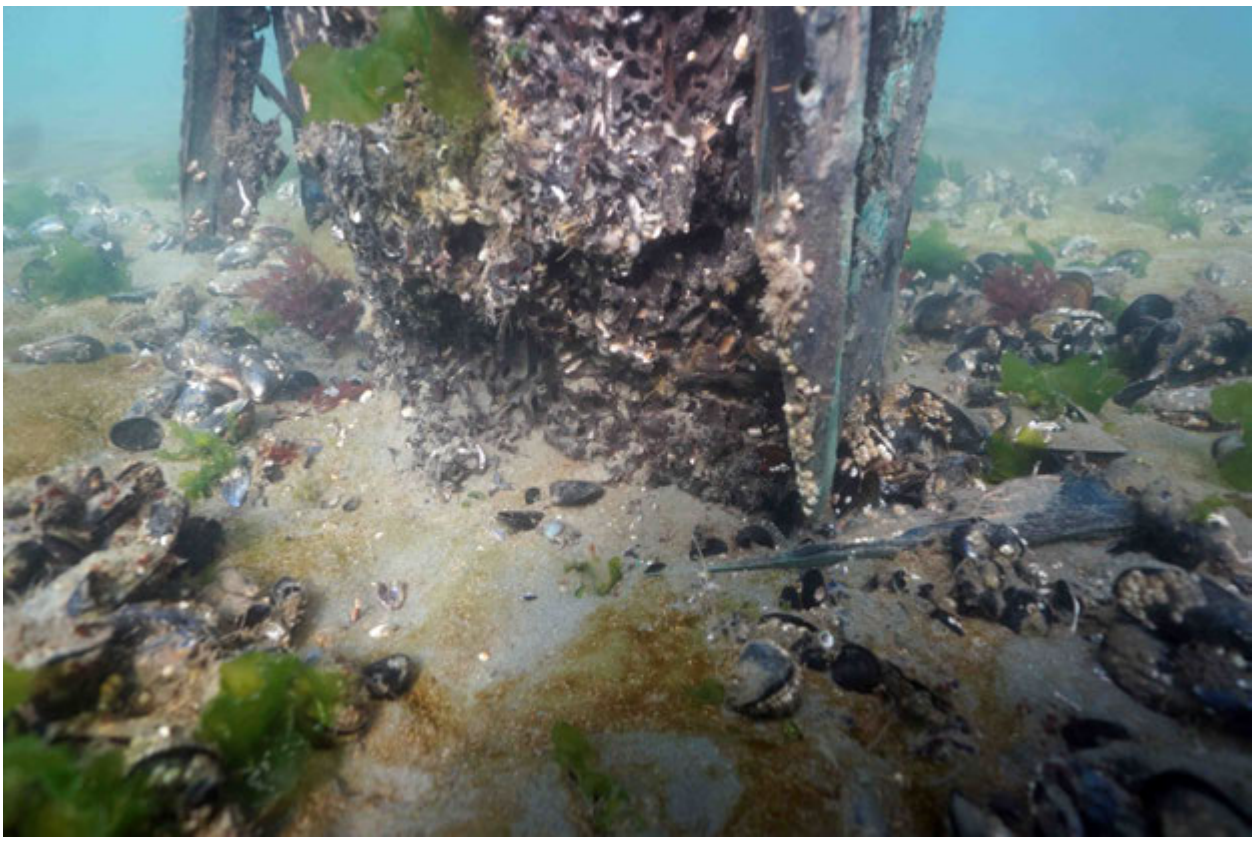
Pile 14D: Poor Condition – 60% loss of section within tidal zone. Severe hollowing

Pile 15C: Poor Condition – 50% loss of section within tidal zone

Pile 16C: Very Poor Condition – broken pile – FRP stump repair completed 13/01/2021

Pile 16D: Very Poor Condition – broken pile

Pile 18C: Poor Condition – 50% loss of section within tidal zone



Pile 18D: Poor Condition – 60% loss of section within tidal zone

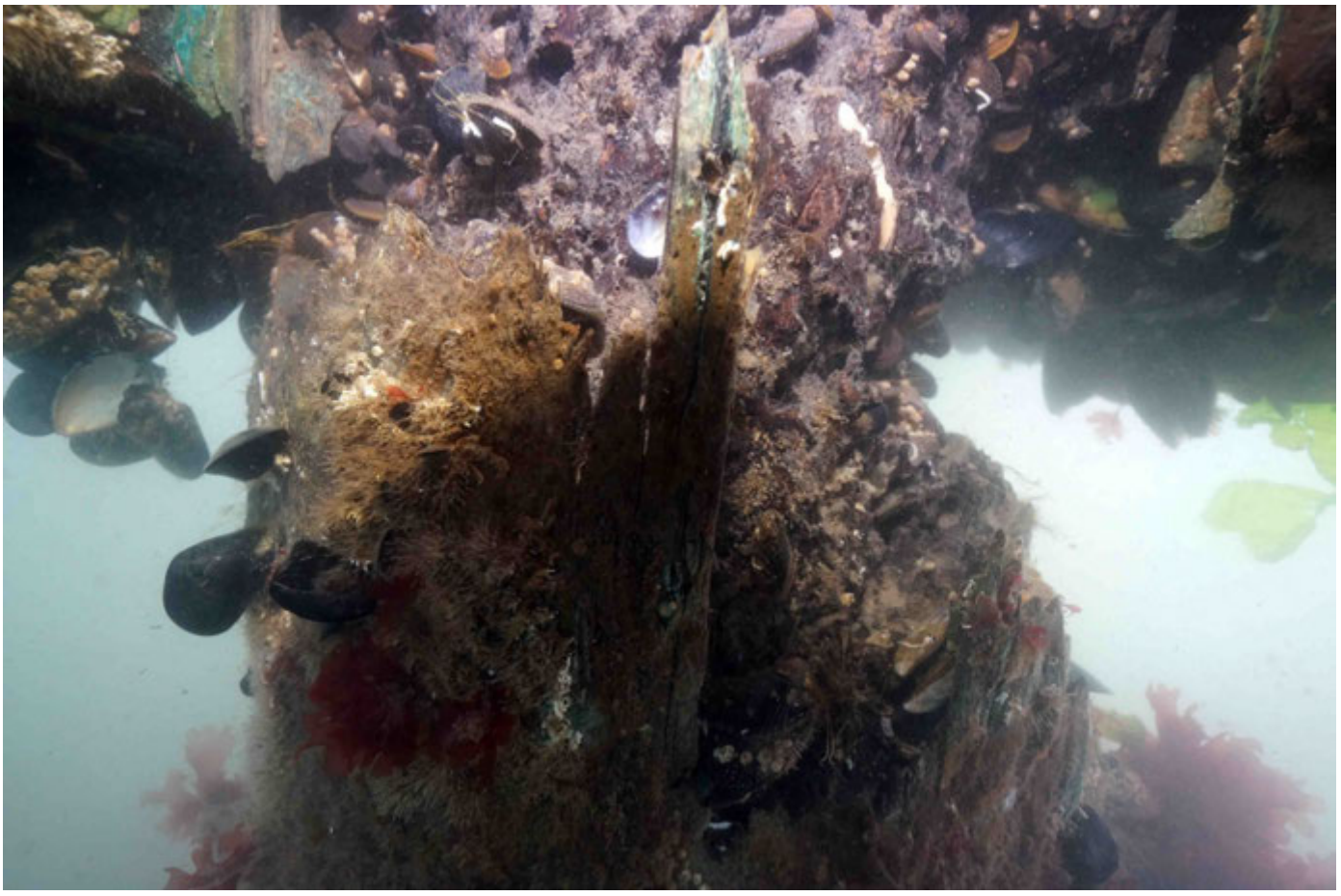
Pile 22D: Poor Condition – 60% loss of section at seabed

Pile 23C: Very Poor Condition – broken pile

Pile 24D: Poor Condition – 50% loss of section within tidal zone

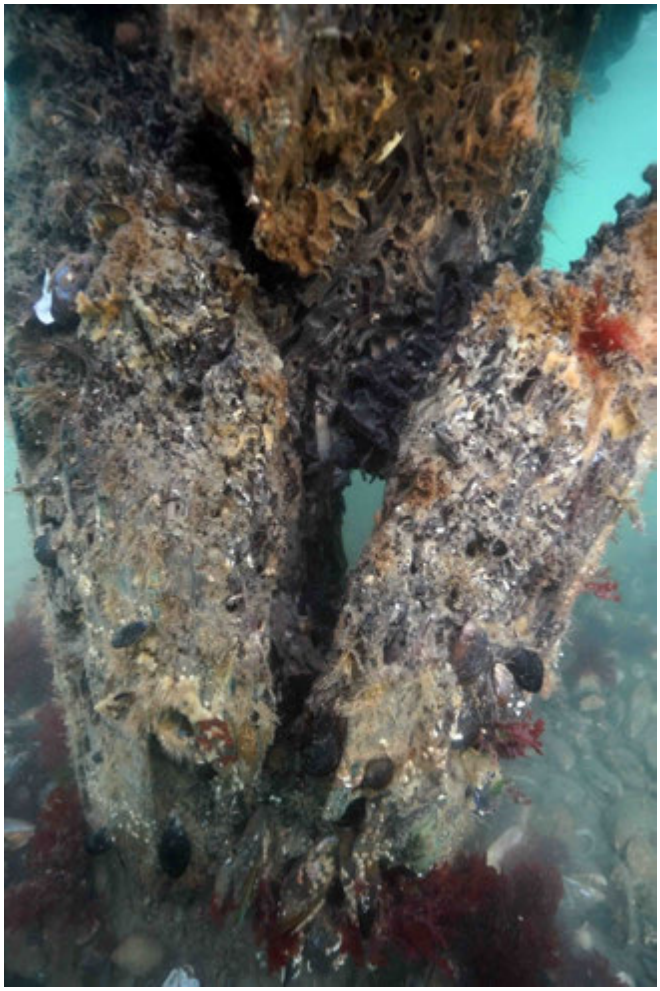
Pile 25C: Poor Condition – 40% loss of section within tidal zone. Severe hollowing

Pile 25D: Poor Condition – 60% loss of section within tidal zone



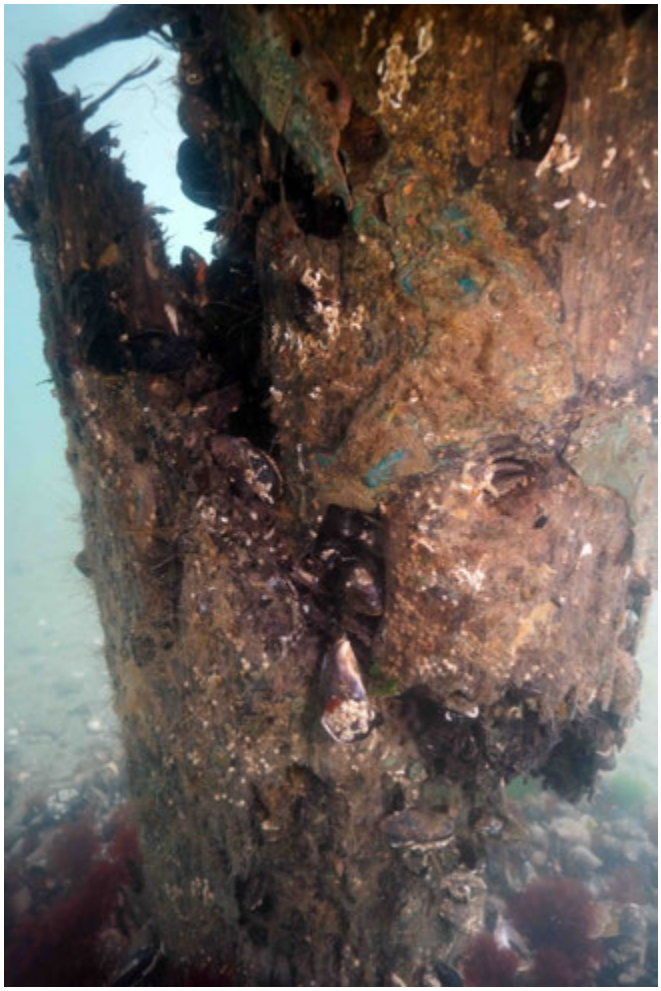
Pile 26F: Poor Condition – 60% loss of section – lower tidal zone

Pile 27C: Very Poor Condition – broken pile

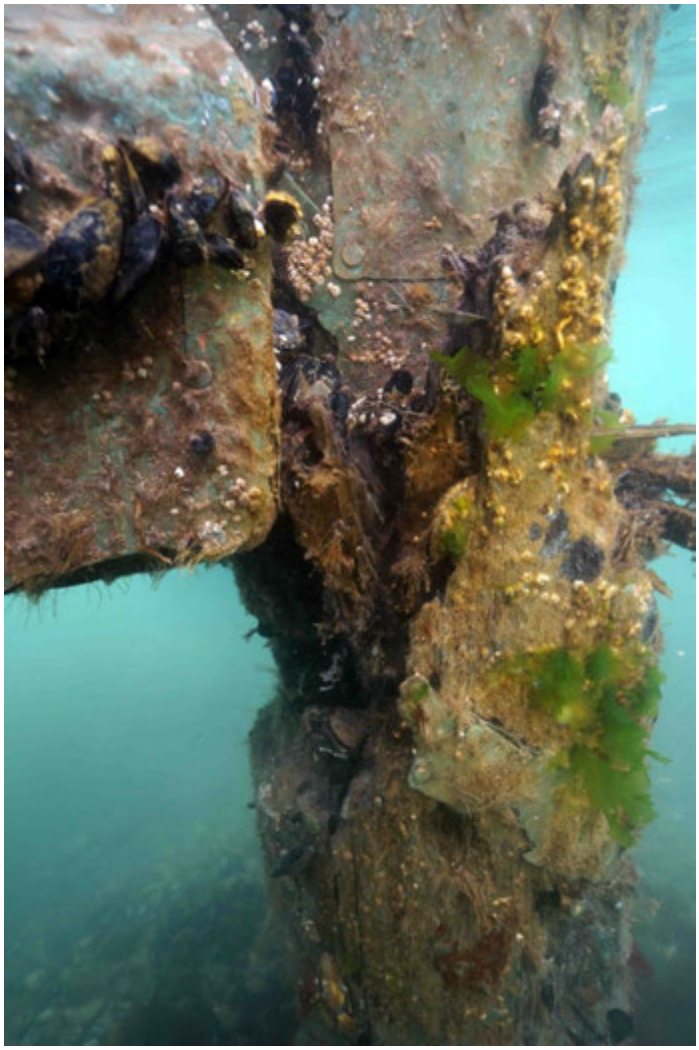


Pile 27D: Very Poor Condition – broken pile

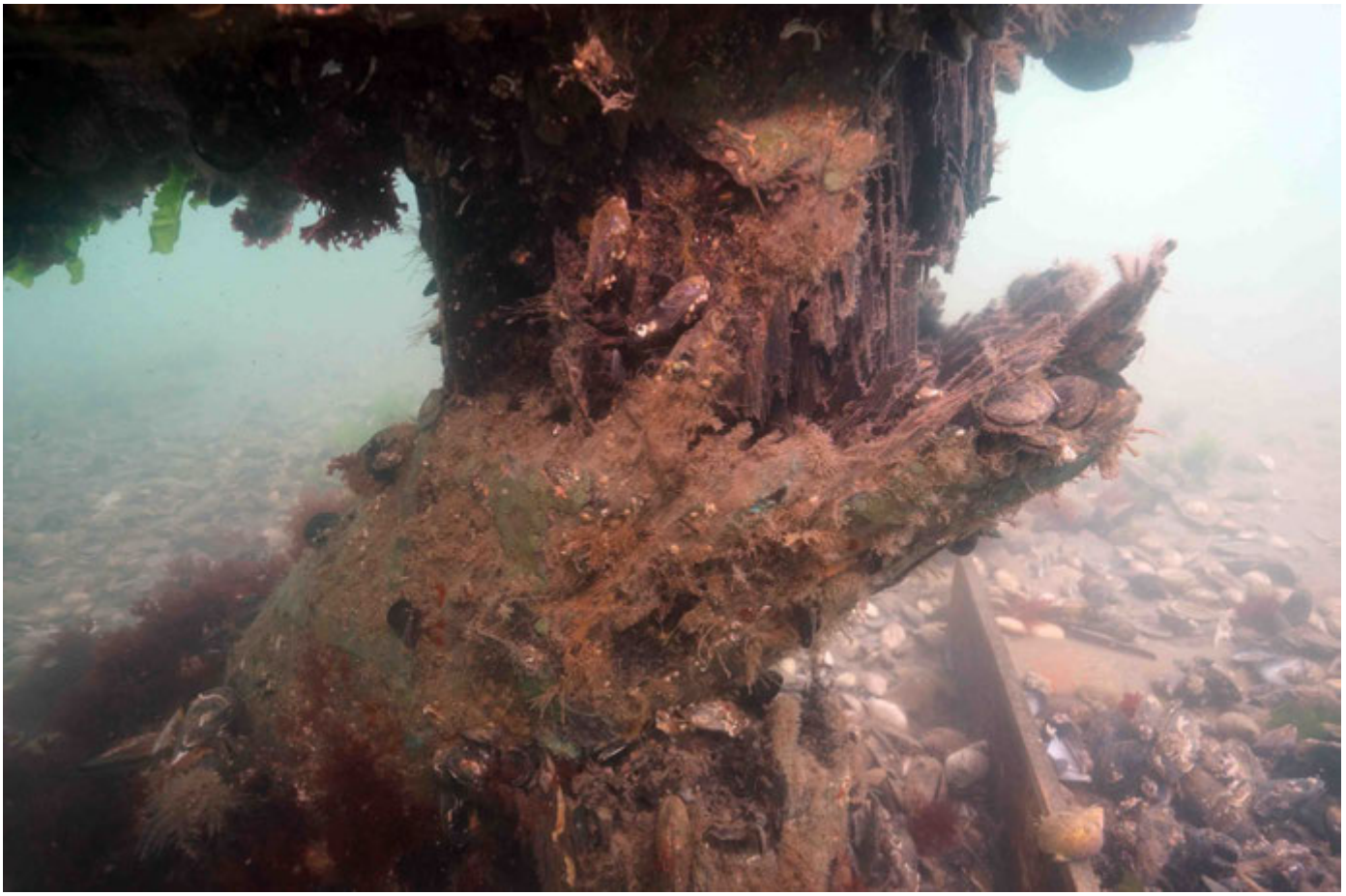
Pile 28C: Very Poor Condition – broken pile

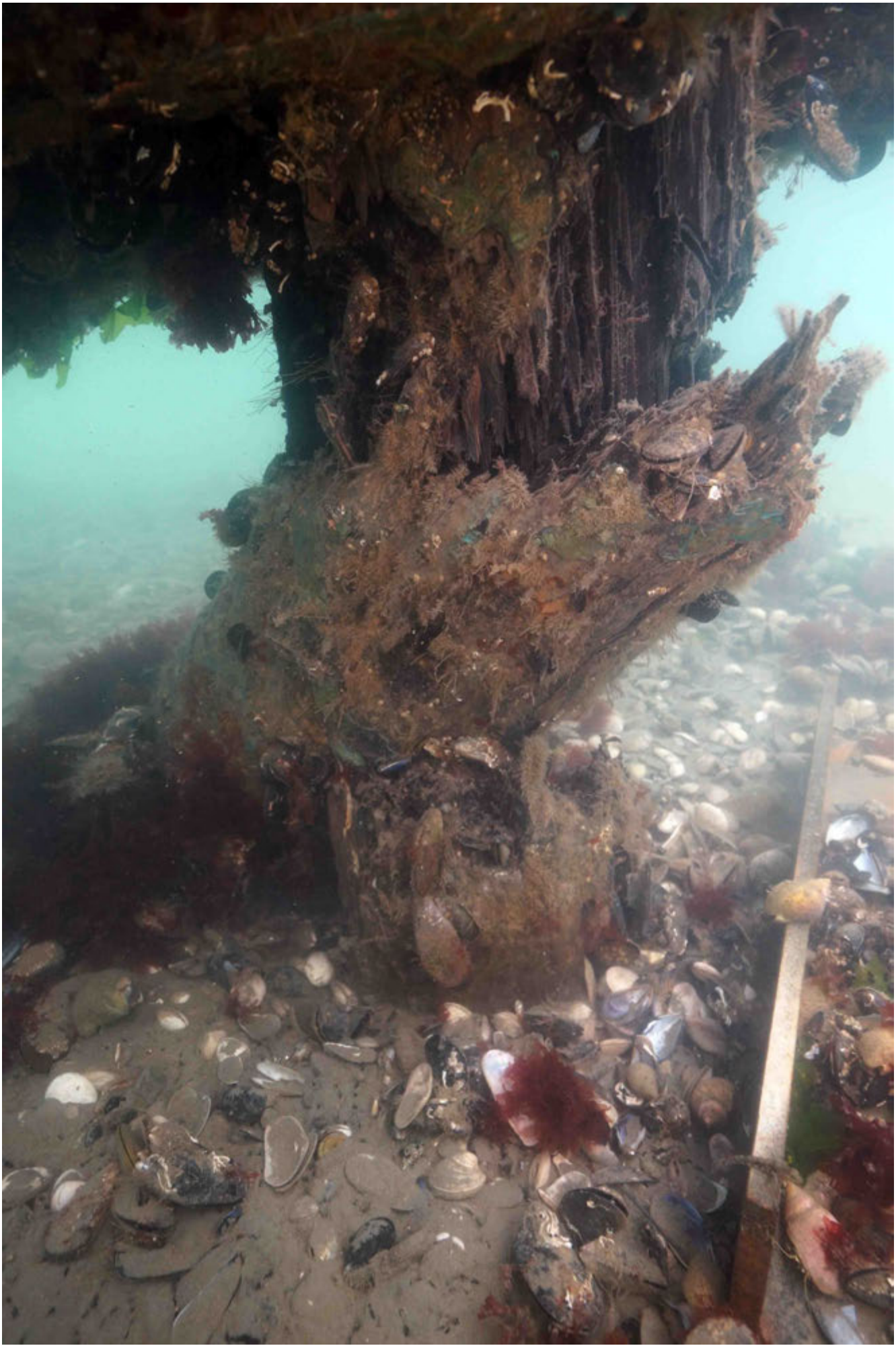


Pile 28D: Very Poor Condition – broken pile

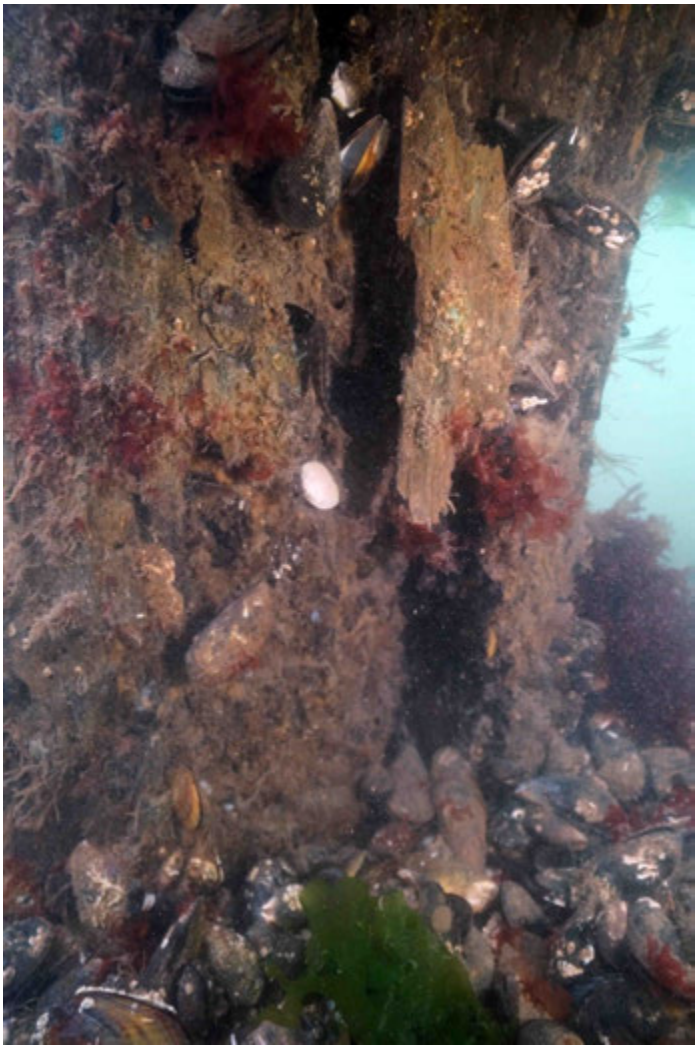


Pile 29C: Very Poor Condition – broken pile

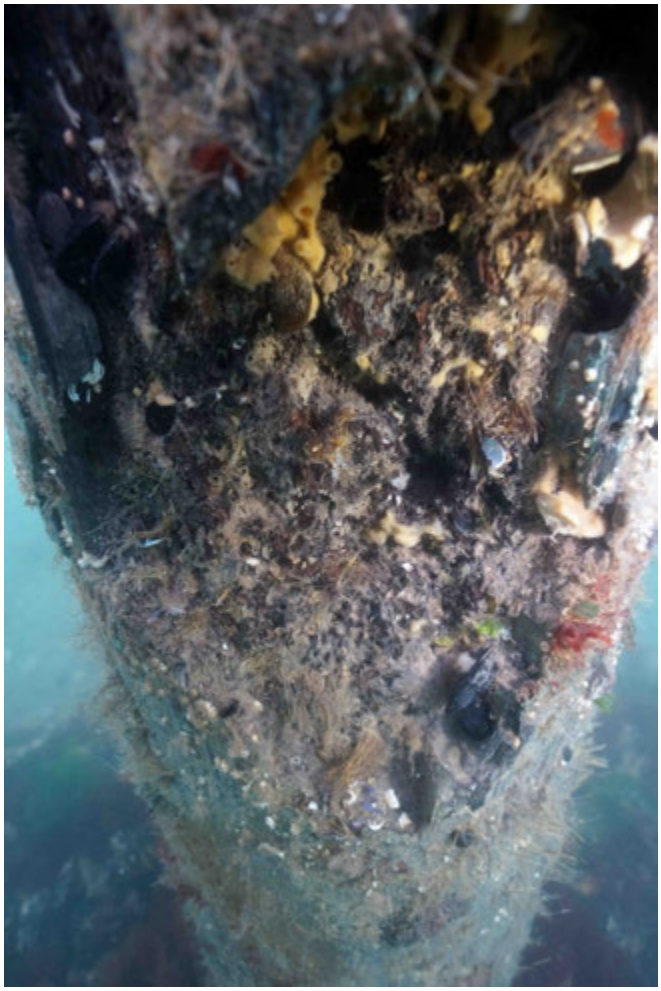




Pile 29D: Very Poor Condition – broken pile



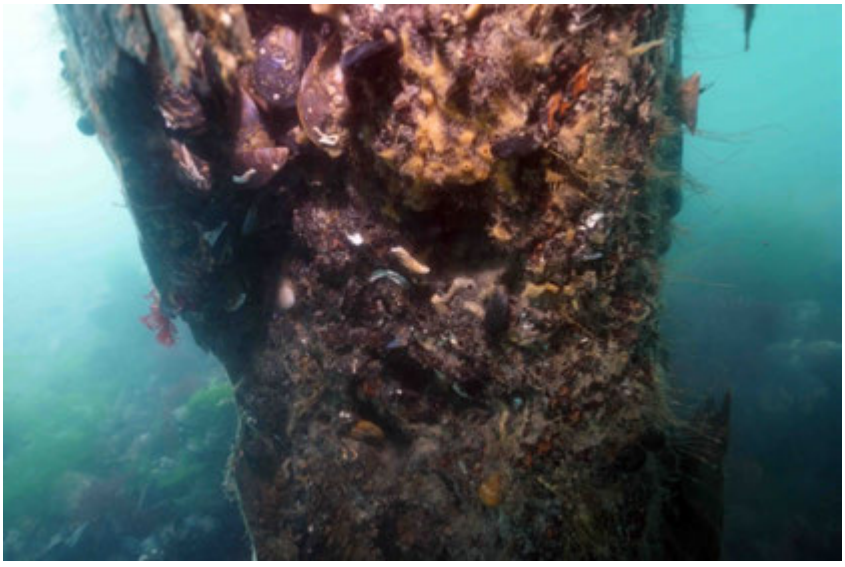
Pile 30C: Poor Condition – 40% loss of section – lower tidal zone



Pile 30D: Poor Condition – 50% loss of section – lower tidal zone

Pile 31C: Poor Condition – 40% loss of section – lower tidal zone to seabed

Pile 31D: Poor Condition – 60% loss of section – at seabed



Pile 33C: Fair Condition – 25% loss of section – lower tidal zone to seabed

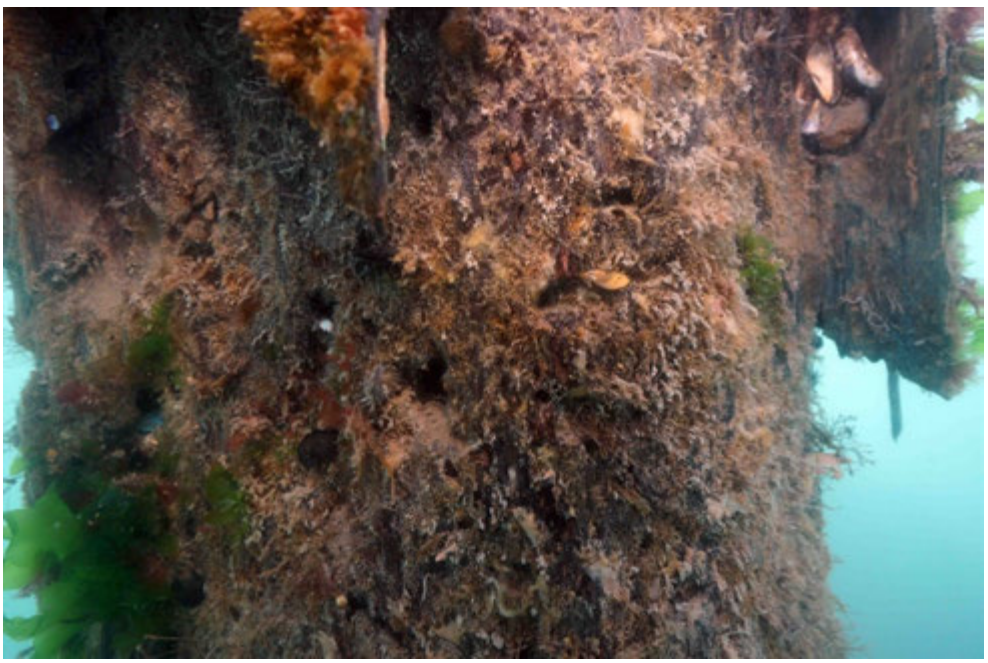
Note: Pictures of Piles 33C & D, and Pile 34D – have been entered for the benefit of those persons viewing this Report – to provide relevant detail of Fair Condition rated piles

Pile 33D: Fair Condition – 20% loss of section – lower tidal zone

Pile 34C: Poor Condition – 35% loss of section – lower tidal zone to seabed

Pile 34D: Fair Condition – 30% loss of section – lower tidal zone
Note: Failed Wale Beams require removal

Pile 35C: Poor Condition – 40% loss of section – lower tidal zone



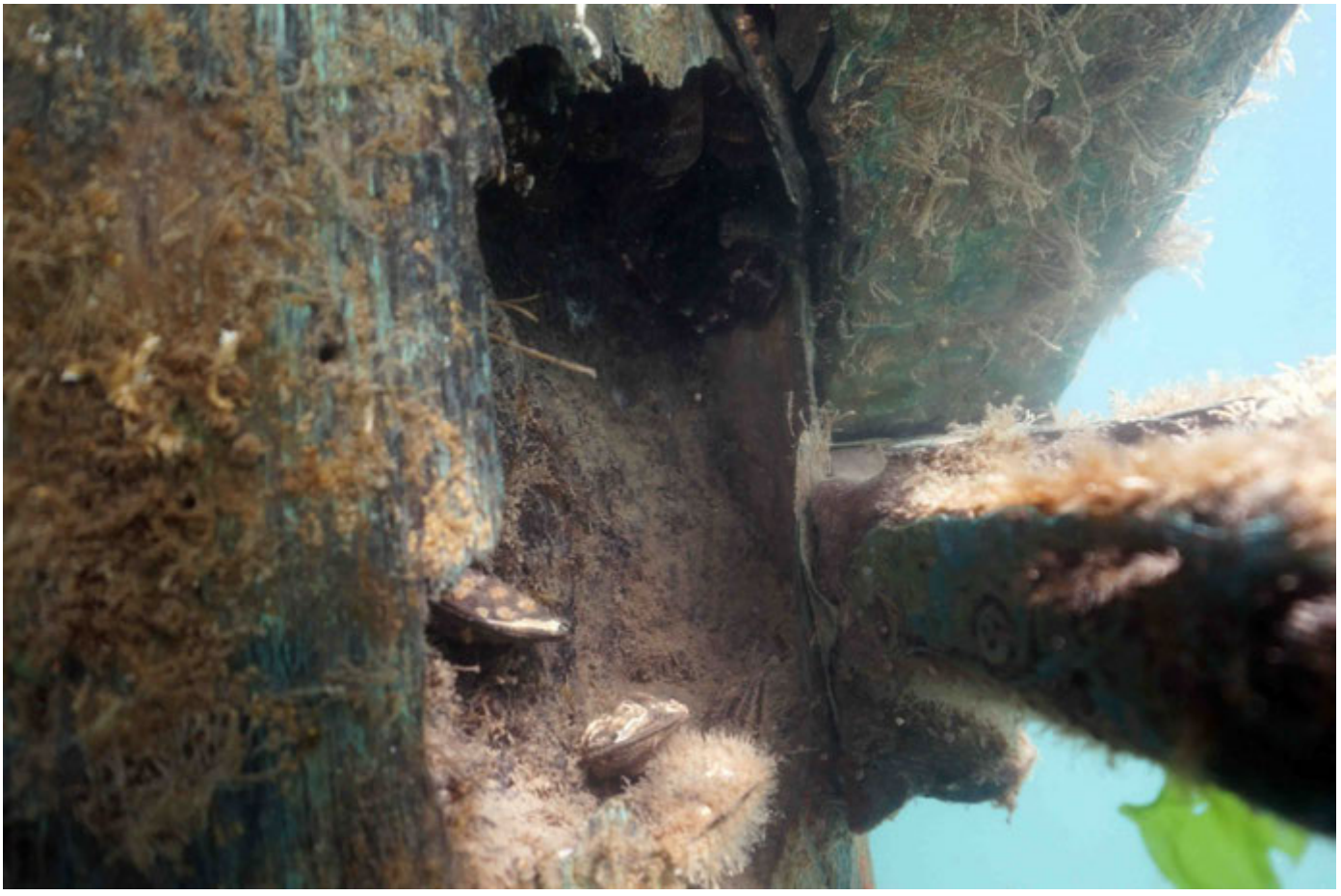
Pile 36C: Poor Condition – 35% loss of section – lower tidal zone. Moderate hollowing

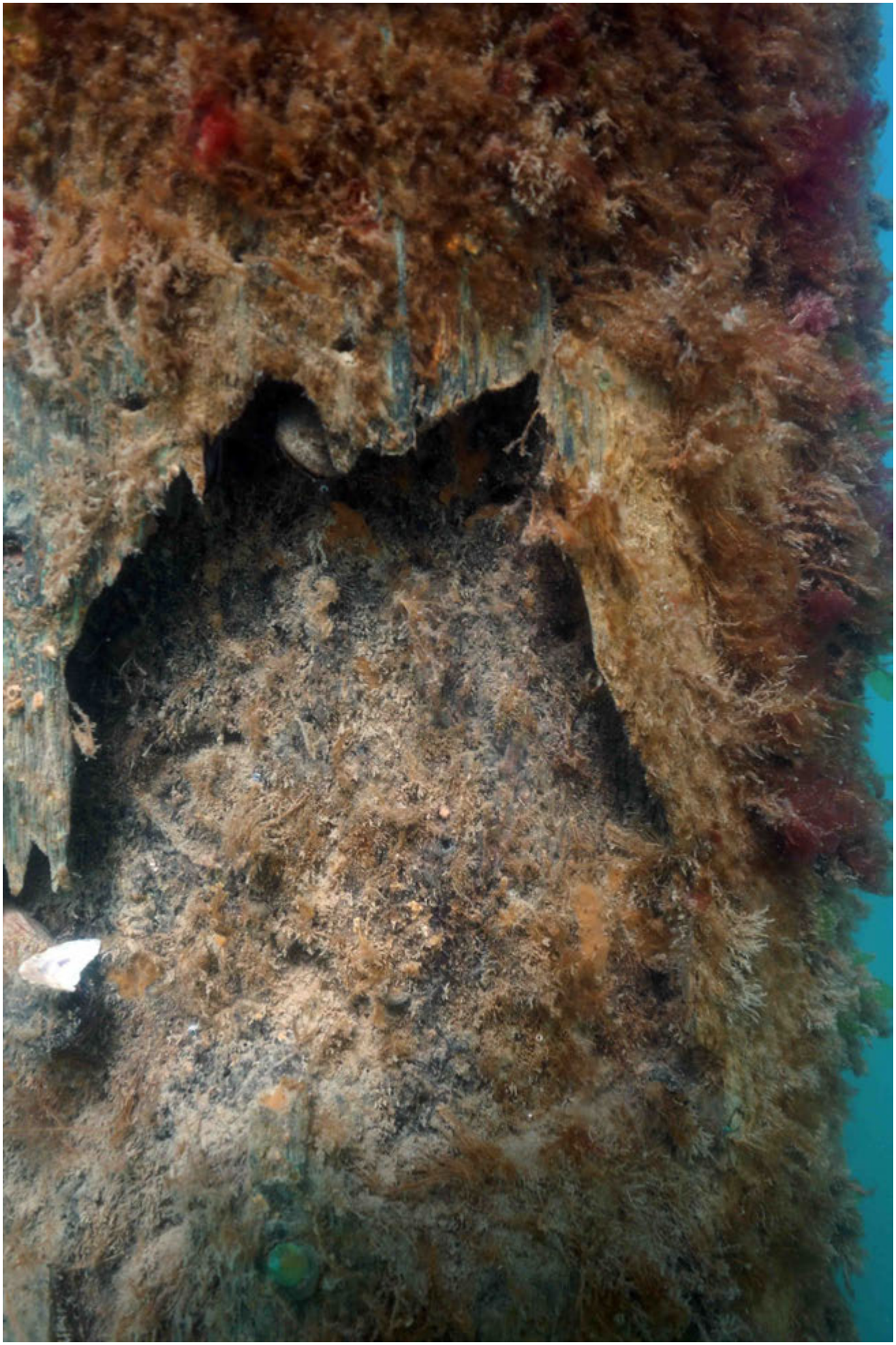



Pile 37C: Poor Condition – 45% loss of section – lower tidal zone to seabed



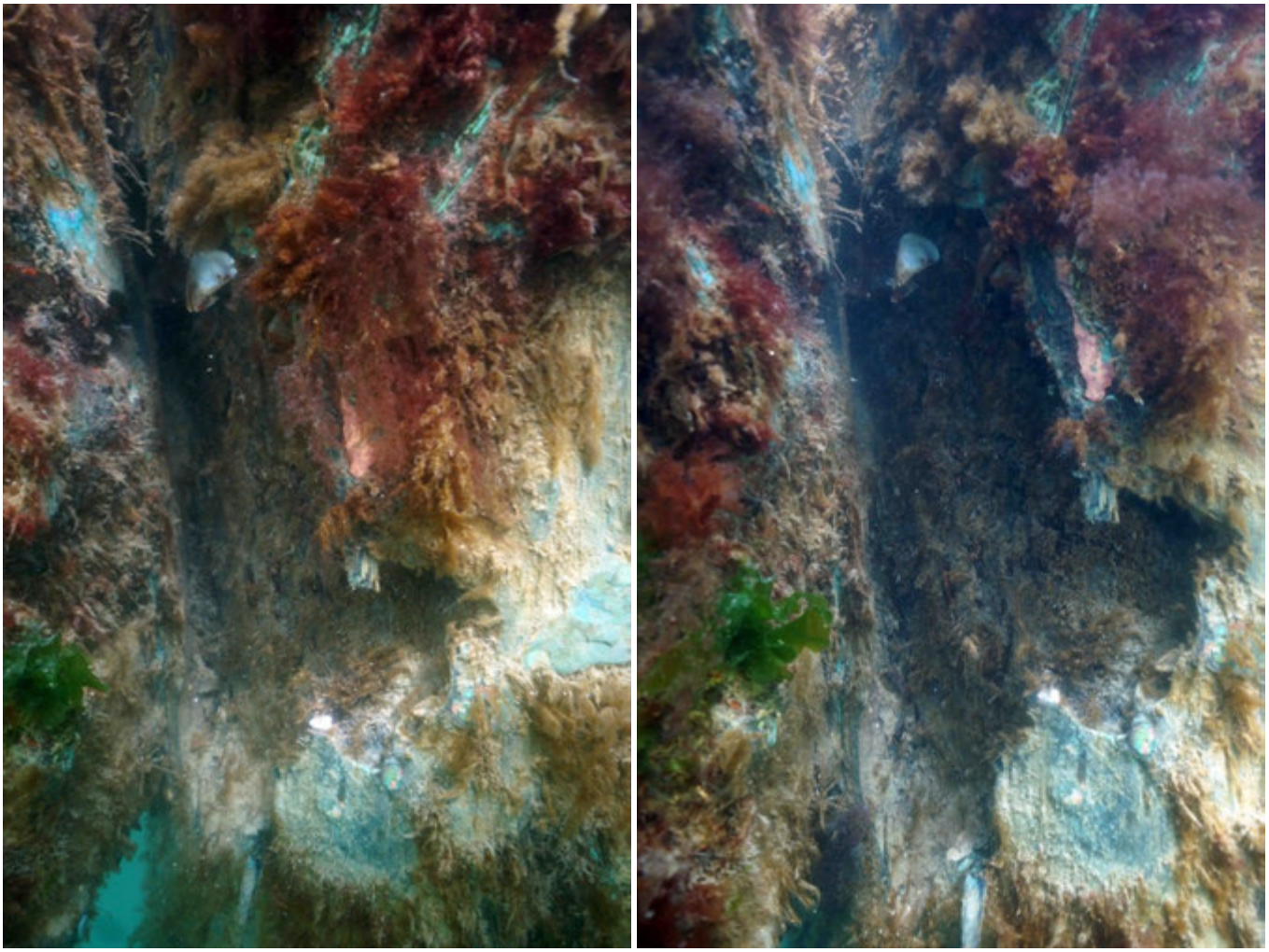

Pile 37D: Poor Condition – 35% loss of section – lower tidal zone



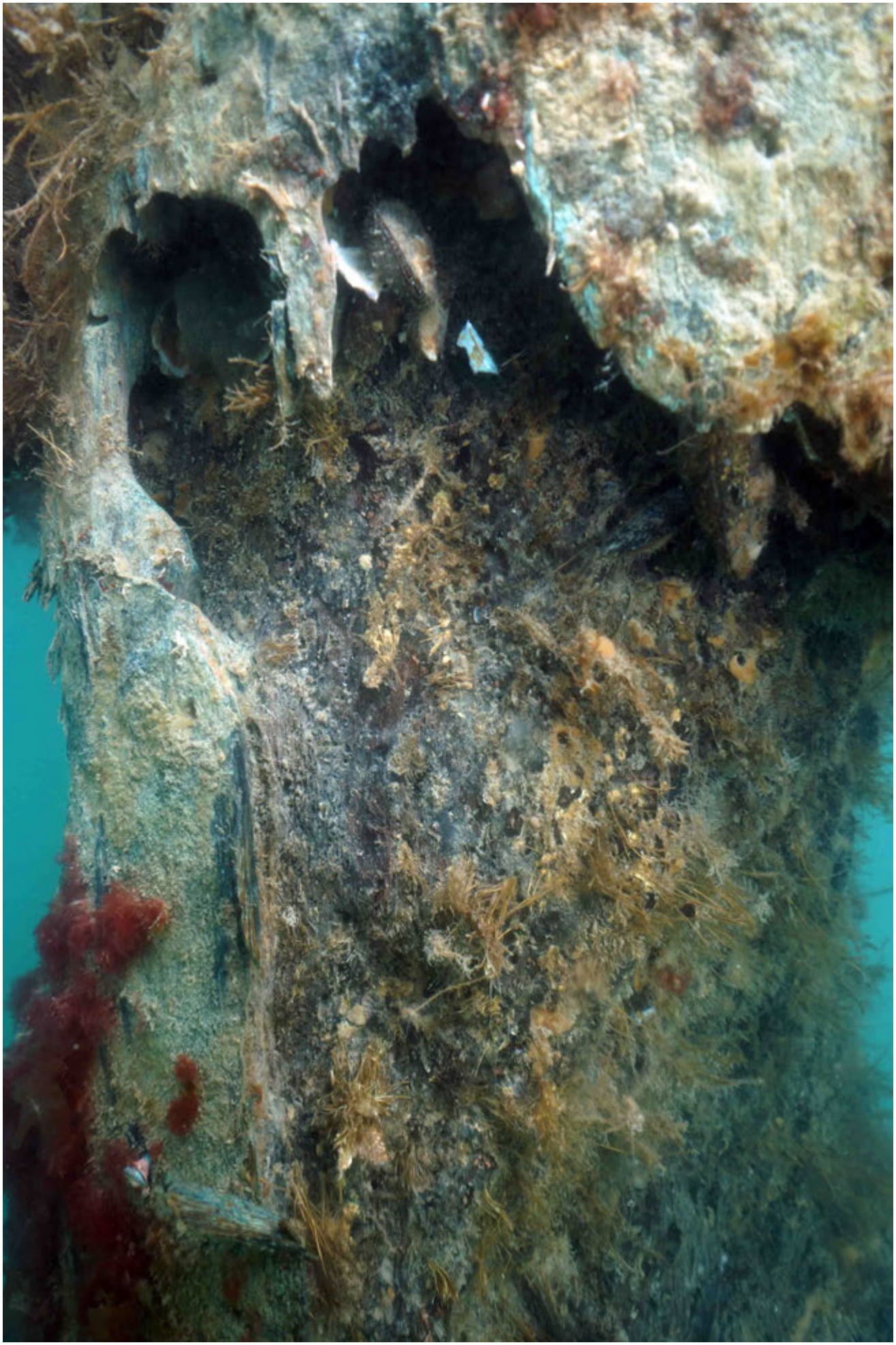


Pile 38D: Poor Condition – 35% loss of section – above tidal zone. Moderate hollowing & decay

Pile 43C: Poor Condition – 35% loss of section – lower tidal zone



Pile 44C: Poor Condition – 40% loss of section – lower tidal zone. Top-end splitting



Summary and Recommendations

Petone Wharf – Approach Structure – Pile Bents 06 – 47

IMPORTANT NOTE: Within the documented contents of Petone Wharf – Approach Structure – Table 2: Timber Piles Condition Assessment for Pile Bents 25 to 47; you will note that even piles assessed to be in Fair Condition include proposed recommendations to: 'Consider FRP Jacket'.
There are multiple reasons for this recommendation, including:

- All piles exhibit evidence (to varying degrees) of areas where partial loss of sapwood has occurred. This exposes the heartwood; where upon assessment the Surveyor visually confirmed physical evidence of Teredo infestation.
  All survey work to date has been non-destructive and non-intrusive to the timber piles integrity. To learn how advanced and to what degree the Teredo infestation has damaged, and continues to damage these piles, a more destructive method of survey would be required.
  Gauging the mean loss of internal timber mass and extent of damage resulting from Teredo activity can be achieved through the process of 'wafering' (cutting biscuit sections) from failed timber piles. When failed piles are cut into sections relative to known positions, e.g. seabed or tidal zone, it can be determined where the Teredo entered the pile, and the extent (depth of hole boring) of their destructive activity.
- It's extremely obvious from an experienced and visual perspective that Teredo infestation in all of the Wharf Approach piles exists; and limited investigations of failed timber piles confirm the immensity of the problem. Teredo is present in high numbers, and it's destruction of pile and connected wale timbers are rampant.
- When having to remove / reinstall, and in many cases renew a high proportion of wale and diagonal bracing beam timbers, it definitely becomes false economy to FRP Jacket only 1 pile in a Bent: then in a predicted 2 – 3 years, as it will; be required to remove / reinstall these timbers a second time to complete remedial works on the non-jacketed pile, due to its deterioration advancing into a Poor or Very Poor condition rating.
- For maximum protection of piles within Bents 25 – 47, a 3.0 metre length FRP Jacket is recommended to be installed to piles.

While investigations have not yet fully quantified required horizontal wale and diagonal brace timbers renewal numbers; Teredo damage and other deterioration modes to the existing timbers, as briefly observed during the pile condition survey, confirms it's reasonable to anticipate that between Bents 25 – 47 the following to be relevant:

- Horizontal Wale timbers - a required renewal rate of 70 – 80%
- Diagonal Bracing timbers - a required renewal rate of approximately 50%

Pile Condition Designation (Bents 06 – 47 ratings)	**Sum**
Satisfactory:	09
Fair (Bents 06 – 24):	22
Fair (Bents 25 – 47):	22 (+ 3 'redundant')
Poor:	25 (+ 1 'redundant')
Very Poor:	09 (+ 2 'redundant')

Note: 'Redundant' piles are additional pile rows C1 & D1 on Bents 45, 46 & 47.
The Consultant Engineer needs to confirm the status of these 6 piles is in fact 'redundant'.

It's recommended that as an absolute minimum, all Piles with a Poor and Very Poor designation be repaired by remedial process immediately.

Piles, especially those between Bents 25 – 47 designated to be in Fair Condition, remain vulnerable and at risk of rapid deterioration. In predicting a remaining 2 – 3 year service life for the Wharf Approach timber piles designated to be in Fair Condition, and consistent with the reasons outlined above, it makes good economic sense to protect the asset from further damage and failure through applying the proactive approach of installing FRP Jackets to these piles now; rather than enduring the risk implications of the escalating costs subsequently involved with secondary handling, the inconvenience and Public perception of further Wharf closures, and further pile losses over and beyond that period.