



Rich Passage Fort Ward Atlantic Salmon Net Pens Engineering Assessment

January 29, 2018

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Acronyms and Abbreviations

AGS	American Gold Seafoods
AIS	marine vessel Automatic Identification System
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BAP	Best Aquaculture Practices
DNR	Washington State Department of Natural Resources
ECY	Washington State Department of Ecology
ft.	feet
Hs	Significant Wave height
in.	inch
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
NOAA	National Oceanographic and Atmospheric Administration
OHW	Ordinary High Water
ORN	Orchard Rocks – North
ORS	Orchard Rocks - South
PATON	Coast Guard Private Aids to Navigation
ROV	Remotely Operated Vehicle
Tp	Peak wave period
USACE	US Army Corps of Engineers

Certifications

This report has been prepared by Mott MacDonald under the supervision of a Professional Engineer, including all findings and recommendations.



Date: January 29, 2018

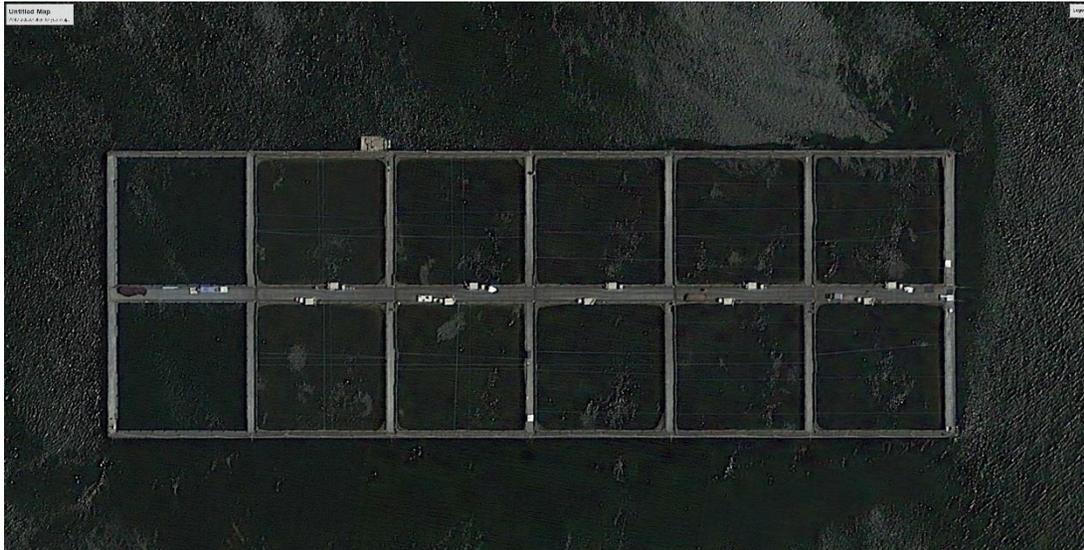


January 29, 2018

1 Introduction

This report presents the results of a document review, site visit and assessment of the net pen facilities at Fort Ward in Rich Passage owned by Cooke Aquaculture. **Figure 1** is an aerial photo of the facility. This work has been performed by Mott MacDonald for the State of Washington Department of Natural Resources (DNR). The dive inspection portion of the work has been performed by Collins Engineers, Inc. as a sub-consultant to Mott MacDonald.

Figure 1: Fort Ward Net Pens – Oblique Aerial Photo - May 2017



Source: Google Earth Aerial Photo

This report is one of seven engineering assessment reports that are being prepared by Mott MacDonald, one for each net pen at different sites in Puget Sound and Port Angeles. DNR holds several lease agreements with Cooke that authorize Cooke to operate Atlantic salmon net pen facilities in Washington state waters at four locations. The locations of these facilities and the planned reports by Mott MacDonald are as follows:

Hope Island	(1 facility)
Port Angeles Harbor	(2 facilities; Primary net pen and Secondary net pen)
Rich Passage	(2 facilities; Orchard Rocks net pen and Fort Ward net pen)
Cypress Island	(2 facilities; Site 1 and Site 3)

In addition to these seven reports, Mott MacDonald previously prepared a report for DNR in October 2017 concerning the Clam Bay net pen facility in Rich Passage. Mott MacDonald is also involved in the investigation of the Cypress Island Site 2 net pen failure that occurred in August 2017.

1.1 Purpose and Methods

The purpose of the work is to conduct a site visit and review available documents to provide an engineering assessment of the Rich Passage Fort Ward net pen facility. This report is for use by DNR and state agencies in making proprietary and regulatory decisions

The document review and site visit includes review of the following general elements:

- DNR lease requirements.
- Best Aquaculture Practices (BAP).
- Permit applicant documentation (inspection reports, design conditions, etc.).
- Inspection type and frequency.
- Maintenance and repair history.
- Facility design documentation and lease requirements.
- Industry standards for design, operations, maintenance, and best management practices.
- Site visit observations and dive inspection with respect to the above listed documents and standards.

This work is limited in scope. Detailed inspection and physical material sampling were not performed. A load rating or structural analysis has not been performed. Repair or maintenance recommendations are not included in this report.

The site visit and inspection only included those elements above water at the time of the site visit. Not included in this review are mechanical systems and utilities, such as lighting, power and water lines and pumps. This assessment is focused on the structural elements of the net pens.

1.2 Inspection Scope and Standards

Mott MacDonald and Collins Engineers have followed the recommended standards and practices in ASCE Manual No. 130 - *Waterfront Facilities Inspection and Assessment* published by the American Society of Civil Engineers (ASCE, 2015).

The above water inspection by Mott MacDonald staff is consistent with a Level I visual and tactile inspection of all surfaces that were visible without removing coatings or opening hatches. The methods were consistent with a “Routine” type of inspection. The Collins Engineers dive inspection is consistent with a Level I inspection with a Level II inspection at selected areas. The Level I and II methods and Routine inspection type are defined in ASCE No. 130.

Condition assessment definitions from ASCE Manual No. 30 are applied in this report, copied below in **Table 1**. These are assigned to the major components of the facility.

Table 1: Condition Assessment Rating

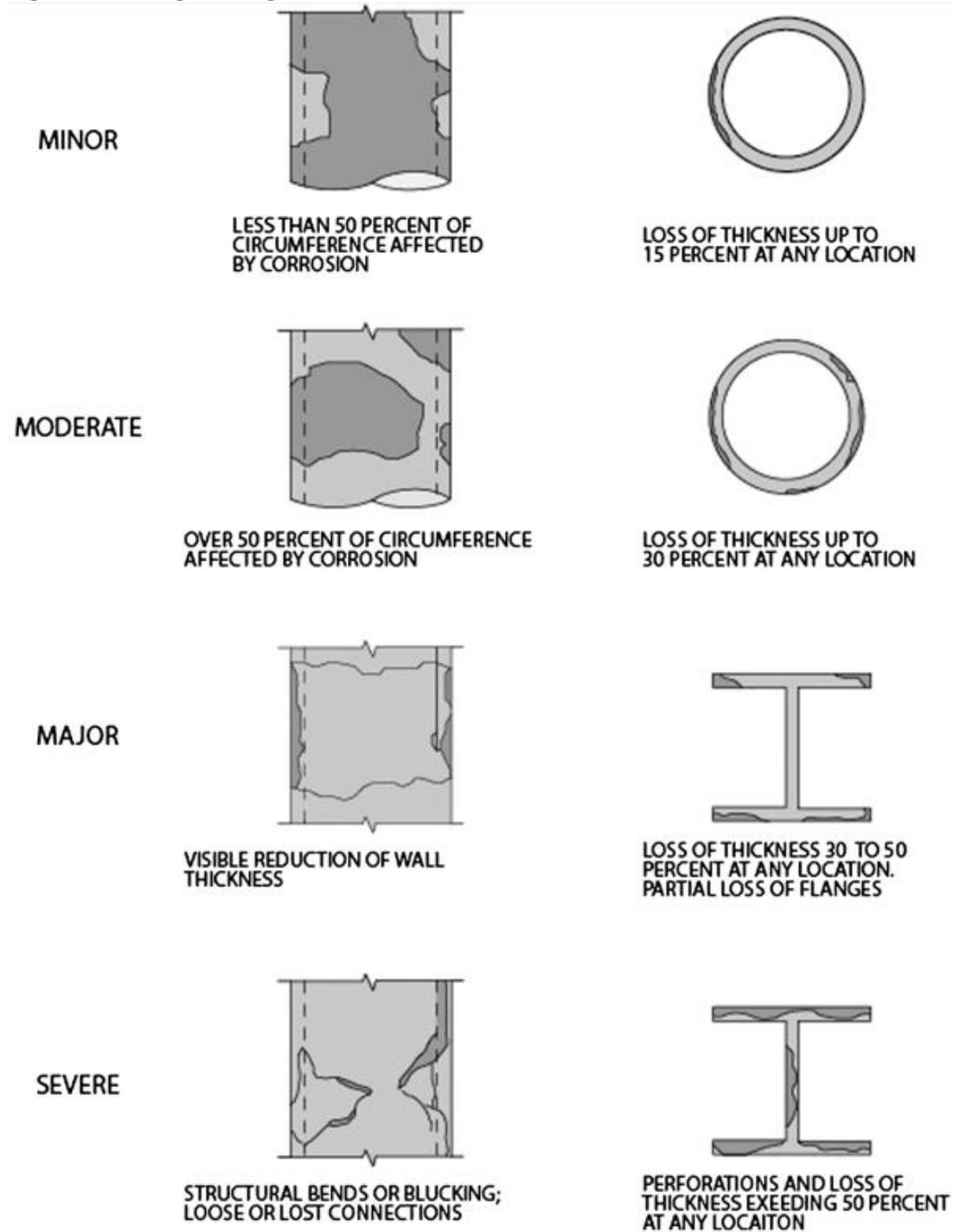
Rating	Description
6 Good	No visible damage or only minor damage noted. Structural elements may show very minor deterioration, but no overstressing observed. No repairs are required.
5 Satisfactory	Limited minor to moderate defects or deterioration observed but no overstressing observed. No repairs are required.
4 Fair	All primary structural elements are sound but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.
3 Poor	Advanced deterioration or overstressing observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.
2 Serious	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible, and loading

Rating	Description
1 Critical	restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency. Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high-priority basis with strong urgency.

Source: Table 2-14 in ASCE Manual No. 130

The damage/condition rating system in ASCE Manual No. 130 is applied in this report. It includes the following condition ratings “Minor, Moderate, Major, and Severe,” which are defined for different material types. The damage rating definitions for steel elements are shown below in **Figure 2** for ease of reference. Similar figures from ASCE Manual No. 130 exist for mooring hardware, timber, and other materials.

Figure 2: Damage Rating for Steel Elements

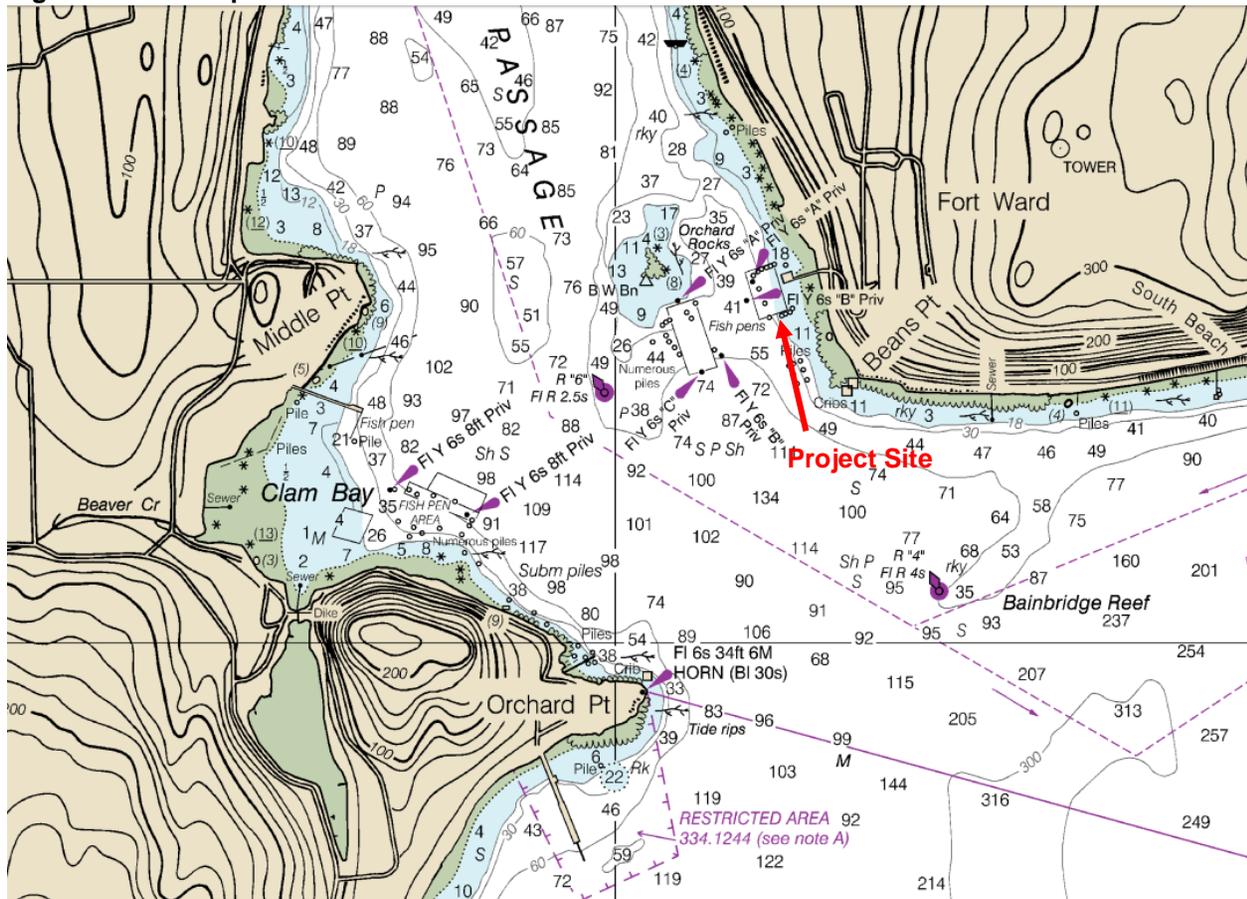


Source: ASCE Standard of Practice No. 130 "Waterfront Facilities Inspection and Assessment"

2 Document Review

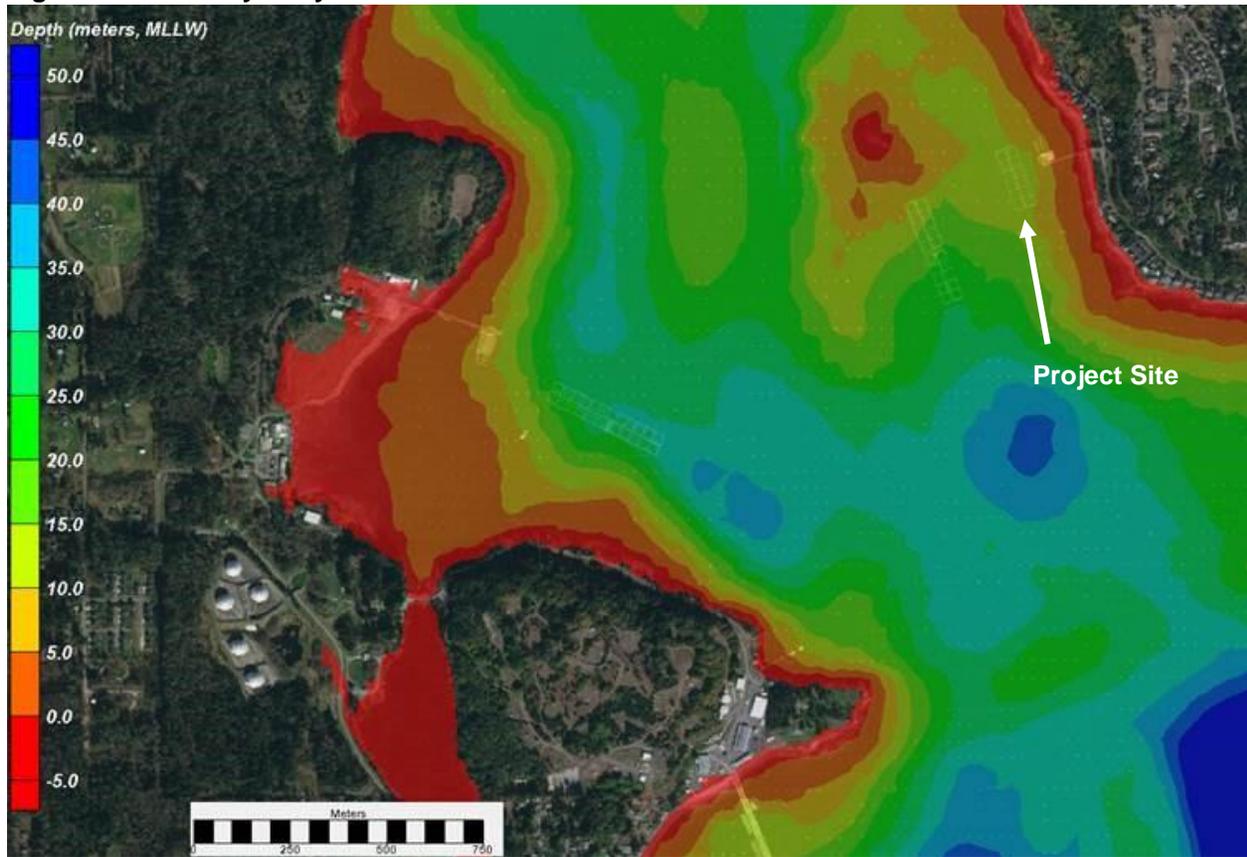
The Fort Ward net pens are near the east end of Rich Passage, between Bainbridge Island and the Kitsap Peninsula. The net pen facilities owned by Cooke Aquaculture are located east of Fort Ward and west of Orchard Rocks. **Figure 3** is an area map. **Figure 4** shows the bathymetry in more detail. The depths are between 15 feet and 50 feet (MLLW) along the length of the Fort Ward net pens. Drawings in Appendix A show a general plan and photos of the existing facilities. Additional site photos are in Appendix C.

Figure 3: Area Map



Source: NOAA Chart 18449

Figure 4: Site Bathymetry



Source: NOAA Digital Elevation Model (DEM) of Puget Sound Bathymetry

2.1 Document Review

Documents reviewed by Mott MacDonald are described in Table 2. Document interpretations are included elsewhere in this report.

Table 2: Document Review – Summary

No.	Description	Comments
General Documents received from Cooke		
1	Procean Ocean Catamaran Brochure and Design Drawings, 22 pages.	The brochure and drawings contain general information from the manufacturer on the steel pontoon and superstructure, but not the nets or mooring system.
2	October 2017 Pollution Prevention Plan Updated, 6 pages	Not relevant to this report.
3	October 2017 Spill Prevention Control and Response Plan Undated, 5 pages.	Not relevant to this report.
4	2017 Cooke Aquaculture Fish Escape Prevention Plan. Updated January 2017, 9 pages.	Outlines requirements for moorage system damage inspections, frequency of inspection and post-storm inspection.

No.	Description	Comments
Fort Ward Specific Documents received from Cooke		
5	DNR Rich Passage Lease agreement (No. 20-B10237), executed 2008, 40 pages plus exhibits.	Lease agreement for all 3 Rich Passage net pen sites. Exhibit A includes the land survey. Exhibit B Includes the facility description and plan of operations.
6	Fort Ward site plan fuel storage and spill kit locations, 1 page	Includes a site map.
7	Surface Inspection Sheets for 10/30/2017 and 11/6/2017, 2 pages	Inspection sheets including repair logs and inspections for mooring points, shackles, thimbles, hardware, mooring lines, chain connections, hinge points, grating conditions.
8	Ultrasonic Gauging Survey completed by International Inspection on September 9 th , 2016, 7 pages	Ultrasonic thickness measurements of pontoons No.1-7 and walkways. Schematic drawings of pontoons and walkways.
9	Fort Ward Mooring Diagram, Excel spreadsheet	Mooring diagram of existing conditions, includes piles, anchors, chains, roads, and information on inspection and replacement
10	NPDES Permit Fort Ward, 30 pages	Issued 2007 and expired 2012. Not relevant to this report.
11	Square Net Cage drawings, 3 pages	Diagrams and instructions for the net cages
12	Land Survey of Rich Passage net pens in 2008	Survey of the net pen locations and dimensions with legal descriptions.
13	October 2017 Net Inventory	Inventory includes dimensions, mesh size, make, year made, etc.
Standards, Guidelines, Studies, Plans		
14	Norwegian Standard NS 9415.E:2009 -- Marine fish farms Requirements for site survey, risk analyses, design, dimensioning, production, installation, and operation	The standard includes site survey requirements, load and load combinations, general requirements for the main components of a marine fish farm, requirements regarding net pens, floating collars, rafts, and mooring.
15	Aquaculture Facility Certification Salmon Farms Best Aquaculture Practices (BAPs) Certification Standards, Guidelines, - by the Global Aquaculture Alliance	BAPs are practices adopted and self-enforced by the industry. A number of references are available from different states and countries. In Washington state, the BAPs are assumed to include the 1986 interim guidelines (described below).
16	Recommended Interim Guidelines for the Management of Salmon Net-Pen Culture in Puget Sound – Dec. 1986	These interim guidelines prepared for the Washington Department of Ecology are intended to provide a coordinated agency approach to management of salmon net-pens in the Puget Sound. The guidelines are for interim use until a programmatic EIS can be completed and focus on environmental protection. Guidelines include water quality, site selection, and environmental surveys.
Miscellaneous		
17	2014 Fin Fish Aquaculture Plan of Operation – updated June 2014 by American Gold Seafoods	Obtained by Mott MacDonald. The 2014 plan includes an overview of existing farming sites, stock species, and health certifications and screenings. Attachment A lists the facility locations and permits, 2014 Fish Escape Prevention Plan, Employee and guidance for routine handling procedures to minimize the potential for escape.

Source: Mott MacDonald

3 Metocean Review

A metocean review was conducted for two net pens, known as Fort Ward and Orchard Rocks, located in Rich Passage, WA as part of a facility review. Metocean conditions were described by American Gold Seafoods, LLC (the Owner) in Exhibit B of the lease records. This technical memorandum provides qualitative review of the wind, wave, water level, and tidal currents conditions described by the Owner.

3.1 Winds

Winds at the Rich Passage Net Pen site were described in the DNR lease agreement as follows:

- Wind speed is “in excess of 50 knots during major storm events”.
- Estimate was based on “personal observation of farm staff”.

No information on typical wind direction was provided.

A review of nearby wind stations was conducted, based on previous project experience in this area. Long-term (~30-years) wind data records are available from NOAA’s West Point Wind Station (WPOW1). A sustained wind of 50 knots (as reported by the owner) corresponds to a return period of approximately 50 years (2-minute averaged) at West Point.

Mott MacDonald takes no exception to wind conditions reported in the lease agreement.

3.2 Waves

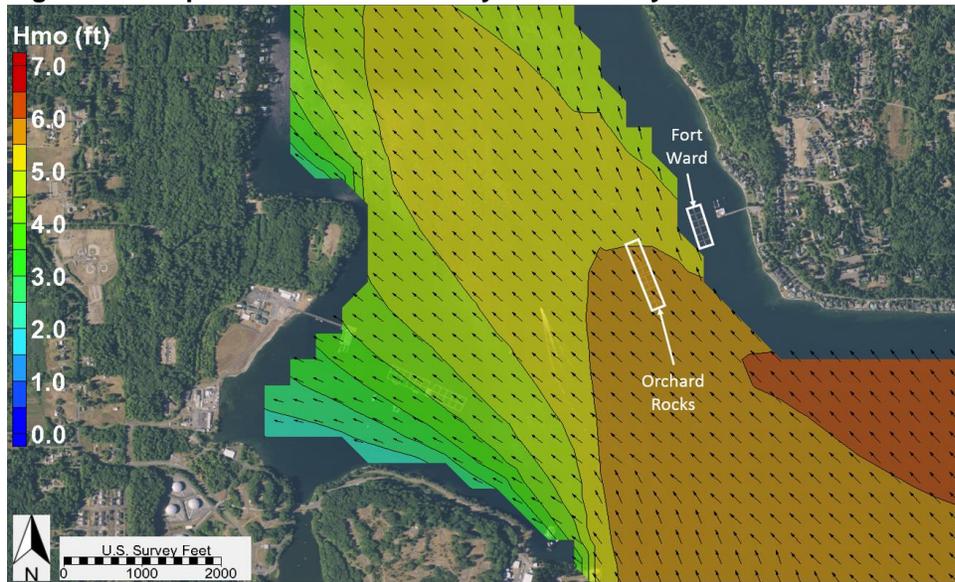
Waves at the Rich Passage Net Pen site were described in the DNR lease agreement as follows:

- Southeast winds create largest waves in the area, typically maximum wave is less than 4 feet
- Primary wave exposure for Fort Ward and Orchard Rocks net pens is for wind-generated waves caused by southeast to easterly winds.
- The largest fetch to the Fort Ward and Orchard Rocks net pens is to the southeast.

No wave measurements were available at the net pen site. In lieu of this, Mott MacDonald has relied on its internal Puget Sound Numerical Wave Model. This model is based on extreme wind analysis from the NOAA West Point wind station, available bathymetric data, and standard wind-wave generation propagation model software. The wave model shows that storm waves can propagate to the project site, with significant wave height (H_m0) for a 50-yr southerly storm estimated at approximately 6 feet at Orchard Rocks and 5 feet at Fort Ward (shown in color format in **Figure 5**). Storms out of the North generate smaller waves than storms from the south due to limited fetch length (~ 4 miles). Significant wave height due to storms out of the north are expected to be less than 2 feet.

Mott MacDonald takes no significant exception to wave conditions reported in the lease agreement. Typical storm (e.g. annual) waves may be less than 4 feet; however, extreme storm significant wave height will likely be greater than 5 feet.

Figure 5: Computer Wave Model – 50-year Southerly Storm



Source: Mott MacDonald

3.3 Water Levels

Water levels in Rich Passage were described by the owner as follows: “Extreme tide range is 14.5 feet.”

No long-term tide measurement data was available for the Fort Ward or Orchard Rock net pen sites. In lieu of this available data, nearby tide measurement stations were reviewed. The extreme tide reported by the owner corresponds exactly to the maximum tide range recorded by the nearest water surface elevation measuring station in Seattle (NOAA Station 9447130).

Mott MacDonald takes no exception to water levels reported in the lease agreement.

3.4 Currents

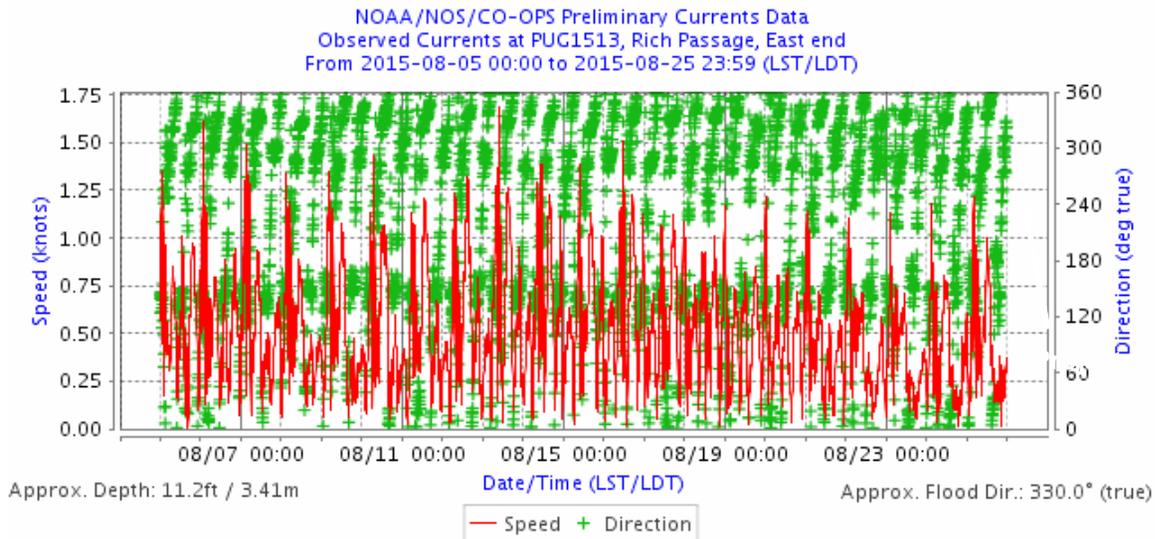
Current speed in Rich Passage were described by the owner as follows: Average is 110 cm/sec (2.1 knots) at midway in water column”. It is not clear whether the reported value is intended to represent the average daily maximum current at the site, or the average current over the entire day.

Current measurements are not available directly at the project site. NOAA has available short-term measured current data, measured at the east end of Rich Passage (NOAA Station PUG1513). NOAA also provides predicted currents at this station.

Currents reported by measurements or predictions at this station may differ from currents at the net pen sites, but may be used as a reference to approximate conditions. The maximum daily predicted current speed in middle of the water column (55-foot depth) was reviewed over a period of 4 months. Predicted current speed was often greater than 2 knots, with a maximum near 4 knots. Measured currents are available for the measurement period of August and September of 2015 only. The maximum current measured (38-foot depth) in the measurement period was approximately 1.8 knots. **Figure 6** shows the measured near-surface currents speed (red) and direction (green) during August of 2015.

Mott MacDonald takes no exception to current speeds reported in the lease agreement, based upon review of measured current data at station PUG1513.

Figure 6: Observed Currents at Rich Passage



Source: NOAA

3.5 Vessel Traffic

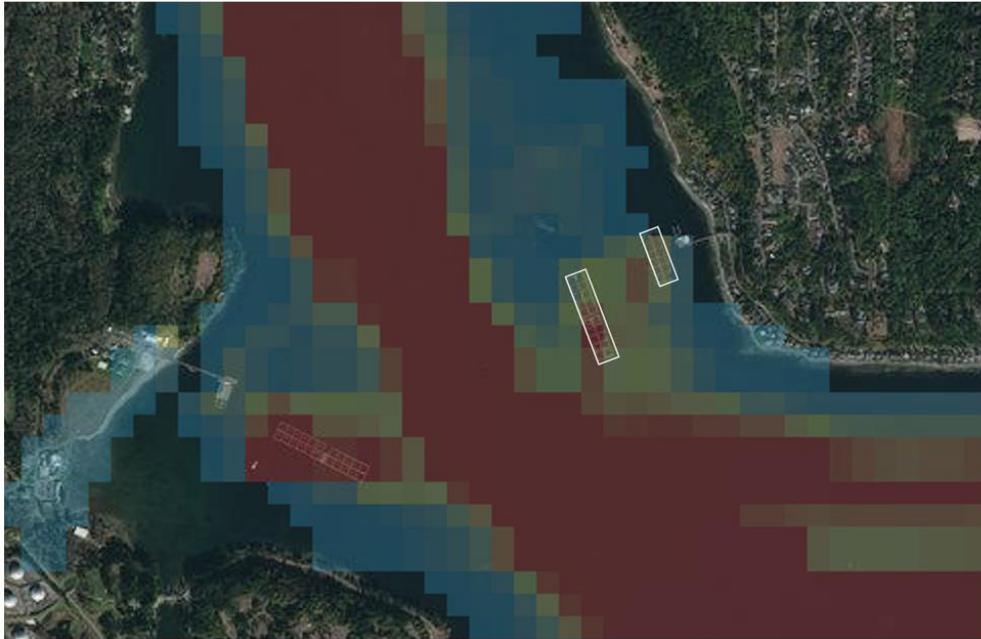
Vessel Traffic conditions at the Rich Passage Net Pen site were described in the DNR lease agreement as follows:

- The marine waters around Rich Passage are open for commercial, private, and public navigation. There is no commercial navigation use of the immediate project site.
- The net pens are registered with the Coast Guard Private Aids to Navigation (PATON) Program. Proper navigational warning lights are maintained by farm personnel.
- There is no impact to commercial navigational uses of Rich Passage. The sites are located well outside the navigation channel of Rich Passage.

Federal navigation charts, publicly available AIS (Automatic Information System) historical vessel tracking data, and state ferry routes were reviewed. Historical AIS (2017) data for Rich Passage is shown in **Figure 7**. It appears that fishing vessels, cargo vessels, pleasure craft, tugboats, Navy ships and passenger vessels were present. A submarine was observed transiting Rich Passage during the site visit by Mott MacDonald. The Washington State Ferries Seattle-Bremerton ferry is routed through Rich Passage, and appears to be within 1,000 feet of the net pen facility. In addition, the Kitsap Transit Rich Passage Fast Ferry began service in 2017.

Mott MacDonald takes no significant exception to the vessel traffic conditions reported in the lease agreement. However, the channel appears to be in high use.

Figure 7: Historical AIS data (2011) in Rich Passage



Source: Mott MacDonald

Note: Red indicates higher usage. Net pens are outlined in white.

4 Net Pen Structure

The three Rich Passage net pen structures were initially permitted and installed in the mid 1970's per the lease documents. The net pens have undergone several structural improvements, including complete replacement of the floating structures and anchoring equipment during its service life. The lease documents state the last replacement cycle began in 2000 when all three cage structures in Rich Passage (Clam Bay, Fort Ward, and Orchard Rocks) were replaced with new steel floating structures. From GoogleEarth, the Fort Ward net pens appear to have been installed between 7/4/2007 and 4/30/2009. Based on all available information, the age of the net pen structures (but not the mooring lines) is estimated to be approximately 9 years for Fort Ward. There are 12 pens at Fort Ward.

All the net pen facilities are an Ocean Catamaran Platform system manufactured by Procean. The Ocean Catamaran Platform system is composed of pontoons or catamarans as the main flotation. These pontoons are located crosswise in the system and act as support for the center bridges and outer beams. The pontoons, center bridges, and outer beams are all a fabricated and welded steel. The system also includes mooring brackets, predator and net pen support pipes, and handrail and walkway structures that span between the steel pontoons used for flotation.

The net pen system is a moored floating structure relying upon forces imposed on the flotation pontoons and net systems to be resisted by a series of mooring chain and anchors. The following is a summary of the key components of the system which we reviewed as a part of our site assessment work. The basis of the information includes the documents provided for review and our observations during the site visit. Drawings of the net pen structure are in Appendix A.

4.1 Anchors

The mooring line is shackled to the anchor at the seabed. The anchor types include Danforth drag anchors, and connections back to the fixed facility pier that extends off of the easterly shore adjacent to the Fort Ward net pen. The anchor lines appear to match the diagram provided by Cooke.

4.2 Mooring Line & Hardware

The mooring line is composed of a combination of stud link and navy chain, rode line, shackles, and other mooring hardware. The mooring line is connected to the float frame at the top and the anchor at the seabed. 1.5" thick shackles were the most common however some shackles were measured as 2.25" that were more common at the ends.

Freeboard was measured between 31" and 43" and varied along its length and width. Generally, the freeboard was measured higher at each end of the net pen.

4.3 Mooring Line to Float Connection

The mooring lines connect to fixed steel plate mooring brackets on the sides and hinged steel mooring brackets on the ends attached to the walkway structure frame near the walking surface. No buoys are used on any of the mooring anchors to relieve stress on the above water mooring connection. The mooring lines on many locations on the net pens were connected to the perimeter pipe with synthetic rope.

4.4 Predator Exclusion Net

The perimeter predator exclusion net attaches to a 3.5" and 5" diameter steel perimeter pipe that attaches to the outside of the walkway. Additional vertical supports extend the predator exclusion net to roughly 6 feet above the walkway surface.

4.5 Fish Pen Net

The fish stock containment nets were attached to a mixture of the hand railing and 2.5" diameter steel net pen pipes connected to the walkway.

4.6 Walkway Frame

The fabricated steel walkway frame structure provides support for the walkways, main bridge, mooring lines, predator nets and fish pen applied loads. The frame spans between the flotation pontoons and is the primary fixed structure that supports applied loads to the mooring system and flotation pontoons. The center walkway transverse to the pontoons is called the main bridge on the drawings by Procean and is 10' wide. Forklifts only travel on the main bridge. The transverse walkways are 5' wide.

4.7 Pontoon

The steel fabricated float pontoons are an octagon cross-section which provide flotation and support to the rest of the structure. The pontoons are 4'-10" tall and 2'-4" wide per the manufacturer's details.

5 Inspection, Maintenance & Repair History

A review of the inspection, maintenance and repair history was conducted based on the information provided and as described by Cooke personnel during our site visit.

5.1 Background

The following documents and standards apply to the net pen system inspection and maintenance activities.

- Aquatic Lease #20-B10237 (February 7, 2008). Minor maintenance to the cage structures, anchor lines and netting occurs throughout the year and on a continual basis. Major maintenance of cage structures is typically replacement. Average service life expectancy is approximately 15 years. Metal fatigue can be a factor based on constant wave action and corrosive environment. Inspection of submerged mooring systems are to be made periodically by divers and surface connections checked daily.
- Cooke Aquaculture Fish Escape Prevention Plan (January 2017). Document outlines requirements for moorage system damage inspections. It also outlines requirements for frequency of inspection and post-storm inspection requirements.
- Procean - Ocean Catamaran Net Pen System Product Documentation. The manufacturer outlines recommendations for adjustment and tightening of anchor lines (1000 kg per line and even distribution to all lines), maximum level of net fouling (50% of net and thickness not greater than 50 mm), weekly inspections, monthly inspections, annual, and extreme weather event special inspections. Details of each of these types of inspections are outlined for each component of the net pen system.
- Industry Standards. Various industry standards and other governmental standards for marine fish farming facility inspection and maintenance exist. These include requirements in other U.S. States, Canada, and Norway. These other governments and industry practice have a summary of recommended inspection and maintenance activities for net pen systems.

5.2 Inspection

The following documents were reviewed pertaining to inspection of the net pen facility.

- Two weekly inspection forms were reviewed, from October 30 to November 6, 2017. They include a table with condition of the following:
 - System Mooring Points (Pad eyes, Mooring Plates)
 - Surface Shackles, Thimbles, Hardware
 - Mooring Lines
 - Surface Chain Connections
 - Walkway Hinge Points
 - Walkway Grating Condition

- No Dive Inspection Reports were included in our documentation review. Risk Management surveys describe facility staff visual dive inspections occur 3 times per week of the stock nets, but documentation thereof is not available. The tri-weekly dive inspections are understood to be primarily focused on fish mortality and not the stock nets.

5.3 Maintenance & Repair History

- Square Net Cage Diagrams (5 pages): Contains dimensions and descriptions of the net cage components. Document was prepared by Garware-Wall Ropes Ltd (GWRL) on July 21, 2016. The company is based in India.
- ORFW (Orchard Rocks Fort Ward) Pet Net Inventory (1 page): October 2017. Spreadsheet lists the ID number of each net, its location (pen number), nominal dimensions, depth, mesh size, make, net type, twine type, and year made. The nets are made by Garware and are all from June 2017.

5.4 Ultrasonic Thickness Measurements

Mott MacDonald reviewed documents by International Inspection; Sept. 9, 2016 report titled "Ultrasonic Gauging Surveys". The documents indicate corroded areas, and include drawings that indicate suggested repairs. The documents do not include an explanation of the figures or provide recommendations for repairs.

The documents do not provide a complete survey. If we are interpreting it correctly it appears the gauging was done at selected areas, called "bands" in the document. The bands circle the pontoons, measuring areas both above and below water, and are spaced approximately 22 feet along the pontoons. The width of the sampling bands is not indicated. It appears parts of the pontoons and structure were not gauged. It is possible weak areas with corrosion exist in the areas between the bands that were not measured.

5.5 Assessment

The following is our assessment of the inspection, maintenance and repairs being conducted at the facility.

- Inspections appear to be occurring as required by the lease agreement between DNR and the net pen owners.
- Nets, pontoons, walkways, and mooring line systems are inspected on a regular basis and prior to stocking, with repairs and component replacement conducted prior to restocking.
- No documentation was provided showing inspection of other key float frame and net support systems such as the predator net support frame and fish net support pipe system. Consideration for inspection of these elements should be made on a go forward basis as they are integral elements of the overall net pen structural support system.
- Inspections as outlined in the supplier documentation and industry standards typically require a greater level of inspection and documentation thereof than what appears to be conducted and as outlined in the information provided for this assessment.

- Although not required in the lease and fish escapement plan, documentation of repairs conducted to implement deficiencies identified in the inspection reports should be provided.

6 Site Visit and Existing Conditions

Mott MacDonald visited the net pen facility between 7:30 am and 4:30 pm on December 11 and December 15, 2017. Collins Engineers performed dive inspections between December 11 and 16, 2017. The time period included dive inspections of the Orchard Rocks net pens. The personnel present included Nels Sultan and Evan Edgecomb with Mott MacDonald, engineer-divers with Collins, Cooke Aquaculture employees, and Washington State staff. **Figure 5** shows the net pens. Photographs are included in Appendices A and C. The dive inspection report by Collins is in Appendix B.

Figure 8: Fort Ward Net Pens – View from East



Source: Mott MacDonald photograph December 15, 2017

During the site visit observations were made and photos were taken. On both days the weather was cold at roughly 40°F at noon with winds light and variable, and the sea calm. Wake waves from ferries up to 1 feet high were observed passing through the structure with no observable motion of the net pen while the waves propagated through the facility. The predicted tide elevations on the first day are below in **Table 3**. Mean Higher High Water (MHHW) is elevation +11.5 feet, MLLW. The mean tide range is 6.7 feet. The predicted currents are in **Table 4**. The maximum predicted current speed during the site visit was approximately 0.7 knots. However, the measured current near the south-east corner of the Fort Ward net pen was approximately 1.1 knots at 2017-12-11 15:38h, determined by measuring the time and distance of a floating object relative to points on the net pen. This is approximately equal to the predicted current speed at that time.

Table 3: Predicted Tide: Daily Highs and Lows – Clam Bay (Pacific Daylight Time)

Tide	Time (Pacific Daylight)	Elevation
Low	12/11/2017 4:44 am	+3.1 feet, MLLW
High	12/11/2017 11:46 am	+12.3 feet
Low	12/11/2017 6:42 pm	+3.1 feet

Source: *Tides&Currents Software*

Table 4: Predicted Currents at Rich Passage: Daily Maximum Floods and Ebbs (Pacific Daylight Time)

Time (Pacific Daylight)	Speed	Direction
12/11/2017 3:21 am	0.8 knots	143°, Ebb
12/11/2017 6:30 am	0	slack
12/11/2017 9:27 am	0.9	321°, Flood
12/11/2017 12:30 pm	0	slack
12/11/2017 4:26 pm	1.2 knots	143°, Ebb
12/11/2017 8:30 pm	0	slack

Source: *Tides&Currents Software*

The components and observed deficiencies are discussed below, and summarized in **Table 5**. The assessment is based on the conditions observed on December 11 and 15, 2017, our document review and our professional judgment and experience. See the drawings in Appendix A for the numbering system.

The year built is estimated based on available documents, discussions with Cooke Aquaculture employees on site, and our experience with marine facilities in the region.

Table 5: Fort Ward Net Pens – Existing Conditions Summary

Component	Year Built (estimate)	Description	Deficiencies	Overall Assessment
Anchors	varies	See diagram provided by Cooke Aquaculture. Most underwater anchors appeared in good condition	Anchor 6, a Danforth type anchor was not embedded at all in the seabed and was essentially just resting on the seabed.	good
Mooring Lines	varies	See diagram provided by Cooke Aquaculture. Most underwater mooring lines and hardware appeared in good condition, although some are covered in marine growth	The mooring lines were typically in good to satisfactory condition. However, Anchor 15 had severe corrosion with 75% estimated loss of section in the chain links.	satisfactory
Pontoon Floats	2008	steel octagon cross-section pontoons (hollow)	surface rust on pontoons with roughly a third of the anodes needing replacement	fair
Superstructure above pontoons	2008	spans and structures that support walkway, support nets and attach to anchor chain	Some surface rust with localized minor corrosion.	fair
Walkways and Railings	2008	steel fabrication with metal grate walking surface and hinge connections	Some surface rust with localized minor corrosion, The railing also appeared newer but the connections to the walkway had areas of minor corrosion.	fair
Predator Nets	N/A	bird nets and marine mammal nets	none observed	good
Stock Containment Nets	N/A	nets that contain the salmon	not inspected	--
Records and Documents at site	N/A	The operations plan notes that records are kept on site	not inspected	--

Source: Mott MacDonald

6.1 Anchors

- The anchors and chains are a mix of old and new because they have been replaced over time. The records of anchor maintenance, inspection and replacement are not clear. The type and condition of the anchors has not been directly observed. The age was not certain.
- The anchors are different types, including 3,000-pound and 10,000-pound Danforth, and pier steel piles. The extent and capacity of the pier steel piles are not known. Manufacturer's documentation indicated drag type anchors and no mention of other anchor types.
- A dive inspection by Collins Engineers (see Appendix B) observed portions of the anchor (or other means of anchorage) were found exposed at Anchor Lines 1, 2, 3, 4, 5, 6, 7, 11, 13, 14, 15, 16, 17 18, and 19. Overall, all of the anchors (those that were Danforth type), with one exception (Anchor 6), observed were sufficiently buried in the seabed, and there were no anchors that displayed indications that the anchor was unstable and/or shifting its position in the seabed. At Anchors 1 through 4, the anchorage was either dolphin piles or structure piles related to the fixed facility pier that extends off of the easterly shore, and in those instances, all conditions suggested adequate stability.
- Slightly less than 33% of the anchor lines inspected had, in most instances, an estimated 90' (full shot length) or less of the anchor leg chain exposed directly above and/or partially embedded in the seabed, with the anchor shackle and anchor fully buried in the seabed (no anchor exposure).
- As indicated above, at Anchor 6, the Danforth type anchors (two anchors in series at this location) were not embedded at all in the seabed and were essentially just resting on the seabed. There were, however, no apparent indications that either of the anchors have shifted appreciable since original placement.
- Drag anchors must trip, dig-in, and remain stable as they are dragged into place. The holding capacities are dependent not just on the anchor weight and sediment properties, but also the fluke angle, the angle of the chain relative to the bottom, and the lengths that the anchors are dragged upon installation. Keeping the chain angle near zero degrees relative to the bottom, and dragging the anchors for longer distances during installation increases the anchor holding capacities. The mooring system should be designed so that the anchor will drag before the mooring line, mooring bracket, or other structure component fails. Anchor dragging is preferable to a mooring line break because the anchor dragging will re-distribute the load to the other anchors.
- The U.S. Navy (2012) *Handbook for Marine Geotechnical Engineering* recommends sizing the drag embedment anchor as the "weaker link" of a mooring system. In particular, the manual states that "It is preferable to allow the anchor to drag instead of breaking the mooring line. Anchor drag results in redistribution of the overstressed mooring line to its neighboring lines and helps the mooring to survive in storms when environmental loads exceed the design loads". Accurate soil properties are needed for design.
- Det Norske Veritas (2012) notes that monitoring of the anchor installation should, as a minimum, provide data on line tension, line pitch angle, anchor drag, and anchor penetration. This information was not available for review.

6.2 Mooring Lines

- Above water the anchor mooring lines consist of a mix of new and old steel chains and shackles ranging from 1.5-inch to 2.25-inch diameter. Several mooring lines are taut and at a relatively shallow angle of the chain to the water where it connects to the net pen. Others the mooring line appears to go straight down vertically from the net pen. No buoys are used on any of the mooring anchors to relieve stress on the above water mooring connection. See for example the mooring chain on the net pen in Appendix C. Mooring lines with too much tension or ones without enough tension when there is minimal wind, wave and current load may become overloaded during an extreme storm event. The Procean manual, section 3.11 notes that “A mooring plan and associated engineering study and report should be conducted...”. We have not reviewed an engineering study or mooring plan for this facility.
- Above water mooring brackets were observed during our site visit to be in fair condition with minor to moderate corrosion. A few of the mooring brackets had reduced steel edge distance where a mooring shackle is connected. This was noted at Anchor 13, 14 and 15. This would result increased stress in the shackles and reduced capacity at the mooring bracket. Moderate corrosion was observed at the mooring bracket connecting elements to the steel frame.
- Above water the anchor mooring lines consist of steel chains and shackles connected to the steel frame. Several mooring lines are at a relatively shallow angle of the chain to the water where it connects to the net pen. A mooring line with too much tension when there was minimal wind, wave and current load may become overloaded during an extreme storm event. We have not reviewed an engineering study or mooring plan for this facility.
- The dive inspection of the anchor line assemblies were typically found to be in good to mostly satisfactory condition, with no structurally significant deterioration in most instances, and in all cases with all connection elements intact and secure. Regarding the various shackles used throughout the system, although presently secure, there were, however, random instances of no cotter pin or safety wire, or locations where the pin nut was deteriorated loose, but still held in place by the cotter pin. It should be noted that in comparison to the Orchard Rocks Net Pens System, the Fort Ward generally appeared to have an older overall makeup, with far lower percentage of anchor lines that have been more recently renewed.
- The extent of marine growth on the anchor line ropes varied with the apparent age (time in service) of the rope, with heavy amounts of marine growth on the ropes of Anchor Lines 1, 2, 5, 7, 9, 10, 11, 12, 13, 14 and 15, and with minimal amounts of marine growth (typically newer vintage ropes) on the ropes of Anchor Lines 4 and 8. Note: Anchor Lines 3 and 6 only had chain along their runs and no rope portion. The anchor rope eye splices had a mixture of thimbles, protective sleeves, and just bare rope at their connections with no concerns observed.
- Heavier and more notable corrosion with related pitting (generally up to 1/16 in. deep) of the steel was present for some or all of the steel components (chains and shackles) at Anchor Lines 1, 2, 5, 6, 9, 11, 12, 13, 14 and 15. The heaviest of all corrosion noted was present at Anchor Lines 11, 12, 14 and 15 with the specific details as follows:
 - At Anchor Line 1, the lower anchor chain had random links that exhibited up to 50% loss of original section (± 1 in. diam. remaining).

- At Anchor Line 9, the upper anchor chain and a shackle within the overall run of the lower anchor chain exhibited up to an estimated 25% loss of original section.
- At Anchor Lines 11 and 12, in addition to very heavy marine growth, the anchor leg chain and related shackles had areas of up to an estimated 20% loss of original section. At Anchor Line 12, there was also one link in particular (smaller chain – see below) at a shackle connection that exhibited up to an estimated 50% loss of section ($\pm 1/2$ in. diam. remaining) due to corrosion and wear.
- At Anchor Line 14, in addition to very heavy marine growth, both the upper leg and anchor leg chains and related shackles exhibited up to 1/8 in. deep pitting and areas of up to an estimated 20% loss of original section.
- At Anchor Line 15, in addition to very heavy marine growth, the anchor leg chain and related shackles exhibited, on average, up to an estimated 25% loss of original section, with some chain links having an estimated loss of up to 75% ($\pm 1/2$ in. diam. remaining).
- At Anchor Lines 11, 12, 14 and 15, the anchor leg chain included portions of a smaller-sized chain, having no stud in the link, which appeared to be of older vintage and was at times the portion of the overall chain length that exhibited the greatest corrosion-related section losses.

6.3 Pontoon Floats

- The pontoon system was inspected by International Inspection in September 2016 with condition and corrective actions noted.
- The pontoons are hollow steel tubes that provide flotation for the entire structure. The metal thickness is 5/16-inch. The pontoons are coated but there is no description of the system used. The Procean drawings call out both paint and primer, but not specifically the pontoons. The Procean drawings say the primer is “WB-14a Zinc”.
- Above water portions of pontoons were visually reviewed by Mott MacDonald and appeared to be in fair condition with surface corrosion and areas of localized minor damage. Steel struts extend from the top of the pontoons to support the net pen superstructure.
- Freeboard was measured and varied by up to 12-inches at different points along the structure. (see Appendix A) The freeboard variability observed was relatively small between each segment. It is not known or could be inspected if the freeboard differences are caused by flooding into the pontoons.
- All of the steel pontoons of the Fort Ward net pens system were inspected under water, and overall were found to have no structurally significant deterioration. The pontoons generally had 20% to 25% overall coverage of minor surface corrosion, with negligible related section loss, with much of corrosion apparently related to marine growth cleaning operations (conducted by the facility) that may have allowed more of the pontoon steel to become exposed. Approximately 33% of the zinc anodes on the pontoons were 80% or more consumed, with the remaining 67% of the anodes typically showing 20% or less consumption. In addition, approximately 33% of the anodes were missing one of two fasteners that secure the anode bracket to the pontoon, and there three anodes that were completely missing. There were also some additional (four)

anodes added to the system by virtue of hanging them from lines suspended from the walkway structure above.

- Thickness measurements of the steel by International Inspection (2017a, 2017b) indicate areas of corrosion of 7% of the thickness of the steel in places, most of the corrosion identified in the ultra-sound thickness survey was located at or below the waterline.
- Note that under visual inspection, it is difficult to tell the difference between 5/16-inch thick steel (pontoon design thickness) and 1/4-inch thick. This is especially true underwater.
- Corrosion protection includes coating (paint) and sacrificial anodes.

6.4 Steel Framing Superstructure

- The primary structural framing consists of large, steel members. Along the exterior, the frame is approximately 30 inches wide and 30 inches deep. The framing running down the center of the pen, the main bridge, is smaller and there are two main frames. The framing has some surface corrosion but is generally in good condition.
- The framing runs north to south and acts as a bridge, spanning between the pontoons. Steel barrel hinges connect the steel frame segments. Steel framing members and hinges are in good condition.
- No thickness measurements of the steel were conducted by International Inspection (2016).
- The cross-sectional shape of the framing was visually verified due to the higher freeboard. The cross sections are assumed to be the same as those shown in the Procean drawings.
- No anodes were observed protecting the above water steel structure.

6.5 Walkways and Railings

- The walkways include steel grating panels with diamond surfacing. The main walkway grating runs down the center of the pens and is 78 inches wide, 5 inches deep. It is a heavy duty grating capable of supporting net pen equipment and forklifts, as observed on site. The grating was loose and damaged in places.
- The exterior and pontoon walkways are narrower at only 30" have no steel grating.
- The railings are galvanized 1.5" diameter pipe and border all sides of the walkways. They are removable as needed, slotted into brackets connected to the steel framing. Most of these brackets were moderately covered in rust, with localized cases of major corrosion. The deterioration of the brackets caused the railing to become loose and rotate when pressure was applied.
- Primary structure elements and hinges were exhibiting severe corrosion in places and should be repaired.

6.6 Predator Nets and Connections

- Predator nets include both in-water nets to prevent seals and other marine mammals from entering the pens, and above water nets to prevent bird predation of the salmon.
- The in-water nets are supported by 4-inch diameter pipe rails that are attached to the steel framing are in fair condition with surface rust. The nets are taut, extending straight down into the water and held in place by weighted pipes. Full replacement is reported done about every 4 years.

6.7 Stock Containment Nets and Connections

- The stock containment nets confine the salmon inside each individual pen. The nets are supported by 2.5" diameter pipe rails that surround the perimeter of each pen and the handrails. Surface corrosion was observed on the pipe connections to the frame. The nets observed were in new condition.
- It is not known if it is acceptable by the manufacturer to have the nets be supported by the handrails.

6.8 Records and Documents On-Site

Reviewed documents from Cooke indicate that copies of routine inspection reports would be stored on site. We did not inspect documents on site.

7 Conclusions

Based on our review of all available information and documents, the site investigation and our experience and judgment Mott MacDonald offers the following findings.

1. **Site History and Facility Age:** Net pens have been at the site since the 1970's based on information in the lease agreement. The exact age of the existing net pens has not been determined. Based on a review of Google Earth aerial photos the Fort Ward net pens appear to have been installed between 7/4/2007 and 4/30/2009.

Based on all available information, the age of the net pen structures (but not the mooring lines) is estimated to be approximately 9 years for Fort Ward. The lease agreement states that "the new cages have an average expected service life of approximately 15 years".

2. **Environmental Forces:** The net pens are exposed to moderate to strong tidal currents. Wave forces are important due to frequent passing vessel wakes and wind waves from the southeast. This level of tidal current has the potential to exert substantial loads on the nets, structure, and mooring systems. Current induced drag forces, wind wave and passing vessel wakes need to be accounted for in the design and site-specific mooring analysis.
3. **System Design.** No site specific stamped engineering drawings were available for either the net pens or the mooring system.
4. **Net Pen System:** Net pens are an Ocean Catamaran Platform system manufactured by Procean. The fabricated steel structure includes mooring and net pen system and hardware attached to walkway structures which are supported by steel pontoons for flotation. The net pen system is a moored floating structure relying upon forces imposed on the flotation pontoons and net systems to be resisted by mooring chains and anchors.
5. **Net Connections:** The perimeter predator net attaches to a 3.5" diameter steel perimeter pipe that attaches to the outside of the walkway. The fish pen nets were attached to a mixture of the hand railing and 2.5" diameter steel net pen pipes connected to the walkway. A few of the handrail supports and the 2.5" diameter steel pipe as well as the connection back to the walkway displayed areas of minor to moderate corrosion.
6. **Mooring Plan:** A schematic mooring diagram and notes describing the existing components were provide by Cooke. Several lines had new galvanized shackles and chain. The mooring plan states the anchors are a mix of different types and sizes of anchors.
7. **Mooring Brackets:** The mooring lines connect to fixed steel plate mooring brackets on the sides and hinged steel mooring brackets on the ends attached to the walkway structure frame near the walking surface. Most mooring brackets were in good condition with a few showing minor corrosion with several brackets showing reduced edge hole distance that introduces increased stress to the mooring line shackles. No buoys are used on any of the mooring anchors to relieve stress on the above water mooring connection. It was observed that several shackles and chains were recently replaced. However some of them were displaying a fair amount of corrosion.

8. Underwater Components: The following are some of the findings based on the underwater inspection.
 - a. The anchor and mooring line assemblies were typically found by the divers to be in good to satisfactory condition, with some exceptions. At Anchor Lines 11, 12, 14 and 15, the anchor leg chain included portions of a smaller-sized chain, having no stud in the link, which appeared to be of older vintage and was at times the portion of the overall chain length that exhibited the greatest corrosion-related section losses.
 - i. At Anchor Lines 11 and 12, in addition to very heavy marine growth, the anchor leg chain and related shackles had areas of up to an estimated 20% loss of original section. At Anchor Line 12, there was also one link in particular at a shackle connection that exhibited up to an estimated 50% loss of section and capacity due to corrosion and wear.
 - ii. At Anchor Line 14, in addition to very heavy marine growth, both the upper leg and anchor leg chains and related shackles exhibited up to estimated 20% loss of original section and capacity.
 - iii. At Anchor Line 15, in addition to very heavy marine growth, the anchor leg chain and related shackles exhibited, on average, up to an estimated 25% loss of original section, with some chain links having an estimated loss of up to 75% section and capacity.
 - b. The steel pontoons at Fort Ward were found to have no structural significant deterioration. The pontoons had approximately 25% overall coverage of minor surface corrosion, with negligible related section loss.
 - c. Zinc anodes were observed attached to the bottom of the pontoons. They ranged from new to almost depleted needing replacement. Approximately a third of the zinc anodes had 20% or less section left.
 - d. The mooring system includes a mix of different anchor types, mooring lines, line tension, angles, and lengths. Moorings should be designed to be symmetrical where possible, with the same anchor type, holding capacity and line tension around the perimeter of the structure.
9. Above Water Components: The above water portions of the net pen structure float system appear to be in satisfactory condition. Surface rust was minimal, with minor localized corrosion damage observed. This includes the steel walkway frame connecting the pontoons, the mooring brackets, the predator and net pen supports, the supports for the handrail. Freeboard was measured on site and varies as much as foot between different net pen segments.
10. Inspections and Maintenance: Inspections of critical structure elements should be conducted weekly, monthly, and annually per the manufacturer's specifications. It could not be determined the frequency and thoroughness of the inspections by the Owner. Maintenance conducted by the Owner does not appear in accordance with manufacturer's recommendations or industry standards.
11. Anchor Locations: It could not be confirmed if the Fort Ward anchors at the ends were inside of the lease boundary based on the length of the diver umbilical line used for anchor line inspection. Several moorings heading east from Fort Ward end on or near the dock, which is an entirely separate lease. The moorings heading east may not be

within the lease boundary for the floating net pens. A multi-beam bathymetric survey is recommended to locate the anchors.

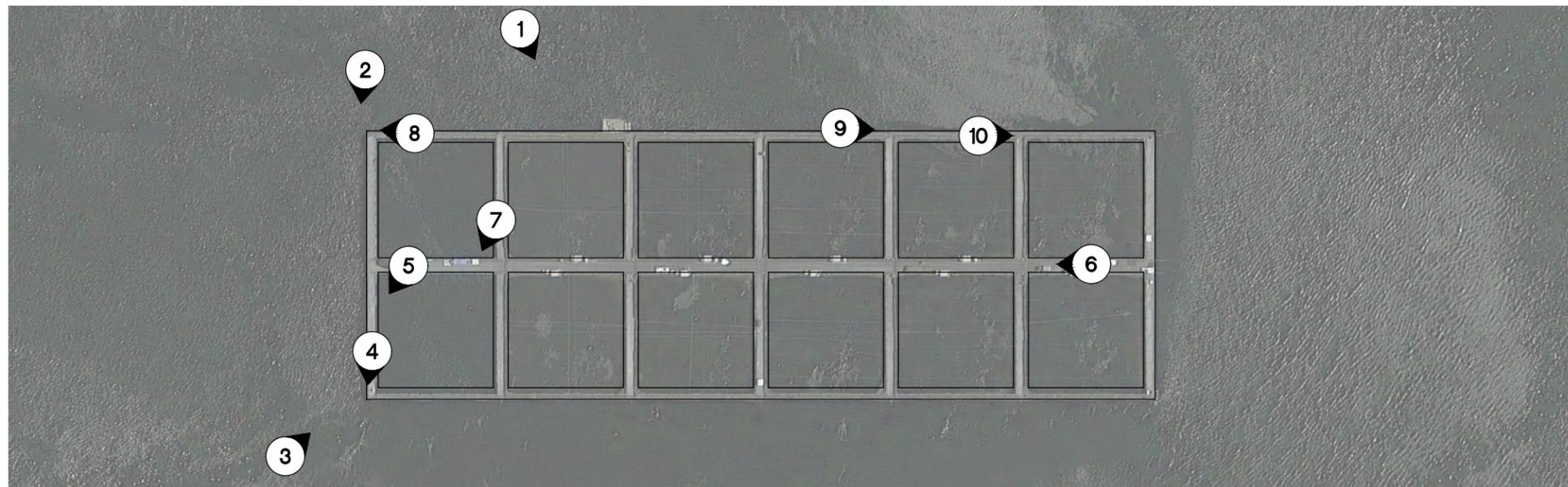
The findings and results of this assessment work by Mott MacDonald do not constitute a certification of the facility structural integrity but rather an overall review of the condition as represented by the applicant and verified in the field during a site visit and dive inspection.

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LEGEND

1 PHOTO LOCATION AND ORIENTATION

NOTES

MOORING SYSTEM NOT SHOWN, SEE SHEET 2

FORT WARD NET PEN

PHOTOS-PLAN

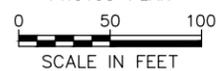


PHOTO 1
EXTERIOR VIEW OF NET PENS
LOOKING WEST



PHOTO 2
EXTERIOR WALKWAY / PREDATOR NET /
ANCHORS 9 AND 10



PHOTO 3
NET PENS LOOKING EAST



PHOTO 4
MARINE GROWTH AND CORROSION
ON ANCHOR 17 CHAIN



PHOTO 5
SOUTH FISH PENS



PHOTO 6
CENTER BRIDGE



PHOTO 7
ACCESS LADDER ON
CENTER BRIDGE



PHOTO 8
CORRODED CHAIN AT
ANCHOR 1



PHOTO 9
NEW SHACKLE AND CHAIN
AT ANCHOR 4



PHOTO 10
HINGE CONNECTION BETWEEN PENS



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Rev	Date	Drawn	Description	Ch'k'd	App'd
1	1/5/18	CT	PLAN AND PHOTOS	JL	NS

Project Number
391980

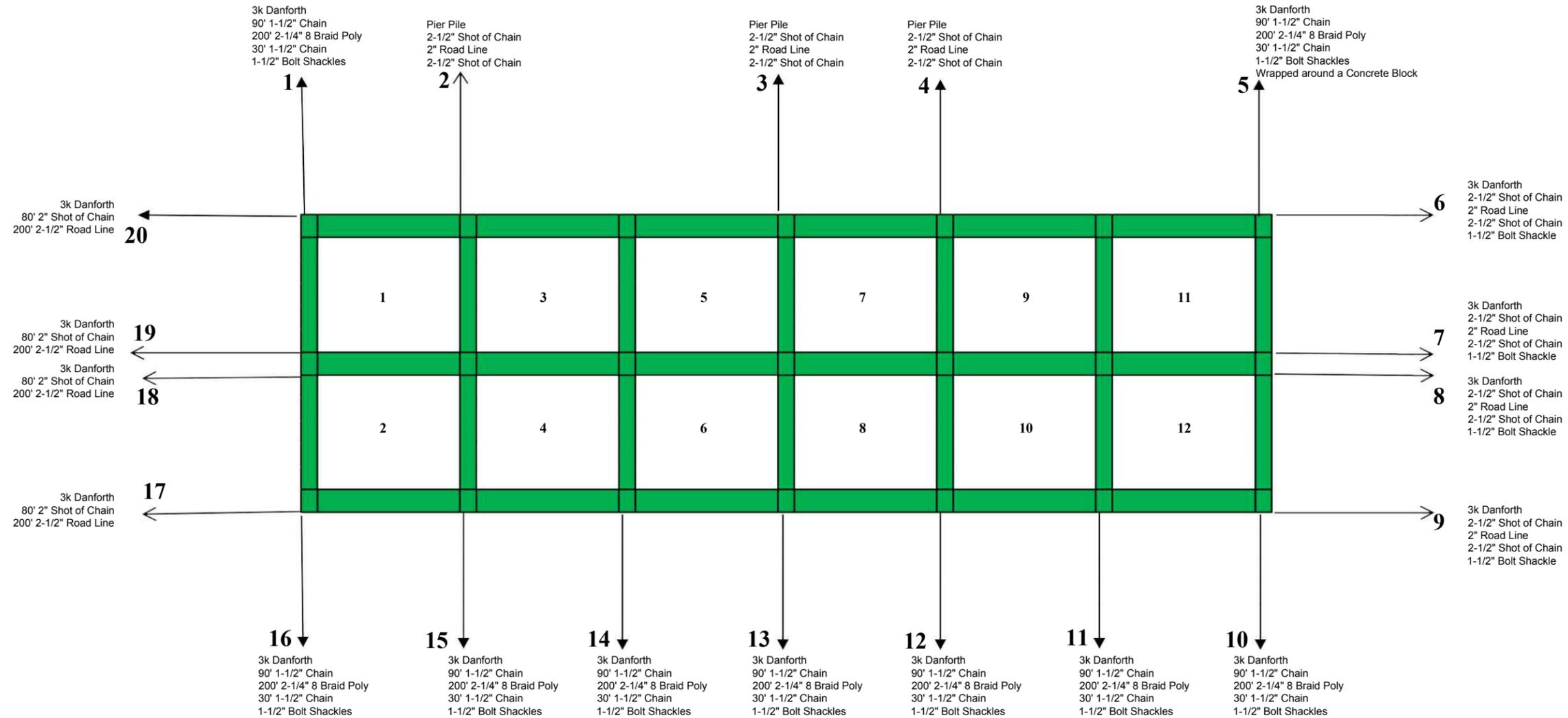
B/O
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Total
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Drawn	C. Taylor	Coordination	
Dwg check	N. Sultan	Approved	
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As Shown			
Drawing Number			

Title
Washington State
Department of Fish and Wildlife
Fort Ward Net Pen

Site Assessment Plan



FORT WARD NET PEN
MOORING PLAN
NOT TO SCALE

NOTES
MOORING SYSTEM SCHEMATIC PLAN
PROVIDED BY COOKE AQUACULTURE.

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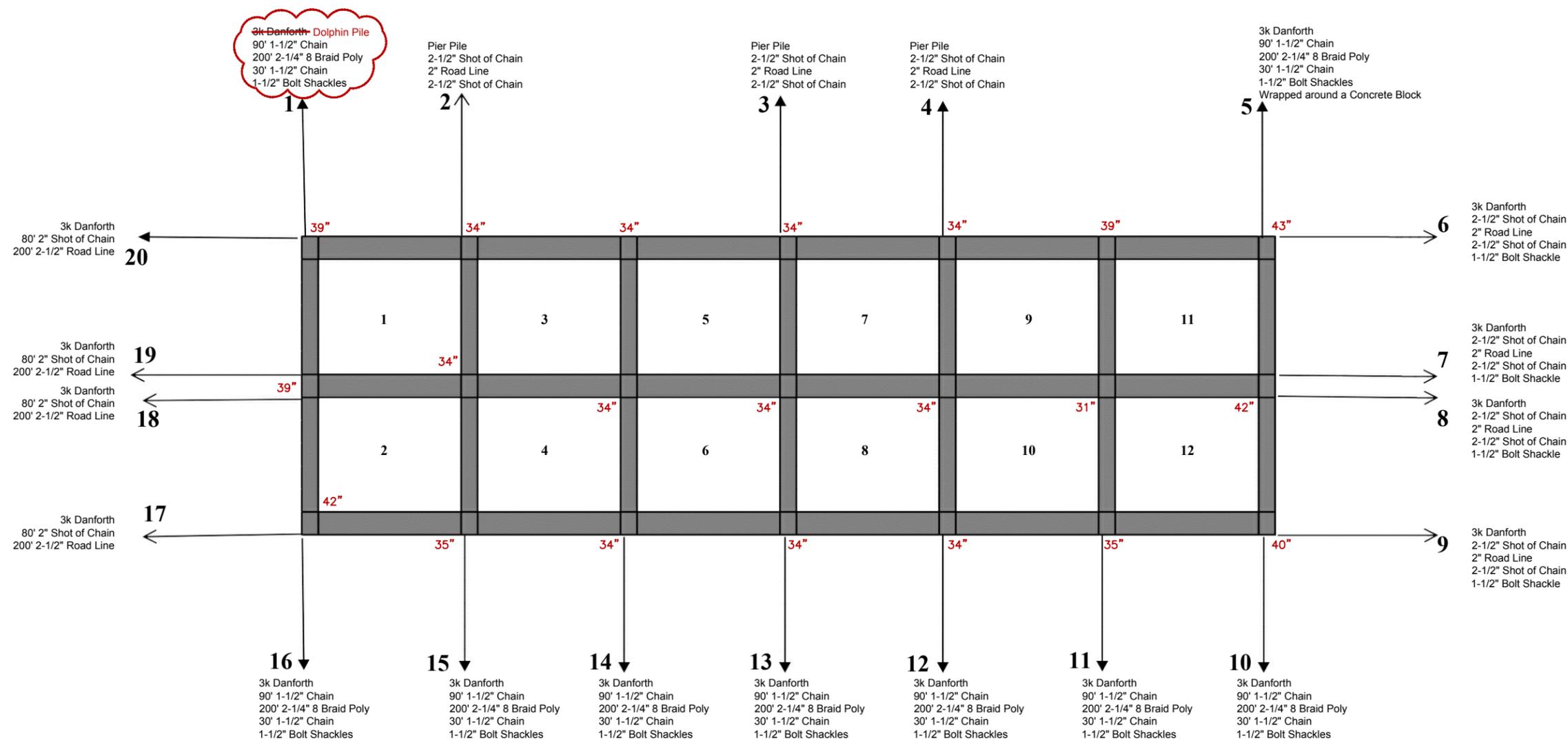


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Drawing Number			

Title
Washington State
Department of Fish and Wildlife
Fort Ward Net Pen
Mooring Schematic



FORT WARD NET PEN
MOORING PLAN
NOT TO SCALE

LEGEND
18" FREEBOARD MEASURED 12-5-2017

NOTES
1. MOORING SYSTEM SCHEMATIC PLAN PROVIDED BY COOKE AQUACULTURE.
2. CORRECTIONS AND NOTES BY MOTT MACDONALD ARE IN RED.

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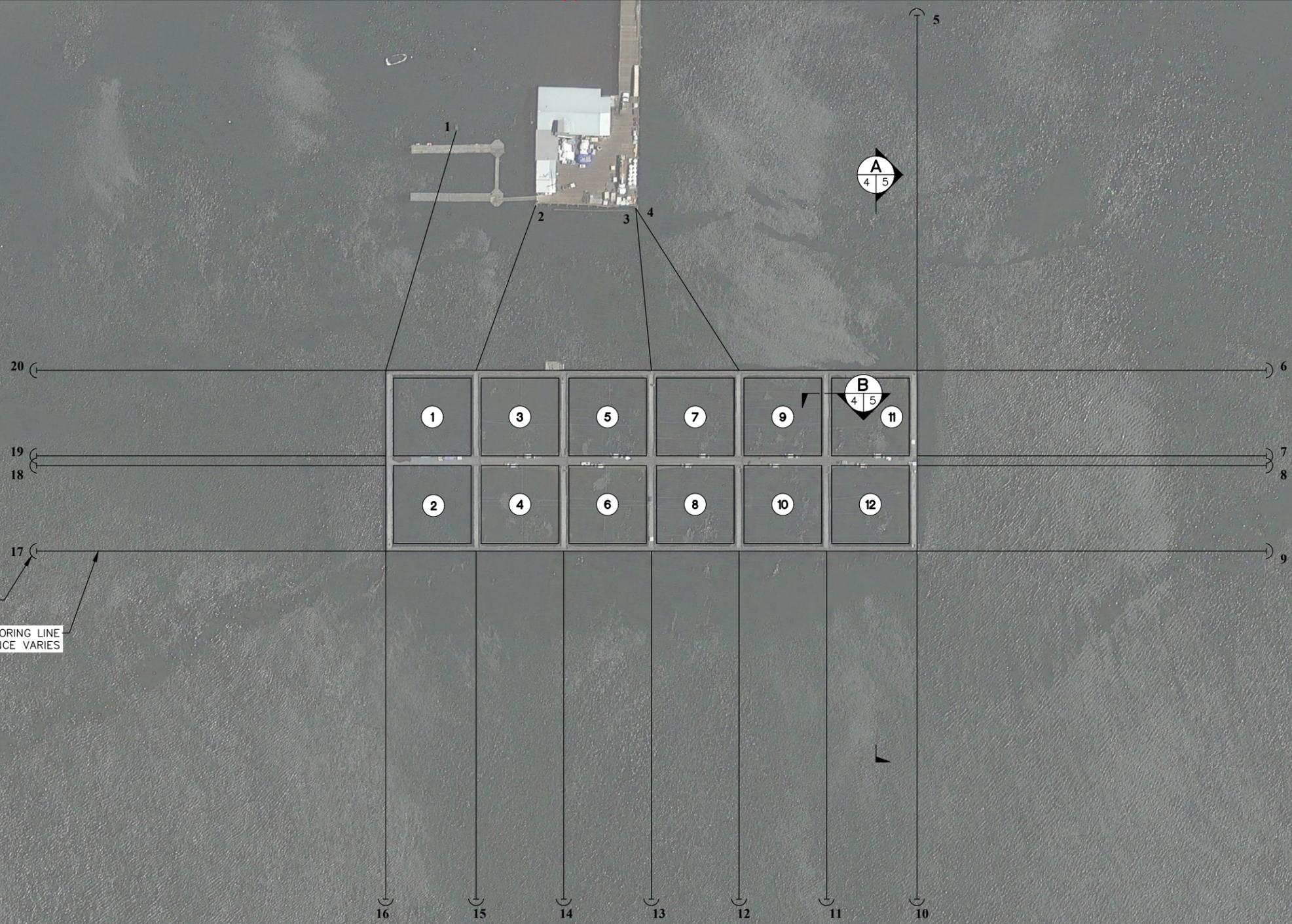
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Dwg check	N. Sultan	Approved	
Scale at ANSI D	Status	Rev	Security
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Drawing Number			

Washington State
Department of Fish and Wildlife
Fort Ward Net Pen

Mooring Schematic
Revised, with Notes



FORT WARD NET PEN



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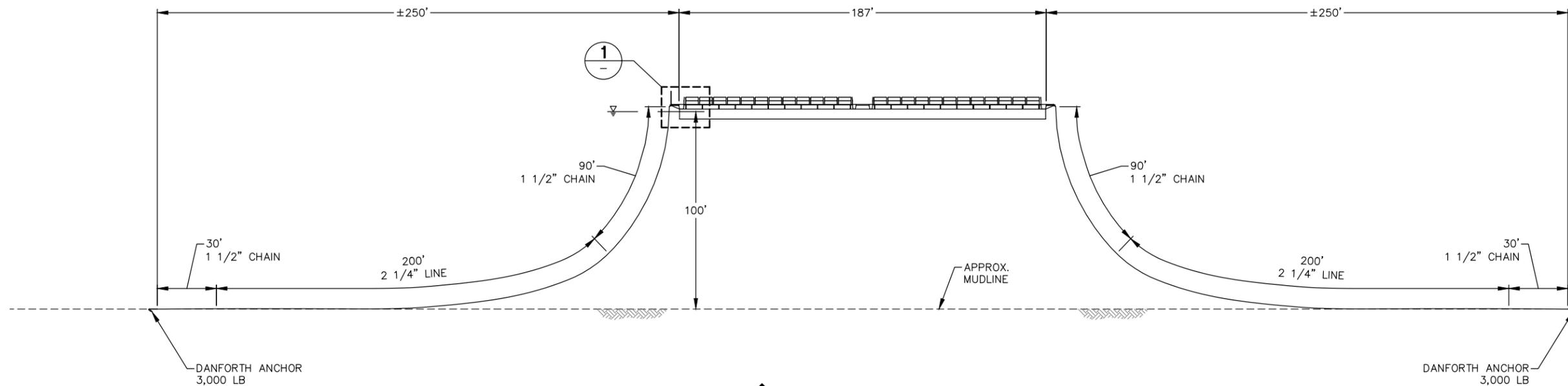
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Project Number **391980** B/O **4** Total **5**

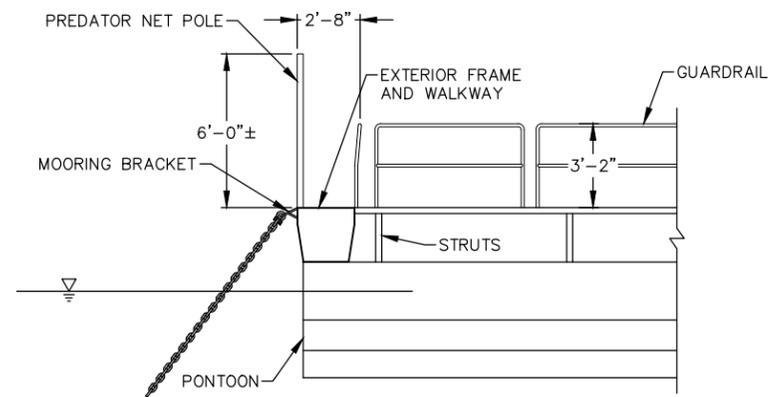
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Washington State
Department of Fish and Wildlife
Fort Ward Net Pen

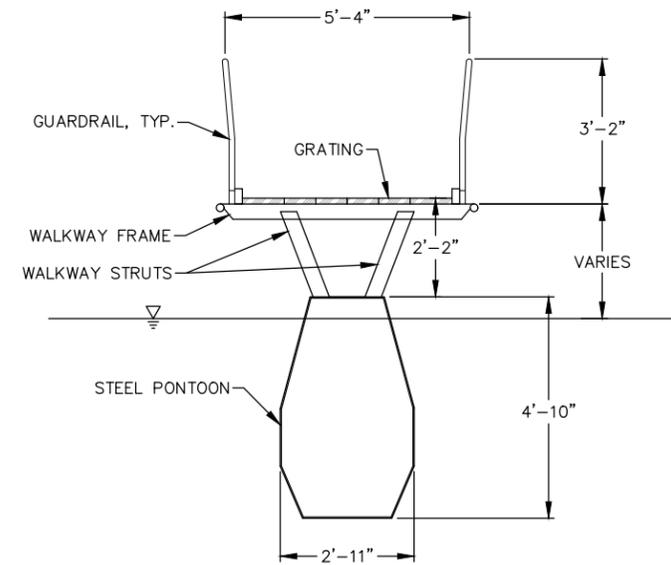
Existing Site - Moorings



SECTION A
SCALE IN FEET



DETAIL 1
SCALE IN FEET



SECTION B
SCALE IN FEET



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Project Number	B/O	Total
391980	5	5

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Scale at ANSI D	Status	Rev	Security
As Shown			
Drawing Number			

Washington State
Department of Fish and Wildlife
Fort Ward Net Pen
Section - Mooring

January 29, 2018
Collins Job No. 45-10819

Underwater Inspection of the Fort Ward
Fish Net Pen System in Rich Passage, WA

Mr. Nels Sultan, Ph.D, P.E.
Principal Engineer
North America Ports, Coastal and Offshore
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Edmonds, WA 98020

Dear Mr. Sultan,

Collins Engineers, Inc. conducted an underwater inspection of the Fort Ward Fish Net Pens System located in Rich Passage, WA from December 11 through December 16, 2017. The scope of the inspection was to perform a below water visual and tactile inspection of the facility, consisting of the anchor line assemblies and the floating pontoons of the net pens system, and then based on the findings, comment on the integrity and stability of those submerged components of the fish net pen system.

The fish net pens system components inspected included all of the floating pontoons that support the overall system, their attachments to the various anchor lines, and all of the anchor line assemblies. The inspection intensity consisted primarily of a Level I inspection effort (visual and tactile techniques), with very limited cleaning of existing marine growth, and the overall inspection process followed the guidelines established by the ASCE Manual of Practice 101 – Underwater Investigations: Standard Practice Manual and ASCE Manual of Practice 130 – Waterfront Facilities Inspection and Assessment. The inspection was performed by a dive team consisting of five (5) Association of Diving Contractors (ADCI) engineer/divers with rotating rolls to optimize dive time and safety. Since all of the submerged fish net pens system components inspected were located in water depths of 100 fsw or less (low tide conditions were utilized for some anchor line inspections to ensure water depths no greater than 100 fsw, which is the OSHA limitation for commercial dive operations not requiring a recompression chamber to be onsite), all inspections were accomplished by diving.

It should be noted that the inspection of the anchor lines was accomplished with the use of surface-supplied diving equipment (air hose and hard-wire communications gear) that included a 300 ft

umbilical in support of the diver's movements during inspection. At times, given the waterway currents creating a bow in the umbilical and/or the anchor location (either an exposed anchor or the point where the anchor chain became embedded in the seabed), there was a need to supplement the range of the diver's umbilical with a line from the inspection vessel that allowed it to move away from the fish net pens system for some necessary distance. Although no record or rough measurement of length of umbilical and/or line from the vessel was ever made during the inspection, it is reasonable to say that some of the anchor lines, to the point of inspection completion, may have reached a length from the net pens of up to 350 ft.

Refer to Photographs 1 through 70 for views of the typical and specific conditions observed during the underwater inspection of the Fort Ward fish net pens system components. In addition, all of the photographs and videos taken during the underwater inspection of the Fort Ward fish net pens system components have been made available for reference digitally.

Overall, the underwater inspection revealed the following key findings:

- The anchor line assemblies were typically found to be in good to mostly satisfactory condition, with no structurally significant deterioration in most instances, and in all cases with all connection elements presently intact and secure. Regarding the various shackles used throughout the system, although presently secure, there were, however, random instances of no cotter pin or safety wire, or locations where the pin nut was corroded and loose, but still held in place by the cotter pin. It should be noted that in comparison to the Orchard Rocks Net Pens System, the Fort Ward system generally appeared to have an older overall makeup, with far lower percentage of anchor lines that have been more recently renewed.
- The extent of marine growth on the anchor line ropes varied with the apparent age (time in service) of the rope, with heavy amounts of marine growth on the ropes of Anchor Lines 1, 2, 5, 7, 9, through 15 and 17 through 20, and with minimal amounts of marine growth (typically newer vintage ropes) on the ropes of Anchor Lines 4, 8 and 16. (Note: Anchor Lines 3 and 6 only had chain along their runs and no rope portion.) The anchor rope eye splices had a mixture of thimbles, protective sleeves, smaller rope lashing, and just bare rope at their connections with no concerns observed.
- Heavier and more notable corrosion with related pitting (generally up to 1/16 in. deep) of the steel was present for some or all of the steel components (chains and shackles) at Anchor Lines 1, 2, 5, 6, 9, 11, 12, 13, 14 and 15. The heaviest of all corrosion noted was present at Anchor Lines 1, 9, 11, 12, 14 and 15 with the specific details as follows:
 - At Anchor Line 1, the lower anchor chain had random links that exhibited up to 50% loss of original section (± 1 in. diam. remaining)

- At Anchor Line 9, the upper anchor chain and a shackle within the overall run of the lower anchor chain exhibited up to an estimated 25% loss of original section.
- At Anchor Lines 11 and 12, in addition to very heavy marine growth, the lower anchor chain and related shackles had areas of up to an estimated 20% loss of original section. At Anchor Line 12, there was also one link in particular (smaller chain – see below) at a shackle connection that exhibited up to an estimated 50% loss of section ($\pm 1/2$ in. diam. remaining) due to corrosion and wear.
- At Anchor Line 14, in addition to very heavy marine growth, both the upper and lower anchor chains and related shackles exhibited up to 1/8 in. deep pitting and areas of up to an estimated 20% loss of original section.
- At Anchor Line 15, in addition to very heavy marine growth, the lower anchor chain and related shackles exhibited, on average, up to an estimated 25% loss of original section, with some chain links having an estimated loss of up to 75% ($\pm 1/2$ in. diam. remaining).
- At Anchor Lines 11, 12, 14 and 15, the lower anchor chain included portions of a smaller-sized chain, having no stud in the links, which appeared to be of older vintage and was at times the portion of the overall chain length that exhibited the greatest corrosion-related section losses.
- Slightly less than 33% of the anchor lines inspected had, in most instances, an estimated 90' (full shot length) or less of the anchor leg chain exposed directly above and/or partially embedded in the seabed, with the anchor shackle and anchor fully buried in the seabed (no anchor exposure). Portions of the anchor (or other means of anchorage) were found exposed at Anchor Lines 1, 2, 3, 4, 5, 6, 7, 11, 13, 14, 15, 16, 17, 18, and 19. Overall, all of the anchors (those that were Danforth type), with one exception (Anchor 6), observed were sufficiently buried in the seabed, and there were no anchors that displayed indications that the anchor was unstable and/or shifting its position in the seabed. At Anchors 1 through 4, the anchorage was either dolphin piles or structure piles related to the fixed facility pier that extends off of the easterly shore, and in those instances, all conditions suggested adequate stability.
- As indicated above, at Anchor 6, the Danforth type anchors (two anchors in series at this location) were not embedded at all in the seabed and were essentially just resting on the seabed. There were, however, no apparent indications that either of the anchors have shifted appreciable since original placement.

- All of the steel pontoons of the Fort Ward net pens system were inspected and overall were found to have no structurally significant deterioration. The pontoons generally had 20% to 25% overall coverage of minor surface corrosion, with negligible related section loss, with much of corrosion apparently related to marine growth cleaning operations (conducted by the facility) that may have allowed more of the pontoon steel to become exposed. Approximately 33% of the zinc anodes on the pontoons were 80% or more consumed, with the remaining 67% of the anodes typically showing 20% or less consumption. In addition, approximately 33% of the anodes were missing one of two fasteners that secure the anode bracket to the pontoon, and there three anodes that were completely missing. There were also some additional (four) anodes added to the system by virtue of hanging them from lines suspended from the walkway structure above.

Anchor Line Assemblies

The anchor line assemblies typically consisted of:

- Connection to floating pontoon of net pens system
- Upper Anchor Chains (± 30 ft)
- Ropes (± 200 ft – rode line)
- Lower Anchor Chains (± 90 ft – one shot of chain)
- Anchors (Danforth or can/pile type)

Regarding the connection of the anchor lines to the various pontoons around the entire perimeter of the net pen system, they were always found to be fully intact and secure in what could always be deemed as being in good to mostly satisfactory condition. Typically, the item of the pontoon-to-anchor line connections that exhibited the greatest deterioration was observed to be the steel plate (padeye) that serves as a means of connecting the anchor line shackle to the steel bracket assembly that connects to the pontoon and pen system perimeter walkway. As for these connection plates, which reside in the splash zone, they typically exhibited moderate corrosion that had some associated pitting (generally up to 1/8 in. deep) and rust delaminations. Overall, however, there still appeared to be minimal loss of original steel plate thickness related to the corrosion. Attached to these connection plates, the anchor line shackles typically exhibited little, if any, deterioration, and in many instances appeared to be relatively new hardware. The upper anchor chain shackles were always found to be properly aligned and secure, and cotter pins for the shackle pins were typically in place. The exception to this was for the “screw-in” type shackle pins, which although always secure, typically did not have any pin-restraining wire in place. The inspection of the accessible portions of the steel framing that provides the overall attachment between the aforementioned shackle plates, the pen system pontoons, and the perimeter walkway construction typically revealed that framing to be sound and secure with no concerns for instability.

The upper and lower anchor chain (shackle) to rope eye splice connections (bare rope, steel thimble, protective hose sleeve or smaller rope lashing/protection) were also typically found to be

fully intact, secure, and in good to satisfactory condition. The steel thimbles, when used for the rope eye splices, typically exhibited minimal deterioration, and the ropes were typically secured beyond the thimble with an eye splice weave of sufficient length and integrity. Similarly, adequate eye splice lengths were typically present and the rope loop was adequately protected at locations where a protective sleeve (blue PVC or “fire hose” type material) or smaller rope lashing was used for the eye splice connection. At the two locations, where only bare rope was around the shackle, at Anchor Lines 4 and 15, there was again sufficient splice weave and presently no apparent damage to the unprotected rope.

In most instances, the steel shackles at the rope to chain connections exhibited no structurally significant deterioration, and were typically found to be properly aligned and secure with cotter pins for the shackle pins typically in place and properly installed. When corrosion was present on the shackles, it generally had minimal associated section loss, and ranged in extent from just surface corrosion to corrosion with pitting that was up to 1/16 in. deep. The exceptions to this was found at Anchor Line 14, where the shackle at the upper end of the rode line rope exhibited an estimated 20% of section loss with pitting that was up to 1/8 in. deep. In general, when the shackles exhibited corrosion, it appeared to be related to an overall anchor line that was older in vintage. Conversely, Anchor Lines 3, 4, 8 and 16 appeared to be relatively new and had very little or essentially no shackle corrosion. For the shackles that were the type with the pin held in place by a nut, as previously indicated, the pins in most instances were properly secured with a cotter pin. There were, however, random locations where no cotter pin was in place, but presently for those cases, the shackle pins were still sufficiently secure. There were also one instance at Anchor Line 13, where the cotter pin was present and holding the pin nut in place, but the nut was no longer engaged due to thread deterioration. There was a similar situation at Anchor Line 16 as well; however, the shackle was newer, so it appeared that the nut was able to spin because of being the wrong size.

The ±30 ft long upper anchor chains were typically found to be in good to satisfactory condition, with corrosion levels, similar to that of the shackles, which ranged, depending on the apparent age of the overall anchor line, from little or no corrosion (refer to previous newer anchor line listing in shackle discussion) to more advanced corrosion with pitting that generally was up to 1/16 in. deep. In addition, the older upper anchor chains also had heavier pitting and rust delaminations between the padeye connection and the water surface (above water splash zone), with pitting depths and delam thicknesses of up to 1/8 in. (±3/16 in. at Anchor Lines 5, 9 and 12). In general, however, regardless of the current extent of corrosion, none of the upper chain corrosion exhibited what would be deemed as structurally significant loss of section. Similar to the corrosion, the amount of marine growth on the upper lengths of chain again varied with the apparent time in service of the chain, with newer lengths having essentially no growth and older lengths having 3 in. to 6 in. thick growth that included hard, large barnacle growth.

The ± 200 ft long ropes (rode lines) were typically found to be in good to satisfactory condition with no significant fraying or detectable abrasion damage. The extent of marine growth on the anchor line ropes varied from essentially no growth at all to growth that was generally 3 in. to 6 in. thick, and at times up to 12 in. thick, that included both soft growth and hard, large barnacle growth. Clearly, the amount of growth on each anchor line was directly related to the apparent age (time in service) of the rope, with heavy amounts of marine growth on the ropes (as well as adjoining upper shackles and chains) of Anchor Lines 1, 2, 5, 7, 9 through 15 and 17 through 20, and with minimal amounts of marine growth (typically newer vintage ropes) on ropes (as well as adjoining upper shackles and chains) of Anchor Lines 4, 8 and 16. It should also be noted that at the lower rope to chain shackle connection of Anchor Lines 17 through 20, there was a float on a rope attached to the rode line rope. Although not particularly an item of concern, it should be noted that the rode line at Anchor Line 9, there was approximately 10 ft of the rope loosely laying on the seabed, indicating that there was no strain in the anchor line due to the excess rope in the line. It should also be noted that Anchor Lines 3 and 6 did not have any rode line rope, and only consisted of chain from the net pens to the point of anchorage.

The ± 90 ft long (one shot of chain) lower anchor chains were typically found to be in good to mostly satisfactory condition, with no structurally significant deterioration and with lesser amounts of marine growth regardless of the apparent age of the overall anchor line. Similar to the upper anchor chains, the heaviest corrosion for the lower anchor chains typically only had pitting that was 1/16 in. deep or less and negligible loss of original chain section. The exceptions to this were noted at Anchor Lines 1, 11, 12, 14 and 15, where the lower anchor chain had notably heavier corrosion with link section losses that were typically in the range of 20% to 25% and as much as an estimated 50% in some instances. In addition, at Anchor Line 15, which was found to have the heaviest corrosion on average, there were some chain links with up to 75% loss of original section. It should be noted that at Anchor Lines 11, 12, 14 and 15, the lower anchor chain run included a portion of a smaller-sized chain, having no stud in the links, which appeared to be of older vintage and was most often where the greatest loss of link section was observed.

For all of the Fort Ward anchor lines, the lower anchor chain was resting on or embedded to some extent in the seabed, as it should be, until the point where it either became completely embedded or the connection to the anchor was reached. In most instances, the length of lower anchor chain exposed to some extent for inspection ranged between 45 ft and 90 ft (full shot length). At Anchor Lines 8 and 9, there was approximately 135 ft (± 1.5 shots of chain) of lower anchor chain exposed before the chain became fully embedded in the seabed, and similarly, at Anchor Line 7, there was approximately 180 (± 2 shots of chain) exposed before the anchor was reached. At Anchor Lines 3 and 6, there was chain exposed for the full distance between the fish net pens and the seabed anchorage, since those anchor lines did not have any rope as part of their makeup. The lower anchor chain typically resting on and/or embedded in the seabed suggests an appropriate anchor location and anchor line assembly length (scope) to promote proper setting and subsequent grip of the Danforth type anchors. In most instances, the manner in which the chain was on or in the

seabed, with no notable rutting or plowing of the seabed, suggests that the lower anchor chains are not being lifted up or being moved from side-to-side in the seabed. The exception to this was noted at Anchor Lines 10, 13 and 16, where there was some slight rutting/plowing (up to 8 in. deep/high channel bottom differences), although it did not appear to be enough seabed disruption to suggest that there was any problem with the anchor line's overall anchorage.

As for the anchors of the Fort Ward system, 25% (5 of the 20 total anchor lines) were found to be completely buried (including the shackle connection), which suggests that those anchors (reported to be Danforth type) were well-seated and adequately gripping into the seabed. The Danforth type anchors that were found to be exposed to some extent were located at Anchor Lines 5, 6, 7, 11 and 13 through 18, with two Danforth type anchors in series at both Anchor Lines 5 and 6. Typically, the amount of anchor exposure at these anchors was minimal, with a majority of the anchor stem and flukes typically embedded in the seabed, such that each anchor was adequately founded in the channel bottom with no indications of any recent anchor slippage or other movement. The exception to this was at Anchor Line 6, where both of the two Danforth type anchors were just resting on the seabed with no embedment, although also with no indications of any anchor shifting or movement since original placement. At Anchor Lines 1, 2 and 3, the means of anchor line anchorage was accomplished by wrapping the lower anchor chain around the timber piles of either the dolphin pile cluster or the structure support piles of the fixed pier facility that is to the east of the net pens system. Also with no Danforth type anchor used, at Anchor Line 4, the type of anchor was that of a driven pipe pile, with the lower anchor chain secured to the pile anchor using a loop of rope shackled to the chain, and at Anchor Line 19, the lower anchor chain ran under a large steel box, which was presumed as being used as the anchor. In all instances, the existing conditions for the anchor lines without a Danforth type anchor suggested a stable anchorage, although there was some minor abrasion of the timber piles used for the anchorage at Anchor Lines 2 and 3.

Floating pontoons of the Net Pens System

As for the floating pontoons of the net pen system, the inspection of those components always revealed them overall to be in good to satisfactory condition with no significant deterioration, damage or any other reasons for concern identified. For the most part, the submerged surfaces had the majority of their protective coatings intact and well-adhered. In general, all of the pontoons exhibited between an estimated 10% to 25% of protective coating (black colored top coat) breakdown and failure. Where coating loss was evident on the below water surfaces of the pontoons, there was always just minor surface corrosion and a light dusting of rust scale, which could be easily brushed away with a gloved hand, with no notable loss of steel section related to the corrosion detected. In regard to the corrosion that was present, it appeared to be related in large part to marine growth cleaning operations (conducted by the facility) that may have allowed more of the pontoon steel to become exposed and subject to subsequent corrosion. As for the marine growth, there was typically very minimal amounts of growth on the pontoons because of the aforementioned cleaning operations.

The pontoon inspections also included the inspection of the various cathodic protection anodes attached to the pontoons, with the majority of the sacrificial anodes (zincs) attached with a bracket bolted directly to the pontoons. Overall, approximately 33% of the anodes were 80% to 100% consumed, with the remaining 67% of the anodes exhibiting 20% or less consumption. In an effort to perhaps augment the heavily consumed anodes, there were also some additional anodes (4 total) that were incorporated into the cathodic protection system by hanging them from lines suspended from the walkway structure above the pontoons. Aside from the indicated amounts of consumption, it was also observed that three anodes were completely missing, and for approximately 33% of the in place anodes, while still securely attached to the pontoon, there was one of the two bracket connecting bolts missing.

Conclusions

Overall, the anchor line assemblies were typically found to be in good to mostly satisfactory condition, with for the most part no structurally significant deterioration, and with all connection elements presently sound and secure. The rating of good to satisfactory is deemed appropriate since good implies essentially no deficiencies, and satisfactory implies that there may be some deterioration or other defects present, but those conditions are primarily minor and not compromising the integrity of the affected component. The only exception to this would be for Anchor Lines 1, 11, 12 14 and 15, and particularly Anchor Lines 1, 12 and 15, where there was more significant corrosion and related section loss noted for some of the chain or shackle components. With respect to these more heavily deteriorated anchor lines, it was clearly evident they were some of the oldest anchor lines of the Fort Ward net pens system, and therefore, should most likely be the first lines to be considered for renewal in the future. As for the aforementioned other anchor lines that appeared to be of older vintage, the current extent of corrosion on the steel components, as well as the generally heavy marine growth on the upper anchor chains and rode line ropes, did not appear to be overly detrimental to the anchor lines themselves or the overall facility at this time. Regarding the older vintage anchor lines, however, it should be noted that compared to the Orchard Rocks system, the Fort Ward system generally appeared to have an older overall makeup, with a far lower percentage of anchor lines that have been more recently replaced. As for the floating pontoons of the net pens systems, they also were found to be in good to satisfactory condition, with no significant deterioration and no other concerns for the pontoons. In light of the present amount of anode consumption, however, there may not be enough anodes to afford proper cathodic protection of the pontoons, although presently the pontoon steel still seems relatively protected given the very minimal and light corrosion on the areas of exposed pontoon steel below water.

Mr. Nels Sultan

January 29, 2018

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If you have any questions or require any additional information with respect to the underwater inspection findings, please don't hesitate to contact me.



Very truly yours,

COLLINS ENGINEERS, INC.

Daniel G. Stromberg, P.E.
Chief Structural Engineer/Diver

January 29, 2018



Photograph 1: Overall View of the Fort Ward Fish Net Pens System, Looking Northwest.



Photograph 2: Overall View of the Fort Ward Fish Net Pens System, Looking North.



Photograph 3: Overall View of the Fort Ward Fish Net Pens System, Looking North.



Photograph 4: Overall View of the Fort Ward Fish Net Pens System, Looking West.



Photograph 5: View of the Steel Pontoon Condition at Fort Ward Fish Net Pens System, Looking Northwest.



Photograph 6: View of the Bolted Style Anode Condition on the Steel Pontoons at Fort Ward Fish Net Pens System, Looking West.



Photograph 7: View of the Hanging Style Anode Condition on the Steel pontoons at Fort Ward Fish Net Pens System, Looking West.



Photograph 7: View of an 80% Consumed Anode on the Steel pontoons at Fort Ward Fish Net Pens System, Looking West.



Photograph 8: View of Upper Anchor Chain to Float Connection at Fort Ward Anchor Line 6, Looking Northeast.



Photograph 9: View of Upper Anchor Chain to Float Connection at Fort Ward Anchor Line 15, Looking East.



Photograph 10: View of Upper Anchor Chain to Float Connection at Fort Ward Anchor Line 19, Looking South.



Photograph 11: View of Rope with Heavy Marine Growth at Fort Ward Anchor Line 1, Looking North.



Photograph 12: View of Lower Anchor Chain Heavy Section Loss at Fort Ward Anchor Line 1, Looking Northeast.



Photograph 13: View of Lower Anchor Chain Around Timber Dolphin Pile Anchors at Fort Ward Anchor Line 1, Looking East.



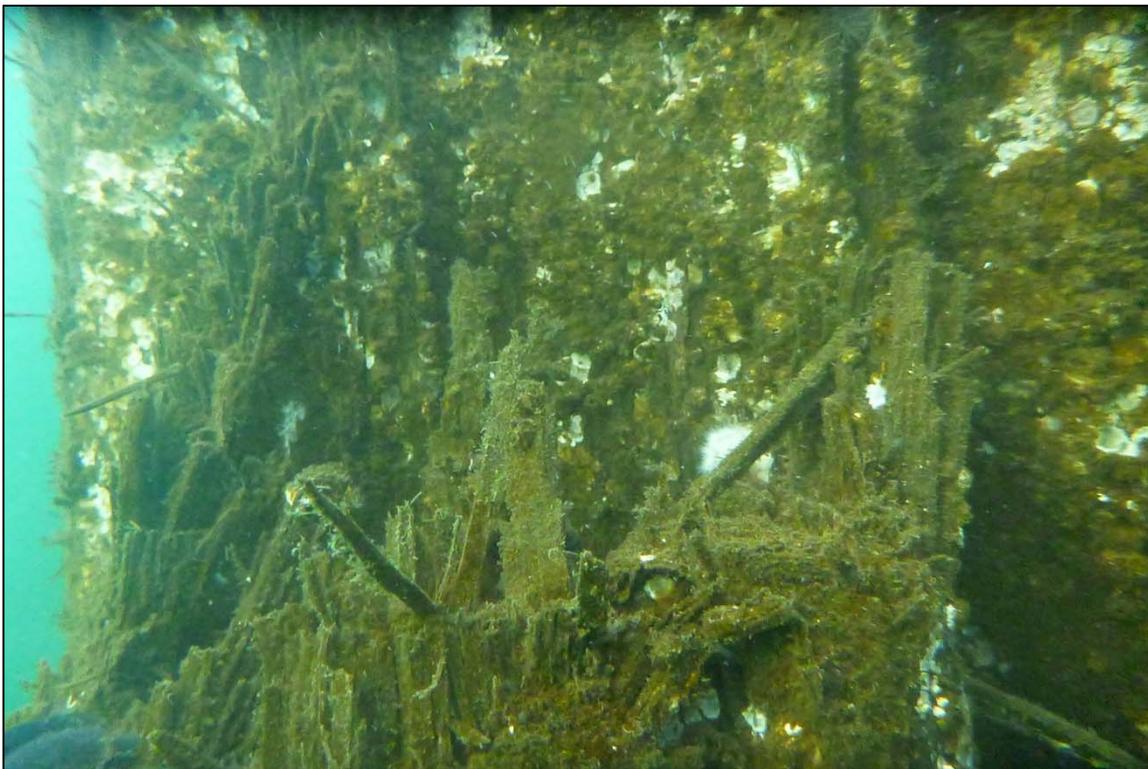
Photograph 14: View of Upper Anchor Chain Marine Growth at Fort Ward Anchor Line 2, Looking West.



Photograph 15: View of Upper Anchor Chain to Rope Connection (Shackle and Sleeve) at Fort Ward Anchor Line 2, Looking North.



Photograph 16: View of Rope to Lower Anchor Chain Connection (Shackle and Sleeve) at Fort Ward Anchor Line 2, Looking East.



Photograph 17: View of Dolphin Pile Anchor Section Loss at Fort Ward Anchor Line 2, Looking North.



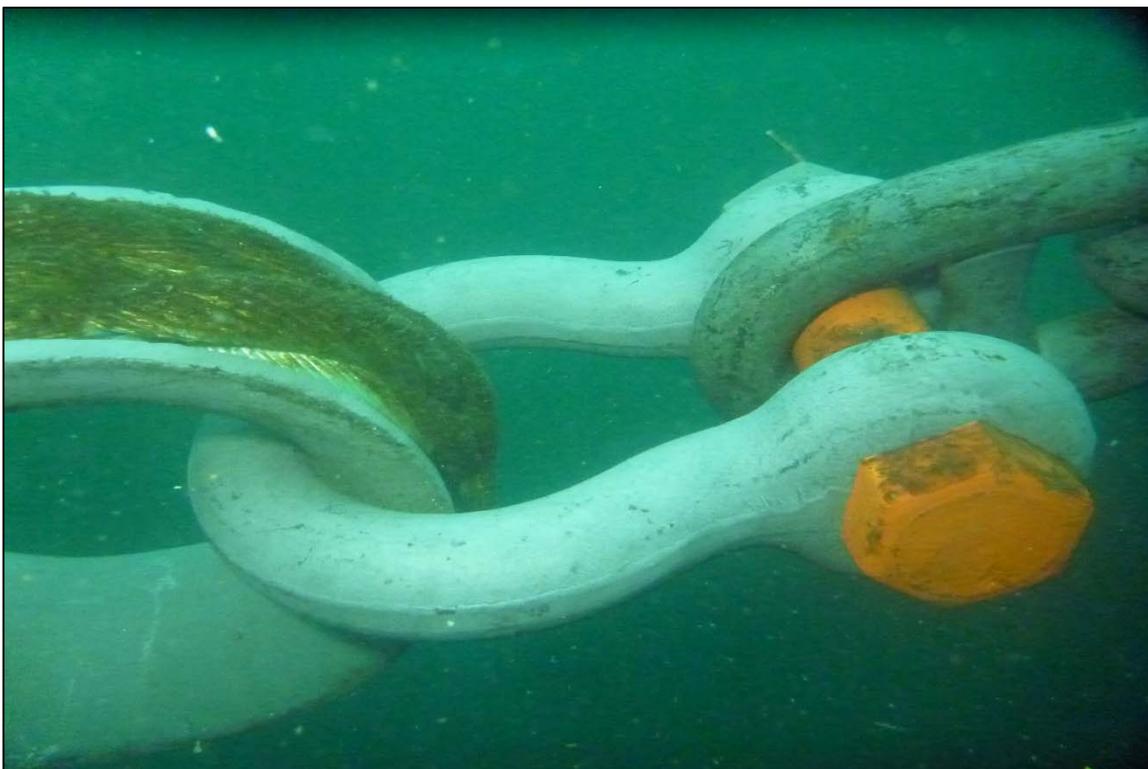
Photograph 18: View of Upper Anchor Chain Condition at Fort Ward Anchor Line 3, Looking West.



Photograph 19: View of Upper Anchor Chain to Rope Connection (Shackle) at Fort Ward Anchor Line 3, Looking North.



Photograph 20: View of Dolphin Pile Damage due to Lower Anchor Chain Abrasion at Fort Ward Anchor Line 3, Looking North.



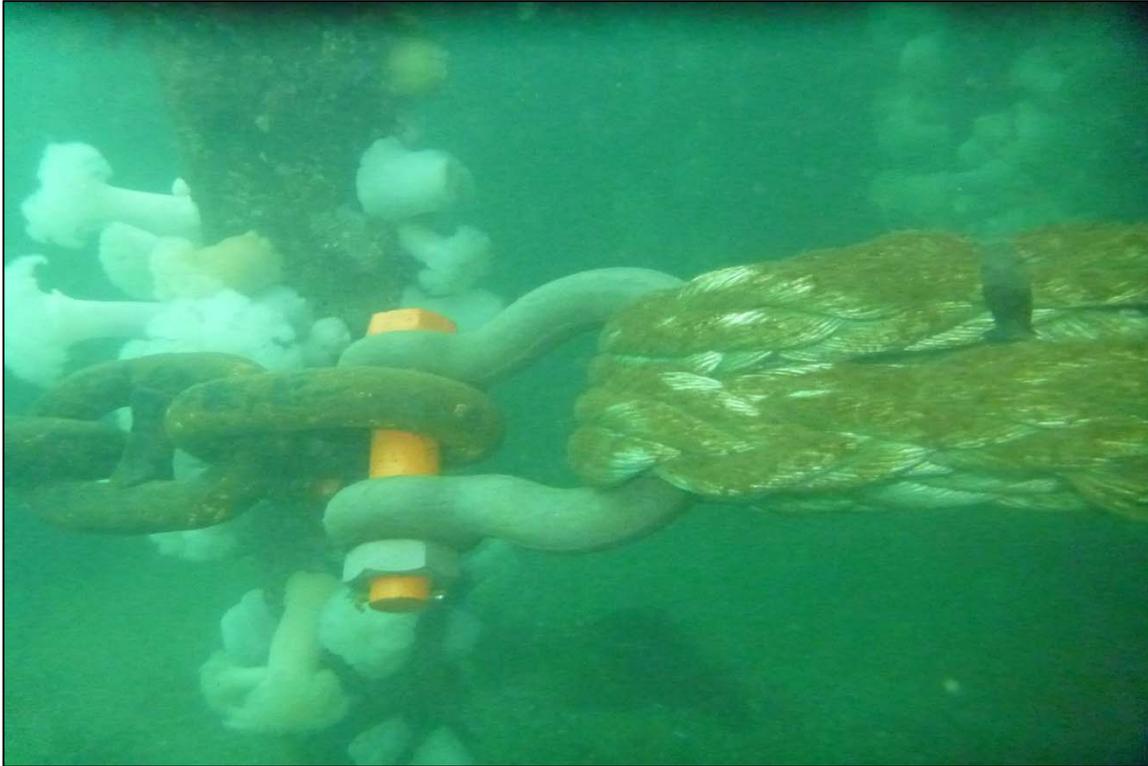
Photograph 21: View of Upper Chain to Rope Connection (Shackle and Thimble) at Fort Ward Anchor Line 4, Looking South.



Photograph 22: View of Rope Lower Splice Condition at Fort Ward Anchor Line 4, Looking North.



Photograph 23: View of Rope to Lower Anchor Chain Connection (Shackle and Sleeve) at Fort Ward Anchor Line 4, Looking South.



Photograph 25: View of Lower Anchor Chain to Rope Loop Connection (Shackle) at Fort Ward Anchor Line 4, Looking North.



Photograph 26: View of Steel Pipe Pile Anchor at Fort Ward Anchor Line 4, Looking North.



Photograph 27: View of Upper Anchor Chain Condition with Heavy Corrosion at Fort Ward Anchor Line 5, Looking North.



Photograph 28: View of North Fluke Embedment at Fort Ward Anchor Line 5, Looking East.



Photograph 29: View of Slack in the Anchor Chain at Fort Ward Anchor Line 6, Looking North.



Photograph 30: View of Anchor Chain Condition at Fort Ward Anchor Line 6, Looking South.



Photograph 31: View of Anchor #1 on the Channel Bottom at Fort Ward Anchor Line 6, Looking East.



Photograph 32: View of Anchor #2 on the Channel Bottom at Fort Ward Anchor Line 6, Looking East.



Photograph 33: View of Upper Anchor Chain to Rope Connection (Shackle and Sleeve) at Fort Ward Anchor Line 7, Looking West.



Photograph 34: View of West Fluke Slightly Embedded in the Channel Bottom at Fort Ward Anchor Line 7, Looking Southeast.



Photograph 35: View of Upper Anchor Chain laying on the Predator Net at Fort Ward Anchor Line 8, Looking North.



Photograph 36: View of Rope on the Channel Bottom at Fort Ward Anchor Line 8, Looking South.



Photograph 37: View of Lower Anchor Chain Condition at Fort Ward Anchor Line 8, Looking South.



Photograph 38: View of Upper Anchor Chain to Rope Connection (Shackle and Sleeve) at Fort Ward Anchor Line 9, Looking West.



Photograph 39: View of Lower Anchor Chain to Rope Connection Section Loss at Fort Ward Anchor Line 9, Looking North.



Photograph 40: View of Rope to Lower Anchor Chain Connection (Shackle and Thimble) at Fort Ward Anchor Line 10, Looking West.



Photograph 41: View of Lower Anchor Chain on the Channel Bottom at Fort Ward Anchor Line 10, Looking North.



Photograph 42: View of Rope Condition with Heavy Marine Growth (Cluster of Barnacles) at Fort Ward Anchor Line 11, Looking East.



Photograph 43: View of Rope to Lower Anchor Chain Connection (Shackle) with Section Loss on the Shackle and Chain at Fort Ward Anchor Line 11, Looking West.



Photograph 44: View of Rope to Lower Anchor Chain Connection (Shackle) with Heavy Marine Growth at Fort Ward Anchor Line 12, Looking North.



Photograph 45: View of Lower Anchor Chain Embedment with Heavy Corrosion at Fort Ward Anchor Line 12, Looking West.



Photograph 46: View of Upper Anchor Chain to Rope Connection (Shackle and Thimble) at Fort Ward Anchor Line 13, Looking Southeast.



Photograph 47: View of Rope to Lower Anchor Chain Connection (Shackle and Thimble) at Fort Ward Anchor Line 13, Looking Southwest.



Photograph 48: View of Lower Anchor Chain to Anchor Connection (Shackle) at Fort Ward Anchor Line 13, Looking North.



Photograph 49: View of North Fluke Embedment at Fort Ward Anchor Line 13, Looking West.



Photograph 50: View of Upper Anchor Chain Condition with Heavy Corrosion and Delamination at Fort Ward Anchor Line 14, Looking East.



Photograph 51: View of Upper Anchor Chain Condition with Heavy Corrosion and Pitting at Fort Ward Anchor Line 14, Looking South.



Photograph 52: View of Anchor Rope with Heavy Marine Growth at Fort Ward Anchor Line 14, Looking East.



Photograph 53: View of Anchor Embedment at Fort Ward Anchor Line 14, Looking West.



Photograph 54: View of Lower Anchor Chain Condition with Heavy Corrosion and Pitting at Fort Ward Anchor Line 14, Looking South.



Photograph 55: View of Lower Anchor Chain Condition with Heavy Corrosion and Section Loss at Fort Ward Anchor Line 15, Looking North.



Photograph 56: View of Lower Anchor Chain Condition with Heavy Corrosion and Section Loss at Fort Ward Anchor Line 15, Looking North.



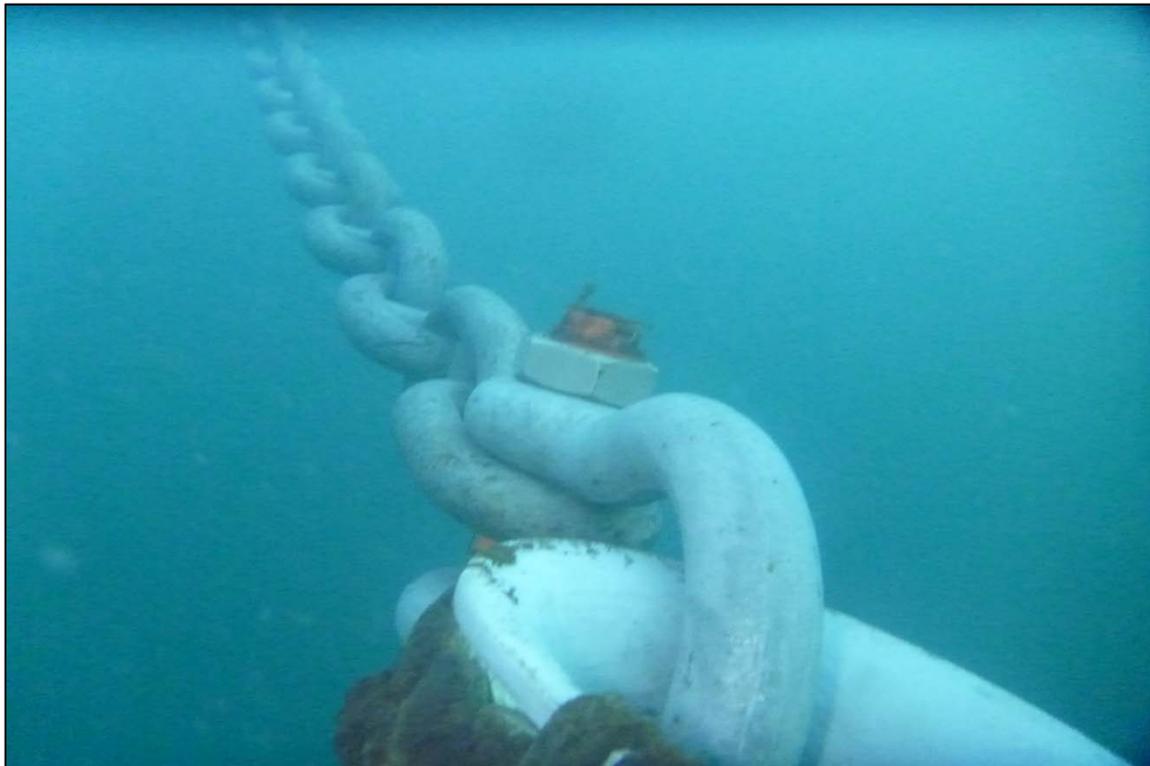
Photograph 57: View of Lower Anchor Chain Condition with Heavy Corrosion and Section Loss at Fort Ward Anchor Line 15, Looking North.



Photograph 58: View of Lower Anchor Chain Condition with Heavy Corrosion and Section Loss at Fort Ward Anchor Line 15, Looking North.



Photograph 59: View of Anchor Slightly Embedded in the Channel Bottom at Fort Ward Anchor Line 15, Looking Northwest.



Photograph 60: View of Upper Anchor Chain Condition at Fort Ward Anchor Line 16, Looking East.



Photograph 61: View of Upper Anchor Chain to Rope Connection (Shackle and Thimble) at Fort Ward Anchor Line 16, Looking East.



Photograph 62: View of Rope Condition at Fort Ward Anchor Line 16, Looking East.



Photograph 63: View of Anchor Embedment in the Channel Bottom at Fort Ward Anchor Line 16, Looking Southwest.



Photograph 64: View of Lower Anchor Chain Condition at Fort Ward Anchor Line 17, Looking West.



Photograph 65: View of Float Attached to Rope Near the Rope to Lower Anchor Chain Connection at Fort Ward Anchor Line 17, Looking West.



Photograph 66: View of Rope to Lower Anchor Chain Connection Embedment at Fort Ward Anchor Line 18, Looking North.



Photograph 67: View of Rope to Lower Anchor Chain Connection at Fort Ward Anchor Line 19, Looking East.



Photograph 68: View of Rope Condition with Moderate Marine Growth at Fort Ward Anchor Line 19, Looking East.



Photograph 69: View of Anchor Embedment at Fort Ward Anchor Line 19, Looking North.



Photograph 70: View of Upper Anchor Chain to Rope Connection (Shackle) at Fort Ward Anchor Line 20, Looking East.

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Figure C-1: Rich Passage – Fort Ward Net Pens (GoogleEarth - 2017)



Figure C-2: Rich Passage – Fort Ward Net Pens - View Looking West



Figure C-3: Rich Passage – Fort Ward Net Pens - View from Northwest, Looking East

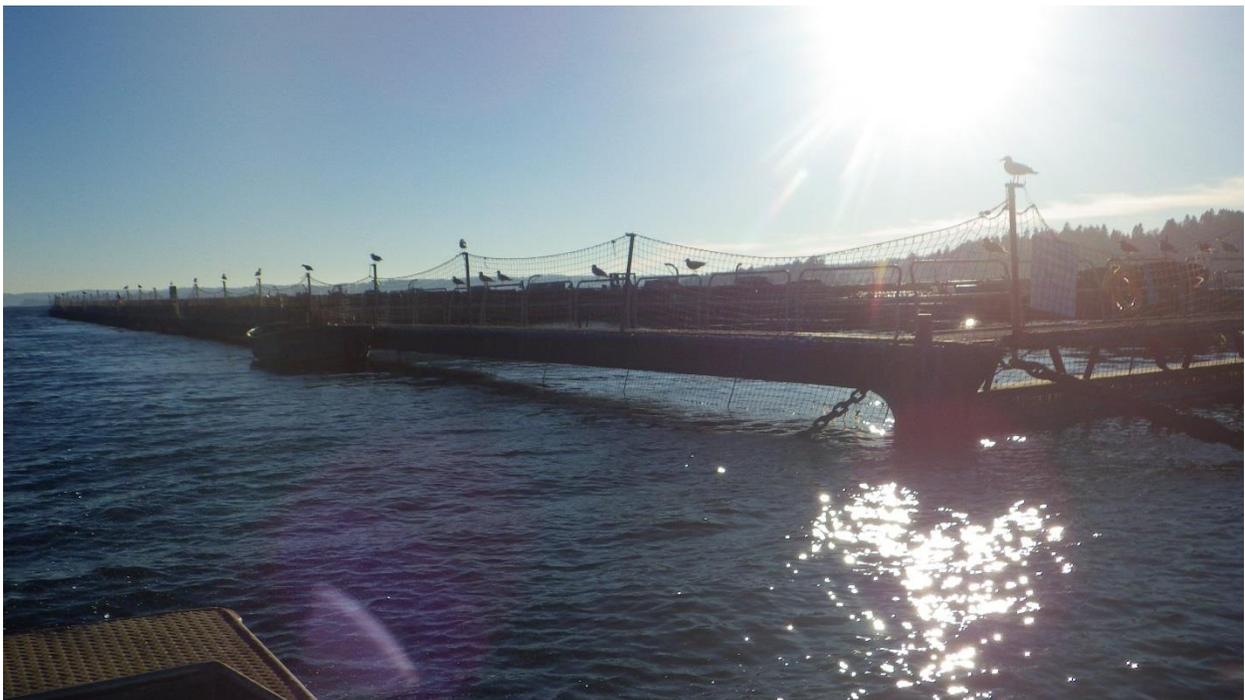


Figure C-4: Rich Passage – Fort Ward Net Pens - View from Northeast, Looking South



Figure C-5: Rich Passage – Fort Ward Net Pens - View from Northeast, Looking Northwest



Figure C-6: Net Pen with no active fish or deployed nets. Note lack of handrail.



Figure C-7: Net Pen with no active fish or deployed nets. Walkway in good condition.



Figure C-8: Steel Pontoon with braces supports grated walkways



Figure C-9: Steel Pontoon with braces supports grated walkways

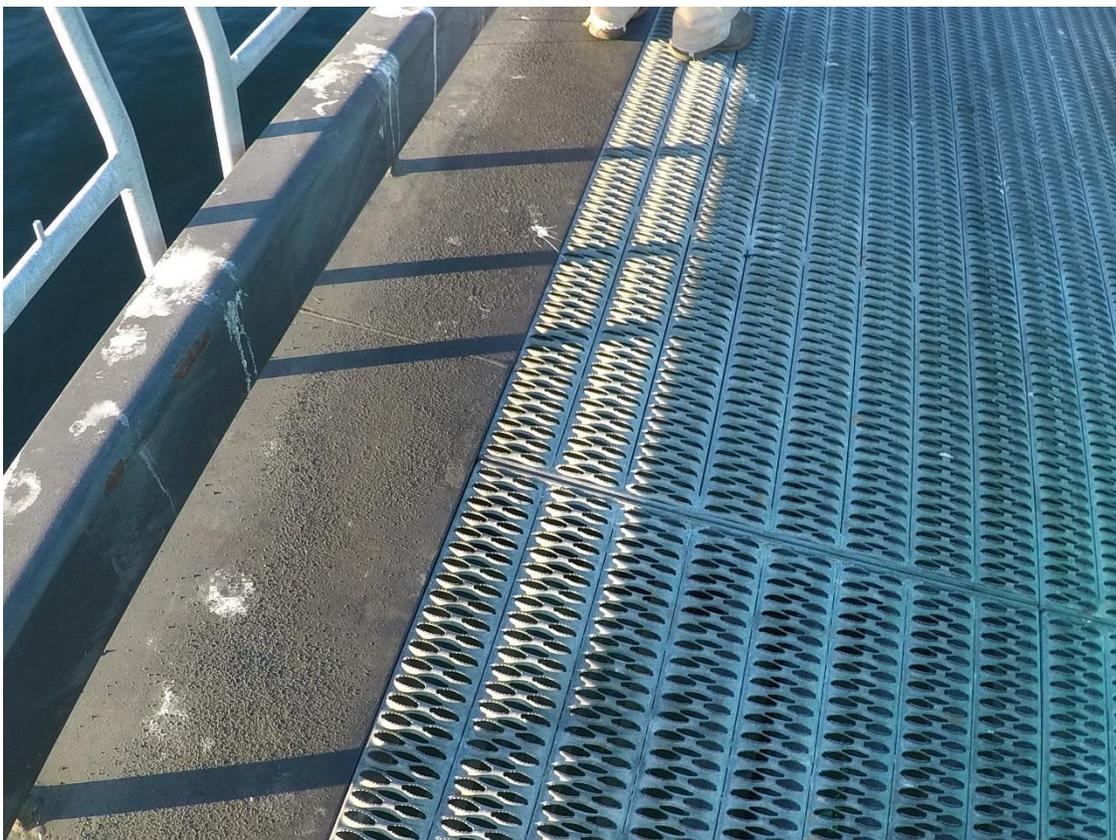


Figure C-10: Steel Framing and Grating at Center Bridge



Figure C-11: Steel Pontoon connection to Steel Walkway framing



Figure C-12: Steel Pontoon connection to Steel Walkway framing. Minor Corrosion.

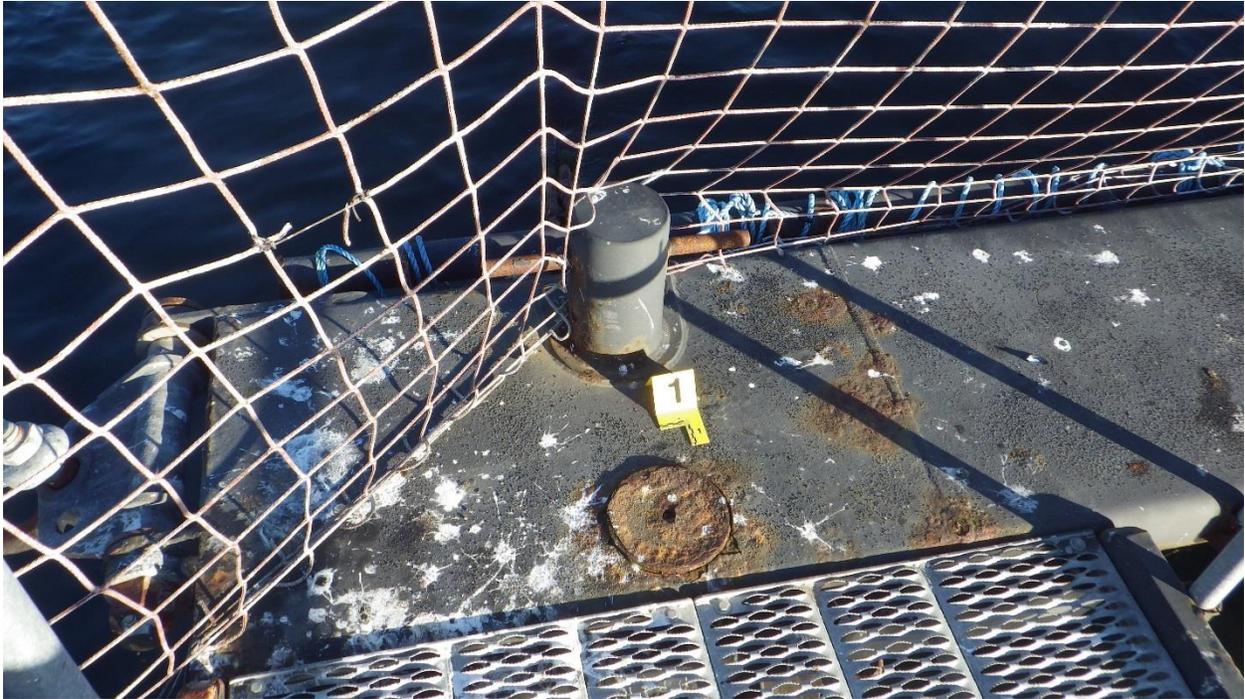


Figure C-13: Anchor #1, NE Corner of Net Pen



Figure C-14: Anchor #1, NE Corner of Net Pen. Chain with moderate corrosion.



Figure C-15: Anchor #2, East Side of Net Pen



Figure C-16: Anchor #2, East Side of Net Pen. Chain with moderate corrosion.



Figure C-17: Anchor #3, East Side of Net Pen



Figure C-18: Anchor #3, East Side of Net Pen. New chain and shackle.

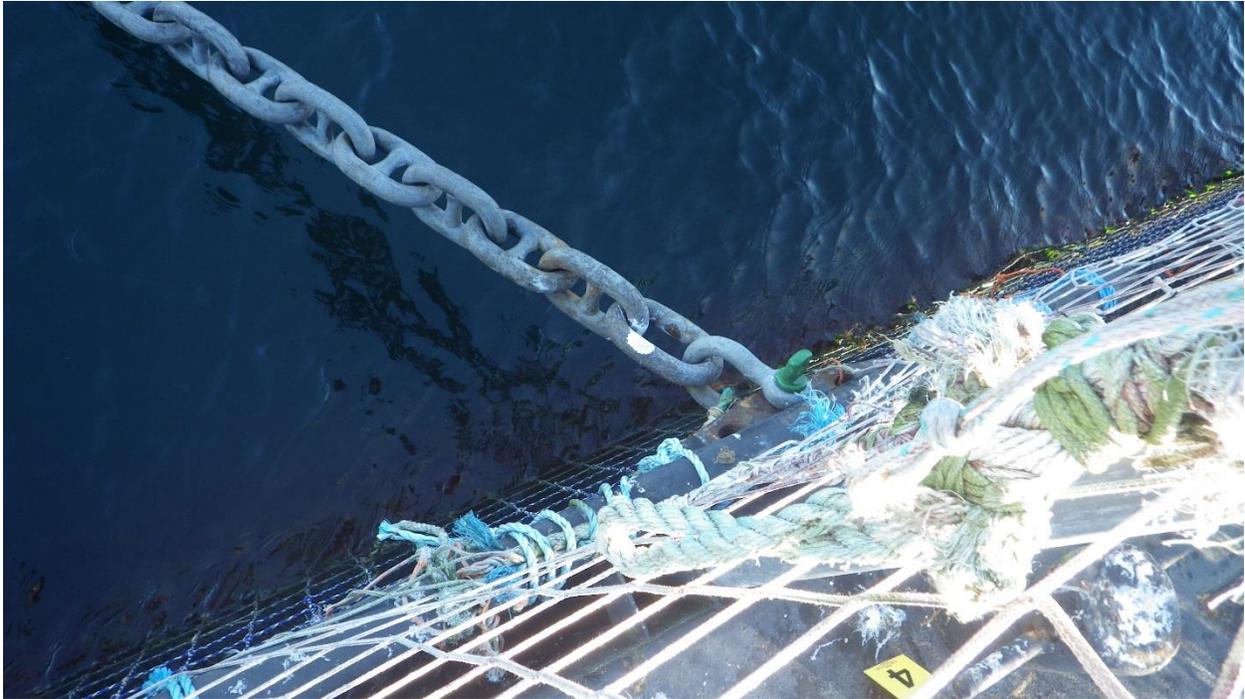


Figure C-19: Anchor #4, East Side of Net Pen

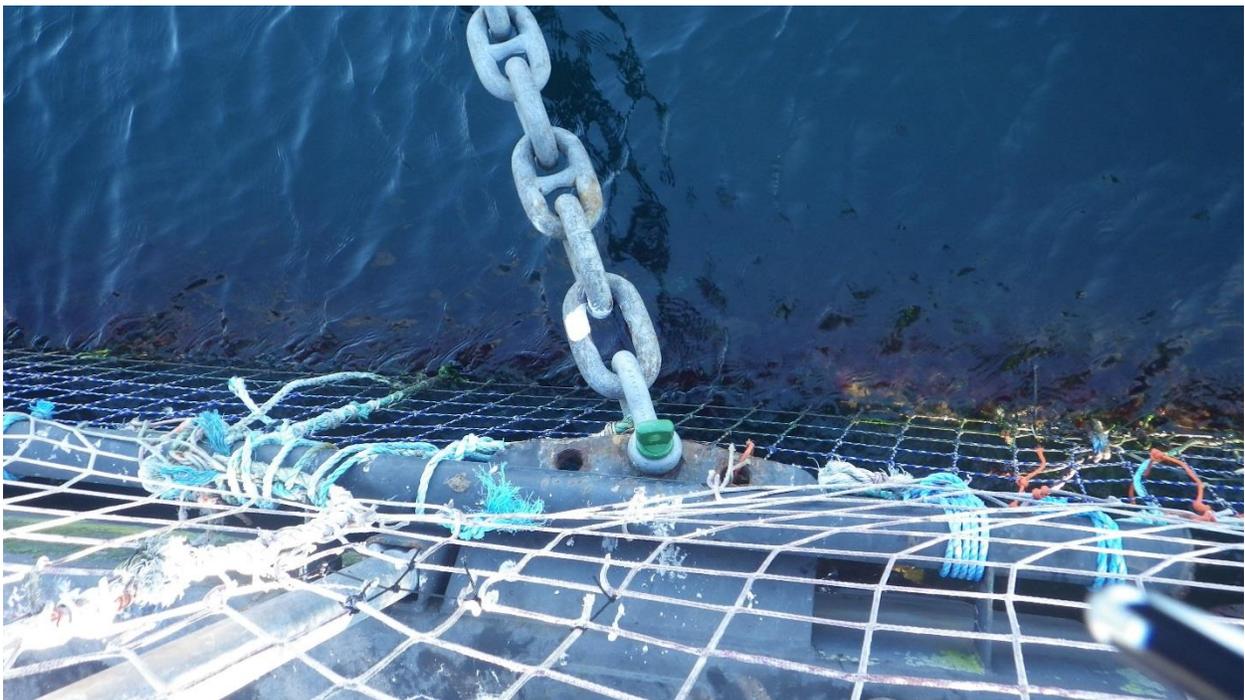


Figure C-20: Anchor #4, East Side of Net Pen. New chain and shackle.



Figure C-21: Anchor #5, SE Corner of Net Pen. Chain with moderate corrosion.



Figure C-22: Anchor #6, SE Corner of Net Pen



Figure C-23: Anchor #7, South Side of Net Pen. Hinge connection with minor to moderate corrosion.



Figure C-24: Anchor #7, South Side of Net Pen



Figure C-25: Anchor #8, South Side of Net Pen. Hinge connection with moderate corrosion.

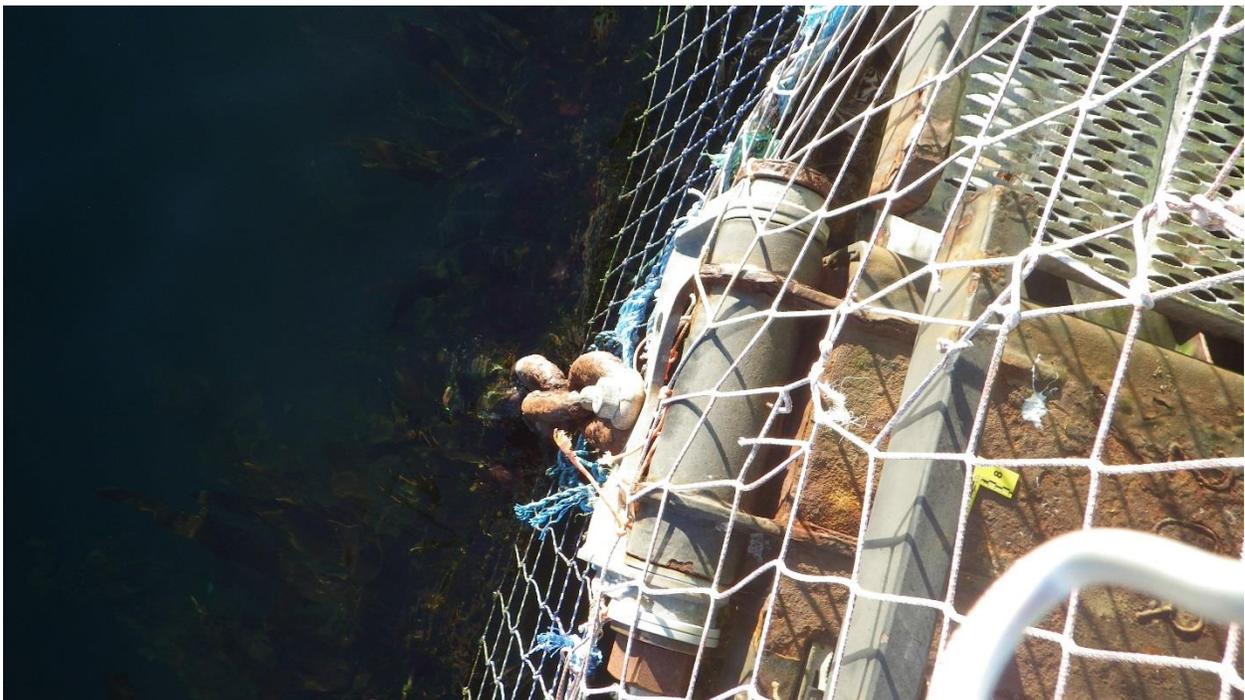


Figure C-26: Anchor #8, South Side of Net Pen



Figure C-27: Anchor #9, SW Corner of Net Pen



Figure C-28: Anchor #9, SW Corner of Net Pen



Figure C-29: Anchor #10, SW Corner of Net Pen



Figure C-30: Anchor #11, West Side of Net Pen



Figure C-31: Anchor #12, West Side of Net Pen. Chain with moderate corrosion.

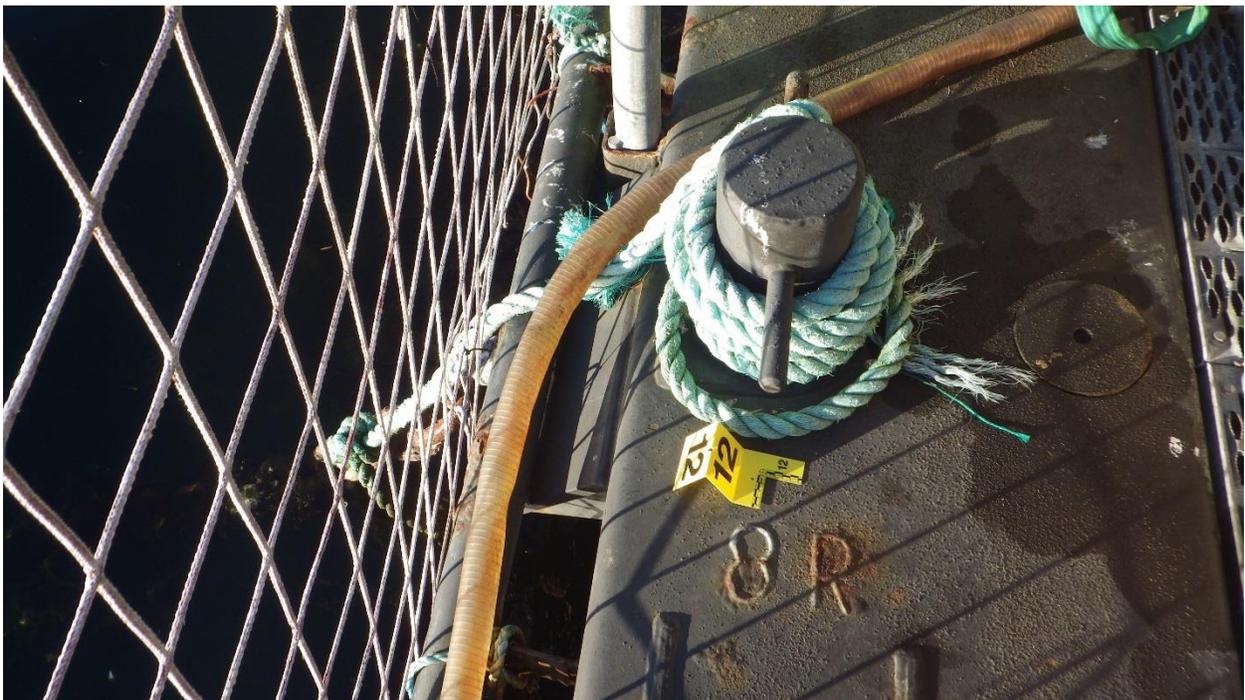


Figure C-32: Anchor #12, West Side of Net Pen



Figure C-33: Anchor #12, West Side of Net Pen. Chain with moderate corrosion.

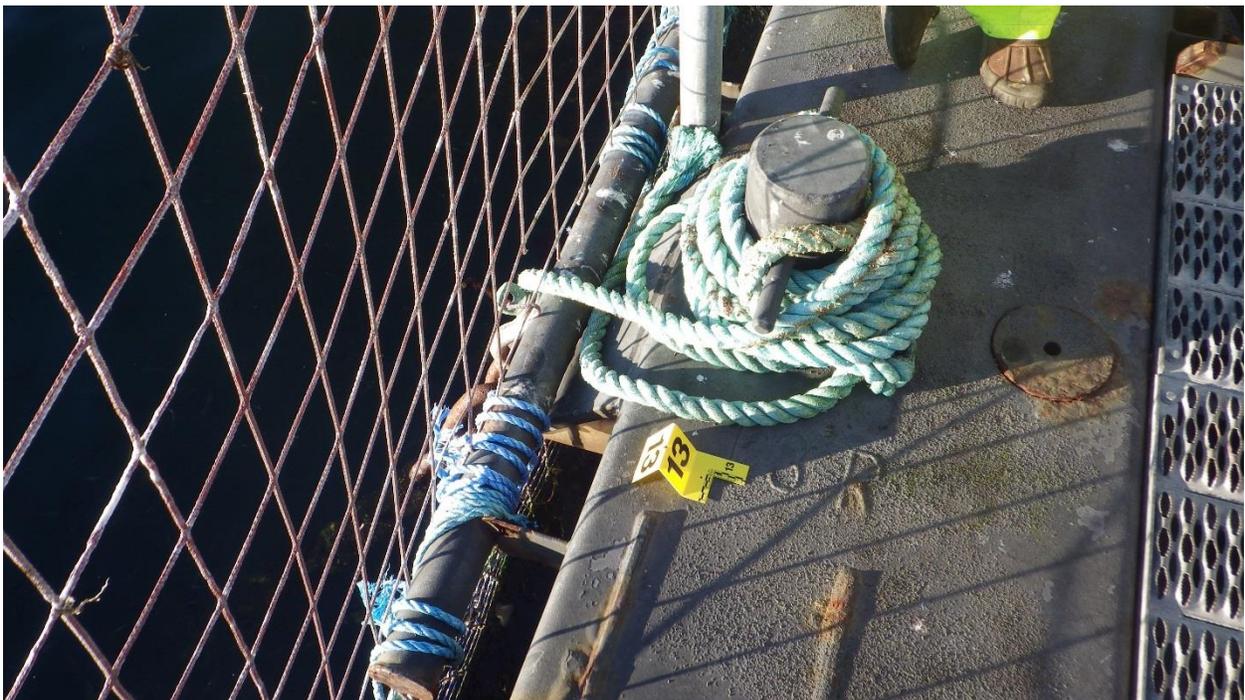


Figure C-34: Anchor #13, West Side of Net Pen



Figure C-35: Anchor #13, West Side of Net Pen. Chain with minor corrosion.

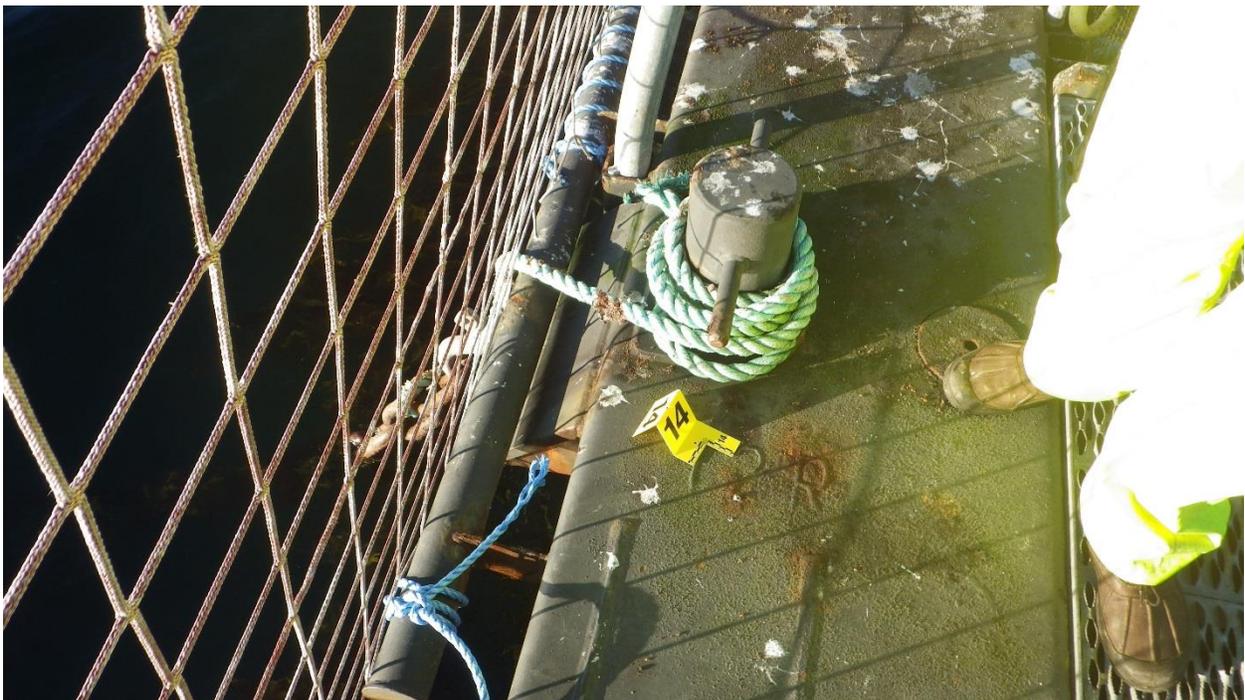


Figure C-36: Anchor #14, West Side of Net Pen



Figure C-37: Anchor #14, West Side of Net Pen. Chain with moderate corrosion.

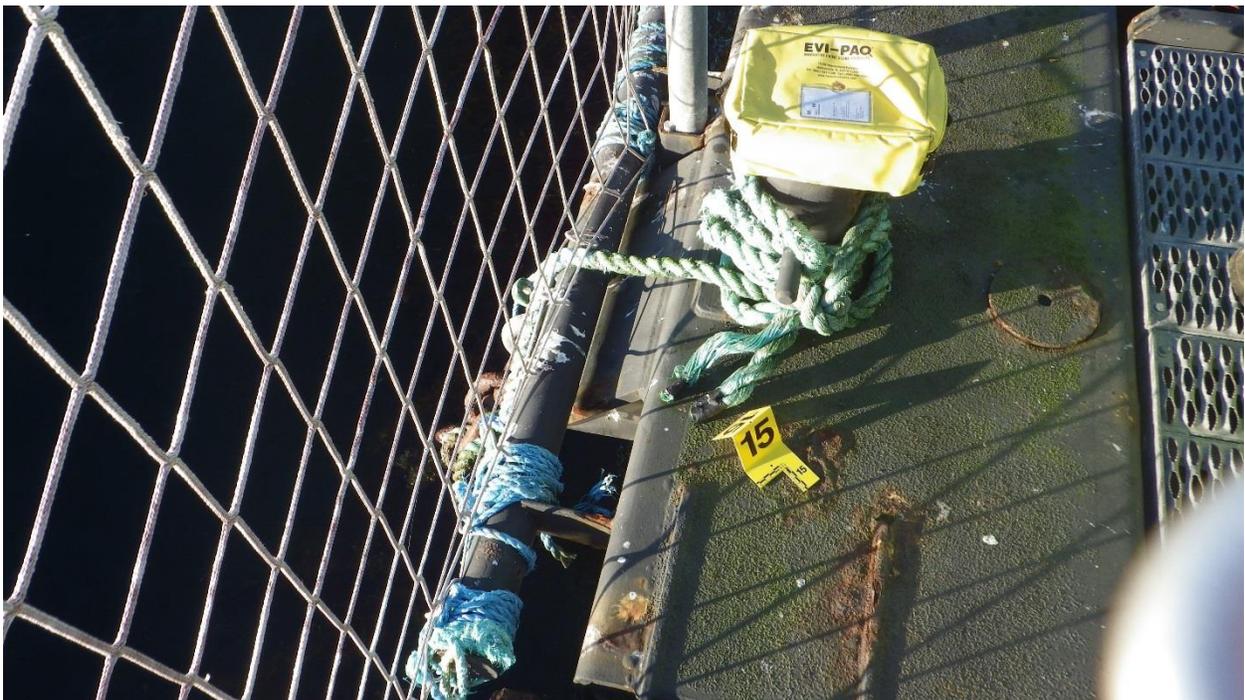


Figure C-38: Anchor #15, West Side of Net Pen



Figure C-39: Anchor #15, West Side of Net Pen. Chain with moderate corrosion.

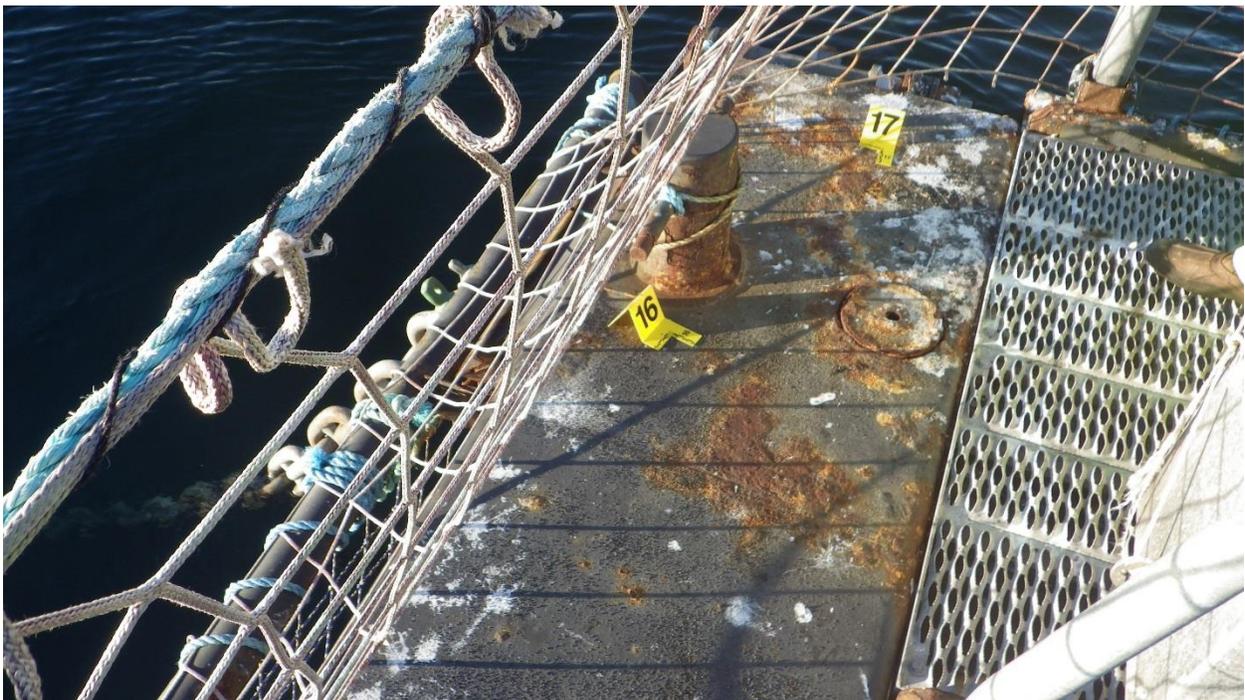


Figure C-40: Anchors #16 and #17, NW Corner of Net Pen



Figure C-41: Anchors #16 and #17, NW Corner of Net Pen

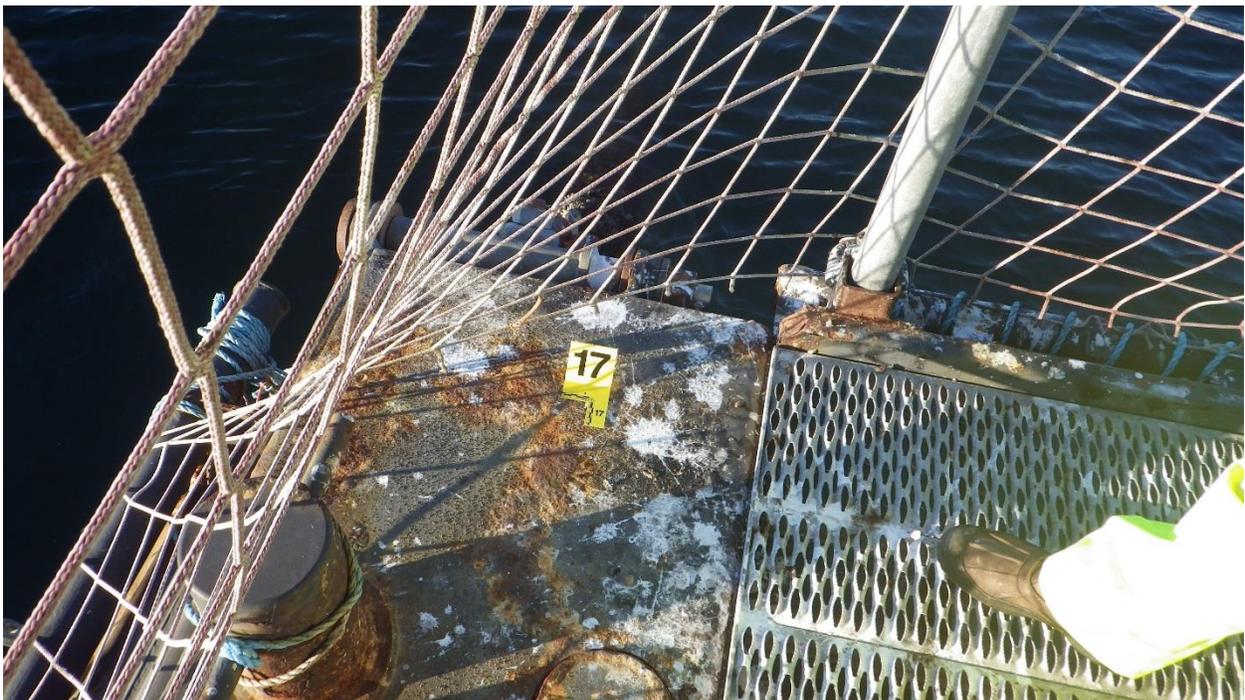


Figure C-42: Anchor #17, NW Corner of Net Pen



Figure C-43: Anchor #17, NW Corner of Net Pen. Chain with moderate corrosion.



Figure C-44: Anchor #18, North Side of Net Pen



Figure C-45: Anchor #18, North Side of Net Pen. Chain with minor corrosion.

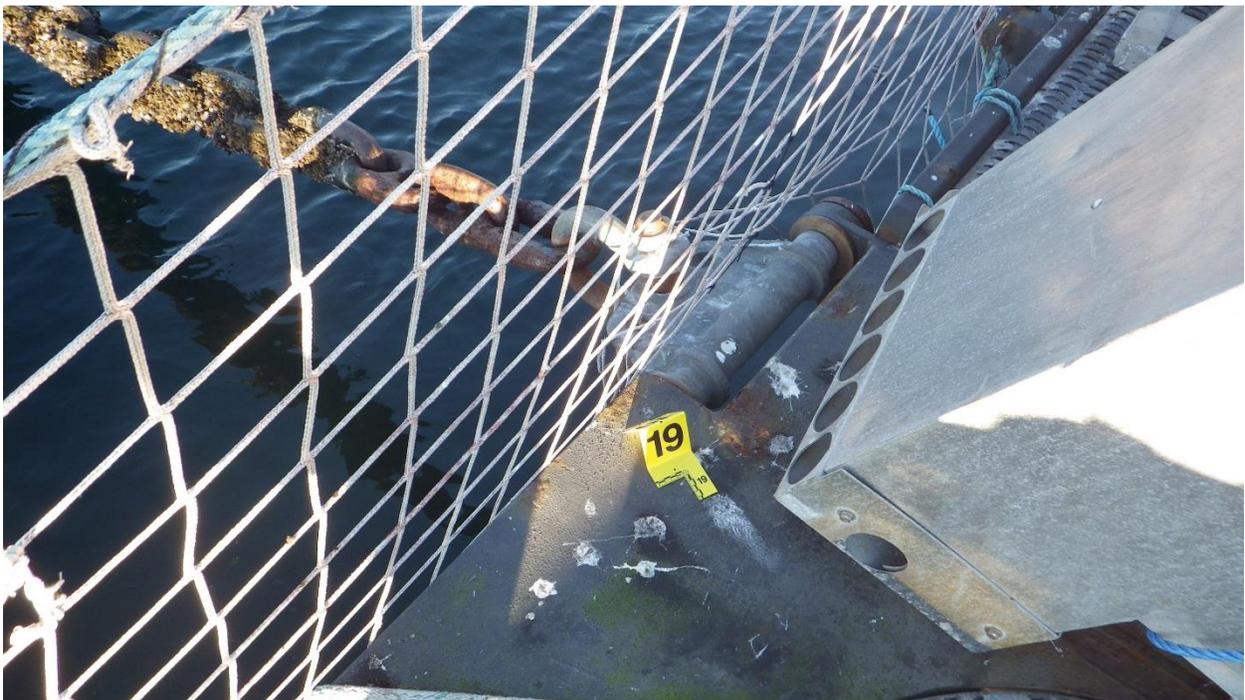


Figure C-46: Anchor #19, North Side of Net Pen



Figure C-47: Anchor #19, North Side of Net Pen. Chain with moderate corrosion.

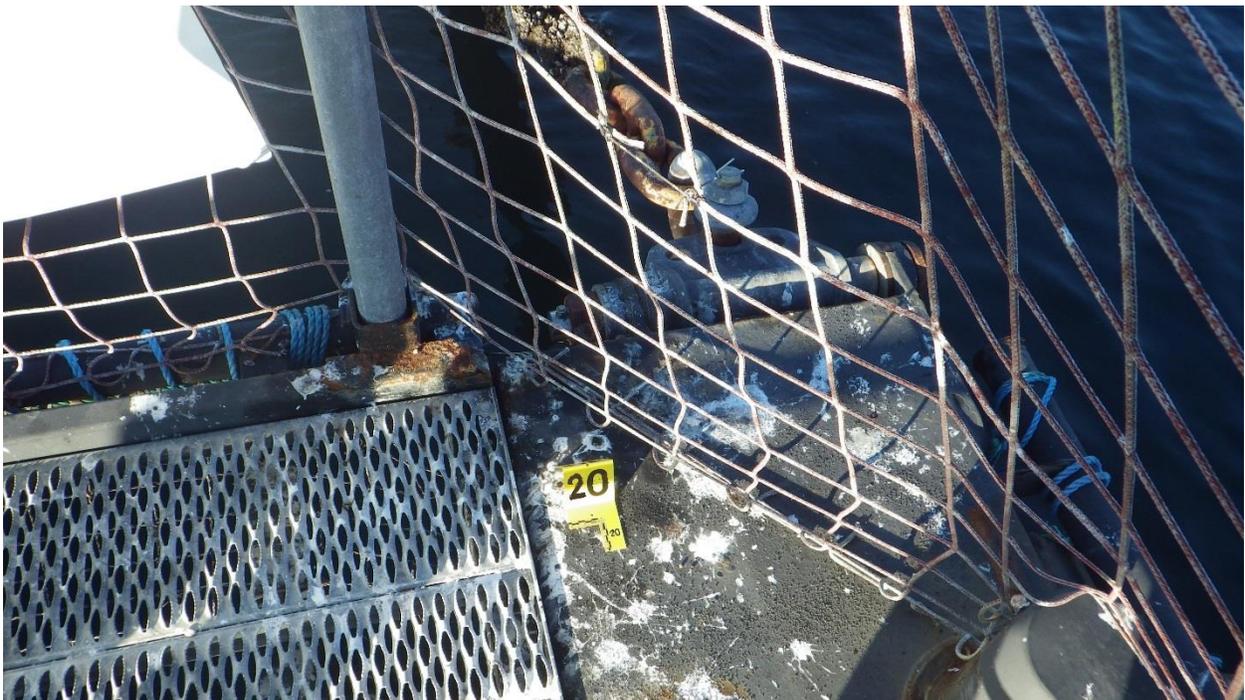


Figure C-48: Anchor #20, NE Corner of Net Pen



Figure C-49: Anchor #20, NE Corner of Net Pen. Chain with minor corrosion.

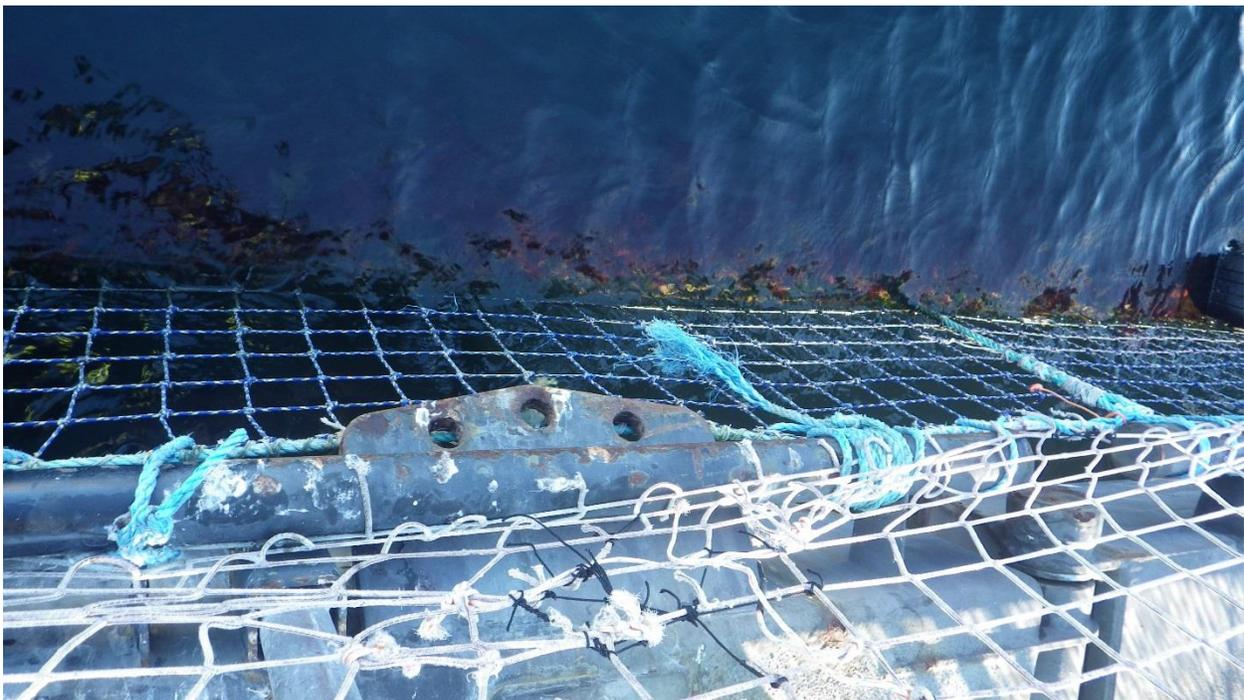


Figure C-50: Anchor Bracket between Anchor #2 and #3, East Side of Net Pen



Figure C-51: Hinge Connection Between Anchor #4 and #5, East Side of Net Pen. Minor corrosion.

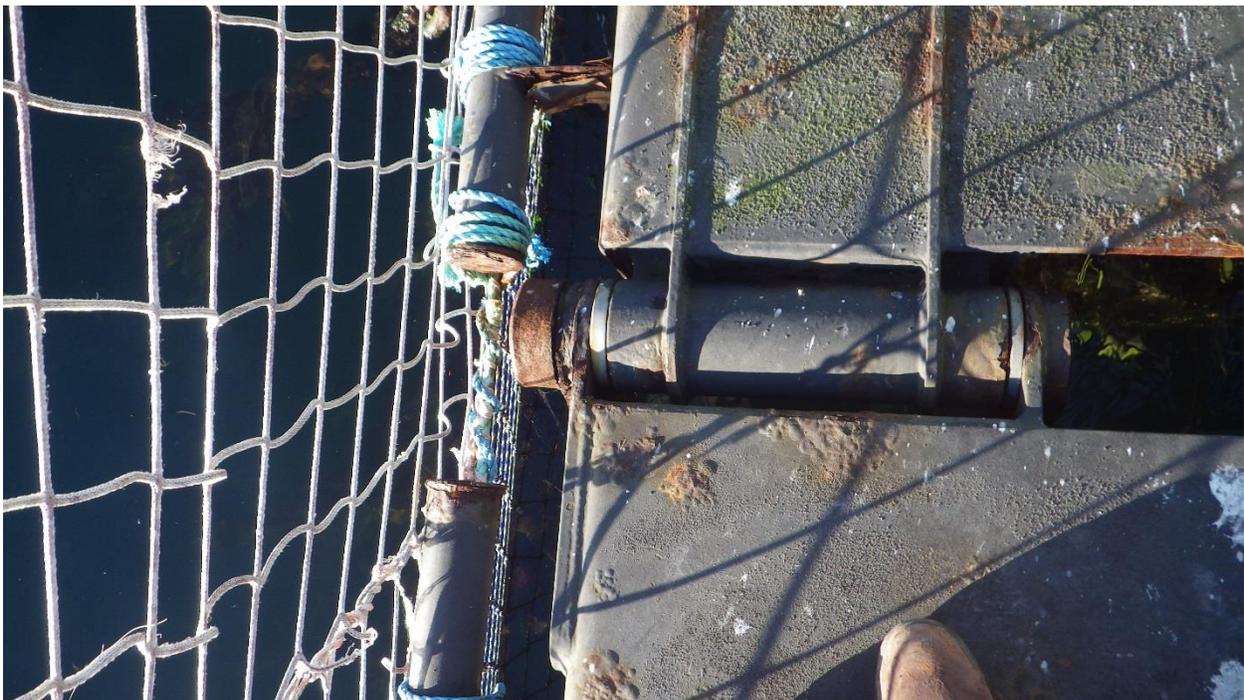


Figure C-52: Hinge Connection Between Anchor #11 and #12, West Side of Net Pen. Minor corrosion.

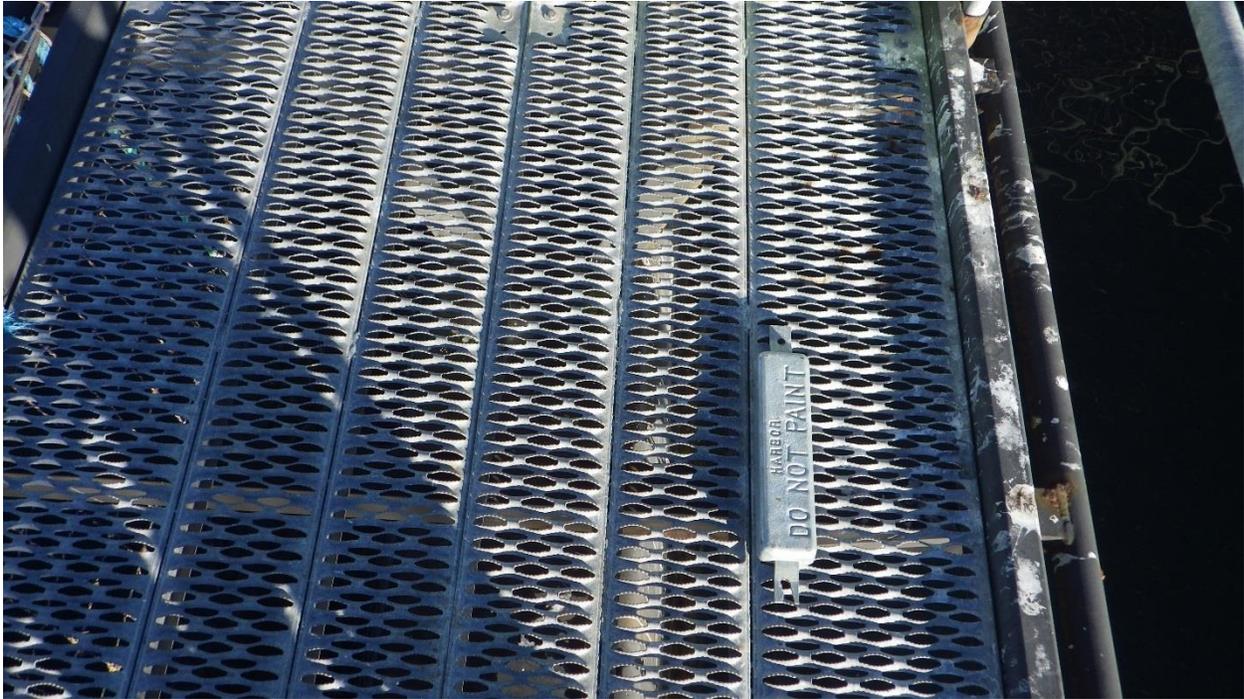


Figure C-53: Sacrificial Anode sitting on walkway



Figure C-54: Rusted Net Pen Support Railing. Moderate corrosion.



Figure C-55: Rusted Steel Framing and Handrail Bracket. Moderate corrosion.



Figure C-56: Anchor Chains 18 through 20, Extending out Away from the Net Pen



Figure C-57: Temporary Access Steel Ladder Inside of Net Pen



Figure C-58: Predator Net Support Railing, Anchor 2. Good condition.

