INVITATION FOR PROPOSAL #03-24-30028
Bremerton Marina Underwater Inspections

Addendum 1, 11/13/2024

The 2023 underwater inspection report is attached and has been made available.

BREMERTON MARINA BREAKWATER

The objective of this project is to provide a general description and assessment with recommendations of the underwater condition of the floating breakwater's mooring system and cathodic components. The structures are generally covered in heavy marine growth which limited some of the level I inspection. Representative areas were cleaned using hand tools for closer examination. The photos within this report provide a visual representation of the typical underwater conditions and deterioration.

Observations

The underwater components of the floating breakwater associated mooring system, connections, and cathodic protection are overall in **Fair** condition. The mooring lines are generally covered in heavy marine growth. The upper chains are typically completely covered in large tube worm colonies which limits visual inspection capabilities and utilizes a tactile inspection. The cables have approximately 80% surface coverage of anemones and barnacle growth. The bottom chains and anchors have approximately 50% surface coverage of anemones and other hard growth. The anodes were generally covered in 50% hard growth but this varied from 0%-100%. **(See photos 1-4)**

Material loss percentages are conservative estimates based on a visual inspection of select areas with a layer of corrosion chosen for cleaning and further inspection. These estimates were then applied to other sections with identical characteristics as a level I inspection does not require further investigation of these sections. Only Partially Destructive Testing with cleaning and material thickness measurements would provide accurate material loss readings. The extent of visible deterioration on the anchor chains was typically localized to the edges on a few chain links. The extent of deterioration on the cables was typically located throughout the upper third of the mooring cable but extended throughout the entire cable on a few mooring lines. The top chains were relatively free of any corrosion or deterioration.

A typical mooring line in Fair condition consists of little to no surface corrosion, no deterioration, with more than 90% of the galvanizing still intact on any visible surface area. Roughly half of the mooring lines have at least one section encased in black surface corrosion or have surface rust throughout the mooring line. When the black corrosion layer was chipped away, it revealed minor surface deterioration. The same conditions were present when the surface rust was brushed away. There was typically <10% material loss on the cables and top chains, and <20% material loss on the bottom chains. **(See photos 5-9)**

The sections with surface deterioration were graded as **Poor**. SDS found an increase in both the amount of corrosion and deterioration throughout the mooring system since lasts year's inspection. Cathodic protection should be installed as soon as possible to correct & prevent further damage to the system. All sections with advanced corrosion & the details of each mooring condition are laid out in the Breakwater Mooring Condition Table and should be given priority when scheduling maintenance & repairs.

We gave the anodes a **Poor** grade due a few problems with the anodes: Improper installation, age, and anode location. All mooring lines have 4 locations for anodes. The first location is on the shackle that connects the top chain to the top end of the cable. The next two locations are mounted directly to the cable. The first is 1/3 down the cable and the second is 2/3 down the cable. The fourth anode is located on the shackle that connects lower end of the cable to the bottom chain. **(See photo 11)**

The first anode location is ideal due to the minimal marine growth near the chain to cable connection whereas the rest of the top chain is covered in large tube worm colonies. The horizontal anodes with hardware on both ends seem to be less effective than the vertically hanging anodes. It does appear the dual rod-type anodes would be more difficult to install rather than a single rod anode. Marine growth also spreads much more aggressively over the horizontally mounted anodes providing less surface area for the anodes to do their job. **(See photo 12 -13)**

We found all of the newer anodes to be installed with oversized u-bolts. The old anode hardware was still remaining and had a tight, snug fit. Due to the loose nature of the hardware, it is assumed there is insufficient metal to metal contact, leaving the chains exposed to galvanic corrosion. In addition, the anode strap only has one bolt hole which the u-bolt attaches to, providing minimal surface area for a metal to metal connection. Whereas all previous anodes utilized the proper size u-bolt and each anode strap had two holes providing a tight and secure connection to the cables and chains. These also used double hex nuts to prevent any hardware from backing off.

When the previous anode hardware was grabbed and checked by the inspection diver, it was not possible to move any of the hardware. The anodes installed in 2021/2022 used oversized u-bolts with single nuts, nearly all of the hex nuts securing the backing plate were finger tight, backing off, or had fell of completely. Some of the anodes themselves had fallen off since the last inspection in 2022.

The anodes also were installed over existing marine growth. Or, due to the loose nature of the hardware, allowed marine growth to form between the cable and anode hardware, making a metal to metal bond impossible. A handful of the cable anodes were rod-type anodes with a rod extending from both ends of the anode & both rods wrapped around the cable. We also noticed these were either installed over existing marine growth or the rods we not wrapped tightly enough so marine growth was allowed to grow on the cable, between the rods preventing to a metal to metal bond. When looking at the anode percentage chart, newer anodes with a high percentage of material remaining have **poor** or no metal-metal connection. **(See photos 14-19)**

The two cable anodes were intentionally spread out to provide equal cathodic protection to the mooring system. On some of the mooring lines, we found two of the newer anodes installed within feet of each other. With no other anodes remaining on the cable, this exposes unprotected sections of the mooring system and can cause some of the anodes to deplete faster than they typically would.

The majority of the bottom chain anodes are fully depleted or have less than one year of service life left. Those bottom chains are forming a layer of corrosion that when chipped away, reveals up to 20% material loss, weakening the overall integrity of the mooring line. It is high importance to ensure when the new anodes are installed, marine growth and this corrosion layer is removed, and a secure connection must be made. Otherwise, the bottom chains will deteriorate and need replacement within 10 years. By looking at the original plans for the mooring systems and the old anode hardware on the mooring chains, it appears that **two** anodes were originally installed at the connection point. This should be considered when planning future maintenance. **(See photo 20)**

Remaining anodes percentages are provided in Anode Percentage Table. Any percentages at 0% were either fully depleted at that location or missing. In general, SDS found the newer anodes to have a 10% reduction in material since the inspection in 2022. The older anodes seemed to be depleting faster, closer to a 20% annual burn rate since last year. Of course, a factor for a faster burn rate could be age, as well as the anodes covering more than their fair share due to the overall lack of cathodic protection. A poor metal to metal connection should be taken into account for newer anodes with higher remaining material percentages.

A handful of anodes installed on the cable were rod type hanging anodes with a 1/4" rod extending from each end of the anode and around the cable. When grabbed and checked by the inspection diver, the anodes we able to spin on the cable. There was also marine growth forming between the rods and the cable, creating minimal metal to metal connection. It appears the rods were wrapped around the cable by hand as tight as possible.

These anodes seem to be a more diver friendly installation option than the u bolt anodes with multiple pieces of hardware. We recommend a single rod type anode that can hang vertically, this style of anode seemed to be effective for the Port Orchard Breakwater mooring chains. Proper pre-cleaning would allow for a tighter wrap and more secure connection. **(See photos 13 & 21)**

Assessments

Based on our underwater inspection, the floating breakwater associated mooring systems, connections, and cathodic protection are generally in overall **Fair** condition due to localized areas of advanced deterioration. The detailed examination of the breakwater mooring system determined the mooring lines require cathodic protection as soon as possible to provide an extended service life.

It was noted in the 2022 inspection that many of the recently installed anodes have already failed and fallen off the mooring system. There even were more anodes that have fallen off since last year's inspection. These anodes have oversized hardware and finger loose hex nuts, installed over marine growth. This makes a metal-metal bond impossible, preventing effective cathodic protection. In other words, the newer anodes are providing no protection and the entire mooring system is relying on the old anodes which are almost fully depleted.

Virtually all of the mooring lines are in **Fair** condition however, the cathodic protection system in general is in P**oor** condition as nearly all of the anodes are depleted or newer anodes have a poor connection. With the majority of the mooring lines missing multiple anodes, we are seeing the remaining anodes deplete faster than they typically would as they struggle to provide protection for the rest of the system, not just their assigned section.

Recommendations

For future anode maintenance contracts, the Port should highlight the importance of a tight, secure, metal to metal connection. Pre-cleaning of the anode locations should be required in the scope of work. Due to the magnitude of the overall structure, the port should consider requiring photos of each anode installation post-installation.

It does appear the dual rod-type anodes with one rod on each end would be more difficult to install. SDS also noted these horizontally mounted anodes to be covered in more marine growth with little to no surface area exposed. This in turn provides less cathodic protection and could make it harder to find these anodes during inspections. If rod type anodes are used, a singe rod option appears to be the best choice as they were effective for the Port Orchard Marina breakwater.

The Port/ Port Engineer should consider including anodes with poor connections, loose hardware, failed hardware and marine growth on the mooring lines in a repair contract as soon a practical. The single hex nuts were finger loose and some hex nuts were missing. At a minimum these should be tightened to prevent losing more anodes. In addition, consider a section of bendable rod that can provide a better connection between the existing u-bolt hardware and the mooring lines. This would help salvage the remaining service life of these anodes, it is assumed they are providing little to no cathodic protection for the mooring system.

There are 107 anode locations marked 0% and 44 sections given a Poor grade. These locations should have an anode installed immediately. There are 12 anodes with 10-20% material remaining, these anodes should be considered for replacement next year.

The Port should include CP (Corrosion Potential) Testing on annual inspection contracts. The Port already requires CP testing on the Pilot Piles in the marina, this would provide valuable information for a low cost increase from a dive inspection team with the inspection equipment already onsite for the project. Lines such as 8, 17N, & 18 should be included for CP testing until surface corrosion subsides. This would also help the port & port engineer determine the longevity of the anodes, mooring line sections, and assist the port with future project planning. SDS can assist the Port/ Port Engineer with selecting pilot lines for CP monitoring.

The Port should continue with annual inspection of the breakwater to ensure the safety of the marina and it’s tenants.

Bremerton Mooring Anode Percentages

Mooring Line #	Top Chain Anode %	Upper Cable Anode %	Lower Cable Anode %	Anchor Chain Anode %
1S	0	60	0	30
1N	70	70	70	0
2	0	0	60	0
3	0	50	70	0
4	50	70	50	0
5	0	0	70	0
6S	10	0	70	0
6N	0	80	80	0
7	10	70	60	0
8	0	0	0	0
9	80	0	70	10
10	60	0	0	0
11	0	40	60	10
12	60	60	60	0
13	80	0	40	0
14	0	60	50	0
15	0	0	60	0
16	0	0	50	30
17S	0	0	0	20
17N	0	0	0	0
18	0	40	40	0
19	40	70	0	40
20S	40	70	70	40
20N	50	40	70	70
21	40	0	40	40
22	30	0	0	0
23	60	0	30	0
24	0	40	30	30
25	0	30	60	0
26	60	0	50	40
27	60	80	10	10
28	30	0	0	0
29	0	0	0	20
30	0	70	10	20
31S	50	70	20	30
31N	0	0	0	40

32	0	0	0	10
33	0	0	0	0
34	0	0	0	0
35	0	0	0	30
36S	0	80	0	0
36N	0	0	0	0
37	40	0	0	30
38	0	0	0	0
39	0	0	0	0
40	0	0	30	30
41	0	40	0	0
42	80	0	30	0
43	90	60	0	0
44	30	70	30	0

Total @ 0%	**28**	**28**	**21**	**30**
Total @ <20%	**2**	**0**	**3**	**7**

(TABLE 2)

Bremerton Breakwater Mooring Condition Table

Mooring Line #	Top Chain	Cable	Bottom Chain
1S	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	**Poor –** Chain deterioration, up to 20% material loss
1N	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Anode has poor connection.	Fair – Moderate surface rust throughout chain & anchor
2	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Anode has poor connection.	Fair – Typical/ minor surface corrosion
3	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Anode has poor connection.	Fair – Typical/ minor surface corrosion
4	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Anode has poor connection.	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Anode has poor connection.	Fair – Moderate surface rust throughout chain & anchor
5	Fair – Typical surface corrosion, isolated areas of advanced corrosion	Fair – Isolated areas of advanced black surface corrosion	Fair – Typical/ minor surface corrosion, chain enters seabed
6S	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	Fair – Moderate surface rust throughout chain & anchor
6N	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced black surface corrosion. Anode has poor connection.	Fair – Typical/ minor surface corrosion
7	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion, chain enters seabed
8	**Poor –** Advanced surface rust & corrosion, minor surface deterioration. No anode.	**Poor –** Advanced surface rust & corrosion, minor surface deterioration. Anode has poor connection.	**Poor –** Advanced surface rust & corrosion & surface deterioration. No anode. Chain enters seabed.
9	Fair – Typical/ minor surface corrosion. Anode has poor connection.	Fair – Minor black corrosion forming on cable surface	Fair – Typical/ minor surface corrosion, chain enters seabed
10	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced corrosion	**Poor –** Minor deterioration beginning on chain, <10% material loss
11	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced black surface corrosion. Anode has poor connection.	**Poor –** Minor deterioration beginning on chain, <10% material loss

12	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	**Poor –** Minor deterioration beginning on chain, <10% material loss
13	Fair – Typical surface corrosion, isolated areas of advanced corrosion	**Poor –** Advanced black surface corrosion, minor deterioration. Poor anode connections.	Fair – Typical surface corrosion, isolated areas of advanced corrosion
14	Fair – Typical surface corrosion, isolated areas of advanced corrosion	**Poor –** Advanced black surface corrosion, minor surface deterioration. Anode has poor connection.	Fair – Typical surface corrosion, isolated areas of advanced corrosion
15	Fair – Typical/ minor surface corrosion. Newer anode fell off and is missing.	Fair – Typical surface corrosion, isolated areas of advanced black surface corrosion. Anode has poor connection.	Fair – Moderate surface rust throughout chain & anchor
16	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	**Poor –** Minor deterioration beginning on chain, <10% material loss
17S	Fair – Typical/ minor surface corrosion	Fair – Typical surface corrosion, isolated areas of advanced corrosion	Fair – Typical/ minor surface corrosion
17N	**Poor –** Advanced surface corrosion throughout entire chain, no material loss.	**Poor –** Advanced black surface corrosion, minor surface deterioration. No anodes.	Fair – Typical/ minor surface corrosion, chain enters seabed
18	**Poor –** Advanced surface rust & corrosion, minor surface deterioration. No anode.	**Poor –** Advanced surface rust & corrosion, minor surface deterioration. Surface rust on top eye socket. Anode has poor connection.	Fair – Typical/ minor surface corrosion
19	Fair – Typical/ minor surface corrosion	**Poor –** Advanced surface corrosion throughout entire cable. Anode has poor connection with loose nuts.	Fair – Typical/ minor surface corrosion
20S	Fair – Typical/ minor surface corrosion	**Poor –** Advanced rust & surface corrosion throughout entire cable. Newer anode fell off and is missing from upper cable. Anode on lower cable area has poor connection with loose nuts.	Fair – Typical/ minor surface corrosion
20N	**Poor –** Advanced surface corrosion throughout entire chain	**Poor –** Advanced black surface corrosion & deterioration throughout entire cable. Anode missing hardware and has poor connection.	Fair – Typical/ minor surface corrosion, anode has loose connection
21	Fair – Typical/ minor surface corrosion	**Poor –** Advanced black surface corrosion & deterioration throughout entire cable. No anode on upper half of cable.	**Poor –** Advanced surface corrosion throughout entire chain & anchor, <10% material loss. Anodes have poor connection.
22	Fair – Typical/ minor surface corrosion	**Poor –** Advanced black surface corrosion & deterioration throughout entire cable. No	**Poor –** Advanced surface corrosion throughout entire chain & anchor, <10% material loss

		anode on upper half of cable. Both newer anodes installed next to each other, poor connections for both.	
23	Fair – Typical/ minor surface corrosion. Top chain has minor wear from abrasion from opposing mooring line	**Poor –** Advanced black surface corrosion throughout entire cable. Anode missing hex nut.	**Poor –** Advanced surface corrosion throughout entire chain & anchor, no material loss
24	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion. Anodes have poor connection.	Fair – Typical/ minor surface corrosion
25	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	**Poor –** Chain deterioration, up to 20% material loss
26	**Poor –** Advanced surface corrosion throughout entire chain, no material loss	Fair – Previously noted corrosion has subsided	**Poor –** Advanced surface corrosion throughout entire chain & anchor, no material loss
27	Fair – Typical/ minor surface corrosion	**Poor –** Advanced surface corrosion throughout entire cable. Anode has poor connection.	Fair – Typical/ minor surface corrosion
28	Fair – Typical/ minor surface corrosion. Anodes have poor connection.	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion
29	Fair – Typical/ minor surface corrosion. Newer anode fell off and is missing.	**Poor –** Advanced surface corrosion throughout entire cable. Anodes fully depleted.	Fair – Typical/ minor surface corrosion
30	Fair – Typical/ minor surface corrosion	Fair – Advanced surface corrosion throughout entire cable. Anode has loose connection.	**Poor –** Advanced surface deterioration on chain near cable connection, up to 20% material loss. Iron oxidation has subsided.
31S	Fair – Typical/ minor surface corrosion	**Poor –** Advanced surface corrosion throughout entire cable, newer anode still has poor connection & loose hardware	**Poor –** Advanced surface deterioration, no material loss
31N	Fair – Typical surface corrosion, isolated areas of advanced corrosion	**Poor –** Advanced surface corrosion throughout entire cable. Anodes fully depleted.	**Poor –** Advanced surface deterioration, no material loss
32	Fair – Typical/ minor surface corrosion, typical chaffing from opposing mooring chain	**Poor –** Advanced black surface corrosion & deterioration throughout entire cable. Anodes fully depleted.	Fair – Typical/ minor surface corrosion, no material loss
33	Fair – Typical/ minor surface corrosion, typical chaffing from opposing mooring chain	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Anodes fully depleted.	**Poor –** Advanced surface corrosion throughout entire chain & anchor, no material loss
34	Fair – Typical/ minor surface corrosion	**Poor –** Advanced black surface corrosion & deterioration throughout entire cable.	Fair – Typical/ minor surface corrosion, no material loss

35	Fair – Typical/ minor surface corrosion	**Poor –** Advanced surface corrosion throughout entire cable. Anodes fully depleted.	Fair – Typical/ minor surface corrosion, no material loss
36S	Fair – Typical/ minor surface corrosion, typical chaffing from opposing mooring chain. Minor material loss on cable from chaffing.	Fair – Typical/ minor surface corrosion, typical chaffing from opposing mooring chain, isolated areas of advanced corrosion	Fair – Typical/ minor surface corrosion, no material loss
36N	Fair – Typical/ minor surface corrosion, typical chaffing from opposing mooring chain. Anode fully depleted.	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Newer anode fell off and is missing	Fair – Typical/ minor surface corrosion, no material loss
37	Fair – Typical/ minor surface corrosion, no material loss	Fair – Typical surface corrosion, isolated areas of advanced corrosion. Newer anode fell off and missing.	Fair – Typical/ minor surface corrosion, no material loss
38	Fair – Typical/ minor surface corrosion. Anode fully depleted.	**Poor –** Advanced black surface corrosion & deterioration throughout entire cable. No anodes remaining.	Fair – Typical/ minor surface corrosion throughout entire chain
39	Fair – Typical/ minor surface corrosion. Anode fully depleted.	Fair – Typical/ minor surface corrosion. No anodes remaining.	Fair – Typical/ minor surface corrosion
40	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion	Fair – Typical/ minor surface corrosion
41	**Poor –** Advanced black surface corrosion & deterioration throughout entire chain.	**Poor –** Advanced surface corrosion throughout entire cable	Fair – Typical/ minor surface corrosion, bridle in good condition
42	Fair – Typical/ minor surface corrosion.	Fair – Typical/ minor surface corrosion	**Poor –** Advanced surface corrosion throughout entire chain & anchor
43	Fair – Typical/ minor surface corrosion	Fair – Previously noted corrosion has subsided. Lower cable anode fully depleted.	**Poor –** Advanced surface corrosion throughout entire chain
44	Fair – Typical/ minor surface corrosion	**Poor –** Advanced surface corrosion throughout entire cable. Anode has poor connection.	Fair – Typical/ minor surface corrosion

Total Poor Grades	**6**	**21**	**17**

Photo 1: Line 3 - Typical top chain marine growth

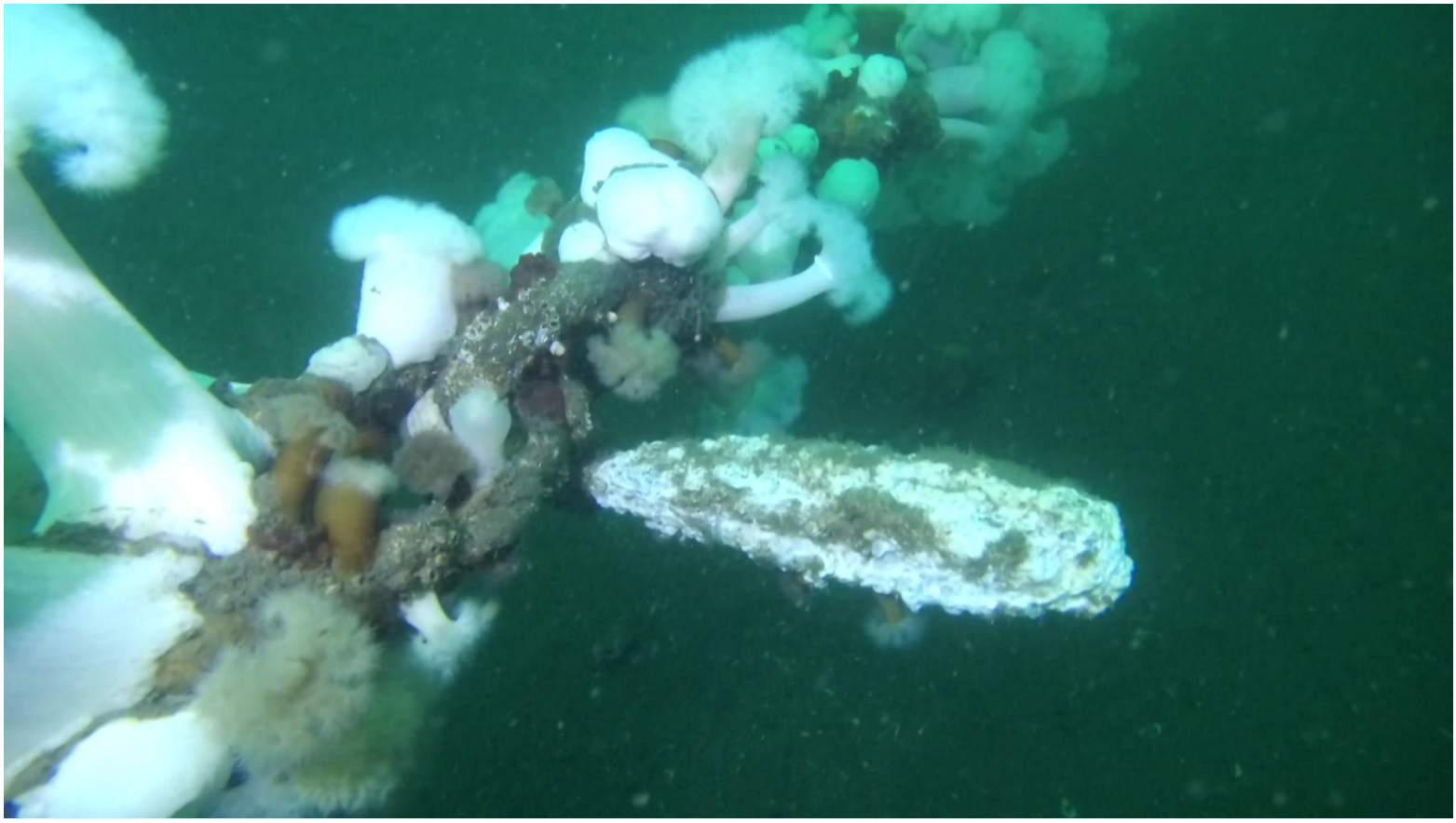

Photo 2: Line 1S - Typical bottom chain condition

Photo 3: Line 1N - Anode with 100% marine growth

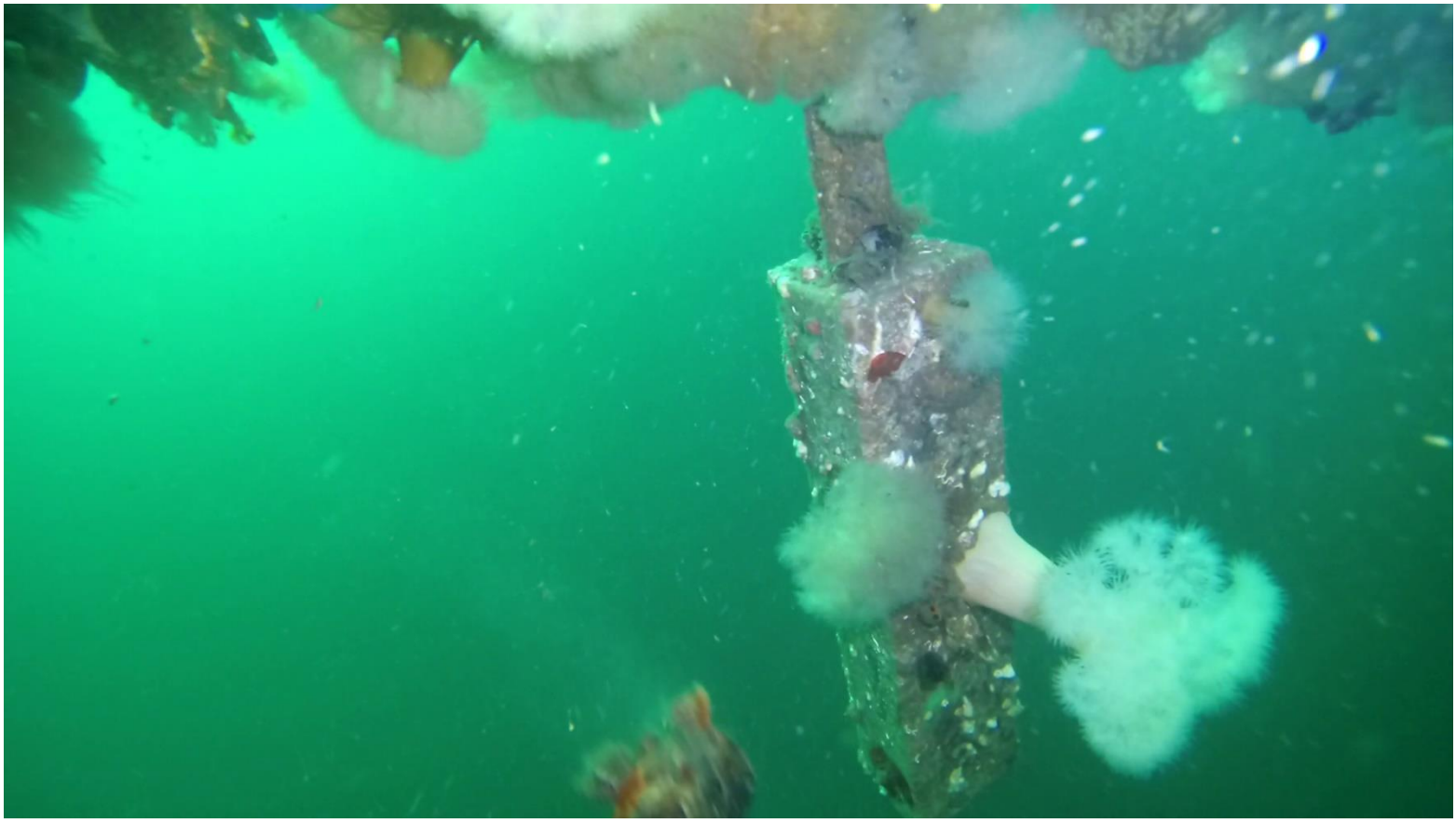

Photo 4: Line 20N - Anode with minimal marine growth

Photo 5: Line 18 - Surface rust on top cable eye socket

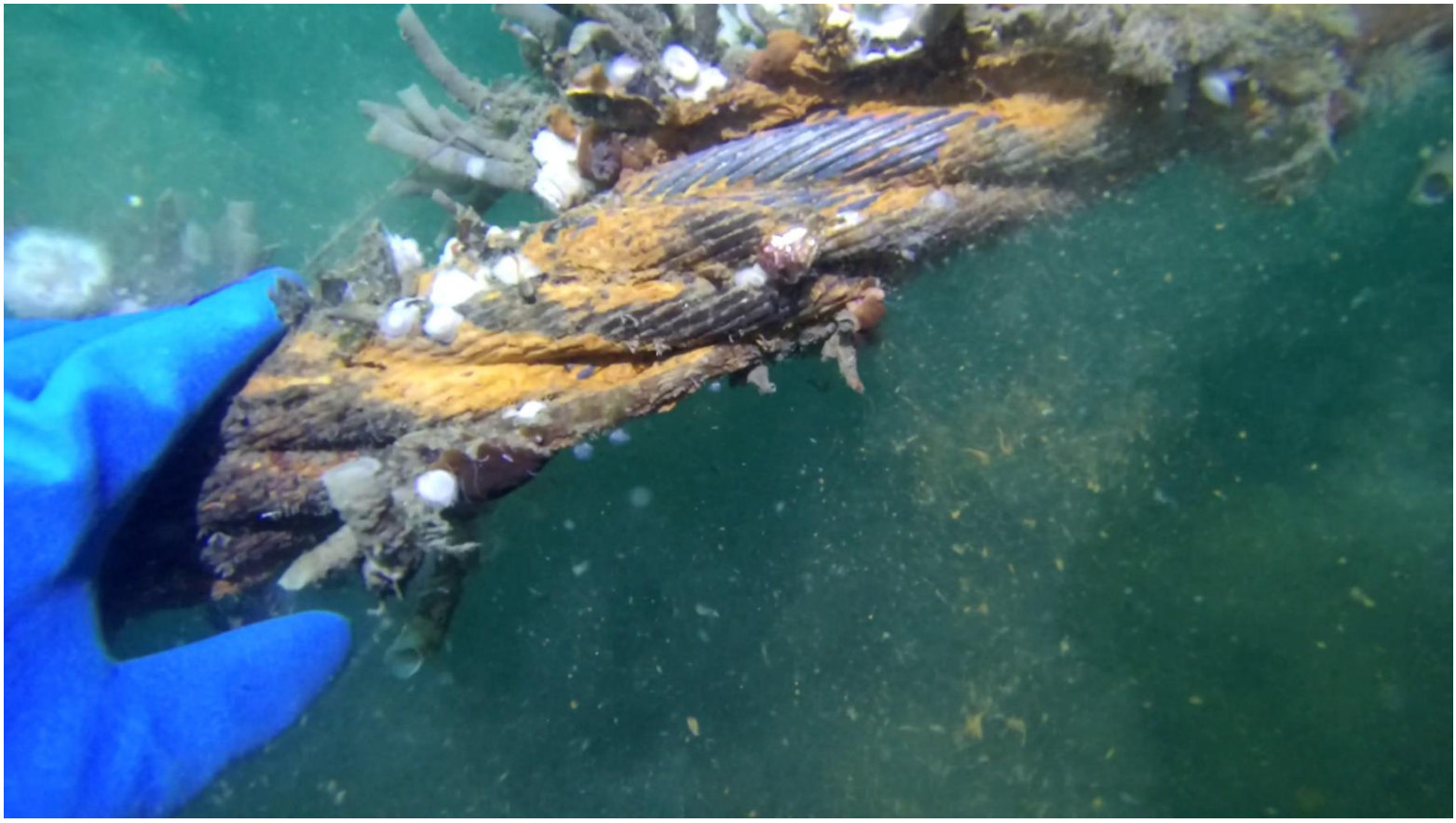

Photo 6: Line 8- Rust & surface deterioration on cable

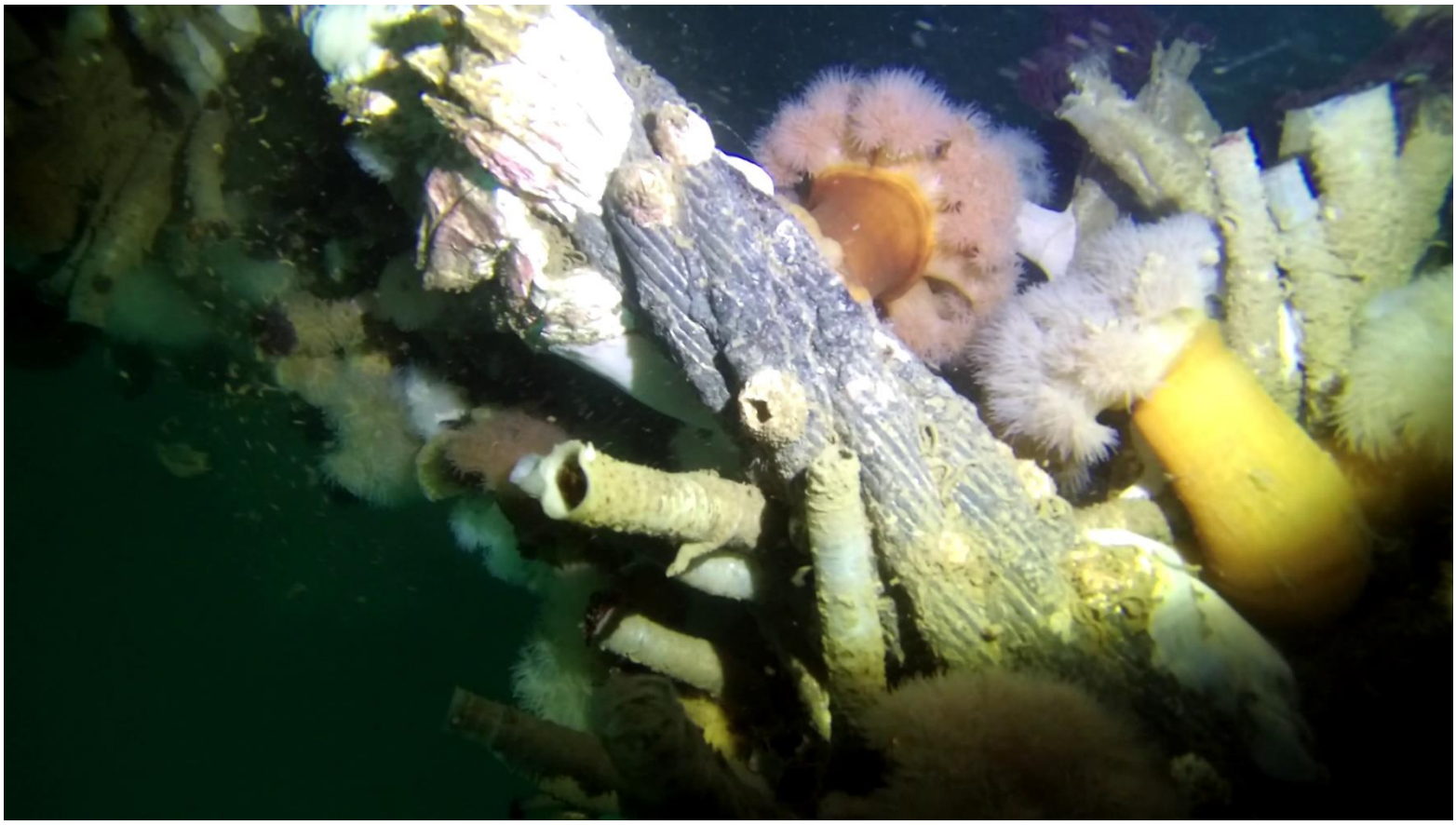

Photo 7: Line 29 - Black corrosion & deterioration on cable

Photo 8: Line 21- Black corrosion layer on cable

Photo 9: Line 22 - Anchor chain link corrosion cleaned for further inspection

Photo 10: Line 19 – Rust & deterioration on lower eye socket & anchor chain shackle. Typical growth conditions.

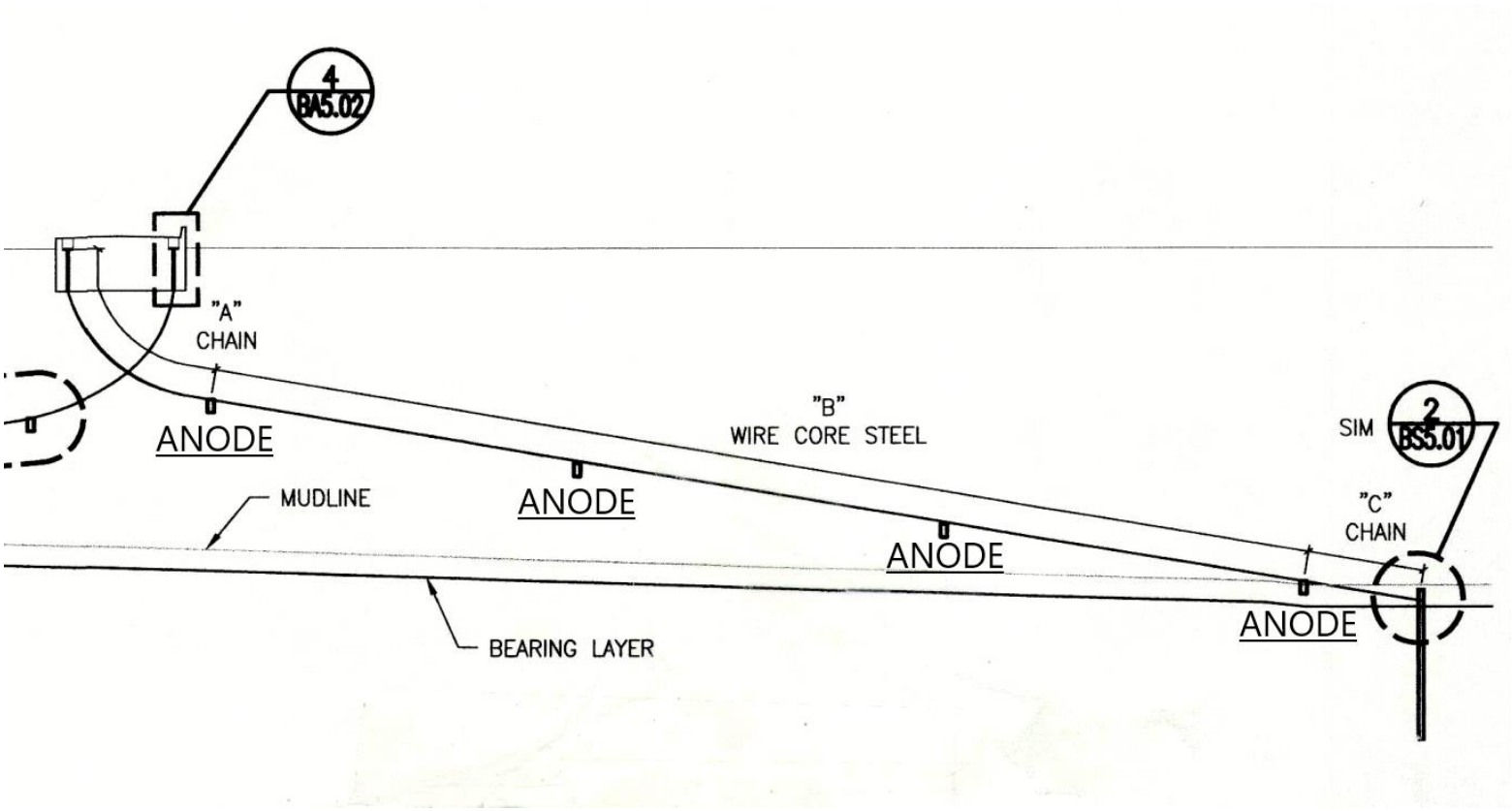

Photo 11: Mooring line anode locations

Photo 12: Line 3 - Horizontal rod anode on cable covered in marine growth

Photo 13: Line 8 - Rod anode on cable with loose connection, & severe corrosion

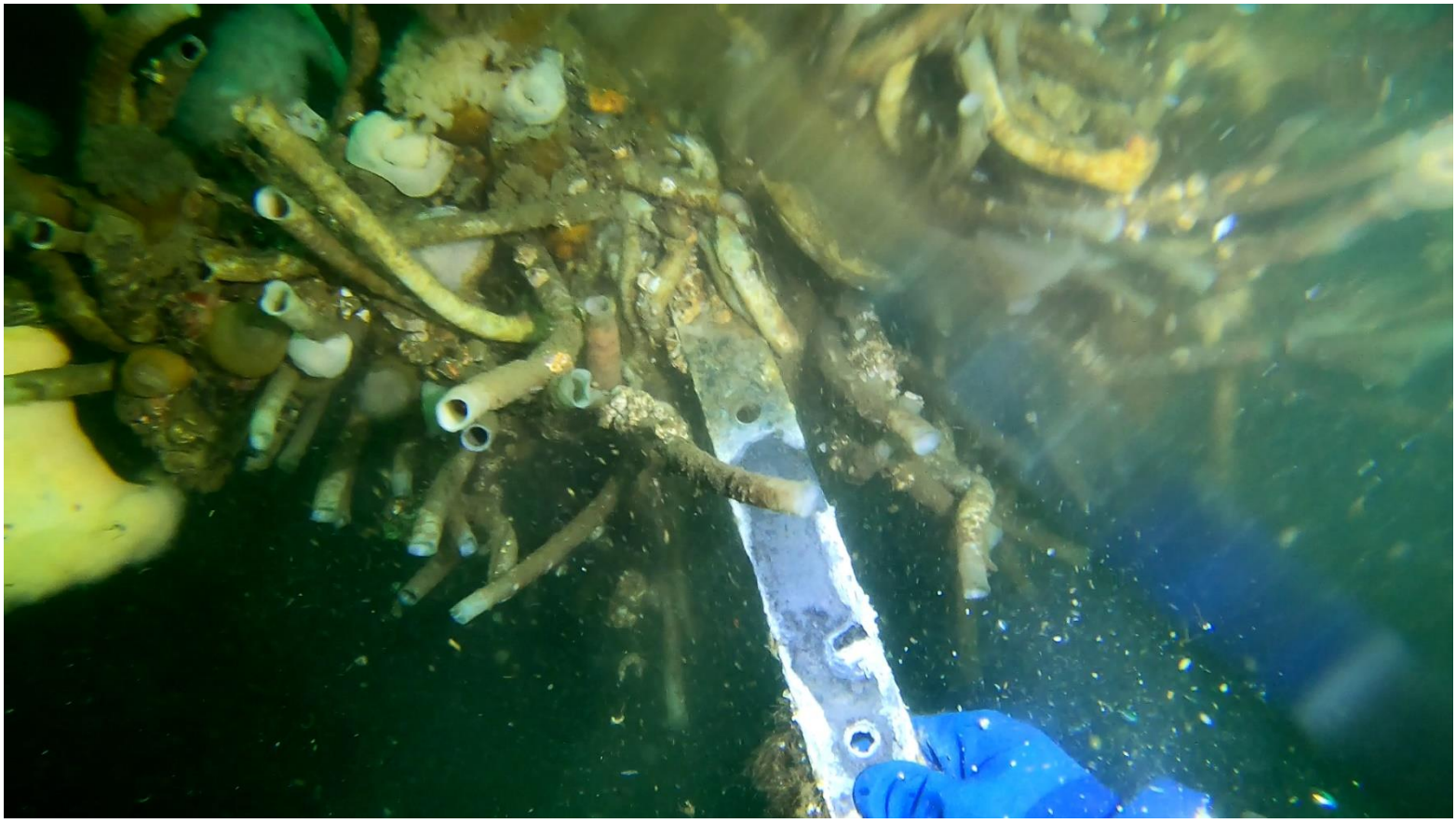

Photo 14: Line 5 - Old hardware attached securely to mooring line

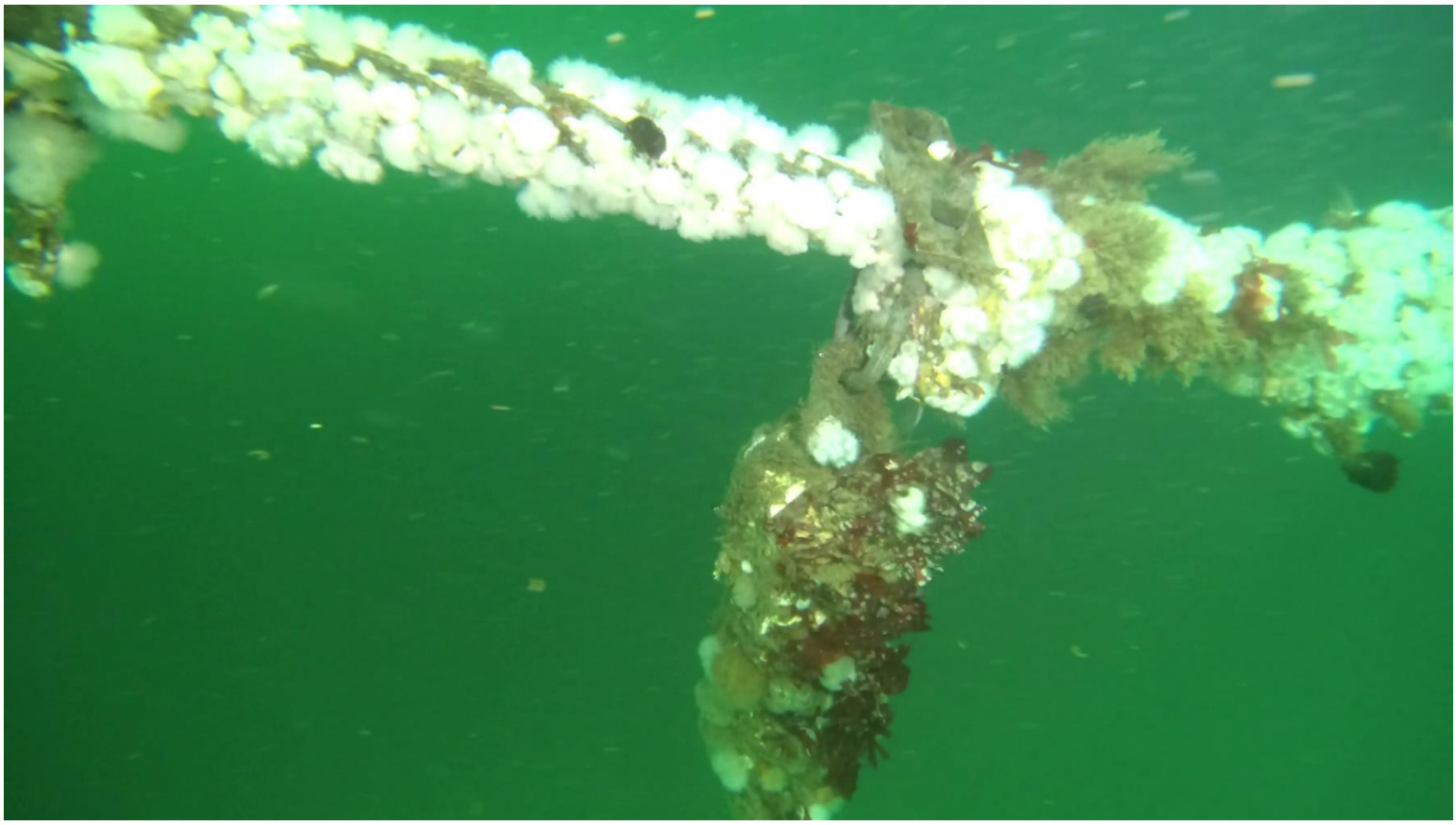

Photo 15: Line 44 - Typical newer anode with loose hardware, nuts backing off

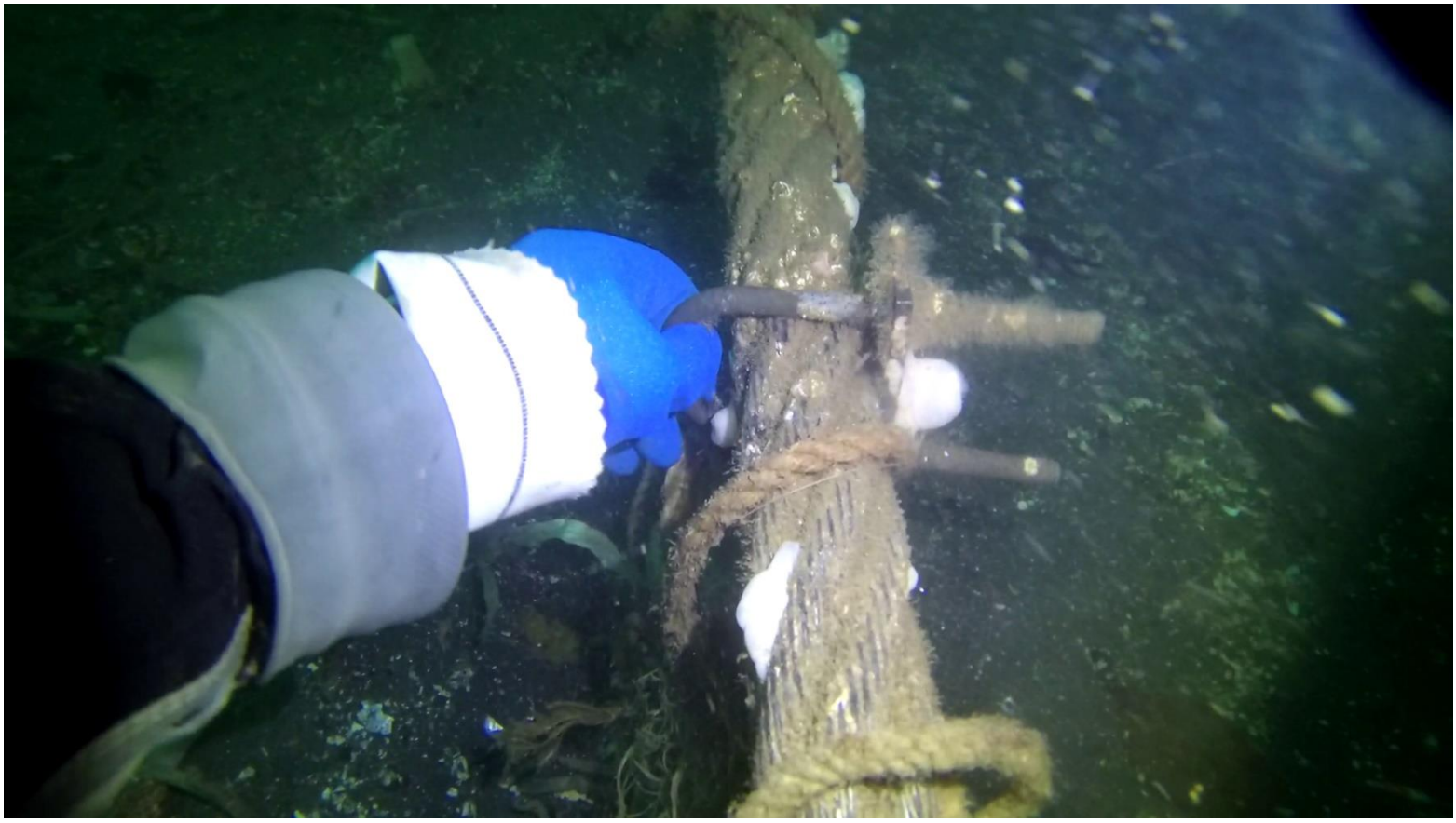

Photo 16: Line 30 - Typical newer anode with loose hardware, nuts fully tightened

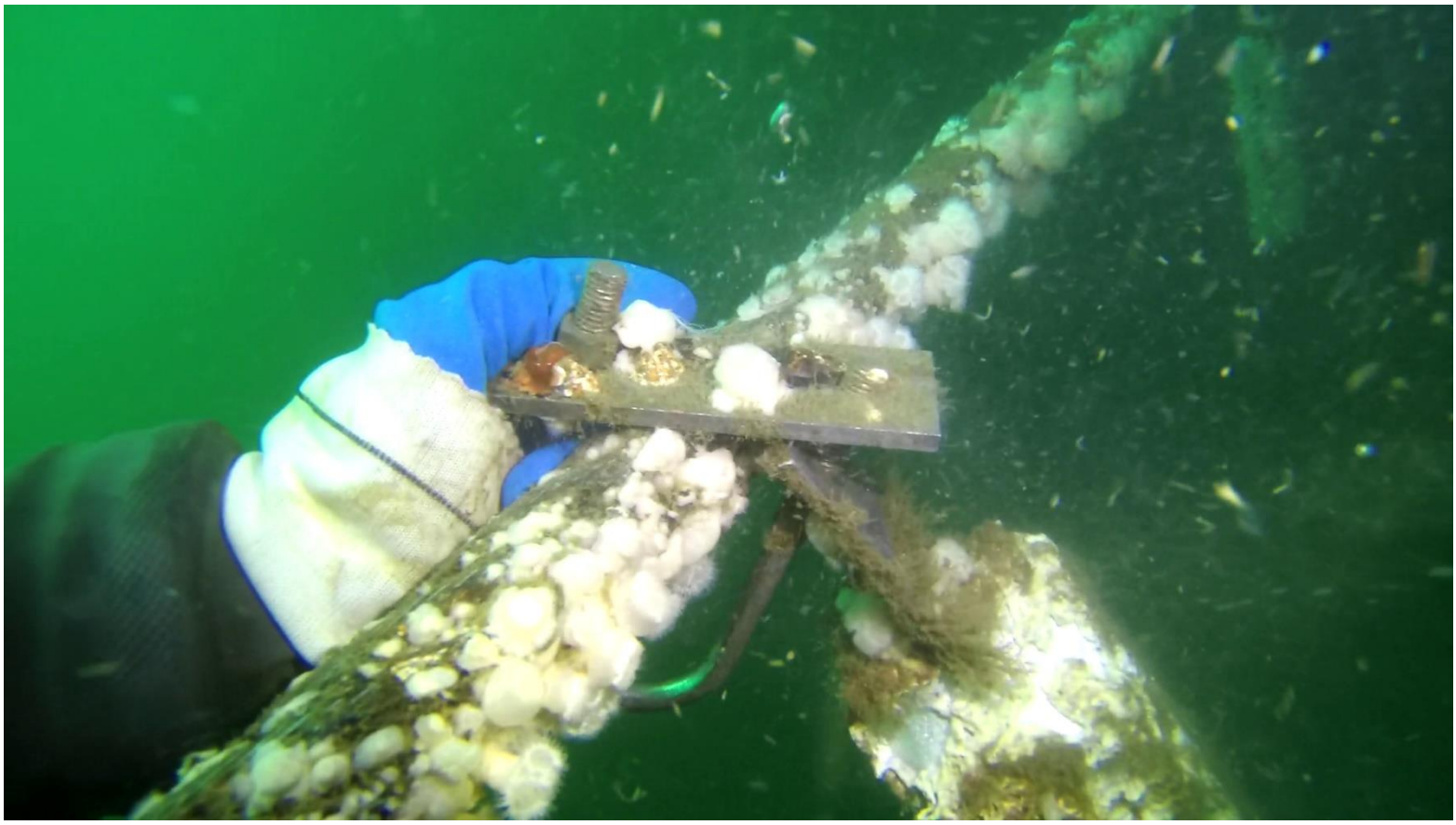

Photo 17: Line 23 - Typical newer anode with hex nut missing

Photo 18: Line 20N - Typical newer anode with hex nut missing

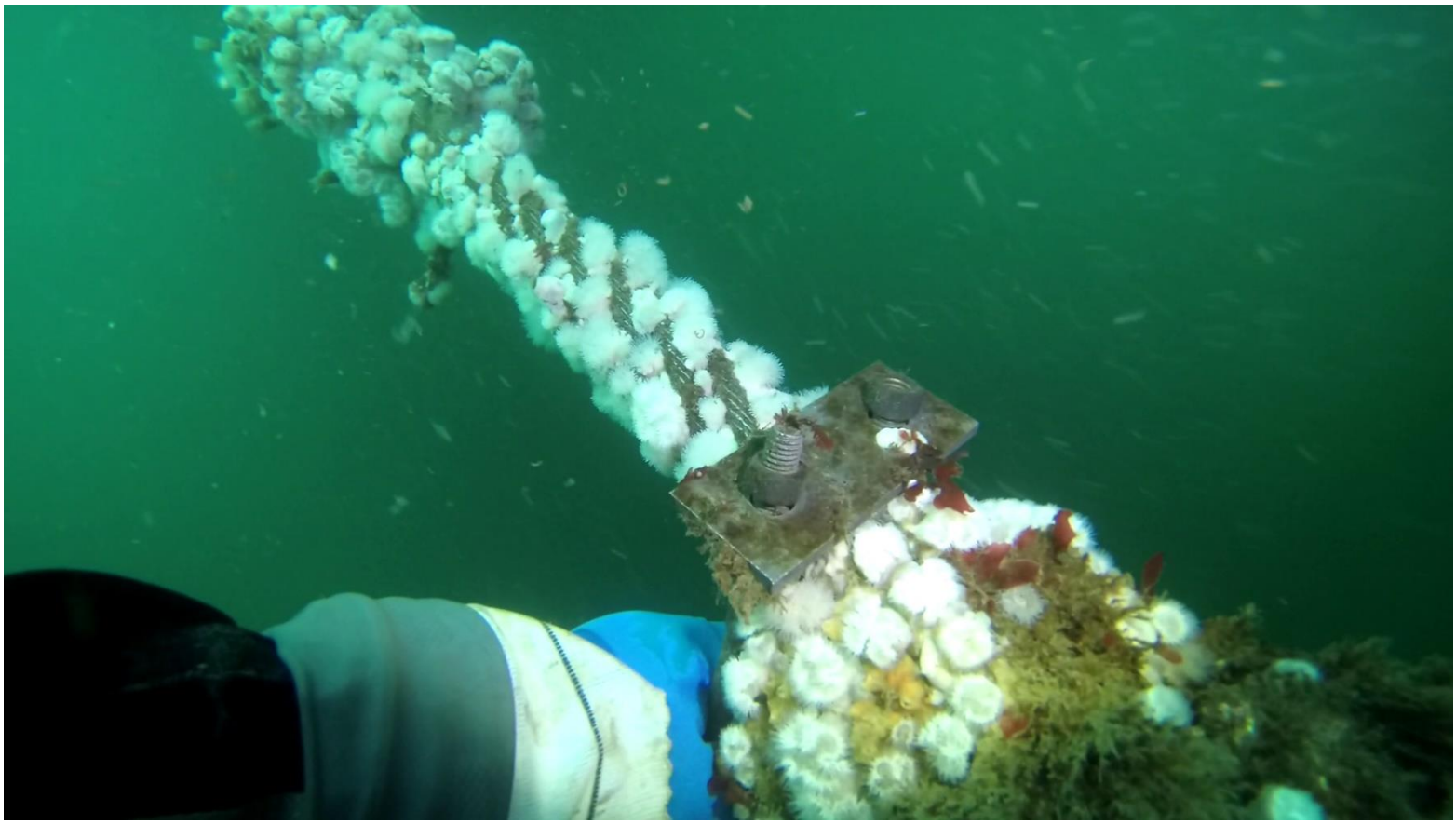

Photo 19: Line 44 - Typical newer anode with loose hardware, nuts backing off

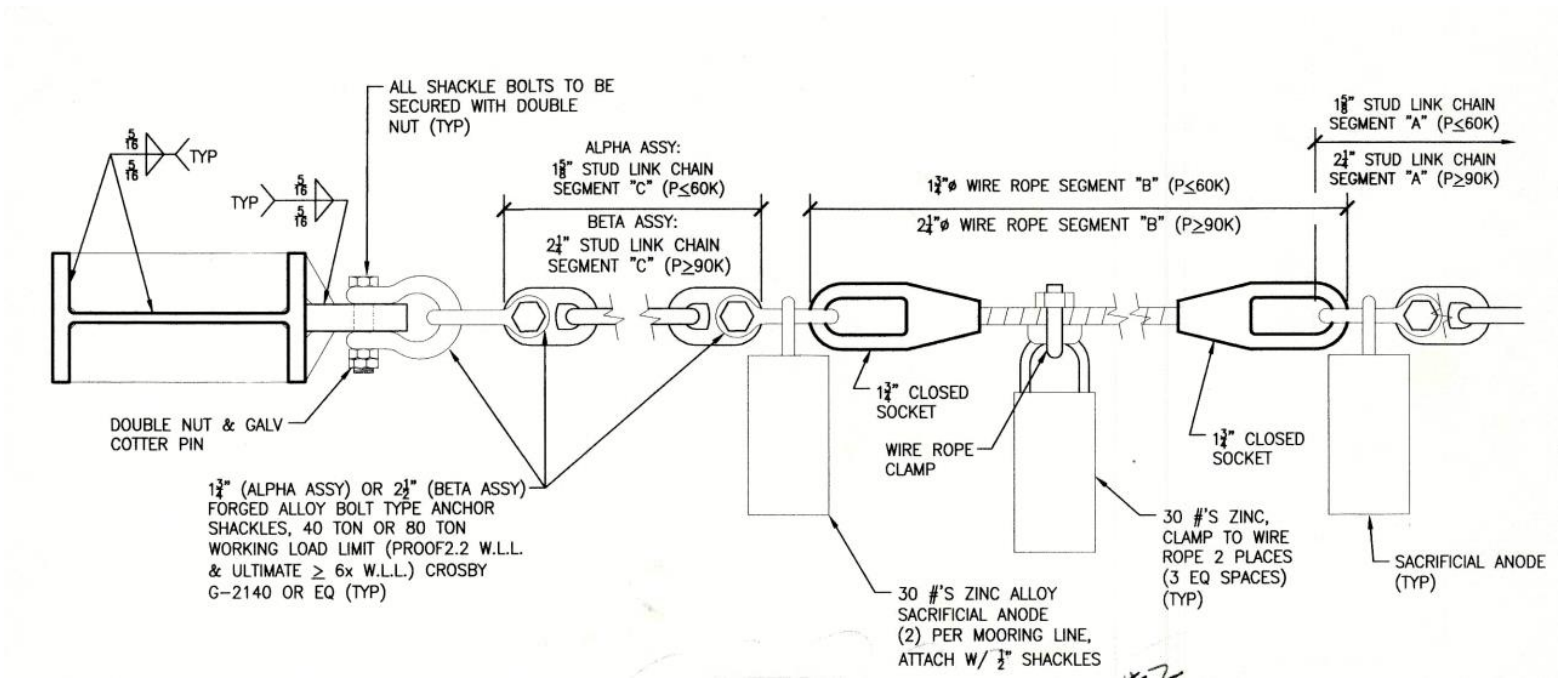

Photo 20: Original anode specs & locations


Photo 21: Line 2 - Typical dual rod anode condition

USS TURNER JOY - MOORING SYSTEM

The objective of this project is to provide a general description and assessment with recommendations of the underwater condition of the bow anchors, chains, floats, cathodic protection components, & rear bridle connection of the USS Turner Joy. The structures are generally covered in moderate marine growth and representative areas were cleaned using hand tools for closer examination. The photos within this report provide a visual representation of the typical underwater conditions and deterioration.

Observations

The mooring systems are in overall in **Fair** condition overall with limited areas of advanced deterioration & corrosion. The buoy chains are generally free of marine growth while the bow and anchor chains below the surface have about 75% surface coverage of moderate marine growth. The anodes were generally free of marine growth but this varied from 0% - 50% surface coverage. In general, all four mooring lines and associated hardware are in identical condition. **(See photos 22-25)**

Material loss percentages are conservative estimates based on a visual inspection of select areas with a layer of corrosion chosen for cleaning and further inspection. These estimates were then applied to other sections with identical characteristics as a level I inspection does not require further investigation of these sections. Only Partially Destructive Testing with cleaning and material thickness measurements would provide accurate material loss readings. The extent of visible deterioration on the anchor chains was typically localized to the edges on a few chain links. The extent of deterioration on the buoy chains & hardware extended throughout the entire system. The bow chains were relatively free of any corrosion or deterioration.

A typical mooring line in **Fair** condition consists of little to no surface corrosion, no deterioration, with more than 90% of the galvanizing still intact on any visible surface area. All four of the buoy chains & hardware were given a **Poor** grade as they have 100% coverage of surface rust. The bow chains were in Fair condition as surface corrosion was limited to the splash zones on all four chains. The anchor chains were given a Poor grade due to moderate surface corrosion & <20% material loss.

Surface corrosion on the bow chains seems to have subsided since the last inspection. With the exception of the splash zone, the wax coating applied to the bow chains seems to be limiting corrosion and marine growth. The wax coating on the splash zones likely washed away over time from weathering, etc. Each of the bow chains have one anode installed. The bow chain anodes are installed with oversized u-bolt hardware. There is not a tight, secure connection but there is little to no corrosion below the surface on the bow chains. **(See photos 26-27)**

The mooring float chains & associated hardware are in **Poor** condition as they have advanced surface rust, pitting, & deterioration. They do not have a strong enough bond to the rest of the mooring system to receive residual cathodic protection from the bow or anchor chain anodes. All

four of the chains have approximately 20% material loss and are completely covered in surface rust. A rod type anode would be an effective solution to slow down the deterioration.

Each mooring buoy has a 54" long x 3/4" threaded rod running through it. At the bottom of each rod is a 5/8" eye nut which the buoy chain attaches to. Below this eye nut there *should* be an additional hex nut to secure the eye nut and prevent it from backing off. The hex nuts on buoys A2 & A3 were missing and it appears the eye nut had backed off. In addition, some of the cotter pins for the shackles were mild or galvanized steel and had corroded away. The biggest concern with the buoys are the threaded rods, they are covered in a thick layer of surface rust & the rods, eye nuts, and shackles are deteriorating. If this continues, the threads could weaken and the eye nuts could eventually fail. An anode installed on the buoy chain, close to the buoy as possible would help prevent further corrosion & deterioration. These rods likely have a service life of less than 3 years. **(See photos 28-30)**

Two rod-type anodes were installed on each anchor chain. One near the upper portion of the anchor chain, and one near the middle of the anchor chain. Each anode has two rods, one extending from each end of the anode. It appears the anchor chain links were not cleaned down to bare metal as there is marine growth as well as a thick corrosion layer on the chain links. The anodes are installed horizontally and with the rods essentially bent at a 90 degree angle and sticking through the chain links making little connection to the chain surface. These rods should wrap around the anchor chain links.

The anodes are ineffective and providing no cathodic protection and there is still visible surface corrosion throughout the anchor chains. The existing anodes can still be used. We recommend cleaning the chain link surface area and reinstalling the anodes, ensuring the rods have a tight wrap & secure connection to the chain links. **(See photos 31-37)**

A-1, A-2, & A-3 anchor flukes were dug into the seabed. Anchor flukes on Anchor A-4 were not dug into the seabed. However it does not appear to have moved at all since the last inspection in 2022. All anchor chains were partially buried indicating secure anchoring for the Turner Joy.

The rear bridle connections consist of three pivoting brackets allowing for tidal fluctuations between the fixed piles and the USS Turner Joy stern. Brackets, bolts and connections to the concrete pile cap were covered in heavy barnacle growth and appear to be in good, secure condition. Typical but minor surface corrosion was found on brackets and bolts. The USS Turner Joy has a male pivot bracket welded directly to the hull that mates up to the female bracket on the steel bridle. Both brackets were in good condition with no marine growth and relatively little iron oxidation on the surface. Also found were hardened clumps of grease resting on the side of the bracket pins with little fresh grease on the pins themselves. Bolts joining the two halves of the bridal were subject to advanced corrosion and deterioration as they are in the splash zone of the bracket and subject to the most electro-chemical corrosion. No anodes are currently installed.

There are 8 pilings providing support for the rear bridle bracket. All 8 pilings currently have minor surface corrosion with minimal deterioration. The majority of the piling coating is still intact. Each piling had a pad eye welded to it which was a location for anodes to be installed. Completely depleted anodes were found in some of the pad eyes with only the bare rods

remaining. Some of the pad eyes corroded and failed completely. There is currently no cathodic protection for these pilings.

Assessments

Based on our underwater inspection, the underwater condition of the USS Turner Joy's Mooring System is in F**air** condition due to localized areas of advanced deterioration. The detailed examination of the mooring system determined the buoy & anchor chains require cathodic protection as soon as possible to provide an extended service life.

All four of the mooring buoys were in **Poor** condition due to the rods, hardware, and chains experiencing significant surface deterioration and have up to 20% material loss in some areas. The buoy rods and chains are not bonded to the rest of the anchoring system. Not only does it have the smallest hardware in the system but is also exposed to constant wave action which accelerates the corrosion process.

All four of the anchor chains were observed to be in **Poor** condition due to the amount of corrosion and deterioration throughout the system.

Detailed examinations of the bow chains were observed to be in **Fair** condition due limited amount of surface corrosion. The wax coating appears to have significantly helped combat subsurface corrosion. The anodes are installed with over sized hardware. However, they appear to be protecting the bow chains.

Based on current burn rates, bow & anchor chain anodes have 2-3 years of remaining service life.

Recommendations & Repairs

Each mooring float chain needs an anode installed on the buoy chain as soon as possible to prevent further corrosion and failure.

The anchor chain anodes need to be removed, chain links cleaned down to bare metal, and anodes reinstalled properly with rods wrapping the chain links tight & securely. This should be carried out as soon as possible.

The rear bridle connections appear to be in good condition. It is unknown when the last time the pins were greased or how often they are greased. These connections should be cleaned of marine growth and greased. If they are not already part of a maintenance schedule, they should be placed on one.

The eight piles supporting the concrete cap for the rear connection are in Fair condition but are currently without cathodic protection. The port should develop a plan to have anodes installed as soon as practical.

Annual inspection of the Turner Joy & associated mooring system should continue to be inspected annually to ensure the safety of the marina and it's tenants.

Turner Joy Mooring Condition Table

Mooring Line #	Bow Chain	Float, Chain & Associated Hardware	Anchor Chain & Anchor
A1	Fair – Previously noted surface corrosion is still present. All other corrosion below the surface has subsided <10% material loss, mostly at splash zone. Anode @ 70%, has poor connection. Hardware is loose and installed over growth.	Poor- Advanced surface corrosion throughout entire chain & hardware, <20% material loss. Lots of surface rust on buoy rod, eye nut, & shackle. Anode recommended.	Poor – Typical/ minor surface corrosion, advanced surface corrosion near flounder plate, <20% material loss. Rods from new anodes have no connection to chain. Two anodes @ 80%
A2	Fair – Previously noted surface corrosion is still present. All other corrosion below the surface has subsided <10% material loss, mostly at splash zone. Anode @ 70%, has poor connection. Hardware is loose and installed over growth.	Poor- Advanced surface corrosion throughout entire chain & hardware, <20% material loss. Lots of surface rust on buoy rod, eye nut, & shackle. Anode recommended.	Poor – Typical/ minor surface corrosion, advanced surface corrosion near flounder plate, <20% material loss. Rods from new anodes have no connection to chain. Two anodes @ 80%
A3	Fair – Previously noted surface corrosion is still present. All other corrosion	Poor- Advanced surface corrosion throughout entire chain & hardware, <20%	Poor – Typical/ minor surface corrosion, advanced surface corrosion

	below the surface has subsided <10% material loss, mostly at splash zone. Anode @ 80%	material loss. Lots of surface rust on buoy rod, eye nut, & shackle. Anode recommended.	near flounder plate, <20% material loss. Rods from new anodes have no connection to chain. One is disconnected and wedged under anchor chain. Two anodes @ 70%
A4	Fair – Previously noted surface corrosion has subsided. <10% material loss Anode @ 80%	Poor- Advanced surface corrosion throughout entire chain & hardware, <30% material loss. Anode recommended.	Poor – Typical/ minor surface corrosion, advanced surface corrosion near bow chain connection, <20% material loss. Rods from new anodes have poor connection. Two anodes @ 70% Anchor flukes facing up, not dug into the seafloor but doesn't appear to be moving.

Photo 22: Typical bow chain anode condition

Photo 23: Typical buoy chain, flounder plate, & hardware conditions

Photo 24: Typical buoy chain, flounder plate, & hardware conditions

Photo 25: Typical anchor chain and anode condition

Photo 26: Typical bow chain splash zone condition

Photo 27: Typical bow chain splash zone condition

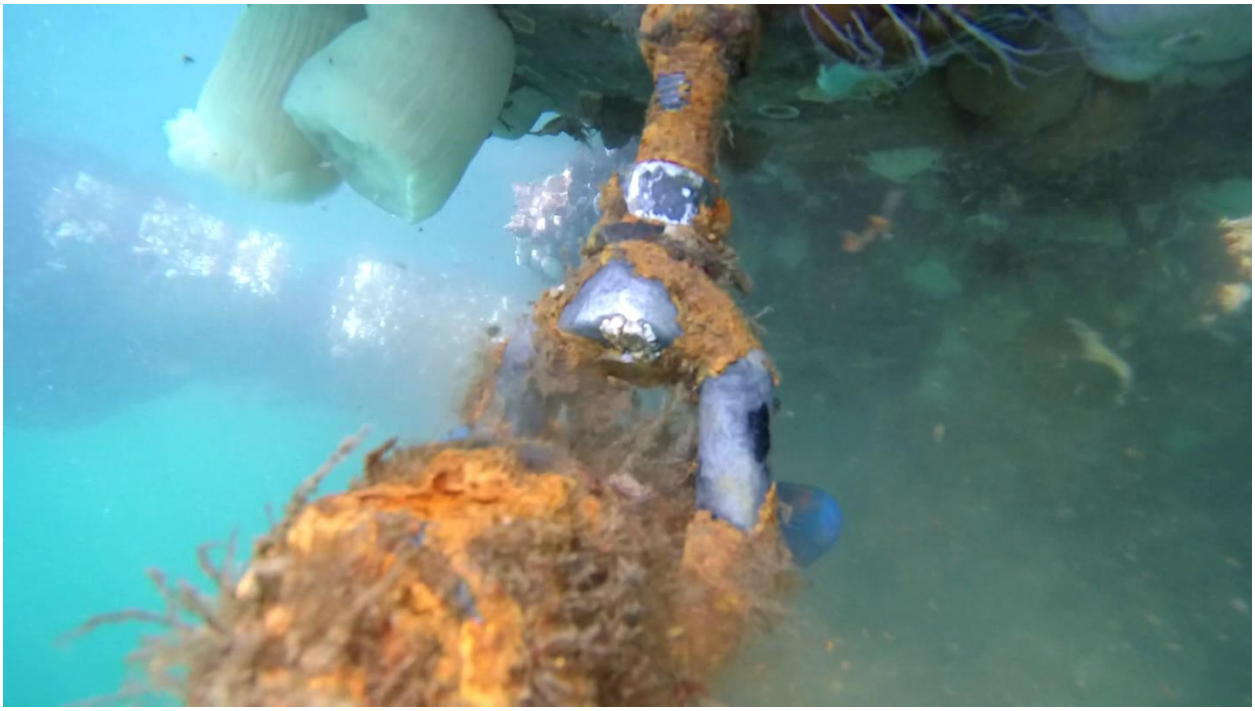

Photo 28: Typical rust & deterioration of buoy rod, eye nut, & hardware. Missing hex nut.

Photo 29: Typical rust & deterioration of buoy rod, eye nut, & hardware. Missing hex nut.

Photo 30: Typical rust & deterioration of buoy rod, eye nut, & hardware. Missing hex nut.

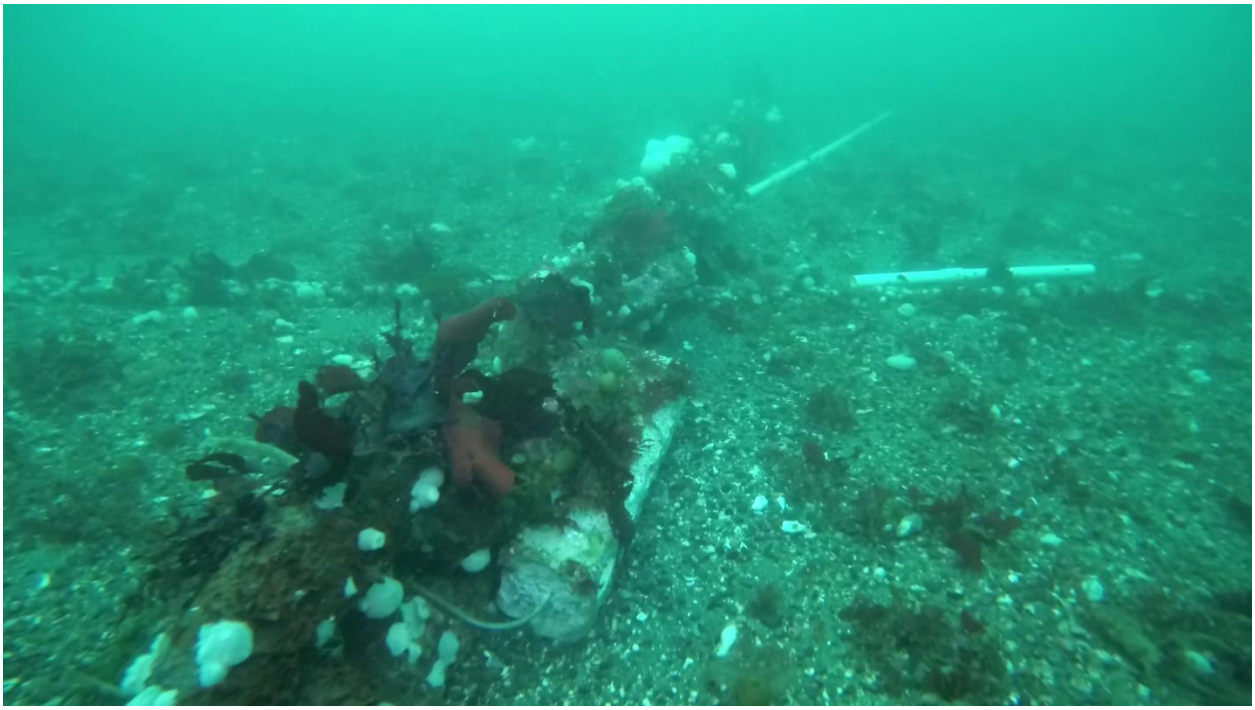

Photo 31: Typical anchor chain anode condition

Photo 32: Typical anchor chain anode condition

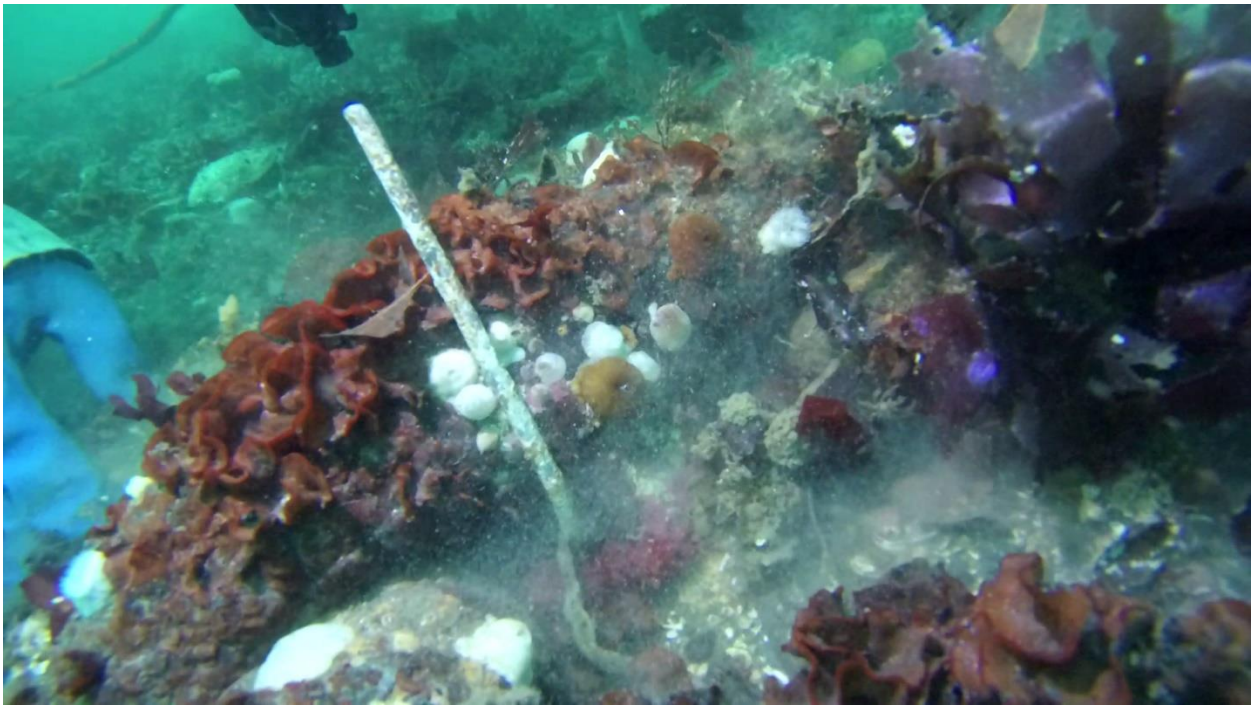

Photo 33: Typical anchor chain anode condition

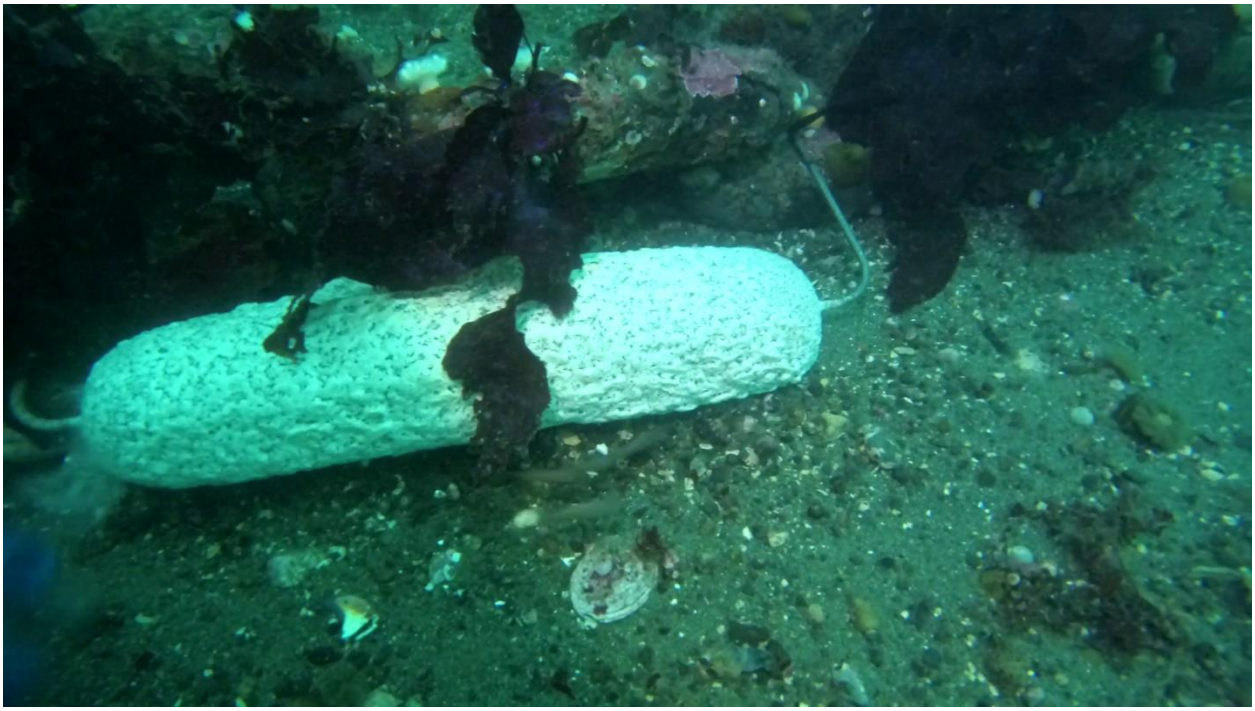

Photo 34: Typical anchor chain anode condition

Photo 35: Typical anchor chain anode condition

Photo 36: Typical anchor chain surface rust & deterioration

Photo 37: Typical anchor chain surface rust & deterioration