twb Environmental Research and Consulting

Wedgewire Screen Pilot Project

Final Report

December 7, 2020 – February 9, 2022

Prepared for Poseidon Resources (Channelside), LP

May 19, 2022

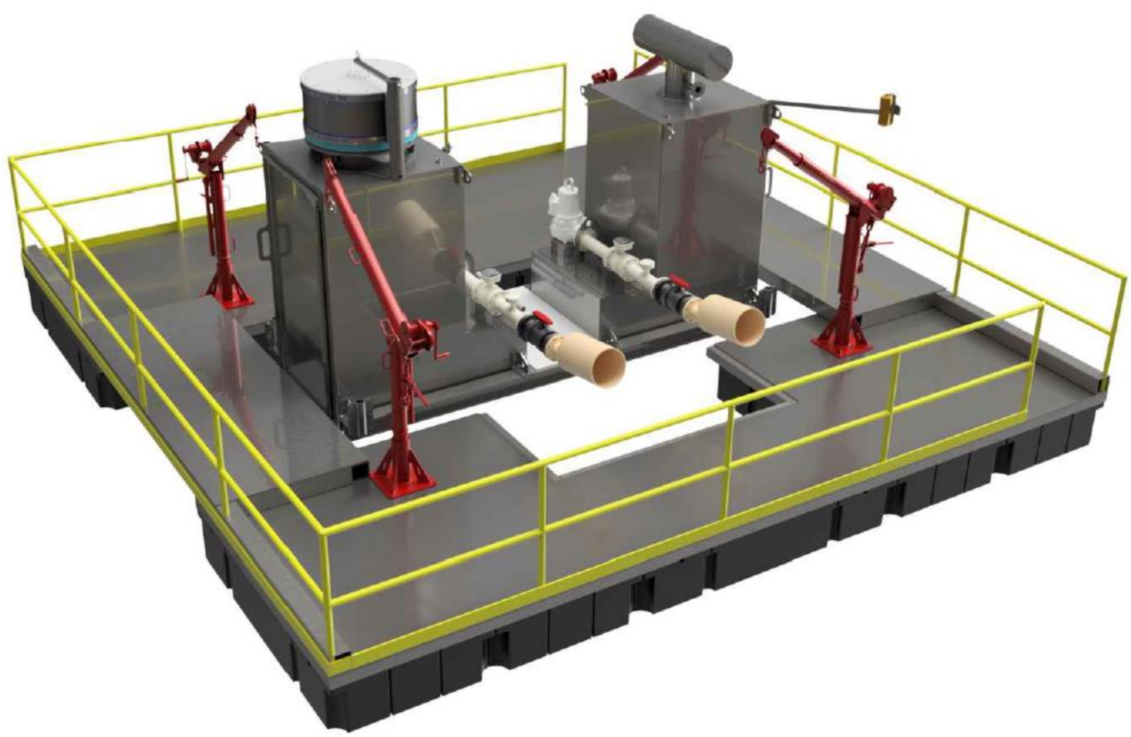

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Table of Contents

1. Introduction **7**

2. Report Organization **7**

3. Pilot Project Components **8**

3.1. WWS Evaluation 8

3.1.1 Design 8

3.1.2 Operation 14

3.1.3 Measures of Screen Performance 16

3.2. Plankton Exclusion Study 18

3.3. Coupon Coating Study 19

4. Maintenance **20**

5. Results **23**

5.1. Q1 (December 7, 2020 – March 15, 2021) 30

5.2. Q2 (March 16, 2021 – August 12, 2021) 35

5.3. Q3 (August 13, 2021 – November 17, 2021) 40

5.4. Q4 (November 18, 2021 – February 9, 2022) 44

6. Discussion **47**

6.1. Free Floating Debris and Biofouling 47

6.1.1 Materials 48

6.1.2 Coatings 48

6.1.3 Cleaning Methods 49

7. Conclusions **50**

Appendix A **51**

Appendix B **63**

Appendix C **76**

Appendix D **80**

Appendix E **89**

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List of Figures

Figure 1. Generalized site plan for the WWS Pilot Project showing the offshore and onshore components; inset is a photo of the boom and warning buoys installed to mark the stand-off zone around the submerged skid. 8

Figure 2. Final design of the WWS Pilot Project test skid. 9

Figure 3. Wedgewire screen Pilot Project test skid. 10

Figure 4. View of passive wedgewire screen during an airburst (top) and active wedgewire screen (bottom) from submersible, self-cleaning camera during Q1. 11

Figure 5. Pilot-scale 1-mm passive wedgewire screen from Aqseptence (left) and pilot-scale 1-mm active wedgewire screen from Intake Screens, Inc. (right). 12

Figure 6. Portable control room onsite near the existing intake for the Carlsbad Desalination Plant (left) and a view inside the PCR (right). 13

Figure 7. Example screen of the human-machine interface of the programmable logic controller. 13

Figure 8. Installation of the 900-ft long umbilical for the wedgewire screen Pilot Project. Skid can be seen floating offshore in Lagoon while umbilical is paid out; shore end of umbilical was connected to the portable control room after full extent had been paid out. 14

Figure 9. Distribution of head loss through a passive WWS designed for a through-slot velocity of 0.5 ft/sec. 18

Figure 10. Plankton sampling gear. Clockwise from left: ambient sample collection gear (intake cone, flexible hose, trash pump, and plankton net), ambient sample collection gear in field, ambient sample discharge into plankton net, cod end of plankton net attached to discharge from a WWS, mouth of plankton net hose-clamped to discharge from a WWS. 19

Figure 11. PVC frame for deploying coupons (left), coupons prior to deployment (top right), and coupons after two weeks of immersion (bottom right). 20

Figure 12. Principal unplanned offline periods for the wedgewire Pilot Project based on pump amperage (on/off). 24

Figure 13. Unplanned offline period (associated with the skid becoming partially un-anchored) based on differential pressure. Note the passive WWS decrease in pressure (i.e., increase in differential pressure) between mid-April and mid-June, 2021. At the time the skid becomes partially un-anchored (gray box), the active and passive pressure transducers shift depth as well – captured as the change in pressures (relative to ambient) during the offline period. 24

Figure 14. Cumulative depth (inches) change by month through May 20 dive survey (Q1 and most of Q2). Change is relative to the red lines in the charts which indicate the starting depth of sediment (Dec 9, 2020): above the red line was assumed to be sedimentation; below the red line was assumed to be scour. 27

Figure 15. Differential pressure through passive wedgewire screening assembly during Q1. 31

Figure 16. Effectiveness of cleaning method for controlling DP in pilot-scale passive wedgewire intake screening assembly. Data show a four-day period (December 29, 2020 – January 2, 2021) during which a suspected clogging event occurred. 31

Figure 17. Photos of the passive WWS before and after external cleaning by divers during months 1 (January 2021 dive survey) and 2 (February 2021 dive survey) of Q1. Note that no photos are available from Month 3 due to poor visibility. 32

Figure 18. Differential pressure through active wedgewire screening assembly during Q1. 33

Figure 19. Effectiveness of cleaning method for controlling DP in pilot-scale active wedgewire intake screening assembly. Data show a four-day period (December 29, 2020 – January 2, 2021) during which a suspected clogging event occurred. 33

Figure 20. Photos of the active WWS during months 1 (January 2021 dive survey) and 2 (February 2021 dive survey) of Q1. Note that no photos are available from Month 3 due to poor visibility. 34

Figure 21. Differential pressure through passive wedgewire screening assembly during Q2. 36

Figure 22. Photos of the passive WWS before and after external cleaning by divers during months 4 (April 2021 dive survey) and 5 (May 2021 dive survey) of Q2. 37

Figure 23. Photo of biofouling inside of passive WWS after month 6 of operation (June 2021 dive survey) – endcap removed. 37

Figure 24. Differential pressure through active wedgewire screening assembly during Q2. Note Y axis scale extends to 4 psi for comparison with the passive wedgewire screening assembly. 38

Figure 25. Photos of the passive WWS during months 4 (April 2021 dive survey) and 5 (May 2021 dive survey) of Q2. 39

Figure 26. Photos of the passive WWS before and after external and internal cleaning by divers during months 7 (September 2021 dive survey), 8 (October 2021 dive survey), and 9 (November 2021 dive survey) of Q3. 41

Figure 27. Differential pressure through active wedgewire screening assembly during Q3. Note Y axis scale extends to 4 psi. 42

Figure 28. Differential pressure through active wedgewire screening assembly during Q3. Note Y axis scale has been reduced substantially to illustrate a trend of increasing (albeit small) DP. 43

Figure 29. Photos of the active WWS during months 7 (September 2021 dive survey), 8 (October 2021 dive survey), and 9 (November 2021 dive survey) of Q3 43

Figure 30. Differential pressure through passive wedgewire screening assembly during Q4. Data were limited to the period after the new passive pressure transducer was installed and functioning correctly. 44

Figure 31. Photos of the passive WWS before and after external and internal cleaning by divers during months 10 (December 2021 dive survey), 11 (January 2022 dive survey), and 12 (February 2022 dive survey) of Q4. 45

Figure 32. Differential pressure through active wedgewire screening assembly during Q4. 46

Figure 33. Photos of the active WWS divers during months 10 (December 2021 dive survey), 11 (January 2022 dive survey), and 12 (February 2022 dive survey) of Q4. 46

Figure 34. Heavy macrofouling growth in the discharge diffuser piping (diameter of 12 inches). 46

List of Tables

Table 1. Automated cleaning regimes for each wedgewire screen by project quarter. 15

Table 2. Dive survey dates by project quarter. 16

Table 3. Water quality at the reference (Ref) and discharge (Dis) monitoring stations by month. Values are means. 26

Table 4. Levelness of skid through May 20 dive survey. 28

Table 5. Distance between bottom of skid and lagoon floor during Q3 and Q4. 28

Table 6. Principal conclusions of the WWS Pilot Project. 50

1. Introduction

Poseidon Resources (Channelside) LP (Poseidon) conducted a temporary small-scale pilot project (Pilot Project) in the Agua Hedionda Lagoon – Outer Basin (Lagoon), for the Carlsbad Desalination Plant (CDP). The Pilot Project generated site-specific performance data for two types of wedgewire screens (WWS) in the seawater environment of the Lagoon.

The Pilot Project was conducted with actual cylindrical WWS which provide more comprehensive information than coupons or screen sections that have been used in other such pilot studies. In addition, the Pilot Project was conducted under active pumping conditions which more accurately reflects typical operating conditions that would exist in a full-scale intake system for the CDP. The study was designed as a side-by-side evaluation of a passive WWS with an airburst cleaning system and an active, rotating, brush-cleaned WWS. The study was designed to provide data on the capabilities of each WWS type to manage both free-floating debris and biofouling that may accumulate on the screening surfaces. The overall goal was to assess the operability of each screen type as the potential intake system for the full-scale, stand-alone CDP. The specific objectives included:

1. Determining the operability of an air-bursted 1-mm passive super-duplex stainless steel WWS and an actively rotated, brush-cleaned super-duplex stainless steel WWS during a period of one year and under operating conditions representative of the full-scale intake within the Lagoon. This is supported by data collection of key operating parameters coupled with monthly dive surveys for visual inspection and maintenance.
2. Refining the site-specific design parameters and operation and maintenance (O&M) requirements for each WWS and confirm the operation and maintenance (O&M) costs of WWS-based intake system.

2. Report Organization

This final report summarizes the results for the full operational period of the WWS Pilot Project (December 7, 2020 – February 9, 2022). The Pilot Project was deployed for a total of approximately 14 months (12 months in operation and approximately 2 months offline).

This Final Report includes:

- a description of the various project components in Chapter 3,
- a description of the principal maintenance items in Chapter 4,
- the results of the project in Chapter 5,
- a discussion of the results in Chapter 6, and
- conclusions in Chapter 7

3. Pilot Project Components

The WWS Pilot Project was originally designed to evaluate the in-situ performance of WWS. Over the course of the project, additional study components were added to evaluate the plankton exclusion potential of the screens (Appendix A) and to evaluate the effectiveness of non-toxic, foul-release coatings for minimizing biofouling on submerged components. A description of each Pilot Project component is given in the sections below, though the focus of this Final Report is on the WWS Pilot Project.

3.1. WWS Evaluation

3.1.1 Design

The Pilot Project was comprised of offshore and onshore components. Figure 1 provides a generalized site plan for the Pilot Project.

Figure 1. Generalized site plan for the WWS Pilot Project showing the offshore and onshore components; inset is a photo of the boom and warning buoys installed to mark the stand-off zone around the submerged skid.

The Pilot Project was skid-mounted and deployed at the location a full-scale WWS array would most likely be constructed (Figure 1). This location ensured that the pilot-scale WWS were exposed to similar debris loads and ambient sweeping currents as the full-scale WWS. The skid included two separate pump chambers from which submersible pumps drew intake flow.

The installation, commissioning, operation (including water quality monitoring in the Lagoon), and decommissioning were completed per the permits/approvals issued by the relevant authorities (City of Carlsbad, San Diego Regional Water Quality Control Board, California Coastal Commission, U.S. Army Corps of Engineers)

The Pilot Project was designed as a skid-mounted installation to eliminate the need for two intake pipelines and an onshore pump station (and their associated maintenance). The skid (approximately 14 feet long by 6 feet wide by 9 feet tall) was comprised of two separate pumping chambers. Submersible pumps (Flygt, 5 hp, 600 gallons per minute [gpm]) attached to the exterior of each pump chamber withdrew flow through each of the WWS at a through-slot velocity of 0.5 ft/sec or less. Withdrawn flow passed through each WWS and was discharged immediately back to the Lagoon via 4-inch diameter discharge pipes connected to the pump chambers. The 4-inch discharge pipes expanded into 12-inch diameter diffusers at the discharge point in order to minimize the discharge velocity. The Pilot Project test skid final design in Figure 2 and Figure 3 shows the assembled skid during factory acceptance testing.

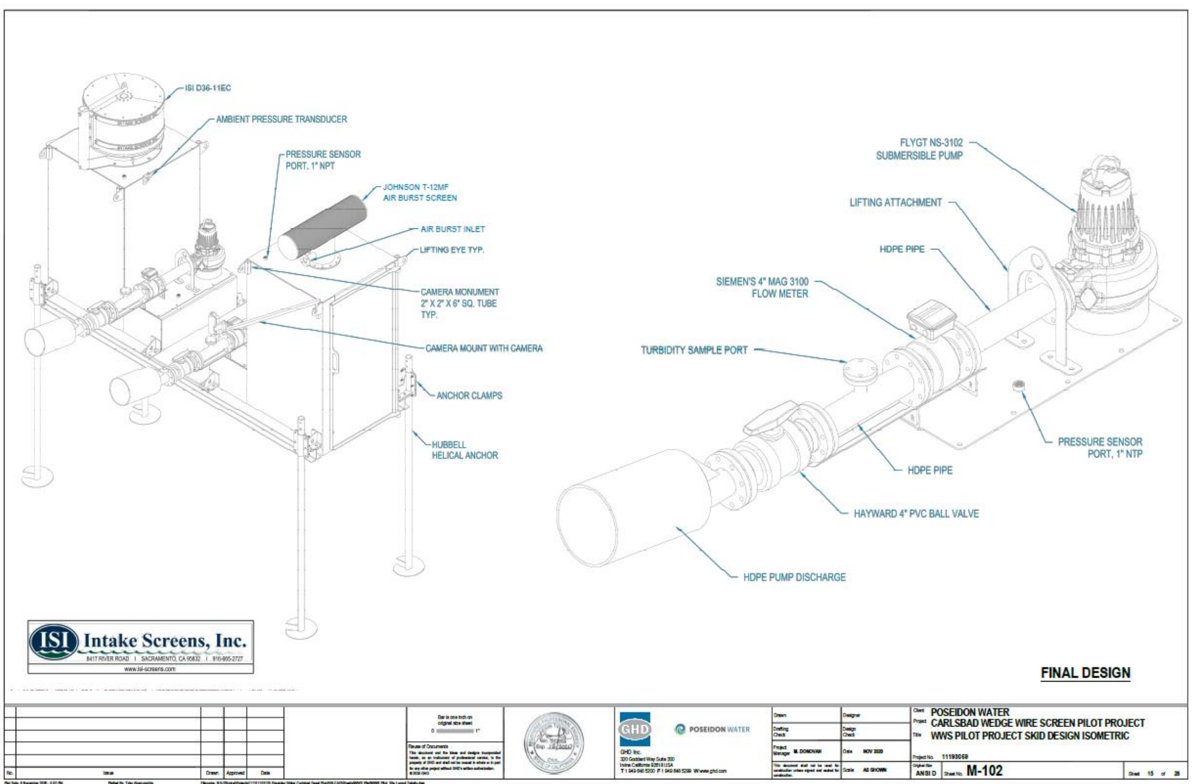


Figure 2. Final design of the WWS Pilot Project test skid.

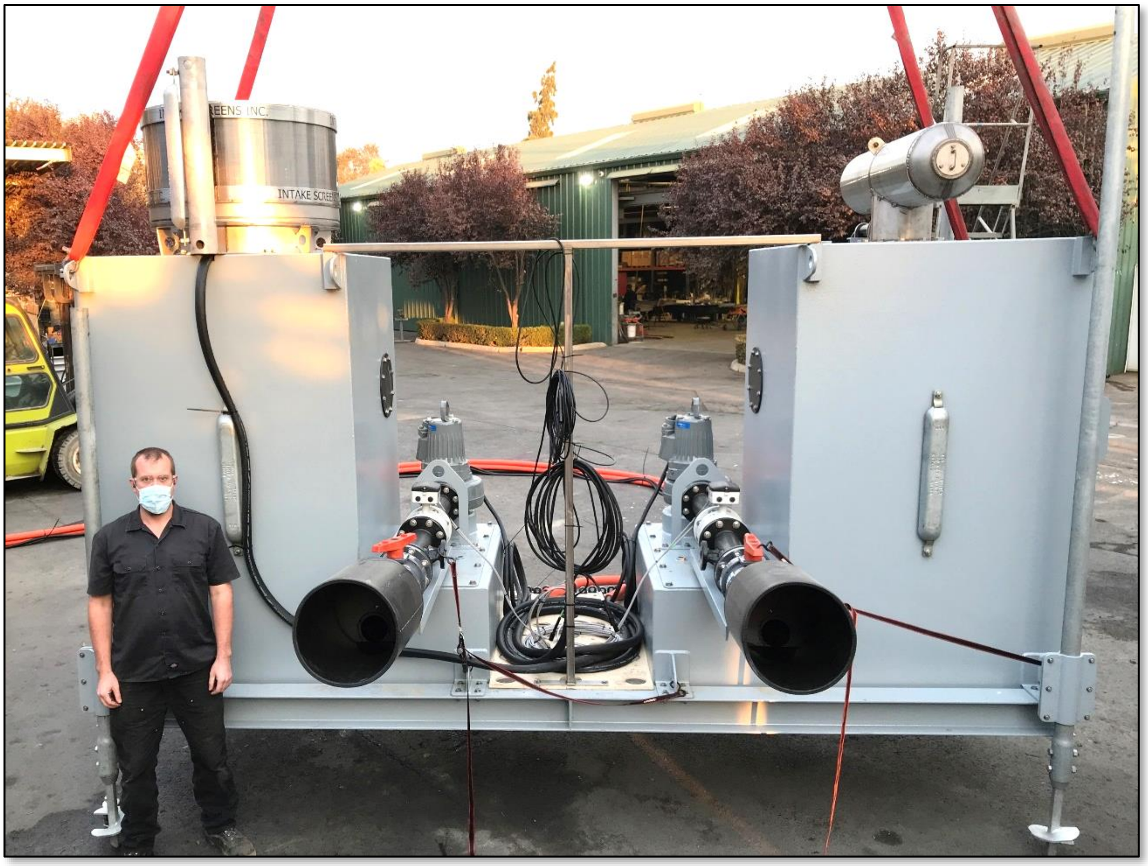


Figure 3. Wedgewire screen Pilot Project test skid.

The skid was equipped with instrumentation to allow remote monitoring of the operation status of the system. The submersible pumps were equipped to transmit a pump amperage signal which provided an indication of pump operation. Three pressure transducers were installed on the skid: one to collect ambient pressure (i.e., tidal stage) and one in each pumping chamber. The difference between ambient pressure and pressures within the pumping chambers gave a rough measure of differential pressure (DP) through each screening system. The discharge flow rates were monitored by submersible 4-inch magnetic flowmeters installed in each discharge pipe. All data were monitored continuously and logged to an onshore data acquisition system (DAS). Alarms were set to notify the operator by email of any operational anomalies.

During Q1 of operation, a submersible, self-cleaning vision system (ViewIntoTheBlue, Angler model) was in operation. The camera was mounted on the skid to allow real-time observation of screen conditions (Figure 4). The camera was capable of 180-degree rotation to allow viewing of both screens. It was powered from the PCR and transmitted a video signal to shore; real-time video was accessible via the internet.

Figure 4. View of passive wedgewire screen during an airburst (top) and active wedgewire screen (bottom) from submersible, self-cleaning camera during Q1.

The passive WWS was a horizontal T-shaped Max Flow screen supplied by Aqseptence (Figure 5, left). It was designed for a through-slot velocity of 0.5 ft/sec or less. It was 12.62 inches in diameter and 49.96 inches long overall (42.50-inch screening length) and fabricated of uncoated 2507 super duplex stainless steel. The passive WWS was equipped with an airburst system. The compressor and receiver for the airburst system were located onshore in the Portable Control Room (PCR) with 2-inch air piping delivering compressed air to the passive WWS offshore. The airbust system was initiated at a timed interval set via a Programmable Logic Controller (PLC) according to the cleaning regime being tested.

The active WWS was a vertical cylinder supplied by Intake Screens, Inc. (ISI) (Figure 5, right). It was designed for a through-slot velocity of 0.5 ft/sec or less. It was 36 inches in diameter and 20.875 inches tall overall (11.5-inch screening height) and fabricated of uncoated 2507 super duplex stainless steel. The active WWS included an automated self-cleaning system that was comprised of fixed external and internal brushes against which the screen drum was rotated at a timed interval set via a PLC according to the cleaning regime being tested.

Figure 5. Pilot-scale 1-mm passive wedgewire screen from Aqseptence (left) and pilot-scale 1-mm active wedgewire screen from Intake Screens, Inc. (right).

All onshore components were housed within the PCR, a modified shipping container (Figure 6). The PCR-based components include the airburst system (compressor, receiver, and control panel), turbidimeters and associated peristaltic pumps, flowmeter converter, master control panel (MCP), PLC with a human-machine interface (HMI, Figure 7), and DAS that allowed real-time monitoring of multiple data inputs.

Figure 6. Portable control room onsite near the existing intake for the Carlsbad Desalination Plant (left) and a view inside the PCR (right).

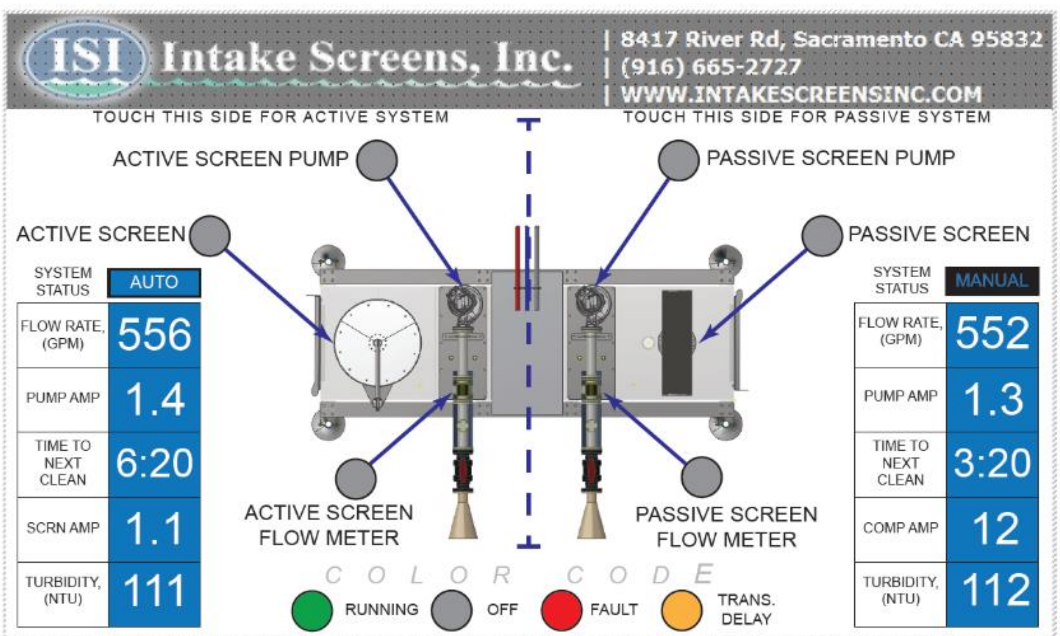


Figure 7. Example screen of the human-machine interface of the programmable logic controller.

An umbilical connected the offshore skid to the onshore PCR (Figure 8). The umbilical was approximately 900 feet long and contained the power cables for the skid-mounted submersible pumps, the 2-inch diameter airburst piping, turbidity sampling tubing, and signal cables. The umbilical was anchored to the Lagoon floor with concrete clump weights.

Figure 8. Installation of the 900-ft long umbilical for the wedgewire screen Pilot Project. Skid can be seen floating offshore in Lagoon while umbilical is paid out; shore end of umbilical was connected to the portable control room after full extent had been paid out.

In addition to the skid-connected instrumentation, additional data were collected to characterize the source water (Lagoon). An acoustic doppler current profiler (ADCP) was deployed near the skid to collect data on the magnitude and direction of ambient currents nearby. Monthly water quality monitoring was conducted (per the Clean Water Act Section 401 requirements) at two locations near the skid (a discharge station and a reference station) to assess any water quality changes associated with the discharge from the project.

3.1.2 Operation

The pilot-scale WWS was operated at the same through-slot velocity (0.5 ft/sec or less) as intended for the full-scale intake. The automated cleaning regime for each screen was adaptively managed based on observations on a quarterly basis. Initially, the screens were set to be cleaned based on vendor-recommended frequencies:

- The passive WWS was automatically airburst once/day
- The active WWS was automatically cleaned three times/day. Each cleaning event consisted of a one-minute rotation in each direction (i.e., a total of two minutes of rotation per cleaning event).

The automated WWS cleaning regimes were modified as needed during the course of the year-long study to ensure proper cleaning of the screens. Table 1 summarizes the cleaning regimes by quarter.

Table 1. Automated cleaning regimes for each wedgewire screen by project quarter.

Project Quarter	Dates	Passive WWS	Active WWS
Q1	12/07/2020 – 01/11/2021	1 airburst/day	3 rotations/day[1]
	01/12/2021 – 02/17/2021	4 airbursts/day	3 rotations/day[1]
	02/18/2021 – 03/15/2021	Based on flow rate and DP[2]	Based on flow rate and DP[2]
Q2	03/16/2021 – 08/12/2021[3]	4 airbursts/day	3 rotations/day
Q3	08/13/2021 – 11/17/2021	8 airbursts/day	3 rotations/day
Q4	11/18/2021 – 02/09/2022	8 airbursts/day[4]	3 rotations/day

[1] Duration of each rotation was two minutes (one minute in one direction and one minute in the other direction).
[2] Cleaning was initiated by either (a) flow rate ≤ 550 gpm for 15 seconds or (b) pressure differential pressure ≥ 1 psi for 15 seconds.
[3] Skid was offline 06/18/2021 through 08/12/2021.
[4] Passive WWS was also manually cleaned by divers internally and externally on a monthly basis.

In addition to the automated cleaning controlled by the PLC settings, dive surveys were also conducted on a monthly basis (

Table 2). The following tasks were completed during each dive survey:

- Skid inspection for sedimentation, scour, biofouling on skid components (other than screens), corrosion
- Screen inspection (internal and external surfaces)
- Clean external surface of passive WWS (internal surface cleaned during Q4 as well)
- Measure corrosion of WWS (gap width and wire thickness)
- Perform any skid maintenance required (e.g., replace sacrificial anodes)
- Inspect umbilical and concrete anchors (umbilical inspections were suspended in Q3 and Q4 due to time constraints)

Table 2. Dive survey dates by project quarter.

Quarter	Date	Purpose
Q1	12/09/20	Post-installation baseline survey
	01/12/21	Monthly survey #1
	02/18/21	Monthly survey #2
	03/16/21	Monthly survey #3
Q2	03/26/21	Maintenance - Pump anode replacement
	04/09/21, 04/12/21	Maintenance - Umbilical re-anchoring
	04/13/21	Monthly survey #4
	05/20/21	Monthly survey #5
	06/18/21	Monthly survey #6 and passive flowmeter removal
	08/09/21 - 08/12/21	Maintenance - Skid re-anchoring
	08/13/21	Post re-anchoring baseline survey
Q3	09/14/21	Monthly survey #7
	10/19/2021, 10/20/21	Monthly survey #8 and active flowmeter replacement
	11/18/21	Monthly survey #9
Q4	12/15/21	Monthly survey #10 and passive pressure transducer replacement
	01/18/22	Monthly survey #11
	02/09/22	Monthly survey #12

Continuous data from the skid were logged to the DAS and were also available in real-time. The DAS was connected to the PLC via an Edge Device which, in turn, collected the data points, provided alarm notifications, and included a full web-based graphical user interface (GUI). The Edge Device sent the data to the cloud for long-term storage and also stored data locally for up to one week as a backup in the case of a loss of communications with the server.

A virtual private network allowed remote control and monitoring of the screens, alarm notification responsibilities, and real-time and historical data viewing/plotting. Wireless communication from the MCP was via a dedicated cellular connection.

3.1.3 Measures of Screen Performance

Screen performance was assessed using both qualitative and quantitative data. Qualitative data collected for measuring screen performance included the following:

- **Visual observations –** photographs, video, and audio collected near the skid by divers during each monthly dive survey. Some indicative photographs and videos were also collected during Q1 with the submersible, self-cleaning camera. Diver

notes were also captured in monthly dive survey reports. Diver observations proved to be the best information with which to assess screen performance.
- **Cleaning frequency** – changes to cleaning frequency (as dictated by diver observation) were indicative of screen condition.

Quantitative data collected for measuring screen performance included the following:

- **Flow rate** – continuously measured per pump and recorded automatically by DAS. Flow rate data were not reliably collected over the majority of the Pilot Project (each flowmeter failed over the course of the study); therefore, flow rate data were less valuable in assessing screen performance.
- **Pump amperage –** continuously measured per pump and recorded automatically by DAS. Pump amperage data were a reliable indicator of pump operational status (on/off); however, they were not a reliable predictor of fouling on the screening systems.
- **Differential pressure** – measured in each pumping chamber and in the ambient Lagoon water and recorded automatically by DAS. DP data reliably measured the effect of biofouling in the screening assemblies and provided high resolution data. However, the DP measured by the pressure transducers does not represent solely the fouling on the screening surfaces. Instead, based on the location of the pressure transducers, the transducers are measuring head loss through the entire screening structure: from the screen surface, through the internal structures (e.g., flow distribution manifold), around all turns, and into the pump boxes. The locations where flow changes direction are typically where the greatest head losses occur (Figure 9). Note that the passive pressure transducer failed during the study (see Chapter 4).
- **Turbidity –** turbidity was monitored in real-time via instrumentation in the PCR. The intent was to monitor: 1) the effect of screen cleaning on turbidity of the withdrawn flow and 2) the turbidity of the source water at this offshore intake location. The velocity in the sample tubing was too low (and hence travel time of the sampled flow to high) to reliably measure turbidity for either purpose. In addition, turbidity data near the skid were also collected monthly with a handheld multimeter deployed from the Dive Support vessel.   Data logging sondes were also subsequently deployed to better measure turbidity in the Lagoon (data not reported here as part of the WWS Pilot Project).
- **Ambient currents** – an ADCP was deployed to collect data on the magnitude and direction of ambient currents near the Pilot Project. The intent was to monitor any correlation between episodic screen occlusion events and the ambient hydrodynamic conditions in the Lagoon at the time. As the greatest risk to screen performance was shown to be biofouling on the screening surface, the ambient current data were not

good predictors of screen performance. A technical memorandum summarizing the ADCP data is provided in Appendix B.

- **Corrosion** – Divers conducted monthly spot checks of wedgewire slot width and wire thickness using a feeler gauge and calipers, respectively. These inspections did not provide any reliable indication that the screen wires (2507 super duplex stainless steel) were corroding over the course of the study.
- **Underwater and above water noise** – a hydrophone and a microphone were deployed near the operational skid to characterize noise levels (ambient and screen-generated) both underwater and above the water surface. Acoustic data were collected with the equipment (pumps and screen cleaning mechanisms) both on and off. Acoustic survey results are provided in Appendix C.

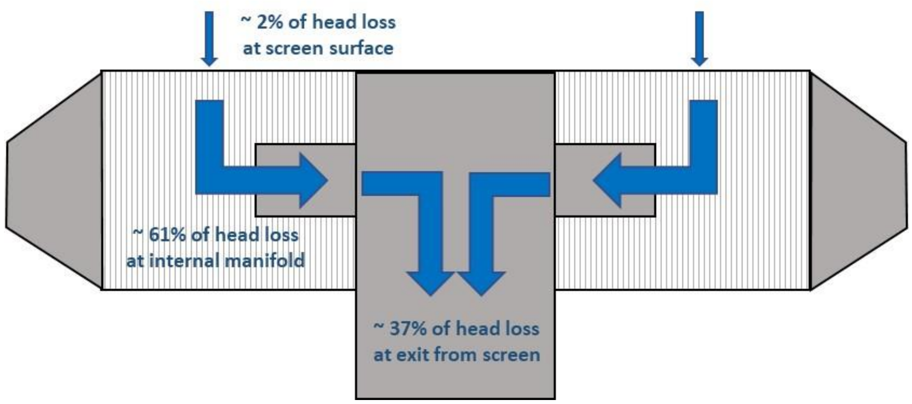


Figure 9. Distribution of head loss through a passive WWS designed for a through-slot velocity of 0.5 ft/sec.

3.2. Plankton Exclusion Study

A plankton exclusion study was not part of the original study but was added per the request of California Department of Water Resources. The study was conducted to quantify the biological efficacy of 1-mm WWS for excluding marine organisms from entrainment. Samples were collected concurrently from both screens and the ambient source water to compare entrainment densities.

All plankton nets were fabricated of 335-µm mesh. Nets were attached to the discharge ports of the active and passive WWS (Figure 10). For ambient samples, a custom-fabricated intake cone was attached to flexible hose and drew ambient source water from the same depth as the screens via a portable trash pump. As with samples from the WWS, the ambient samples were also collected through a 335-µm plankton net at the water’s surface. By sampling concurrently, temporal differences were minimized.

Sampling events were conducted on September 30, October 21, and November 5, 2021. To ensure diver safety, samples were only collected during daylight hours. The target sample volume was 50 m^3. After fixation in the field with formalin, samples were transported to a laboratory, and transferred into ethanol. Samples were then sorted, identified to the lowest practicable taxonomic level, and measured. Additional details and results are provided in the Plankton Study Report (Appendix A).

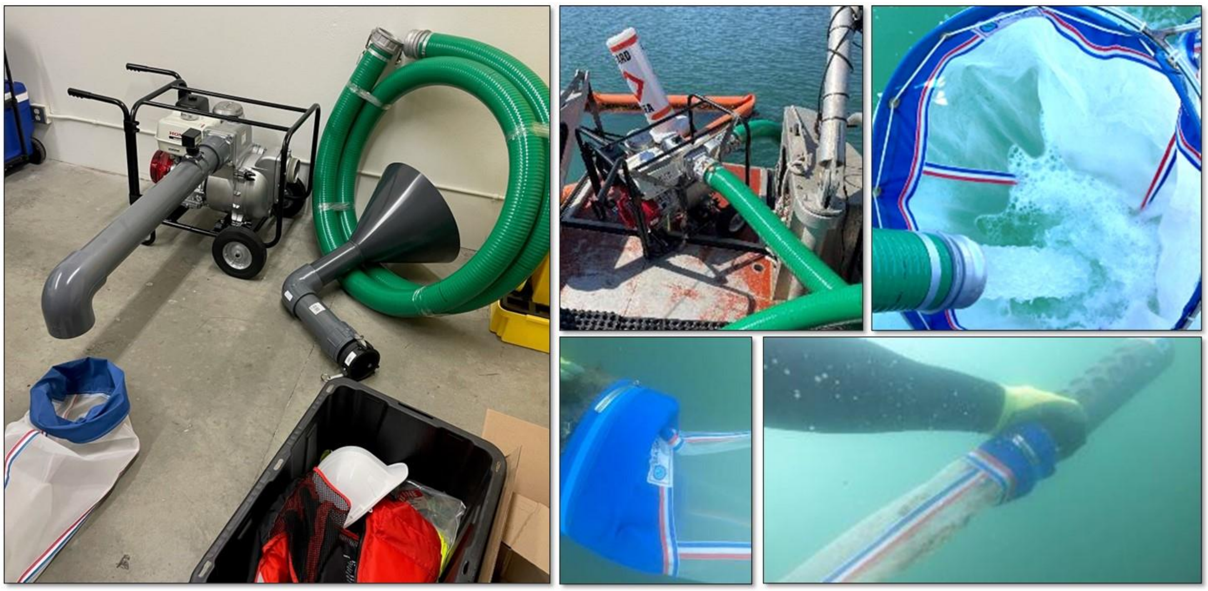


Figure 10. Plankton sampling gear. Clockwise from left: ambient sample collection gear (intake cone, flexible hose, trash pump, and plankton net), ambient sample collection gear in field, ambient sample discharge into plankton net, cod end of plankton net attached to discharge from a WWS, mouth of plankton net hose-clamped to discharge from a WWS.

3.3. Coupon Coating Study

A coupon coating study was not part of the original scope but was added after the Pilot Project began. After internal and external inspection of the WWS at the end of Q2, the project team decided to add an evaluation of coupons painted with non-toxic, foul-release coatings to control biofouling. At full-scale, such coatings may reduce biofouling accumulation on internal screen components that would be labor-intensive to clean manually.

The coupon study is evaluating two non-toxic, foul-release coatings relative to an uncoated coupon. A total of six, 6.5-in diameter coupons were prepared using 2507 super duplex stainless steel. Two coupons were coated with Hempel X3+, two were coated with Intersleek 1100SR, and two were passivated but uncoated. All of the coupons were installed in a PVC frame and deployed near the existing CDP intake structure (Figure 11).

The coupons are retrieved every other week for observation and photographs. During each retrieval, the intake velocity is measured at one-foot increments. Photographs are processed through image analysis software to determine the percent fouling.

The coupons were deployed on December 7, 2021 and the study is ongoing through December 6, 2022.

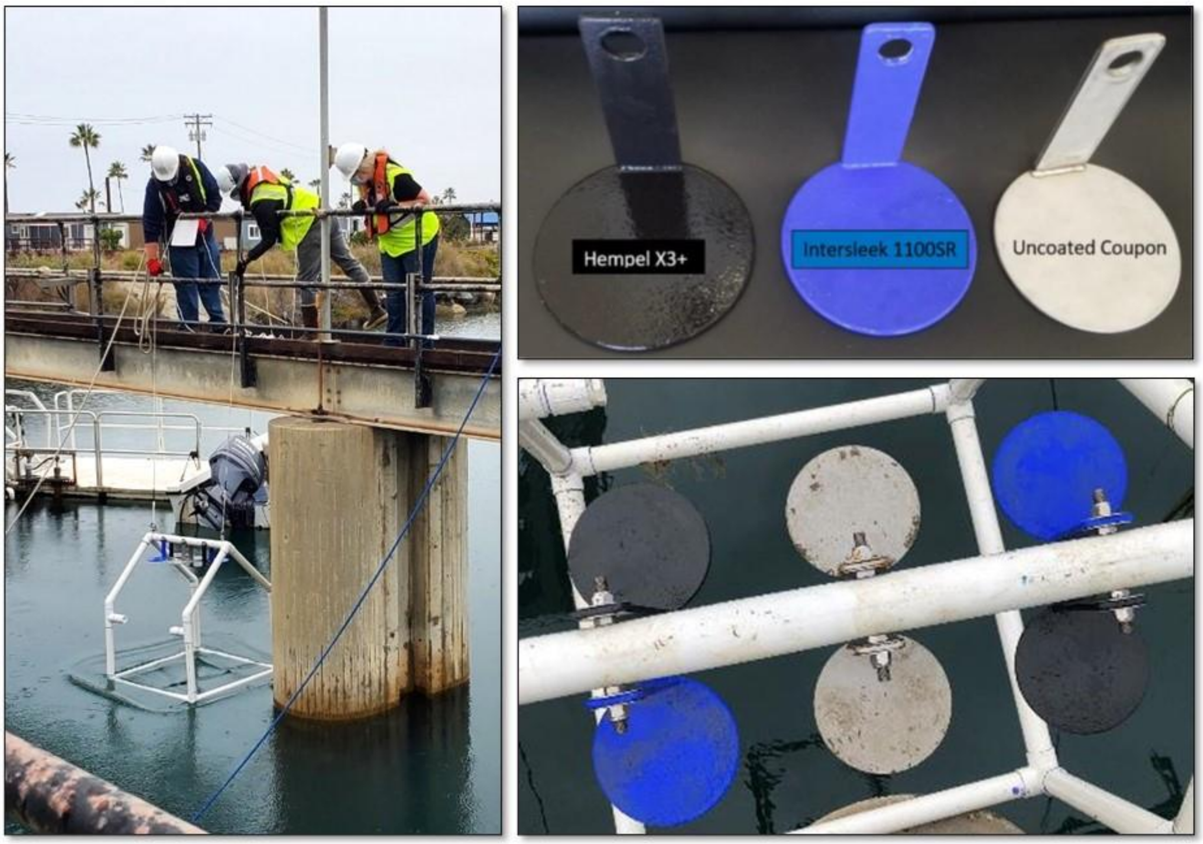


Figure 11. PVC frame for deploying coupons (left), coupons prior to deployment (top right), and coupons after two weeks of immersion (bottom right).

4. Maintenance

The Pilot Project experienced both routine and unplanned maintenance over the course of operation. Planned maintenance included:

December 7, 2020 – February 9, 2022

- Weekly – PCR visits were conducted weekly to inspect equipment for leaks, check cable connections, empty condensation pan from airburst system, inspect turbidimeter discharge lines (flowrate was measured from Q2 on), backflush turbidimeter sample lines, and other occasion maintenance tasks as needed

- Monthly – Dive surveys were conducted monthly to observe screen conditions; however, they also provided an opportunity to complete routine maintenance such as sacrificial anode replacement, instrument replacement, biofouling removal from non-screening surfaces (e.g., pressure transducers), and reconnecting concrete anchors to umbilical as needed.

Unplanned maintenance was required for a number of system components. The principal unplanned maintenance efforts are described below in chronological order.

Q1 (December 7, 2020 – March 15, 2021)

- Sacrificial anodes on the submerged pumps were being consumed at an accelerated rate. A new cathodic protection plan was developed and implemented for the submerged pumps. The anodes provided by the manufacturer were replaced with larger, custom fabricated anodes on March 26, 2021 to provide an extended period of protection to the pumps.
- The turbidity monitoring system experienced periods during which data were unreliable. Troubleshooting involved adjusting the variable frequency drives (VFDs) for the onshore peristaltic sample pumps, replacing the piping connections between the sample tubing and peristaltic pumps, continuing to backflush the sample tubing (per the Standard Operating Procedures [SOPs]), adding steps to the SOPs to measure flow rate and clean the optical chambers of the turbidimeters, reviewing the sample tubing pressure rating, and coordinating pump operability and design characteristics with the peristaltic pump vendor.
- The passive screen flowmeter experienced a failure. Troubleshooting included consultation with the meter manufacturer, inspection by divers for physical damage to meter and/or cable connections, review of error codes in the transmitter head in the PCR. The passive pump could not be brought online (though airbursting continued) between March 19, 2021 and May 3, 2021 due to an automatic low-flow alarm that continually shut the pump down. The alarm was disabled and the passive pump was placed back into service on May 3. The passive flowmeter was removed on June 18, 2021 and replaced with an HDPE spool piece until a new flowmeter was available.

Q2 (March 16, 2021 – August 12, 2021)

- Approximately 50 feet of the umbilical closest to shore floated to the surface on April 3 with an additional approximately 150-foot portion of the umbilical floating to the surface on April 5. Out of an abundance of caution, the skid components were locked-out-tagged-out (LOTO) between April 5 and 13, 2021. Divers were mobilized on April 9 and 12, 2021 to re-anchor the floating section of umbilical. Divers re-anchored the umbilical using additional concrete clump weights with polypropylene rope in lieu of large cable ties.

- Visibility from the submersible, self-cleaning camera deteriorated during Q2 until the video feed was completely lost on May 27, 2021. Troubleshooting included coordination with the manufacturer and diver inspection for loose connections/kinked cabling. During the August 12, 2021 dive survey, the camera was removed for inspection and divers noted intrusion of water into the camera housing and accumulated biofouling due to ineffective action of self-cleaning brush.
- At some point during Q2, the active flowmeter developed a 1/16-inch corrosion hole in the body of the meter. Flow rate data appeared unaffected.
- The skid became partially un-anchored from the Lagoon floor and tipped with its passive side moving up toward the surface and the active side moving down toward the Lagoon floor. DP data indicate that it happened on June 14, 2021. Since the dive survey was not conducted until June 18, 2021, the skid was in operation for approximately four days while partially un-anchored. Out of an abundance of caution, the skid components were LOTO'd until divers and surface support personnel righted, repaired, and re-anchored the skid during a four-day period between August 9 to 12, 2021. All skid surfaces including both WWS were cleaned of all fouling prior to re-commissioning the Pilot Project system on August 12, 2021 (see Appendix D for additional detail on the skid tipping and re-anchoring effort). A post-re-anchoring baseline survey was conducted on August 13, 2021 as a starting point for subsequent monthly surveys. Analysis of the data and sequence of events leading to the skid becoming partially un-anchored indicate that during the approximately two and a half-week period during Q1 when the passive WWS was not airburst (PLC was programmed to trigger cleaning only when a low flow rate or high DP occurred; see Table 1), hard macrofouling organisms likely settled on the internal surfaces of the screen, particularly the internal flow distribution manifold. Due to approximately two and half weeks of no airbursting, the settled organisms had attached strongly enough to resist any dislodging forces created by the airburst and eventually grew to foul the majority of the internal surfaces. After experimenting with cleaning regimes and frequencies during the three phases of Q1, a timed sequence (i.e., a certain number of cleaning cycles per day) was identified as the best method to ensure stable operation. For a full-scale installation, a timed airburst frequency would be recommended at a minimum before considering additional cleaning strategies (i.e., triggering airburst cleaning based on flow rate or differential pressure).

Q3 (August 13, 2021 – November 17, 2021)

- The passive pressure transducer failed on August 8, 2021, triggering multiple alarms. The failure caused it to send excessive current to the PLC input card, which then shut down to protect itself. Since multiple signals are directed to that one input card, multiple alarms were triggered. The signal wires from the passive pressure transducer were physically disconnected at the MCP to restore functionality to the other components. A new passive pressure transducer was ordered, but not received for installation until Q4.

- The damaged active flowmeter was replaced and operational on October 20, 2021.

Q4 (November 18, 2021 – February 9, 2022)

- A new anode bracket was installed on November 18 to provide cathodic protection to the new active flowmeter.
- The passive pressure transducer was replaced on December 15, 2021.
- The external brush on the active WWS was adjusted to be in closer contact with the screening surface on December 15, 2021.

5. Results

The WWS Pilot Project was commissioned on December 7, 2020 and was decommissioned on February 9, 2022. Of these approximately 14 months, the Pilot Project was in operation for 12 months; it was offline for two months.

During the 12 months of operation, the submersible pumps were set at approximately 600 gpm and the screen cleaning mechanisms were set as described in Table 1. The system was taken offline weekly for planned maintenance (15 to 20-minute per week) so that the turbidity sample lines could be backflushed. The system was also taken offline monthly to conduct the planned dive surveys (six to eight-hours per month) during which all skid components were LOTO for diver safety. Additional unplanned offline periods for maintenance are described in Chapter 4 (e.g., anode replacement, umbilical anchoring, skid tipping, flowmeter replacement); the major unplanned offline periods are shown in Figure 12 and Figure 13.

ADCP data are provided in Appendix B.

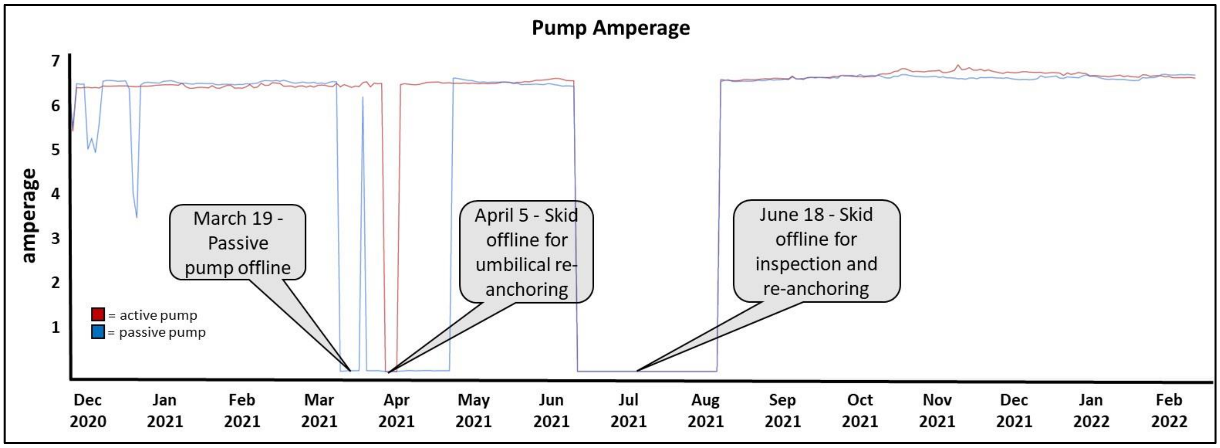


Figure 12. Principal unplanned offline periods for the wedgewire Pilot Project based on pump amperage (on/off).

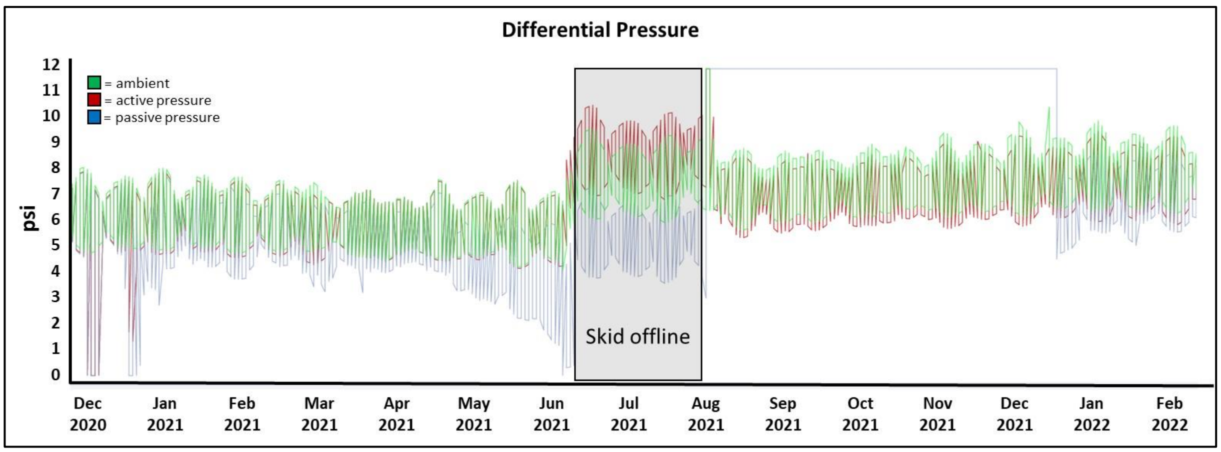


Figure 13. Unplanned offline period (associated with the skid becoming partially un-anchored) based on differential pressure. Note the passive WWS decrease in pressure (i.e., increase in differential pressure) between mid-April and mid-June 2021. At the time the skid becomes partially un-anchored (gray box), the active and passive pressure transducers shift depth as well – captured as the change in pressures (relative to ambient) during the offline period.

Table 3 provides a summary of monthly water quality monitoring data as well as additional data collected opportunistically while in the Lagoon. The data do not indicate any effect of the Pilot Project on the ambient water quality in the Lagoon. The data do indicate that the location of the Pilot Project in the Lagoon is exposed to seasonal algal blooms (e.g., November 2021 data).

Monthly diver inspections did not provide any reliable indication that the screen wires (2507 super duplex stainless steel) were corroding over the course of the study. During every monthly dive survey, divers noted that both the passive and active WWS were in good structural condition with no signs of wear, corrosion, or damage inside or out.

Divers monitored monthly for sedimentation and scour around the skid at eight stations. Data were collected using the skid as a reference – if scour had occurred, it would manifest as an increase in depth relative to the skid; if sedimentation had occurred, it would manifest as a decrease in depth relative to the skid. In addition, divers monitored the skid for levelness which is an absolute check of the skid position.

Sedimentation and scour data from Q1 and Q2 were valuable in documenting the partial un-anchoring of the skid during Q2 when scour appeared to be increasing each month (Figure 14). However, inspection of the passive WWS after the skid became partially un-anchored on June 14 revealed heavy internal biofouling that likely prevented the airburst air from escaping the screen. The lift created by trapped air inside the passive WWS likely caused helical anchors to pull out of the Lagoon floor. Skid levelness measurements support this conclusion with data indicating a slope downward to the east which would have resulted from the west side slowly lifting (Table 4).

Assessment of sedimentation and scour was simplified in Q3 and Q4 by tracking the distance between the bottom of the skid and the Lagoon floor on the east and west side. A trend of scour occurred during Q3 and a trend of sedimentation during Q4 (Table 5). Regardless, diver observations indicated that the skid was remaining level (less than 1 inch of vertical variation over a four-foot length) through Q3 and Q4.

An acoustic survey was conducted on May 21, 2021 to evaluate the sound generated by each screen's cleaning system (both with and without the skid pumps running). Sound was measured both above and below the water for each screen. The active and passive WWS generated an additional 1 to 7 decibels (dBZ) and 1.5 to 3 dBZ, respectively, of underwater sound relative to background/ambient noise (117-118 dBZ). The skid pumps themselves contributed 8 to 10 dBZ of underwater sound relative to background, though the full-scale intake for the CDP will not include submersible pumps in the Lagoon. Neither the active nor passive WWS cleaning technologies affected airborne sound levels which were dominated by vehicular traffic. Additional detail on the acoustic survey is provided in Appendix C.

Table 3. Water quality at the reference (Ref) and discharge (Dis) monitoring stations by month. Values are means.

	Temp (F)		Salinity (ppt)		Turbidity (NTU)		DO (mg/L)		pH		Chl-A (ug/L)	
Date	Ref	Dis	Ref	Dis	Ref	Dis	Ref	Dis	Ref	Dis	Ref	Dis
12/09/2020	58.27	58.92	33.58	33.6	10.95	14.66	8.33	8.33	8.23	8.26	1.07	0.98
01/12/2021	56.87	56.9	34.06	34.07	4.06	4.77	8.35	8.63	8.05	8.08	2.62	2.36
02/18/2021	58.27[1]	58.06	33.77[1]	33.91	5.75[1]	4.04	7.91[1]	8.43	8.04[1]	8.08	1.64[1]	2.46
03/16/2021	57.55	57.56	33.37	33.46	6.65	7.08	8.50	8.26	8.04	8.06	5.20	5.04
04/13/2021	64.43	64.83	34.21	34.16	2.04	0.69	8.23	7.82	8.18	8.18	4.40	5.09
05/11/2021	67.15	67.1	35.02	35.01	NA[2]	NA[2]	8.12	8.13	8.21	8.18	3.42	2.73
05/20/2021	66.18	66.24	34.58	34.57	6.46	12.56	7.77	7.65	8.17	8.18	3.30	3.60
06/28/2021	68.19	68.15	34.39	34.57	1.50	1.02	8.31	8.11	8.13	8.15	2.22	1.78
07/13/2021	74.23	74.18	27.97	27.83	1.91	4.59	8.43	8.75	8.16	8.22	4.44	2.97
08/13/2021	68.70	68.02	34.64	34.62	NA[2]	NA[2]	7.92	8.02	8.10	8.11	2.34	1.96
09/14/2021	64.85	64.46	32.06	32.06	1.30	1.54	7.75	7.83	8.14	8.14	2.09	2.09
10/21/2021	64.51	64.4	32.12	32.11	1.67	1.33	7.89	7.98	8.15	8.15	0.85	1.44
11/05/2021	61.43	61.35	34.72	34.71	1.35	1.23	7.71	8.07	8.14	8.18	21.17[3]	18.21[3]
11/17/2021	61.66	NA[4]	33.7	NA[4]	0.91	NA[4]	7.95	NA[4]	8.17	NA[4]	2.04	NA[4]
11/19/2021	62.20	62.36	33.66	33.64	1.33	2.35	8.66	8.30	8.25	8.25	6.62	6.19
12/15/2021	58.21	58.15	32.71	32.78	3.33	3.50	8.45	8.28	8.15	8.14	1.67	1.56
01/20/2022	59.14	59.19	33.49	31.82	-0.21[5]	0.22	8.00	8.04	8.15	8.16	0.26	1.58
02/11/2022	58.57	58.57	33.79	33.9	-0.71[5]	0.14	8.38	8.15	8.33	8.34	1.14	1.29

[1] An alternate reference station was used to avoid maintenance dredging near the Lagoon inlet.

[2] Anomalous data were omitted due to meter malfunction

[3] Measurements taken during an algal bloom (HAB)

[4] Sampling boat mechanical issues; discharge station data not collected

[5] Values are not accurate; turbidity meter was not measuring properly

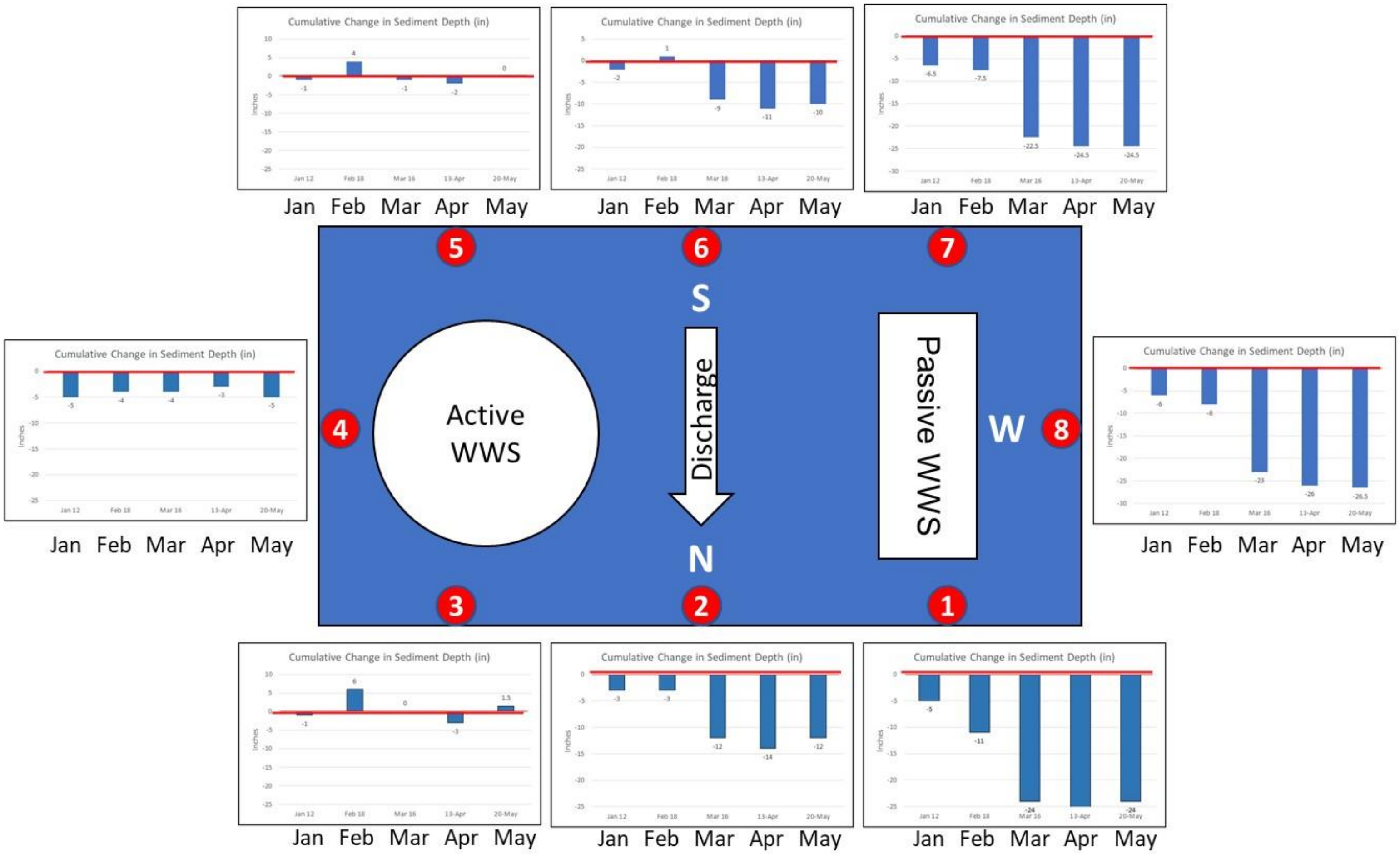


Figure 14. Cumulative depth (inches) change by month through May 20 dive survey (Q1 and most of Q2). Change is relative to the red lines in the charts which indicate the starting depth of sediment (Dec 9, 2020): above the red line was assumed to be sedimentation; below the red line was assumed to be scour.

Table 4. Levelness of skid through May 20 dive survey.

Survey date	North side slope to the east (measured in inches over a 4 ft length)	East side slope to the south (measured in inches over a 4 ft length)
12/09/20 (installation)	0.5 in	0
01/12/2021	0.5 in	0
02/18/2021	1.5 in	0.25 in
03/16/2021	1.5 in	1 in
04/15/2021	6 in	1 in
05/20/2021	6 in	1 in

Table 5. Distance between bottom of skid and lagoon floor during Q3 and Q4.

Survey date	West side height (inches) above the Lagoon floor	East side height (inches) above the Lagoon floor
08/13/2022 (re-anchored)	6-8	12-17
09/14/2022	6-8	12-17
10/19/2022	12-13	14-17
11/18/2022	7-14	9-16
12/15/2021	7-16	9-16
01/18/2022	12	14
02/09/2022	10	12

Qualitative observations during the dive surveys revealed the following general trends over the course of the 12 months of operation. Appendix E provides a month-by-month summary of the diver observations with indicative photographs.

Passive WWS

- External biofouling accumulated to 100% coverage in 6 out of the 12 months of operation, but was never less than approximately 60-70%.
- Exterior biofouling was soft growth (algae and some sediment) and was easily removed manually by divers.
- The airburst system was effective for free-floating debris, but not effective in controlling external biofouling accumulation.
- Internal biofouling accumulated over the first six months as a result of the internal surfaces not being manually cleaned each month. Soft growth progressed to hard growth (predominantly blue mussels) during that period. Periods of no airbursting

(Table 1) and no pumping due to maintenance issues likely exacerbated the accumulation of hard macrofouling organisms inside the WWS.

- The airburst system alone was not effective in controlling internal biofouling accumulation.
- Monthly internal cleaning was implemented for the final six months of operation and hard growth was better controlled.

Active WWS

- External biofouling was well-controlled by the mechanical brush-cleaning system. There was no substantial accumulation over the 12 months of operation.
- Some small areas of light streaking developed during the final four months of operation. The external brush required adjustment to ensure contact between the brush and screen face was maintained.
- Internal biofouling of the screen surface (which is brushed) was light at the 6-month inspection point

Quantitative data were limited due to the instrumentation maintenance issues summarized in Chapter 4. As noted, however, DP data was the best corollary for intake assembly cleanliness (and conversely, the degree to which the intake assembly is biofouled). The DP through each screen assembly is a result of both the hydraulic design (i.e., a product of the screen's internal geometry and the flow's path) and the magnitude of biofouling. For these reasons, despite the fact that DP does not represent solely the fouling on the screening surfaces, it remains the best measure of performance of each screening assembly.

More detailed results are presented below by quarter.

5.1. Q1 (December 7, 2020 – March 15, 2021)

Passive WWS

During the first month of operation, passive DP increased over time (Figure 15) indicating the presence of biofouling accumulation in the passive WWS assembly that was not mitigated by the airburst system operating at one airburst per day. In addition, there were a few incidents of increased DP which may indicate that a clogging event (free-floating debris, not biofouling) was taking place. Figure 16 illustrates how DP recovered in the passive WWS after a suspected clogging event during Q1. Though the passive WWS recovered, the recovery did not last long at the airburst frequency of once per day. During the dive survey at the end of the first month, divers indicated that the biofouling that had accumulated on 100% of the passive WWS external surface (Figure 17), though the material was soft and loosely attached. No hard macrofouling organisms were present on the exterior of the WWS. Removing the biofouling required very little effort; essentially a gloved hand was sufficient to sweep all external fouling off of the screen face. Divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions.

During the second month of operation, the passive WWS cleaning frequency was increased to four airbursts per day which appeared to improve performance (more gradual increase in DP) (Figure 15). Divers noted at the end of the second month that the passive WWS condition was the same – biofouled on 100% of the external screening surface with soft growth that was loosely attached (Figure 17). No hard macrofouling organisms were present on the exterior of the WWS. Removing the biofouling required very little effort; essentially a gloved hand was sufficient to sweep all external fouling off of the screen face. Divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions.

During the third month of operation, the passive WWS cleaning was programmed to initiate airbursts based on low flow rate or high DP (Table 1). This cleaning regime resulted in faster increase in DP, since none of the threshold triggers were reached to initiate an airburst for approximately two and half weeks. This allowed biofouling to accumulate unimpeded on the external screening surface. Biofouling also became established on the internal screening surface as would be evidenced in subsequent observations. Divers noted no difference in the external appearance of the passive WWS – biofouled on 100% of the external screening surface with soft growth that was loosely attached. No hard macrofouling organisms were present on the exterior of the WWS. Removing the biofouling required very little effort; essentially a gloved hand was sufficient to sweep all external fouling off of the screen face. Divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions.

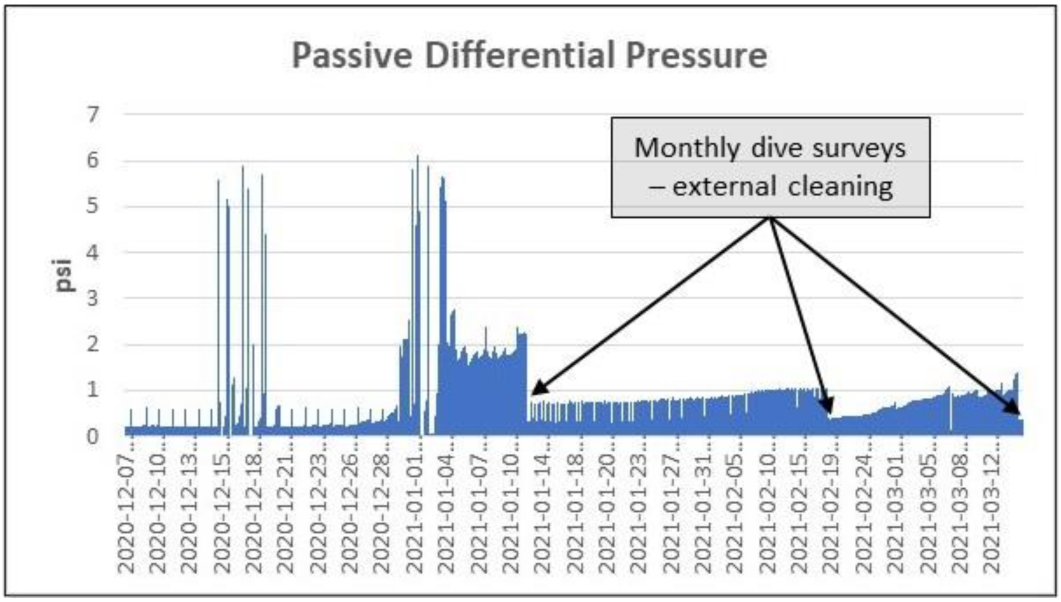


Figure 15. Differential pressure through passive wedgewire screening assembly during Q1.

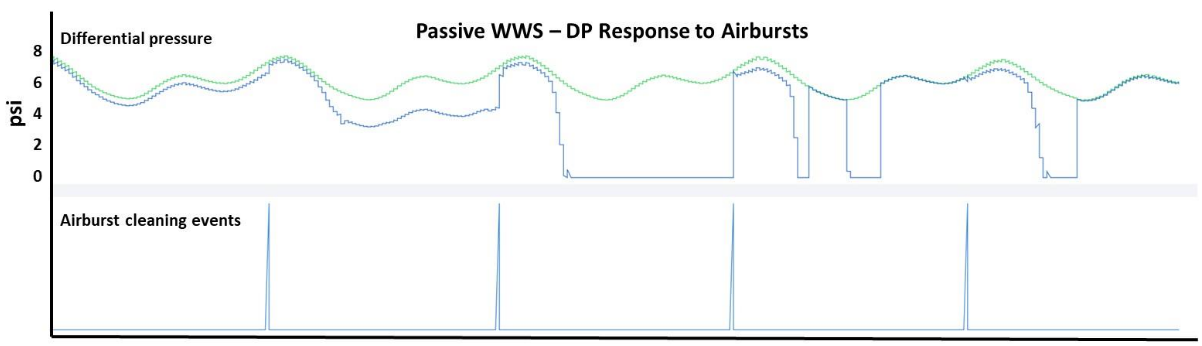


Figure 16. Effectiveness of cleaning method for controlling DP in pilot-scale passive wedgewire intake screening assembly. Data show a four-day period (December 29, 2020 – January 2, 2021) during which a suspected clogging event occurred.

Figure 17. Photos of the passive WWS before and after external cleaning by divers during months 1 (January 2021 dive survey) and 2 (February 2021 dive survey) of Q1. Note that no photos are available from Month 3 due to poor visibility.

Active WWS

During the first month, the active WWS maintained stable operation at a cleaning frequency of three times per day. DP remained low except for a few incidents of higher DP which may indicate that a clogging event (free-floating debris, not biofouling) was taking place and affecting both screens (Figure 18). Automated cleaning of the active WWS resulted in recovery of DP. Figure 19 illustrates how DP recovered in the active WWS after a suspected clogging event during Q1. The active WWS recovered quickly and was able to maintain low DP at a screen cleaning frequency of three times per day. Note that the active WWS has both external and internal brushes. Divers indicated that the active screen was in excellent condition with no biofouling on the screening surface.

During the second month, the active WWS continued operating reliably at a cleaning frequency of three times per day with no measurable change in DP. Divers indicated that the active screen was still in excellent condition with no biofouling on the screening surface.

During the third month, the active WWS did not initiate any cleaning cycles (since the cleaning regime was based on flow rate or DP, see Table 1) and, as a result, accumulated a layer of biofouling on the external screening surface. Once the timed cleaning schedule was resumed in the third month, the active WWS reverted to a clean condition with DP dropping from approximately 0.4 psi to at the end of Q1 to approximately 0.02 psi at the beginning of Q2.

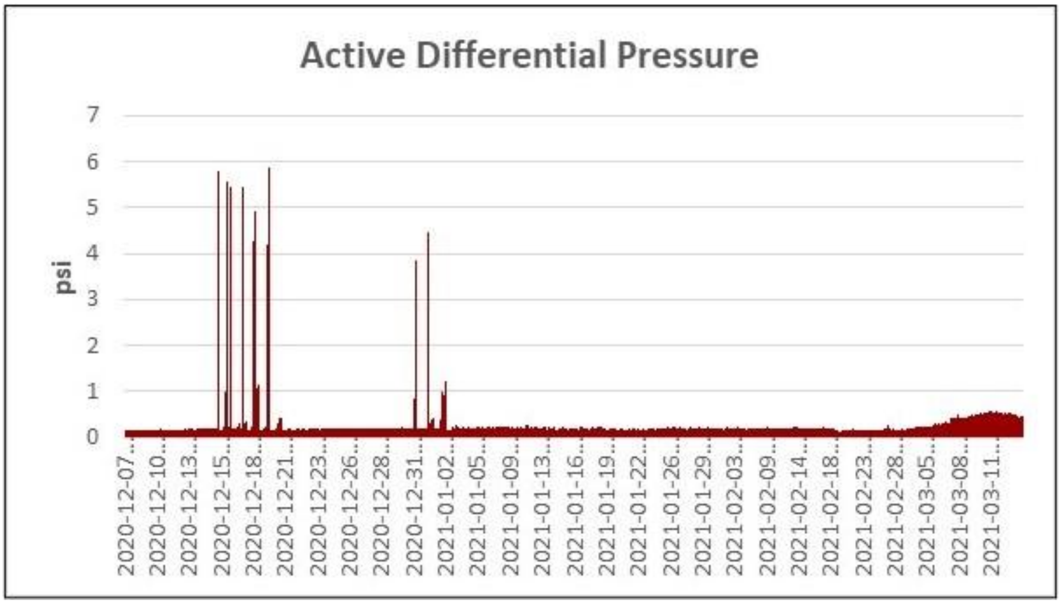


Figure 18. Differential pressure through active wedgewire screening assembly during Q1.

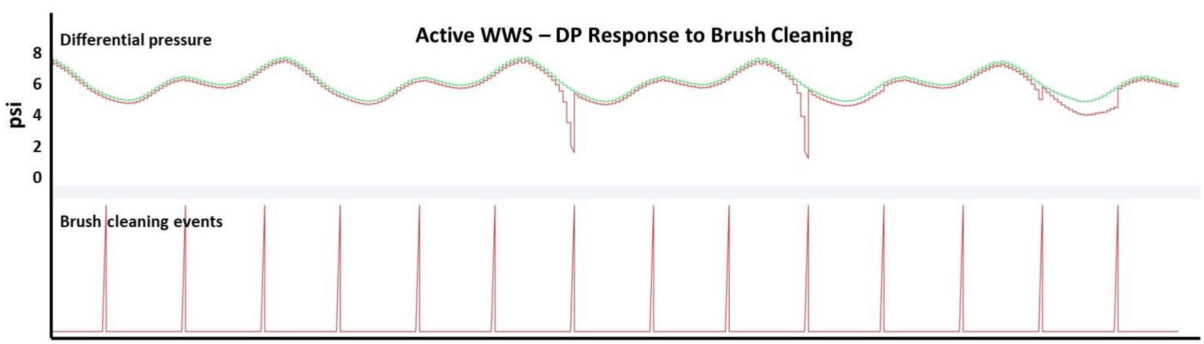


Figure 19. Effectiveness of cleaning method for controlling DP in pilot-scale active wedgewire intake screening assembly. Data show a four-day period (December 29, 2020 – January 2, 2021) during which a suspected clogging event occurred.

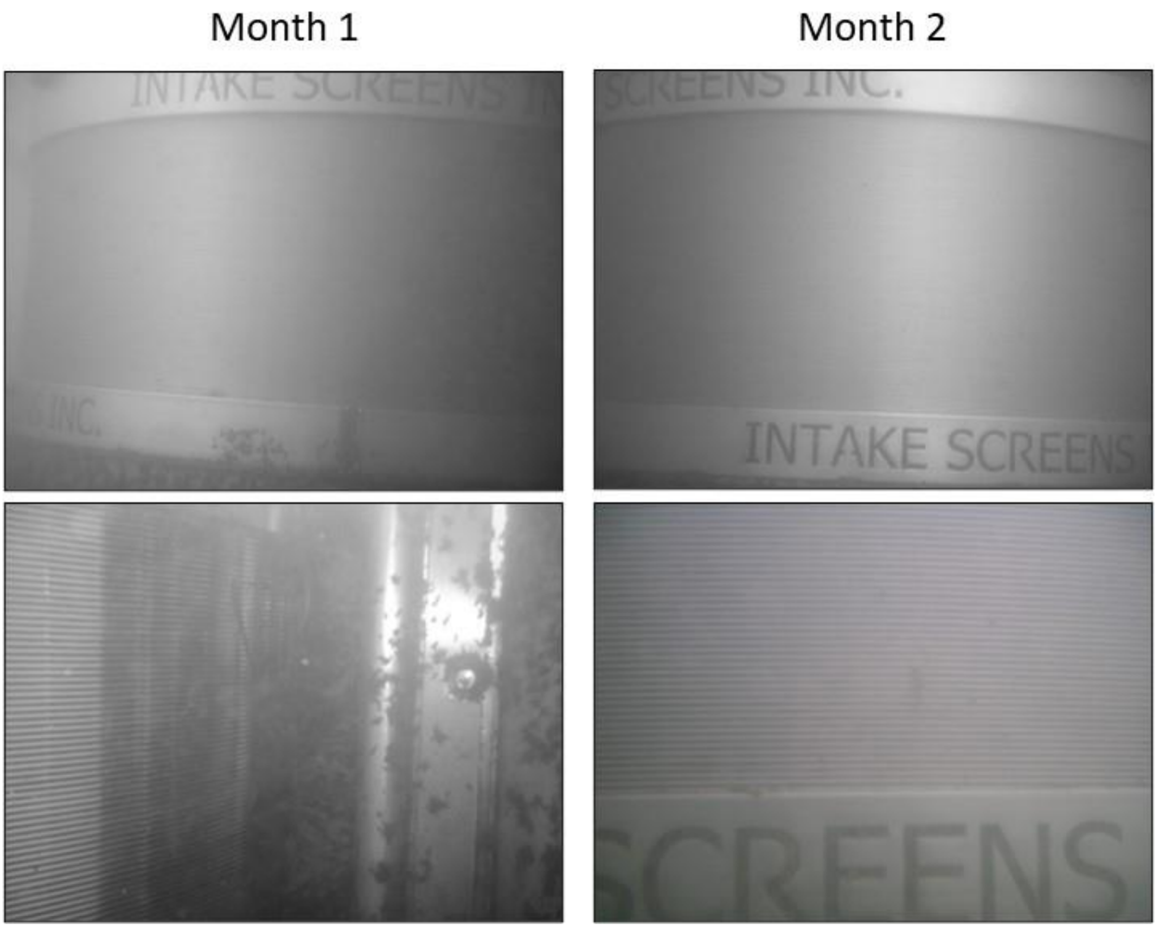


Figure 20. Photos of the active WWS during months 1 (January 2021 dive survey) and 2 (February 2021 dive survey) of Q1. Note that no photos are available from Month 3 due to poor visibility.

5.2. Q2 (March 16, 2021 – August 12, 2021)

Passive WWS

During the fourth month of operation, the passive pump was offline (airburst continued to function at four times/day) between March 19 and May 3 for troubleshooting of the faulty flowmeter; no flow was withdrawn through the passive WWS during that period. During the dive survey at the end of the fourth month, divers indicated that the biofouling had accumulated on 100% of the passive WWS external surface (Figure 22). No hard macrofouling organisms were present on the exterior of the WWS. Removing the biofouling required very little effort; essentially a gloved hand was sufficient to sweep all external fouling off of the screen face. Divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions.

During the fifth month of operation, airburst continued to function at 4 times/day, The passive pump was returned to service (May 3) and DP began between 1.2 and 1.5 psi – no change from where it was before the manual cleaning by the divers. DP increased from approximately 1.5 to over 2 psi during that month (Figure 21) and divers noted between 80 and 100% biofouling coverage on the passive WWS external surface (Figure 22). No hard macrofouling organisms were present on the exterior of the WWS. Removing the biofouling required very little effort; essentially a gloved hand was sufficient to sweep all external fouling off of the screen face. Divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions.

During the sixth month of operation, airburst continued to function at 4 times/day and the passive WWS experienced a sharp increase in DP, reaching over 3.5 psi. No hard macrofouling organisms were present on the exterior of the WWS. Removing the biofouling required very little effort; essentially a gloved hand was sufficient to sweep all external fouling off of the screen face. Divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions. Given the clean condition of the external passive WWS surface, this high DP is indicative of internal biofouling. Heavy internal fouling was confirmed at the end of the sixth month when divers had to inspect the skid after it became partially un-anchored. Divers opened one endcap of the passive WWS and noted that it was essentially completely clogged with mussels and sediment (Figure 23). Under these conditions, airburst air would have difficulty escaping from the screen. See Appendix D for additional details on the June 18, 2021 dive survey during which inspection of the partially un-anchored skid was completed.

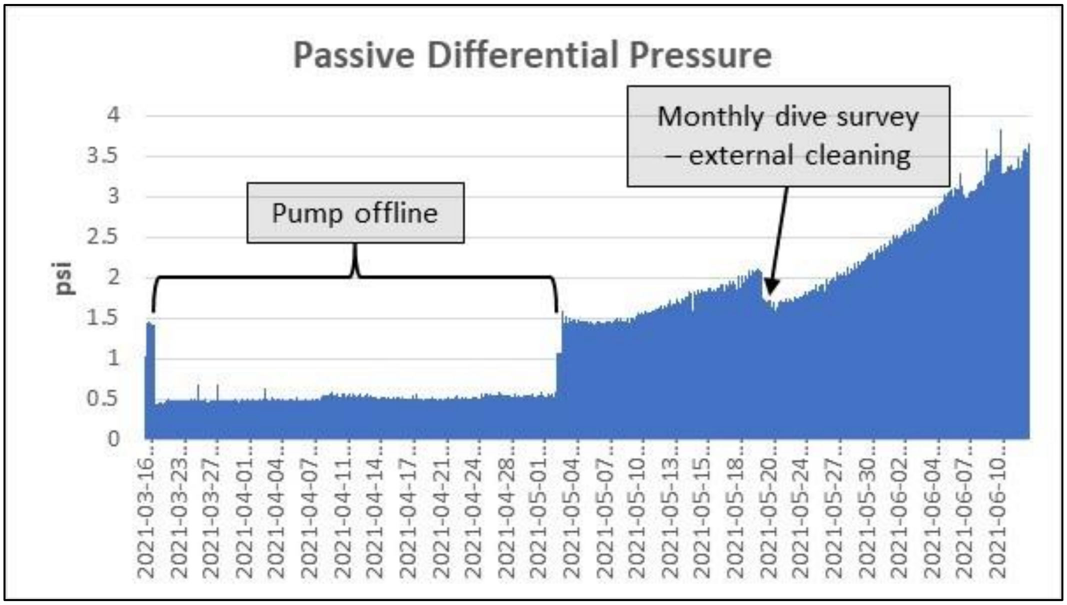


Figure 21. Differential pressure through passive wedgewire screening assembly during Q2.

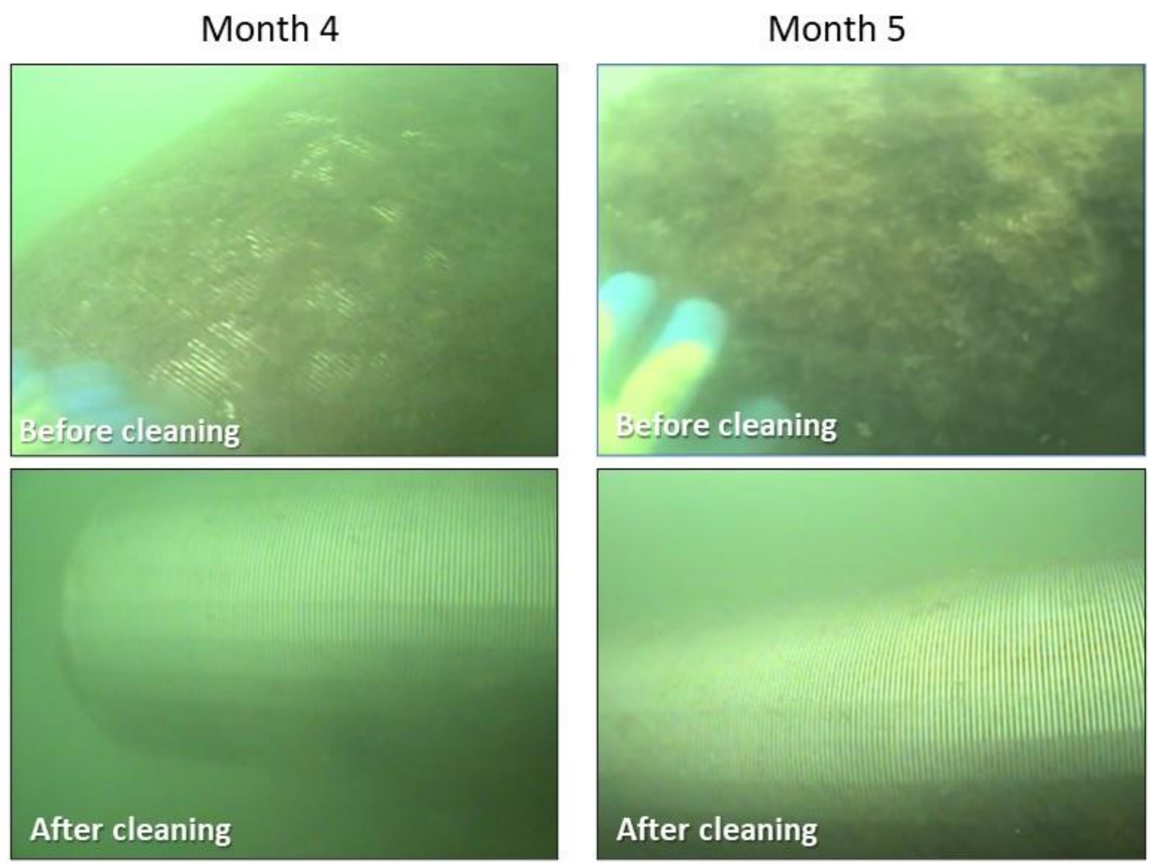


Figure 22. Photos of the passive WWS before and after external cleaning by divers during months 4 (April 2021 dive survey) and 5 (May 2021 dive survey) of Q2.

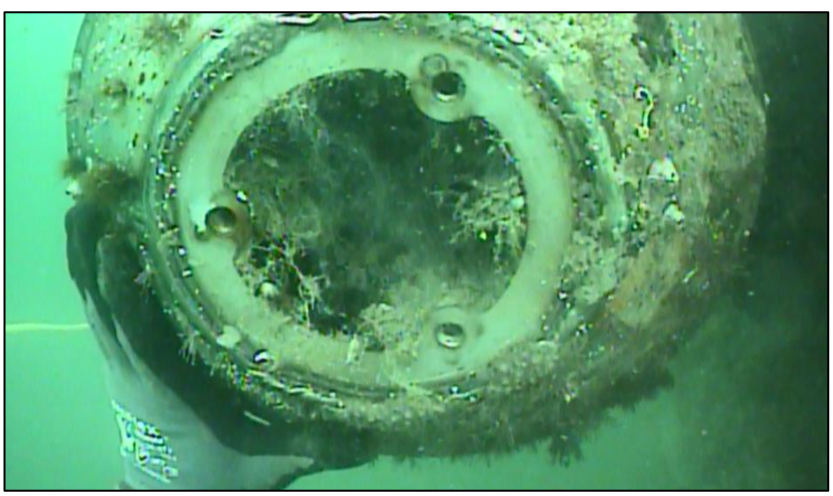


Figure 23. Photo of biofouling inside of passive WWS after month 6 of operation (June 2021 dive survey) – endcap removed.

Active WWS

During months four and five of operation, the active WWS functioned reliably at a cleaning frequency of three times/day (no change from other operational periods in this study). DP never exceeded approximately 0.2 psi (Figure 24). Divers noted small streaks of soft growth on portions of the active WWS external surface (Figure 25). No hard macrofouling organisms were present on the exterior of the active WWS.

As noted above, Appendix D contains additional details on the month 6 (June 18, 2021) dive survey during which inspection of the partially un-anchored skid was completed. During that inspection, a section of the top cover of the active WWS was removed to inspect the internal surfaces. Divers cleaned the internal surface and noted that the internal screening surface was only lightly biofouled (mostly soft growth, a few hard macrofouling organisms – blue mussels) confirming the effectiveness of the internal brush.

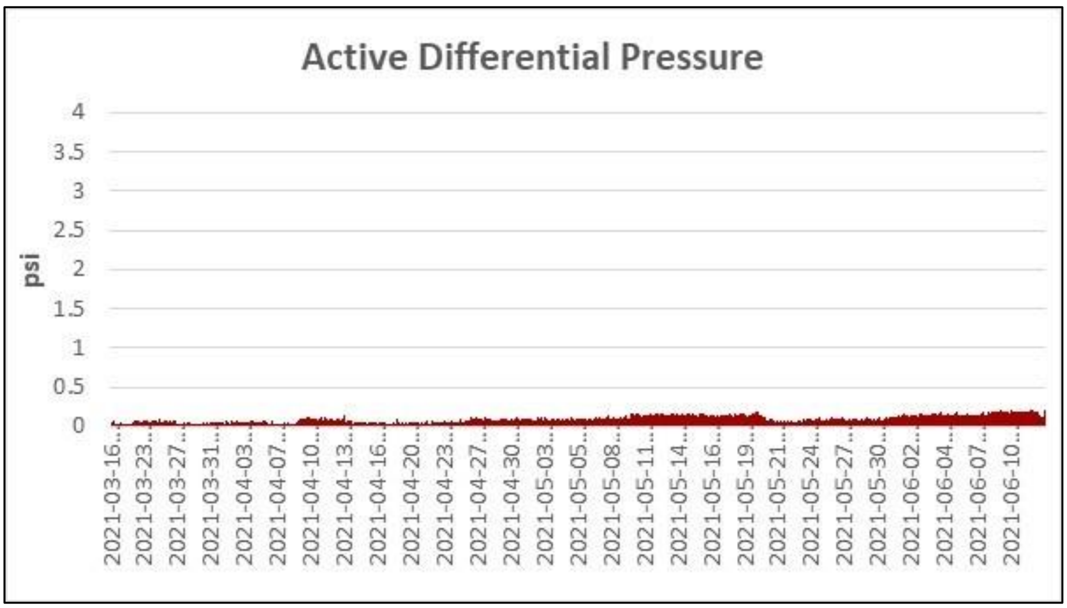


Figure 24. Differential pressure through active wedgewire screening assembly during Q2. Note Y axis scale extends to 4 psi for comparison with the passive wedgewire screening assembly.

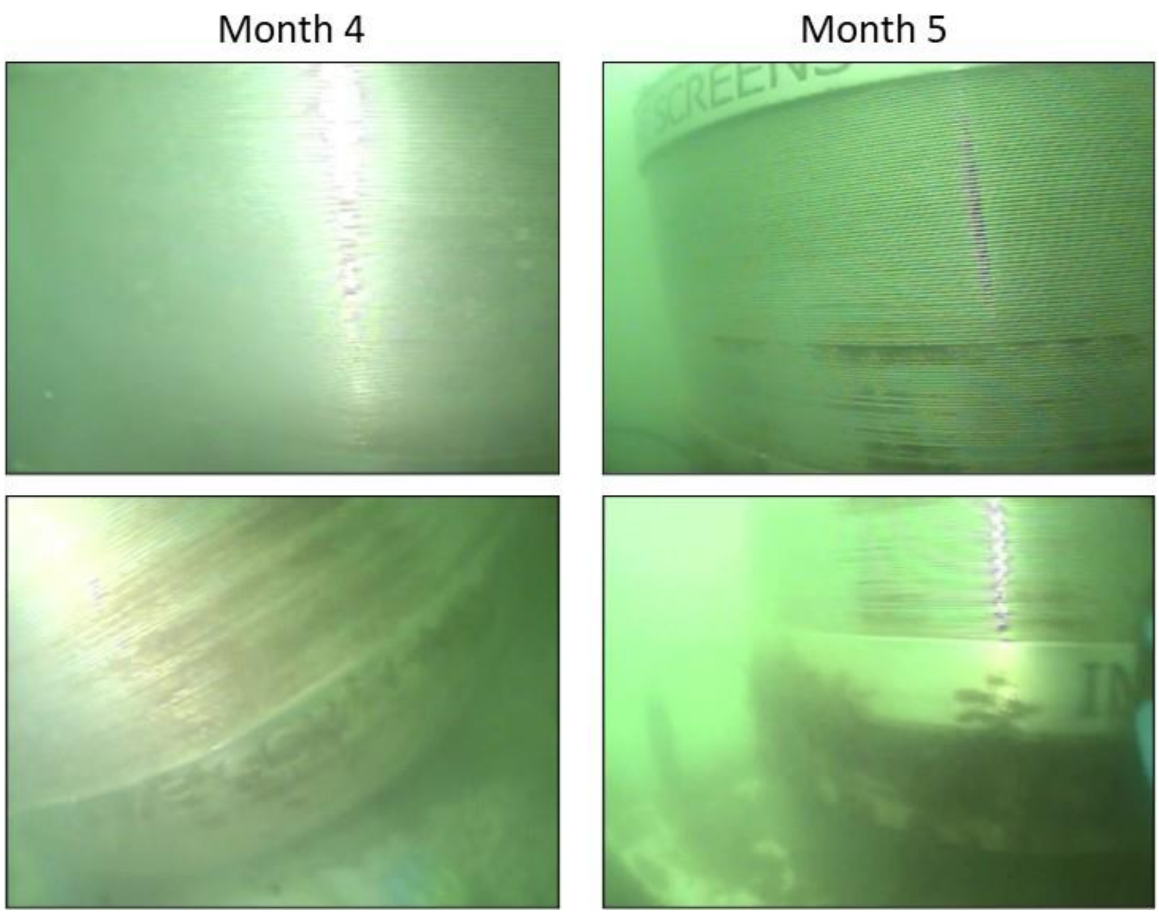


Figure 25. Photos of the passive WWS during months 4 (April 2021 dive survey) and 5 (May 2021 dive survey) of Q2.

5.3. Q3 (August 13, 2021 – November 17, 2021)

Passive WWS

The seventh month of operation was also the first month after the skid was re-anchored. This is noteworthy as both screens were thoroughly cleaned as described in Appendix D before being re-commissioned.

The cleaning frequency for the passive WWS was increased from four airbursts per day to eight in an effort to prevent the settlement of any hard macrofoulers on the interior of the screen. The passive WWS was cleaned in place both internally and externally each month throughout Q3 using a pressure washer and a wire brush. This updated cleaning regime proved to be sufficient for maintaining the passive WWS in good condition. Due to the failure of the passive pressure transducer on August 8, 2021 (replacement transducer not available until December 15, 2021) and the passive flowmeter, no quantitative data were available for the passive WWS during Q3; therefore, data collection was limited to the monthly dive observations conducted (Figure 26).

In Q3, an approximately one-inch thick layer of soft growth had accumulated on 100% of the passive WWS external surface during the seventh and eight months, though video observations indicate it was a bit less (60-70% coverage of up to ½-inch of soft growth) during the ninth month. No hard macrofouling organisms were present on the external surfaces. Biofouling was removed with a pressure washer and, where required, divers also used a wire brush to ensure that the gaps between wires were cleared of any occlusions. Inspection of the internal surfaces showed a light layer of soft growth and minimal hard growth (small mussels) for all three monthly dive surveys during Q3. Divers noted that during the November survey, there was approximately 50% coverage of hard growth on the inside surface the passive and active pump boxes.

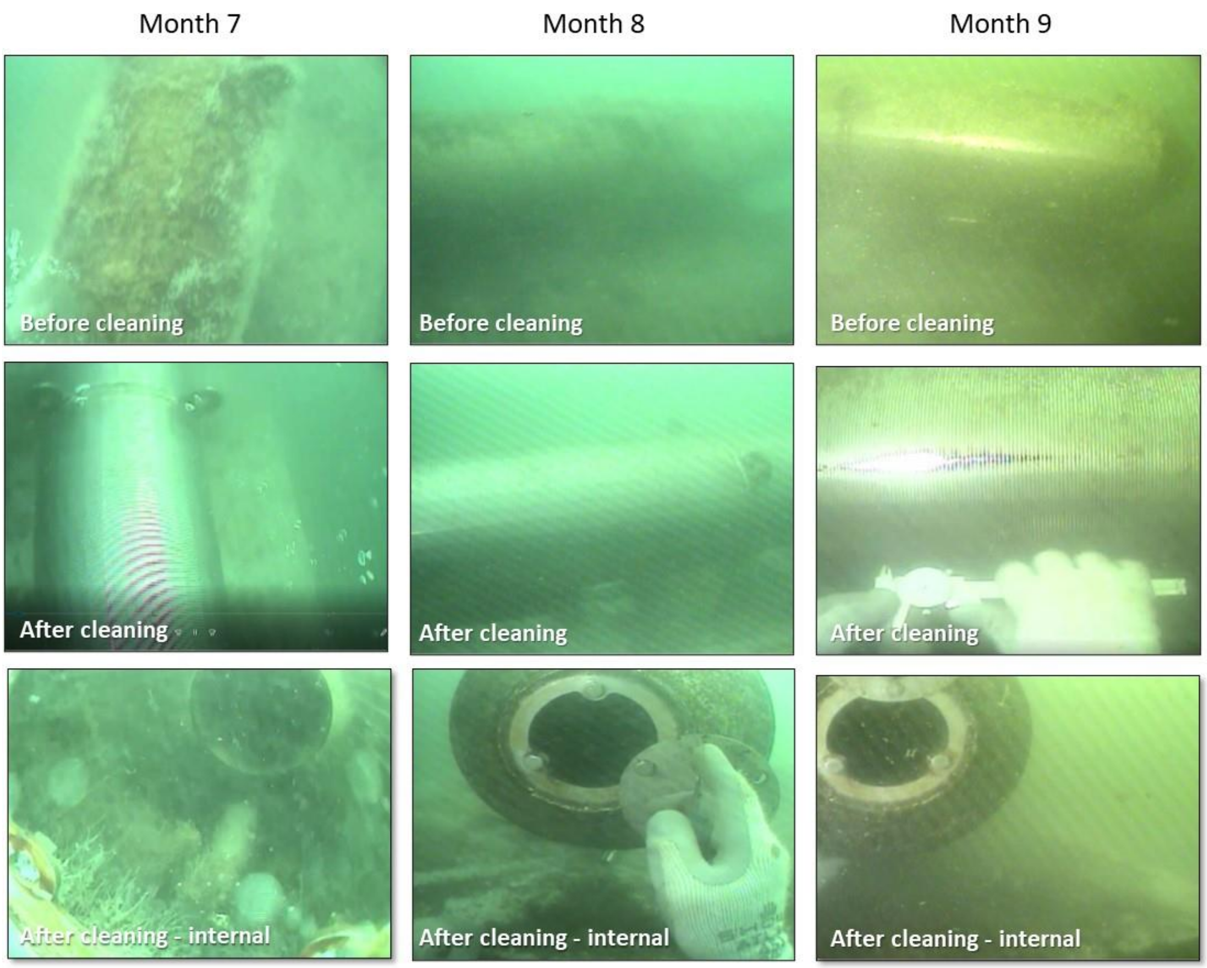


Figure 26. Photos of the passive WWS before and after external and internal cleaning by divers during months 7 (September 2021 dive survey), 8 (October 2021 dive survey), and 9 (November 2021 dive survey) of Q3.

Active WWS

During Q3 of operation, the active WWS functioned reliably at a cleaning frequency of three times/day (no change from other operational periods in this study). DP remained below approximately 0.5 psi (Figure 27). Figure 28 presents the same DP data on a greatly reduced Y-axis scale to simply illustrate the DP trend.

Throughout Q3 reporting, the active screen was clean, with little biofouling. The external surface of the screen developed some streaks of soft growth (Figure 29) which appeared to be the result of the brush not being in close contact with the screen face. Diver video showed some accumulation of free-floating macroalgae at the interface between the brush and screen surface, though it appears to have little/no effect on the overall open area of the

WWS; additionally, the debris is likely released from the brush when the WWS rotates in the opposite direction during a cleaning cycle. No hard macrofouling organisms were present on the external surfaces during any of the Q3 diver surveys. Divers adjusted the brush to make full contact with the screen. Divers noted that during the November survey, there was approximately 50% coverage of hard growth on the inside surface of the active and passive pump boxes.

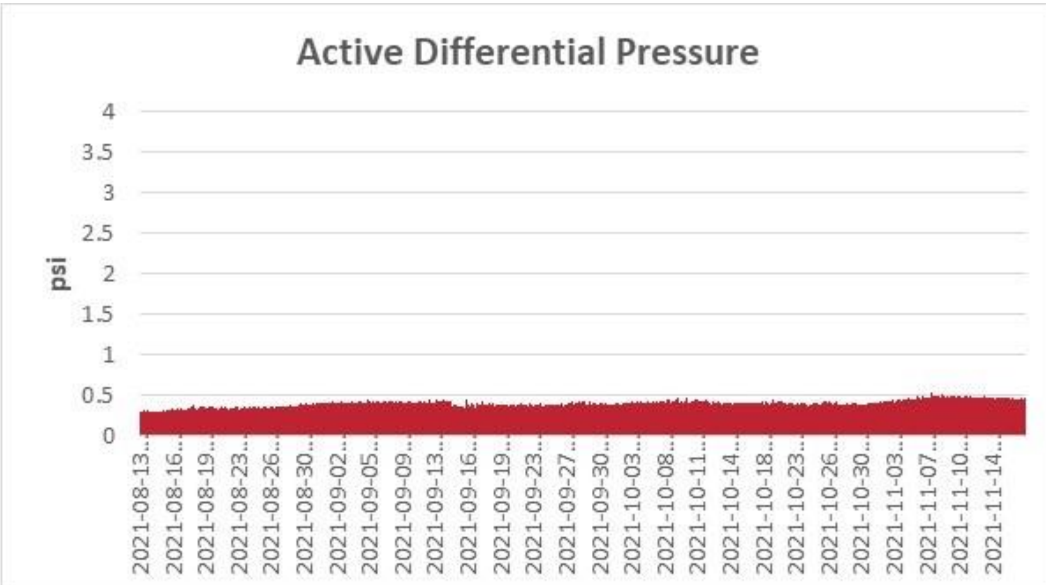


Figure 27. Differential pressure through active wedgewire screening assembly during Q3. Note Y axis scale extends to 4 psi.

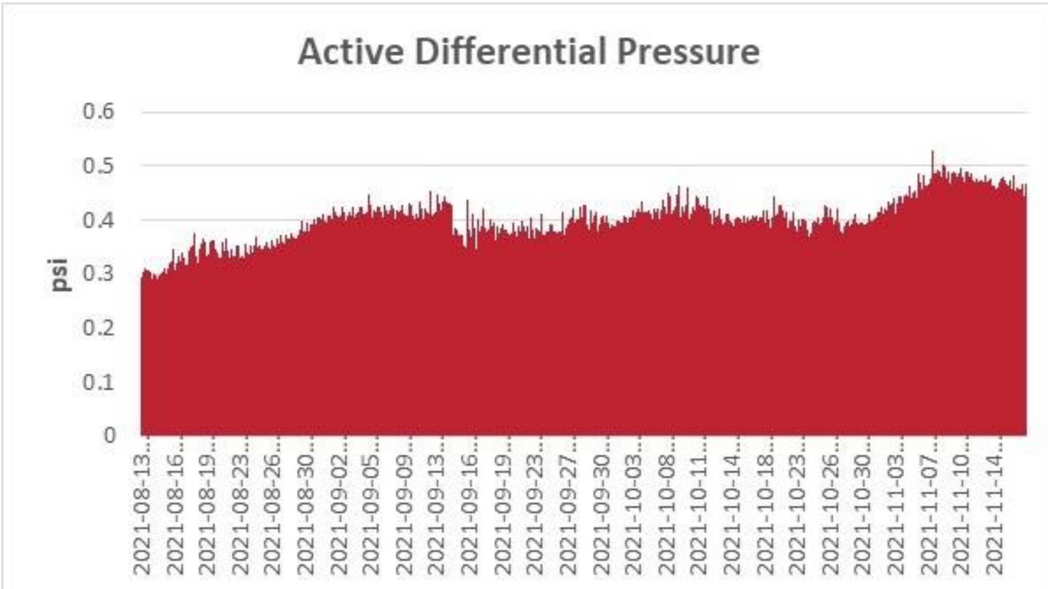


Figure 28. Differential pressure through active wedgewire screening assembly during Q3. Note Y axis scale has been reduced substantially to illustrate a trend of increasing (albeit small) DP.

Month 7 Month 8 Month 9

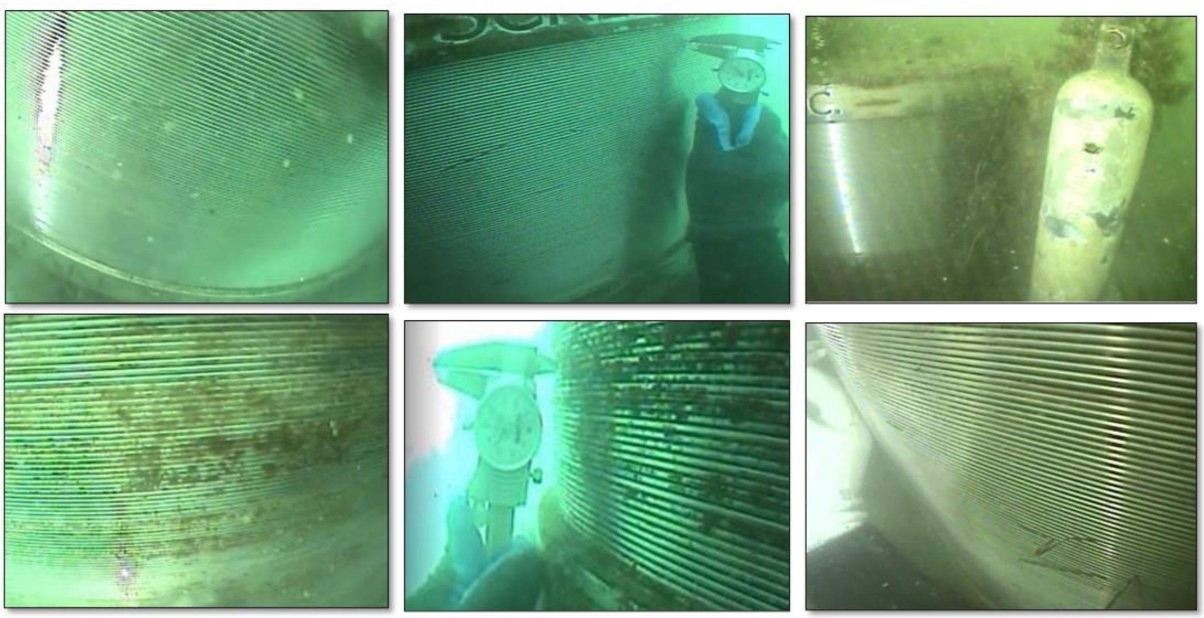


Figure 29. Photos of the active WWS during months 7 (September 2021 dive survey), 8 (October 2021 dive survey), and 9 (November 2021 dive survey) of Q3

5.4. Q4 (November 18, 2021 – February 9, 2022)

Passive WWS

During the final quarter of the study, the passive WWS cleaning frequency remained at eight airbursts per day; the DP fluctuations in Figure 30 correspond to the airburst frequency. DP gradually increased during the period that a functional passive pressure transducer was available (December 27, 2021 through February 9, 2022) (Figure 30). The passive WWS was cleaned in place both internally and externally each month throughout Q4 using a pressure washer and a wire brush. Manual internal and external cleaning by divers was effective for relieving high DP; though, even after the cleaning completed during month 11 (January 2021 dive survey), DP remained at approximately 1 psi.

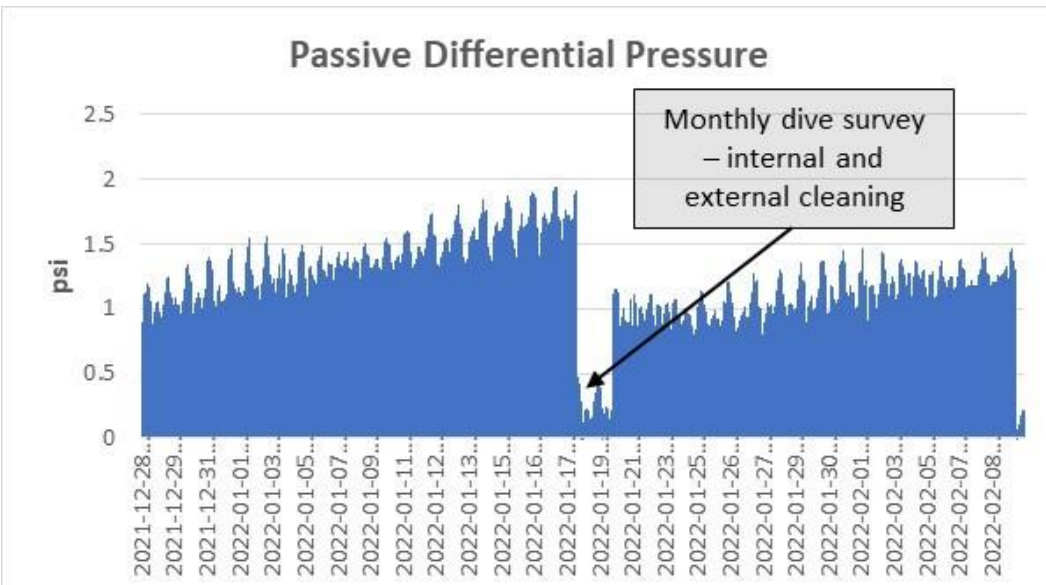


Figure 30. Differential pressure through passive wedgewire screening assembly during Q4. Data were limited to the period after the new passive pressure transducer was installed and functioning correctly.

Month 10 Month 11 Month 12

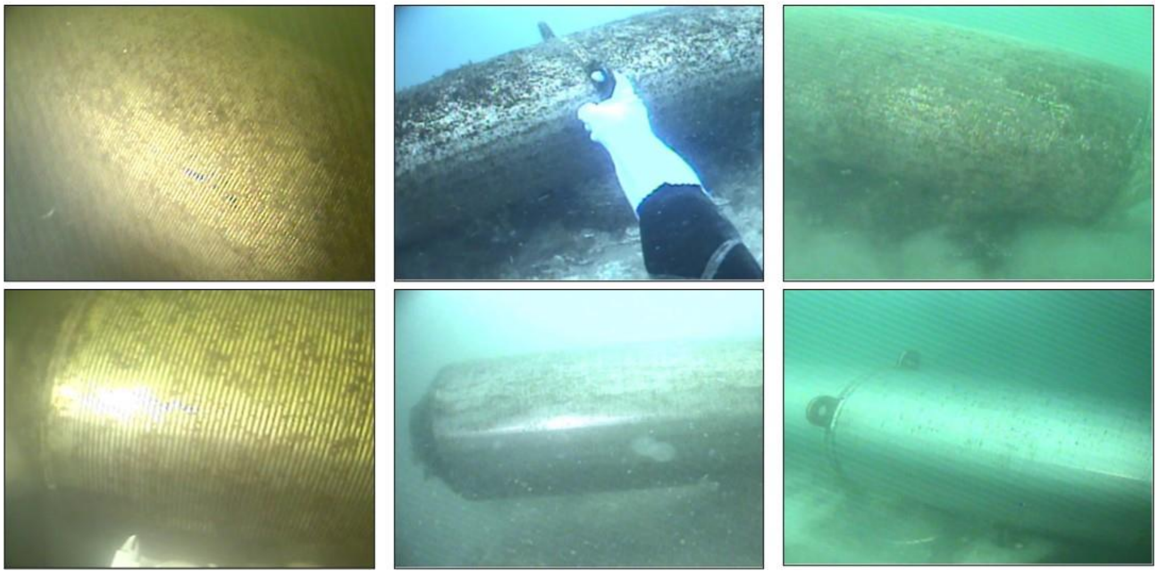


Figure 31. Photos of the passive WWS before and after external and internal cleaning by divers during months 10 (December 2021 dive survey), 11 (January 2022 dive survey), and 12 (February 2022 dive survey) of Q4.

Active WWS

During Q4 of operation, the active WWS functioned reliably and DP remained low through the screening assembly. Cleaning remained on a timed schedule of three times/day (no change from other operational periods in this study). DP remained stable between 0.3 and 0.5 psi (Figure 32).

During Q4, divers noted that the active WWS remained clean, with little biofouling. The external surface of the active WWS still had some streaks of soft growth (Figure 33). Although the divers adjusted the brush during month 10, some streaking remained, indicating that the brush may require more frequent inspection for proper engagement. Regardless, the active WWS operated reliably maintained low DP. No hard macrofouling organisms were present on the external surfaces during any of the Q4 diver surveys.

Discharge Diffusers

Divers also made an interesting observation during the tenth month (December 2021 dive survey): heavy growth of hard marcofoulers (possibly tubeworms) within the discharge diffuser (Figure 34). Based on the size of the community, these biofoulers must have been growing for many months. This would indicate that ancillary flow conveyance structures for any full-scale WWS intake system design would need to be maintained to ensure biofouling is controlled.

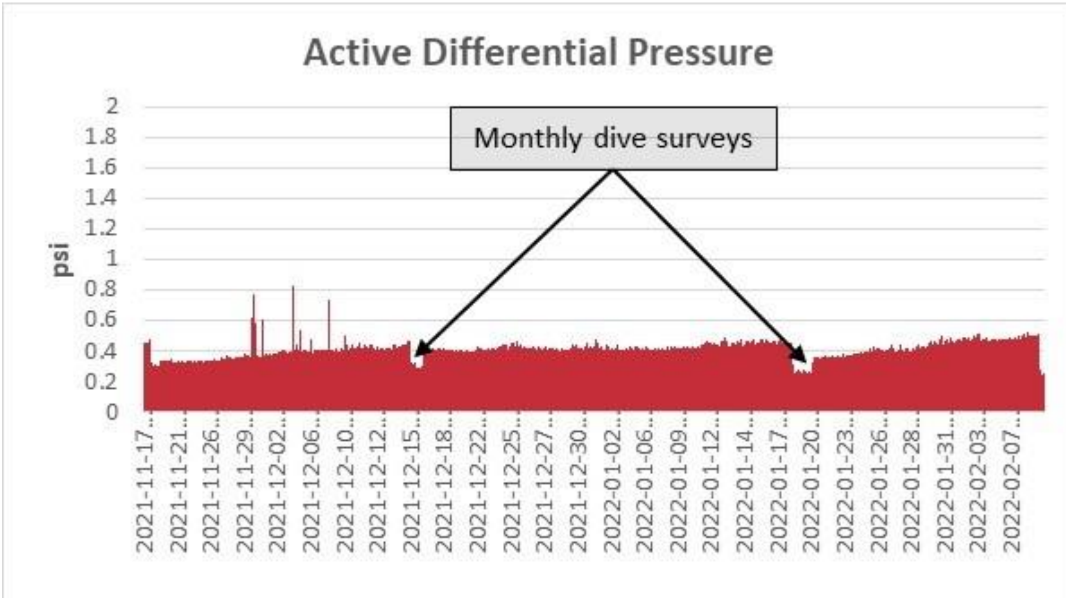


Figure 32. Differential pressure through active wedgewire screening assembly during Q4.

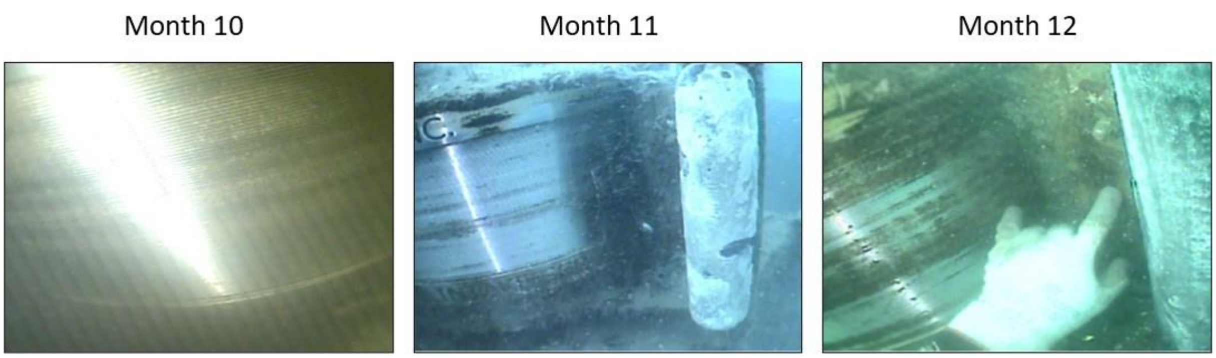


Figure 33. Photos of the active WWS divers during months 10 (December 2021 dive survey), 11 (January 2022 dive survey), and 12 (February 2022 dive survey) of Q4.

Figure 34. Heavy macrofouling growth in the discharge diffuser piping (diameter of 12 inches).

6. Discussion

This Final Report presents the results from 12 months of operation of pilot-scale WWS in Agua Hedionda Lagoon. Per the Study Plan, the objectives of the Pilot Project were:

1. Determine the operability of a 1-mm passive, air-bursted, super-duplex stainless steel WWS and an actively rotated, brush-cleaned, super-duplex stainless steel WWS during a period of one year and under operating conditions representative of the full-scale intake within the Lagoon. This was to be supported by data collection of key operating parameters coupled with monthly dive surveys for visual inspection and maintenance.
2. Refine the site-specific design parameters and O&M requirements for each WWS and confirm the O&M costs of WWS-based intake system.

Maintenance of fully submerged pilot-scale equipment (i.e., flowmeters, instrumentation, pumps, pressure transducers) in the marine Lagoon environment is an operational challenge. This lesson translates well to what should be expected for a full-scale installation of a WWS array in the Lagoon. Although there was no corrosion observed of the 2507 super duplex stainless steel screens, careful consideration would have to be given to the means and frequency of maintenance of other submerged equipment.

All submerged instrumentation must include proper cathodic protection. Divers would need to inspect instrumentation in order to determine the adequacy of the cathodic protection design. Any offshore instrumentation included in a full-scale WWS would also need to be inspected frequently enough to identify biofouling before it affects the data being collected. This would be critical for any instrumentation designed to provide input on WWS performance (e.g., submersible camera, pressure transducers).

6.1. Free Floating Debris and Biofouling

The operational effectiveness of the WWS technologies depend on the adequacy of the screening systems to control two types of intake threats: 1) episodic, free-floating debris that can occlude open screening area and 2) chronic biofouling that accumulates over time and can subsequently occlude open screening area. The data indicate that free-floating debris may have impinged on and was subsequently cleared by each screens cleaning method (Figure 16 and Figure 19). The Pilot Project highlighted that biofouling on the screening surfaces poses a much greater risk to reliable operation of a 1-mm intake screen in the Lagoon. Therefore, the operability of a 1-mm super-duplex stainless steel WWS in the Lagoon (Objective 1 of the Pilot Project) depends on the adequacy of the biofouling control provisions of each screen type.

The control of biofouling on submerged intake screening equipment in the marine environment can be grouped into three categories:

1. Materials – selection of the proper materials for fabrication
2. Coatings – applicability of anti-foul or foul-release coatings
3. Cleaning methods – airbursted and manual cleaned or mechanical brush-cleaned

6.1.1 Materials

Material selection is a critical consideration for submerged screening applications; whereby, the material selected can confer both a fouling prevention and corrosion resistance capacity to the submerged screen. WWS are available in various grades of stainless steel, duplex and super-duplex stainless steel, and copper nickel. When considered for a marine application, super duplex stainless steel is preferrable for corrosion resistance; however, when overlaying the need for controlling biofouling growth, copper nickel is preferred. Selection of the screen material is therefore a balance between the need to resist corrosion and the need to resist biofouling.

State Water Resources Control Board (SWRCB) staff members have expressed concern about the leaching of copper to the environment. Therefore, both WWS tested in this Pilot Project were fabricated of 2507 super duplex stainless steel WWS which is known to foul.

The Pilot Project results confirm that, without cleaning, biofouling readily accumulates on super-duplex WWS within a one-month period. As such, the management (rather than prevention) of biofouling on the screening surface is a critical component to ensuring reliable operation of a 1-mm WWS in a marine environment.

6.1.2 Coatings

Anti-foul and foul-release coatings are often applied to submerged components as a means to control fouling. Anti-foul coatings rely on the dissolution of biocides to kill biofouling organisms; such coatings have been phased out of use in most industries and are not considered a viable option for use in California. Non-toxic, foul-release coatings function by reducing the strength with which fouling organisms, films, or deposits attach to the surface. Those loosely attached fouling organisms are then easily released by water flowing over their surfaces. While coatings hold potential for managing biofouling, most must be reapplied at regular intervals (every 5-10 years) which requires removing the component from service, cleaning the surface, drying it completely, and re-coating.

While there is potential for coatings to be used on certain sections of WWS assembly, coating the WWS wires is not practical and is generally avoided by WWS manufacturers. That said, coatings may be applicable for internal WWS surfaces where flow passages are larger (e.g., flow distribution manifold).

6.1.3 Cleaning Methods

The passive and active WWS differ in their means to manage intake blockage threats: free-floating debris and biofouling; each of which is discussed below for each WWS type.

The passive WWS relies on the use of a compressed air cleaning system (the Hydroburst™ system) to release impinged free-floating debris from the screening surface. The pilot-scale system included all of the components that would be used in a full-scale system: a compressor, an accumulator/receiver, controls, and air piping that directs a burst of air to the inside of the passive WWS. The burst of high-pressure air is capable of dislodging impinged debris which can then be swept away from the screen by ambient currents. Based on the results of this Pilot Project, a timed airburst frequency would be recommended at a minimum before considering additional cleaning strategies (i.e., triggering airburst cleaning based on flow rate or differential pressure).

A passive WWS fabricated of super duplex stainless steel has no inherent biofouling prevention capacity and requires divers to manually clean the biofouled surfaces. Moreover, divers must be able to access not just the external surface but must also be able to manually clean the inside surfaces of the WWS. Based on the results of this Pilot Project, monthly cleaning (at a minimum) by divers is recommended for both the internal and external surfaces; going longer than one month between inspections and cleanings would not be recommended due to the increased potential for settlement of hard macrofouling organisms (e.g., mussels, barnacles). Though manual removal of accumulated biofouling with brushes worked, the use of the pressure washer proved to be better. A pressure washer would also be more efficient for a full-scale WWS.

The active WWS fabricated of super duplex stainless steel utilizes a self-cleaning design whereby the screen drum rotates at a fixed frequency against fixed external and internal brushes. Monthly dive surveys did not reveal any appreciable accumulation of free-floating debris or biofouling on the screening surface that would be of concern (i.e., present a screen occlusion risk). Divers noted that some filamentous debris (e.g., algae and sea grasses) had accumulated on the fixed external brush, though its effect on the open area for flow to pass is inconsequential. Based on the results of this Pilot Project, a timed screen rotation frequency would be recommended, at a minimum, before considering additional cleaning strategies (e.g., triggering screen rotation based on flow rate or differential pressure). A screen rotation frequency of three times per day was maintained throughout the full 12 months of Pilot Project operation and seems sufficient.

Based on the Pilot Project results, quarterly inspections (internal and external) by divers would be recommended for full-scale active WWS until operational experience is gained. During quarterly inspections, divers should monitor screening surface condition, adjust/replace brushes as needed, and clean any non-screening surfaces as needed.

7. Conclusions

The following are the key conclusions from the WWS Pilot Project:

- The control of biofouling on super-duplex stainless steel is the principal O&M concern for a WWS in the Lagoon environment.
- The brush-cleaned, active WWS fabricated of super duplex stainless steel is better equipped to control biofouling in the Lagoon under operating conditions representative of a full-scale intake. The data and observations made during the WWS Pilot Project support this conclusion. The active WWS would likely result in less maintenance.
- The airbursted, passive WWS fabricated of super duplex stainless steel has no provisions to control biofouling on the super duplex stainless steel from which it is fabricate. Therefore, it requires divers for manual cleaning.

Table 6 summarizes the conclusions of the WWS Pilot Project.

Table 6. Principal conclusions of the WWS Pilot Project.

<table>
<tr><th></th><th>Active WWS</th><th>Passive WWS</th></tr>
<tr><td rowspan="3">Biofouling</td><td>External surfaces noted as clean each month; coverage never exceeded 10-20% of soft growth</td><td>External surface were 100% covered by soft growth in 11 of the 12 months</td></tr>
<tr><td>Mechanical rotation against brushes at frequency of 3 events/day was effective for preventing biofouling attachment</td><td>Airburst system did not remove attached biofouling</td></tr>
<tr><td>Automated brush cleaning worked to keep brushed internal surfaces clean</td><td>Manual diver cleaning was required for keeping internal surfaces clean</td></tr>
<tr><td>Free-floating Debris</td><td>Minor accumulation at brush/screen interface; rotation system was effective; no entanglement of large macroalgae was observed</td><td>Airburst system was effective; no entanglement of large macroalgae was observed</td></tr>
<tr><td>O&M</td><td>Diver inspection recommended quarterly</td><td>Diver inspection and manual cleaning (internal and external) recommended monthly</td></tr>
<tr><td>Principal Challenge</td><td>Ensure brushes remain in contact with screen</td><td>Labor-intensive biofouling control</td></tr>
<tr><td rowspan="2">Design Changes to Consider</td><td colspan="2">Coat internal flow distribution pipe/other non-screening surfaces with non-toxic, foul-release coating</td></tr>
<tr><td colspan="2">Fabricate screening surface of copper nickel if permissible</td></tr>
</table>

Appendix A

Plankton Exclusion Study

Plankton Exclusion Study for Wedgewire Screen Pilot Project

Final Report

Prepared for Poseidon Resources, Channelside, LP

May 19, 2022

1. Background

Poseidon Water (Channelside) LP (Poseidon) has been investigating the operability of 1-mm wedgewire screen (WWS) intake screening technology. Poseidon implemented a 12-month long Pilot Project (Pilot Project). The intake screening technologies piloted were a passive 1-mm wedgewire screen (WWS) equipped with an airburst cleaning system and an active (rotating), brush-cleaned WWS.

Both WWS were operated in compliance with the Desalination Amendment to the Water Quality Control Plan for Ocean Waters of California, California Ocean Plan (Ocean Plan Amendment or OPA) which regulates the design, construction, and operation of new and expanded seawater desalination plants operating in California's ocean waters. The OPA requires that intakes be screened with mesh no larger than 1 mm and that the intake be designed for a through-screen velocity of 0.5 ft/sec or less.

The purpose of this Pilot Project was to generate site-specific operational performance data for 1-mm WWS in the seawater environment of the Agua Hedionda Lagoon (Lagoon), as well as provide data on the capabilities of each WWS technology (passive vs. active) to manage free-floating debris and biofouling.

The study described herein was conducted opportunistically to collect data which may be useful in determining the biological efficacy of 1-mm WWS for excluding marine organisms from entrainment through both active and passive pilot-scale WWSs. TWB Environmental Research and Consulting, Inc. (TWB) was the lead investigator and Miller Marine Science and Consulting, Inc. (MMSC) collected and processed (sorted and identified) all samples.

2. Introduction

Plankton samples were collected at the Pilot Project in the Lagoon in Carlsbad, California. The Pilot Project was designed as a side-by-side evaluation of the passive and active WWS (Figure A-1). The Pilot Project was designed to simulate, to the extent practical, the operating and environmental conditions that would be experienced at a full-scale WWS array in the Lagoon. The skid was installed approximately 900 feet north of the existing Encina Power Station intake (Figure A-2). Intake flow was drawn through each WWS via submersible pumps (600 gpm) that were mounted on the skid. Withdrawn flow passed through each WWS and was discharged immediately back to the Lagoon via 4-inch diameter discharge pipes connected to the pump chambers. The 4-inch discharge pipes expanded into 12-inch diameter diffusers at the discharge point in order to minimize the discharge velocity.

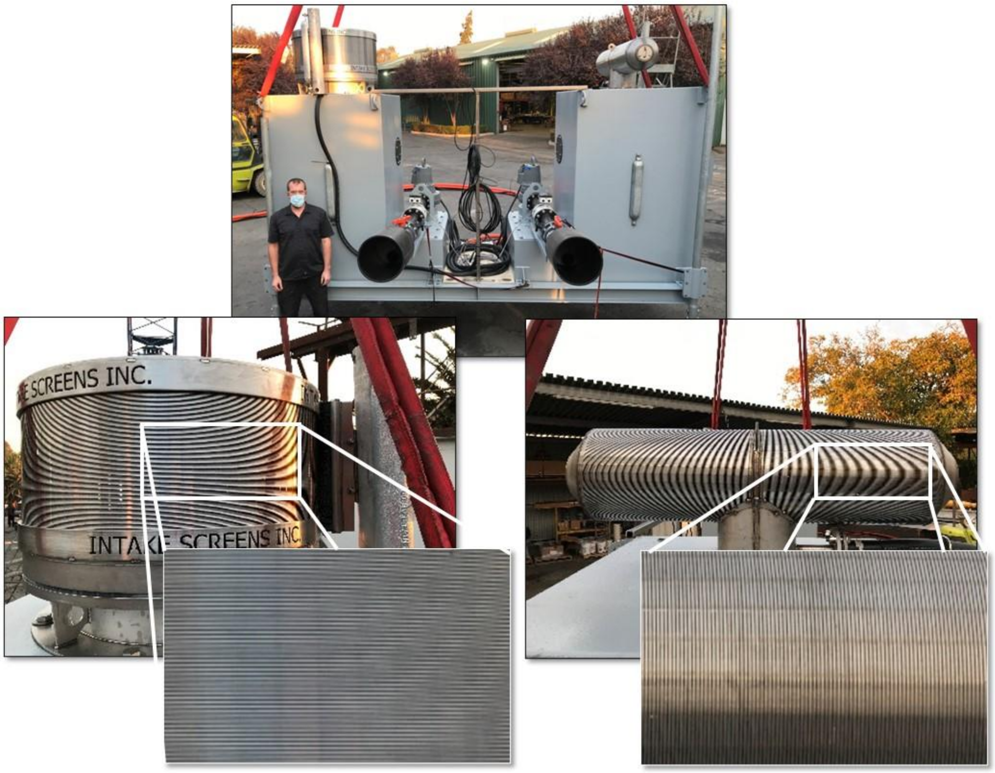


Figure A-1. WWS Pilot Project skid (top), pilot-scale 1-mm active wedgewire screen from Intake Screens, Inc. (bottom left) and pilot-scale 1-mm passive wedgewire screen from Aqseptence (bottom right).

Figure A-2. Location of the Pilot Project components. Plankton sampling was conducted at the location of the "pilot skid". The inset photo shows the boom and warning buoys installed to mark the stand-off zone around the submerged skid.

3. Materials and Methods

The plankton study was conducted over three months, with one plankton sampling event completed each month. Sampling events were completed on September 30th, October 21st, and November 5th of 2021.

Plankton samples were collected downstream of each 1-mm WWS as well as from an ambient unscreened intake cone. All samples were collected with custom fabricated 335-µm mesh nets. Samples from the active (rotating brushed) and passive (airburst cleaned) WWS were collected by divers attaching the plankton nets directly to the discharge ports. The plankton nets were designed to fit around the discharge port and were large enough to allow the discharge velocity to dissipate without damaging or extruding plankton through the 335-micron mesh netting. For ambient samples, a custom-fabricated, unscreened intake cone was attached to flexible hose and drew ambient source water from the same depth as the screens via a vessel-mounted portable trash pump. The intake cone was sized based on pumping flow rate and open area to match the through-slot velocity of the WWS (0.5/ft/sec or less). The principal sampling gear is shown in Figure A-3.

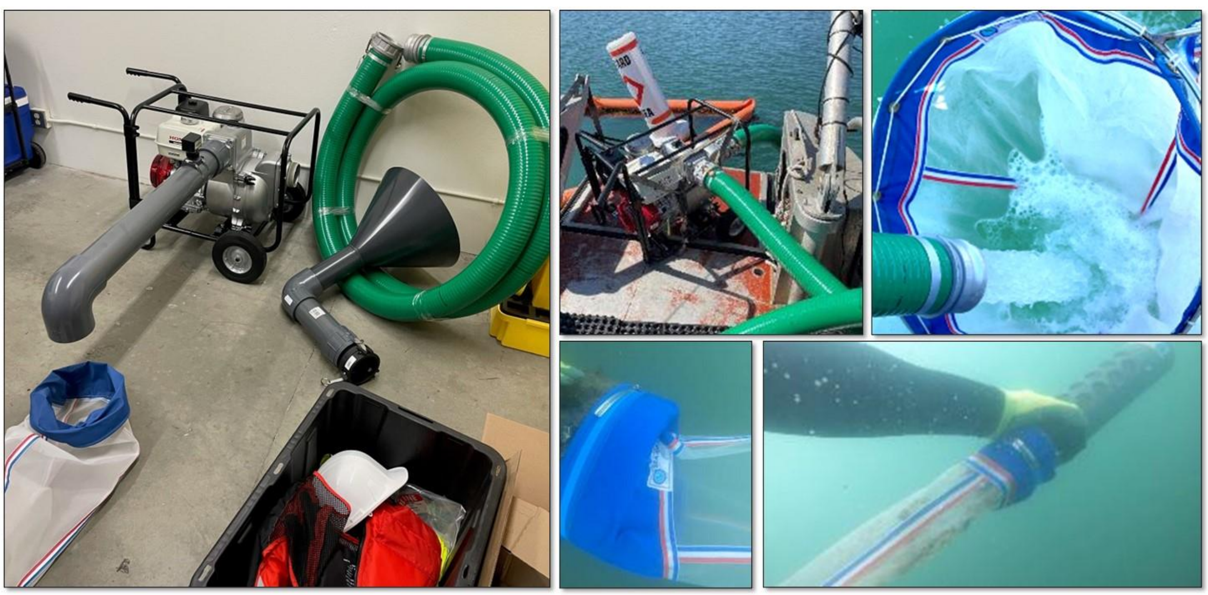


Figure A-3. Plankton sampling gear. Clockwise from left: ambient sample collection gear (intake cone, flexible hose, trash pump, and plankton net), ambient sample collection gear in field, ambient sample discharge into plankton net, cod end of plankton net attached to discharge from a WWS, mouth of plankton net hose-clamped to discharge from a WWS

Based on recent larval sampling in the Lagoon, the target sampling volume was 50 m^3 for all sampling. Sampled flow through the WWSs was estimated using the existing flowmeters installed on the skid and took approximately 20 minutes to collect. The target sample volume through the unscreened intake cone (ambient) was achieved by operating the trash pump at its maximum flow rate and took approximately 32 minutes to collect.

3.1. Sampling Process

For diver safety, samples were only collected during daylight hours. The Pilot Project airburst system for the passive WWS was shut down and locked out at the control panel in the portable control room (PCR) onshore for the duration of each sampling event. The submersible pumps for each WWS were shut down at the PCR between samples to allow divers to safely install and retrieve the plankton nets that sampled the two WWSs. All three nets (active, passive, and ambient) were installed as concurrently as possible to minimize any temporal variation. Two replicate samples were collected from each of the three sampling locations during each sampling event.

Each WWS sampling net was fitted with a rubber coated hose clamp to secure the net to the screen discharge port. Each plankton net included a collection bucket at the cod end with the same 335-micron mesh (Figure A-3). To filter 50 m^3 of water, the nets were attached to the WWS discharge ports and the WWS submersible pumps were switched on at the PCR control panel. After 20 minutes, the WWS submersible pumps were turned off and the nets were retrieved by divers and brought to the surface for rinsing. The time the nets were installed and removed as well as the total time each net sampling was recorded and cross-checked with existing flowmeters to calculate the actual flow volume through each net.

For the ambient pump samples, water was withdrawn through a flexible hose and custom - fabricated intake cone mounted at the centerline depth of the WWS on the skid; this ensured samples were all collected from the same depth. The flexible hose was connected to a gas-powered-trash pump on the deck of the support vessel. The pump was operated at full throttle for 32 minutes to achieve approximately 50 m^3 of water pumped. The longer run time was needed for the ambient pump to reach the achieved 50 m^3 of volume since its maximum flow rate was less than the WWS submersible pumps. The trash pump's discharge was routed through an identical 335-µm mesh plankton net positioned over the side of the support vessel with the net resting in the water to dissipate energy in the discharged flow (Figure A-3, top right). After 32 minutes, the plankton net was raised for processing.

After sampling was complete, all plankton nets were rinsed identically. Nets were rinsed from the outside using a seawater wash-down hose to concentrate collected material into the cod end bucket. The cod end was then removed and its contents were rinsed into a 200-µm mesh screen to condense the sample before transferring it into a pre-labeled sample jar (Figure A-4). Each sample jar was filled with a 5% buffered formalin and seawater solution to fix the samples and prevent decomposition. Samples were stored in a cooler for transport to the MMSC laboratory located in Aliso Viejo, CA for further processing.

Figure A-4. Contents from a sampling event rinsed into a 200-μm mesh screen to condense the sample before transferring to a sample jar for later laboratory analysis.

3.2. Laboratory Processing

All samples were transferred from formalin to 70% ethanol after approximately 72 hours in the formalin solution. Trained sorters removed all ichthyoplankton from each sample. A trained taxonomist reviewed the ichthyoplankton to identify each to the lowest practicable taxonomic level in accordance with available identification guides such as “The Early Stages of Fishes in the California Current Region.” Each individual was then measured to the nearest 0.01- mm by scaling pixel measurements using a 1-mm staged micrometer at 0.7x magnification for September samples, and 2.0x magnification for October and November samples (at 0.7x, 252 pixels = 1 mm, at 2.0x, 689 pixels = 1 mm). This was done using videomicroscopy and image analysis software. All samples have been processed through the MMSC laboratory.

4. Results

Sampling on September 30 and October 21 occurred under clear skies and normal water quality conditions (i.e., no harmful algal bloom); however, the November 5 sampling event took place under overcast skies with a strong algal bloom underway in the Lagoon and surrounding coastal areas. Water quality data on November 5 documented abnormally high chlorophyll-a concentrations.

Only 19 ichthyoplankton were collected throughout the duration of this study. Five were entrained through the active WWS, one through the passive WWS, and 13 through the ambient intake cone. Table A-1provides the breakdown of the taxa entrained during each sampling event and their lengths. Samples that contained no ichthyoplankton were not included in Table A-1 (Appendix A includes all raw data).

Species collected included Combtooth Blenny, CIQ Gobies (a complex of gobies made up of three similar genera that cannot easily be distinguished between, *Clevelandia*, *Ilypnus* and *Quietula*) and one Northern Anchovy.

There were no ichthyoplankton entrained in either the active or passive WWS samples during the September 30 sampling event; however, four ichthyoplankton were entrained in ambient pump samples. October was the only sampling month where ichthyoplankton were entrained at all three locations with the ambient pump samples entraining six organisms, the active WWS samples entraining two, and the passive WWS samples entraining one. There were no ichthyoplankton entrained in the passive WWS samples during the November 5 sampling event and both the active WWS samples and ambient pump samples entrained three organisms.

Due to very low number of larvae collected (n=19), statistical analysis was not possible. Qualitatively, the number of ichthyoplankton entrained in the ambient pump samples was more than double when compared to both WWS samples combined. Three sampling events conducted over three months was insufficient to allow analysis of inter-annual variation of ichthyoplankton abundances in the Lagoon or any seasonal trends in lengths of organisms entrained.

Table A-1. Samples containing ichthyoplankton collected throughout the duration of the study

Date	Location	Taxon	Quantity	Average Length (mm)
9/30/2021	Ambient	CIQ Goby	4	2.9
10/21/2021	Passive	CIQ Goby	1	2.0
10/21/2021	Active	CIQ Goby	2	2.0
10/21/2012	Ambient	Combtooth Blenny	5	2.4
10/21/2021	Ambient	Northern Anchovy	1	4.4
11/5/2021	Active	CIQ Goby	3	2.1
11/5/2021	Ambient	Combtooth Blenny	3	2.0

5. Discussion

Ichthyoplankton were collected from ambient pump discharge samples consistently throughout all sampling events, whereas ichthyoplankton in both WWS samples were not. Numbers of entrained organisms in both WWS samples were lower or equal to ambient pump values in each sampling month, but never higher. During the October 21 sampling event, the ambient pump entrained twice as many ichthyoplankton as both WWS samples combined. Additionally, overall numbers of entrained ichthyoplankton in the ambient pump samples (n=13) were more than double the active and passive WWS samples combined (n=6). This may hint that both the active and passive WWS function in reducing ichthyoplankton entrainment relative to an unscreened intake (ambient). However, additional data would be required to confirm this statistically.

There is too little data to make any reasonable conclusions about whether one WWS confers a greater exclusion benefit than the other. That said, being equipped with the same 1-mm slot widths, one would expect similar exclusion performance from each WWS.

6. Conclusion

Three plankton sampling events were completed to quantify the biological exclusion potential of the WWS used in the WWS Pilot Project. However, sample sizes were too small to drawn any reliable quantitative conclusions. At a high level, the data do reveal that entrainment of ichthyoplankton was more than double through the unscreened intake (ambient) when compared to the active and passive WWS samples combined. Further studies are needed to determine whether the WWS confer a statistically higher level of exclusion from entrainment than an unscreened intake port.

Appendix A - Wedgewire screen plankton exclusion sampling raw data.

Date	Station	Rep	Mins	Flow m^3	Taxon	Count	Concentration #/m^3	Length mm
9/30/2021	Active	1	20	50	None	0	0	
9/30/2021	Active	2	20	50	None	0	0	
9/30/2021	Passive	1	20	50	None	0	0	
9/30/2021	Passive	2	20	50	None	0	0	
9/30/2021	Ambient	1	32	50	CIQ Goby	1	0.02	2.842262
9/30/2021	Ambient	1	32	50	CIQ Goby	1	0.02	2.701587
9/30/2021	Ambient	2	32	50	CIQ Goby	1	0.02	2.650794
9/30/2021	Ambient	2	32	50	CIQ Goby	1	0.02	3.385754
10/21/2021	Passive	1	20	50	None	0	0	
10/21/2021	Passive	2	20	50	CIQ Goby	1	0.02	1.97884
10/21/2021	Active	1	20	50	None	0	0	
10/21/2021	Active	2	20	50	CIQ Goby	1	0.02	1.947928
10/21/2021	Active	2	20	50	CIQ Goby	1	0.02	2.096105
10/21/2021	Ambient	1	32	50	Combtooth Blenny	1	0.02	2.720016
10/21/2021	Ambient	2	32	50	Combtooth Blenny	1	0.02	2.14124
10/21/2021	Ambient	2	32	50	Combtooth Blenny	1	0.02	2.323232
10/21/2021	Ambient	2	32	50	Combtooth Blenny	1	0.02	2.471555
10/21/2021	Ambient	2	32	50	Combtooth Blenny	1	0.02	2.475763
10/21/2021	Ambient	2	32	50	Northern Anchovy	1	0.02	4.425723
11/5/2021	Active	1	20	50	CIQ Goby	1	0.02	1.979943
11/5/2021	Passive	1	20	50	None	0	0	
11/5/2021	Ambient	1	32	50	Combtooth Blenny	1	0.02	2.024991
11/5/2021	Ambient	1	32	50	Combtooth Blenny	1	0.02	1.942398

Date	Station	Rep	Mins	Flow m^3	Taxon	Count	Concentration #/m^3	Length mm
11/5/2021	Active	2	20	50	CIQ Goby	1	0.02	2.030753
11/5/2021	Active	2	20	50	CIQ Goby	1	0.02	2.234123
11/5/2021	Passive	2	20	50	None	0	0	
11/5/2021	Ambient	2	32	50	Combtooth Blenny	1	0.02	1.988433

Appendix B

Acoustic Doppler Current Profiler Report

Data Report

Date: May 19, 2022

Prepared For: TWB Environmental Research and Consulting

Prepared By: Miller Marine Science & Consulting, Inc.

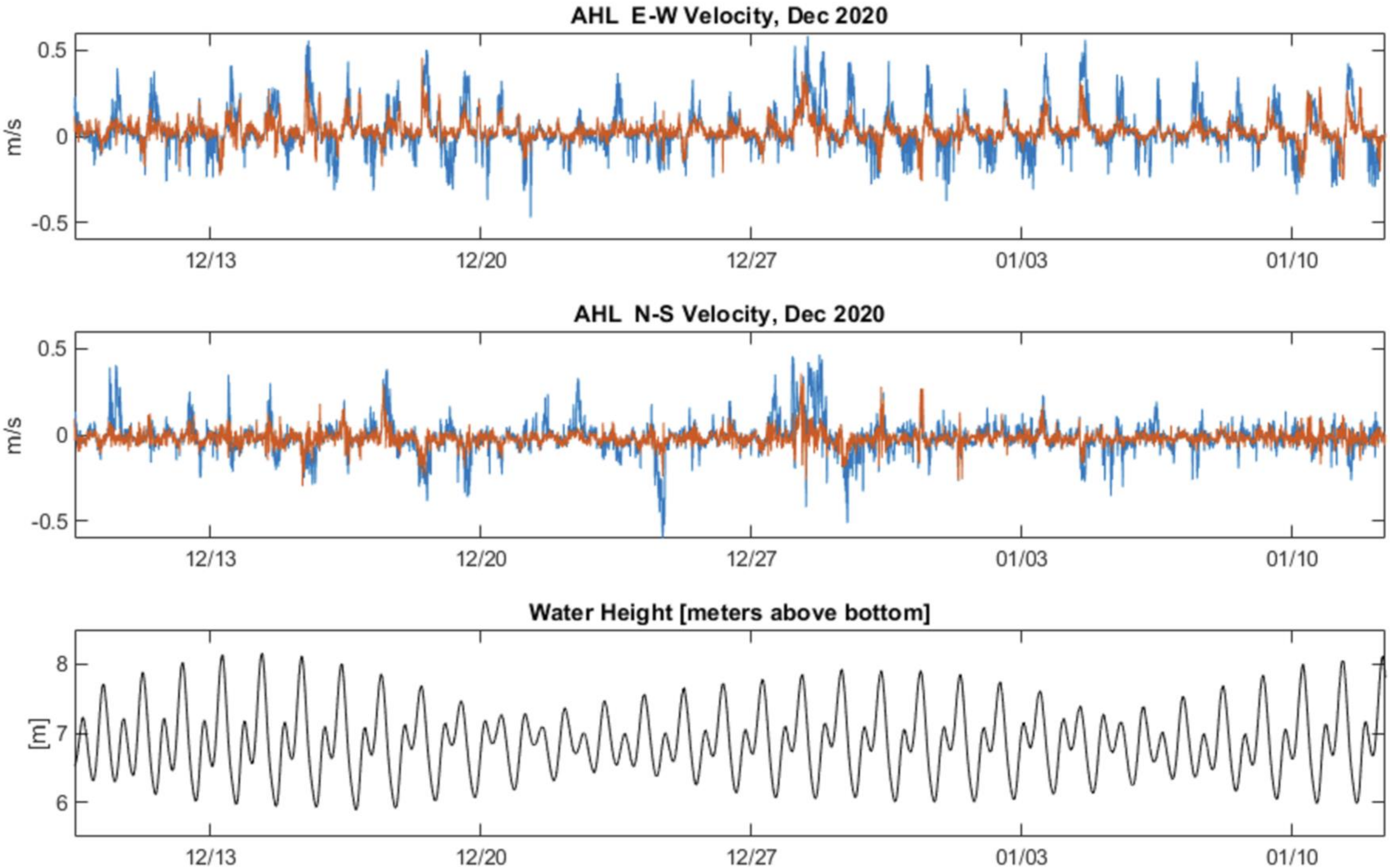
Subject: Wedge Wire Screen Demonstration Study Acoustic Doppler Current Profiler Data

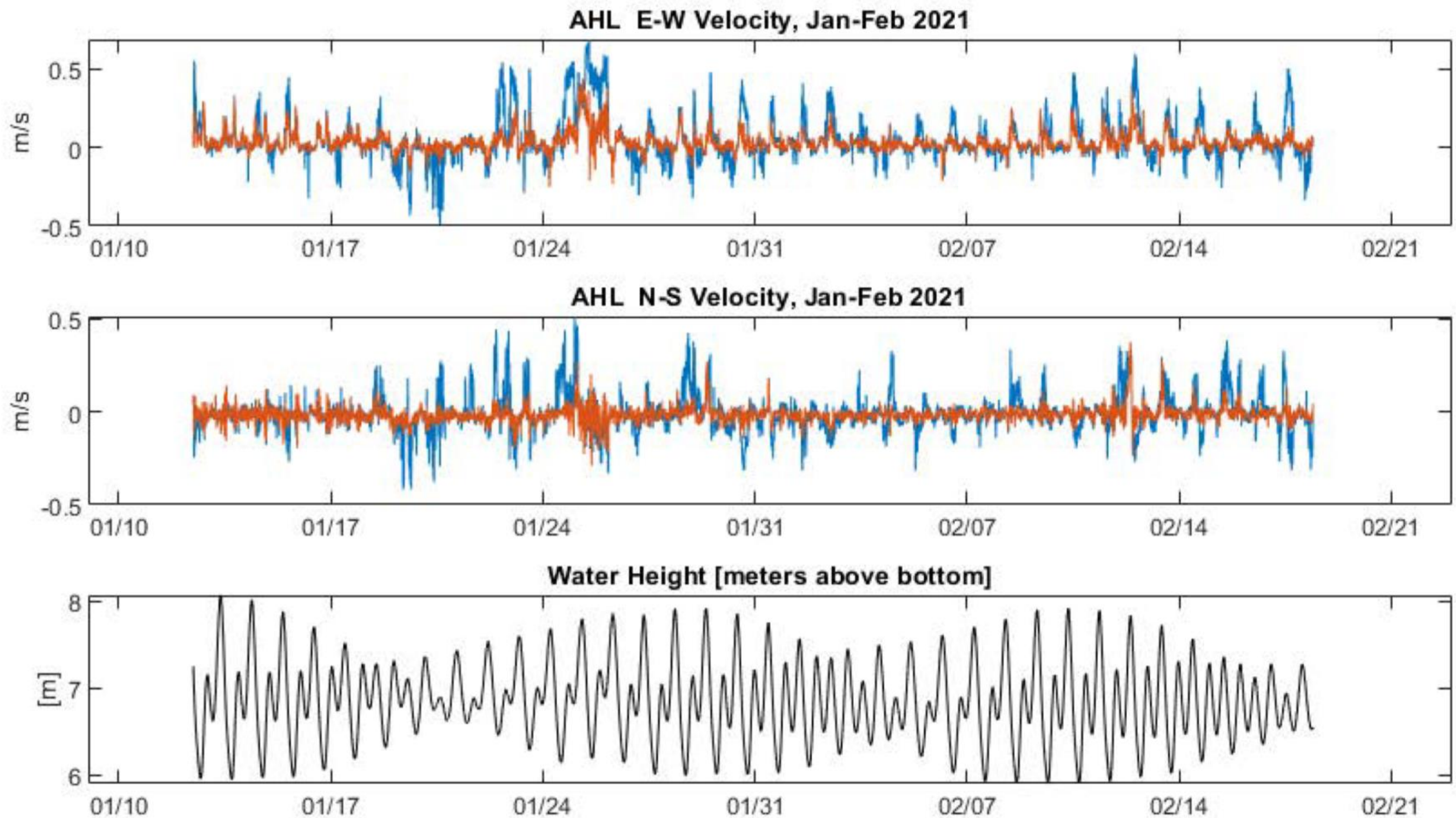
Over a 14-month period, the ambient currents in the Agua Hedionda Lagoon near the wedge wire screen demonstration study skid (WWS skid) were measured using an acoustic doppler current profiler (ADCP). The ADCP was mounted in a tripod on the lagoon floor approximately 100 feet away from the WWS skid. Approximately every two months, divers retrieved the ADCP from the tripod and returned it to the surface for servicing. Servicing included cleaning any biofouling or debris off the ADCP, downloading the recorded data, changing the batteries if needed, and relaunching the ADCP to continue recording data. After servicing, the divers returned the ADCP to the tripod mount.

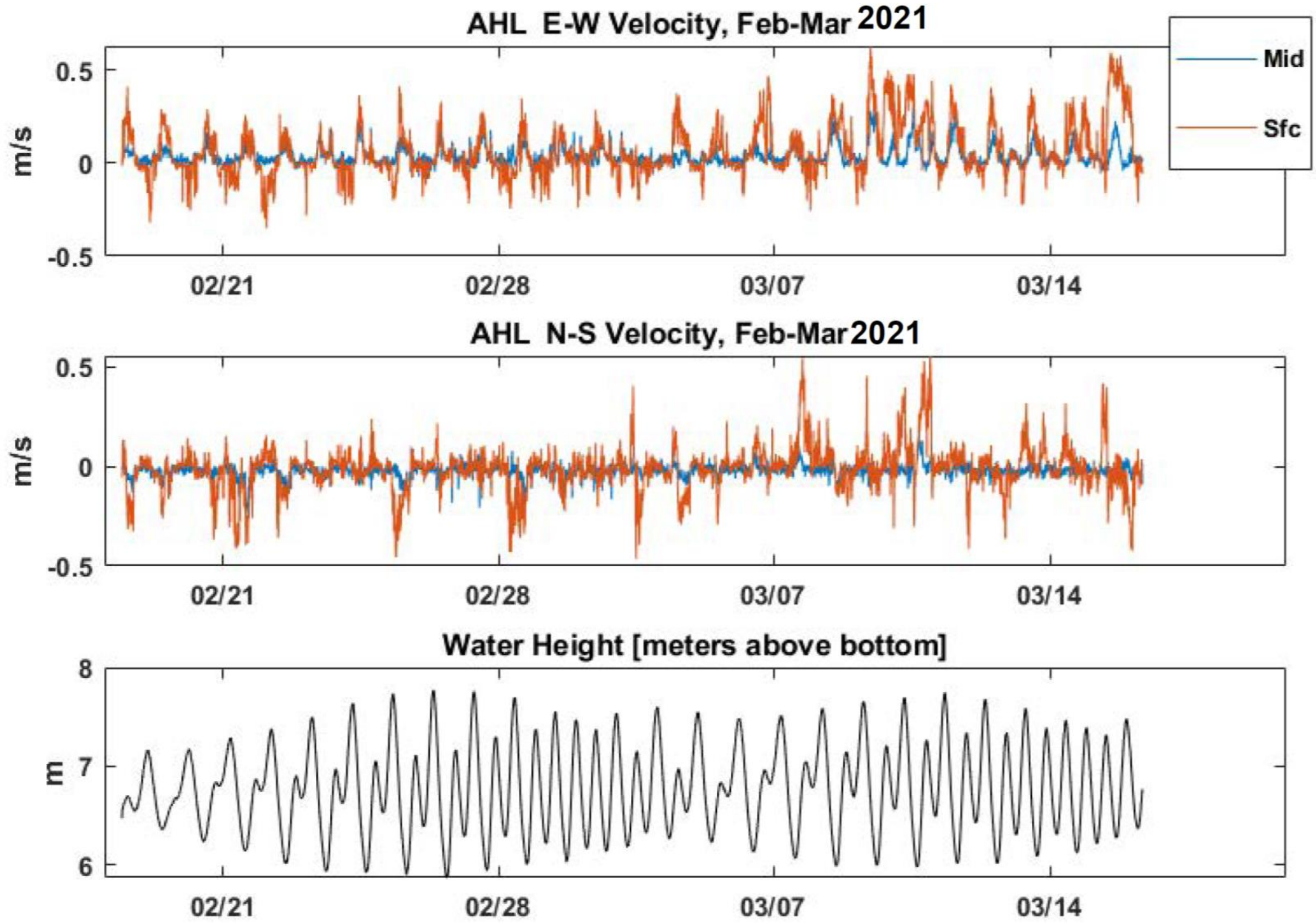
The ADCP was programmed to conduct soundings for one minute every 10 minutes throughout the water column from approximately 1.5 meters above the lagoon floor to near the surface. The ADCP averaged the 1-minute sounding data resulting in six measurements of water velocity and direction in 2-meter-deep depth bins per hour. The final depth bin may be inaccurate at times of the low tide.

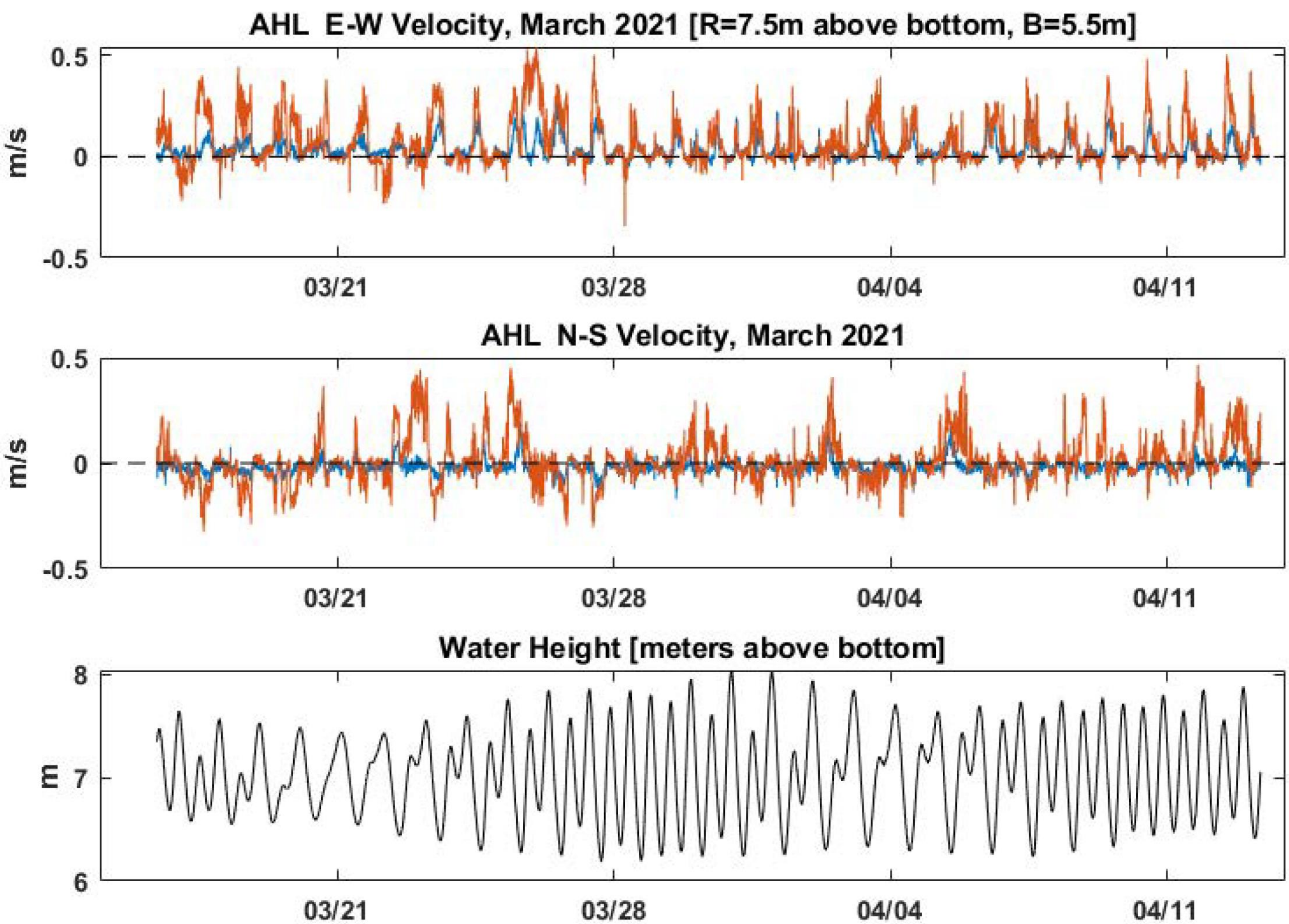
During each deployment, the highest current velocities were measured near the surface, with a range of 50-60 centimeters per second in all seasons. Maximum subsurface current velocities were approximately 20 centimeters per second. Average current speeds were much lower, 7-9 centimeters per second near the surface and 2-3 centimeters per second near the bottom.

Data summaries for each deployment period are provide in the plots below.

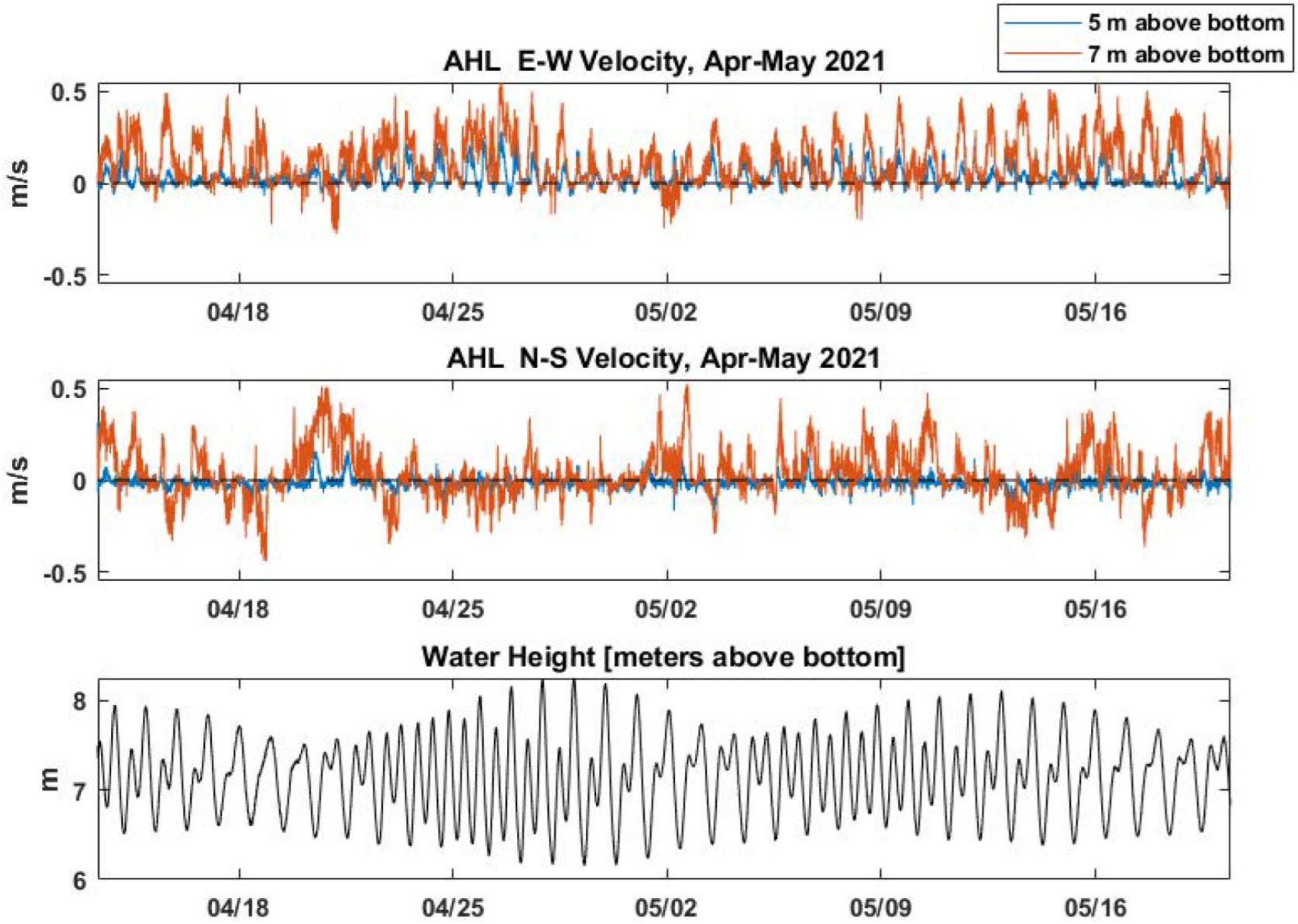

AHL E-W Velocity, Dec 2020
m/s
0.5
0
-0.5
12/13
12/20
12/27
01/03
01/10
AHL N-S Velocity, Dec 2020
m/s
0.5
0
-0.5
12/13
12/20
12/27
01/03
01/10
Water Height [meters above bottom]
[m]
8
7
6
12/13
12/20
12/27
01/03
01/10

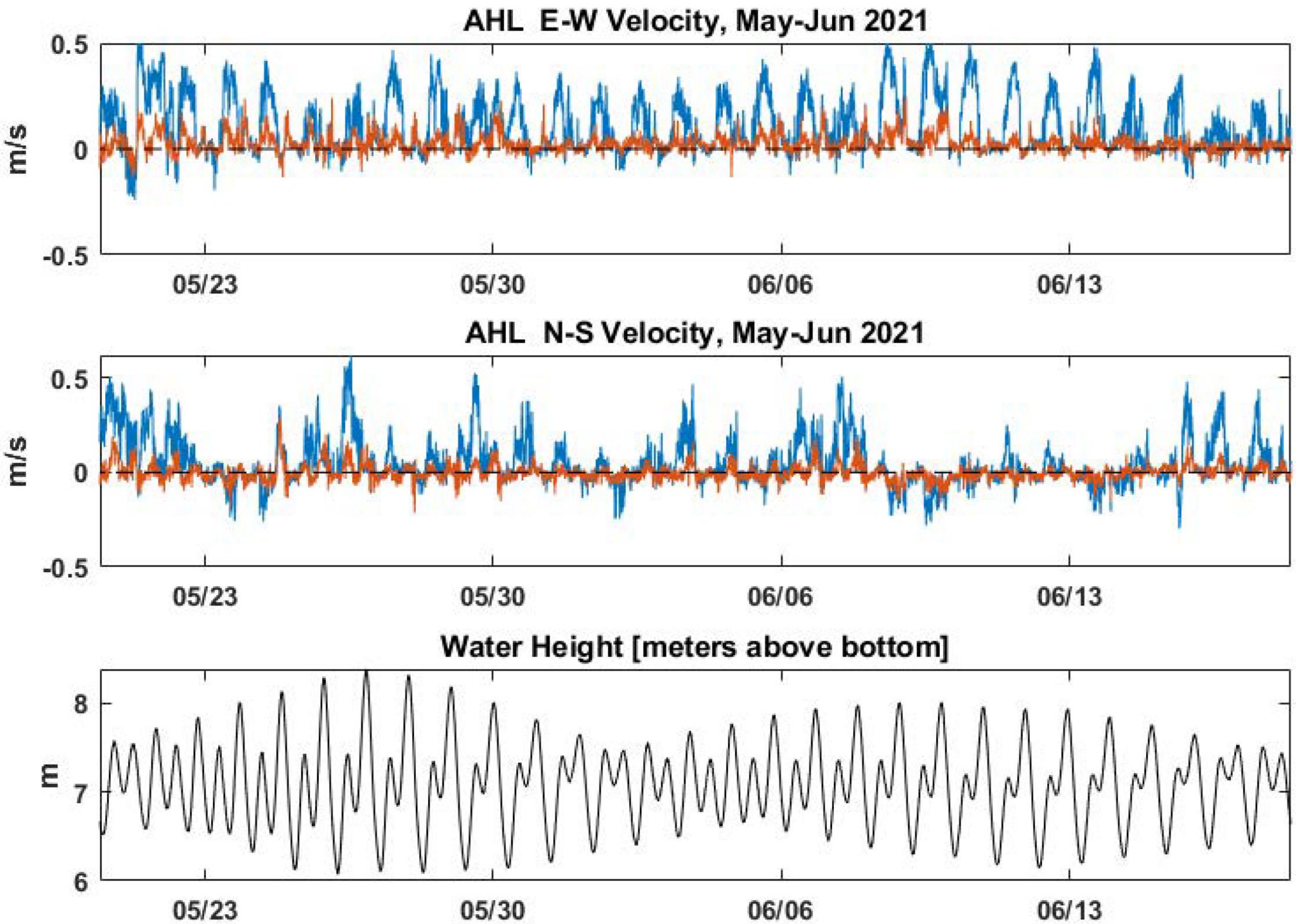

AHL E-W Velocity, Jan-Feb 2021
m/s
0.5
0
-0.5
01/10
01/17
01/24
01/31
02/07
02/14
02/21
AHL N-S Velocity, Jan-Feb 2021
m/s
0.5
0
-0.5
01/10
01/17
01/24
01/31
02/07
02/14
02/21
Water Height [meters above bottom]
[m]
8
7
6
01/10
01/17
01/24
01/31
02/07
02/14
02/21

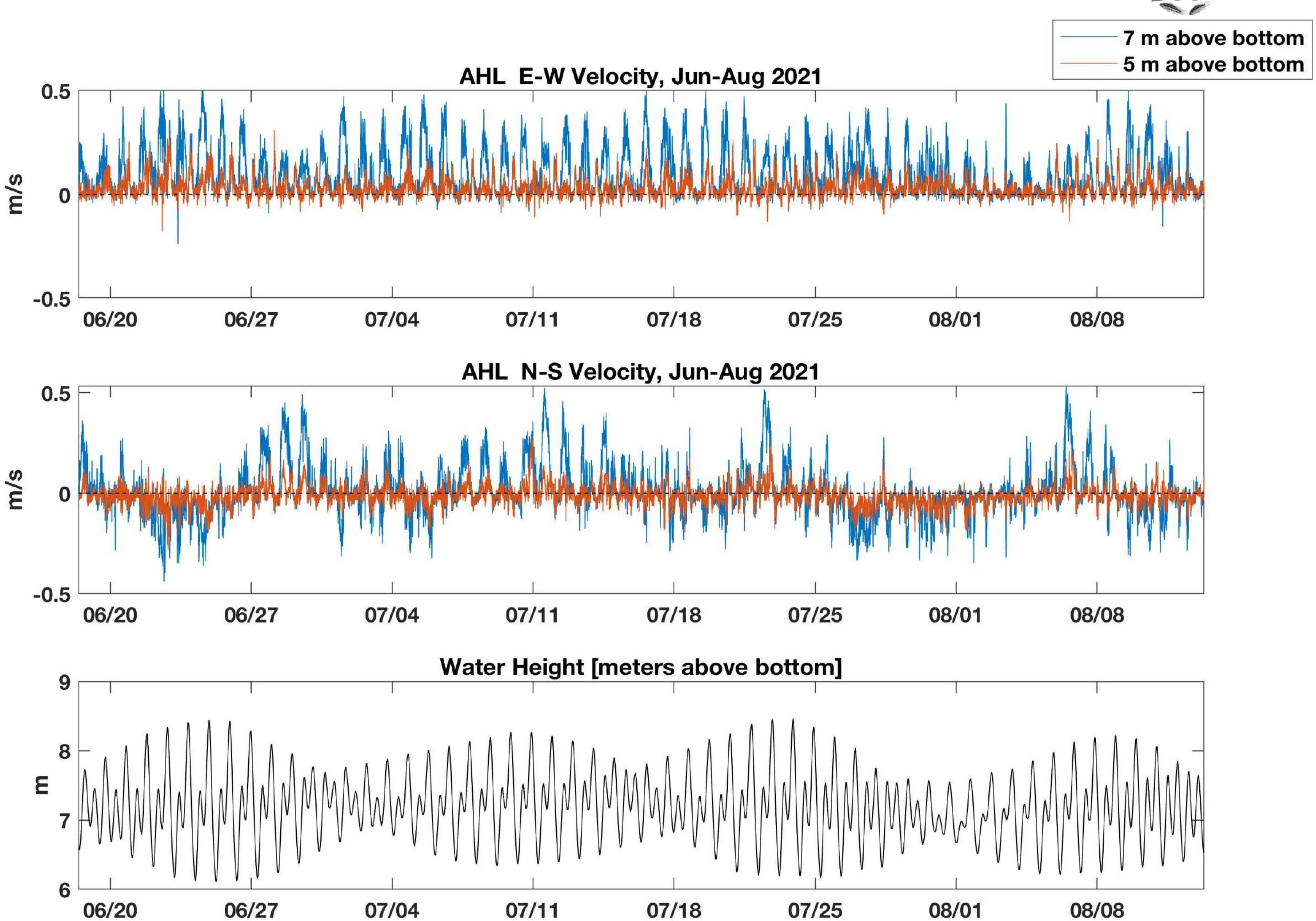

AHL E-W Velocity, Feb-Mar 2021
m/s
0.5
0
-0.5
02/21
02/28
03/07
03/14
Mid
Sfc
AHL N-S Velocity, Feb-Mar 2021
m/s
0.5
0
-0.5
02/21
02/28
03/07
03/14
Water Height [meters above bottom]
m
8
7
6
02/21
02/28
03/07
03/14

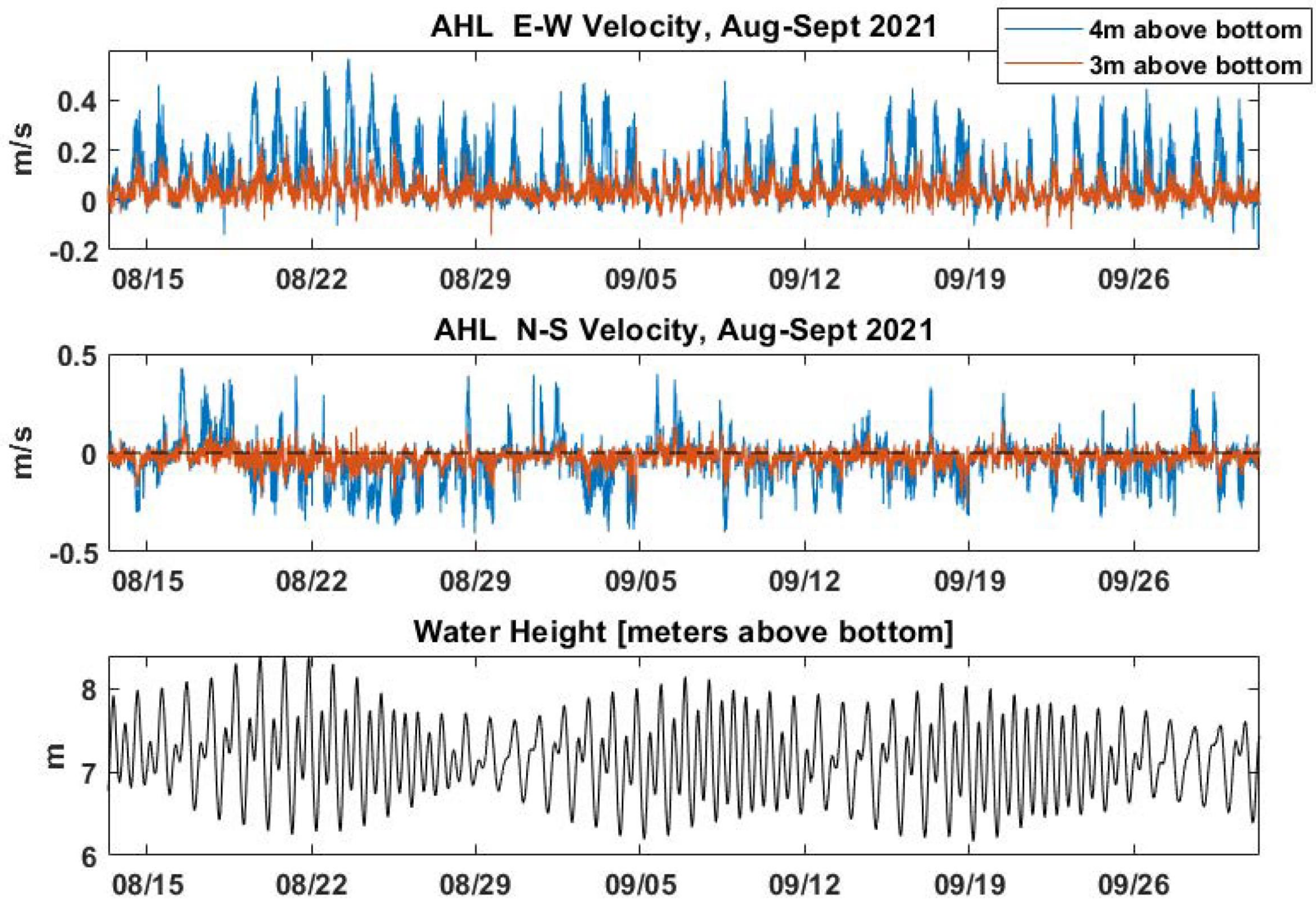


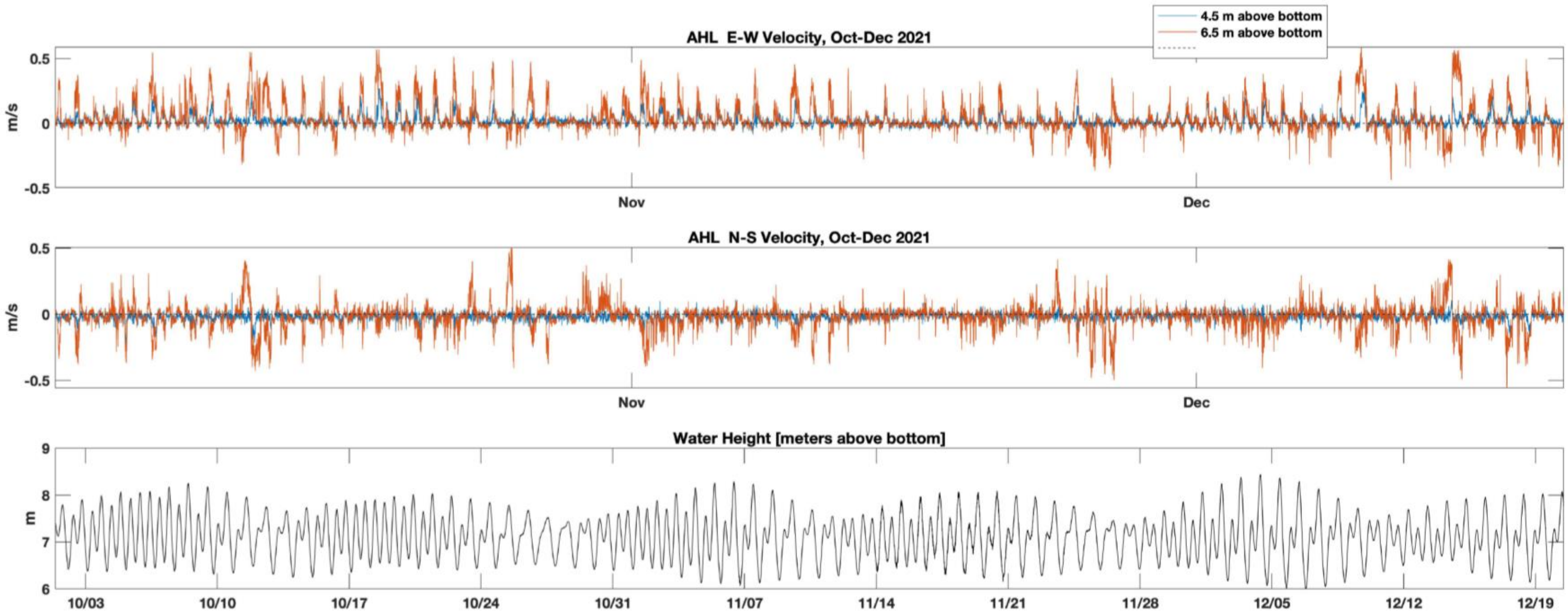
AHL E-W Velocity, March 2021 [R=7.5m above bottom, B=5.5m]
m/s
0.5
0
-0.5
03/21
03/28
04/04
04/11
AHL N-S Velocity, March 2021
m/s
0.5
0
-0.5
03/21
03/28
04/04
04/11
Water Height [meters above bottom]
m
8
7
6
03/21
03/28
04/04
04/11

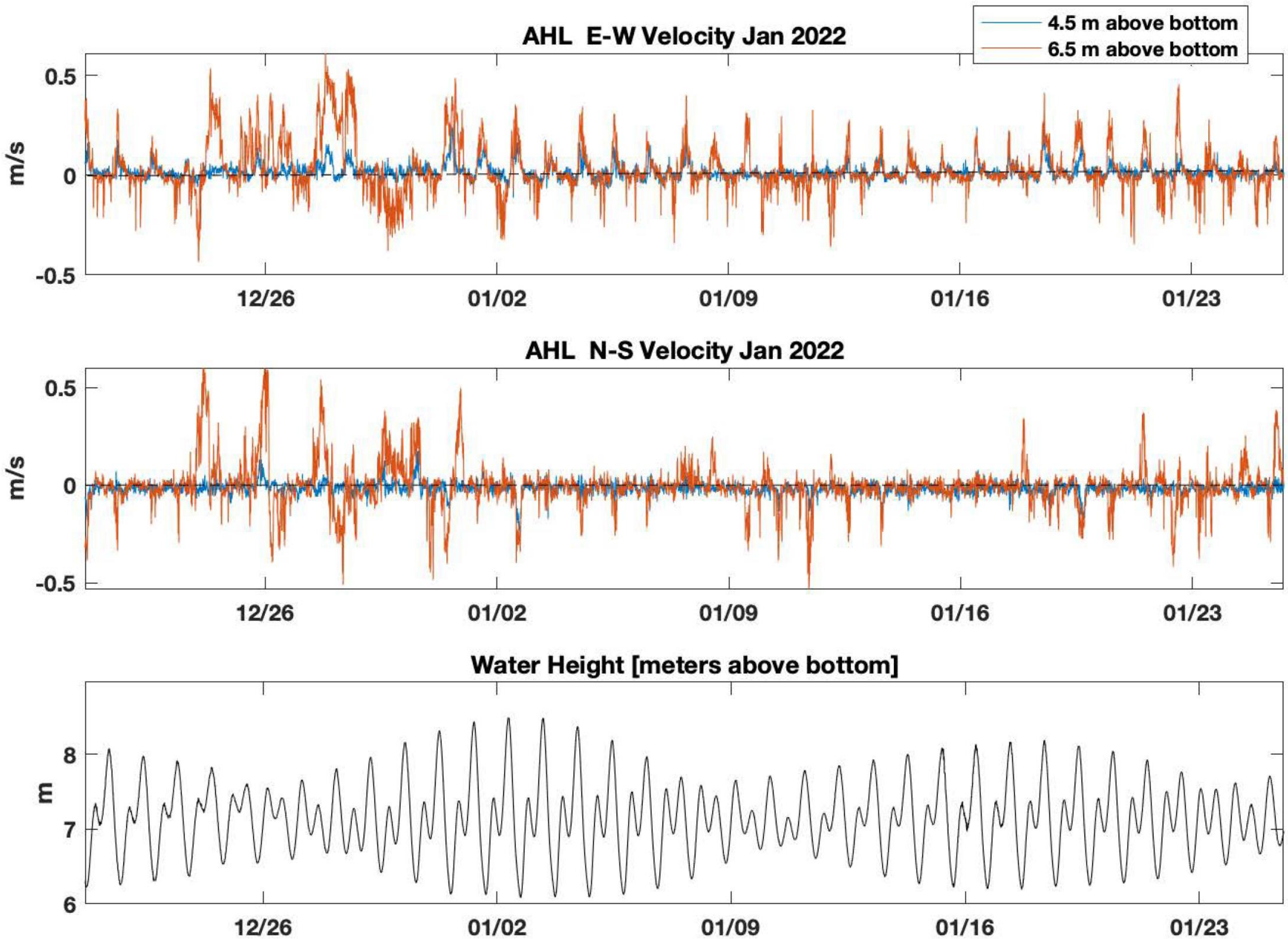

5 m above bottom
7 m above bottom
AHL E-W Velocity, Apr-May 2021
m/s
0.5
0
-0.5
04/18
04/25
05/02
05/09
05/16
AHL N-S Velocity, Apr-May 2021
m/s
0.5
0
-0.5
04/18
04/25
05/02
05/09
05/16
Water Height [meters above bottom]
m
8
7
6
04/18
04/25
05/02
05/09
05/16


AHL E-W Velocity, May-Jun 2021
m/s
0.5
0
-0.5
05/23
05/30
06/06
06/13
AHL N-S Velocity, May-Jun 2021
m/s
0.5
0
-0.5
05/23
05/30
06/06
06/13
Water Height [meters above bottom]
m
8
7
6
05/23
05/30
06/06
06/13

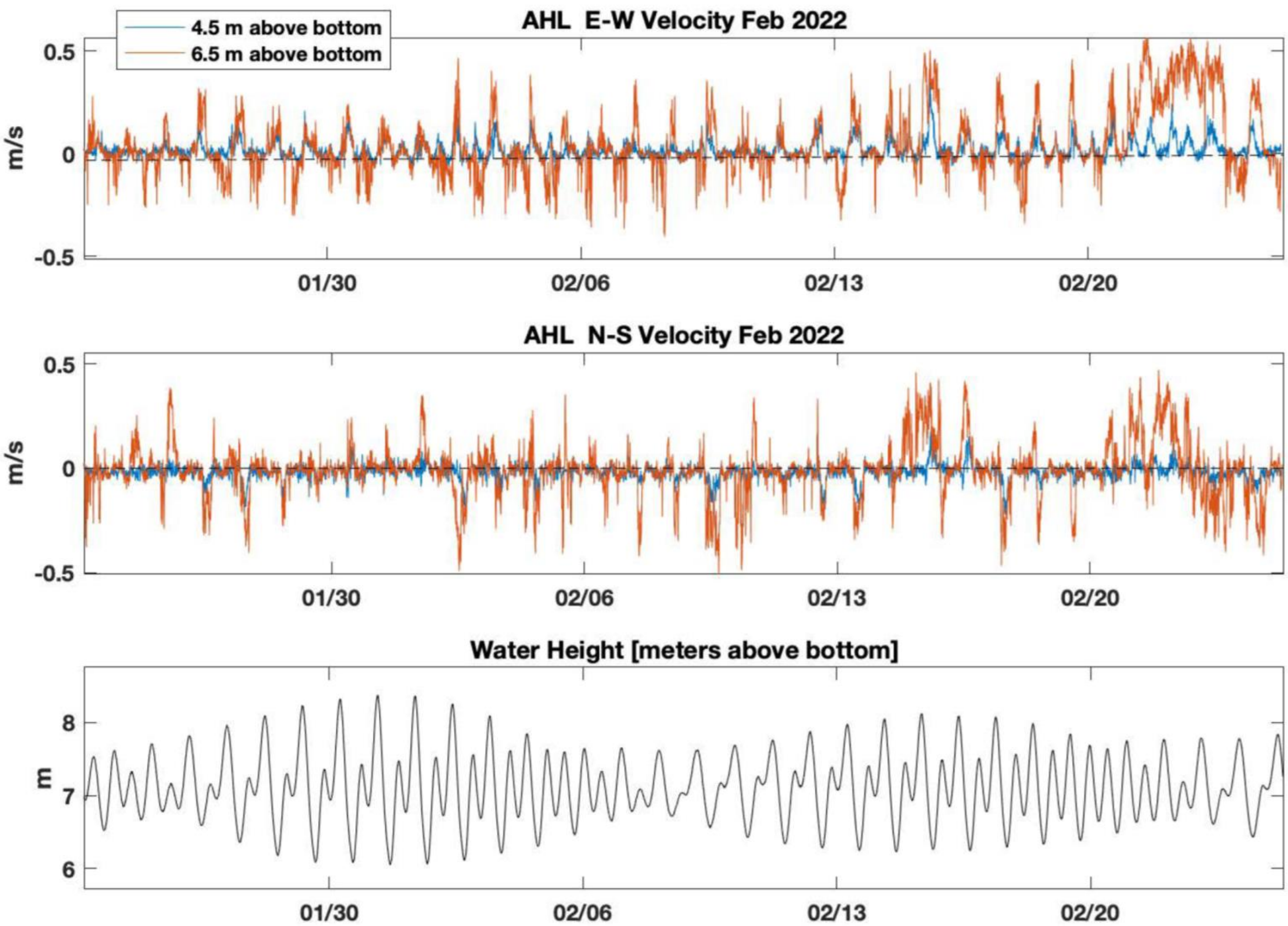

7 m above bottom
5 m above bottom
AHL E-W Velocity, Jun-Aug 2021
m/s
0.5
0
-0.5
06/20
06/27
07/04
07/11
07/18
07/25
08/01
08/08
AHL N-S Velocity, Jun-Aug 2021
m/s
0.5
0
-0.5
06/20
06/27
07/04
07/11
07/18
07/25
08/01
08/08
Water Height [meters above bottom]
m
9
8
7
6
06/20
06/27
07/04
07/11
07/18
07/25
08/01
08/08


AHL E-W Velocity, Aug-Sept 2021
4m above bottom
3m above bottom
m/s
0.4
0.2
0
-0.2
08/15
08/22
08/29
09/05
09/12
09/19
09/26
AHL N-S Velocity, Aug-Sept 2021
m/s
0.5
0
-0.5
08/15
08/22
08/29
09/05
09/12
09/19
09/26
Water Height [meters above bottom]
m
8
7
6
08/15
08/22
08/29
09/05
09/12
09/19
09/26


4.5 m above bottom
6.5 m above bottom
AHL E-W Velocity, Oct-Dec 2021
m/s
0.5
0
-0.5
Nov
Dec
AHL N-S Velocity, Oct-Dec 2021
m/s
0.5
0
-0.5
Nov
Dec
Water Height [meters above bottom]
m
9
8
7
6
10/03
10/10
10/17
10/24
10/31
11/07
11/14
11/21
11/28
12/05
12/12
12/19



AHL E-W Velocity Jan 2022
4.5 m above bottom
6.5 m above bottom
m/s
0.5
0
-0.5
12/26
01/02
01/09
01/16
01/23
AHL N-S Velocity Jan 2022
m/s
0.5
0
-0.5
12/26
01/02
01/09
01/16
01/23
Water Height [meters above bottom]
m
8
7
6
12/26
01/02
01/09
01/16
01/23



AHL E-W Velocity Feb 2022
4.5 m above bottom
6.5 m above bottom
m/s
0.5
0
-0.5
01/30
02/06
02/13
02/20
AHL N-S Velocity Feb 2022
m/s
0.5
0
-0.5
01/30
02/06
02/13
02/20
Water Height [meters above bottom]
m
8
7
6
01/30
02/06
02/13
02/20

Appendix C

Acoustic Survey Memorandum

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AUBURN, CALIFORNIA 95603
T 530.887.8500 F 530.887.1250

MEMORANDUM

To:	Tim Hogan, TWB
From:	Michael Carr, INCE
Subject:	Carlsbad Wedge Wire Screen Pilot Project Underwater and Airborne Noise Monitoring
Date:	June 22, 2021
Attachment(s):	Measurement Reports

Poseidon Water, with the assistance of TWB Environmental Research and Consulting, Inc. is currently performing a pilot study of potential cleaning methods for a wedge wire screen at the intake of the Claude "Bud" Lewis Carlsbad Desalination Plant. The intake is located in the southern portion of the Agua Hedionda outer lagoon, approximately 775-feet north of the cold-water intake for the NRG Cabrillo power plant. Due to the unknown potential for the project activities to generate underwater and airborne noise levels in the immediate vicinity of the wedge wire screen, Dudek was retained to provide monitoring services. This technical memorandum provides a summary of the setting, methodologies, and results of the noise measurement program conducted in the vicinity of the project.

1 Existing Setting

The airborne noise environment in the project vicinity is primarily influenced by vehicle traffic on Interstate 5 (I-5) and Carlsbad Blvd, and passenger rail activity to the east. Noise sources contributing to a lesser degree included distant recreational activities, operations at Carlsbad Aquafarm and natural noise sources (e.g., wind, waves breaking, birds, etc.). There were no notable sounds associated with either the desalination plan or power plant during the monitoring period.

The underwater noise environment in the project vicinity was fairly quiet, with the primary noise sources being from wave motion, as the outer lagoon of Agua Hedionda is a restricted zone with a very limited access, including harvesting operations of the Carlsbad Aquafarm, support and maintenance activities for the desalination and power plants and almost no other authorized boat traffic. Both airborne and underwater background ambient levels were measured during the testing period.

2 Monitoring Methodology

Measurements were performed at a distance of approximately two meters from the mid-point between the marker buoys, and repeated for on the southern, western and eastern sides of the safety boom/marker buoys. The hydrophone sensor was suspended at approximately mid-depth in the water column at all monitoring locations. The microphone (for airborne sound pressure measurement) was located on the deck of the vessel, approximately 6-feet above the deck.

Hydroacoustic measurements were performed using Reson Model TC 4013 hydrophone feeding a Larson Davis Model 831 Type 1 precision integrating acoustic analyzer. Field calibrations were performed on the analyzer configured for hydroacoustic measurements using a G.R.A.S. 42AA pistonphone calibrator and hydrophone coupler to allow for calibration re: 1µPa. Airborne sound pressure level measurements were similarly performed with a Larson Davis Model 831 analyzer, equipped with a PRM831 preamp and random-incident microphone. Field calibrations were performed on the analyzer configured for airborne sound pressure level measurements using a Larson Davis Cal 200 acoustical calibrator to allow for calibration re: 20 µPa. Both measurement setups were calibrated before and after the measurements to ensure accuracy and the validity of the measurements

Weather during the measurement period was favorable, with clear skies throughout the day and calm conditions inside the lagoon. Temperatures ranged from the low of 60° F at the beginning of the measurements to high of 64° F. Wind speeds at the nearest weather station averaged 6 to 10 mph, gusting up to 16 mph; however, within the outer lagoon, winds remained below 5 mph. Wave heights were approximately 0 to 1 feet, with the tide flowing out of the lagoon for the majority of the measurement period. Low tide occurred at approximately 12:15 PM. Minimal cloud cover was present, and no precipitation was experienced during the measurement period.

3 Monitoring Results

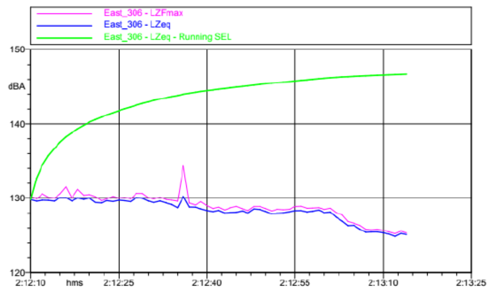
Hydroacoustic/underwater and concurrent airborne noise monitoring was conducted by Dudek acoustics specialists on Friday, May 21, 2021, from approximately 10:00 AM until 4:00 PM. Monitoring was intended to collect representative sound level data for the operation of both the active screen rotation and the passive screen airburst cleaning cycles, with and without operation of the pumps. The scenarios that were tested during the monitoring are presented in Table 1.

Table 1 – Underwater and Airborne Noise Measurement Summary

Component Status			Pressure Level by Measurement Position – Average (Maximum)					
			Underwater, dBZ			Airborne, dBZ		
Pumps	Active Screen Rotation	Passive Screen Airburst	South	West	East	South	West	East
Off	Off	Off	117.6 (124)	117.2 (120.5)	118.1 (124.1)	88.4 (101.4)	85.3 (95.5)	85 (95.8)
	On	Off	125.1 (131.2)	118 (126.4)	119.7 (132.8)	86.2 (96.2)	85.6 (97.7)	84.1 (94.8)
	Off	On	120.7 (133.5)	118.7 (127)	119.6 (128.7)	85.7 (96.1)	86.9 (99.8)	83 (92)
On	Off	Off	137 (139.8)	125.6 (132.9)	128.2 (130.3)	85.2 (97.7)	84 (96.7)	86.3 (99.9)
	On	Off	138.5 (140.6)	124.6 (129.1)	128.6 (132.3)	85 (98.8)	81.8 (95.3)	84.9 (97.8)
	Off	On	139.5 (144.7)	125.2 (134.1)	128.6 (134.4)	86 (99.1)	84.8 (98.1)	83.4 (94.6)

As shown in Table 1, underwater background ambient noise levels were reasonably consistent at all three measurement locations (South, West, East) at 117 to 118 dBZ Leq, with maximum background noise levels reaching 124 dBZ. With the pumps in the off position, the active screen rotation was between approximately 1 and 7 dBZ above the background noise levels; and, noise levels generated by the airburst at the passive screen ranged between 1.5 to 3 dBZ above the background.

With the pumps in the on position baseline average noise levels increased by approximately 8 to 10 dBZ. Rotation of the active screen was barely audible above the noise generated by the pumps, and only for brief periods of time. The active screen rotation did not appreciably affect measured noise levels with the pumps turned on. Noise generated by the airburst at the passive screen resulted in a marginal increase of the measured noise levels at the southern and eastern measurement positions, and a slight decrease in noise levels at the eastern measurement position, with the pumps on. The initial airburst still remains visible in the time histories, even with the pumps on, as shown below. Also visible on the time histories is a decrease in the measured pressure levels during the middle and latter portions of the airburst, which is a direct result of the air being introduced into the water column.



As shown in Table 1, the airborne noise levels during all of the measurement periods remained unaffected by the project activities, with average airborne noise levels ranging from approximately 83 to 88 dBZ Leq and reaching a maximum noise level of 101.4 dBZ Lmax. The airborne noise levels measured during the monitoring period were noted to be caused by vehicular traffic on the local and regional roadways surrounding the project. The initial portion of the airbursts at the passive screen were audible on the audio recordings but only for very brief moments and did not affect the measured pressure levels.

Regulatory Discussion

While not directly applicable to this project National Oceanic and Atmospheric Administration - Fisheries and National Marine Fisheries Service (NOAA-Fisheries/NMFS) joined with Caltrans, other regulatory agencies and researchers to form the Fisheries Hydroacoustic Working Group (FHWG) with the intent to provide guidance and establish criteria for the evaluation. The FHWG and NMFS issued interim guidance on hydroacoustic levels resulting from pile driving activities and subsequently agreed upon a dual metric criterion of 206 dB re: 1µPa Peak for any single strike and an accumulated SEL of 187 dB re: 1µPa2-s for all fish greater than 2 grams in size. The agreed upon criteria for fish less than 2 grams lowers the accumulated SEL limit to 183 dB re: 1µPa2-s. In addition, NMFS believes a threshold of 150 dB re: 1µPa RMS average pressure levels for behavioral responses for salmonids and green sturgeon is appropriate, until new information indicates otherwise.

The project does not generate hydroacoustic impact pressure levels that would be evaluated against the impact threshold intended for the evaluation of pile driving activities. The accumulated SEL and average RMS levels generated by the project activities do not approach or exceed any of the remaining FHWG criterion.

Appendix D

Progress Report #5 - Account of Partial Un-Anchoring and Re-anchoring of Skid

Carlsbad Desalination Wedge Wire Screen Pilot Plant

Progress Report #5

Date: October 14, 2021

By: Tim Hogan, TWB Environmental Research and Consulting, Inc.

Josie McKinley, Poseidon Water

Background

- Project was commissioned and became operational on Monday, Dec 7 at 9:29 am PST
- Progress Report #1 covered operation through Jan 20, 2021
- Progress Report #2 covered operation between Jan 21 and Feb 25, 2021
- Quarterly Report # 1 covered operation between Dec 7, 2020 and Mar 15, 2021
    - PPT delivered to SDCWA on Mar 26, 2021
- Progress Report #3 covered operation between Mar 16 and May 17, 2021
- Progress Report #4 covered operation between May 18 and Jun 17, 2021
- **Progress Report #5 covers operation between Jun 18 and Aug 13, 2021**

General

This progress report serves as a record of the June 18 tipping of the skid and the re-anchoring and recommissioning effort.

Operations Summary

The summary below is based on the dives that were conducted during this period. No operational data were collected as the skid components were locked-out/tagged out due to the skid tipping over.

June 18 Dive

- The passive flow meter was removed by divers and replaced with a dummy spool piece.
- An ISI technician was on the Dive Support Vessel with the divers to oversee the removal of the passive flowmeter and to waterproof the loose cables after removal.
- Meter was shipped to Siemens for diagnostics and found to be covered by the warranty. New meter will be shipped by Sept 23.

- After flowmeter was removed, diver noticed that skid had become partially un-anchored, with the passive side rising toward the surface and active side toward the Lagoon floor. Skid was almost vertical with a slight lean toward the south toward the EPS intake (Figure D-1).
- Upon notification of the tipping, all powered components were locked-out/tagged-out in the PCR. This included both skid pumps, the active screen motor, and the passive screen airburst.
- Divers were tasked with assessing skid condition and noting any damage.
- Goal was to assess whether skid was stable in current position or not. Divers noted skid was stable and safe in current position.
- Only damage appeared to be to the two active-side helical anchors which were bent.
- Both helical anchors on the passive (west) side were completely pulled out of the Lagoon floor. The tips that were once buried were about 13 ft above the seafloor.
- The umbilical section closest to the skid was inspected and was not damaged

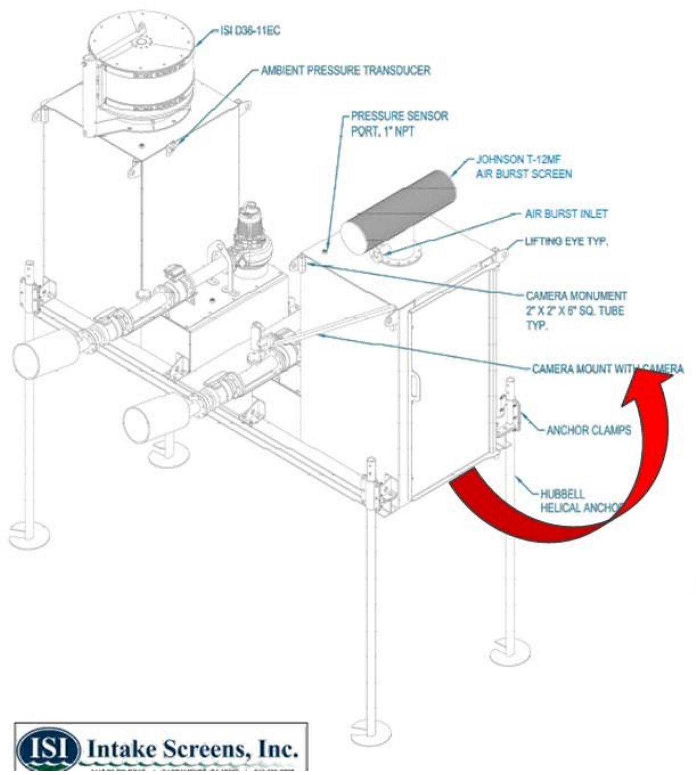


Figure D-1. Direction that skid tipped indicated with arrow. Passive (west) side floated to surface and active (east) side sank toward Lagoon floor.

- No damage to the screens or pumps
- Active screen was partly embedded in sediment
- The skid was still fully contained within the orange stand-off boom
- Divers opened one end (on the high side) of the passive screen to see inside and to vent any air that could have been trapped

- There wasn't much air trapped
- The inside of the passive screen was "packed" with mussels (Figure D-2)
- Divers did not clean inside of passive screen – waiting until skid is reanchored and re-commissioned.

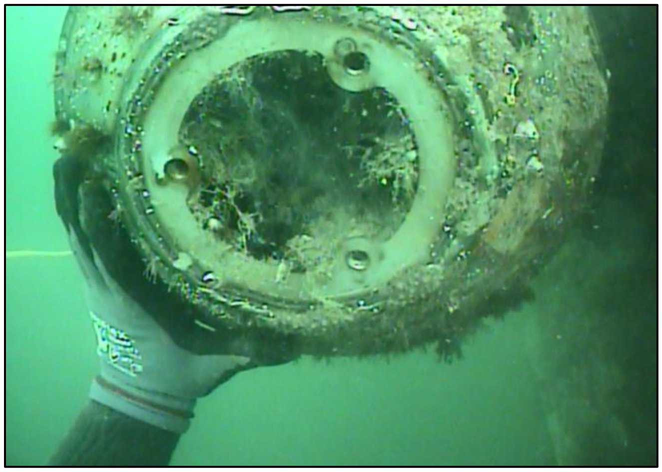


Figure D-2. Diver photo of fouling inside of passive screen – endcap removed.

- Divers opened the passive pump box door – only a small burp of air was released.
- Review of the diver videos and survey report indicate that the most likely cause was trapped air inside of the passive screen creating sufficient lift to pull the passive helical anchors out of the Lagoon floor. With the screen heavily fouled on the inside, air from airbursting may not have been able to escape.

Planning for Skid Re-anchoring

- Between July 5 and Aug 8, the Pilot Project team planned for the re-anchoring of the skid and recommissioning of the system.

August 9 Dive (Mobilization and Skid Re-inspection)

- Global and ISI arrived on site at CA Water Sports boat ramp and launched the Scully and the ISI floating platform
- ISI floating platform was towed to skid and secured to orange boom
- Global conducted dive inspection of skid and found:
  - skid was in basically the same condition as when first inspected after the tipping (June 18)
  - all components looked ok
  - service loops on cables for other components look ok
  - umbilical was undamaged and still connected to skid
  - clamps holding the active (east) side helical anchors are bent. The northeast clamp was bent about 45 degrees and the southeast clamp was bent about 20 degrees.
- ISI checked the Master Control Panel (MCP) in the PCR and determined that all recent alarms were caused by a failed pressure transducer on the passive side of the

skid. The failure caused it to send excessive current to the PLC input card, which then shut down to protect itself. We got multiple component alarms since more than one signal is directed to that input card. Jordan disconnected the wires for the passive pressure transducer at the MCP and restored functionality to the other components. A new passive pressure transducer was ordered.

August 10 Dive (Skid Re-anchoring)

- Removed two passive helical anchors which were no longer embedded in Lagoon floor (Figure D-3)

Figure D-3. One of the two passive side helical anchors that had removed itself from the Lagoon floor during the skid tipping.

- Removed camera to prevent damage during winching. Note: Camera had previously lost its video signal on May 27. We were not able to troubleshoot camera issue.
- Attached skid to wire winches on ISI floating platform
- Clamps were opened and skid was freed from anchors
- Bent clamps were successfully straightened (Figure D-4)

Figure D-4. Bent anchor clamps on active side being straightened with come-along (left) and using helical anchor shaft for leverage (right)

- Old/bent active side anchors were not yet removed from Lagoon floor
- Two holes were dug to get the helical heads of new anchors started on the active side
- Two new anchors were driven to refusal on the active side (NE anchor embedded to 7'9", SE anchor embedded to 8'2")
- The active side clamps were closed on the new anchors
- Passive side of skid was resting on bottom

<u>August 11 Dive (Skid Re-anchoring)</u>

- Removed the two old/bent active side anchors (Figure D-5)

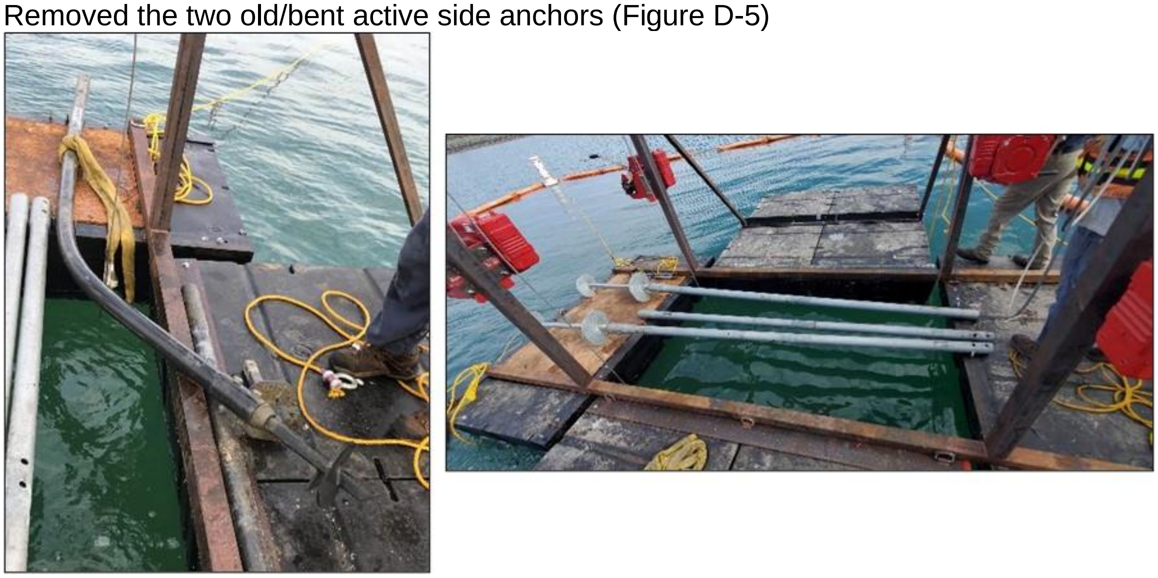


Figure D-5. One of the two bent active side helical anchors removed (left) and two of the four new helical anchors installed.

- Dug two holes to get the helical heads of new anchors started on the passive side
- Drove two new anchors to refusal on the passive side (NW anchor embedded to 8’7”, SW anchor embedded to 8’5”); active side anchors were already installed the previous day (Tues).
- Closed all clamps on passive side anchors; active side anchors were already secured the previous day (Tues)
- Pressure washed skid to clear of biofouling organisms
- Pressure washed passive screen flange (not screen) and airburst flange to make it easier to remove passive screen on Aug 12 (Thursday)
- Turned on active screen to clean overnight every 20 min (i.e., 72 cycles/day); all other components remained LOTO

<u>August 12 Dive (Screen and Skid Cleaning)</u>

- Shut off active screen and LOTO in PCR
- Removed passive screen and brought to shore for Aqseptence representative inspection
- Cleaned (internal) active screen underwater with ISI representative watching via diver video feed
- Cleaned (internal and external) passive screen above water by hand and with pressure washer (Figure D-6) and re-installed on skid

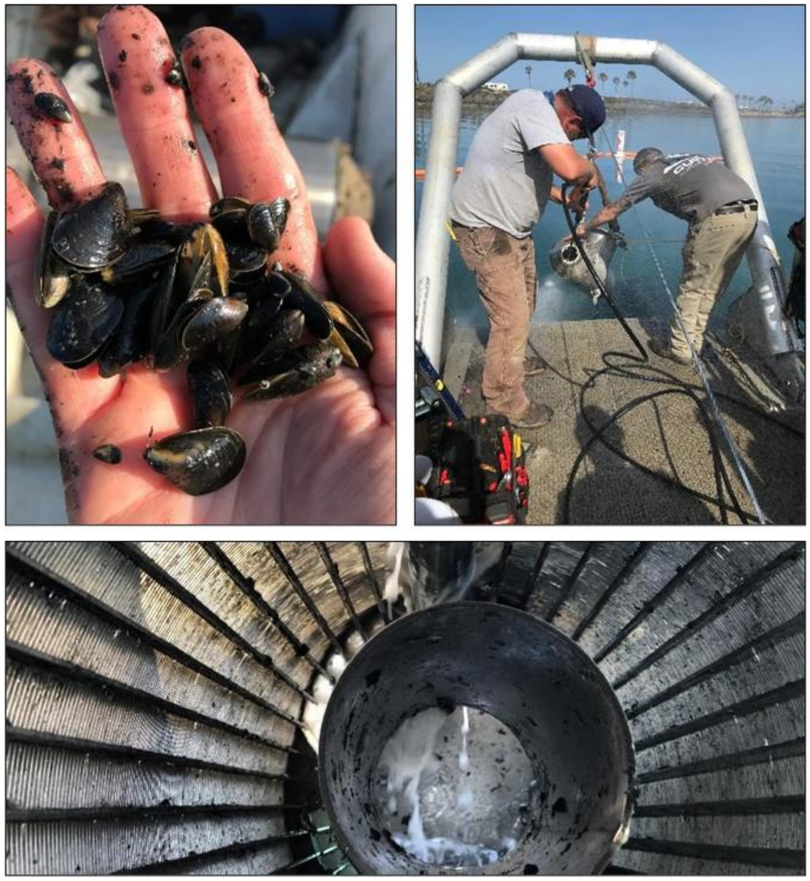


Figure D-6. Blue mussels removed from inside passive screen (top left), divers cleaning passive screen with pressure washer after it had been recovered to the surface (top right), and view through endcap of cleaned internal surfaces.

- Inspected/cleaned skid components (pressure transducers, active flow meter)
- Re-commissioned skid and this is the status of each component:
    - Active and passive pumps working and drawing correct amperage
    - Active and passive peristaltic pumps working and drawing flow – will need to operate for a bit before turbidity data are reliable
    - Active screen cleaning motor working
    - Passive airburst system working
    - Ambient and active pressure transducers working; passive pressure transducer had failed on Aug 8 – ISI has ordered a replacement
    - Passive flowmeter – was returned for diagnosis to vendor – warranty replacement will be shipped by Sept 23
    - Active flowmeter – once active pump was placed back into service, it gave odd readings and was behaving similarly to passive flowmeter which previously failed. Divers also noted a pinhole leak in meter during inspection. We spoke to vendor and have initiated a Return Merchandise Authorization.

   - Camera is not working – stopped brushing effectively and appears there is water intrusion. We have spoken to the vendor who is planning to send a newer model replacement
- Cleaning frequency set based on vendor recommendation:
   - Active – brush cleaned three times/day – no change from previous setting
   - Passive – increased from four to eight airbursts/day

August 13 Dive (Baseline Survey)

- Serviced ADCP and collected monthly water quality data
- Re-installed cleaned camera in order to make sure wet mate connectors are not exposed for an extended period of time. Camera connection was having problems – call placed to camera vendor.
- Completed baseline survey to document current installed conditions after re-anchoring. Both screens are in like-new condition (Figure D-7)

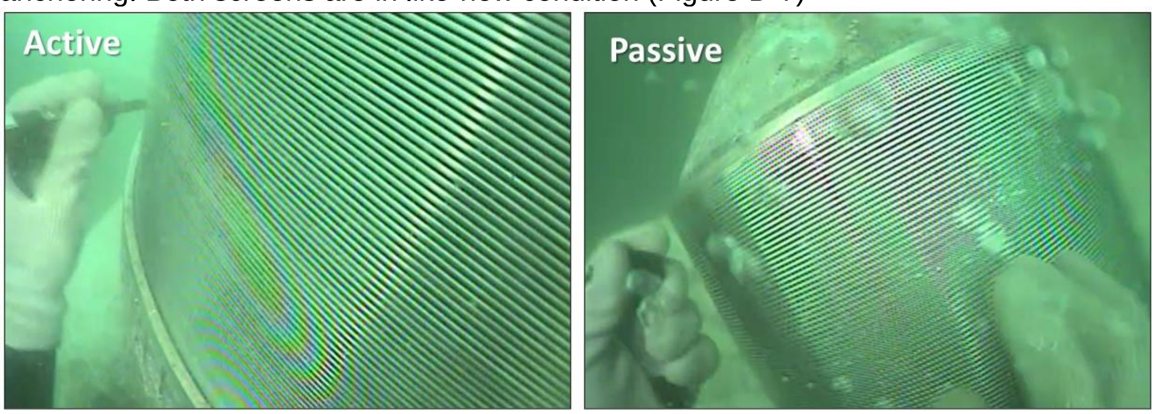


Figure D-7. Like-new condition of external screening surfaces of active screen (left) and passive screen (right).

Next Steps

- Next monthly survey is tentatively planned for September 14, 2021.
- New monthly protocol is to open both ends of the passive screens and clean the internal surfaces.
- Receive new passive flowmeter from Siemens – based on delivery date of Sept 23, installation may not occur until October monthly dive.
- Remove malfunctioning active flowmeter and return to Siemens for diagnosis.
- Receive and install new passive pressure transducer – based on quoted lead time of approximately 11 weeks, installation may not occur until November monthly dive.
- Procure and install coated coupons – based on long lead times quoted by coatings vendors, installation date may be up to eight weeks.
- Continue tracking turbidity monitoring system performance; consider alternative turbidity monitoring system to get more reliable data.
- Continue monitoring the skid via the remote data acquisition system.
- Troubleshoot underwater camera.

Appendix E

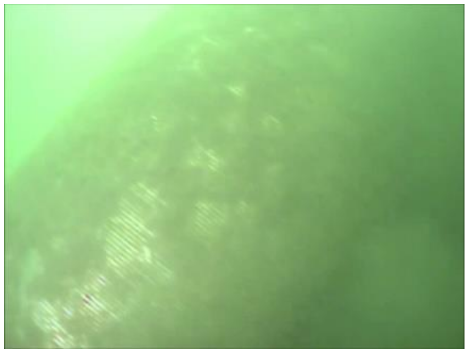
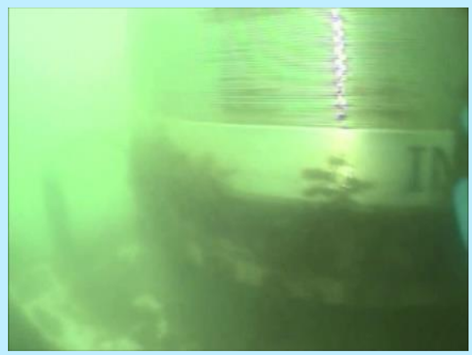
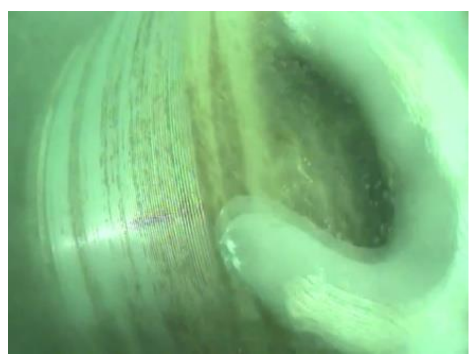
Monthly Diver Observations of Screen Conditions

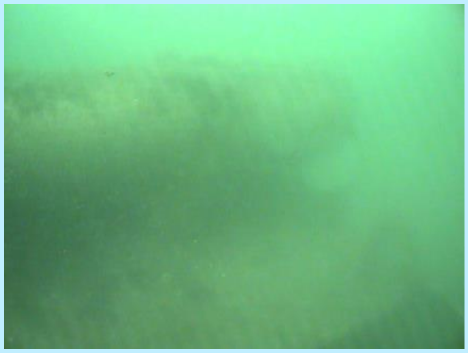
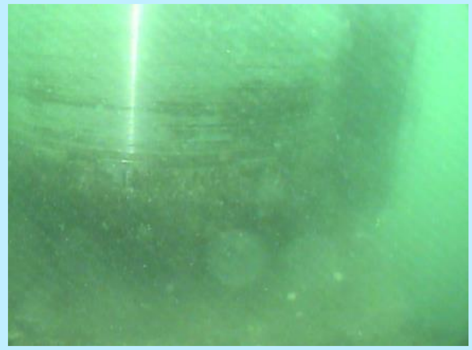
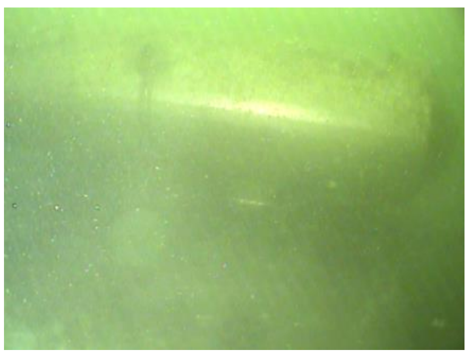
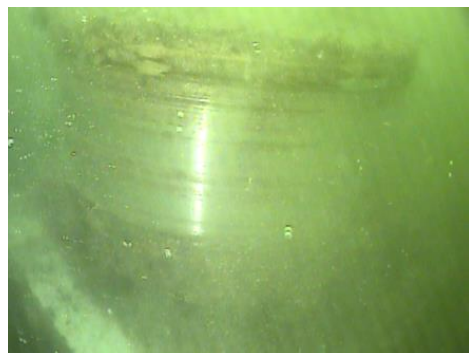
Table E-1. Summary of monthly diver observations of screen conditions.

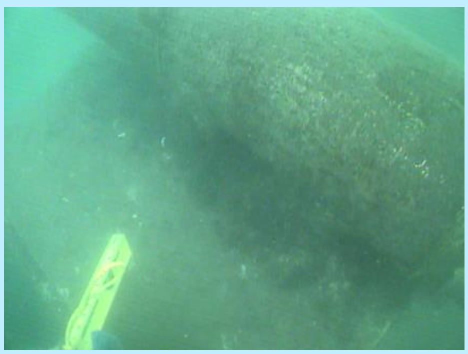
Diver Observations		
Dive Survey Date	**Passive WWS**	**Active WWS**
01/12/21	100% coverage, 1/4-1/2 inch thick, soft growth.	Clean
02/18/21	100% coverage, 1/4-1/2 inch thick, soft growth.	Clean
03/16/21[1]	100% coverage, 1/4-1/2 inch thick, soft growth.	Thin layer of soft growth (1/8-1/4 in).
04/13/21	100% coverage, soft growth, didn't indicate thickness, appears to be the same as previous survey (1/4-1/2 in).	"Mostly clean", some faint streaks on screen.
05/20/21	Almost 100% (80-100%) coverage, soft growth. Didn't indicate thickness.	Very minimal soft growth (didn't indicate how thick, appears to be 1/8-1/4 in) light corrosion on bottom (non-screening) base of screen.
09/14/21	100% coverage, soft growth, 1 inch thick.	Clean, slight discoloration (streaks) in small areas. Does not appear to be corrosion.
10/19/21	100% coverage, soft growth, 1 inch thick.	Clean, streaks still present.
11/19/21	Less growth coverage than previous months. Thickness not quantified/% coverage not indicated.	Light film "dusting" (<1/8 in) – appears to include sediment, streaky but mostly clean.
12/15/21	100% coverage, soft growth. Was not quantified. Buildup of growth inside pump box.	Light film, "dusting" (<1/8 in) – appears to include sediment, streaky but mostly clean, brush adjusted.
01/18/22	80-100% soft growth. Didn't indicate thickness. Appears 1/4-1/2 in thick.	Light film, "dusting" (<1/8 in) – appears to include sediment, streaky but mostly clean.
02/09/22	80-100% soft growth. Didn't indicate thickness. Appears 1/4-1/2 in thick.	10-20% soft algae growth. Sporadic across screen. Diver noted brush may need to be adjusted again.
[1] **This dive survey followed the third month of operation during which the screens were programmed to initiate cleaning cycles based on low flow rate or high DP**. During this period, the passive WWS did not airburst for approximately 2.5 weeks and the active WWS did not rotate at all.		

Table E-2. Photographs of monthly diver observations of screen conditions.

Dive Survey Date	Passive WWS	Active WWS
01/12/21		
02/18/21		
03/16/21[1]		

Dive Survey Date	Passive WWS	Active WWS
04/13/21		
5/20/21		
09/14/21		

Dive Survey Date	Passive WWS	Active WWS
10/19/21		
11/19/21		
12/15/21		

Dive Survey Date	Passive WWS	Active WWS
01/18/22		
02/09/22		

[1] This dive survey followed the third month of operation during which the screens were programmed to initiate cleaning cycles based on low flow rate or high DP. During this period, the passive WWS did not airburst for approximately 2.5 weeks and the active WWS did not rotate at all.