TENERA Environmental

September 24, 2014

Steve Tedesco
Tetra Tech
17885 Von Karman Ave., Suite 500
Irvine, CA. 92614

Subject: September 2014 WBMWD Biofouling Test Rack I Inspection

Dear Steve:

Here are my notes from the biofouling inspection of the first of the test racks installed at the West Basin intake on June 17, 2014. The test rack was retrieved on September 16th, after 92 days. In brief, the 90-10 copper-nickel and Z-Alloy Wedgewire samples and coupons looked very good, with a minimum of attached macrofouling. The 70-30 Cu-Ni was similar, but with slightly more fouling. The stainless steel samples were heavily fouled with hydroids and barnacles; little of the bare metal was visible. The stainless steel with the foul-release coating looked pretty good, especially in comparison with the uncoated samples, and the fouling was easily removed with just a light brushing with a soft nylon brush. I've mailed you some DVDs with underwater video and stills of the racks and individual stills of the samples from the post-retrieval inspection. The DVDs also include underwater stills taken during the June deployment.

The PVC test racks were heavily fouled with hydroids, acorn barnacles, and a wide variety of other invertebrates. Using the racks as a "control" reference, this brings into question the validity of the pipe spool test controls. It would appear that the low flow rate and macrofouling within the 2,000 foot supply line leading to the pipe rack test, has depleted the seawater of fouling larvae prior to their arrival at the test apparatus. Should the test be continued? Also, considering the performance of the uncoated SS Wedgewire samples and coupons, should any continued effort be put into analyzing those samples by Manny's group or Tenera?

Sincerely,

Fred Steinert
Tenera Environmental

West Basin Intake Biofouling Test
Test Rack I
September 17, 2014

Duration of Testing: June 17, 2014 – September 16, 2014 (92 days)

Biofouling Inspection notes
(Photos and video have been sent on a separate DVD)

- **PVC test rack:**
  - The PVC test rack was heavily fouled to the point where almost none of the PVC was visible. The two dominant fouling species were a hydroid (*Pinauay crocea* / *Tubularia crocea* or Tubularia-like) and the acorn barnacle *Megabalanus californicus*. The hydroids were present in dense tufts and mats up to a length of about 3 cm. The baranacles range from about 2 mm to 12 mm in diameter and covered most of the rack (thousands). Intermingled with the hydroids were mussels (*Mytilus galloprovincialis*) up to about 10 mm in length, small white bivalves (possibly *Hiatella*), small scallops, tube worms, amphipods, sponges, tunicates, and a variety of other invertebrates. There were also several species of red and green algae mixed in with the hydroids.
- **CDA 706 (90 – 10 Copper Nickel) wedgewire sample and coupon (A1 and B1):**
  - Wedgewire sample (A1)
    - The sample was quite clean, with some attached hydroids covering less than 1 percent of the surface. Some loose silt. A green patina covered much of the surface. About 50 percent of the surface had a very light covering of diatoms and entrapped silt.
  - Coupon (B1)
    - The coupon was also quite clean, with hydroids attached to about 1 percent of the surface. About 70 to 80 percent of the surface had a light covering of diatoms and entrapped silt.
- **Z-Alloy wedgewire sample and coupon (B2 and A2):**
  - Wedgewire sample (B2)
    - The sample was quite clean, similar to the CDA 706 (A1) with some attached hydroids covering less than 1 percent of the surface. Some loose silt. The surface had a green patina. About 50 percent of the surface had a very light covering of diatoms and entrapped silt.
  - Coupon (A2)
    - The coupon had two acorn barnacles (*Megabalanus californicus*) attached to it; one about 3 mm in diameter and the

other about 5 mm. A light layer of diatoms and silt covered about 50 percent of the surface.

- **2205 SS (stainless steel) with antifouling coating wedgewire sample and coupon (A3 and B3):**
  - Wedgewire sample (A3)
    - About 30 percent of the samples surface had hydroids attached to it (up to 3 cm long). About 2 percent of the surface was covered with an encrusting bryozoans and another 5 percent had a filamentous red alga attached to it. The foul-release coating was in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush.
  - Coupon (B3)
    - The coupon was quite clean with about 1 percent of the surface with attached hydroids, about 5 percent covered by an encrusting bryozoans, and about 7 percent with a light film of diatoms and silt. The foul-release coating was in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush.
- **2205 SS (stainless steel) wedgewire sample and coupon (B4 and A4):**
  - Wedgewire sample (B4)
    - This sample was very heavily fouled with hydroids covering most of the surface. Beneath the hydroids, attached to the sample, were approximately several thousand barnacles (*M. californicus*) ranging from 1 to 10 mm in diameter. Also intermixed with the hydroids were small mussels (*Mytilus galloprovincialis*), scallops, tube worms, amphipods, red algae, and probably other small invertebrates. The original weight of the sample was about 300 g and the fouling added about another 200g. The fouling was firmly attached and was not removed for fear of damaging the sample prior to metal analyses.
  - Coupon (A4)
    - The coupon was also heavily fouled, with hydroids and red algae covering most of its surface. Beneath the hydroids were an estimated 200 barnacles (*M. californicus*) ranging in size from 1.5 to 8 mm. Intermixed with the hydroids were mussels, scallops, some other small bivalves, and amphipod tubes. The fouling was firmly attached and was not removed for fear of damaging the coupon prior to metal analyses.
- **CDA 715 (70 – 30 Copper Nickel) wedgewire sample and coupon (A5 and B5):**
  - Wedgewire sample (A5)

    - The CDA 715 WW sample was similar to the CDA 706 and Z-Alloy samples , but with more hydroids (about 30 percent coverage), more of a diatom and silt film/layer, and only a few small patches of green patina on the metal's surface.
  - Coupon (B5)
    - The CDA 715 WW coupon was similar to the CDA 706 and Z-Alloy coupons. Hydroids were attached to about 2 percent of the coupon surface. Diatoms and entrapped silt covered about 80 percent of the surface.

Conclusions and Questions

- In comparison with the macrofouling observed on the PVC rack and the uncoated stainless steel samples, all of the copper-nickel samples (90-10, 70-30, and Z-Alloy) appear to be performing well at deterring the settlement of macrofouling organisms.
- The uncoated (bare metal) stainless steel Wedgewire sample and coupon have shown no antifouling properties and have about the same degree of fouling (species composition and growth) as the PVC racks.
- The SS samples that were painted with the foul-release coating had considerably less attached fouling that the uncoated samples, and were almost as clean as the Cu-Ni samples. The fouling that was present was easily removed with a light brushing using a soft-bristled nylon brush. The coating was in good condition, with no visible damage after three months of exposure.
- The heavy fouling on the PVC racks and the SS samples calls into question the performance of the control spools in the pipe rack test. Fouling larvae were obviously present in the seawater, but have not settled and grown in the control pipe spools. This is probably due to the low flow rate through the supply line and the macrofouling growing within the 2,000 foot run of the supply line.
- Should the pipe rack test be continued? The efficacy of the treatments cannot be evaluated if there is little or no macrofouling growth in the control pipe spools.
- Should analyses of the uncoated SS samples be continued considering their performance during the first three months of testing?

TENERA Environmental

January 12, 2015

Steve Tedesco
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17885 Von Karman Ave., Suite 500
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Subject: December 2014 WBMWD Biofouling Test Rack II Inspection

Dear Steve:

Here are my notes from the biofouling inspection of the second of the test racks installed at the West Basin intake on June 17, 2014. Test Rack II was retrieved December 29, 2014 after 196 days. As previously observed on Test Rack I after 92 days of exposure, the 90-10 copper-nickel and Z-Alloy Wedgewire samples and coupons looked very good, with a minimum of attached macrofouling. The 70-30 Cu-Ni was similar, but with slightly more fouling. The stainless steel samples were heavily fouled with hydroids and barnacles; little of the bare metal was visible. The stainless steel with the foul-release coating looked fairly clean, especially in comparison with the uncoated samples, and the fouling was easily removed with just a light brushing with a soft nylon brush. I will be sending you DVDs with underwater video and stills of the racks and individual stills of the samples from the post-retrieval inspection.

The PVC test racks were heavily fouled with hydroids, acorn barnacles, and a wide variety of other invertebrates. Using the racks as a “control” reference, this brings into question the validity of the pipe spool test controls. It would appear that the low flow rate and macrofouling within the 2,000 foot supply line leading to the pipe rack test, has depleted the seawater of fouling larvae prior to their arrival at the test apparatus. All three of the pipe spools removed from the test on December 22, 2014, including the control (untreated) spool, had little or no biofouling. The few barnacles that were found in the spools were all 4 mm or less in diameter. This is about the same size as the few barnacles found in the spools back in June 2014.

The mesh bags covering the 4 inch alloy plates were also replaced during this trip and the plates were photographed. A biofouling assessment and photos are included in this report.

Sincerely,

Fred Steinert
Tenera Environmental

West Basin Intake Biofouling Test
Test Rack II
December 30, 2014
Duration of Testing: June 17, 2014 – December 29, 2014 (196 days)

Wedgewire Samples, Alloy Coupons, and PVC Test Rack

Biofouling Inspection notes
(Additional photos and video have been sent on a separate DVD)

- **PVC test rack II:**
  - The PVC test rack was heavily fouled to the point where almost none of the PVC was visible. The two dominant fouling species were a hydroid (*Pinauay crocea* / *Tubularia crocea* or Tubularia-like) and the acorn barnacle *Megabalanus californicus*. The hydroids were present in dense tufts and mats up to a length of about 4 cm. The baranacles range from about 1 mm to 15 mm in diameter and covered most of the rack (thousands). Intermingled with the hydroids were mussels (*Mytilus galloprovincialis*) up to about 2 cm in length, small white bivalves (possibly *Hiatella*), small scallops, tube worms, amphipods, sponges, tunicates, and a variety of other invertebrates. There were also several species of red and green algae mixed in with the hydroids.
- **CDA 706 (90/10 Copper/Nickel) wedgewire sample and coupon (IIA1 and IIB1):**
  - Wedgewire sample (IIA1) (**Figure 1**)
    - The sample was quite clean, with four small patches of hydroids covering about 2 percent of the surface. The hydroids were associated with the locations of the plastic cable ties used to secure the sample to the PVC rack and were easily detached. A green patina covered much of the surface. About 70 percent of the surface had a very light covering of diatoms and entrapped silt. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.
  - Coupon (IIB1) (**Figure 2**)
    - The coupon was also quite clean, with no hydroids, barnacles or other attached macrofouling. About 80 percent of the surface had a light covering of diatoms and entrapped silt. All silt and diatoms were easily removed with a soft nylon brush after photographing and inspection.

- **Z-Alloy wedgewire sample and coupon (IIB2 and IIA2):**
  - Wedgewire sample (IIB2) (**Figure 3**)
    - The sample was quite clean, similar to the CDA 706 (IIA1) with a few hydroids covering less than 1 percent of the surface. The hydroids were associated with the locations of the plastic cable ties used to secure the sample to the PVC rack and were easily detached. The surface had a green patina. About 80 percent of the surface had a very light covering of diatoms and entrapped silt. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.
  - Coupon (IIA2) (**Figure 4**)
    - The coupon had no macrofouling (barnacles, hydroids, etc.) attached to it. There was a light layer of diatoms and silt covered about 30 percent of the surface.
- **2205 SS (stainless steel) with antifouling coating wedgewire sample and coupon (IIA3 and IIB3):**
  - Wedgewire sample (IIA3) (**Figure 5**)
    - About 30 to 40 percent of the sample's total surface had hydroids attached to it (up to 3 cm long). About 2 percent of the underside ribs were covered with an encrusting bryozoans and another 5 percent had a filamentous red alga attached to it. 12 half-slipper shells (*Crepipatella lingulata*), similar to limpets, measuring 5 to 20 mm in diameter were found on the reinforcing ribs of the underside of the sample. A single 7 mm white bivalve (Hiatella?) was nestled in the hydroids. The foul-release coating was in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush.
  - Coupon (IIB3) (**Figure 6**)
    - The coupon was quite clean with about 5 percent of the surface covered with attached hydroids, and another 5 percent covered with a light film of diatoms and silt. There was one 7 mm half-slipper shell. The foul-release coating was in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush.
- **2205 SS (stainless steel) wedgewire sample and coupon (IIB4 and IIA4):**
  - Wedgewire sample (IIB4) (**Figure 7**)
    - This sample was very heavily fouled with hydroids covering most of the surface. Beneath the hydroids, attached to the sample, were approximately several thousand barnacles (*M. californicus*) ranging from 1 to 10 mm in diameter. Also intermixed with the hydroids were small mussels (*Mytilus*

galloprovincialis) up to 12 mm in length, scallops, tube worms, amphipods, crabs, erect and encrusting bryozoans, red algae, and probably other small invertebrates. The original weight of the sample was about 314 g and the fouling added about another 229 g. The fouling was firmly attached and was not removed for fear of damaging the sample prior to metal analyses.

    - Coupon (IIA4) (**Figure 8**)
        - The coupon was also heavily fouled, with hydroids and red algae covering most of its surface; no metal was visible. Beneath the hydroids were an estimated 200 barnacles (*M. californicus*) ranging in size from 1.5 to 12 mm. Intermixed with the hydroids were mussels (2 to 4 mm), some other small white bivalves (*Hiatella*?), and amphipod tubes. The original weight of the coupon was about 22 grams, with the attached fouling the weight was about 55 grams. The fouling was firmly attached and was not removed for fear of damaging the coupon prior to metal analyses.
- **CDA 715 (70/30 Copper/Nickel) wedgewire sample and coupon (A5 and B5):**
    - Wedgewire sample (IIA5) (**Figure 9**)
        - The CDA 715 WW sample was similar to the CDA 706 and Z-Alloy samples, but with slightly more hydroids (about 4 percent coverage), more of a diatom and silt film/layer, and only a few small patches of green patina on the metal's surface. The hydroids are located near the corners of the sample where the plastic cable ties were positioned. The hydroids most likely originated on the cable ties and later overlapped onto the Wedgewire. No barnacles or other macrofouling aside from the hydroids. All hydroids and debris was easily removed with a soft nylon brush after photographing and inspection.
    - Coupon (IIB5) (**Figure 10**)
        - The CDA 715 WW coupon was similar to the CDA 706 and Z-Alloy coupons. A few hydroids were attached near the holes in the coupon. The hydroids most likely originated on the cable ties and later overlapped onto the coupon. Diatoms and entrapped silt covered about 80 percent of the surface. The coupon had more green patina than the CDA 715 Wedgewire sample, especially on the test welds.

Weight Change

Prior to the biofouling inspections and assessments, each Wedgewire sample and alloy coupon was blotted to remove any excess water and then weighed along with any accumulated fouling. The resulting weight was then compared with the dry weight that was recorded prior to deployment of the test racks. Presented below is the percentage change in weight for each of the samples retrieved from Rack I on September 16, 2014 and Rack II on December 29, 2014:

Wedgewire Samples	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	-2.8%
Test Rack II	-2.5%
CDA 715 (70/30 Cu/Ni)	
Test Rack I	3.5%
Test Rack II	2.8%
Z-alloy	
Test Rack I	-2.1%
Test Rack II	-2.2%
2205 Stainless Steel (uncoated)	
Test Rack I	64.9%
Test Rack II	73.0%
2205 Stainless Steel (coated)	
Test Rack I	4.5%
Test Rack II	12.5%

Alloy Coupons	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	0.7%
Test Rack II	-0.3%
CDA 715 (70/30 Cu/Ni)	
Test Rack I	1.1%
Test Rack II	0.0%
Z-alloy	
Test Rack I	0.7%
Test Rack II	0.1%
2205 Stainless Steel (uncoated)	
Test Rack I	121.3%
Test Rack II	148.5%
2205 Stainless Steel (coated)	
Test Rack I	0.5%
Test Rack II	1.3%

Alloy Test Plates

Five 4-inch square alloy test plates, one each of the same materials as the Wedgewire samples and the alloy coupons, were attached to frames made of ¾ inch PVC pipe, enclosed in plastic mesh bags (1/4 inch Vexar) and suspended about 12 inches below the intake structure grating. The test was designed to approximate the conditions that might be found in the interior of a Wedgewire intake module (relatively low water velocity and screening that excludes large predatory organisms such as fish, crabs, and sea stars). The plates were deployed along with the Wedgewire/coupon test racks on June 17, 2014. On September 16, 2014, after 92 days of exposure, the original mesh bags were removed and replaced with new bags. No photos were taken at that time. December 29, 2014, after 196 days of exposure, the bags were again replaced with new bags; this time the plates were photographed, in situ, prior to being enclosed in the new bags. The plates were then returned to their original positions beneath the grating.

The following biofouling assessment is based on what could be discerned from the underwater photos taken of the plates. Photographs of each plate are also included.

- **CDA 706 (90/10 Copper/Nickel), Plate 1,** (**Figure 11**)
  - The plate is almost entirely covered with a blue-green patina.
  - No attached macrofouling is visible in the photographs of the plate. There is a brittle star crawling across the plate; this is not a resident organism.
  - Hydroids, acorn barnacles, colonial tunicate, and other invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame.
- **CDA 715 (70/30 Copper/Nickel), Plate 2,** (**Figure 12**)
  - The plate is very clean with almost no discoloration or oxidation visible in the photo.
  - No attached macrofouling.
  - Hydroids, acorn barnacles, solitary and colonial tunicates, bryozoans, mussels, scallops, sponges, and other invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame.
- **Z-alloy, Plate 3,** (**Figure 13**)
  - The plate is quite clean. It has a duller finish than the CDA 715 plate, but does not have the patina of the CDA 706 plate.
  - There is a single Abalone Jingle, or possibly a Half-Slipper Shell, that appears to have grown from one of the cable ties onto the plate. Aside from that shell, the plate is clean of attached macrofouling.
  - As with Plates 1 & 2, a variety of encrusting invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame.
- **2205 Stainless Steel (uncoated), Plate 4,** (**Figure 14**)
  - This plate is almost completely covered with macrofouling, primarily a large, expansive colonial tunicate. Hydroids and bryozoans are also

visible. There may be other species underneath the tunicate or, if the tunicate colonized the plate first, it may have excluded settlement by other species. Regardless, this material shows no apparent antifouling characteristics.
    - As with the other plates, a variety of encrusting invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame. In this case, there is little to differentiate between the stainless steel plate and the plastic components.
- **2205 Stainless Steel with foul release coating, Plate 5,** (**Figure 15**)
    - This plate is of the same material as Plate 4, but has been coated with a silicone elastomer foul release coating.
    - About 10 to 15 percent of the surface is covered with, what appears to be, a mixture of hydroids, bryozoans, and algae. Most of the fouling is concentrated near the corners and probably originated on the plastic cable ties and then grew onto the plate surface.
    - Assuming that the coating on the plate performs like the same coating on the Wedgewire samples and the coupons, I would expect that the fouling could easily be removed from the plate with a soft nylon brush or similar instrument, without damaging the coating.

Conclusions

- In comparison with the macrofouling observed on the PVC rack and the uncoated stainless steel samples, all of the copper-nickel samples (90-10, 70-30, and Z-Alloy) appear to be performing well at deterring the settlement of macrofouling organisms.
- The uncoated (bare metal) stainless steel Wedgewire sample and coupon have shown no antifouling properties and have about the same degree of fouling (species composition and growth) as the PVC racks.
- The SS samples that were painted with the foul-release coating had considerably less attached fouling that the uncoated samples, and were almost as clean as the Cu-Ni samples. The fouling that was present was easily removed with a light brushing using a soft-bristled nylon brush. The coating was in good condition, with no visible damage after three months of exposure.
- The heavy fouling on the PVC racks and the SS samples calls into question the performance of the control spools in the pipe rack test. Fouling larvae were obviously present in the seawater, but have not settled and grown in the control pipe spools. This is probably due to the low flow rate through the supply line and the macrofouling growing within the 2,000 foot run of the supply line.
- The test plates appear to be performing like the WW samples and coupons. The copper alloys are, for the most part, clean of fouling, the coated stainless steel is relatively clean, and the uncoated SS is heavily fouled.

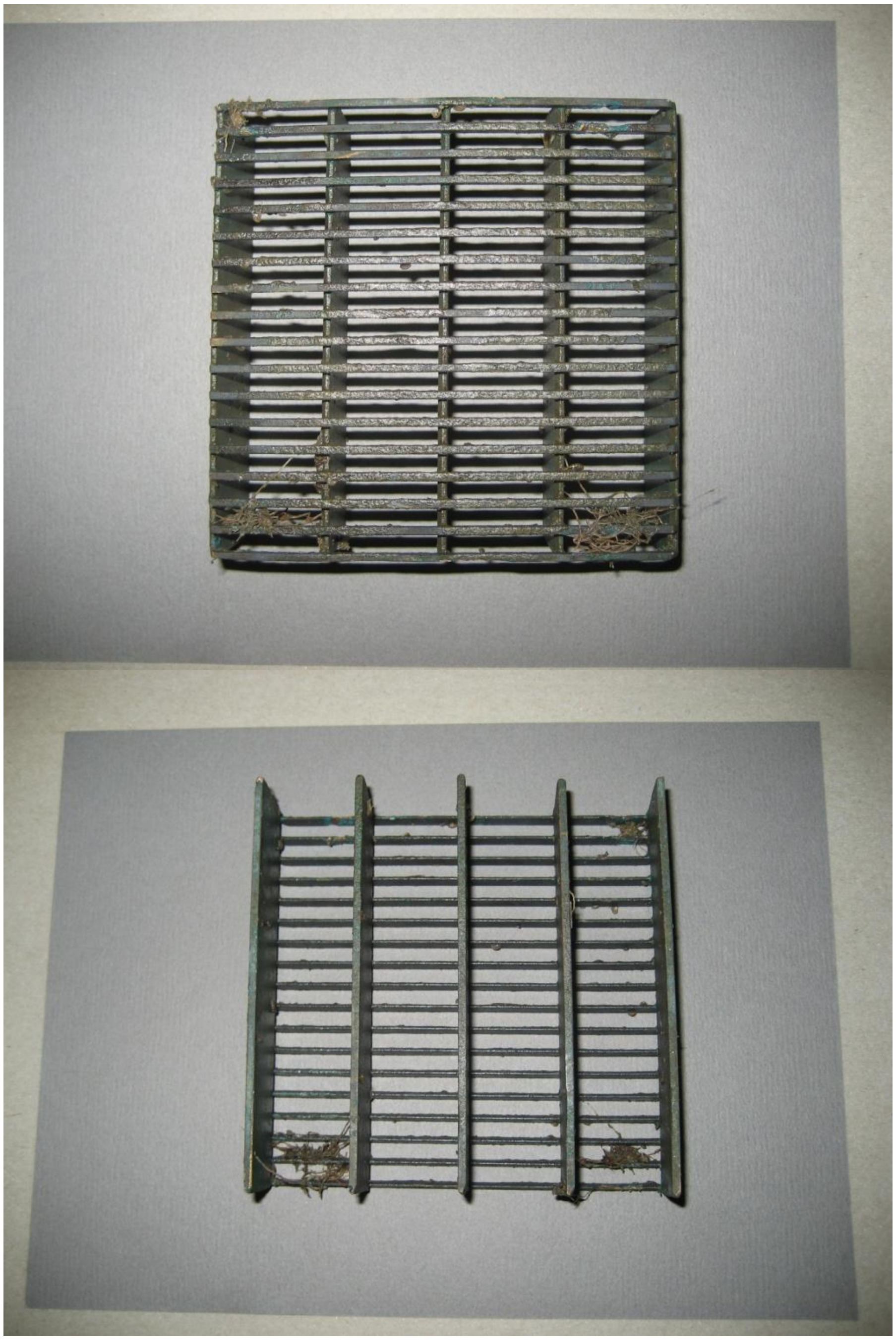


Figure 1. 90/10 Cu/Ni (CDA706) Wedgewire sample, photographed 12/30/14.

Figure 2. 90/10 Cu/Ni (CDA706) coupon, photographed 12/30/14.

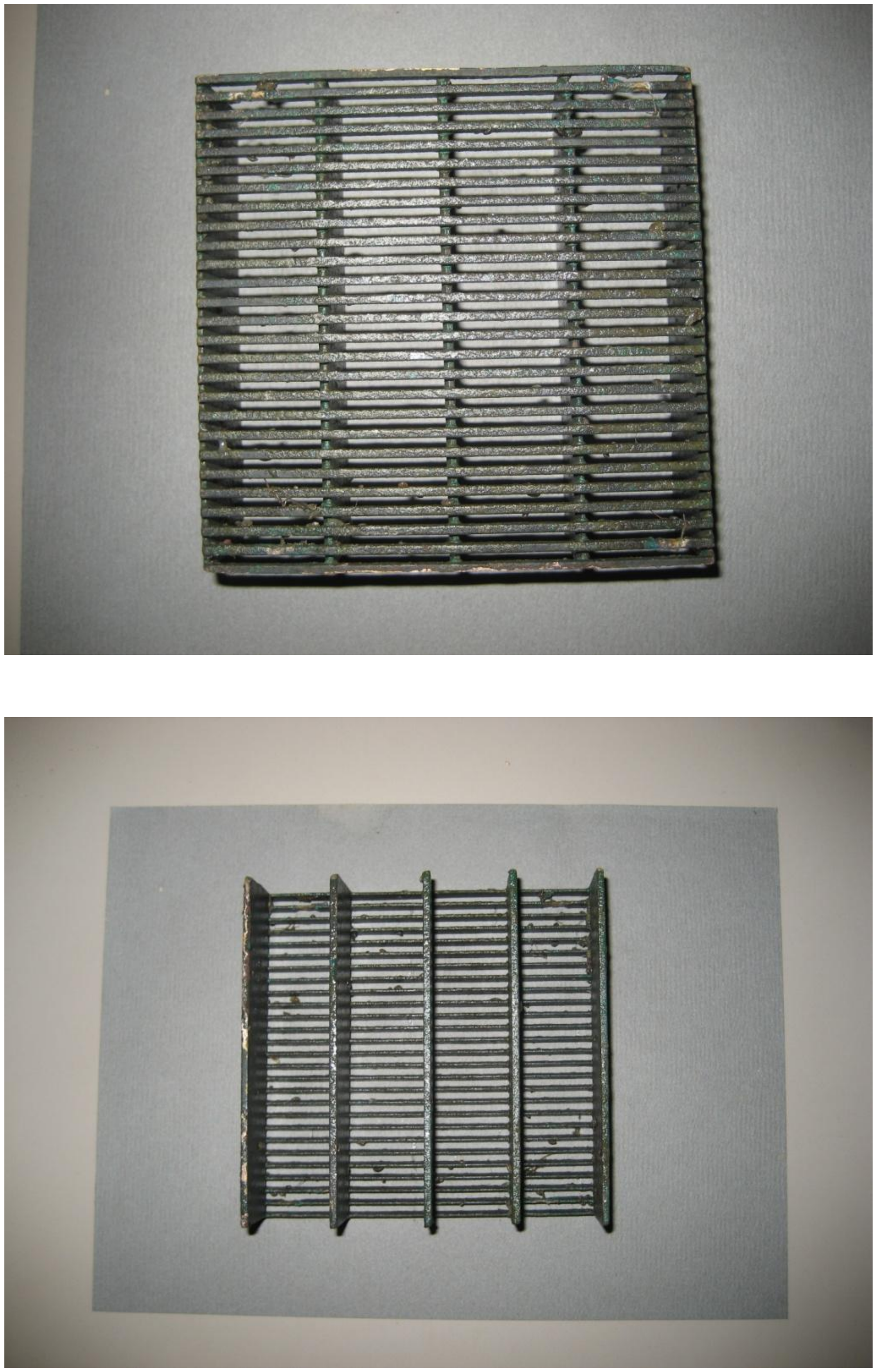


Figure 3. Z-alloy Wedgewire sample, photographed 12/30/14.

Figure 4. Z-alloy coupon, photographed 12/30/14.

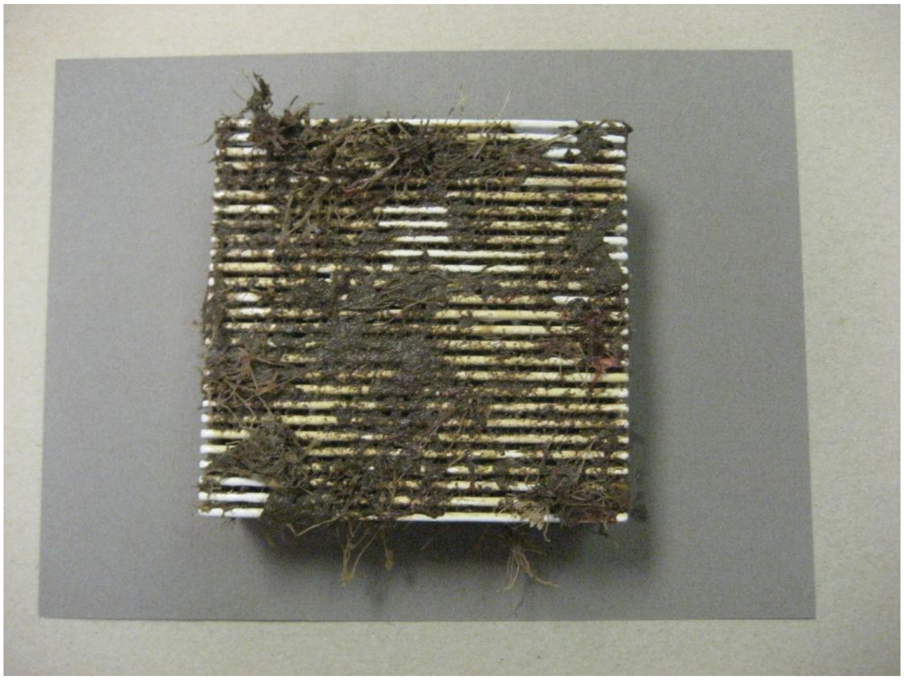


Figure 5. 2205 stainless steel Wedgewire sample with foul release coating, photographed 12/30/14.

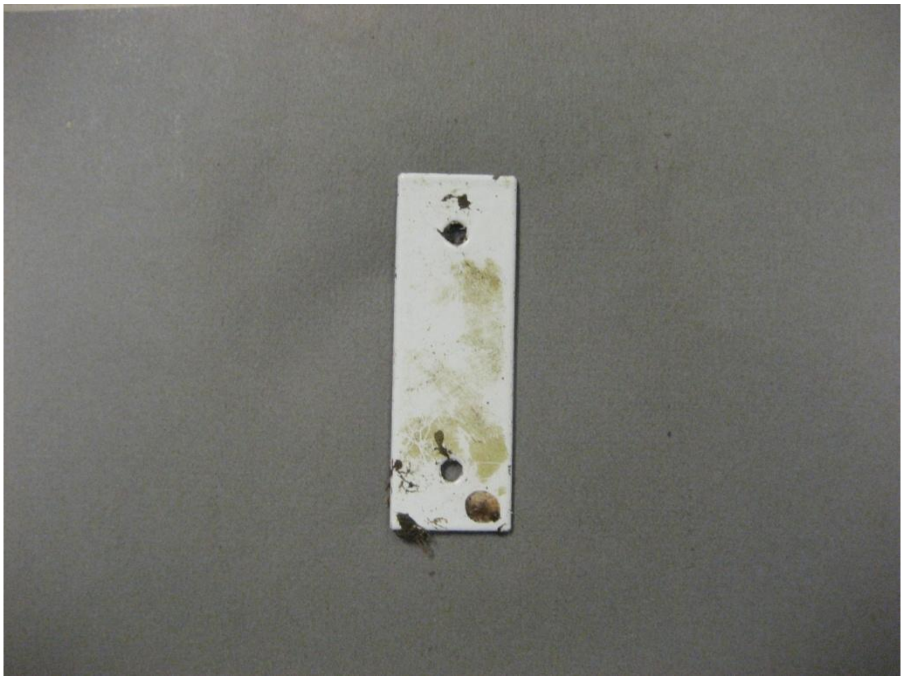


Figure 6. 2205 stainless steel coupon with foul release coating, photographed 12/30/14.

Figure 7. 2205 stainless steel Wedgewire sample, photographed 12/30/14.

Figure 8. 2205 stainless steel coupon, photographed 12/30/14.

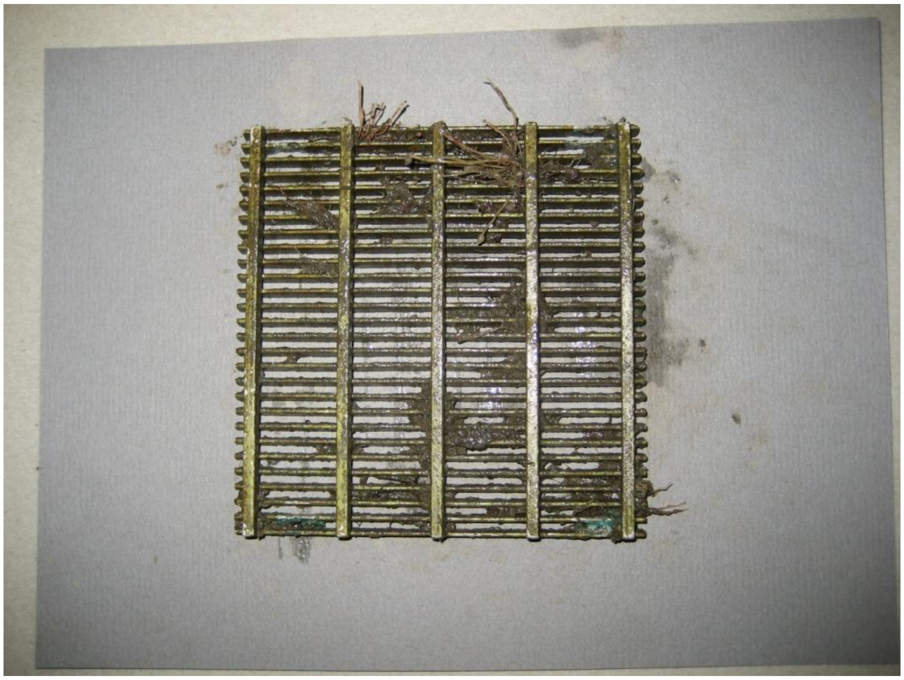


Figure 9. 70/30 Cu/Ni (CDA715) Wedgewire sample, photographed 12/30/14.

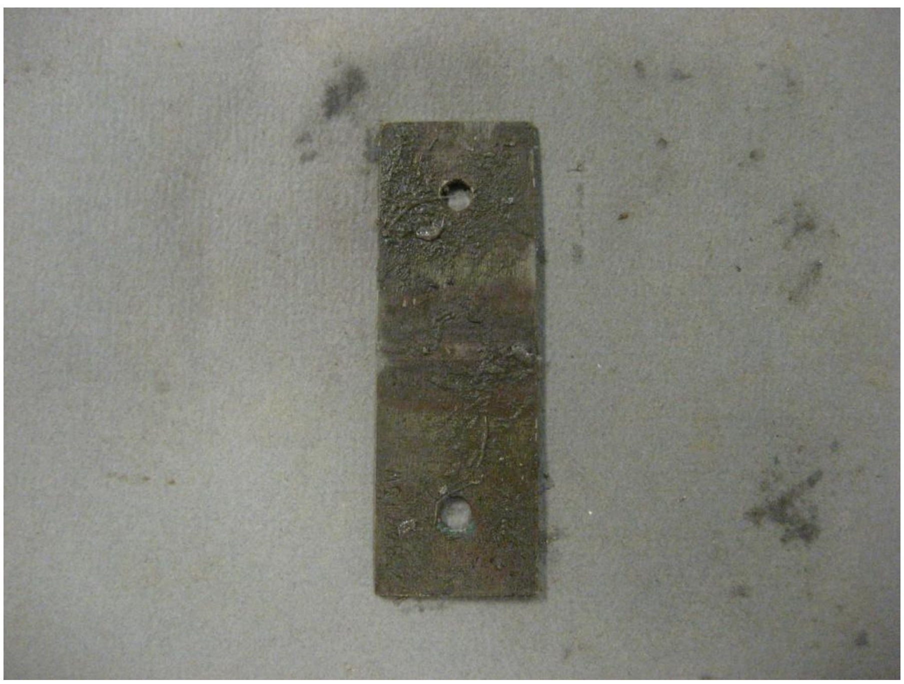


Figure 10. 70/30 Cu/Ni (CDA715) coupon, photographed 12/30/14.

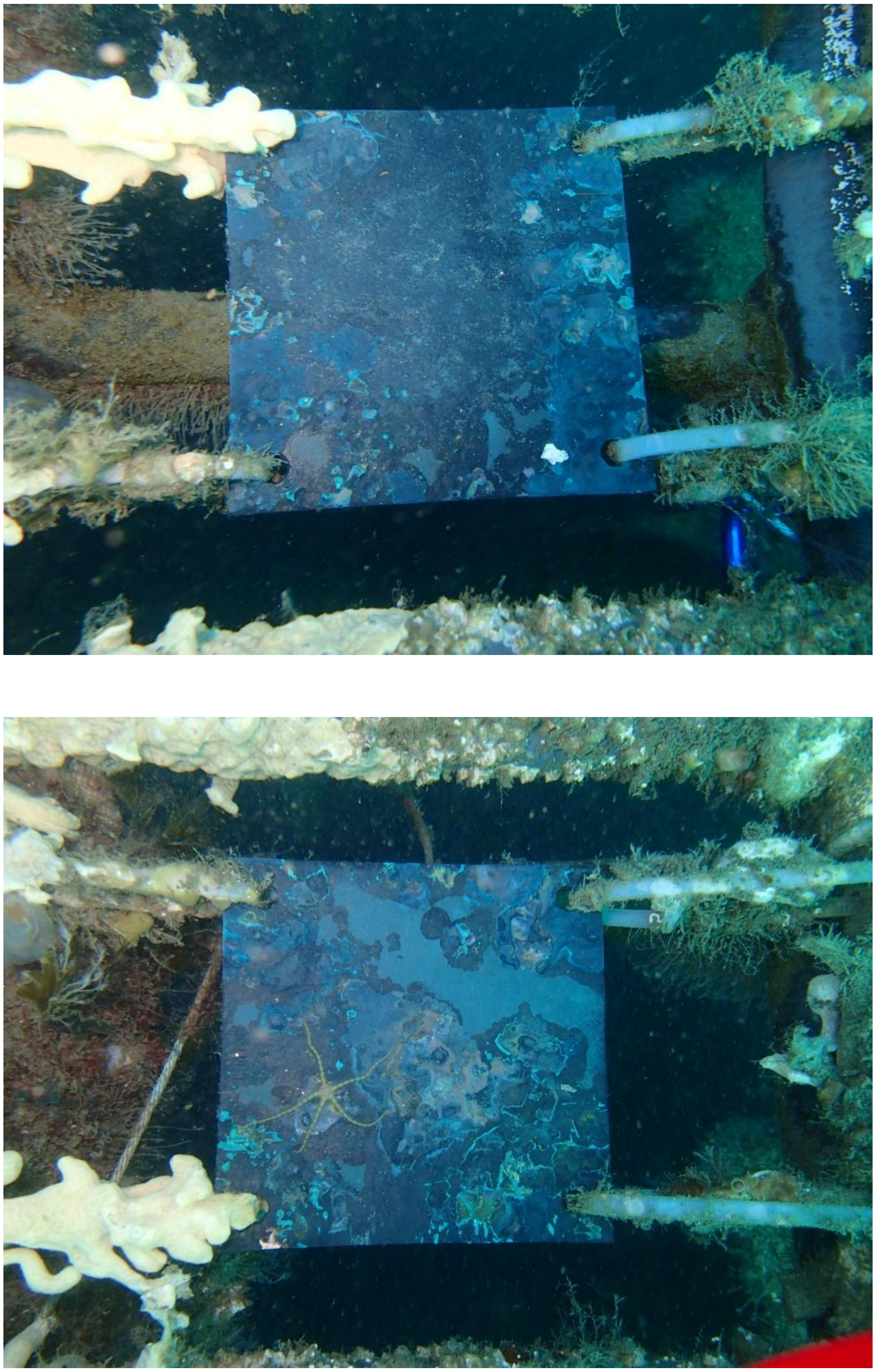


Figure 11. 90/10 Cu/Ni (CDA706) test plate (Test Plate 1), photographed 12/29/14 in situ after removal of its Vexar mesh bag.

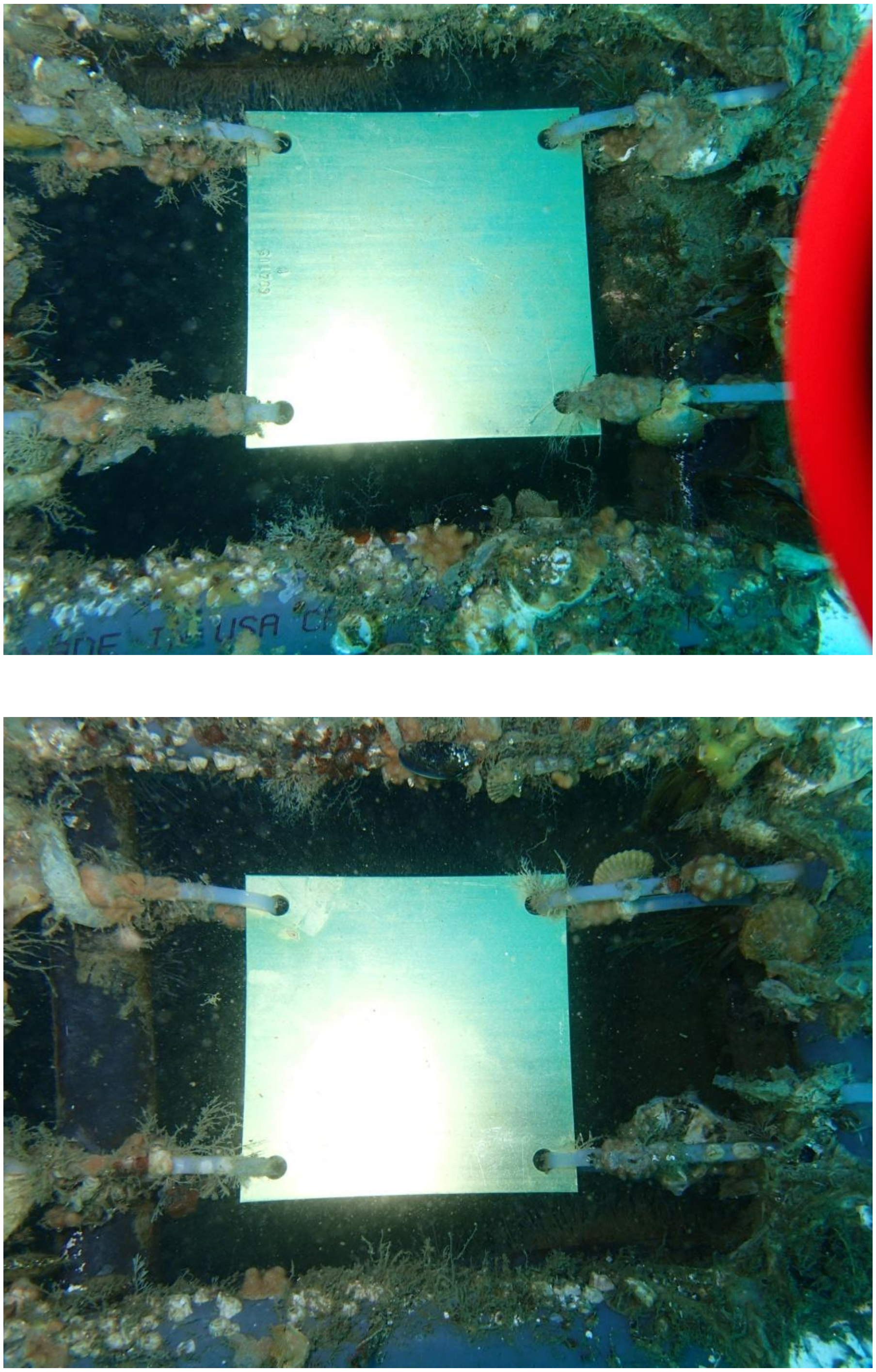


Figure 12. 70/30 Cu/Ni (CDA715) test plate (Test Plate 2), photographed 12/29/14 in situ after removal of its Vexar mesh bag.

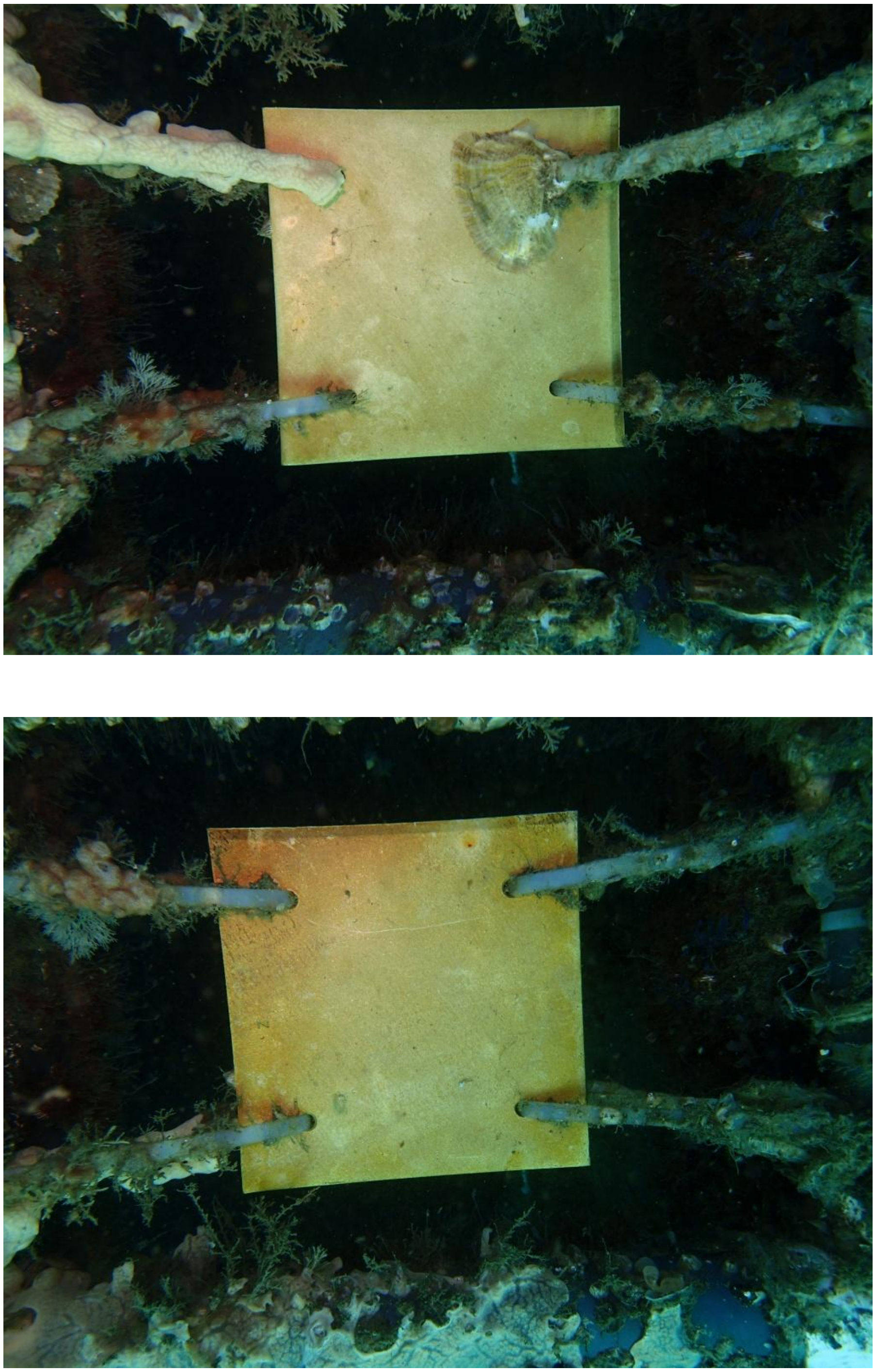


Figure 13. Z-alloy test plate (Test Plate 3), photographed 12/29/14 in situ after removal of its Vexar mesh bag.

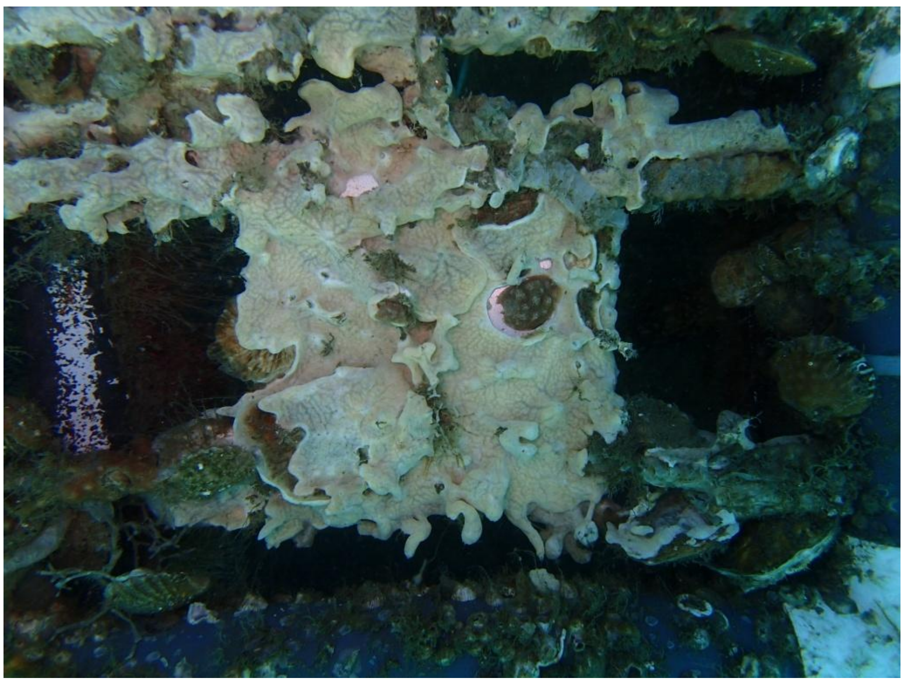
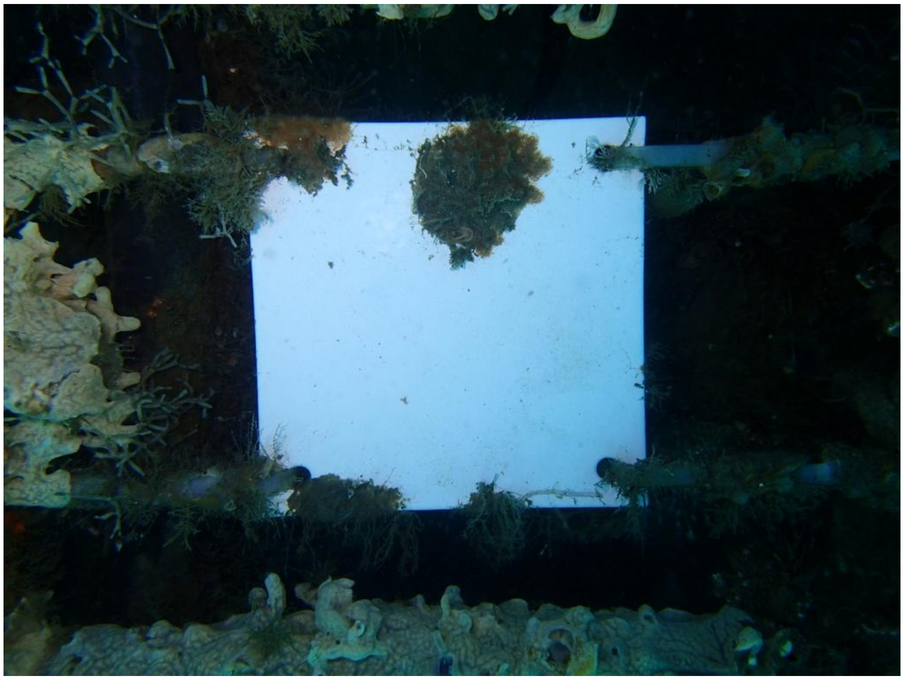


Figure 14. 2205 stainless steel test plate (Test Plate 4), photographed 12/29/14 in situ after removal of its Vexar mesh bag.



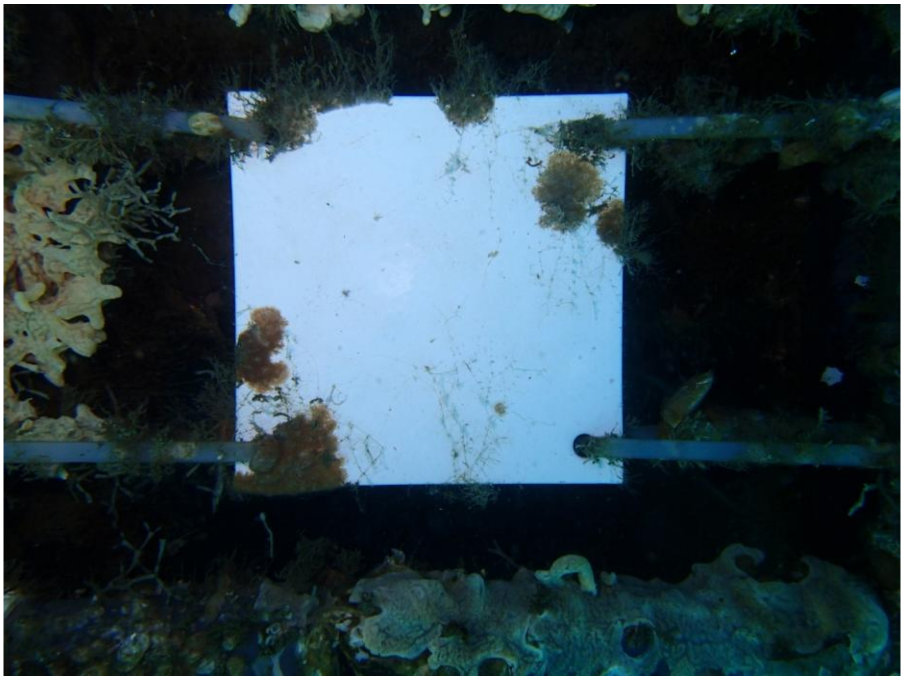


Figure 15. 2205 stainless steel test plate with foul release coating (Test Plate 5), photographed 12/29/14 in situ after removal of its Vexar mesh bag.

TENERA Environmental

April 30, 2015

Steve Tedesco
Tetra Tech
17885 Von Karman Ave., Suite 500
Irvine, CA. 92614

Subject: April 2015 WBMWD Biofouling Test Rack III Inspection

Dear Steve:

Here are my notes from the biofouling inspection of the third of the test racks installed at the West Basin intake on June 17, 2014. Test Rack III was retrieved April 21, 2015 after 309 days. As previously observed on Test Racks I and II after 92 and 196 days of exposure respectively, the 90-10 copper-nickel and Z-Alloy Wedgewire samples and coupons looked very good, with a minimum of attached macrofouling. The 70-30 Cu-Ni was similar, but with slightly more fouling. The uncoated stainless steel samples were heavily fouled with hydroids, barnacles, bryozoans, filamentous algae, tunicates, sponges, bivalves, and a variety of other invertebrates. Very little of the bare metal was visible. The stainless steel with the foul-release coating looked fairly clean, especially in comparison with the uncoated samples, and the fouling was easily removed with just a light brushing with a soft nylon brush. I will be sending you DVDs with underwater video and stills of the racks and individual stills of the samples from the post-retrieval inspection.

The two remaining PVC test racks attached to the grating of the intake structure were also heavily fouled with hydroids, acorn barnacles, and a wide variety of other invertebrates. I have been using the racks as a “control” reference and comparing the fouling found on the racks to that found on the various wedgewire and alloy coupon samples. I am also using the PVC pipe (1½ inch schedule 80) that protects the temperature recorder as a reference. While the racks have been in place since June 2014, the temperature recorder has been replaced during each rack-retrieval event. The recorder retrieved on April 21, 2015 was deployed on December 29, 2014, and any fouling on the housing occurred during that 113 day period.

The mesh bags covering the 4 inch alloy plates were also replaced during this trip and the plates were photographed. A biofouling assessment and photos are included in this report.

Sincerely,

Fred Steinert
Tenera Environmental

West Basin Intake Biofouling Test
Test Rack III
April 22, 2015
Duration of Testing: June 17, 2014 – April 21, 2015 (309 days)

Wedgewire Samples, Alloy Coupons, and PVC Test Rack

Biofouling Inspection Notes
(Additional photos and video have been sent on a separate DVD)

- **PVC test rack III:**
    - The PVC test rack was heavily fouled to the point where almost none of the PVC was visible. The three dominant fouling species were a hydroid (*Pinauay crocea* / *Tubularia crocea* or Tubularia-like), the acorn barnacle *Megabalanus californicus,* and a tan colored colonial/social tunicate. The hydroids were present in dense tufts and mats up to a length of about 5 cm. The barnacles range from about 1 mm to 23 mm in diameter and covered most of the rack (thousands). The c/s tunicate completely covered some portions of the PVC rack, having overgrown the barnacles and other encrusting organisms that had preceded it. Intermingled with the hydroids were mussels (*Mytilus galloprovincialis*) up to about 2 cm in length, small white bivalves (possibly *Hiatella*), small scallops, tube worms, amphipods, sponges, solitary tunicates, and a variety of other invertebrates. There were also several species of red and green algae mixed in with the hydroids.
- **CDA 706 (90/10 Copper/Nickel); wedgewire sample and coupon (IIIA1 and IIIB1):**
    - Wedgewire sample (IIIA1) (**Figure 1**)
        - The sample was relatively clean, with a few hydroids covering about 10 to 20 percent of the surface. The hydroids were densest near the locations of the plastic cable ties used to secure the sample to the PVC rack and were easily detached. A green patina covered most of the surface. About 80 percent of the surface had a very light covering of diatoms, short filamentous algae and entrapped silt. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.
    - Coupon (IIIB1) (**Figure 2**)
        - The coupon was also quite clean, with only three hydroids, no barnacles or other attached macrofouling. About 80 percent of the surface had a light covering of diatoms, some filamentous

red algae and entrapped silt. There was a green/brown patina on most of the surfaces. All silt and fouling was easily removed with a soft nylon brush after photographing and inspection.

- **Z-Alloy; wedgewire sample and coupon (IIIB2 and IIIA2):**
  - Wedgewire sample (IIIB2) (**Figure 3**)
    - The sample was quite clean, similar to the CDA 706 (IIA1) with a few hydroids covering less than 10 percent of the surface. The hydroids were mostly associated with the locations of the plastic cable ties used to secure the sample to the PVC rack and were easily detached. The surface had a green patina. About 80 percent of the surface had a very light covering of diatoms, filamentous red algae, and entrapped silt. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection. Some of the patina was removed by the brushing, exposing fresh metal.
  - Coupon (IIIA2) (**Figure 4**)
    - The coupon had a few hydroids attached to it near one of the mounting holes. There was a light layer of diatoms, filamentous red algae, and entrapped silt that covered about 60 percent of the surface. No green patina.
- **2205 SS (stainless steel) with antifouling coating; wedgewire sample and coupon (IIIA3 and IIIB3):**
  - Wedgewire sample (IIIA3) (**Figure 5**)
    - About 20 percent of the sample's outer surface had filamentous red algae and some hydroids attached to it (up to 3 cm long). There was also some encrusting bryozoans, a 4 mm mussel (*M. galloprovincialis*) and a single 1 cm barnacle (*M. californicus*) About 50 percent of the underside ribs were clean of fouling. The other 50 percent was covered with encrusting bryozoans, filamentous red algae, hydroids, 9 half-slipper shells, or slipper limpets, measuring 10 to 30 mm in diameter, 6 mussels (all < 4 mm), and some solitary tunicates. The foul-release coating was in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush, however one of the slipper shells took a small piece (2 mm x 4 mm) of the coating with it when it was removed.
  - Coupon (IIIB3) (**Figure 6**)
    - The coupon was quite clean with about 10 percent of the surface covered with filamentous red algae, a light film of diatoms and a little silt. There was a patch of encrusting bryozoan about 4 mm in diameter. The foul-release coating was

in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush.

- **2205 SS (stainless steel); wedgewire sample and coupon (IIIB4 and IIIA4):**
  - Wedgewire sample (IIIB4) (**Figure 7**)
    - This sample was very heavily fouled with hydroids covering most of the surface. Beneath the hydroids, attached to the sample, were approximately several thousand barnacles (*M. californicus*) ranging from 2 to 15 mm in diameter. Also intermixed with the hydroids were small mussels (*M. galloprovincialis*) up to 5 mm in length, scallops, tube worms, amphipods, crabs, erect and encrusting bryozoans, red algae (filamentous and foliose), slipper limpets, sponges, and probably other small invertebrates. The original weight of the sample was about 312 g and the fouling added about another 276 g. The fouling was firmly attached and was not removed for fear of damaging the sample prior to metal analyses.
  - Coupon (IIIA4) (**Figure 8**)
    - The coupon was also heavily fouled, with hydroids (up to 5 cm long), filamentous red and green algae, erect and encrusting bryozoans, and tunicates covering most of its surface; no metal was visible. Beneath the hydroids were several hundred barnacles (*M. californicus*) ranging in size from 2 to 13 mm. Intermixed with the hydroids were a few mussels (2 to 4 mm), some other small white bivalves (*Hiatella*?), amphipod and worm tubes, encrusting red coaralline algae, and sponges. The original weight of the coupon was about 22 grams, with the attached fouling the weight was about 62 grams. The fouling was firmly attached and was not removed for fear of damaging the coupon prior to metal analyses.
- **CDA 715 (70/30 Copper/Nickel); wedgewire sample and coupon (IIIA5 and IIIB5):**
  - Wedgewire sample (IIIA5) (**Figure 9**)
    - The CDA 715 WW sample was similar to the CDA 706 and Z-Alloy samples, but with more filamentous red algae (about 10 percent coverage), more of a diatom and silt film/layer, and only a little green patina on the metal's surface. There were a few hydroids and a few erect bryozoans. No barnacles or other macrofouling aside from the hydroids and bryozoans. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.
  - Coupon (IIIB5) (**Figure 10**)

        - The CDA 715 WW coupon was similar to the CDA 706 and Z-Alloy coupons. A few hydroids were attached near the holes in the coupon. The hydroids most likely originated on the cable ties and later overlapped onto the coupon. Diatoms and entrapped silt covered about 80 percent of the surface. The coupon had more green patina than the CDA 715 Wedgewire sample, especially on the test welds. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.

- **Temperature Recorder Housing:**
    - A temperature recorder enclosed in a protective housing made of 1½ inch schedule 80 PVC pipe, was attached to Rack V on December 29, 2014. The recorder and housing were retrieved on April 21, 2015 and replaced with a new unit. The housing had hydroids, filamentous red algae, and 11 *M. californicus* (largest was 7 mm in diameter) growing on the exterior of the pipe. Similar fouling was found on the interior of the pipe along with amphipods, crabs, and some polychaete worms. All of the fouling settlement, and the subsequent growth of the attached species, occurred during the 113 days that the unit was deployed.

Weight Change

Prior to the biofouling inspections and assessments, each Wedgewire sample and alloy coupon was blotted to remove any excess water and then weighed along with any accumulated fouling. The resulting weight was then compared with the dry weight that was recorded prior to deployment of the test racks. Presented below is the percentage change in weight for each of the samples retrieved from Rack I on September 16, 2014, Rack II on December 29, 2014, and Rack III on April 21, 2015:

Wedgewire Samples	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	-2.8%
Test Rack II	-2.5%
Test Rack III	0.3%
CDA 715 (70/30 Cu/Ni)	
Test Rack I	3.5%
Test Rack II	2.8%
Test Rack III	7.2%
Z-alloy	
Test Rack I	-2.1%
Test Rack II	-2.2%
Test Rack III	-1.4%
2205 Stainless Steel (uncoated)	
Test Rack I	64.9%
Test Rack II	73.0%
Test Rack III	88.5%
2205 Stainless Steel (coated)	
Test Rack I	4.5%
Test Rack II	12.5%
Test Rack III	10.9%

Alloy Coupons	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	0.7%
Test Rack II	-0.3%
Test Rack III	0.5%
CDA 715 (70/30 Cu/Ni)	
Test Rack I	1.1%
Test Rack II	0.0%
Test Rack III	2.5%
Z-alloy	
Test Rack I	0.7%
Test Rack II	0.1%
Test Rack III	6.8%

2205 Stainless Steel (uncoated)	
Test Rack I	121.3%
Test Rack II	148.5%
Test Rack III	183.0%
2205 Stainless Steel (coated)	
Test Rack I	0.5%
Test Rack II	1.3%
Test Rack III	0.8%

Alloy Test Plates

Five 4-inch square alloy test plates, one each of the same materials as the Wedgewire samples and the alloy coupons, were attached to frames made of ¾ inch PVC pipe, enclosed in plastic mesh bags (1/4 inch Vexar), and suspended about 12 inches below the intake structure grating. The test was designed to approximate the conditions that might be found in the interior of a Wedgewire intake module (relatively low water velocity and screening that excludes large predatory organisms such as fish, crabs, and sea stars). The plates were deployed along with the Wedgewire/coupon test racks on June 17, 2014. On September 16, 2014, after 92 days of exposure, the original mesh bags were removed and replaced with new bags. No photos were taken at that time. December 29, 2014, after 196 days of exposure, the bags were again replaced with new bags; this time the plates were photographed, in situ, prior to being enclosed in the new bags. The plates were then returned to their original positions beneath the grating. On April 21, 2015, after 309 days of exposure, the bags were again replaced and the plates photographed. One of the frames and its plate (Plate 5, 2205 stainless steel with the foul release coating) had fallen into the intake structure and had to be retrieved by the divers. The reason for the failure of the cords suspending that plate is unknown. The cords suspending all five of the frames/plates were replaced.

The following biofouling assessment is based on what could be discerned from the underwater photos taken of the plates. Photographs of each plate are also included.

- **CDA 706 (90/10 Copper/Nickel), Plate 1,** (**Figure 11**)
  - The plate is almost entirely covered with a blue-green patina.
  - No attached macrofouling is visible in the photographs of the plate.
  - Hydroids, acorn barnacles, colonial tunicate, erect bryozoans, and other invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame.
- **CDA 715 (70/30 Copper/Nickel), Plate 2,** (**Figure 12**)
  - The plate is very clean with almost no discoloration or oxidation visible in the photo.
  - No attached macrofouling.
  - Hydroids, acorn barnacles, solitary and colonial tunicates, bryozoans, mussels, scallops, sponges, tube worms, and other invertebrates are

attached to the PVC frame and the plastic cable ties that secure the plate to the frame.

- **Z-alloy, Plate 3,** (**Figure 13**)
  - The plate is quite clean, except for a mass of colonial/social tunicate that appears to have grown from one plastic cable tie to another on one side of the plate. I couldn't discern from the photo if the tunicate is actually attached to the plate. The diver says that it is not growing on the plate.
  - The plate has a duller finish than the CDA 715 plate, but does not have the patina of the CDA 706 plate.
  - In December there was a single Abalone Jingle, or possibly a Half-Slipper Shell, that appeared to have grown from one of the cable ties onto the plate. The shell appears to still be present under the tunicate.
  - As with Plates 1 & 2, a variety of encrusting invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame.
- **2205 Stainless Steel (uncoated), Plate 4,** (**Figure 14**)
  - This plate is almost completely covered with macrofouling, primarily a large, expansive colonial tunicate. Hydroids and bryozoans are also visible. There may be other species underneath the tunicate or, if the tunicate colonized the plate first, it may have excluded settlement by other species. Regardless, this material shows no apparent antifouling characteristics.
  - As with the other plates, a variety of encrusting invertebrates are attached to the PVC frame and the plastic cable ties that secure the plate to the frame. In this case, there is little to differentiate between the stainless steel plate and the plastic components.
- **2205 Stainless Steel with foul release coating, Plate 5,** (**Figure 15**)
  - As stated earlier, this plate and its frame and bag were missing when the divers arrived at the WB intake. The cords that suspended the frame may have failed, but remained intact on the other four plates. The plate was found lying in the soft sediment and was retrieved from inside the intake by the divers and returned to its original position. The cords were replaced on all five of the plate frames.
  - This plate is of the same material as Plate 4, but has been coated with a silicone elastomer foul release coating.
  - The plate now appears to be clean, but had some fouling on it in the photos taken on December 29, 2014.
  - The fouling that was growing on the plate and on the PVC frame is now gone with the exception of some empty barnacle shells on the frame. The soft sediment at the bottom of the intake was probably anaerobic and the fouling probably suffocated, died, and decayed. The black

coloration on the PVC frame supports the assumption that the sediment had gone anaerobic.

Conclusions

- In comparison with the macrofouling observed on the PVC rack and the uncoated stainless steel samples, all of the copper-nickel samples (90-10, 70-30, and Z-Alloy) appear to be performing well at deterring the settlement of macrofouling organisms.
- The uncoated (bare metal) stainless steel Wedgewire sample and coupon, have shown no antifouling properties and have about the same degree of fouling (species composition and growth) as the PVC racks.
- The SS samples that were painted with the foul-release coating had considerably less attached fouling that the uncoated samples, and were almost as clean as the Cu-Ni samples. The fouling that was present was easily removed with a light brushing using a soft-bristled nylon brush. The coating was in good condition, with little visible damage after 309 days of exposure.
- The test plates appear to be performing like the WW samples and coupons. The copper alloys were, for the most part, relatively clean of fouling, the coated stainless steel was also clean, and the uncoated SS was heavily fouled. The PVC frames and plastic cable ties were also heavily fouled, with the exception of Frame 5, which fell into the anaerobic sediment at the bottom of the interior of the intake structure, thereby suffocating the previously existing fouling.

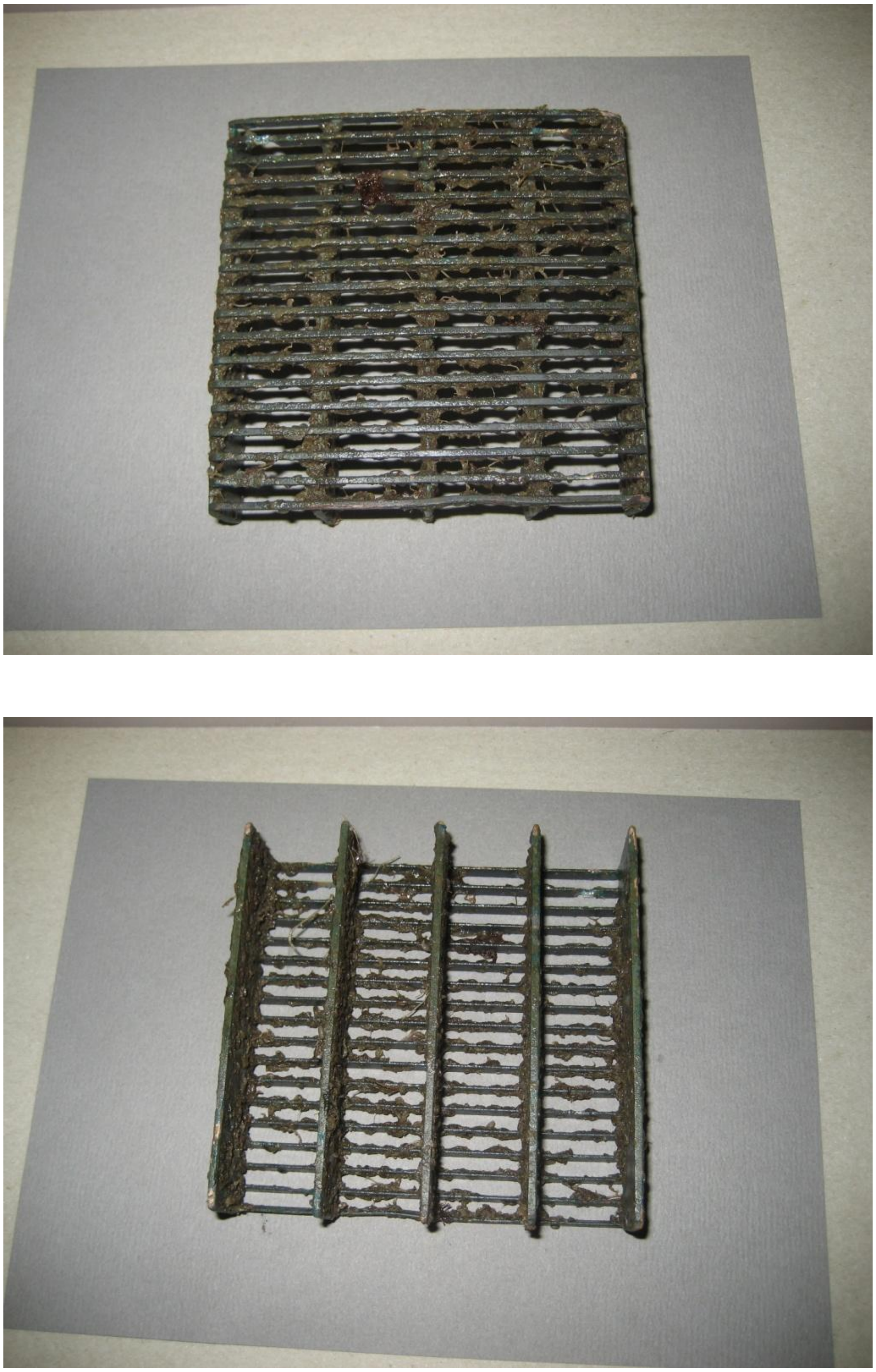


Figure 1. 90/10 Cu/Ni (CDA706) Wedgewire sample, photographed 04/22/15.

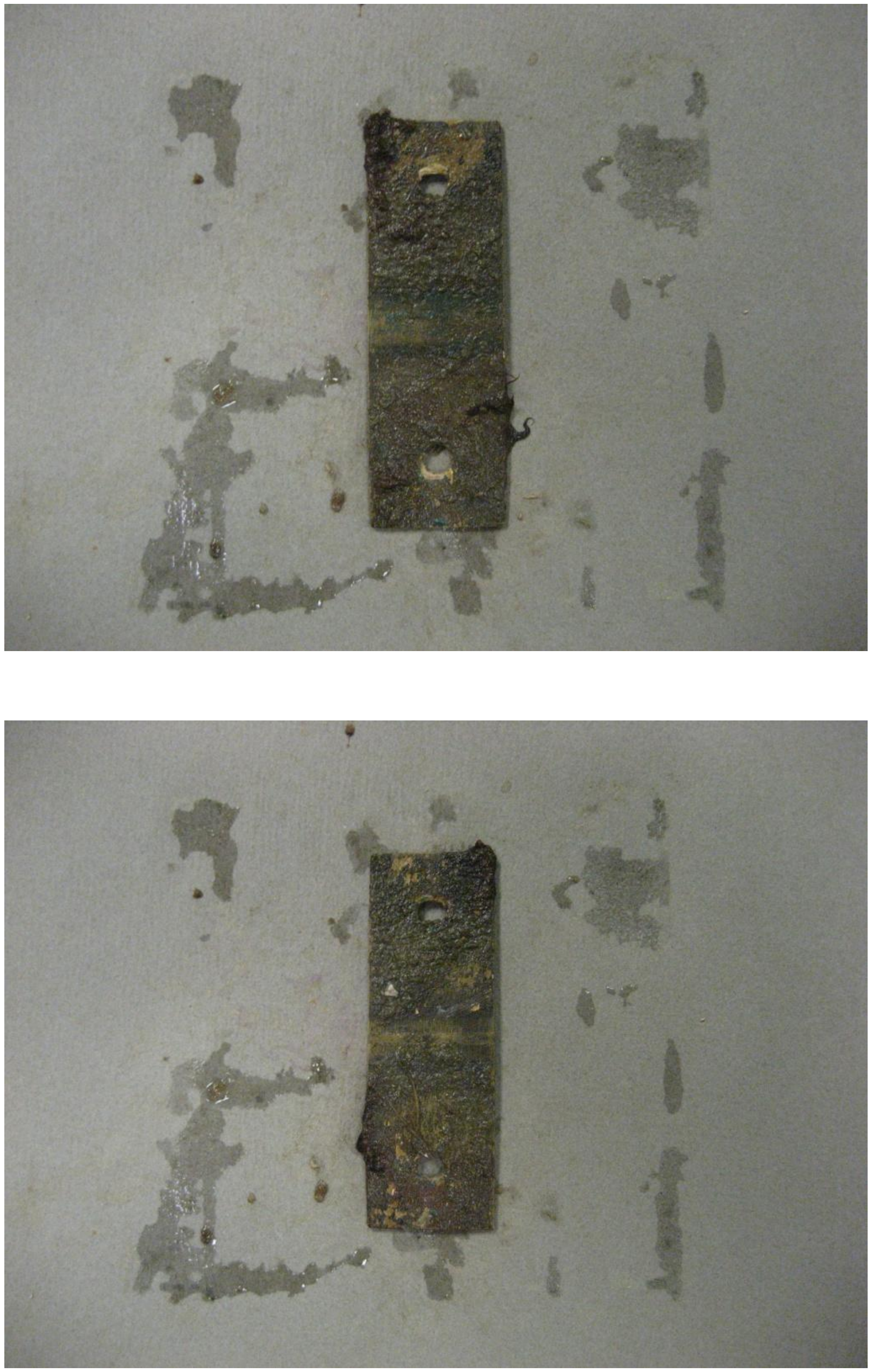
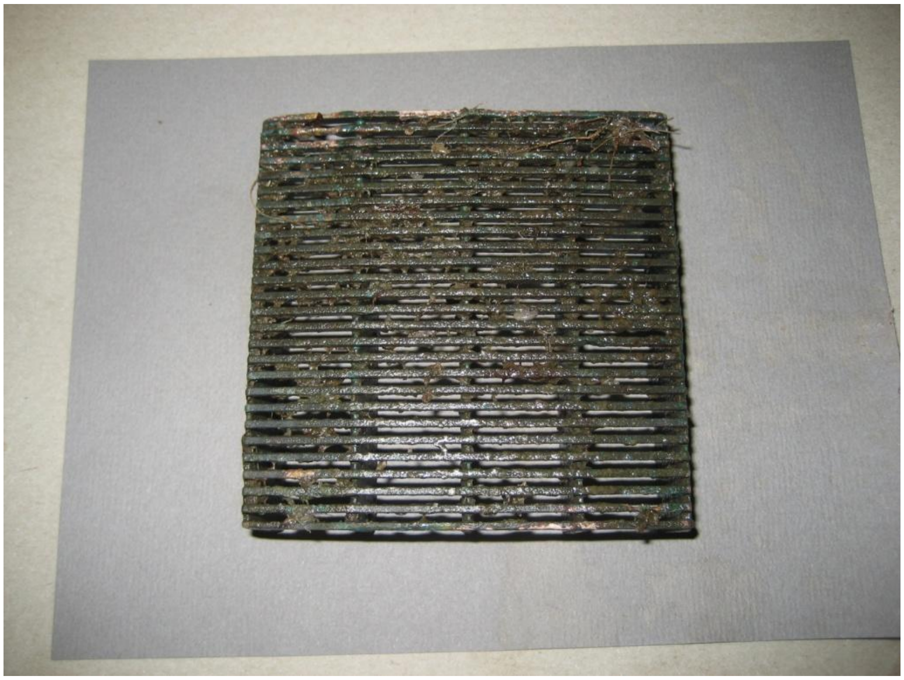


Figure 2. 90/10 Cu/Ni (CDA706) coupon, photographed 04/22/15.



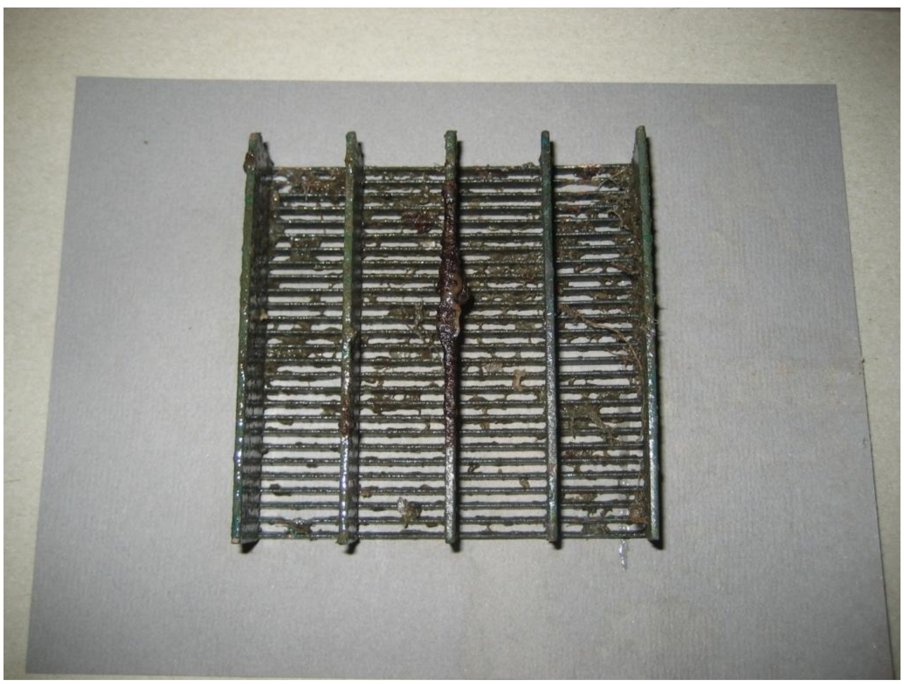


Figure 3. Z-alloy Wedgewire sample, photographed 04/22/15.

Figure 4. Z-alloy coupon, photographed 04/22/15.

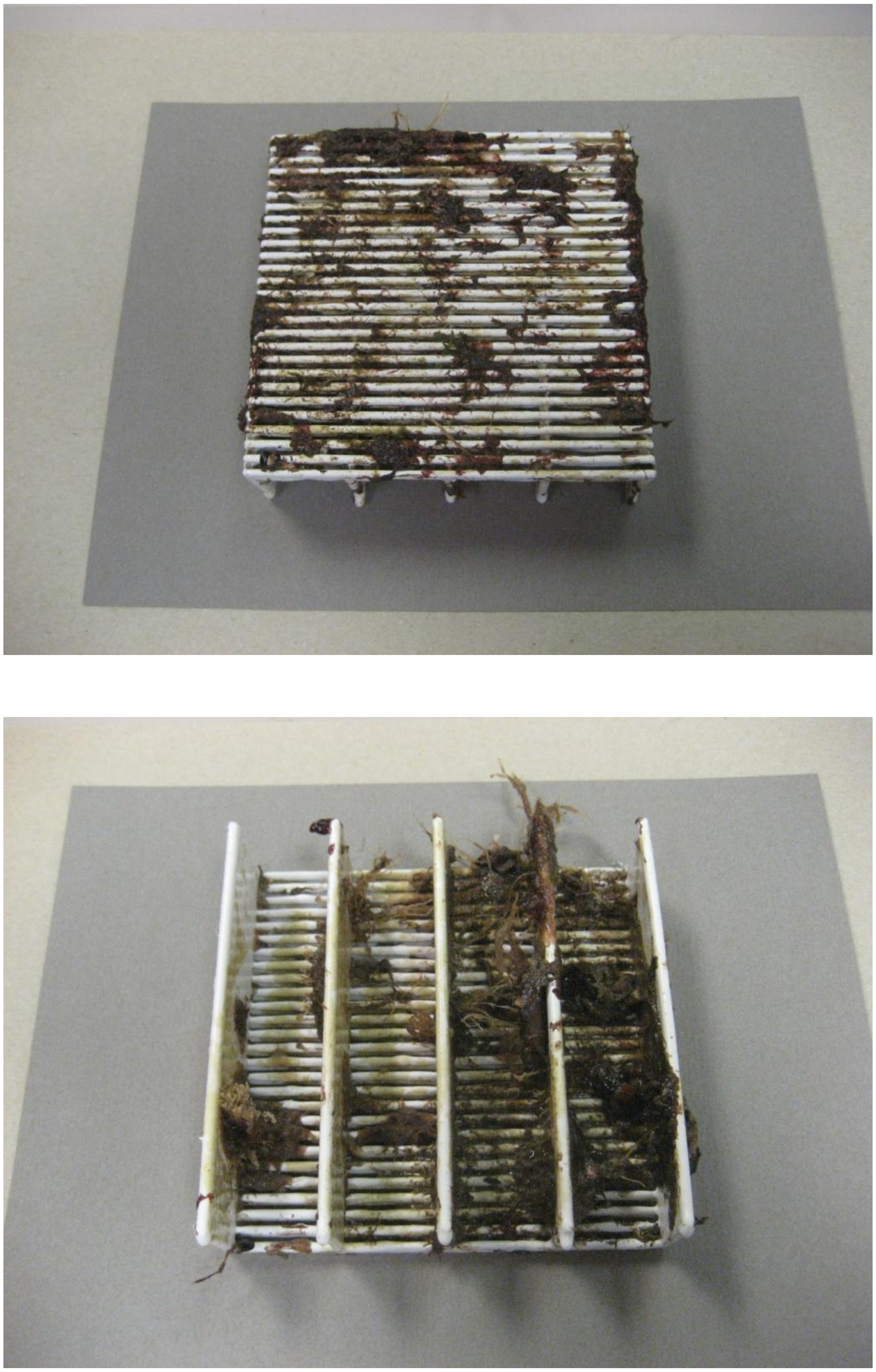


Figure 5. 2205 stainless steel Wedgewire sample with foul release coating, photographed 04/22/15.

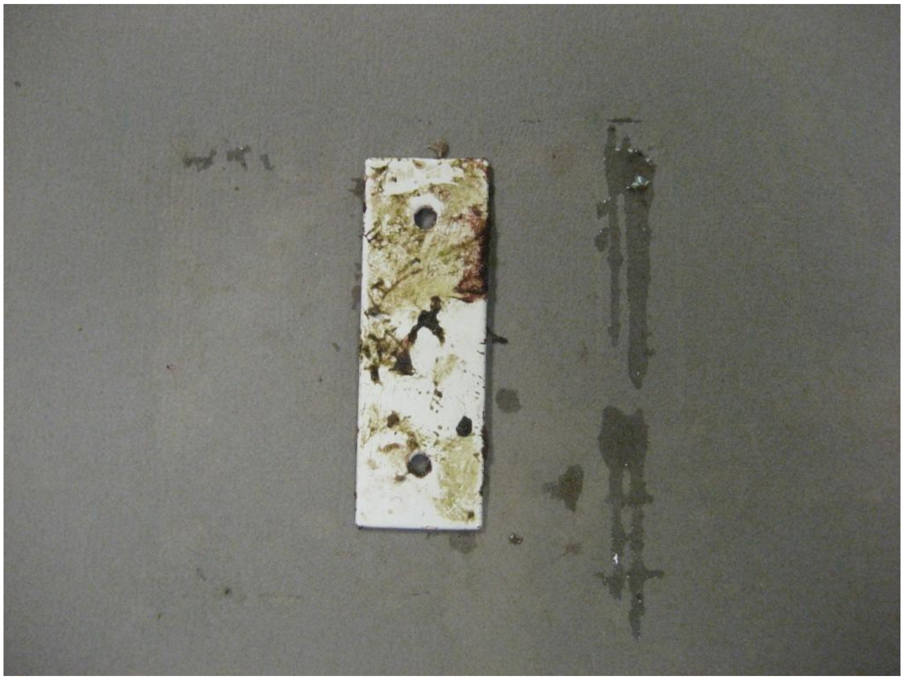


Figure 6. 2205 stainless steel coupon with foul release coating, photographed 04/22/15.

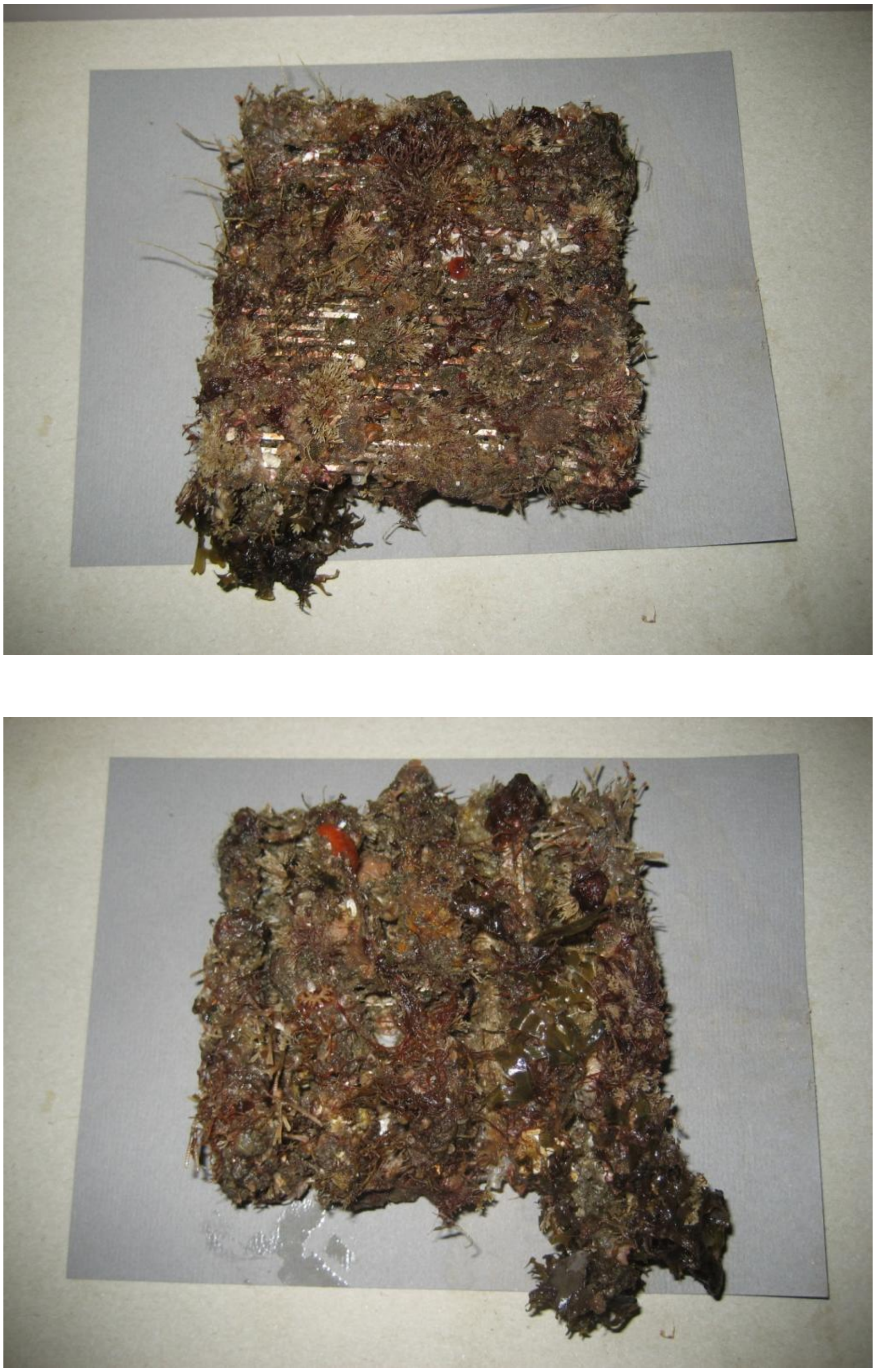


Figure 7. 2205 stainless steel Wedgewire sample, photographed 04/22/15.

Figure 8. 2205 stainless steel coupon, photographed 04/22/15.

Figure 9. 70/30 Cu/Ni (CDA715) Wedgewire sample, photographed 04/22/15.

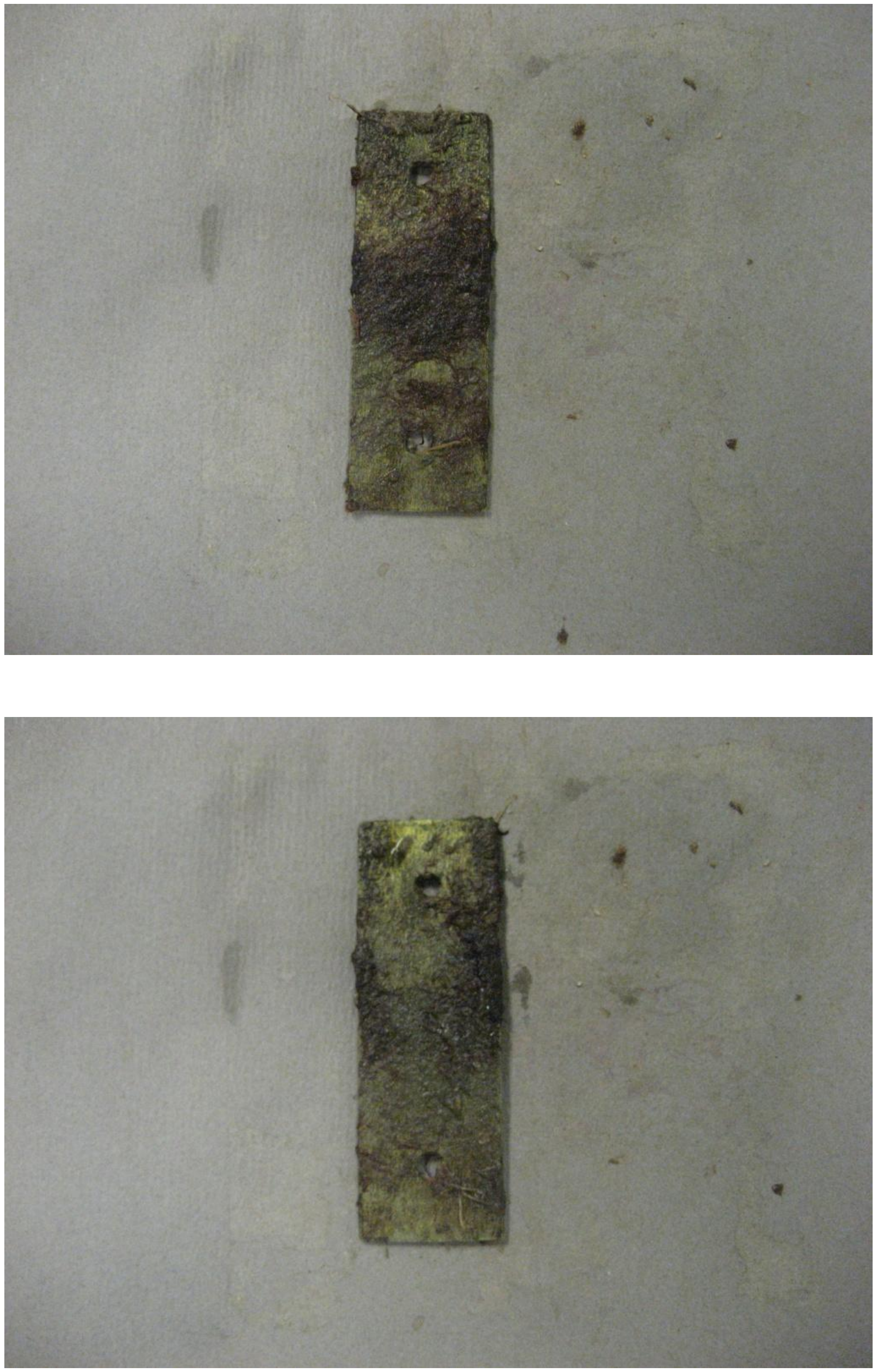


Figure 10. 70/30 Cu/Ni (CDA715) coupon, photographed 04/22/15.

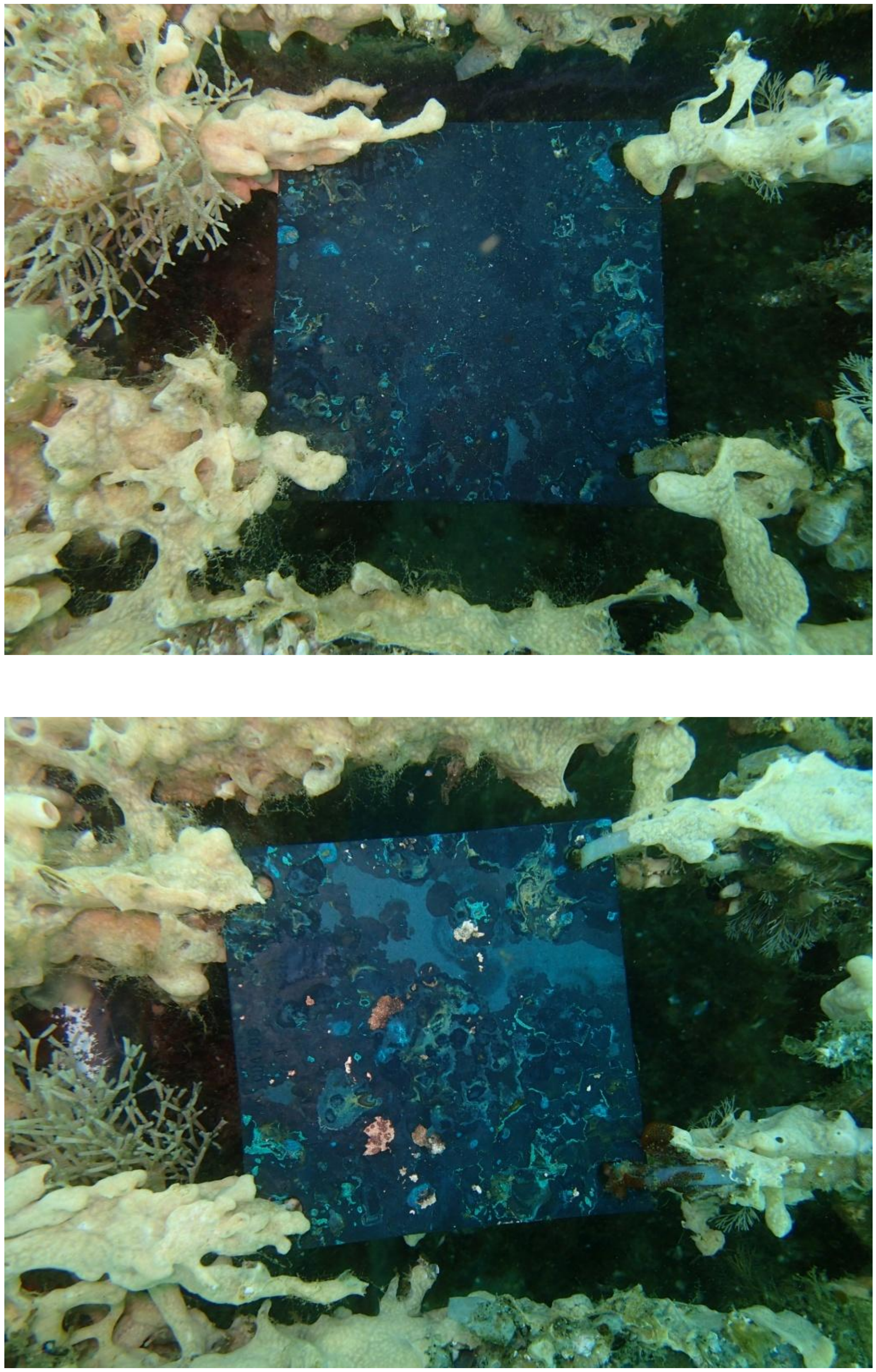


Figure 11. 90/10 Cu/Ni (CDA706) test plate (Test Plate 1), photographed 04/21/15 in situ after removal of its Vexar mesh bag.

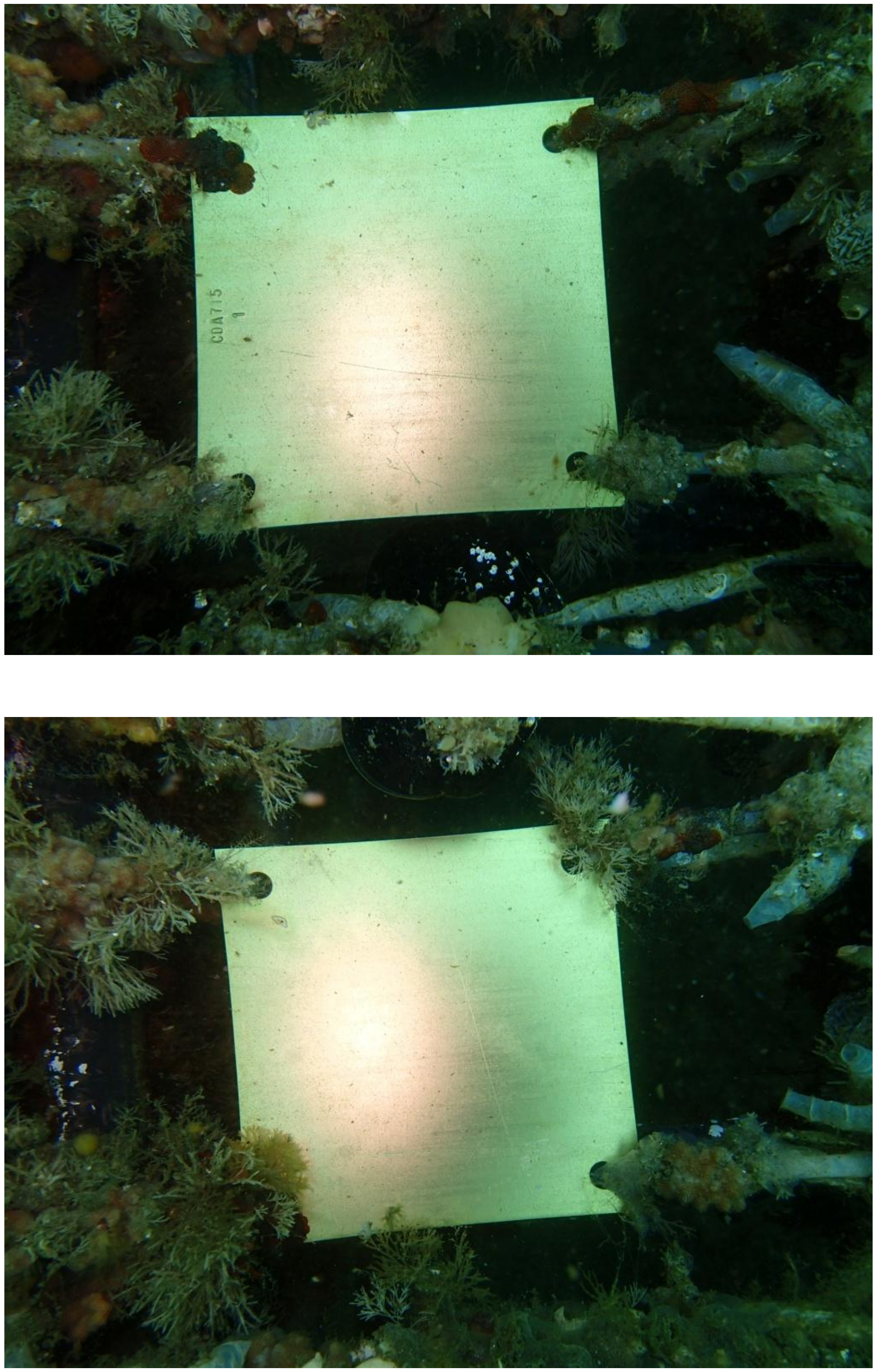


Figure 12. 70/30 Cu/Ni (CDA715) test plate (Test Plate 2), photographed 04/21/15 in situ after removal of its Vexar mesh bag.

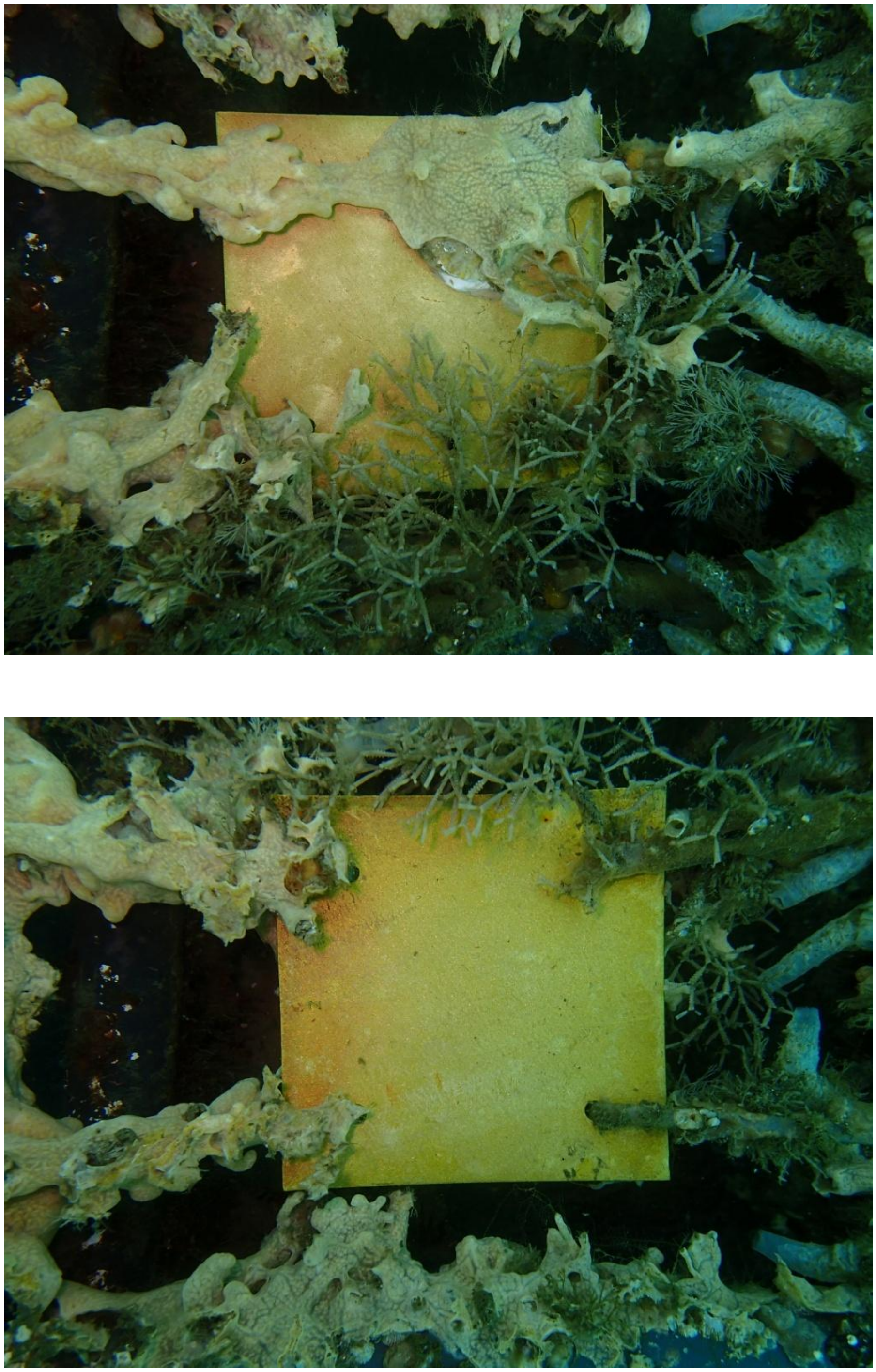


Figure 13. Z-alloy test plate (Test Plate 3), photographed 04/21/15 in situ after removal of its Vexar mesh bag.

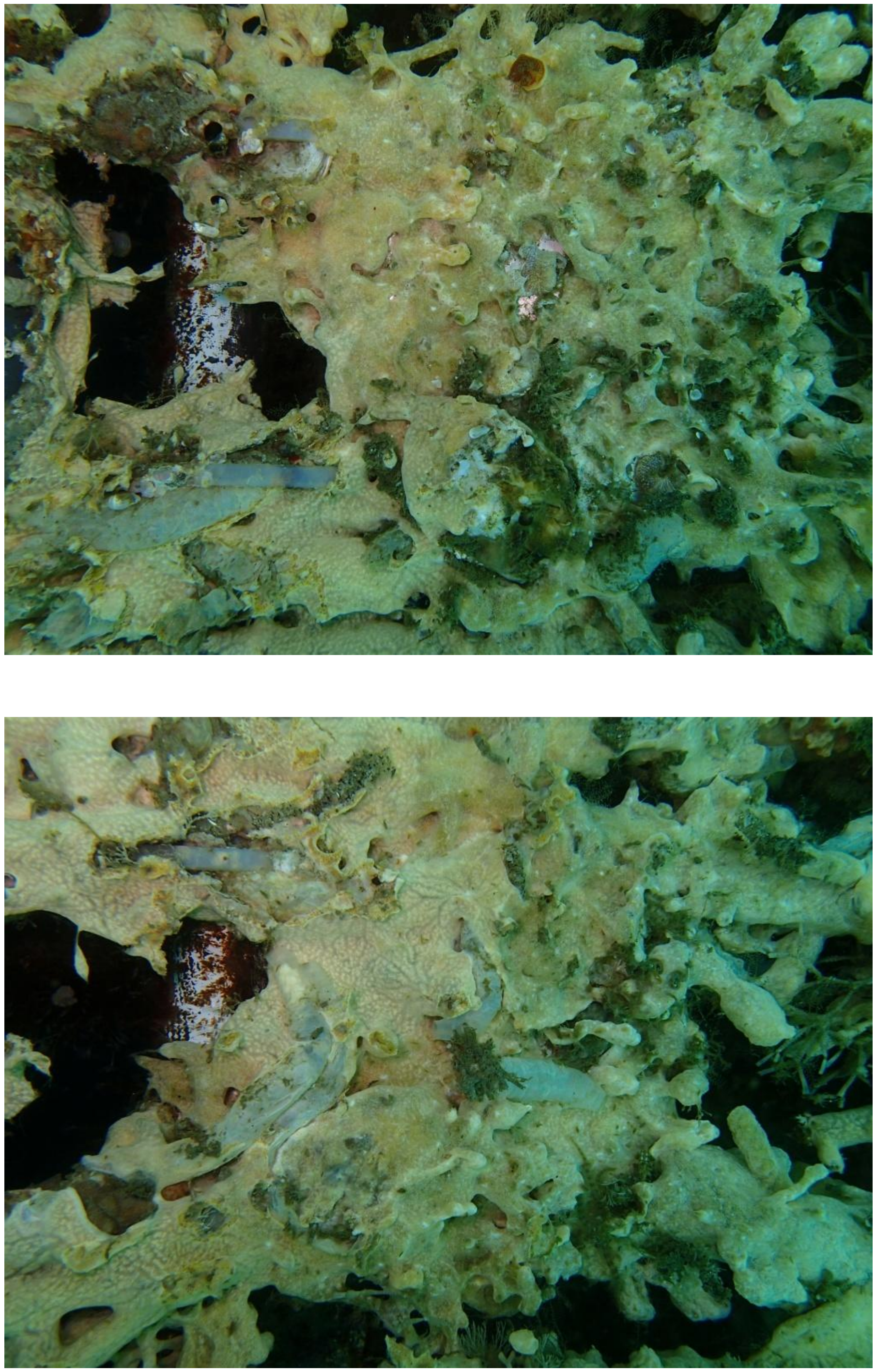


Figure 14. 2205 stainless steel test plate (Test Plate 4), photographed 04/21/15 in situ after removal of its Vexar mesh bag.

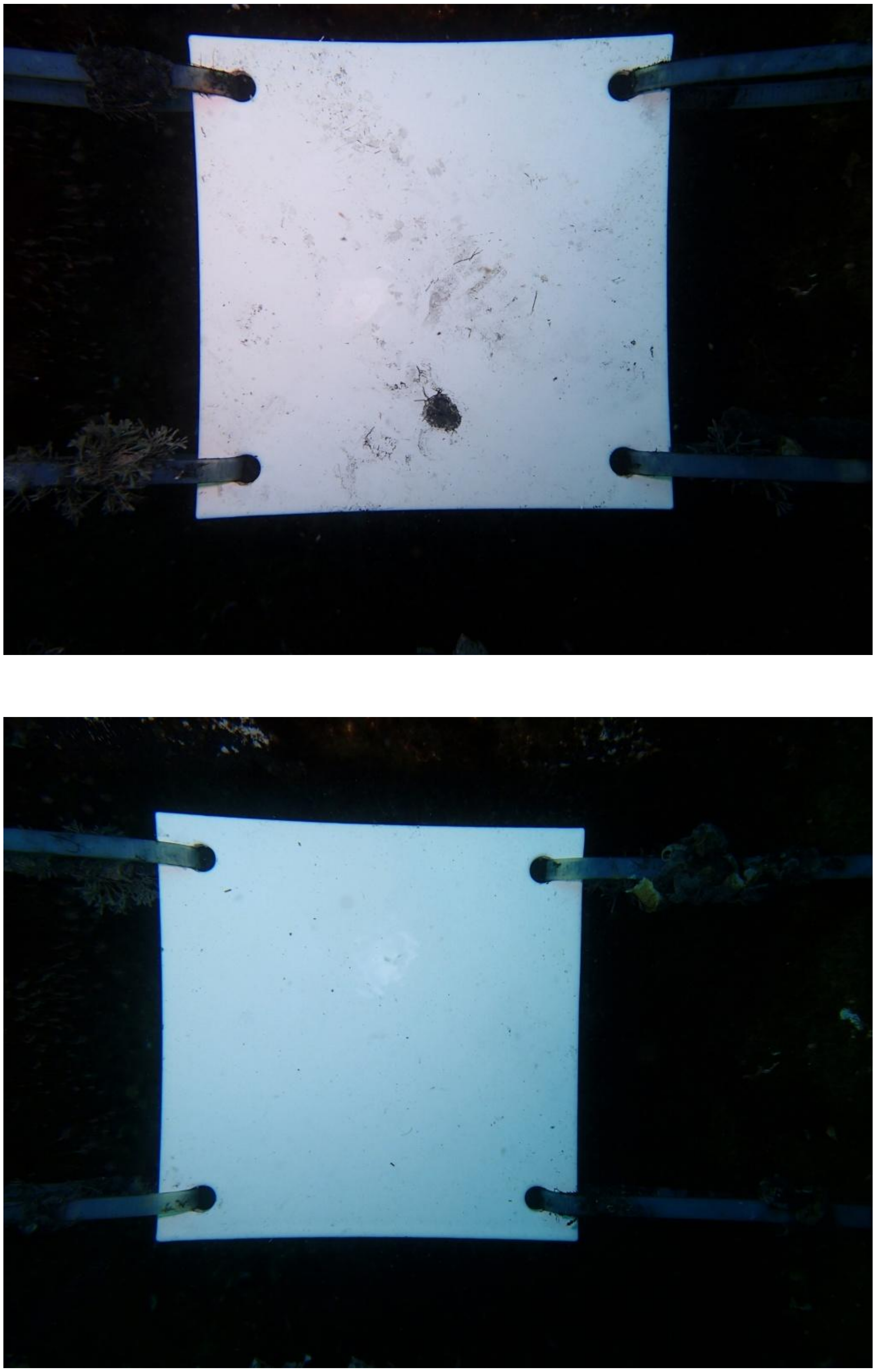


Figure 15. 2205 stainless steel test plate with foul release coating (Test Plate 5), photographed 04/21/15 in situ after removal of its Vexar mesh bag.

TENERA Environmental

June 30, 2015

Steve Tedesco
Tetra Tech
17885 Von Karman Ave., Suite 500
Irvine, CA. 92614

Subject: June 2015 WBMWD Biofouling Test Rack IV and Test Plates Inspection

Dear Steve:

Here are my notes from the biofouling inspection of the fourth of the five test racks installed at the West Basin intake on June 17, 2014. Test Rack IV was retrieved June 16, 2015 after 365 days. As previously observed on Test Racks I, II and III after 92, 196 and 309 days of exposure respectively, the 90-10 copper-nickel and Z-Alloy Wedgewire samples and coupons looked very good, with a minimum of attached macrofouling. The 70-30 Cu-Ni was similar, but with slightly more fouling. The uncoated stainless steel samples were heavily fouled with hydroids, barnacles, bryozoans, filamentous algae, tunicates, sponges, bivalves, and a variety of other invertebrates. Very little of the bare metal was visible. The stainless steel with the foul-release coating looked fairly clean, especially in comparison with the uncoated samples, and the fouling was easily removed with just a light brushing with a soft nylon brush. I will be sending you DVDs with underwater video and stills of the racks and individual stills of the samples from the post-retrieval inspection.

The one remaining PVC test rack (Rack V) attached to the grating of the intake structure was also heavily fouled with hydroids, acorn barnacles, and a wide variety of other invertebrates. I have been using the racks as a "control" reference and comparing the fouling found on the racks to that found on the various wedgewire and alloy coupon samples. I am also using the PVC pipe (1½ inch schedule 80) that protects the temperature recorder as a reference. While the racks have been in place since June 2014, the temperature recorder has been replaced during each rack-retrieval event. The recorder retrieved on June 16, 2015 was deployed on April 21, 2015, and any fouling on the housing occurred during that 57 day period.

Rack V remains deployed on the WB intake grating as originally planned. This rack can be retrieved if any questions arise concerning the long term impacts of corrosion or biofouling on the Wedgewire samples. This rack does not have any of the alloy coupons that were attached to Racks I – IV. The fifth set of coupons was retained by V&A Consulting Engineers for pre-test metal analyses. A new temperature recorder was attached to the rack on June 16, 2015.

The 4-inch alloy plates that have been suspended beneath the intake grating since June 17, 2014, and enclosed in ¼ inch plastic mesh bags, were also retrieved during this trip. The mesh bags had been replaced with new mesh bags during the September 2014, December 2014, and April 2015 rack retrievals. In situ photos of the plates were taken after removal of the bags in December and April, as well as prior to their retrieval on June 16, 2015. As with the PVC racks and the temperature recorder housing, the PVC frames used to suspend and protect the plates were used as a control substrate to gauge the settlement and growth of biofouling in the absence of any of the antifouling influences related to the composition of each test plate. A biofouling assessment and photos are included in this report.

Sincerely,

Fred Steinert
Tenera Environmental

West Basin Intake Biofouling Test
Test Rack IV
June 17 and 18, 2015 Inspection
Duration of Testing: June 17, 2014 – June 16, 2015 (365 days)

Wedgewire Samples, Alloy Coupons, Alloy Plates, and PVC Test Racks and Frames

Biofouling Inspection Notes
(Additional photos and video have been sent on a separate DVD)

- **PVC test rack IV:**
  - The PVC test rack was heavily fouled to the point where almost none of the PVC was visible. The dominant fouling species included a hydroid (*Pinauay crocea* / *Tubularia crocea* or Tubularia-like), the acorn barnacle *Megabalanus californicus*, an opaque tan-colored encrusting sponge. The hydroids were less dense than previously observed on the earlier racks, and had been recorded in the earlier videos of this rack and the surrounding structures (intake grating, Wedgewire modules, etc.). They may have died back (seasonally?) or have been heavily grazed since April. The barnacles range from about 2 mm to 26 mm in diameter and covered most of the rack (thousands of individuals). The pale translucent colonial/social tunicate observed on earlier racks was only sparsely present on Rack IV. There was however, extensive coverage by an opaque tan-colored sponge that had overgrown many of the fouling organisms that had originally colonized the PVC rack. Intermingled with the hydroids were mussels (*Mytilus galloprovincialis*) up to about 2 cm in length, small white bivalves (possibly *Hiatella*), small scallops, tube worms, amphipods, sponges, solitary tunicates, and a variety of other invertebrates. There were also several species of red (filamentous and foliose) and green algae mixed in with the various fouling organisms.
- **CDA 706 (90/10 Copper/Nickel); wedgewire sample and coupon (IVA1 and IVB1):**
  - Wedgewire sample (IVA1) (**Figure 1**)
    - The sample was relatively clean, with only a few hydroids, mostly concentrated by the sites of the plastic cable ties used to secure the sample to the rack. A green patina covered most of the surface. About 80 percent of the surface had a very light covering of diatoms and short filamentous algae along with entrapped silt. Unique to this retrieval were a large number of amphipod tubes, primarily attached to the reinforcing ribs of

this sample. These are short (<1 cm) soft tubes with openings of about 1-2 mm, that are constructed and use by small beach-hopper-like amphipods. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.
I noted that the Wedgewire at the sites of the four cable ties was quite worn; possibly a result of accelerated corrosion beneath the cable tie and erosion due to rubbing of the cable tie against the metal. I reviewed past photos from earlier racks and found the same pattern of wear, but not to this extent.

- Coupon (IVB1) (**Figure 2**)
  - The coupon was also quite clean, with no hydroids, no barnacles or any other attached macrofouling. About 90 percent of the surface had a light covering of diatoms, some filamentous red algae and entrapped silt. There was a green/brown patina on most of the surfaces. All silt and fouling was easily removed with a soft nylon brush after photographing and inspection. There were no signs of accelerated wear at the holes where the plastic cable ties were inserted.

- **Z-Alloy; wedgewire sample and coupon (IVB2 and IVA2):**
  - Wedgewire sample (IVB2) (**Figure 3**)
    - The sample was quite clean, similar to the CDA 706 (IVA1) with only three individual hydroids covering less than 1 percent of the surface. The surface had a green patina. About 60 percent of the Wedgewire (outer) surface had a very light covering of diatoms, filamentous red algae, and entrapped silt. Amphipod tubes covering about 10 percent of the outer surface and about 40 percent of the inner surface (reinforcing ribs). All fouling and debris was easily removed with a soft nylon brush after photographing and inspection. Some of the patina was removed by the brushing, exposing fresh metal.
      This sample also had accelerated corrosion/erosion of the Wedgewire at the sites of the plastic cable ties.
  - Coupon (IVA2) (**Figure 4**)
    - The coupon had no hydroids or other macrofouling invertebrates. There was a layer of diatoms, filamentous red algae, and entrapped silt that covered about 65 percent of the surface. No green patina. All fouling was easily removed with soft nylon brush.

- **2205 SS (stainless steel) with antifouling coating; wedgewire sample and coupon (IVA3 and IVB3):**
  - Wedgewire sample (IVA3) (**Figure 5**)
    - About 50 percent of the sample's outer surface had a light covering of diatoms and filamentous red algae. There were also a few individual hydroids at the cable tie sites. Two small (4-5 mm) mussels (*M. galloprovincialis*) at two different cable tie sites.
      About 50 percent of the inner ribs were cover with what appears to be gastropod eggs. The egg mass was thin (one egg thick) and developing snails could be seen. Another 25 percent of the inner ribs was covered with a combination of a few individual hydroids, 12 half-slipper shells, or slipper limpets, measuring 5 to 32 mm in diameter, 10 mussels (4-20 mm), 6-8 barnacles (*M. californicus*) 2-10 mm in diameter, 4 worm tubes, 4 small white bivalves (3 mm), and a crab (*Cancer sp*., 1 cm carapace width). The foul-release coating was in very good shape even at the cable tie sites. All of the fouling was removed with light brushing using a soft nylon brush or, in the case of the limpets, with light finger pressure.
  - Coupon (IVB3) (**Figure 6**)
    - The coupon was very clean. About 50 percent of the surface had a very light film of diatoms and a little silt. There was a patch of encrusting bryozoan about 2 cm in diameter that appeared to have originated on one of the cable ties. When the cable tie was removed, most of the patch detached from the surface. The foul-release coating was in very good shape and all of the fouling was removed with just a light brushing using a soft nylon brush.
- **2205 SS (stainless steel); wedgewire sample and coupon (IVB4 and IVA4):**
  - Wedgewire sample (IVB4) (**Figure 7**)
    - This sample was very heavily fouled with little of the metal visible. Hydroids covered 40 – 50 percent of the surfaces. The density of hydroids has actually declined since earlier photos (December 2014 and April 2015) of the same sample and the PVC rack; this could be seasonality, species succession, or predation (or all three). Beneath the hydroids, attached to the sample, were several thousand barnacles (*M. californicus*) ranging from 1 to 20 mm in diameter. Also intermixed with the hydroids were small mussels (*M. galloprovincialis*) up to 10 mm in length, scallops, white bivalves, tube worms, amphipods,

crabs, erect and encrusting bryozoans, red algae (filamentous and foliose), slipper limpets (to 30 mm), encrusting sponge, c/s tunicate, and probably other small invertebrates. A dark red erect bryozoan covered about 50 percent of the inner/ribbed side of the sample. The original weight of the sample was about 312 g and the fouling added about another 245 g. The fouling was firmly attached and was not removed for fear of damaging the sample prior to metal analyses.

- Coupon (IVA4) (**Figure 8**)
    - The coupon was also heavily fouled with no metal visible. Hydroids (up to 2 cm long), filamentous red algae, erect and encrusting bryozoans, and tunicates covering most of its surface. Beneath the hydroids were 60 to 80 barnacles (*M. californicus*) ranging in size from 2 to 15 mm. Intermixed with the hydroids were 8 mussels (4 to 6 mm), some other small white bivalves (*Hiatella*?), amphipod and worm tubes, encrusting red coralline algae, and sponges. The original weight of the coupon was about 22 grams, with the attached fouling the weight was about 52 grams. The fouling was firmly attached and was not removed for fear of damaging the coupon prior to metal analyses.

- **CDA 715 (70/30 Copper/Nickel); wedgewire sample and coupon (IVA5 and IVB5):**
    - Wedgewire sample (IVA5) (**Figure 9**)
        - The CDA 715 WW sample was similar to the CDA 706 and Z-Alloy samples, but with more of the surface, about 60 percent, covered by amphipod tubes and filamentous red algae. There was also more of a diatom and silt film/layer, and only a little green patina on the metal's surface. There were a few hydroids and all appeared to no longer have polyps at their tips. Eight very small mussels (largest 2 mm in length).There were no barnacles or other macrofouling aside from the hydroids and mussels. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.
          There was accelerated corrosion/erosion of the Wedgewire at the sites of the plastic cable ties.
    - Coupon (IVB5) (**Figure 10**)
        - The CDA 715 WW coupon was similar to the CDA 706 and Z-Alloy coupons. A few hydroids, without polyps, were attached near the holes in the coupon. The hydroids most likely originated on the cable ties and later overlapped onto the

coupon. Amphipod tubes, diatoms and entrapped silt covered about 80 percent of the surface. The coupon had more green patina than the CDA 715 Wedgewire sample, especially on the test welds. All fouling and debris was easily removed with a soft nylon brush after photographing and inspection.

- **Temperature Recorder Housing:**
    - A temperature recorder enclosed in a protective housing made of 1½ inch schedule 80 PVC pipe, was attached to Rack V on April 21, 2015. The recorder and housing were retrieved on June 16, 2015 and replaced with a new unit. The housing had hydroids, filamentous and foliose red algae, and about 100 *M. californicus* (2 to 12 mm in diameter) growing on the exterior of the pipe. Some encrusting bryozoans , amphipod tubes,and c/s tunicate also found on the exterior along with a layer of gastropod(?) eggs about 50 x 75 mm in overall size. Similar fouling was found on the interior of the pipe along with amphipods and some polychaete worms. All of the fouling settlement, and the subsequent growth of the attached species, occurred during the 57 days that the unit was deployed.

Weight Change

Prior to the biofouling inspections and assessments, each Wedgewire sample, alloy coupon, and alloy plate was blotted to remove any excess water and then weighed along with any accumulated fouling. The resulting weight was then compared with the dry weight that was recorded prior to deployment of the test racks. Presented below is the percentage change in weight for each of the Wedgewire samples and alloy coupons retrieved from Rack I on September 16, 2014, Rack II on December 29, 2014, Rack III on April 21, 2015, and Rack IV on June 16, 2015. Also presented are the weights of the alloy test plates retrieved on June 16, 2015 after 365 days of exposure:

Wedgewire Samples	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	-2.8%
Test Rack II	-2.5%
Test Rack III	0.3%
Test Rack IV	2.8%
CDA 715 (70/30 Cu/Ni)	
Test Rack I	3.5%
Test Rack II	2.8%
Test Rack III	7.2%
Test Rack IV	4.7%
Z-alloy	
Test Rack I	-2.1%
Test Rack II	-2.2%
Test Rack III	-1.4%
Test Rack IV	-0.6%
2205 Stainless Steel (uncoated)	
Test Rack I	64.9%
Test Rack II	73.0%
Test Rack III	88.5%
Test Rack IV	78.5%
2205 Stainless Steel (coated)	
Test Rack I	4.5%
Test Rack II	12.5%
Test Rack III	10.9%
Test Rack IV	15.8%

Alloy Coupons	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	0.7%
Test Rack II	-0.3%
Test Rack III	0.5%
Test Rack IV	1.8%

CDA 715 (70/30 Cu/Ni)	
Test Rack I	1.1%
Test Rack II	0.0%
Test Rack III	2.5%
Test Rack IV	4.3%
Z-alloy	
Test Rack I	0.7%
Test Rack II	0.1%
Test Rack III	6.8%
Test Rack IV	10.5%
2205 Stainless Steel (uncoated)	
Test Rack I	121.3%
Test Rack II	148.5%
Test Rack III	183.0%
Test Rack IV	139.7%
2205 Stainless Steel (coated)	
Test Rack I	0.5%
Test Rack II	1.3%
Test Rack III	0.8%
Test Rack IV	1.3%

Alloy Test Plates (after 365 days exposure)	
Plate 1: CDA 706 (90/10 Cu/Ni)	-1.1%
Plate 2: CDA 715 (70/30 Cu/Ni)	-0.3%
Plate 3: Z-alloy	-0.1%
Plate 4: 2205 Stainless Steel (uncoated)	92.5%
Plate 5: 2205 Stainless Steel (coated)	1.2%

Alloy Test Plates

Five 4-inch square alloy test plates, one each of the same materials as the Wedgewire samples and the alloy coupons, were attached to frames made of ¾ inch PVC pipe, enclosed in plastic mesh bags (1/4 inch Vexar), and suspended about 12 inches below the intake structure grating. The test was designed to approximate the conditions that might be found in the interior of a Wedgewire intake module (relatively low water velocity and screening that excludes large predatory organisms such as fish, crabs, and sea stars). The plates were deployed along with the Wedgewire/coupon test racks on June 17, 2014. On September 16, 2014, after 92 days of exposure, the original mesh bags were removed and replaced with new bags. No photos were taken at that time. December 29, 2014, after 196 days of exposure, the bags were again replaced with new bags; this time the plates were photographed, in situ, prior to being enclosed in the new bags. The plates were then returned to their original positions beneath the grating. On April 21, 2015, after 309 days of exposure, the bags were again replaced and the plates photographed. One of the frames and its plate (Plate 5, 2205 stainless steel with the foul release coating) had fallen into the intake structure and had to be retrieved by the divers. The reason for the failure of the cords suspending that plate is unknown. The cords suspending all five of the frames/plates were replaced.

On June 16, 2015, after 365 days of exposure, the bags were removed, the plates were again photographed in situ and then retrieved. The plates were returned to Tenera's San Luis Obispo, CA. laboratory where they were weighed, photographed, and inspected on June 18, 2015 to assess any biofouling present on each plate. The plates were then shipped to V&A Consulting Engineers in Oakland, CA. for metallurgical analyses.

The following biofouling assessment is based on the biofouling inspections conducted on June 18, 2015 at Tenera's laboratory in San Luis Obispo, CA. In situ and laboratory photographs of each plate are also included.

- **CDA 706 (90/10 Copper/Nickel), Plate 1,** (**Figures 11 and 12**)
  - The plate is almost entirely covered with a dark blue-green patina. This tends to flake off when the plate is handled.
  - No attached macrofouling.
  - No slime detectable
  - No algae, diatoms, or silt.
- **CDA 715 (70/30 Copper/Nickel), Plate 2,** (**Figures 13 and 14**)
  - The plate is very clean with almost no discoloration or oxidation visible (a very slight, light-green discoloration). The plate looks almost new.
  - No attached macrofouling.
  - No algae.
  - A little debris near the cable tie holes.
  - Motile species: one small polychaete and six small amphipods.
  - A little silt and perhaps some diatoms.
- **Z-alloy, Plate 3,** (**Figures 15 and 16**)
  - The plate is very clean, except for a single 19 mm mussel that had been attached to one of the cable ties. When the cable tie was removed, the mussel remained loosely attached to the plate by three byssal threads.
  - No attached macrofouling.
  - The plate has a light brown/gold patina. This is a duller finish than the CDA 715 plate, but does not have the patina of the CDA 706 plate.
  - Motile species: 8 small (3 mm) amphipods stranded on the plate.
- **2205 Stainless Steel (uncoated), Plate 4,** (**Figures 17 and 18**)
  - This plate is very heavily fouled; almost completely covered with macrofouling, primarily a large, expansive encrusting sponge. Very little metal visible. Other species include:
    - Parchment worm tubes (10+ cm long).
    - Sipunculid worms (about 3 cm long).
    - 8 slipper limpets (10 to 20 mm).

        - 10 mussels (*M. galloprovincialis*), 2 to 20 mm long. There could be more mussels in the sponge.
        - 7 Oysters (probably *Ostrea lurida*), 24 to 44 mm).
        - Hundreds of barnacles (*M. californicus*), 2 to 14 mm, diameter.
        - White bivalves (probably *Hiatella sp*.), up to 18 mm.
        - Erect and encrusting bryozoans.
        - Calcareous worm tubes.
        - C/S tunicate.
        - Hydroids.
    - As with the other plates, a variety of encrusting invertebrates were attached to the PVC frame and the plastic cable ties that secure the plate to the frame. In this case, there is little to differentiate between the stainless steel plate and the plastic components.
- **2205 Stainless Steel with foul release coating, Plate 5,** (**Figures 19 and 20**)
    - As stated earlier, this plate and its frame and bag were missing when the divers arrived at the WB intake in April 2015. The cords that suspended the frame may have failed, but remained intact on the other four plates. The plate was found lying in the soft sediment and was retrieved from inside the intake by the divers and returned to its original position. The cords were replaced on all five of the plate frames.
    - The fouling that was observed growing on the plate and on the PVC frame in December 2014 was gone with the exception of some empty barnacle shells on the frame. The soft sediment at the bottom of the intake was probably anaerobic and the fouling probably suffocated, died, and decayed. The black coloration on the PVC frame supports the assumption that the sediment had gone anaerobic.
    - This plate is of the same material as Plate 4, but has been coated with a silicone elastomer foul release coating.
    - On June 18, 2015:
        - The coating was intact and in good shape.
        - The plate was very clean with the exception of some small patches of encrusting bryozoans and a few small patches of erect bryozoans.
        - All of the fouling slid off the plate/coating with just a slight finger pressure.
        - The PVC frame was still much cleaner (less fouling) than the other four frames that had not dropped into the sediment within the intake structure.

Conclusions

- In comparison with the macrofouling observed on the PVC racks and the uncoated stainless steel samples, all of the copper-nickel samples (90-10, 70-30, and Z-Alloy) appear to be performing well at deterring the settlement of macrofouling organisms.
- The uncoated (bare metal) stainless steel Wedgewire sample and coupon, have shown no antifouling properties and have about the same degree of fouling (species composition and growth) as the PVC racks.
- The SS samples that were painted with the foul-release coating had considerably less attached fouling that the uncoated SS samples, and were almost as clean as the Cu-Ni samples. The fouling that was present was easily removed with a light brushing using a soft-bristled nylon brush. The coating was in good condition, with little visible damage after 365 days of exposure.
- The test plates performed like the WW samples and coupons. The copper alloys were, for the most part, relatively clean of fouling, the coated stainless steel was also clean, and the uncoated SS was heavily fouled. The PVC frames and plastic cable ties were also heavily fouled, with the exception of Frame 5, which fell into the anaerobic sediment at the bottom of the interior of the intake structure after December 29, 2014 but prior to April 21, 2015, thereby suffocating the previously existing fouling. Plate 5 was retrieved from the bottom of the intake and re-suspended from the intake grating on April 21, 2015.

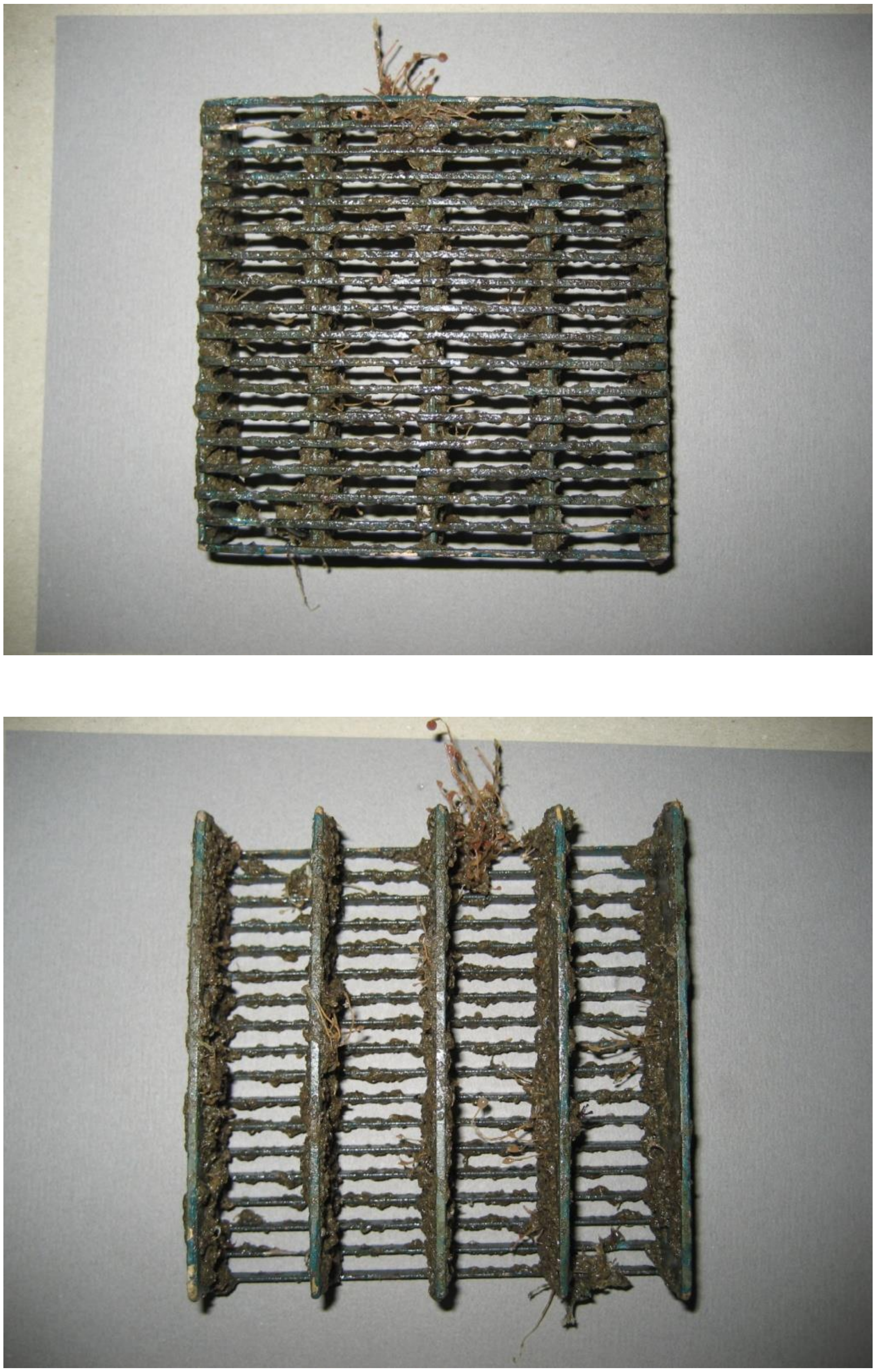


Figure 1. 90/10 Cu/Ni (CDA706) Wedgewire sample, photographed 06/17/15.

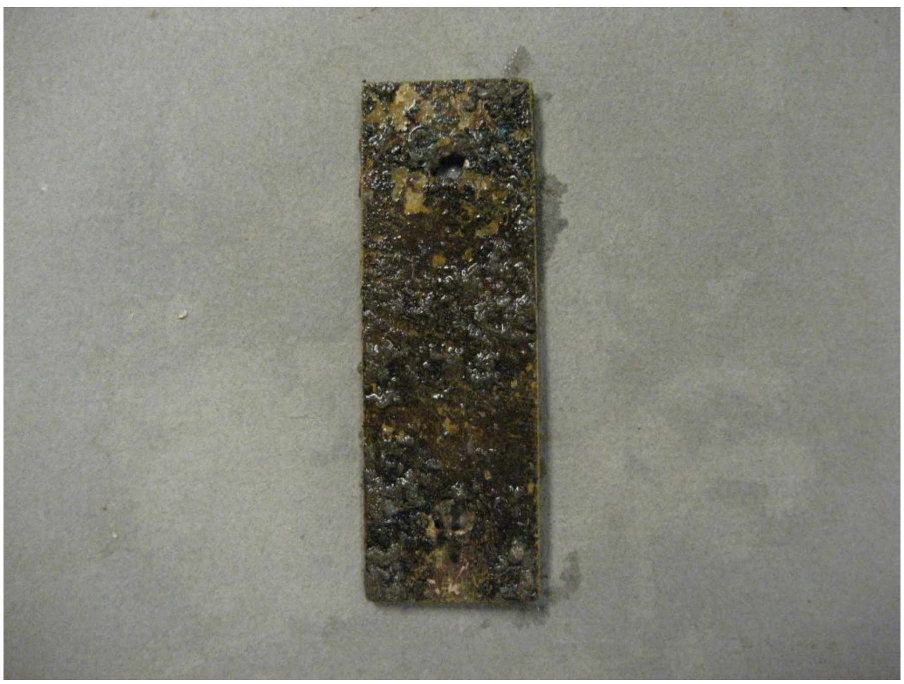


Figure 2. 90/10 Cu/Ni (CDA706) coupon, photographed 06/17/15.

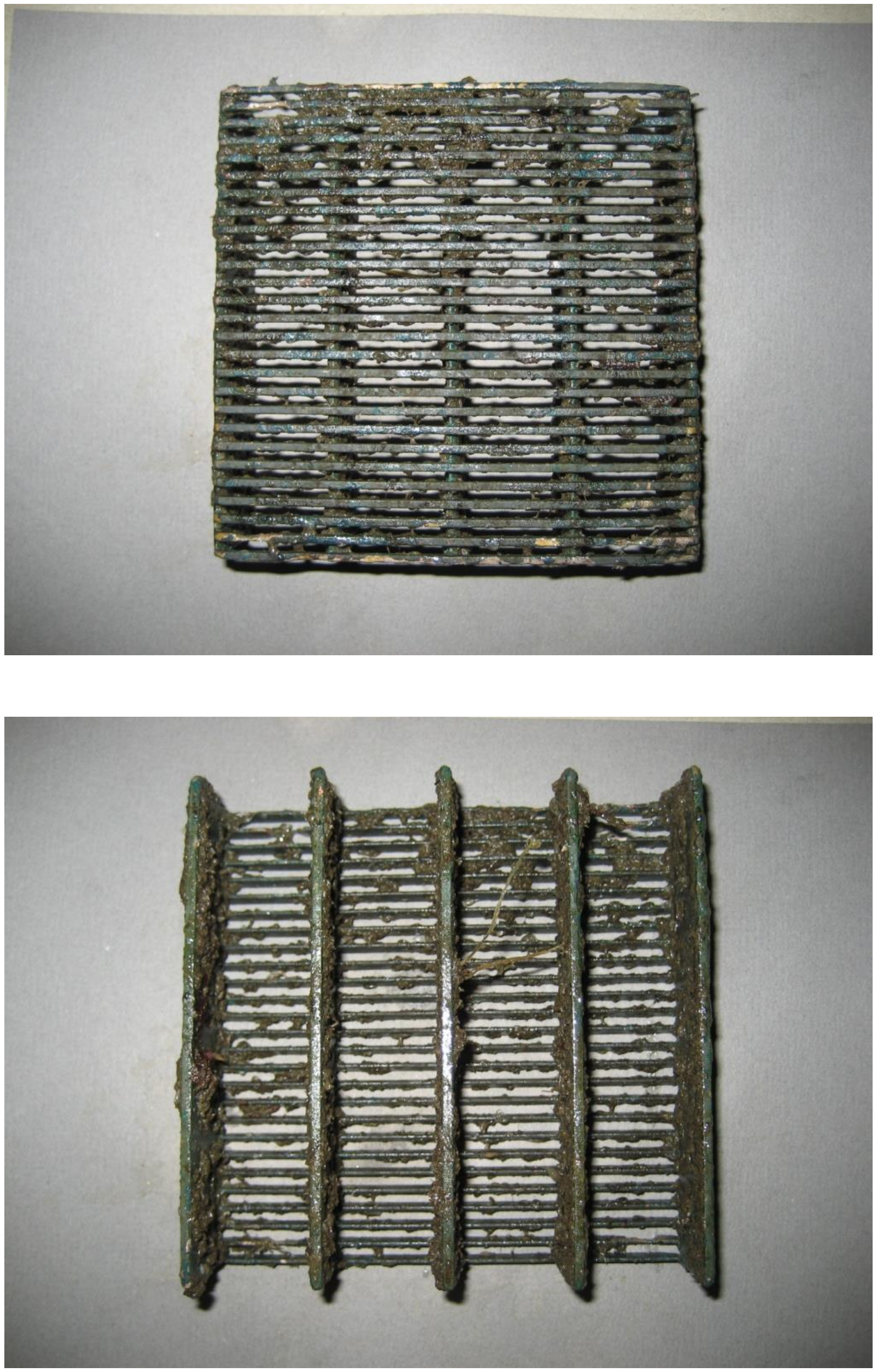


Figure 3. Z-alloy Wedgewire sample, photographed 06/17/15.

Figure 4. Z-alloy coupon, photographed 06/17/15.

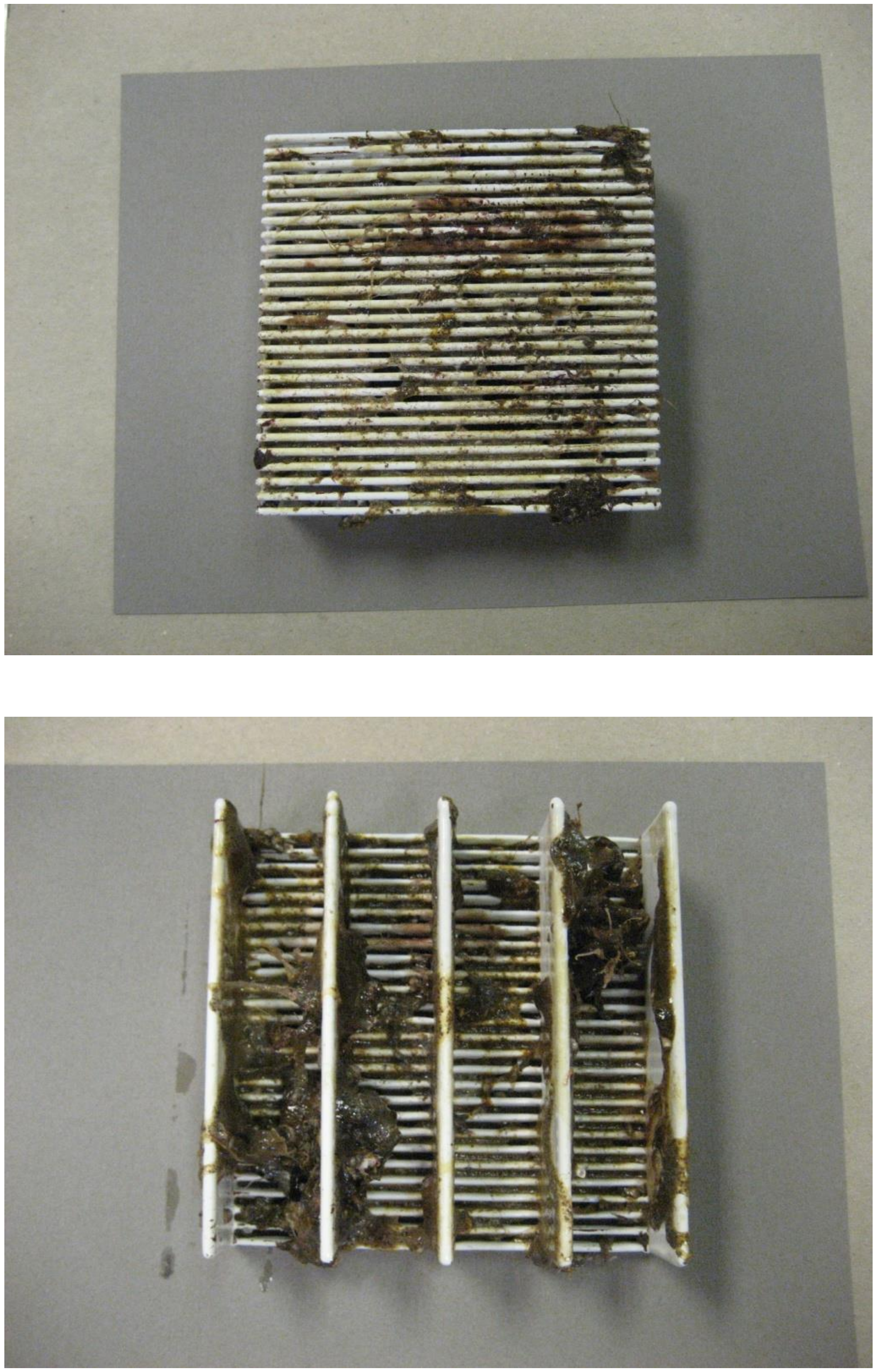


Figure 5. 2205 stainless steel Wedgewire sample with foul release coating, photographed 06/17/15.

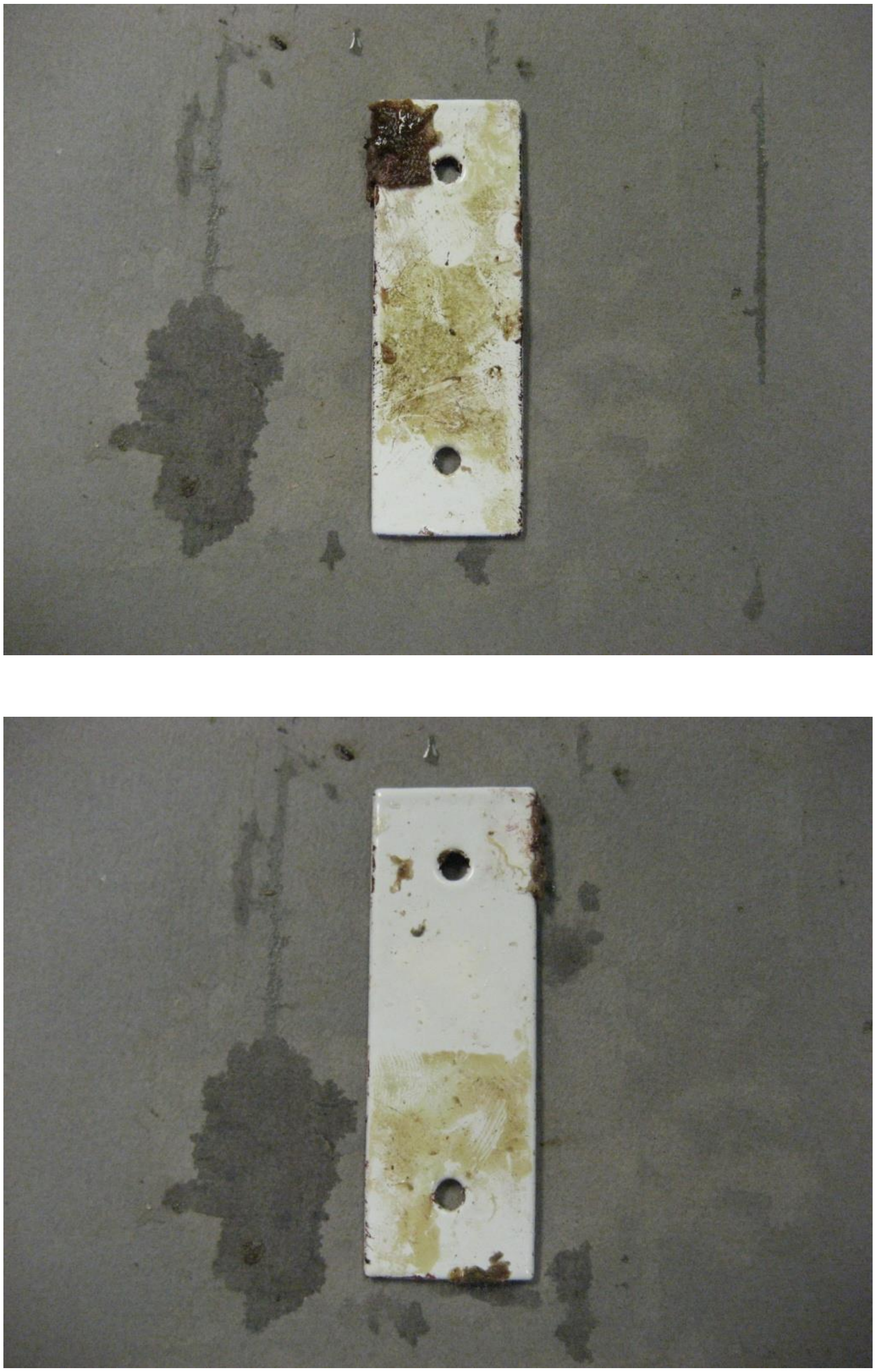


Figure 6. 2205 stainless steel coupon with foul release coating, photographed 06/17/15.

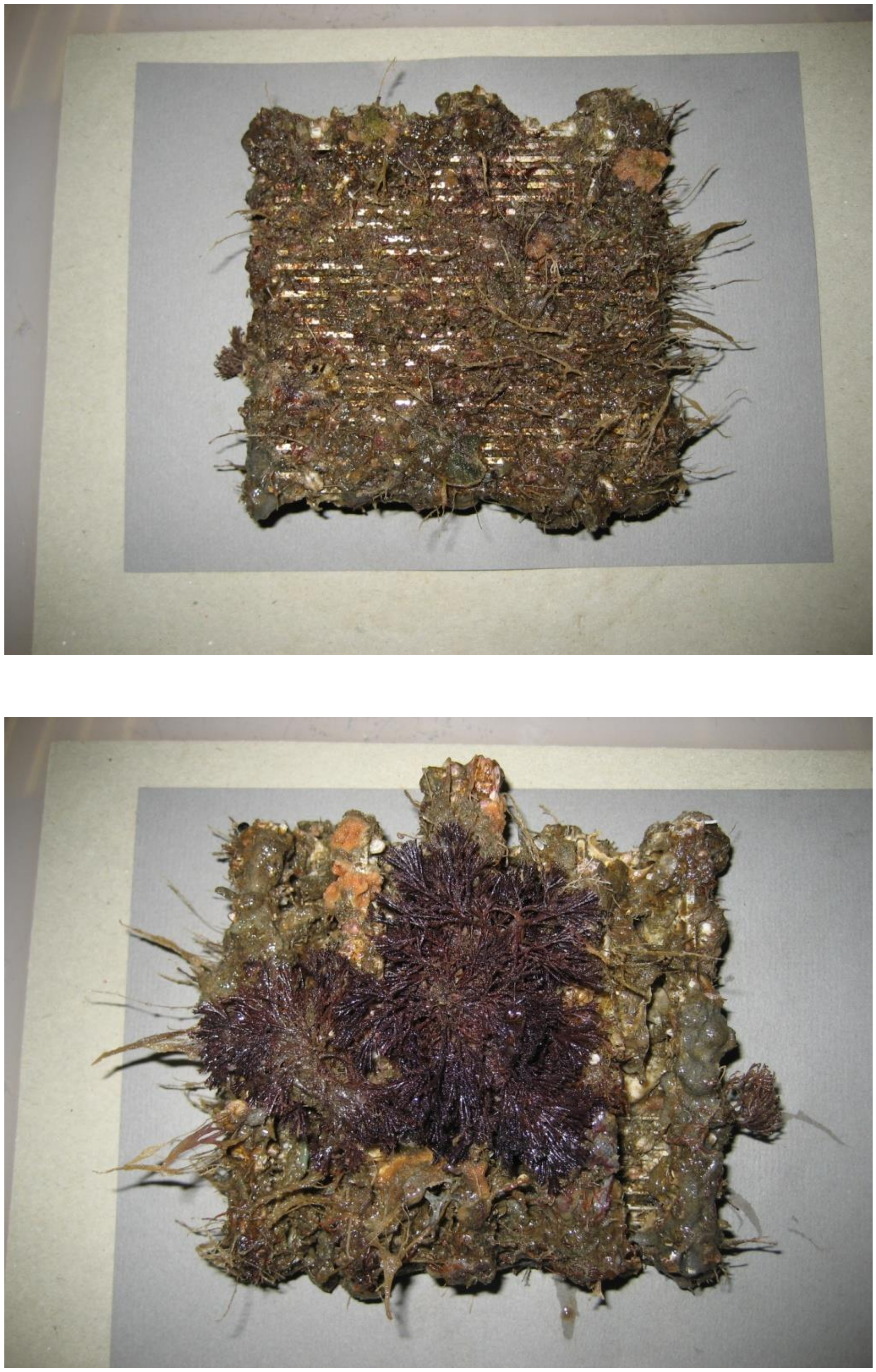


Figure 7. 2205 stainless steel Wedgewire sample, photographed 06/17/15.

Figure 8. 2205 stainless steel coupon, photographed 06/17/15.

Figure 9. 70/30 Cu/Ni (CDA715) Wedgewire sample, photographed 06/17/15.

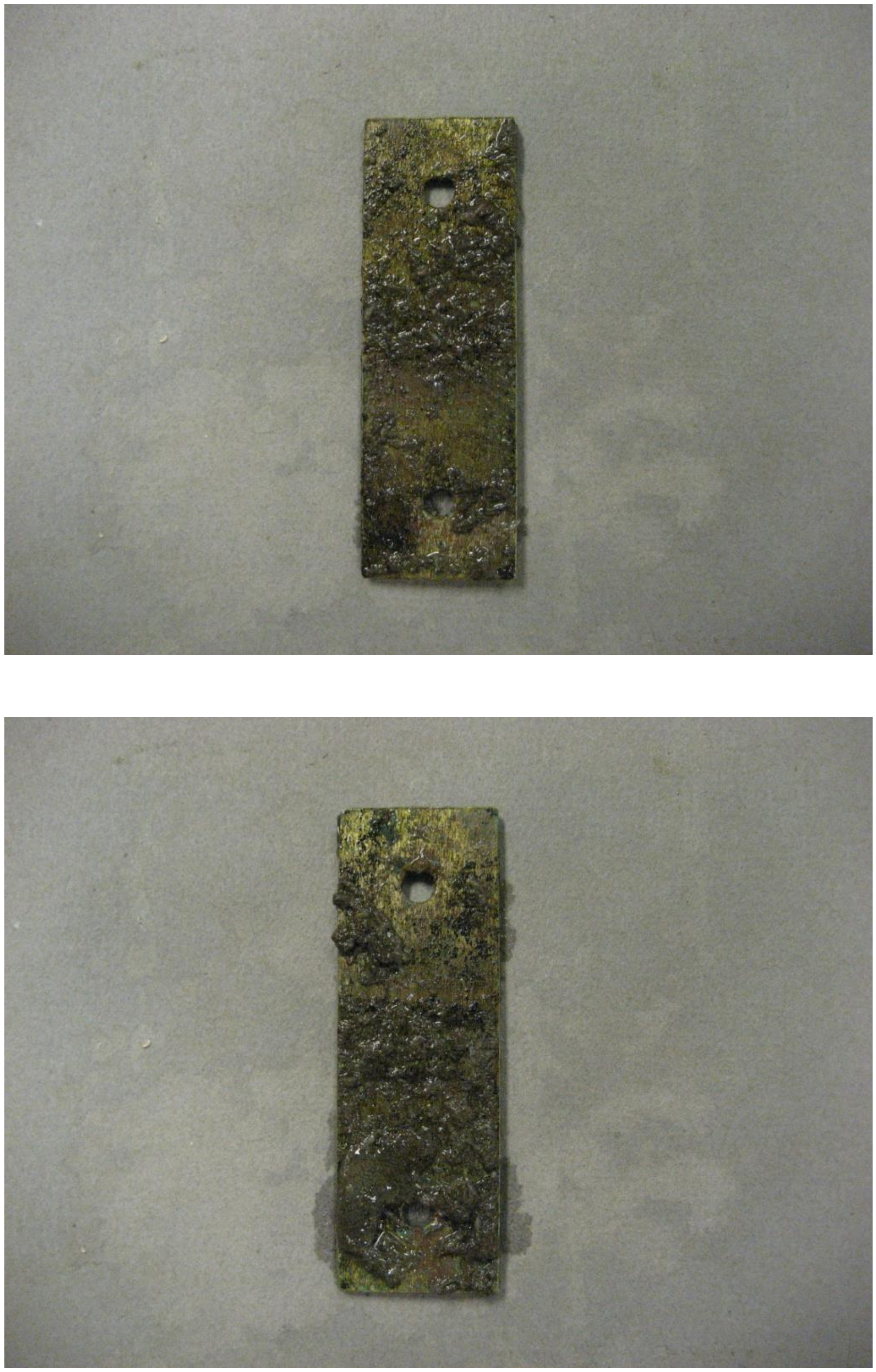
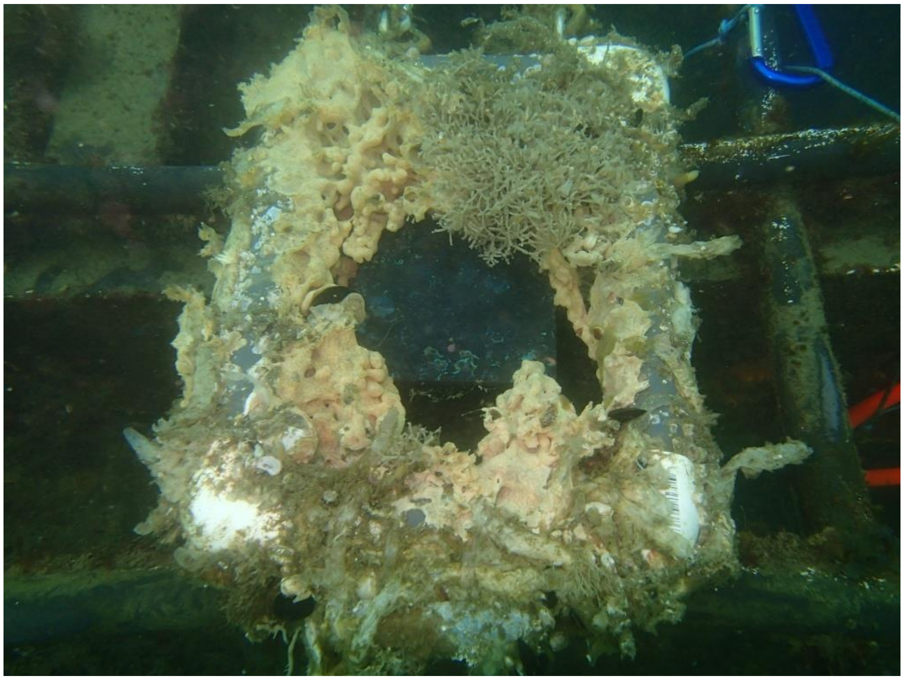


Figure 10. 70/30 Cu/Ni (CDA715) coupon, photographed 06/17/15.



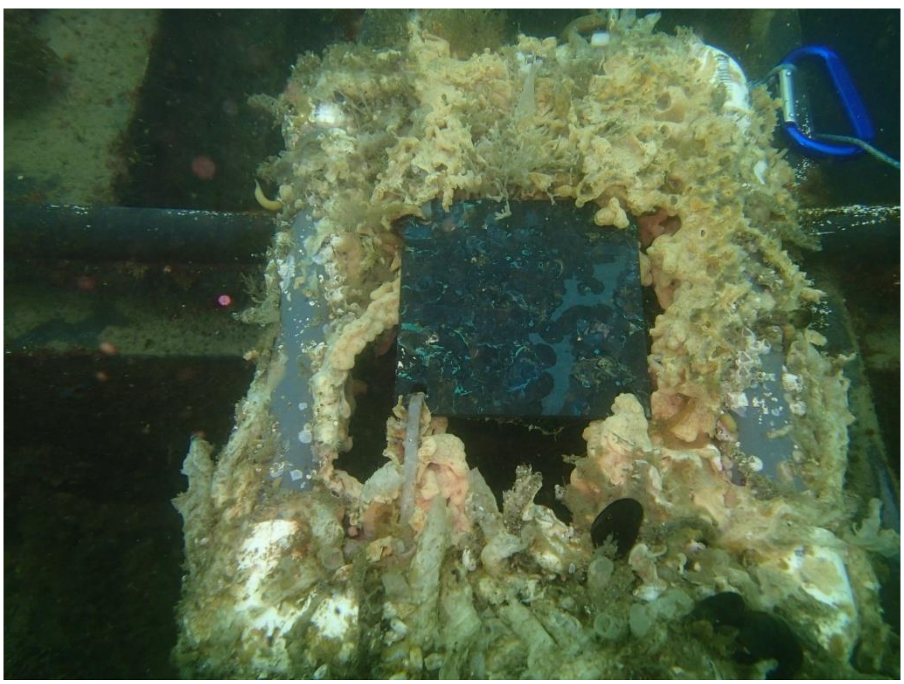


Figure 11. 90/10 Cu/Ni (CDA706) test plate and PVC frame (Test Plate 1), photographed 06/16/15 in situ after removal of its Vexar mesh bag.

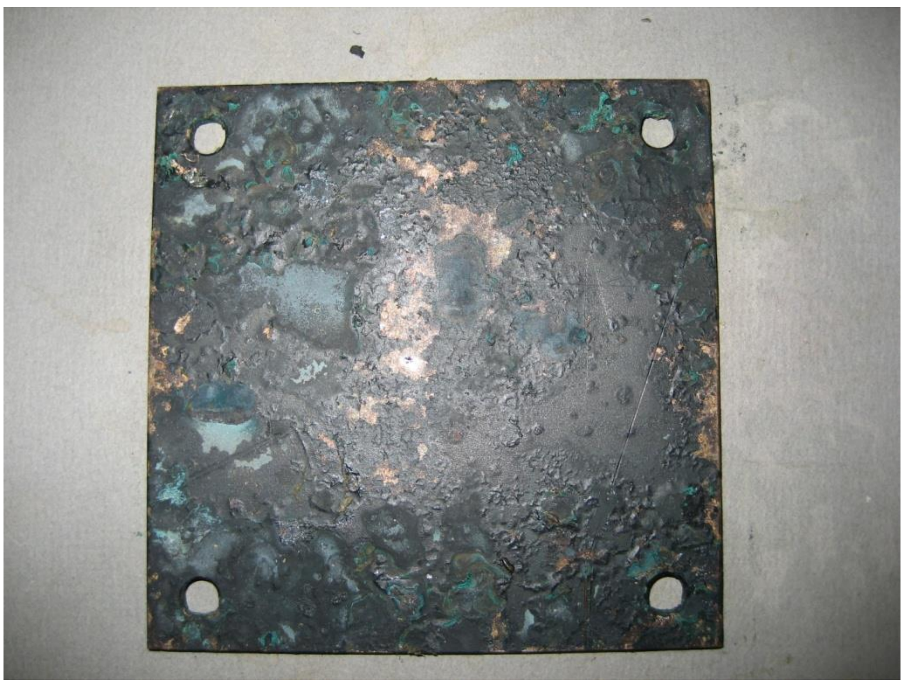


Figure 12. 90/10 Cu/Ni (CDA706) test plate (Test Plate 1), photographed 06/18/15 prior to biofouling inspection.

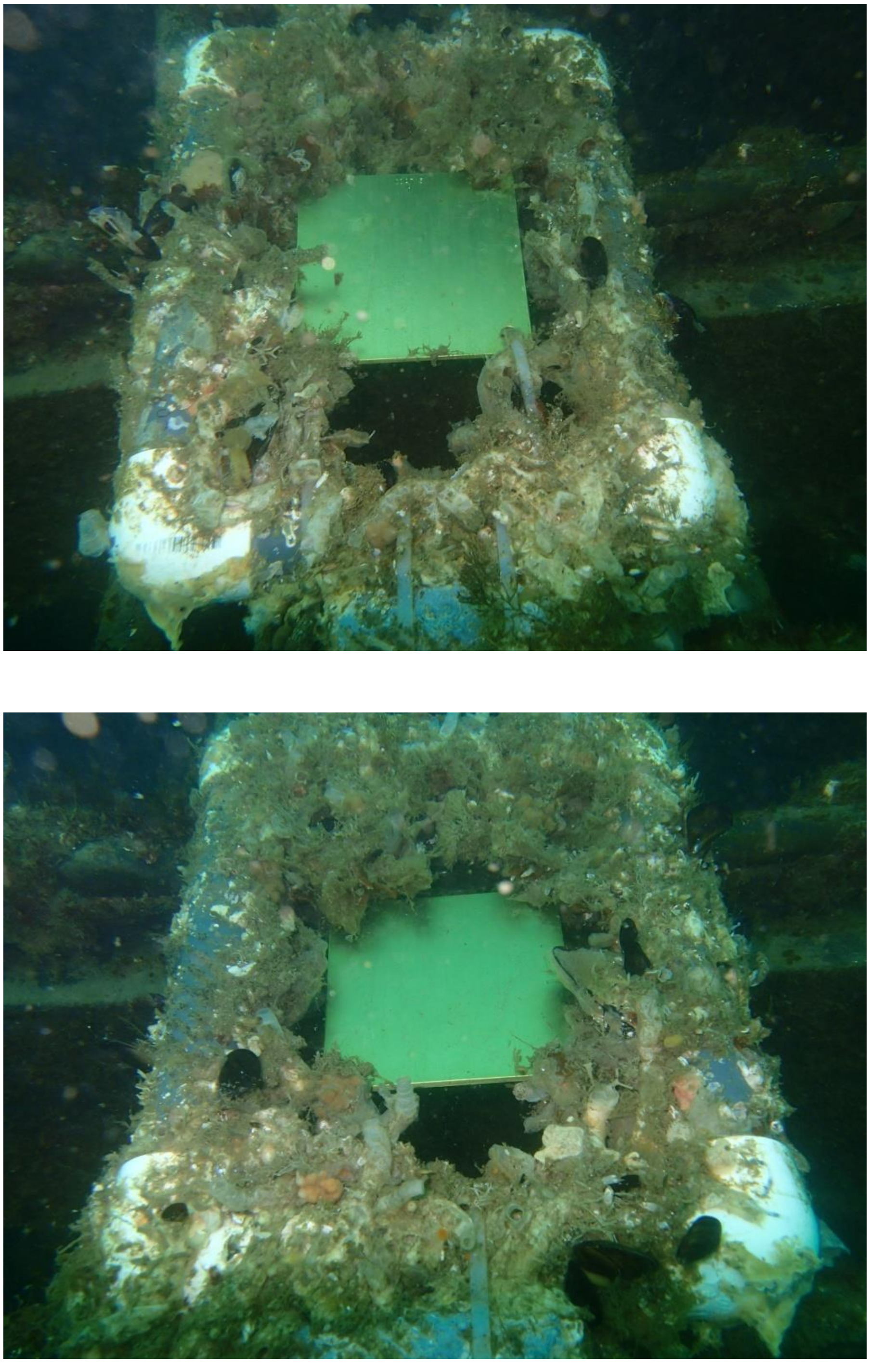


Figure 13. 70/30 Cu/Ni (CDA715) test plate and PVC frame (Test Plate 2), photographed 06/16/15 in situ after removal of its Vexar mesh bag.

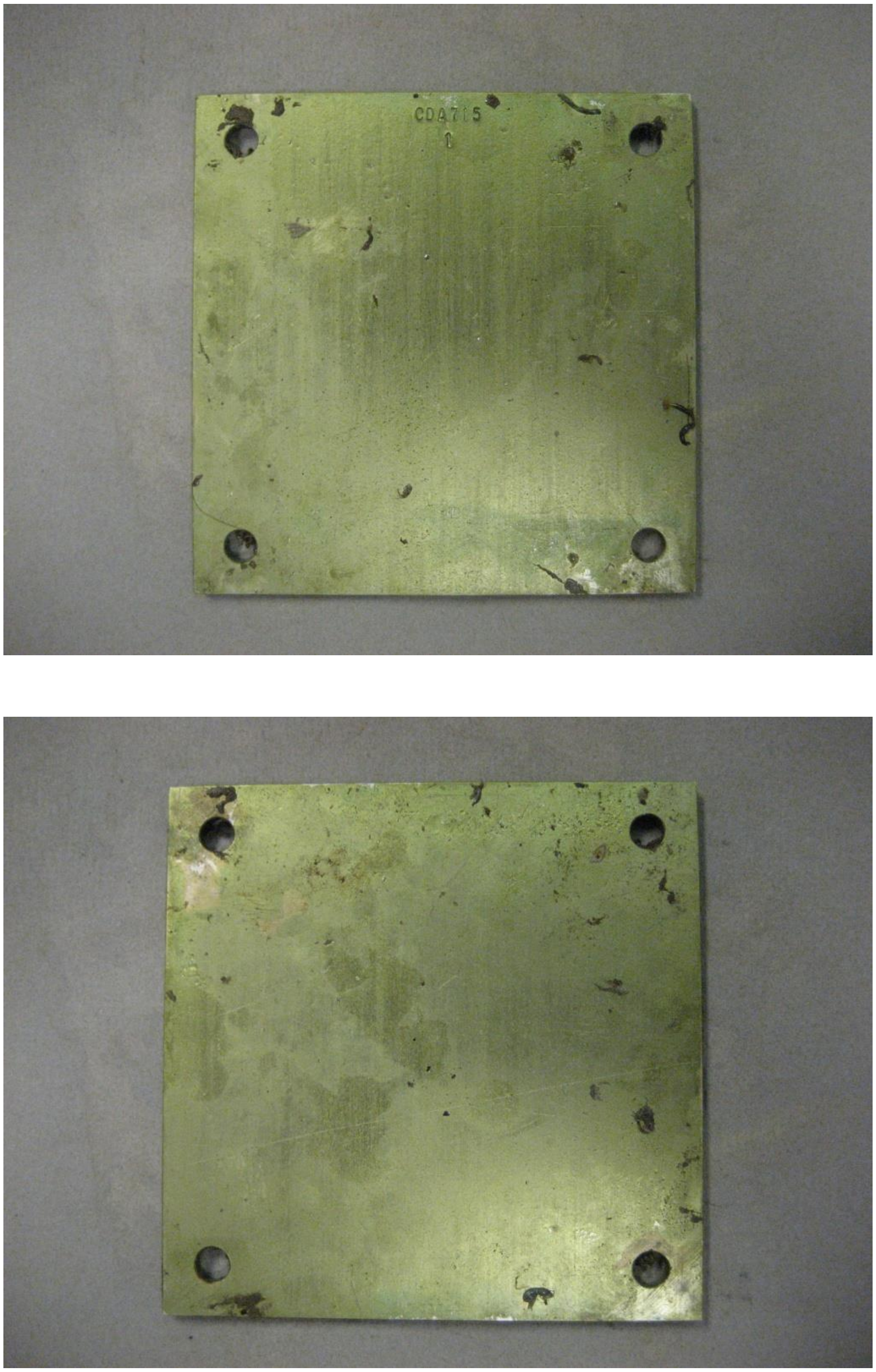


Figure 14. 70/30 Cu/Ni (CDA715) test plate (Test Plate 2), photographed 06/18/15 prior to biofouling inspection.

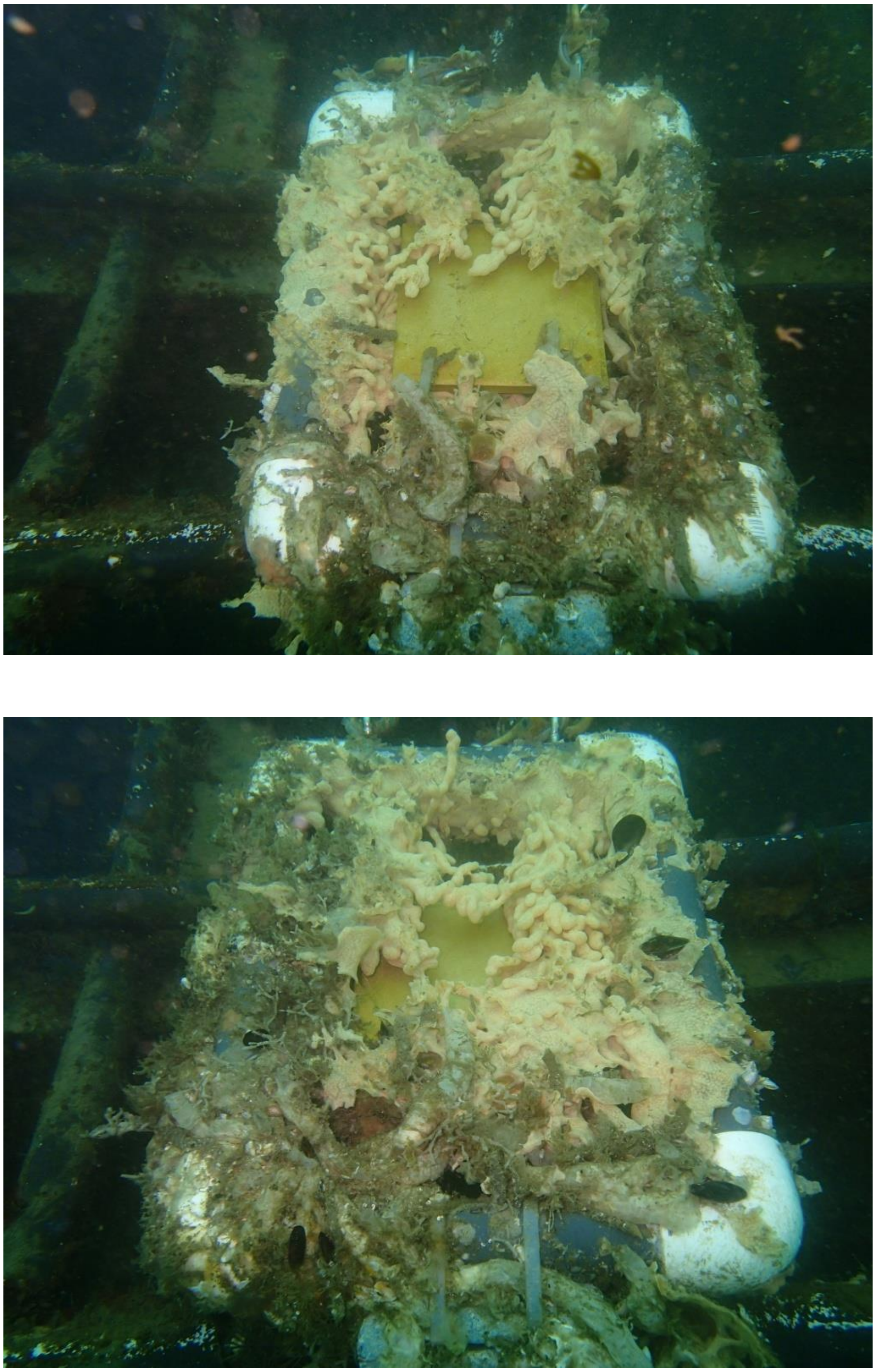


Figure 15. Z-alloy test plate and PVC frame (Test Plate 3), photographed 06/16/15 in situ after removal of its Vexar mesh bag.

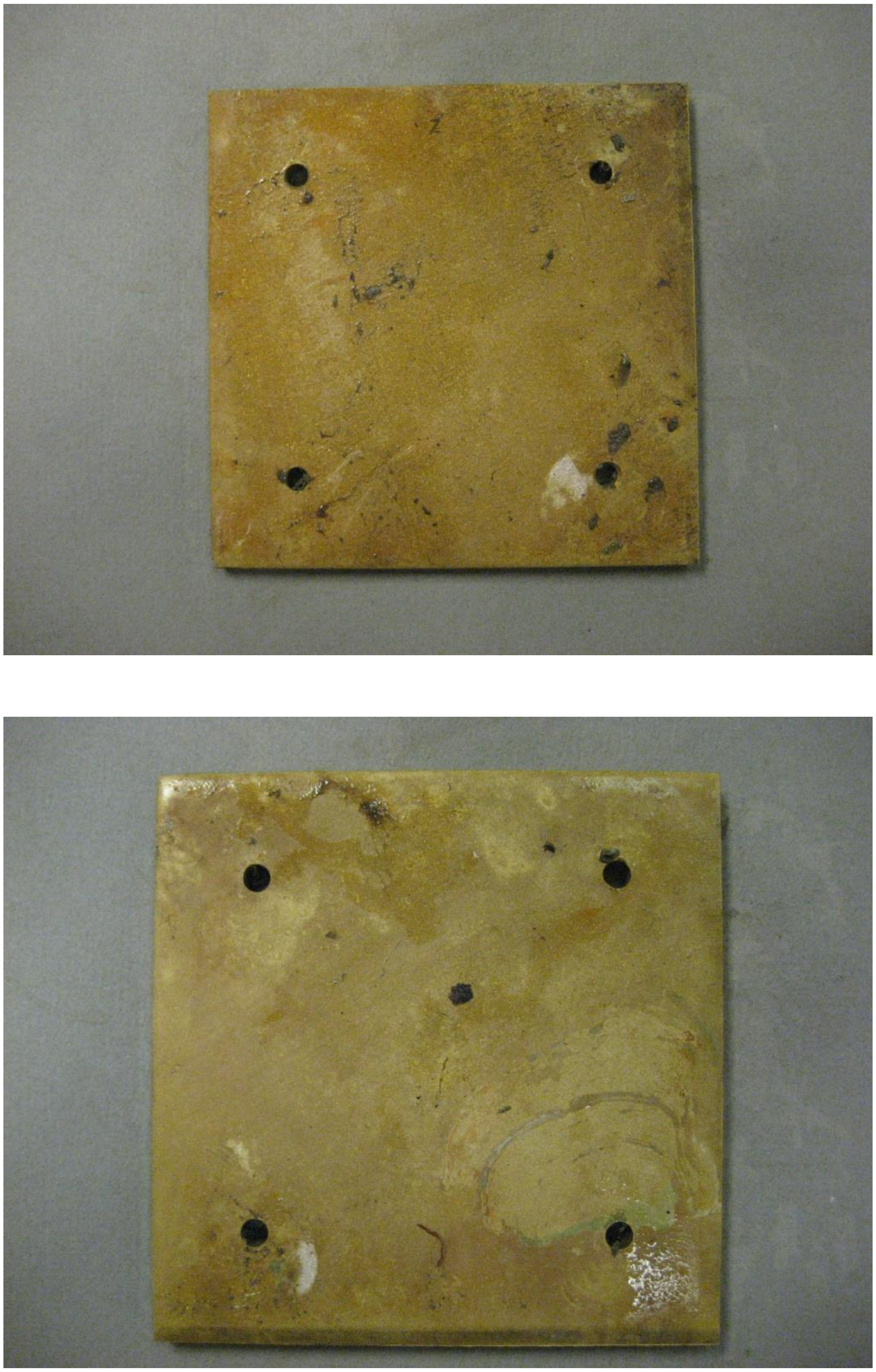


Figure 16. Z-alloy test plate (Test Plate 3), photographed 06/18/15 prior to biofouling inspection.

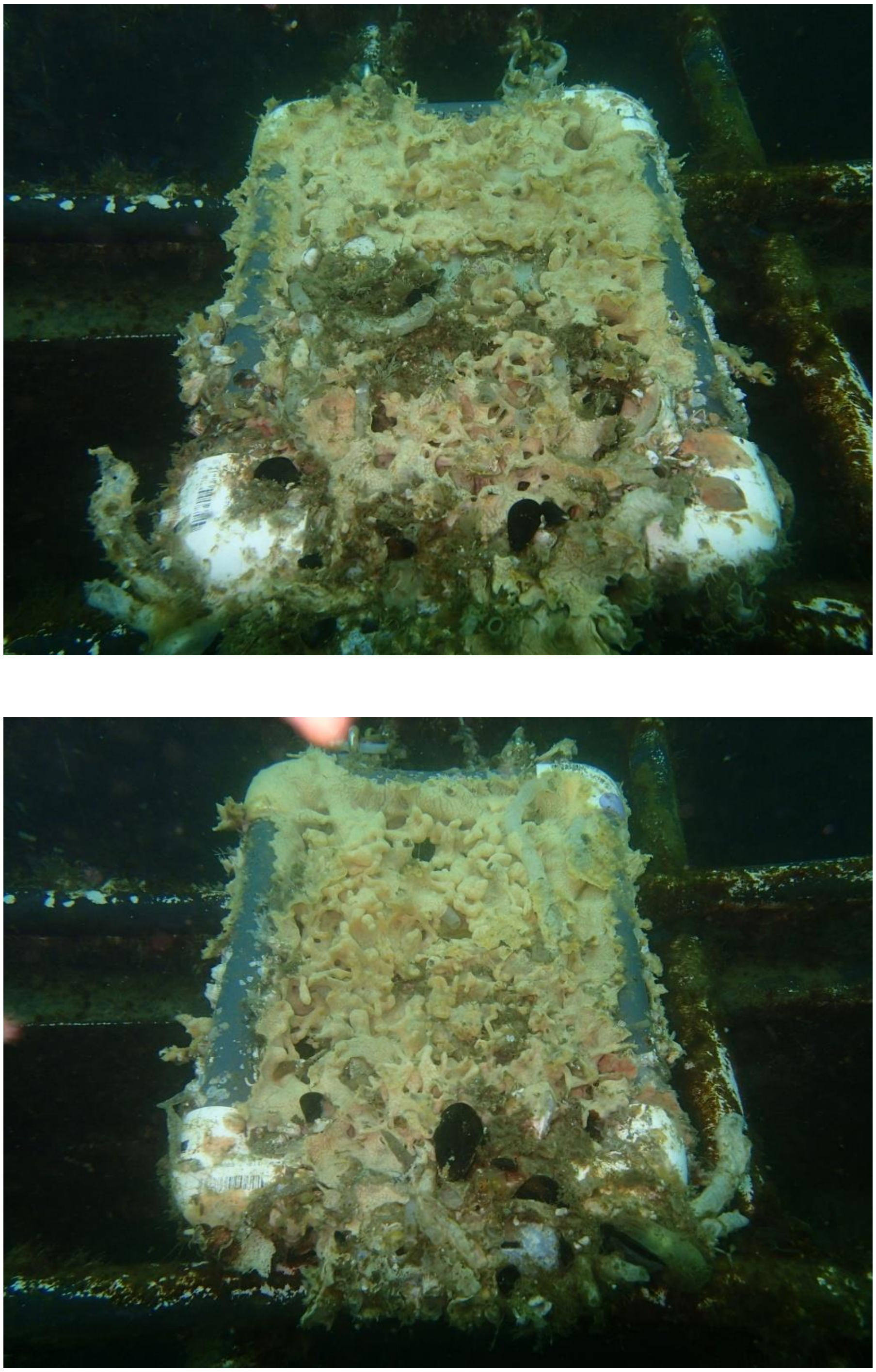
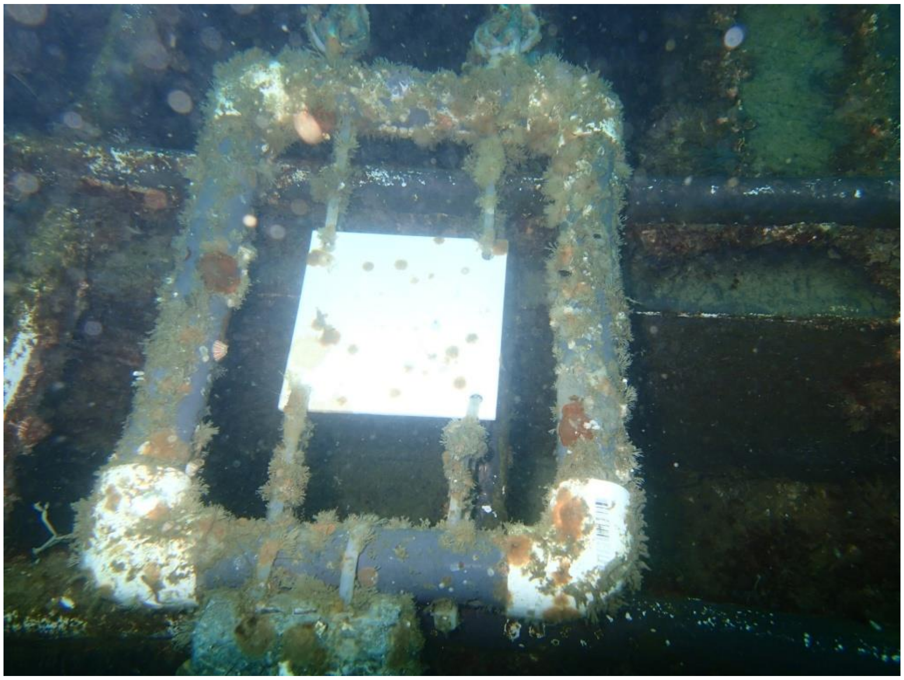


Figure 17. 2205 stainless steel test plate and PVC frame (Test Plate 4), photographed 06/16/15 in situ after removal of its Vexar mesh bag.

Figure 18. 2205 stainless steel test plate (Test Plate 4), photographed 06/18/15 prior to biofouling inspection.



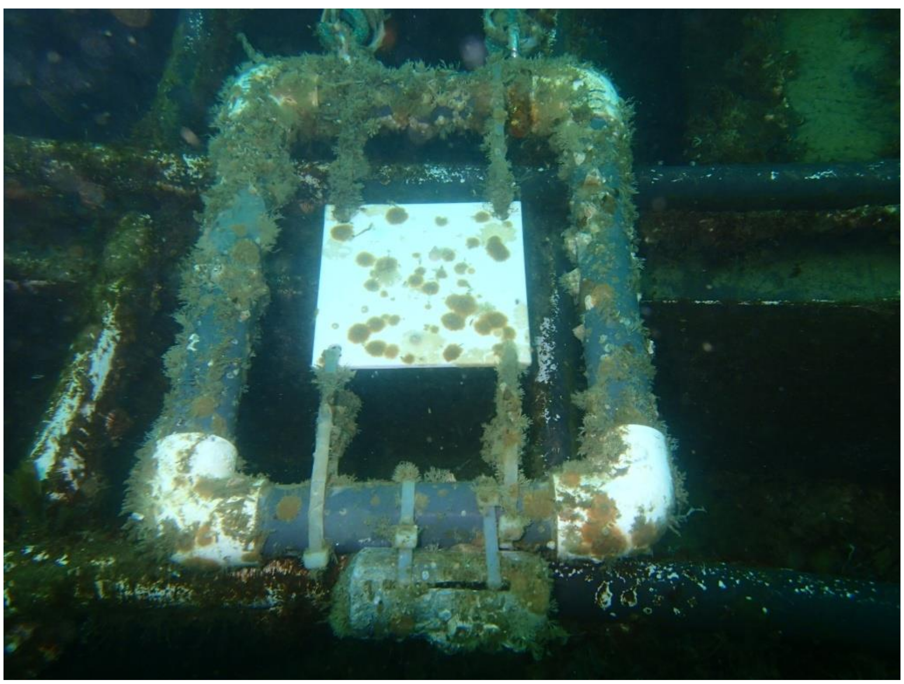


Figure 19. 2205 stainless steel test plate with foul release coating and PVC frame (Test Plate 5), photographed 06/16/15 in situ after removal of its Vexar mesh bag.

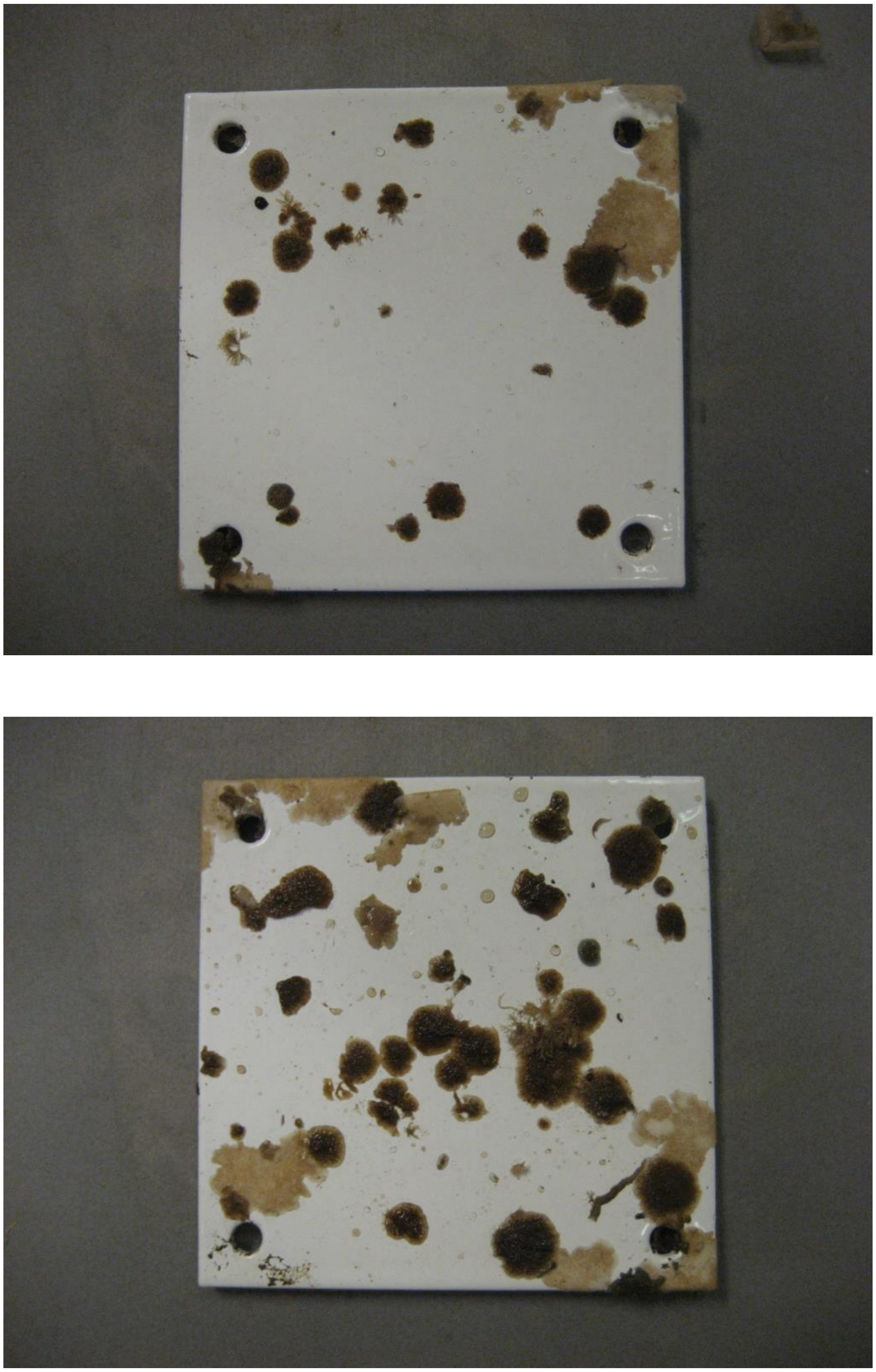


Figure 20. 2205 stainless steel test plate with foul release coating (Test Plate 5), photographed 06/18/15 prior to biofouling inspection.

TENERA Environmental

June 15, 2017

Steve Tedesco
Tetra Tech
17885 Von Karman Ave., Suite 500
Irvine, CA. 92614

Subject: May 2017 WBMWD Biofouling Test Rack V Inspection (ESLO2017-15)

Dear Steve:

This letter report provides our findings from the biofouling inspection of the last of the five test racks installed at the West Basin intake on June 17, 2014. Test Rack V was retrieved May 23, 2017 after 1,072 days. The rack was last inspected in situ and photographed on June 16, 2015 when Rack IV was retrieved. Unlike the previous four test racks, Rack V was deployed with only the five wedgewire samples, and lacked the small metal coupons, which had been retained by V&A Consulting Engineering for testing prior to the June 2014 deployment. When Rack V was retrieved only three of the five wedgewire samples were still attached to the rack. These included the 70-30 copper-nickel (Cu-Ni) sample and the coated and uncoated stainless steel samples. Missing were the 90-10 Cu-Ni and Z-Alloy samples.

When Test Racks I, II, III, and IV were inspected, after 92, 196,309, and 365 days of exposure, respectively, the 90-10 Cu-Ni and Z-Alloy wedgewire samples and coupons had the least amount of attached macrofouling and minimal corrosion. The results for the 70-30 Cu-Ni samples were similar, but with slightly more fouling. The uncoated stainless steel samples were heavily fouled with hydroids, barnacles, bryozoans, filamentous algae, tunicates, sponges, bivalves, and a variety of other invertebrates. Very little of the bare metal was visible. The stainless steel with the foul-release coating looked fairly clean, especially in comparison with the uncoated stainless steel samples, and the fouling was easily removed with just a light scrubbing with a soft nylon brush.

In addition to the PVC rack and the wedgewire samples, an Onset Computer Corporation HOBO Water Temp Pro V2 temperature logger was mounted on the rack. The logger was set to record ambient seawater temperature at 20 minute intervals. Recording with this frequency, the logger’s memory would have been filled sometime in early February 2017. However, at the time of its retrieval the logger’s battery was dead and the data could not be downloaded. The logger was sent to Onset for data recovery by their technical staff. Onset was able to retrieve the data and found that the unit’s memory had been filled prior to the loss of the battery. The temperature data was sent to V&A Consulting Engineering to be used in their corrosion evaluation.

In the past, each test rack had been retrieved by Tenera's divers. Prior to removing the rack from the grating, the divers videotaped and took underwater photos of the rack and the test samples. This provided us with information on the undisturbed condition of the rack, the samples, and any encrusting biofouling. Rack V however, was removed by commercial divers hired by the West Basin Municipal Water District who were also performing a series of maintenance tasks at the intake. It is our understanding that the divers were going to videotape the rack prior to its removal. To date we have not been able to ascertain whether any underwater video or photos were taken of Rack V.

Sincerely,

Fred Steinert
Tenera Environmental

West Basin Intake Biofouling Test
Test Rack V
May 25, 2017 Inspection
Duration of Testing: June 17, 2014 – May 23, 2017 (1,072 days)

Wedgewire Samples and PVC Test Rack

Biofouling Inspection Notes

- **PVC test rack V (Figure 1):**
  - The PVC test rack was heavily fouled to the point where almost none of the PVC was visible. On some portions of the rack, the encrusting biofouling layer exceeded 25 mm (1 inch) in thickness. The dominant fouling species included a hydroid (*Pinauay crocea* / *Tubularia crocea* or Tubularia-like), the acorn barnacle *Megabalanus californicus*, and an opaque tan-colored encrusting sponge. The barnacles ranged from about 4 mm to 28 mm in diameter and covered most of the rack (thousands of individuals). Intermingled with the hydroids were mussels (*Mytilus galloprovincialis*) up to about 20 mm in length, small white bivalves (possibly *Hiatella*), small scallops, tube worms, amphipods, sponges, solitary tunicates, and a variety of other invertebrates. There were also several species of red (filamentous, foliose and encrusting) and green algae mixed in with the various fouling organisms.
- **CDA 706 (90-10 Copper-Nickel); wedgewire sample (rack position VA1):**
  - Wedgewire sample (VA1)
    - This sample was missing from the rack. During past inspections of this material from Racks I – IV, it was noted that it was quite resistant to biofouling, even after 365 days of submergence at the intake. However, it was also noted that the wedgewire at the sites of the four securing cable ties was quite worn; possibly as a result of accelerated corrosion beneath the cable tie and erosion due to rubbing of the cable tie against the metal. This may have eventually caused the metal to wear through at the points of attachment and resulted in the loss of the sample. The plastic cable ties that had secured this sample to Rack V remained intact and were still looped through the rack when it was retrieved. This indicates that the cable ties were neither cut nor worn through resulting in the loss of the sample. WBMWD was informed of the two missing samples (see Z-Alloy below) and they instructed the commercial divers to be on the lookout

for the two samples. At the time of this report, the divers have been unable to find the missing samples.

- **Z-Alloy; wedgewire sample (rack position VB2):**
  - Wedgewire sample (VB2)
    - This sample was also missing when Rack V was retrieved. As with the 90-10 Cu-Ni sample, this material had been very resistant to biofouling during past inspections, but had also shown signs of accelerated corrosion/erosion of the wedgewire at the sites of the plastic cable ties.
- **2205 SS (stainless steel) with antifouling coating; wedgewire sample (VA3):**
  - Wedgewire sample (VA3) (**Figure 2**)
    - About 80 percent of the sample's outer surface had a light covering of diatoms and filamentous or encrusting red algae. There were 45 – 50 acorn barnacles (*Megabalanus californicus*) that ranged in size from 5 – 24 mm. The majority of the barnacles were on the underside of the sample attached to the flat metal sides and reinforcing ribs. About 85% of the outer wedgewire face was not occluded by the barnacles or other fouling.

      Most of the barnacles were firmly attached, usually at locations where some damage or imperfection in the foul-release coating allowed the barnacle to get a foothold on the bare metal or the primer coat under the foul-release coating. Barnacles that had settled on undamaged portions of the coating could be easily removed with gentle pressure.

      There were also some hydroids and amphipod tubes on the underside of the sample and attached to the barnacle shells.
- **2205 SS (stainless steel); wedgewire sample (VB4):**
  - Wedgewire sample (VB4) (**Figure 3**)
    - This sample was very heavily fouled with none of the metal visible prior to the removal of the sample from the rack. Most of the surface was covered by a layer of tan-colored sponge, hydroids, bryozoans, filamentous algae, and amphipod tubes. Beneath and intermixed with the sponge/hydroid layer were hundreds of acorn barnacles (*M. californicus*) ranging in size from about 4 – 25 mm.

      Also intermixed with the hydroids were about 10 small mussels (*M. galloprovincialis*) up to 8 mm in length, scallops, white bivalves, tube worms, amphipods, crabs, erect and encrusting bryozoans, red algae (filamentous and foliose), oysters (to 30 mm), encrusting sponge, c/s tunicate, and probably other small invertebrates. The original weight of the sample was about 312 g and the fouling added another 433 g. The fouling was very firmly attached and some of the material could not be removed prior to sending the sample to V&A Consulting Engineering due to the potential of damaging the sample prior to metal analyses.

- **CDA 715 (70-30 Copper-Nickel); wedgewire sample (IVA5):**
  - Wedgewire sample (VA5) (**Figure 4**)
    - The CDA 715 WW samples from Racks I – IV, were similar to the CDA 706 and Z-Alloy samples, but with more of the surface covered by amphipod tubes and filamentous red algae. There was also more of a diatom and silt film/layer, but less of the green patina than on the other two samples. The sample from Rack V could not be compared with the 90-10 Cu-Ni or the Z-Alloy because those samples were missing. Overall this sample looked very good after being submerged for almost three years. About 70 percent of the outer surface had a light covering of filamentous algae, diatoms, hydroids, and entrapped silt and debris (soft material). The underside had some amphipod tubes, five small (2 – 5 mm diameter) acorn barnacles (*M. californicus*), and three small white bivalves (2 – 3 mm length). All fouling and debris was easily removed with a soft nylon brush after the sample was photographed and inspected.
      There was accelerated corrosion/erosion of the wedgewire at the sites of the plastic cable ties (**Figure 5**), but it was not severe enough to result in the loss of the sample.

- **Temperature Recorder Housing:**
  - A temperature recorder enclosed in a protective housing made of 1½ inch schedule 80 PVC pipe, was attached to Rack V on June 16, 2015. At the time of its retrieval, the housing was very heavily fouled with an assemblage of fouling species similar to that covering the PVC rack. Although the housing had been submerged for a year less than the rack, the quantity and sizes of the fouling species were quite similar. Because of the lengthy deployment, the recorder's battery had died. The unit was returned to the manufacturer for data retrieval, which was successful. The temperature data was forwarded to V&A Consulting Engineering.

Weight Change

Prior to the biofouling inspections and assessments, each wedgewire sample was blotted to remove any excess water and then weighed along with any accumulated biofouling. The resulting weight was then compared with the dry weight that was recorded prior to deployment of the test racks. Presented below is the percentage change in weight for each of the wedgewire samples retrieved from Rack I on September 16, 2014, Rack II on December 29, 2014, Rack III on April 21, 2015, Rack IV on June 16, 2015, and Rack V on May 23, 2017:

Wedgewire Samples	Percent Change
CDA 706 (90/10 Cu/Ni)	
Test Rack I	-2.8%
Test Rack II	-2.5%
Test Rack III	0.3%
Test Rack IV	2.8%
Test Rack V	Missing
CDA 715 (70/30 Cu/Ni)	
Test Rack I	3.5%
Test Rack II	2.8%
Test Rack III	7.2%
Test Rack IV	4.7%
Test Rack V	10.9%
Z-alloy	
Test Rack I	-2.1%
Test Rack II	-2.2%
Test Rack III	-1.4%
Test Rack IV	-0.6%
Test Rack V	Missing
2205 Stainless Steel (uncoated)	
Test Rack I	64.9%
Test Rack II	73.0%
Test Rack III	88.5%
Test Rack IV	78.5%
Test Rack V	138.7%
2205 Stainless Steel (coated)	
Test Rack I	4.5%
Test Rack II	12.5%
Test Rack III	10.9%
Test Rack IV	15.8%
Test Rack V	37.8%

Conclusions

- In comparison with the macrofouling observed on the PVC racks and the uncoated stainless steel samples, the 70-30 Cu-Ni sample performed very well at deterring the settlement of macrofouling organisms.
- The uncoated (bare metal) stainless steel wedgewire sample showed no antifouling properties and had about the same degree of biofouling (species composition and growth) as the PVC racks.
- The SS sample that was painted with the foul-release coating had considerably less attached fouling that the uncoated SS samples, and was almost as clean as the Cu-Ni sample. The barnacles that were present appear to have initially attached themselves at locations where the coating had detached from the sample or some surface irregularity existed. The foul-release coating is fairly soft and can easily be damaged.
- Two of the samples, the 90-10 Cu-Ni and the Z-Alloy were missing. During past inspections of these materials from Racks I – IV it was noted that they were quite resistant to biofouling, even after 365 days of submergence at the intake. However, it was also noted that the wedgewire at the sites of the four securing cable ties were quite worn; possibly as a result of accelerated corrosion beneath the cable tie and erosion due to rubbing of the cable tie against the metal. This may have eventually caused the metal to wear through at the points of attachment and resulted in the loss of the samples. The plastic cable ties that had secured these samples to Rack V remained intact and were still looped through the rack when it was retrieved. This indicates that the cable ties were neither cut nor worn through resulting in the loss of the samples. This was most unfortunate since these two materials were the most resistant to biofouling.

Figure 1. Rack V with three remaining wedgewire samples still attached, photographed 05/23/17.

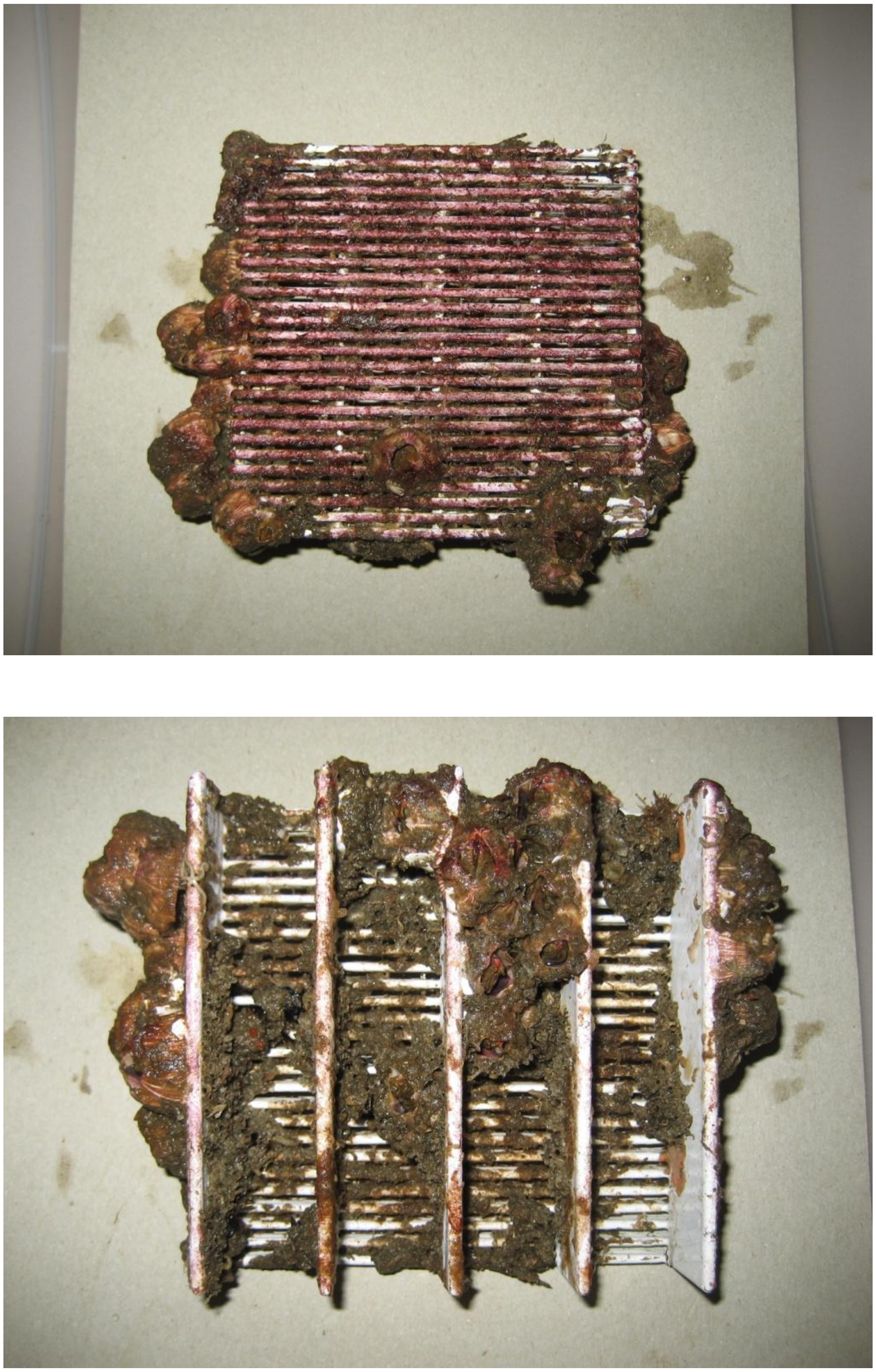


Figure 2. 2205 stainless steel wedgewire sample with foul release coating, photographed 05/24/17.

Figure 3. 2205 stainless steel wedgewire sample, photographed 05/24/17.

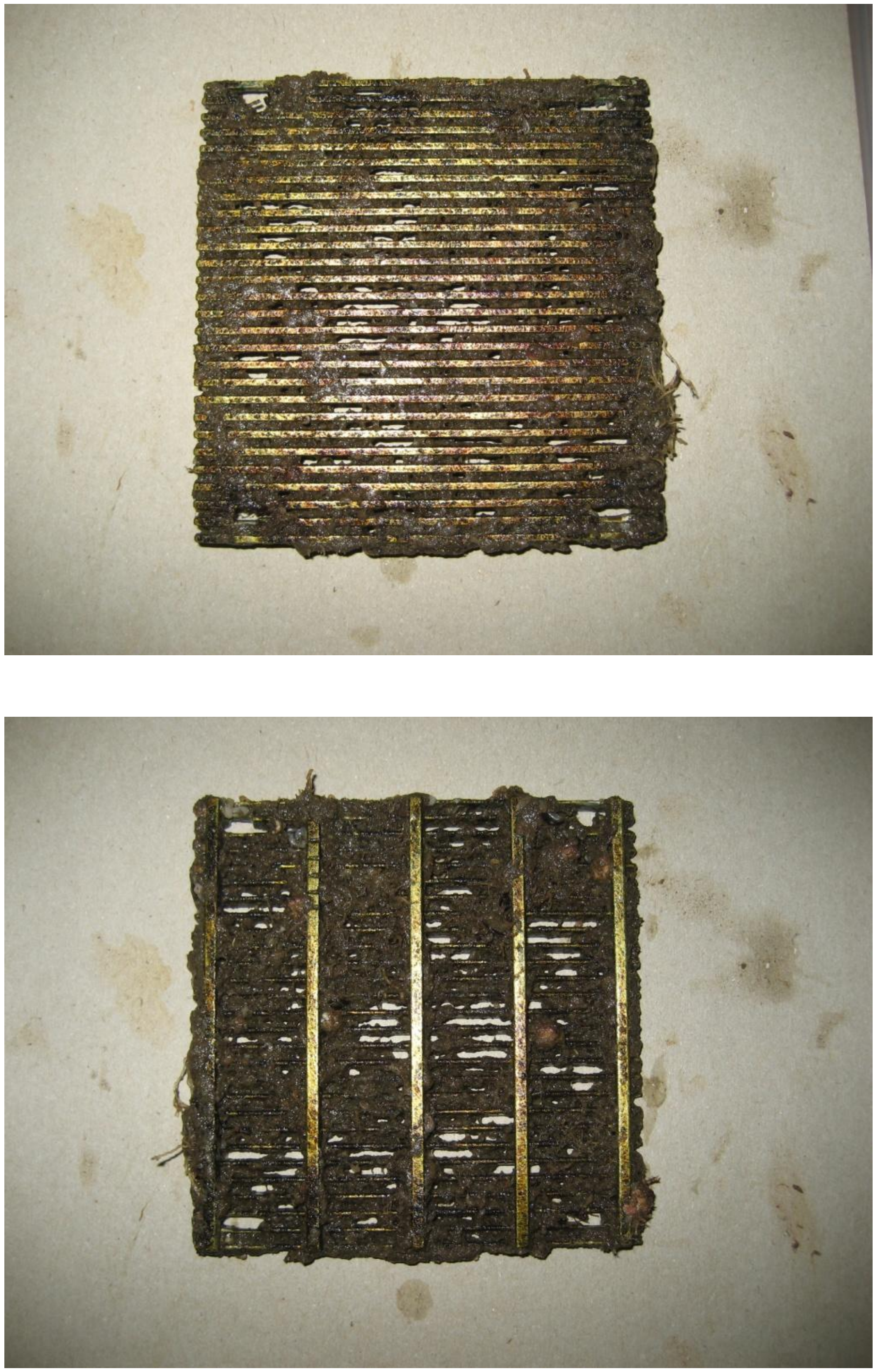


Figure 4. 70-30 Cu-Ni (CDA715) wedgewire sample, photographed 05/24/17.

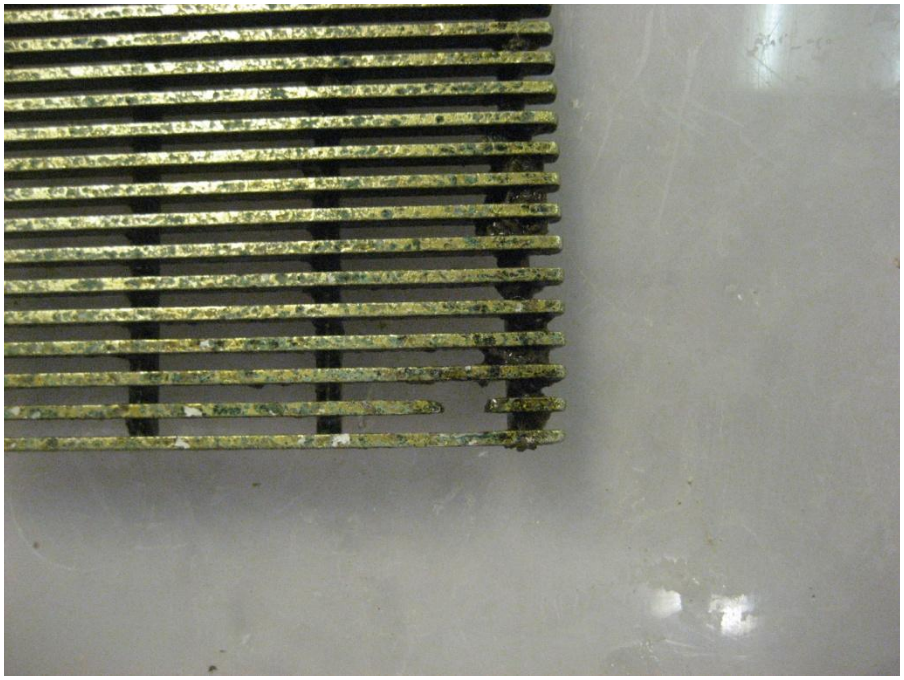


Figure 5. 70-30 Cu-Ni (CDA715) wedgewire sample, photographed 05/25/17, showing erosion/corrosion at one of the four attachment points.