2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review

DNR drone image of Cypress Island net pen #2, August 28, 2017.

January 30, 2018

DEPARTMENT OF ECOLOGY
State of Washington

Washington Department of FISH and WILDLIFE

WASHINGTON DEPARTMENT OF NATURAL RESOURCES
NATURAL RESOURCES

2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review

January 2018

Investigation and Review Panel
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Unless otherwise noted, photographs and video (screen shots) were taken by employees of the State of Washington or consultants working under contract to the State.

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Abbreviations used in this report

AIS = Automatic Identification System (for tracking vessel movement)

Cooke = Cooke Aquaculture Pacific, LLC

DFO-C = Department of Fisheries and Oceans Canada

DFW = Washington State Department of Fish & Wildlife

DNR = Washington State Department of Natural Resources

ECY = Washington State Department of Ecology

EPA = U.S. Environmental Protection Agency

F/V = fishing vessel

M/V = motor vessel

NOAA = National Oceanic and Atmospheric Administration, National Marine Fisheries Service

NWIFC = Northwest Indian Fisheries Commission

UIC = Unified Incident Command

USACE = U.S. Army Corps of Engineers

USCG = U.S. Coast Guard

Executive Summary

This report presents the findings of the Investigation and Review Panel ("Panel") that examined the Cypress Island Atlantic salmon net pen failure that occurred in the summer of 2017. This report documents the facts of the failure and presents the Panel's conclusions based on those facts.

What happened to Cypress Island Atlantic salmon net pen #2 and why?
On August 19, 2017, a ten-cage net pen rearing 305,000 Atlantic salmon off Cypress Island in northern Puget Sound collapsed. The August 19 failure was preceded by another, related incident at the same net pen on July 24-25 in which moorings twice failed and the net pen moved hundreds of feet. At the time, the net pen was one of nine pens owned by Cooke Aquaculture Pacific, LLC, ("Cooke") in Washington State.

Three state agencies have regulatory and proprietary responsibilities over net pen aquaculture: Department of Ecology (water quality), Department of Fish & Wildlife (fish health), and Department of Natural Resources (land leasing). Representatives of these three agencies made up the Investigation and Review Panel.

The probable cause of both the July incident and the August failure was the failure of Cooke to adequately clean the nets containing the fish.

- Insufficient cleaning, termed "net hygiene," led to excessive biofouling by mussels and other marine organisms.
- Breakdowns in net cleaning machines contributed to this condition.
- The excessive biofouling significantly increased the drag (force) on the net pen array from tidal currents.
- The increased drag exceeded the holding power of the mooring system in both the July incident and the August failure.
- On July 24-25, the mooring system experienced both anchor dragging and breaking of attachment points between the moorings and the net pen.
- On August 19, some combination of anchor dragging, failure of mooring attachment points, and failure of structural members of the net pen framing resulted in the collapse of the net pen.
- Failure to address the biofouling effectively after the July incident directly contributed to the August failure.

Tidal currents were the mechanism of the July incident and August failure. The tidal currents on July 24 were the strongest during the summer of 2017 but were not unprecedented. The tidal currents on August 19 were less than those of July 24-25. While tidal currents continued to increase on August 20 and 21, the August 21 solar eclipse did not alter the normal pattern of seasonal tidal strength.

Properly designed, sited, and maintained, salmon net pens should be able to withstand combinations of tidal currents, wind, and wave forces that reasonably could be expected to occur at a site. This net pen had been operated without incident at this site for seven years (and for nine years previously at a location several hundred feet away) before the July incident and August failure, and environmental conditions at the time of the failures were within normal bounds.

The following contributing factors played a role in the July incident and August failure:

- "Weak mooring points," as identified in Cooke internal communications. Based on the information gathered, the Panel concludes that mooring attachment points did fail in both the July incident and August failure. No determination could be made as to whether the failed mooring points were inadequately maintained, under-designed, or over-loaded.
- The poor condition of the net pen steel floats. The corrosion and metal fatigue from 16 years in the marine environment likely meant the capacity of structural components was less than designed capacity.
- Insufficient attention to engineering:
    - The mooring system installed after the July incident did not match the system analyzed and recommended in a 2015 study of the net pen commissioned by the previous owner. After July, the number of mooring lines was reduced from 22 to 19.
    - An "exoskeleton" of chains was installed by Cooke in response to the July incident. Cooke said these chains were intended to reduce the strain on the connection points between the net pen and the moorings. Cooke provided no documentation of an engineering analysis and design of this new system. The net pen failed under weaker currents in August, suggesting that the atypical loads put on the pen by the exoskeleton may have contributed to the failure.

How adequate was the response by Cooke Aquaculture to the July incident and August failure?

Response to the July incident

Despite the seriousness of the July incident, Cooke's response was limited to four actions:

1. Increased net cleaning,
2. Replacing some anchors with heavier versions,
3. Affixing steel beams and plates to steel walkways damaged in July, and
4. Adding the chain exoskeleton.

Options that Cooke did not take included doing emergency net swaps on some or all of the stock nets, which would have reduced the drag on the net pen, or beginning fish harvest early, which would have reduced the number of fish vulnerable to escape. Cooke also did not report any special monitoring of the net pen as the predictable high tidal currents of August 19-21 approached nor did it have personnel and equipment on standby.

Response to August failure

Cooke reacted to the August 19 failure with substantial resources in an attempt to save the net pen again. When its efforts were unsuccessful, the company then turned to stabilizing the

collapsed structure, extracting the dead fish, and salvaging the pen. Cooke removed the surface portions of the net pen by September 24. Although Cooke stated by letter that it had removed all debris from the bottom of Deepwater Bay, an inspection by DNR on October 27 showed that substantial debris remained. DNR required further cleanup that lasted into January 2018.

The Panel concluded that more fish escaped than Cooke reported.

- There were 305,000 fish in the net pen prior to failure.
- In August and September, Cooke reported harvesting/extracting 145,000 fish from the collapsed net pen.
- The Panel concluded that Cooke could only have extracted 42,000 to 62,000 fish, 43% of what Cooke reported.
- The Panel estimates that between 243,000 and 263,000 fish actually escaped. Previous estimates, based on Cooke's reports, put that number at 160,000 fish.
- Of the escaped fish, 57,000 have been caught (recovered).
- Between 186,000 and 206,000 Atlantic salmon remain unaccounted for.

How adequate was the State agencies' response?

Response to July incident

Cooke did not provide accurate and complete information to the state about the July incident. Consequently, the state agencies did not investigate further.

Response to August failure

The state agencies responded in a coordinated way. The three agencies established a Unified Incident Command that ensured scene safety, monitored the stabilization and salvage efforts by Cooke, coordinated between Cooke and the state and federal agencies, documented fish accounting and fish health, and provided information to the public and other governments. Department of Fish & Wildlife worked with the Tribal co-managers and Canada to open fisheries targeting Atlantic salmon and investigated fish health. Department of Ecology took necessary steps to monitor water quality. Department of Natural Resources identified lease defaults and required actions by Cooke to correct those defaults. The most effective response in recovering escaped Atlantic salmon was by Treaty Tribes.

Lessons learned

The state agencies identified "lessons learned" to prevent recurrence of the July incident and August failure and to do a better job of managing Atlantic salmon net pen aquaculture. Some of these lessons have already been adopted while others will be implemented following the completion of this report. Others, such as conducting engineering assessments and doing more permit/lease compliance, will be contingent on more resources being available.

How to Read and Understand this Report

Each chapter in this report is divided into:

- Facts
- Analysis and discussion

Facts

The facts section sets forth all the pieces of information necessary to answer the questions in the Executive Summary. For a variety of reasons, not all facts can be known with certainty. The Panel has tried to confirm all pieces of information that were not directly collected by the state agencies, principally statements/documents by Cooke. Confirmation was enhanced by physical evidence, photographs, video, direct observation by state personnel, and multiple and consistent paper/electronic communication and documentation provided by Cooke. As it reviewed the growing body of information, the Panel identified facts where greater confirmation was needed. In attempting to confirm these facts, the Panel reviewed physical evidence, re-reviewed an extensive photo/video file, conducted research on net pen aquaculture, and sought additional information from Cooke through staff interviews, requests for documents, or written questions. As is typical in investigations, such as associated with oil spills, the party being investigated was not a member of the Panel.

In the interests of maximizing confidence in the facts, ensuring completeness, and being fair, the Panel provided Cooke the opportunity to review this document when it was complete so that Cooke could see what facts the Panel had collected and how it had interpreted those facts. The Panel invited Cooke to correct any factual errors in the Facts section of each chapter.

Analysis/discussion

This section of each chapter is where the Panel explains the significance of the facts particularly important to answering the questions. This section also is where the Panel draws conclusions from the facts to answer the questions listed in the Executive Summary. The Panel lays out its reasons for connecting the facts to its conclusions.

In several instances, the Panel's questions about the certainty of facts led it to develop relatively lengthy analysis before it could assess confidence in those facts and then reach conclusions.

The Panel's approach to ascertaining the facts, analyzing and discussing them, and then reasoning to conclusions is intended to be effective, fair, and transparent.

Investigation and Review Panel

Purpose of the Investigation and Review Panel

The Investigation and Review Panel ("Panel") had two purposes:

I. Conduct an *investigation* into this question:
    1) What were the circumstances of, and causes and contributing factors leading to, the failure of Cypress Island net pen #2?

An investigation may lead to regulatory enforcement actions. One representative from each agency served as an "investigator" whose participation in the Panel process may be referenced for purposes of enforcement.

II. Conduct a *review* of the following three questions*:*
    2) How well did Cooke follow the fish escape response plan?
    3) How should fish escape response plans be improved based on this incident?
    4) What are the "lessons learned" from the incident regarding Atlantic salmon net pen construction and practices that can inform changes to state laws/rules/procedures?

The outcome of the investigation and review process may inform any corrective action – whether enforcement or administrative – taken by state agencies. Each agency will make its own determination about how to use the data collected, analysis conducted, and the conclusions reached.

For ease of readability by the public, the results of the investigation and results of the review are combined in this single report.

Activities of the Investigation and Review Panel
The Panel together with investigators and supporting staff:

- Identified key questions/information needed to answer the four questions listed above;
- Collected, organized, and shared information regarding the incidents, including conducting interviews;
- Identified additional individuals and entities to interpret data about the incidents;
- Developed a factual summary of the incidents (this report); and
- Analyzed and discussed the facts, reaching conclusions where possible (this report).

The Panel itself carried out the following tasks:

- Managed the investigative process and review process to be effective, fair, inclusive of Tribes, and transparent;
- Developed timelines, requested agency resources as needed, and managed external and inter-agency relationships;
- Communicated with the leadership of their respective agencies regarding the progress of the investigation and review;
- Made recommendations about the investigation process and review process to agency managements; and
- Approved the release of work products for public distribution.

Who is the Panel
The Panel consisted of one representative from each state agency:

- ECY: Kessina Lee
- DFW: Amy Windrope
- DNR: Kyle Murphy (Panel Coordinator)

The Panel was supported in its investigation and its review by following state staff and consultant:

ECY: Rich Doenges, Gary Lee, Mike Lynch

DFW: Ray Berg, Eric Kinne, Brian MacDonald

DNR: Sean Carlson, Dennis Clark, Susan Hill, Troy Wood

Mott MacDonald (consulting engineer to DFW): John Jacob, P.E, Shane Phillips, P.E.

Investigators (as discussed above): Marc Pacifico (ECY), Eric Kinne (DFW), Sean Carlson (DNR)

The work of the Panel was observed by representatives of the Lummi Nation and the Samish Indian Nation. Tribal representatives provided comments and information throughout the process that contributed to the work of the Panel.

Timeline of the Panel
The Panel originated September 1, 2017 as the Investigation and Review Branch of the Unified Incident Command established to respond to the August 2017 failure. (Please see chapter "Response by State Agencies to August 2017 Failure.")

Upon the cessation of the Incident Command System on October 3, 2017, the Investigation and Review Branch became the Investigation and Review Panel.

From establishment to issuance of this report, the Panel typically met weekly to conduct its work.

Regulatory Environment

Facts

To protect Washington waters and native Pacific salmon, local governments, state, and federal agencies have a complex set of regulations and policies to address potential net pen risks such as net pen siting, water pollution, fish disease, and escapes.

Washington state agencies

Washington Department of Ecology (ECY)

- All commercial Atlantic salmon net pen facilities in Washington currently operate under National Pollutant Discharge Elimination System (NPDES) permits (Washington Administrative Code 173-221A-110). NPDES permits require water quality and sediment monitoring, fish escape prevention and response plans (plans developed for DFW satisfy this requirement); fish release reporting; pollution and spill prevention plans; disease control and sea lice monitoring reports; monthly fish biomass and feed reports; and underwater photographic surveys.
- Commercial net-pen facilities may need water quality certification under Section 401 of the federal Clean Water Act, based on state and federal review of the facility proposal.
- Activities and development involving federal activities, licenses and permits in Washington's 15 counties with marine shorelines also require a written Consistency Determination by the state's Coastal Zone Management Program, which is currently managed by ECY's Shorelands and Environmental Assistance Program.
- ECY also administers the Shoreline Management Act, including reviewing and approving local shoreline master programs.

Washington Department of Fish & Wildlife (DFW)

- DFW regulates commercial Atlantic salmon net-pen facilities through an aquaculture license, (Washington Administrative Code [WAC] 220-370-100), an aquatic farm registration process, (WAC 220-370-060), and through fish transport permits which can include conditions such as disease screening prior to moving fish (WAC 220-370-190).
- Farm operators must obtain a DFW license to operate net pens in Washington marine waters.
- The license requires fish escape prevention, reporting and recapture (recovery plans) (WAC 220-370-110, WAC 220-370-120).
- DFW rules regarding aquaculture licenses focus on disease prevention, reporting and control, and on escapement prevention and response.
- Anyone seeking to transport fish into or through Washington must get a fish transport permit from DFW to protect native fish species and ensure live fish are free from reportable fish pathogens or undesirable / invasive species (WAC 220-370-190).
- The department also requires access to all commercial net-pen facilities for fish health inspections (WAC 220-370-080).

Washington Department of Natural Resources (DNR)

- DNR is the proprietary land manager for state-owned aquatic lands. All Cooke Aquaculture commercial net pens in Washington have leases to be on state-owned aquatic lands.
- DNR does not grant leases until all permits from local, state and federal agencies are obtained.
- Use of state-owned aquatic lands requires leases from DNR specifying the location, structural development, operational practices, lease terms, environmental monitoring, rent and other requirements. DNR's Aquatic Lands Division manages these leases.
- DNR reviews lease proposals for consistency with state laws and rules, including public benefit criteria. DNR may develop lease conditions to minimize potential impacts to public resources.
- Leases typically are granted for 12 years. Leases cannot be longer than 30 years.

Washington State Department of Agriculture (WSDA)

- WSDA is responsible for fostering the state's aquaculture industry and providing market assistance.
- WSDA's state veterinarian supports the DFW by monitoring and controlling aquaculture diseases. All diagnosis of pathogens in regulated fish must be reported to the state veterinarian.

Local governments

Cities and counties must determine that a new commercial Atlantic salmon net-pen facility complies with their:

- Shoreline master program (including related local shoreline development and use permits),
- Comprehensive land use plans,
- Environmental regulations, and
- Zoning and other codes.

Shoreline master programs / local shoreline permits

- Shoreline master programs contain permitting requirements for substantial shoreline development such as new commercial marine Atlantic salmon net pen facilities.
- A commercial net pen operation may also need a shoreline conditional use permit, issued by local governments and requiring ECY's approval. Local governments or ECY may attach special conditions to the permit.

State Environmental Policy Act (SEPA)

- SEPA requires consideration of significant adverse environmental impacts by completing an environmental checklist and review prior to local or state approval of a proposed net pen facility An environmental impact statement may be required if there are probable significant environmental impacts.

- Cities and counties where a net-pen facility is proposed typically conduct the SEPA review.

Federal agencies

National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS)

- NOAA does not directly oversee commercial Atlantic salmon net pen permits in Washington.
- NOAA does provide consultation to federal agencies on federal actions under the federal Endangered Species Act (ESA), Marine Mammal Protection Act, and Magnuson-Stevens Fishery Conservation Act.
- The consultations may result in recommendations to avoid, minimize, or mitigate for adverse impacts to ESA-listed species, critical habitat, and / or essential fish habitat.
- NOAA provides policy support and research to aquaculture nationally.

U.S. Army Corps of Engineers (USACE)

- USACE regulates discharges of dredged or fill material to U.S. waters. USACE also regulates structures or work in our navigable waters under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act.
- USACE is required to consult with other federal agencies prior to issuing a permit. The agencies must review the project and, if needed, recommend mitigation measures to protect the environment or wildlife.
- Tribal governments can comment on federal permits regarding habitat and treaty-reserved usual and accustomed areas and provide information on potential affects to historic properties.
- In some cases, letters of permission may be used where proposed work would be minor, not have significant individual or cumulative environmental impacts, and not encounter appreciable opposition.

U.S. Coast Guard (USCG)

- USCG administers the Private Aids to Navigation permit for marking structures/object/hazards and ensuring boating public safety. Net pens are required to have a private aid to navigation (PATON).
- While USCG leads the navigation aid permitting program, the U.S. Army Corps of Engineers, DFW, and local governments are involved in the permitting process.

U.S. Environmental Protection Agency (EPA)

- EPA requires water quality or National Pollutant Discharge Elimination System (NPDES) permits to regulate point sources that discharge pollutants.
- NPDES permits are required for discharges associated with concentrated aquatic animal production.
- In Washington, ECY is authorized by EPA to administer the NPDES permit program.

U.S. Fish & Wildlife Service (USFWS)

- The USFWS does not directly administer permits for net pens, though international transport of eggs from Iceland requires a USFWS permit.
- USFWS's Aquatic Animal Drug Approval Partnership provides a way for federal, state, tribal and private agencies or organizations to use certain critical drugs necessary to maintain the health and fitness of aquatic species under investigational new animal drugs.

Treaty Tribes

- In Washington State, Treaty Tribes have reserved certain rights through treaties and are co-managers of fisheries. Questions about tribal jurisdiction will not be addressed in this report and should be addressed directly to individual tribes.

Analysis/discussion

The Panel identified gaps in regulatory and proprietary authorities that, if addressed, could provide improved management and oversite of net pen aquaculture in Washington State. They include:

- Structural integrity of net pens
    - Performing and providing detailed measurement of tidal currents at existing and proposed net pen sites for use in engineering design and review.
    - Providing stamped engineered designs and supporting information for net pens during the permitting/lease application process.
    - Requirement that designs for proposed net pens incorporate the best available technology in use in the industry, appropriate to the site.

- Ensuring ongoing operations maintain structural integrity
    - Providing, on an ongoing basis, evidence to agencies that net pens are maintained in conformance with their engineered designs.
    - Developing a schedule for inspection of all net pen components, with a particular focus on net hygiene (described in chapter on "Biofouling").
    - Maintaining a detailed record of all routine maintenance, repairs, and structural modifications made, and that such records be made available upon demand to agencies for inspection.
    - Granting authority to regulatory agencies to conduct independent inspections of net pen mooring systems and structural integrity.

- Improving preparedness for accidents
    - Granting authority to agencies to conduct drills to test the efficacy of a fish escape plan and to test the ability of net pen operators to implement effectively their fish escape response plan.
    - Granting authority to agencies to require the for-cause removal of stock from net pens or emergency net swaps.
    - Granting authority to agencies to deny, for-cause, the transport and placement of new stock in a net pen.

    - Requiring net pen operators to maintain a list of fishing vessels that may be called upon to set nets in case of a fish escapement event.

- Improving incident response
    - Requiring net pen operators to notify agencies immediately any time a net pen is damaged and/or is at risk of failure, regardless of whether a release of fish has occurred.
    - Requiring net pen operators to have personnel trained in participating in a Unified Command under the National Incident Management System (NIMS) and consistent with the Northwest Area Contingency Plan.
    - Requiring net pen operators to:
        - *Actively and cooperatively participate in the Unified Command structure;*
        - *Provide an organization which is compatible with NIMS/Incident Command System;*
        - *Provide regular communication and documentation that ensures adequate response resources are being rapidly mobilized in proportion to the size of the incident as discussed in the following section; and*
        - *Follow their approved spill contingency/response plan (if applicable) unless otherwise directed, or a deviation is agreed to, by the Unified Command.* [1]

Such requirements and authorities, and funding mechanisms for implementing such requirements and authorities, may be considered for net pen operations in Washington.

[1] Northwest Area Contingency Plan, Change 19, January 1, 2018.

Industry Standards for Atlantic Salmon Net Pen Aquaculture

Facts

Multiple voluntary and national standards apply to fish pen aquaculture. Cooke was enrolled in one of the voluntary standards programs,[1] the Best Aquaculture Practices (BAP) program, but some other standards are reviewed.

Best Aquaculture Practices (BAP)[2]

The BAP Standards, Guidelines for salmon farms are applicable to Atlantic salmon net pen farming. The BAP standards organization states:

> *The BAP standards are achievable, science-based and continuously improved global performance standards for the aquaculture supply chain that assure healthful foods produced through environmentally and socially responsible means. They are designed to assist program applicants in performing self-assessments of the environmental and social impacts, and food safety controls of their facilities, and to lead to third-party certification of compliance, thereby eliminating the most significant negative impacts.*[2]

Cooke Aquaculture Pacific – Deepwater Bay was certified under the BAP program, though that certification has since been removed from the BAP web site.[3]

Pertinent sections of the BAP certification include:

> *1. Community, Property Rights and Regulatory Compliance — Farms shall comply with local and national laws and environmental regulations, and provide current documentation that demonstrates legal rights for land use, water use, construction, operation and waste disposal.*
>
> *2. Community, Community Relations — Farms shall strive for good community relations, conduct their businesses responsibly and be responsive to those affected by their operations.*
>
> *3. Community, Worker Safety and Employee Relations — Farms shall comply with local and national labor laws to assure adequate worker safety, compensation and, where applicable, on-site living conditions.*
>
> *4. Environment, Sediment and Water Quality — Farms shall be located and operated in such a way that they minimize negative impacts on sediment quality outside a defined sediment impact zone, or on water quality within the general vicinity of the farm.*
>
> *6. Environment, Control of Escapes — Salmon farms shall take all practical steps to prevent escapes and minimize possible adverse effects on aquatic wildlife if escapes occur.*

[2] https://bapcertification.org/Downloadables/pdf/standards/PI%20-%20Standard%20-%20Salmon%20Farms%20-%20Issue%202.3%20-%2013-October-2016.pdf
[3] https://bapcertification.org/CertifiedFacilities

Specific standards of note include:

1.1: Current documents shall be available to prove legal land and water use by the applicant.

1.3: Current documents shall be available to prove compliance with applicable environmental and other regulations for construction and operation.

1.5: Where applicable, current documents shall be available to prove compliance with laws protecting the resources of indigenous peoples and/or independent agreements the applicant may have made with them.

2.5: Where applicable, the applicant shall demonstrate dialogue with local native peoples and a process for conflict resolution with them under the laws governing their rights.

3.19: The facility shall identify and eliminate or minimize any workplace health and safety hazards by conducting a thorough risk assessment. This includes a requirement for accident investigation.

4.1: The applicant shall provide documents that describe local standards for benthic impacts under salmon farms, which shall include the benthic indicator "trigger level" above which the farm would not be in full compliance with the local standard, where this is clearly defined, or with its intent where it is not clearly defined.

4.2: For established farms, the applicant shall provide three years of monitoring data to show that the farm meets or exceeds sediment and water quality criteria specified in 4.1, its operating permits and/or its own monitoring plan at current operating levels.

6.1: If the farm operates in a jurisdiction where there are government regulations for fish containment, the applicant shall comply with the regulations and provide proof of so doing.

6.2: Local rules notwithstanding, the applicant shall demonstrate that the farm meets the BAP procedural, performance, documentation and reporting requirements for fish containment required by the Fish Containment Plan outlined under Implementation above, which shall include a classification of the farm site, an engineer's structural report, a mooring certification, an escape risk analysis, monitoring procedures that respond to the risk analysis, predator deterrence procedures, precautions related to the use of boats, fish handling procedures and inventory accounting procedures.

6.3: The applicant shall provide documents to show that all staff members have received training in the Fish Containment Plan, which shall be verifiable by training certificates in employees' files and verified at audit by a subset of interviews.

6.4: If an escape is suspected or has occurred since the last audit, the applicant shall provide reports and farm records to show that these incidents were dealt with in a

manner consistent with the Fish Containment Plan, including deployment of recapture equipment where allowed, investigation of the cause and a report to the regulator.

6.5: If an escape is suspected or has occurred since the last audit, the applicant shall demonstrate, based on the counts of inventory required, that the losses were less, individually or cumulatively, than the limits specified in the Implementation requirements.

Aquaculture Stewardship Council (ASC)[4]

The Aquaculture Stewardship Council (ASC), founded by the World Wildlife Fund (WWF) and IDH (the sustainable trade initiative) has certification standards for salmon aquaculture. According to ASC's information:

The ASC's aquaculture certification programme and logo recognise and reward responsible aquaculture. The ASC is a global organisation working internationally with aquaculture producers, seafood processors, retail and foodservice companies, scientists, conservation groups, social NGOs and the public to promote the best environmental and social choice practices in aquaculture.

The goal of the ASC Salmon Standard is to credibly offer measurable, performance-based requirements that minimize or eliminate the key negative environmental and social impacts of salmon farming, while permitting the industry to remain economically viable.

Standards of note include:

1.1.1 Presence of documents demonstrating compliance with local and national regulations and requirements on land and water use

1.1.4 Presence of documents demonstrating compliance with regulations and permits concerning water quality impacts

3.4.4 Evidence of escape prevention planning and related employee training, including: net strength testing; appropriate net mesh size; net traceability; system robustness; predator management; record keeping and reporting of risk events (e.g., holes, infrastructure issues, handling errors, reporting and follow up of escape events); and worker training on escape prevention and counting technologies

6.5.4 Evidence that all health- and safety-related accidents and violations are recorded and corrective actions are taken when necessary

7.2.2 Evidence that the farm has undertaken proactive consultation with indigenous communities

7.2.3 Evidence of a protocol agreement, or an active process to establish a protocol agreement, with indigenous communities

[4] https://www.asc-aqua.org/wp-content/uploads/2017/07/ASC-Salmon-Standard_v1.1.pdf

International Organization for Standardization (ISO) [5]

The ISO provides some international standards for aquaculture, which includes net pen design and construction. The ISO is an independent, non-governmental international organization with a membership of 162 national standards bodies. The specific standard is ISO 16488:2015(en), "Marine finfish farms – Open net cage – Design and operation" whose introduction states:

> *This International Standard is developed to ensure that a net cage marine finfish farms are adequately designed, constructed, and maintained to meet the anticipated rigours of the marine environment in which they will be deployed to prevent escapes (unintended impacts) during every day operations and unforeseen events. The standard is to be applied by the farm operators on a site-specific basis. Aquaculture producers are recommended to ensure that the combination of technologies that they have selected for a site meets environmental and other operational considerations for that site. Equipment manufacturers can use this International Standard, methodology, and terminology so that their customers (farm operators) can have the opportunity to meet the requirements with this International Standard.*

Norwegian Standards (NS) [6]

The Norwegian Standards focus on the structural integrity and mooring of net pen operations, specifically NS 9415 for floating fish farming installations. The NS describes the focus as follows:

> *This standard contains requirements for the physical design of the installation and the associated documentation. This includes calculation and design rules, as well as installation, operating and maintenance requirements.*

Analysis/discussion

The Panel was not able to locate in any of the industry standards guidelines or standards explicitly addressing biofouling, which, as this report concludes, was central to the July incident and August failure of net pen #2.

The voluntary standards provide context and a framework for the State of Washington to improve oversight. There may be opportunities to align state regulations with international best practices, which may increase consistency with other states and countries relative to aquaculture practices.

[5] https://www.iso.org/obp/ui/#iso:std:iso:16488:ed-1:v1:en

[6] https://www.regjeringen.no/globalassets/upload/kilde/fkd/bro/2005/0013/ddd/pdfv/255320-technical_requirements.pdf

Environmental Conditions of Net Pen #2 Site

Facts

Location

Net pen #2 was located in Deepwater Bay southeast of Cypress Island, Skagit County. Deepwater Bay is located on the west side of the Bellingham Channel, which separates Cypress Island from Guemes Island to the east.

Net pen #2 pen was one of three net pens in the bay, with Cypress net pen #1 located to the south of pen #2 and Cypress net pen #3 located to the north of pen #2 (Figure 1).

Net pen #2 was located in water 65 to 100 feet in depth. Given the depth, the substrate does not feature submerged aquatic vegetation such as kelp or eelgrass. The bottom in the area of the net pen is variously cobble, sand, and silt, with considerable shell hash in places. Closer to shore (west), the substrate features large rock and cobble.

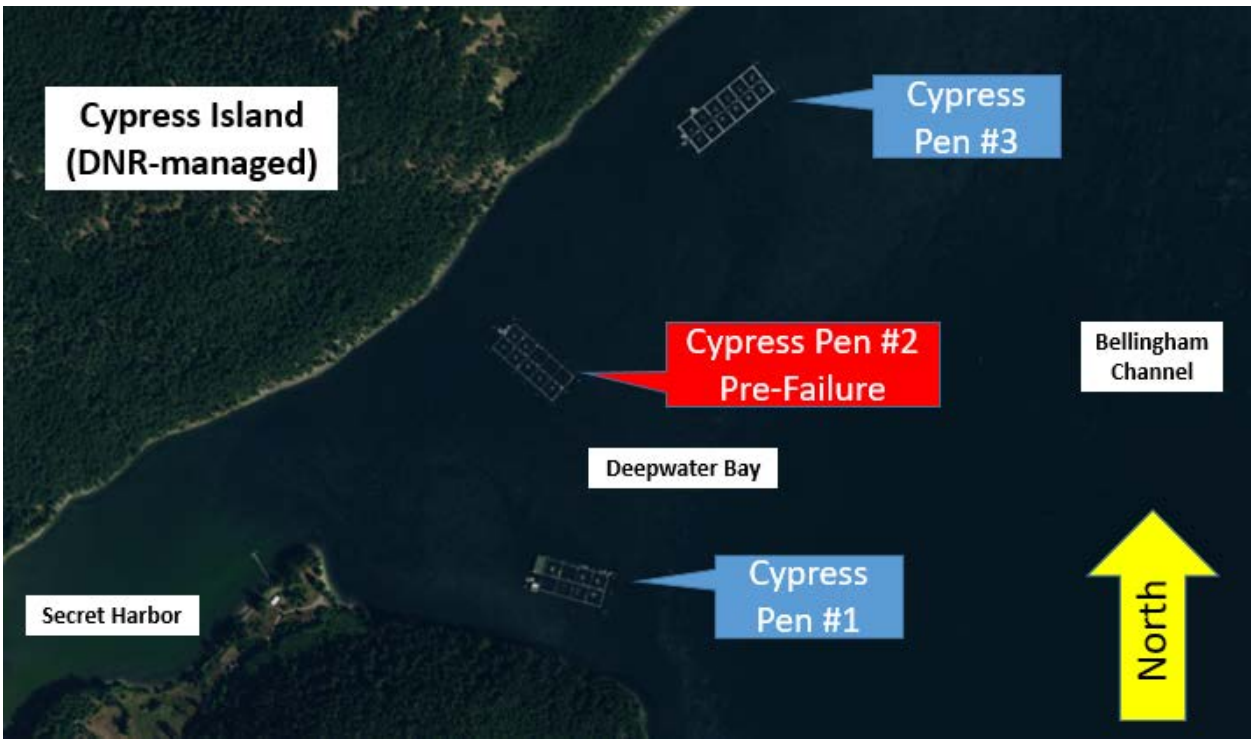

Figure 1. Aerial photo of Cypress Island Atlantic salmon farm, showing net pen #2 in relation to other net pens.

Tidal Currents

During a rising (flood) tide, a counterclockwise gyre sets up in Deepwater Bay as the flooding tidal current flows north in the Bellingham Channel. Multiple Cooke staff reported that the strongest tidal currents affecting net pen #2 come from the north and thus are associated with flood current. State staff verified that tidal current at net pen #2 during the flood is from north to south. Ebb currents in Bellingham Channel reverse the flow, with a clockwise gyre setting up in Deepwater Bay and a current from the south impinging on net pen #2. The strength of the ebb tide current at net pen #2 was reportedly less than flood currents.

There was local “real time” tidal current data for 2017 that was correlated with the incidents that occurred a short distance from the monitoring site (Figure 2).

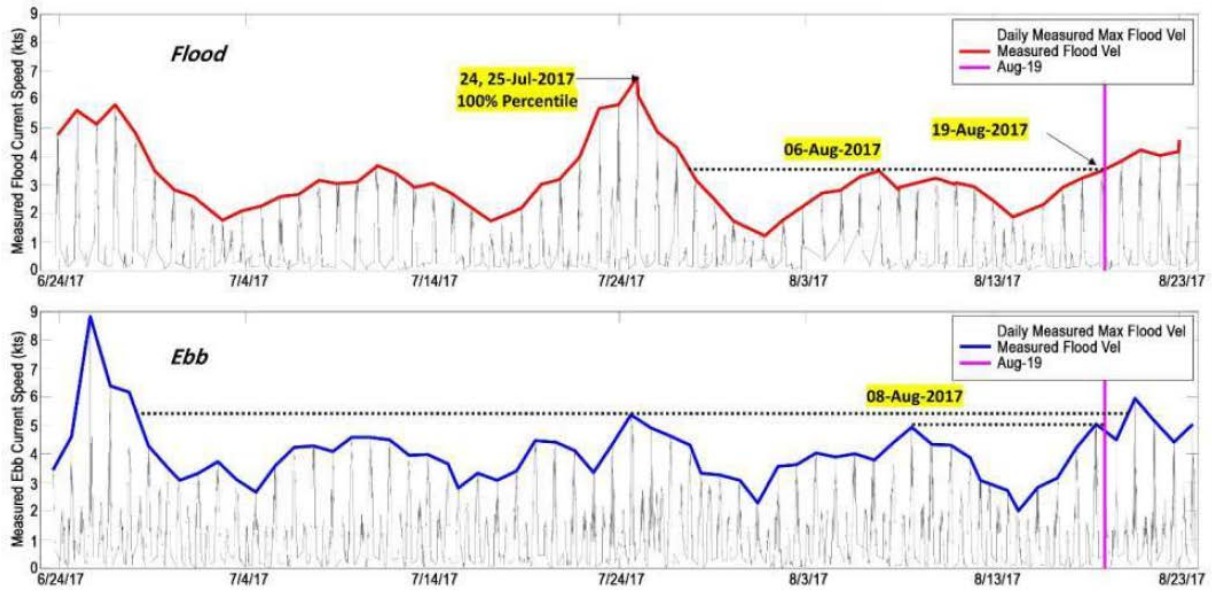

Figure 2. Measured tidal currents in Bellingham Channel 1.2 miles east of net pen #2, 20-foot depth, June – August 2017. Data source: NOAA. Graphic prepared by Mott MacDonald. [Note error in lower graph legend indicates flood, but should indicate ebb.]

Review of the tidal current information measurements revealed the following:

- On July 24 and August 19, the tide range was greater than average. Typically, tidal events with a greater than average range produce faster than average tidal currents.
- During the three-month review period, the fastest flood tidal current at the nearby station occurred on July 24.
- The flood tidal currents on August 19 were the fastest measured since the net pen was stabilized following the July incident.
- The solar eclipse occurred on August 21. The flood tidal currents on the day of the eclipse were greater than on August 19, but by that point the net pen was already significantly damaged. The flood tidal current velocity on August 21 was less than those observed on July 24-26. The solar eclipse did not generate tidal currents outside the norm.

For more detailed information regarding the tidal currents reviewed, please see Appendix 1: Cypress Island Net Pen Failure Engineering Review.

<u>Waves</u>

Waves associated with swells are not a significant factor given the relatively protected location of Deepwater Bay.

Net pen #2 is relatively protected from winds and wind-driven waves during summer months. Examination of wind records from nearby recording stations revealed no significant wind events during June – August 2017.

Vessel Traffic

Deepwater Bay does not typically see large vessels. Other than vessels associated with the fish farm, the largest vessels are typically commercial/Tribal fishing vessels and sport fishing vessels under 75 feet in length. Other recreational vessels typically moor at other locations at Cypress Island.

In contrast, the Bellingham Channel to the east occasionally is used by large ocean-going vessels such as tankers and bulkers. Tug and barge combinations also use the passage. Other common types of vessels are fishing vessels and recreational vessels. Vessels generate wakes that reached net pen #2. Review of information available from commercial vessels transiting the Bellingham Channel on July 24 and August 19 does not suggest vessel wakes were out of the ordinary.

Biofouling

All elements of net pen #2 below the water line were subject to fouling by marine organisms. Biofouling included flora and fauna growing on all lines, chains, floats, and the predator exclusion and stock nets. Please see the later chapter on "Biofouling" for a complete discussion of this environmental factor and operating procedures associated with control of biofouling.

Additional information

For further discussion of environmental conditions, see Appendix 1: Cypress Island Net Pen Failure Engineering Review - Section 5 Environmental Conditions.

Analysis/discussion

Based on the information gathered and reviewed, tidal currents in combination with excessive biofouling were two environmental factors contributing to the July incident and the subsequent August failure.

These tidal currents, due to their magnitude, were the mechanism, or trigger, of the July 24 incident and August 19 failure. Tidal currents, however, should not be considered "the cause" of the two incidents for several reasons:

- Salmon net pens should be able to withstand combinations of tidal currents, wind, and wave forces that could be reasonably expected to occur at a site,
- Net pen #2 had been operated without incident at this location for seven years before the July incident and August failure, experiencing many occurrences of high tidal currents, and
- Without the excessive biofouling that was allowed to grow on the stock nets, tidal currents would not have moved or destroyed the net pen.

Please see the chapter on "Biofouling" for additional information.

Structure of Net Pen #2

Facts

This discussion of the structure is supplemented by Appendix 1: Cypress Island Net Pen Failure Engineering Review, produced by marine structural engineering firm Mott MacDonald of Edmonds, Washington.

Net pens were first installed in Deepwater Bay near Cypress Island in 1985[3]. The owner of the net pens at the time replaced the original net pen with the current net pen (called net pen #2) in 2001.[4] In 2010,[5] net pen #2's position near the Cypress Island shore was moved about 200 feet and rotated counter-clockwise to a northwest-southeast alignment in order to place it in higher current and deeper depth.[6] In February 2017, Cooke submitted permit applications to replace the existing net pen with a newly manufactured net pen of somewhat larger size in a new orientation. The existing net pen #2 was destroyed in August 2017 before a new net pen could be installed.

Cypress Island net pen #2 was a proprietary net pen system and was made up of several components serving different functional and structural purposes: the floating platforms, two types of nets, the mooring ropes, chains and buoys, and the anchors.

The most visible component of the net pen system is the above-water network of floating platforms forming the perimeter for individual net pen "cages" of approximately 79 feet square. These platforms were joined together to make a grid pattern of cages to form a structure two cages wide and five cages long, for a total of ten cages. The overall dimension of net pen #2 was approximately 182 feet wide and 436 feet long. The end of the net pen closest to the shore of Cypress Island also had two or three connected floating platforms used for equipment staging, feed storage, and crew shack and for moorage of visiting vessels (Figure 3).

Figure 3. Cypress net pen #2 on September 30, 2016. View looks east toward Guemes Island.

Cooke had designations for each cage. Starting at the western-most point of the cage and progressing along the long axis to the southeast the cages were numbered 211, 212, 213, 214, 215. The row of cages along the northeast side were similarly numbered 221 – 225 (Figure 4).

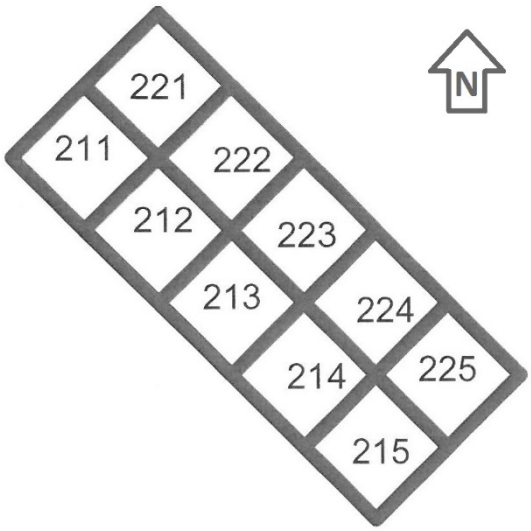

Figure 4. Cypress Island net pen #2 cage designations.

These floating platforms were standardized units manufactured by Marine Construction AS in Norway. The floating platform units varied from 7 to 10 feet wide and from 24 to 39 feet long.[7] The different sizes of platform units were named by the manufacturer “main bridge,” “catamaran,” and “intermediate/outrigger” (Figure 5). They were joined to each other by horizontal fabricated steel hinges so that one floating platform could rotate up or down in relation to its neighbor. The hinge pins were stainless steel. The floating platforms were constructed of welded steel rectangular tubes, pipes, angles, plates and grating, and were hot-dip galvanized after fabrication for corrosion protection. At points around the perimeter of the net pen there were galvanized steel mooring brackets made up of ‘pad eyes’ fixed on horizontal hinges to which mooring ropes and chains to anchors were attached by shackle (Figure 6).

Figure 5. Salvaged floating platforms that made up net pen #2 on September 26, 2017. Note the rectangular flotation units underneath the platforms, which are Styrofoam billets in plastic tubs.

Figure 6. Corner of Cypress net pen #1 on September 30, 2016, showing pad eyes on hinges on side of steel platform ("outrigger" section). Shackles connect anchor chains to pad eyes. Design and configuration of moorings of net pen #1 same as for net pen #2.

The steel floating platforms were supported by rectangular plastic flotation units bolted to the underside of each platform in the number and configuration needed to support the weight of the platforms and equipment with approximately 12 – 18 inches of freeboard. These flotation units consisted of Styrofoam billets encased in black polyethylene plastic tubs (Figure 5).

Each of the ten stock cages consisted of approximately ¾ inch (20 millimeter diagonal) mesh nylon stock net (Figure 7) enclosing the four sides and the bottom, 79 feet (24 meters) on each side and 49 feet (15 meters) deep. This stock net was suspended from the interior side of the platforms. Suspended in the water from the outer perimeter of the net pen floating platform was a 5 inch mesh nylon predator exclusion net enclosing the four sides and the bottom. The predator exclusion net was weighted by long steel 6 inch diameter pipes on the bottom of each side in order for the net to retain its cubic shape. The predator exclusion net extended deeper than the stock net so there was space between the nets. The predator exclusion net prevented marine mammals from accessing the stock net and the fish inside.

Figure 7. Stock net sample showing mesh size and biofouling by mussels, processed for evidentiary purposes on September 8, 2017.

The net pen prior to July 2017 was moored at 22 points: most were anchors resting on the sea floor on three sides while six were moored directly to a large rock and to steel pins, approximately 2 inches in diameter, driven into bedrock located at the island shore.[8] Mooring brackets on the net pen were connected by shackle to a chain that was connected to a 4.5 foot diameter steel buoy 15 to 30 feet away. According to a mooring plan provided by Cooke, this

buoy was then connected by 300 feet of 2 inch to 2 5/8 inch diameter synthetic rope to 90 feet of heavy 1½ inch to 2 inch chain shackled to a Danforth or Delta anchor of 2,500 to 8,000 pounds or to the shore-side rock or pin.[9] According to a mooring plan developed after the July incident, after that event three of the original six anchors to shore were not re-installed.[10]

Bathymetric surveys by DNR on September 7, 2017 and October 26, 2017 showed drag marks of anchors indicating some anchors were outside the DNR leasehold prior to the July incident (Figure 8). The placement of the anchors outside of the leasehold was confirmed during an interview with Cooke's Aquaculture Permit Coordinator.[11]

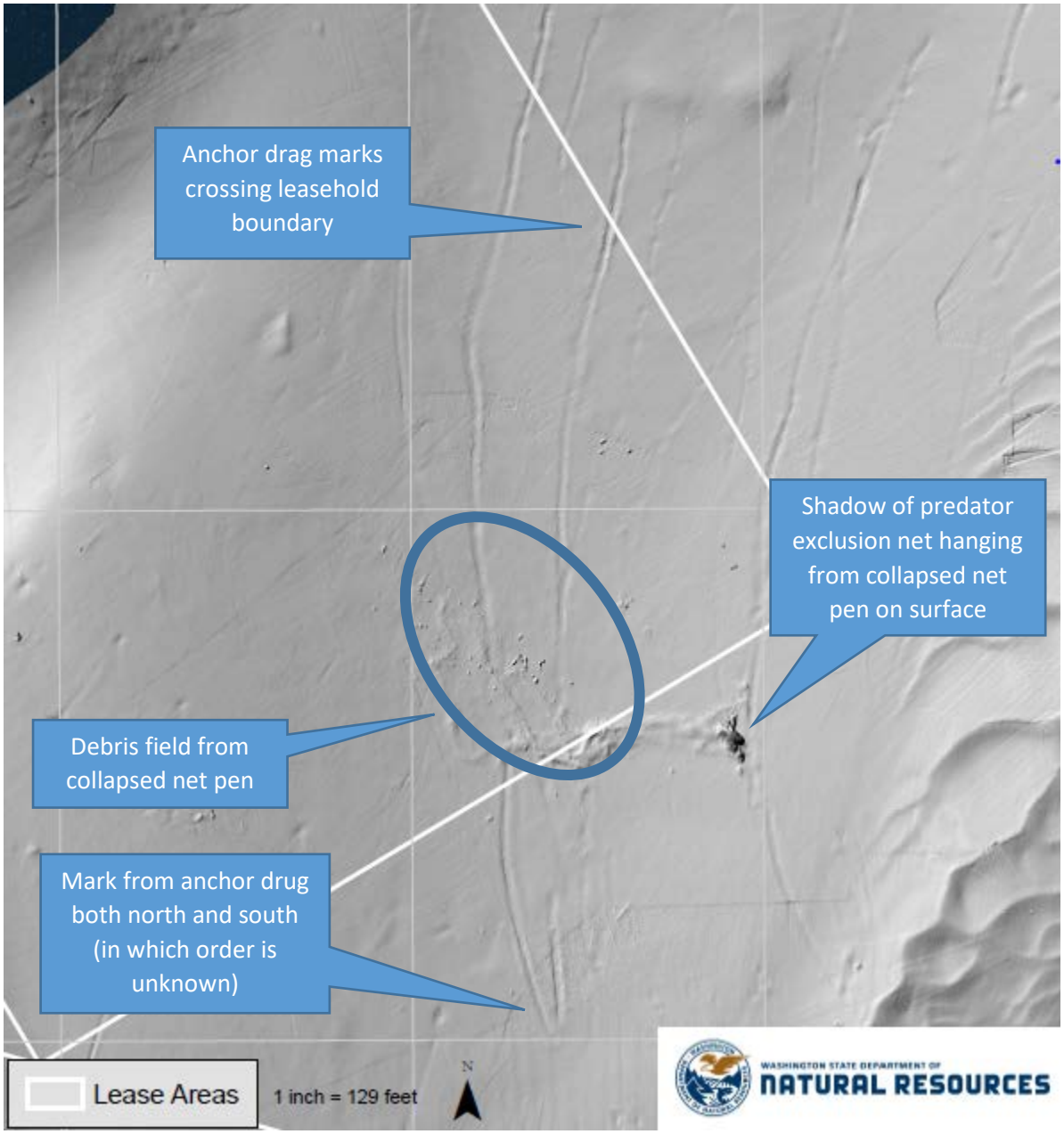

Figure 8. Bathymetric results from DNR sonar survey of Deepwater Bay conducted September 7, 2017, showing anchor drag marks. Net pen #2 drug to the south, indicating that anchors drug from north (outside leasehold boundary) to south.

The Panel visited the site of the salvaged parts of the net pen at the salvage contractor's property near Anacortes to examine the condition of the units and attempt to discern the failure mechanism. The Panel found the net pen structure to be heavily rusted in places. In many places, the thin steel of the bar grating was corroded to the point that it yielded significantly to a person's weight, and in places there were holes in the grating. The structural members of the platforms likewise suffered corrosion. Some structural members of the platforms were highly corroded to the point of producing loose oxide flakes.

Cooke showed in permit applications submitted in February 2017 that anchors were placed at varying distances from the net pen (28 to 200 feet), yet Cooke also documented a 'Mooring Plan' that showed all anchors at the end of 435 feet of rope and chain. For this reason, it is unknown how far away each anchor was from the net pen or the angle of the mooring rope down to the anchor. This distance and angle has a bearing on the resistance an anchor is able to provide against dragging. Bathymetric evidence of the drag marks of anchors demonstrate, however, that multiple anchors were outside the DNR leasehold, contradicting what Cooke presented in the permit applications.

Cooke made repairs to the net pen after the July incident. The Panel noted at least a portion of the long northeast side of the net pen structure was bent down at an angle and out of plane with the rest of the structure. Cooke welded square steel tube members to the floats to reinforce these locations.[12] In addition, Cooke installed a network of chains on the surface of the walkways. A long chain on the main central walkway, securing it to mooring points at each end, then secured the end at cages 211-221 by chain and synthetic rope to a large rock on shore.[13] Chains also were laid across the net pen connecting moorings on the northeast side of the structure to moorings on the southwest side. These chains were intended by Cooke to distribute forces on the mooring brackets and hold the floats together.[14]

Points of structural failure were noted among the salvaged parts, but the timing of the damage could not be discerned simply from examination. This is because following the initial collapse of the pen, the tides compressed and pulled apart the pen, causing additional damage. The probable location of the initial structural failure was reported by Cooke and confirmed in an interview as being at the southeast end (cages 215 and 225).[15] At that location, the floats connected to the end of the central walkway broke away from the rest of the structure.[16] Anchor dragging, broken mooring brackets, and platform structural member failure likely were involved in the progressive collapse of the net pen.[17]

Analysis/discussion

The Panel requested numerous documents and information from Cooke as part of the investigation. The response to those requests as they relate to the structure and its failure are as follows:

1. Original engineering design, including drawings, calculations and modeling of environmental conditions; design must address the requirements of Washington Administrative Code 173-240:

   Cooke's response did not include engineering design drawings or calculations of the net pen structure. Likewise, Cooke did not include engineering design drawings of the moorage installation of either the original 2001 installation or of the 2010 re-orientation. The mooring plans provided by Cooke were on the level of sketches or 'as-builts' of what was installed, and the mooring calculations used engineering principles of a general nature, but did not contain the specificity necessary for the site and conditions.

   Cooke did provide the contemporaneous assembly and operating manual for a net pen array made up of 12 cages,[18] whereas net pen #2 was made up of 10 cages. Nevertheless,

the literature matched the class of structure of net pen #2 and detailed the same construction method so the information is transferable to net pen #2. This manual contained basic diagrams of the arrangement of the floating units but not detailed, dimensioned drawings of its design or manufacture. This manual did not contain any information as to the environmental conditions such as speed and direction of wind, current and waves that the structure was designed for and is capable of surviving under. Additionally, this manual did not contain information as to the strength of the components of the structure, such as the hinge strength, or the mooring brackets (pad eyes).

Cooke provided a letter dated 2015 from the manufacturer of the net pen system, Marine Construction AS, to the former owner providing some of the criteria the system was designed to meet. [19] These included wave height of 3.3 feet (1 meter), current of 1 knot (0.5 meter/second), net mesh of 2 inches (50 millimeters), and net depth of 33 feet (10 meters). It is reasonable to expect each component of the floating structure was designed for the forces produced by these conditions when new.

Cooke also provided two mooring analyses, one undated[20] and the other dated 2015.[21] The undated analysis is also uncredited – no identification of the author or his/her qualifications are provided – and it is unknown whether its design calculations were contemporaneous with the net pen installation or if it was developed later. This analysis was of the lines and anchors securing the floating structure to the seafloor and did not include an analysis on the mooring brackets or pad eyes nor a structural analysis of the floating structure components. The analysis is abbreviated in nature. This analysis does not show many of the assumptions, site characteristics and design criteria one would expect for a mooring analysis. Of the design parameters that it does use, the current velocity exceeds the manufacturer's stated design current, and the amount of assumed marine fouling on the net is likely less than the marine fouling that was found.[22] Heavier fouling as was found on the nets after the August 2017 failure than was modeled in the analysis would have produced greater drag and higher forces on the structure and its components.[23] Due to the deficiencies noted, the Panel considers this mooring analysis as incomplete.

The 2015 mooring analysis was commissioned by the previous owner of the net pen and was conducted by a Norwegian aquaculture services firm. Like the other mooring analysis, it did not do an analysis on the mooring brackets or pad eyes nor a structural analysis of the floating structure components. The analysis is abbreviated in nature. The firm self-reports as being accredited to perform mooring analyses in accordance with Norwegian Standard NS9415:2009 regarding aquaculture facility design and operation.

This analysis took into consideration such environmental conditions as wind and currents, but the physical conditions for the site were incorrect. The mooring analysis' site depths, substrate conditions and relation of the site to the DNR leasehold boundaries were in conflict either with what is known about the site from other materials provided by Cooke or other publicly available sources.[24] The 2015 mooring analysis is lacking in this regard,

and because it fails to describe important elements such as the sizes and types of anchors, the Panel considers it incomplete.

Similar to the other analysis, some criteria used in this 2015 analysis exceeded the manufacturer's stated structure design criteria. In particular, this analysis examined a current of up to 1.6 knots (0.83 meters/sec) and net depth of approximately 53 feet (17 meters).[25] The mesh size appears to have matched the mesh actually used.

This mooring report made some recommendations in size of rope, chain and anchors. The diameter of rope found in the mooring system in the aftermath of the events of summer 2017 differed from the sizes calculated in the 2015 report, particularly on the long northeast side.[26] Although anchors are best designed as the 'weaker link' in a mooring system to ensure the anchor drags before a mooring line breaks[27], the size of the anchors in summer 2017 may have been significantly smaller than the recommended sizes of 'counterweight' listed (although this term is undefined in the report), causing anchor drag prematurely before the required anchoring force specified in the analysis was achieved.

Both analyses specified 22 lines and anchors to secure the net pen; aerial photos predating the events, and contemporaneous mooring diagrams support this number of moorages being in place.[28] However, the mooring diagram provided by Cooke of the mooring arrangement after the July event showed that only 19 were installed. The three missing lines were all on the end closest to shore (cages 211-221).[29] There are enough significant differences between the mooring analyses and what was observed on site that it is apparent that the actual post-July 2017 mooring configuration did not conform to either of them.

In 2016 and 2017 aquaculture facility certification audits were performed to assess the net pen compliance with the Best Aquaculture Practice (BAP) standards of the Global Aquaculture Alliance. One of the BAPs, part 6.2, requires engineering documents supporting the facility's Fish Containment Plan. In each certification, the auditor certified the facility as meeting the engineering requirements by having "an engineers [sic] mooring design, a moorage report by Aquaknowledge [sic] (April 2015)."[30] [31] The Panel has observed that the mooring reports themselves do not reflect site and environmental conditions, do not reflect the design criteria of the net pen structure, and the actual mooring of the net pen did not fully reflect the recommendations of the reports.

A 2015 review of the installation's performance regarding BAPs by an engineering firm recommended that an accurate tidal current study for the site be conducted, "more strength for the outside lateral mooring lines" be supplied, and "a third anchor could be added to the center head" [32] ('center head' is undefined). Cooke did not provide documents reflecting a site study of the currents. It is known that strengthening of lines and a third anchor were not done because Cooke supplied a drawing of the mooring arrangement at the time of the July 2017 event. The mooring plan is dated November 19, 2010[33]. Cooke had not made changes in the mooring configuration between November 2010 and July 2017.

Neither of these mooring reports, nor other documents provided by Cooke in response to the ECY Agreed Order were sealed by a Professional Engineer, which is the attestation that calculations and design have been done in the best practices of the engineering profession, are within the proficiency of the engineer, and in accordance with Washington State law. The mooring analyses had been commissioned by the net pen owner preceding Cooke and used some engineering principles and methods. However, the level of thoroughness and due diligence of the analyses as discussed above may not have been sufficient for the specific conditions.

2. Chronology of structural changes/modifications and relocation/reposition of the facility as well as rationales for each change:

   Cooke's response to the Agreed Order and subsequent interviews described the changes discussed above. The structural changes, the addition of tube steel welded to the structure and the network of chains, were made in the days after the July incident. The rationale for the tube steel additions has not been stated. The stated purpose of the chain network across the walkways was to hold the floats together and to relieve some of the force from the mooring lines to the pad eyes.[34]

3. Design information regarding the July 2017 incident:

   Cooke did not provide documents or interview statements that an engineer was consulted in making the repairs and retrofitting of the float structure nor in the resetting of anchors and installing new mooring ropes and chains.

4. Remedial measures after the July 2017 incident, including the structural and mooring systems, repositioning, and specifications of the original and replacement structural components employed:

   Cooke provided a general narrative of having made structural repairs after the July incident. Cooke provided evidence supporting those general statements by making the salvaged materials and personnel involved with those repairs available to the Panel for inspection and interviewing. The framing repairs were generally to certain locations along the long northeast side of the net pen. Some platforms on this side were bent down at an angle out of plane. At each of these bent locations, Cooke bolted and welded two lengths of heavy steel structural tube to the existing bent frame. In addition to these framing repairs Cooke reports that attachment points were replaced for the entire facility and all mooring lines had been replaced recently. A network of heavy chains was also installed across the walking decks, which was observed during stabilization and salvage. During salvage operations it was observed that all ropes were free of biofouling and some chains had much less biofouling than others, supporting Cooke's statement that they had been replaced. Site visits confirmed some pad eyes looked newer than others and some pad eyes were larger and made of thicker steel than others. The larger ones appeared to be relatively new. It could not be discerned whether the broken pad eyes that were observed at the salvage yard were new replacements or predated the July incident. Cooke

provided strength ratings from the manufacturer of the smaller and the larger pad eyes, indicating the larger pad eyes were 67% stronger.[35]

5. Design information and causal analysis regarding the August 2017 failure:

   Cooke did not provide documents or interview statements that an engineer was consulted or produced designs during or after the August 2017 failure. Cooke did not provide a causal analysis.

Several factors associated with the design and operation of net pen #2 contributed to the failure of net pen #2 (Appendix 1: Cypress Island Net Pen Failure Engineering Review):

- *High forces imparted on the structure due to severe biofouling of the nets;*
- *Corrosion in the net pen structure components resulting in a reduced capacity;*
- *Uneven forces in the structure due to an uneven mooring arrangement different from what was recommended and which had previously resulted in anchors dragging and pad eyes breaking;*
- *Reduced capacity of the structural components that were likely modified without an engineering assessment (e.g. the bent outrigger frames with new steel members welded to them, and the exoskeleton system of chains) or those which were not repaired (e.g. hinges connecting the floats), following the July 2017 incident; and*
- *Atypical loads imparted to the structure from the exoskeleton of chains that were installed following the July 2017 incident.*

Biofouling

As discussed at length in the chapter titled "Biofouling," biofouling of the stock containment nets was such that the plant and animal growth on the nets was significantly greater than normal, and probably significantly greater than the amount used to model the two mooring analyses that Cooke provided. The size of the nets employed in net pen #2 also were deeper and finer-meshed than what the manufacturer stated the floating structure was designed for. These factors contributed to a high drag force experienced by the structure as a result of tidal currents.

Corrosion

Corrosion was severe on the net pen after 16 years of use in the salt water of Puget Sound, to the point that the strength of the structural members probably was reduced to some extent.

Uneven Forces

The connection of the mooring system to the net pen did not conform to the net pen manufacturer's instructions for bridles, the number of mooring lines and anchorages was less than two mooring analyses had recommended. These and other deficiencies resulted in probable uneven forces on the structure from the moorings causing anchors to drag and pad eyes to break.

Structural Modifications and 'Exoskeleton' Chain

Structural modifications constructed in the aftermath of the July incident were made without an engineering analysis of their design nor effect on the behavior of the structure. These

modifications may have induced forces and torques in parts of the structure not designed for them.

Net Pen Operating Procedures

Facts

At the time of the incident, net pen #2 was rearing a reported 305,000 Atlantic salmon (*Salmo salar*). The fish were stocked in the net pen as smolts in May 2016.

Net pen operations up until August 19, 2017, consisted of the following procedures:

- Stocking and harvest. At the time of the failure, stocking at net pen #2 was single year class stocking. This means that the site was stocked with smolts from the hatchery, and the fish remained in this net pen during the entire 18-month grow out period. This practice, adopted at the Cypress Island farm around 2011, represented a change from previous practice in which smolts were raised for the first part of the saltwater salmon life cycle at the Hope Island net pen in Skagit Bay and then moved to Cypress Island farm for final grow out. The approach in use at net pen #2 at the time of the incident is considered an industry "best practice" because it results in the least amount of handling stress to the fish, minimizes the risk of escapes during handling, and reduces the risk of disease transmission between farms in different parts of Puget Sound.

  Harvest of the fish at net pen #2 was expected to begin in September because the fish were larger than anticipated and continue through November at the latest.[36, 37] Had the failure not happened, the harvest would have occurred following standard practice. The harvest vessel comes alongside the net pen and rigs a 12-inch diameter hose connection from a stock pen to a fish vacuum pump on the vessel. By pulling up on the sides of the stock net, the fish are crowded into a small location. Use of a grading net allows larger fish to be sorted for harvest first. The smaller fish stay in the stock containment net to grow for several more weeks before they too are harvested. The harvested fish are sucked through a pipe to a vacuum pump. Passing through the pump, which is designed to operate without the valves touching the fish, the fish are conveyed to a dewatering table. Workers stun and bleed the fish. The fish are placed in the hold, typically with refrigerated seawater. The vessel sails to Seattle where the fish are processed. All blood and any offal from the stunning and bleeding process is contained on the vessel and discharged into the sanitary sewer system in Seattle.

  Following harvest, all nets are removed from the net pen array and sent to an upland facility for cleaning, repairs, and disinfection. The net pen array is not used ("fallowed") for at least an eight-week period to disrupt pathogen life cycles.

- Feeding. The fish are fed two or three times a day. Dry pellet feed is loaded into hoppers located on the center spine of the net pen array. A fan blows the pellets over a net pen using an oscillating gooseneck pipe to distribute the feed. Staff monitore an image from an underwater video camera pointing upward. From the behavior of the fish, staff determined when to cease feeding. Power for the feeder and video monitoring equipment is provided by a generator. Because feeding was not a contributing factor in the failure, it is not discussed further in this document.

- Aeration. From approximately May to November, each stock pen was aerated. A compressor provided compressed air to a diffuser hose submerged in each pen to increase the oxygen saturation level. Aeration is not necessary when the water is cooler and can hold more dissolved oxygen naturally. Clean nets also reduce the need for aeration because oxygen-rich water can more readily flow through the net. Because aeration was not a contributing factor in the failure, it is not discussed further in this document.
- Water quality/sediment quality monitoring. Marine finfish facilities are required to comply with state sediment standards and water quality standards established in statute (Washington Administrative Code 173-204-412, Revised Code of Washington 90.48. 220). Requirements for water quality and sediment quality monitoring are set forth in the NPDES permit administered by ECY. Monitoring of dissolved oxygen in the water column is required, and sediment sampling and analysis is required at established sampling stations. Because water quality/sediment quality and monitoring thereof were not contributing factors in the failure, they are not discussed further in this document.
- Monitoring/inspections can be characterized as four types with a fifth evaluation of importance:
    - Daily monitoring of the net pen facility. Staff were expected to monitor the condition of the net pen on a daily basis. The "Daily Activity Log" had entries addressing the cage structure, nets, and moorings (Figure 9). Daily inspection logs were organized by month. Cooke provided most logs for recent years but logs were not provided for July-September 2016 and August 2017. Cooke reported that the August 2017 daily log was on net pen #2 at the time of the August 19 incident and has not been recovered. Over the two year period reviewed by the Panel, the completeness of entries for each day varied considerably, with some days apparently skipped (all entries blank), some days filled out in part (certain sections filled out and others left blank), and still others filled out in detail.

Morning Surface Inspection	Good	Other
Can Buoys (alignment, condition, height above water)		
Chain, bridles, and shackles		
Cage Integrity		
Nets at waterline		
Waterline ties		
Birdnets		
Debris removal		
Mooring concerns? ___No ___Yes		
Marine Engineer Contacted? ___No ____Yes		

Figure 9. Excerpt from master Daily Activity Log, showing section addressing cage structure, nets, and moorings.

    - Tri-weekly inspections of each containment stock net for dead fish and holes in the net. Typically on Mondays, Wednesdays, and Fridays, a diver entered each stock net to remove dead or distressed fish. These fish were examined for signs of disease and the bodies were removed from the net pen for upland disposal. Holes in the net were identified and repaired. Although the focus of these inspections

appears to be fish health and net integrity, it provides another opportunity to observe the degree of biofouling as well.

- Monthly inspections of the net pens. Recorded in monthly "audit sheets," these inspections included the following items that are relevant to this investigation:
  - "Moorings secure and fit for purpose,"
  - "Pins and bushes [in the platform hinges] secure and fit for purpose,"
  - "Weight ropes tied off properly," and
  - "Cage sections secure and free from cracks."

  Ratings of 1-5, priority (high/medium/low), and action/improvement required were assigned on a monthly basis.

- Underwater inspections of the mooring system including the surface hardware (pad eyes), surface chain, mooring line (rope), anchor chain, and anchor for each mooring. Staff variously reported that these inspections occurred annually or biannually.[38,39] These inspections were by Cooke divers and limited to depths above 100 feet. The Cypress Island farm manager said "a few north anchors" were too deep for regular dive inspection.[40] The deeper anchors were pulled to the surface by a contractor, inspected, and then re-set, reportedly every three years.[41] It is not clear which specific moorings were subject to this type of inspection. Documentation shows that the 22 anchors were inspected in thirds in October 2012, November 2013, and January 2014.[42] All were rated as "good." That same documentation, dated July 1, 2016, states "All system to buoy chain and hardware checked Jan/Feb 2016" and "Sea anchors and hardware to be checked Fall 2016."[43] Whether the fall 2016 inspection occurred is unknown. There is, however, a reference in an email that net pen #2 "[m]oorings were inspected and replaced in June [2017]."[44]
- In addition to the four types of monitoring/inspections listed above, there is the operator's general awareness of the age and condition of the net pen. Cooke assessed the condition of net pen #2 in its application to reorient and replace it in February 2017 as follows:

  > *The current condition of the existing fish pen structure can best be described as "used and nearing the end of serviceable life." . . . Corrosion on the metal walkway grating and substructures is beginning to accelerate. Complete replacement of the floating steel net pen structure with a newly manufactured one is considered a "best management practice" for the safe containment of the cultured fish stocks and a method of routine maintenance by the marine aquaculture industry.*[45]

  Based on a DNR site inspection conducted on September 30, 2016 and observations of pen elements following the August 19 failure, the information above shows Cooke was aware of the general condition of net pen #2.

- Maintenance. Maintenance of moorings and structural elements of the net pen array appears to have been conducted "as-needed" rather than on a set schedule. (Please also see also Appendix 1: Cypress Island Net Pen Failure Engineering Review - Section 6 Maintenance and Repair History.) Examples include:
    - In an August 12, 2014 email from the Permit Coordinator to the Cypress Island farm manager and assistant farm manager with a subject line: "surface connection inspections Aug 11, 2014":

      > *Spent some time looking at the pad eyes and shackles for all of the anchor points on Site 1, 2 and 3. Found a few that could do with replacing with newer ones. They are either beginning to rust up, or have some wear on them from the shackle. One bent one the shore side of Site 2* [sic]*. . . This would be a good thing to do on a routine basis, so I am including blank excel sheets with the site diagrams. Easy enough to take a walk around with a clip board and make notes. Also, good to keep on file so we have records.*[46]

      There is no documentation of whether these suggested maintenance tasks were carried out in a systematic way or if the identified pad eyes and shackles were replaced. (Cooke did not provide records documenting such "walk around" inspections. The pad eyes and shackles were items to be inspected in both the daily logs and monthly audits discussed above, however.)
    - In February 2015, repairs to cracks in the box beam and walkway areas were performed, as evidenced by a February 25, 2015, invoice and a statement in the March 18, 2015, production notes.[47] [48]
    - On April 29, 2015, an "eyelet [was] bent." This presumably was a pad eye. The log indicates it was replaced.[49]
    - On October 28, 2015, staff were "worried about tilt in [2]25/[2]15 end cap."[50] Two weeks later, the daily log states "tilt on 15/25 end cap disconcerting."[51] The end cap most likely refers to the "catamaran" section at the end of the main bridge walkway. This particular section, which connected the 215 and 225 pens may have been where the August 19, 2017, failure began or was centered on.[52] [53] There is no further documentation regarding this concern.
    - On February 2, 2016, a pad eye is reported as "cockeyed."[54] It is located on the north side, which takes the greatest forces from flood tides. It was reported as repaired two days later.
    - The inspection documentation dated July 1, 2016, referenced above, notes that the surface chain and buoy were replaced on 5 of the 22 moorings in February 2016.[55] This replacement followed the January/February 2016 inspection.
    - On July 13, 2016, Cooke's insurer conducted a survey and had one recommendation for net pen #2: "We understand the flotation issue at the ends of the system is being addressed. The deformation of the walkway ends is likely to be stressing the structure in the strong tides and should be rectified as early as

possible." The insurer categorized the recommendation as "amber: medium" and under "What Action Taken" stated "No longer an issue."[56] There is no further information regarding this issue.

- In the May 31, 2017, Monthly Audit Sheet – Cypress Island cages Sites 1, 2, 3, under row "Cage sections secure and free from cracks," a rating of "1" (poor) is assigned and priority "H" (high) is assigned, with "action/improvement required" identified as "Site 1 and 2 walkways very rusty and full of holes. Patching with plywood and other temporary coverings. Site 2 cages to be replaced this fall."[57] (In months prior to the May 2017 entry, this item had been rated a "5" or "excellent.") DNR staff confirmed the May 2017 conditions and applied response on net pen #1 during visits in late August 2017 and January 2018.
- As referenced above, there was a note that net pen #2 "[moorings were inspected and replaced in June 2017]."[58] The Panel did not identify any data documenting this replacement in detail. Cooke did provide an invoice dated May 31, 2017, for 11 shackles and two 600-foot lengths of 2 5/8-inch 8-braid steel poly rope.[59] This length of line would have been sufficient for replacement of four 300-foot long moorings. Prior to the July 2017 incident, there were 22 moorings. Internal documents provided by Cooke indicate that they drew upon spare mooring lines and hardware from other facilities.
- Following the July 2017 incident, Cooke reported it replaced all mooring lines (ropes) during the re-anchoring of net pen #2.[60] Cooke provided an invoice dated July 27, 2017, for five 600-foot lengths of 2 5/8-inch 8-braid steel poly rope.[61] This length of line would have been sufficient for replacement of ten 300-foot long moorings. Post-incident mooring diagrams show 19 moorings; the source of the additional replacement lines is unknown. State staff observing the salvage following the August failure, observed only clean, new lines in the water, however. Cooke also reported replacing pad eyes that failed. Inspections of the net pen #2 components on December 19 showed only six intact pad eyes that were noticeably older than the new pad eyes as evidenced by degree of surficial corrosion. Damaged or destroyed pad eyes and the other intact pad eyes all appeared to be new or relatively new as evidenced by the absence of surficial corrosion.

- Net cleaning/replacement. Please see chapter on "Biofouling" for discussion about this aspect of net pen operating procedures.
- In addition to the activities above, other operating procedures are important to the safe, environmentally-sound operation of the net pen. However, because they were not contributing factors in the failure, they are not discussed in this document. These other procedures include:
  - Worker safety.
  - Biosecurity controls including detection and treatment of disease.
  - Materials and waste handling including fuel spill prevention, containment, and cleanup.

Analysis/discussion

The Panel twice asked Cooke for a causal analysis regarding the cause(s) of the July incident and August failure.[62] [63] Cooke did not directly provide its conclusion regarding the cause(s) and contributing factor(s) beyond what is stated in the documents referenced above.

Inadequate inspections and maintenance *may* have been a contributing factor to the July 2017 incident.

Cooke believed at the time that the July incident "was the result of fouled nets and weak mooring points."[64] This conclusion was repeated in the July 2017 monthly production report's summary for Cypress net pen #2: "Structural failure at surface mooring points due to strong tides and excess net fouling."[65] (See chapter on "Biofouling" for discussion on that factor.)

Exactly why the mooring points were deemed to be "weak" has not been explained in either documents or interviews. There are two reasons why the pad eyes would be considered "weak":

1. The forces on the net pen had increased compared to prior years, causing the pad eyes – because they were the "weakest links" in the mooring system – to fail when they previously were of sufficient strength to hold the farm in position. In other words, the pad eyes were *revealed* to be weak *relative to the rest of the mooring system*.

   and/or

2. Corrosion and/or wear had weakened the pad eyes to the point that they no longer took the loads imparted during the highest tidal currents. In other words, the pad eyes had *become* weaker. It is this possibility that suggests inadequate monitoring and/or maintenance as a contributing factor.

As discussed elsewhere in this report, it is likely that the increase in forces on net pen #2, as the result of biofouling, was the mechanism that caused the net pen to move. The facts also show that pad eyes *did* fail and that they were weak relative to most of the rest of the mooring system (some anchors apparently drug, too).

Due to absence of physical evidence – the pad eyes that failed in July were replaced after that incident – and because of the high level of certainty that biofouling was a cause, it is not possible to determine whether the pad eyes were *physically* weaker than their design strength due to corrosion or wear.

The Panel concludes that because the pad eyes failed, inadequate maintenance and inspections of the pad eyes may have contributed to the July incident.

Monitoring and maintenance of corrosion of the steel walkways – the monitoring record is incomplete, and there is little evidence of maintenance addressing corrosion. However, as discussed above, Cooke viewed complete replacement as a viable response to the extensive corrosion of the pen that existed upon purchase in May 2016. The Panel acknowledges that complete replacement is a reasonable response to widespread and advancing corrosion. Moreover, Cooke applied for permits and began seeking approval for this replacement well in advance of the completion of harvest (scheduled for late 2017), demonstrating its intent to

address the problem through replacement. The Panel has identified corrosion as a possible contributing factor to the August collapse (see chapter “Structure of Net Pen #2 and discussion of corrosion in Appendix 1: Cypress Island Net Pen Failure Engineering Review) but does not conclude that *monitoring and maintenance* of that corrosion were contributing factors. In other words, the corrosion was observed, correctly perceived as serious, and a planned response developed. If the events of August 2017 had not occurred, the response probably would have been implemented.

Biofouling

Facts

All elements of net pen #2 below the water line were subject to fouling by marine organisms. Biofouling included marine plants and animals growing on lines, chains, floats, and the predator exclusion and stock nets.

The pattern and types of biofouling on net pen #2 can be extrapolated from a 2007 report based on a thorough study of biofouling on adjacent net pen #3. [66] Hydroids, a soft-bodied marine organism, and bay mussels (*Mytilus spp.*) were the most common fouling organisms identified in the 2007 study and appeared to likewise dominate the biomass observed in stock nets recovered from net pen #2 following the August 2017 collapse.

Importance of Biofouling of Nets in Finfish Aquaculture

While biofouling occurs on all underwater portions of a net pen array, including on the moorings, weight system, and floats, it is biofouling on the nets that has the greatest potential impact on net pen stability. This is because the nets provide the largest area, or substrate, on which the growth can occur and against which tidal currents exert force.

Biofouling has been identified as greatly increasing loading (drag) on nets and is considered a critical management task in net pen aquaculture. Failure to manage biofouling can result in significant increases in static loading and catastrophic failure of net pens.[67]

> *Exposure to currents causes net cages to change their shape by deflection and deformation. The extent of the change in shape depends on current velocity, original shape and construction of the cage, placement weights, type of netting, and level of biofouling (Fredheim 2005; Lader et al. 2008). Increased mesh occlusion increases drag forces on netting; current-induced forces on a fouled net may be 12.5 times that of a clean net (Milne 1970). Consequently, unless cages are heavily weighted, the shape of the cage may be severely deformed by current flows of 0.5–1 m/s, reducing the effective cage volume by 45–80% (Osawa et al.1985; Aarsnes et al. 1990). Fouling biomass also increases static load on nets up to 200-fold (Milne 1972 in Beveridge 2004), and horizontal drag forces on cage netting can be increased by up to three times by common fouling hydroids and mussels (Swift et al. 2006). Highly deformed nets increase structural stresses on the cage at specific points, with a two to six-fold increase in horizontal forces in the cage corners (Tomi et al. 1979). Cage designers and operators need to account for these increased loads in the design of cage floatation and mooring systems or devastating net failures result which lead to escapes of fish (Jensen et al. 2010).* [68]

Periodic removal of biofouling is required to manage biofouling of nets for two reasons:

1. Maximizing water exchange for flow of oxygen-rich water to the fish and
2. Avoiding cage deformation and structural failure from drag on the net pen

Therefore, net pen aquaculture practices focused on managing biofouling focus on nets as opposed to other elements of the net pen array such as moorings or floats.

Net Hygiene to Control Biofouling of Nets

Documents provided by Cooke show that the management of biofouling on the nets, referred to typically as "net hygiene," was a significant aspect of net pen operations at the Cypress Island farm. Monthly production reports for Cypress Island include a section on "Net Hygiene."

Net hygiene consists of two types of cleaning:

- Cleaning of nets between 18-month grow out cycles. During the eight-week fallowing period between crops, both the predator exclusion net (which consists of panels sewn together) and the individual stock containment nets are removed from the net pen array. The nets are sent to a company in British Columbia where they are washed in machines, strength-tested, repaired as needed, and disinfected. Typically, stock nets are used for three grow out cycles before being replaced.
- In-water cleaning during the grow out cycle. In-water cleaning of nets occurred on a regular, on-going basis year round. During the spring, summer, and early fall, biofouling growth rates were higher and cleaning occurred more frequently.

During the final grow out cycle at net pen #2, biofouling was controlled by mechanical means only. (Until several years ago, nets contained copper as a biocide to reduce biofouling. The nets in net pen #2 as of 2017, however, did not include copper.) Workers used four tools for the in-water cleaning:

1) Stingray net cleaning system, consisting of two rotating heads that scraped material off the net (Figure 10). The cleaning head moved up and down the inside face and bottom of the stock containment nets. It also was used to clean the outside of the predator exclusion net. Video documentation of the effectiveness of the Stingray is shown in this video: https://www.youtube.com/watch?v=oW9ztFfp2Xo The video was filmed at the Cooke net pen at Hope Island in Skagit Bay, which is newer than Cypress net pen #2 but is fundamentally the same design. The video shows the Stingray effectively removing mature and dense mussel growth from both the inside and outside of the predator exclusion net as it cleaned the outside of the net. The predator exclusion net has relatively large mesh (5-inch diagonal) and the video shows mussels on the inside face of the net being pulled through the mesh openings and ground up by the rotating heads on the outside of the net. Cooke's experience was that the Stingray was the most effective of the cleaning machines they use in terms of removing mussels.[69] The footage that shows the Stingray cleaning the stock containment nets, which have considerably smaller mesh, does not show mussel removal. The Stringray is a largely automated system that can be tended by one worker.

2) Multi Pump Innovation (MPI) net washing system, consisting of five rotating heads that used pressurized water to blow material off the net (Figure 11 and Figure 12). When used on the sides of the net, it can be tended by one worker. It reportedly cleans the bottom of the net well but requires use of two divers for that portion of the stock net.

3) AKVA Idema twin-head net washing system, similar to but smaller than the MPI.

4) A pressure washer with 15-foot wand used to blow material off the upper sides of nets from the floats. Divers also can use the pressure washer.

Figure 10. Stingray net cleaning machine at Cypress net pen #3 on September 11, 2017.

Figure 11. MPI net cleaning machine at Hope Island farm on November 27, 2017. Pressurized water rotates the five yellow heads.

Figure 12. MPI net cleaning machine in operation at Port Angeles farm on December 8, 2017.

Cleaning of nets appears intended to manage the rate of biofouling rather than eliminate biofouling entirely. This is because the net cleaning occurred only on the inside of the stock net and the outside of the predator exclusion net. While biofouling on the stock net surface opposite that being cleaned can be dislodged, the effectiveness of that cleaning on the opposite side does not appear to be as effective. During salvage and landing of the stock nets following the August failure, the outside of stock nets were observed to be heavily fouled in places with mature mussels and, in some cases, algae such as kelp. The purpose of cleaning is to limit the rate of growth and prevent heavy biofouling from developing. At the end of the 18 month grow out cycle, all stock nets are removed from the net pen array for thorough cleaning on land or disposal, as discussed above.

Stock containment nets can be and were replaced by Cooke during grow out. In past practice by Cooke and previous owners, it was routine to use smaller mesh size stock nets when smolts were first placed in the pens. While Cooke appears to have shifted to use of a single net for the entire grow out period, during the final grow out for net pen #2, two nets were used. A net with smaller mesh was used when the small smolts were first placed in the pen. When the smolts reached a certain size, the smaller mesh net was swapped with a larger mesh net. Net swaps involve "pursing" the first net, placing the new net in the cage and pulling it around the first net, and then pulling the first net out. The benefit of swapping smaller mesh net for larger mesh net is increased water flow and less dense biofouling. The nets on Cypress net pen #2 were swapped in July 2016, which "re-set" the biofouling to zero. Therefore, the biofouling observed on the nets during salvage was no older than 13 months.

Net pen cleaning must occur frequently and regularly. According to Cooke staff, cleaning "never stops during high growth months" and there was always a staff member – when cleaning machines were operational – washing nets.[70] This was because biofouling grew constantly and because once firmly established, some types of biofouling can be difficult to remove. Mussels (*Mytilus spp.*) in particular, can be hard to clean from nets and once mussels are established, it is hard to catch up.[71] Failing to clean frequently and regularly allows establishment of fouling organisms that subsequent in-water cleaning cannot remove effectively. In the summer, with warmer temperatures and more daylight, net cleaning of each stock net at Cypress was supposed to occur about once per month. This frequency was mentioned by Cooke staff to DNR staff several times during visits but is not documented.

State staff conducted underwater video inspections of six intact stock nets on September 11, 2017 to better understand biofouling. Three stock nets were filmed at Cypress net pen #1 and three stock nets at Cypress net pen #3. A Cooke diver guided a DNR remotely operated vehicle along the sides and bottoms of the stock nets on a path chosen by the state. DNR staff also selected which pens to inspect. While there is no comparison video footage for net pen #2 due to its collapse, the information gathered from the other two net pens illustrated what fouling looks like when nets are in the water. Observations from the videos indicate:

- Mussels represented the dominant type of biofouling in terms of area covered. Hydroids were observed but did not significantly block openings in the mesh. In contrast, mussels were dense enough in some areas to completely block openings in the mesh.

- Biofouling density varied considerably. A single panel could be clean in one area, have scattered mussels a few feet away, and 20% or more mussel coverage another few feet away.
- Mussels were observed on both sides of the net where mussel growth was particularly dense. Frequently, clusters of mussels grew on both sides of the stock net.
- The densest patches of mussels tended to be on bottom panels.

Net hygiene information in documents provided by Cooke was reviewed for the entire grow out period for net pen #2. Information on cleaning in the daily logs (please see chapter "Net Pen Operating Procedures") was incomplete and did not present a clear picture of when individual nets (e.g., pen 111, 112, etc.) were cleaned. However, weekly and monthly production reports indicated that the reliability of the cleaning machines was frequently a concern and deteriorated in 2017. The importance of net hygiene and the concerns of management are documented in reports from which key statements are included below. Problems with the net cleaning machines and consequential impact to biofouling are emphasized with ***bold italics***.

1. March 2016 American Gold Seafood (previous owners) report: "Site 3 only raft with nets down. Growth on nets not alarming-YET. MPI on site 3 prepped and ready to go."[72]

   April/May 2016: post-fallowing, nets would have been installed on net pen #2 about this time, immediately prior to stocking with smolts.

2. Cypress Island May [2016] Results: "MPI working well, currently washing on site 2. Pred net is clean, no issues."[73]
3. June 15, 2016 Mgr. Meeting Notes: "Net swaps with new nets slated to start in late August."[74]
4. July 5, 2016 email from the Cooke Puget Sound General Manager to the Cypress Island Farm Manager: "So not the best tour today: - ***nets dirty, catching all the tide and bagging horrendously*** possibly causing mechanical damage . . . I realize ***the MPI was broken last week***, but . . . to my mind ***that makes it even more vital that someone should have been using it today and even over the weekend*** . . ." and "Positives: We have net to change we have the Clam Digger with a tested crane so you can swap these nets in house . . . Every net changed = one less net to wash"[75]
5. July 6, 2016 email from the Cypress Island Farm Manager to the Puget Sound General Manager stated "I would like to swap site 2 [stock containment nets] first as it is in the most critical condition" and upon approval from the General Manager, the Farm Manager committed to "All site 2 [net replacement will] done next week, quickly as possible."[76]
6. Cypress Island July [2016] Results: "Site 2 nets swapped for new 15 mm growout nets week of July 11-15. Half of Site 3 nets swapped, remaining to be swapped asap. MPI running great, no issues. Site 3 washing complete and MPI is halfway through site 2, expected to be on site 1 by end of week."[77]

   "Net swaps" refers to the replacement of the smaller-mesh stock containment nets with the larger mesh versions, as discussed above.

7. Cypress Island August [2016] Results: "Site 3 net swaps completed. Fish doing well, Site 1 to be done next. Expecting [Stingray] scrubber soon. Nets under control at the moment but pred net will need some attention soon. MPI running great, no issues. Should complete site 1 by end of week and move to site 2."[78]
8. Cypress Island September [2016] Results: "***Growth on nets beginning to slow down. Pred net will need attention once scrubber is received***. MPI running great, no issues. Routinely moving through sites."[79]
9. Cypress Island October [2016] Results: "Growth on nets beginning to slow down. Pred net will need attention once scrubber is received. MPI running great, no issues. Moving through sites routinely. Net swaps for site one tentatively first week in November."[80] Panel note: The first three sentences are identical to those in the September 2016 report. It is unknown if this was deliberate or an oversight.
10. Cypress Island November [2016] Results: "Nets in good shape. Minimal growth during this time. MPI running great, no issues. Net swaps began last week on site 1, working around large tides, should be completed by next week."[81]
11. Cypress Island December [2016] Results: "Nets in good shape. Winter growth slow. ***MPI needs service***. As staffing permits will run through site 2 and move on to site 3."[82]
12. Cypress Island January 2017 results "Nets in good shape. Winter growth slow. ***MPI needs service***. As staffing permits will run through site 2 and move on to site 3."[83] Panel note: The entries for December and January are identical. It is unknown if this was deliberate or not.
13. Cypress Island February 2017 results: "The MPI is moving through site 2, running well, no downtime. The Stingray is moving through site 3. . . . Site 1 nets in good shape, MPI to come to site 1 once 2 is completed."[84]
14. Cypress Island Weekly Production Report March 12 – March 18[, 2017]: "Site 3 and site 2 nets washed. MPI moved to site 1 and Stingray will begin on pred net on site 3."[85]
15. Cypress Island Weekly Production Report March 19 – March 25[, 2017] "1/2 of Site 1 nets washed by end of week. Stingray currently on Site 3 pred net."[86]
16. Cypress Island Weekly Production Report March 26 – April 1[, 2017] "Site 1 net washing nearly completed, MPI will move to site 3. Stingray running excellent, Site 3 pred net completed, will move to site 2."[87]
17. Cypress Island March 2017 results: "The MPI is running great, moving through the sites at 2-3 nets per day. The Stingray is working well, site 3 pred net complete and currently on site 2 pred net. Net integrity at waterline has improved. MPI to address net floors once through site 2 and 3."[88]
18. Cypress Island Weekly Production Report April 2 – April 8[, 2017]: "Site 1 net washing completed. MPI will move to site 2 and the stingray will move to site 2 as well."[89]
19. Cypress Island Weekly Production Report April 9 – April 15[, 2017]: "Site 2 net washing almost complete, will move to site 3 and then address floors. Visual checks of floors confirm they are relatively clean. Stingray will begin site 2 pred net wash."[90]
20. Cypress Island Weekly Production Report April 16 – April 22[, 2017]: "Site 2 net washing complete. Washing on site 3. Stingray working on pred net on site 2."[91]

21. Cypress Island April 2017 results: "***The MPI is down. Currently in transit to Seattle for repair. The Stingray is down, evaluating to resolve issue. Growth is accumulating fast.*** Net integrity at the waterline has improved."[92]
22. Cypress Island Weekly Production Report May 7 – May 13[, 2017]:"***MPI is currently down for repairs.*** Stingray is fixed and washing again."[93]
23. Cypress Island Weekly Production Report May 14 – May 20[, 2017] (4818) "Stingray moving through site 3. ***Nets on site 2 need attention, much needed Akva [Idema] washer (or 2) arriving soon***."[94]
24. May 19, 2017 email from Cypress Island Farm Manager to Puget Sound General Manager: "***Nets on site 3 are dirtier than 2 and 1***. The stingray is moving through them and I have a pressure washer with 15 foot wand going around the cage edges to open them up. . . . Drastic DO fluctuation this week, lowest 4.9 to mid to upper 7's on site 3, inside cages. Site 2 and 1 better readings inside cages."[95]
25. Cypress Island Weekly Production Report May 21 – May 27[, 2017]: "Stingray continues to wash on site 2, ***waiting for MPI to return and arrival of AKVA washer***."[96]
26. Cypress Island May 2017 results: "***MPI was down this month. Idema twin washer to arrive this week. The Stingray is running through all sites to try and keep up.*** Caprella [shrimp] on nets has decreased, ***net washers arriving will help get nets back on track***."[97]
27. Cypress Island Weekly Production Report May 28 – June 3[, 2017]: "Stingray operating daily, ***MPI down***."[98]
28. Cypress Island Weekly Production Report June 4 – June 10[, 2017]: "Stingray operating daily until new washer arrives/MPI re[TEXT CUT OFF]; Washing on Site 2 complete. Back to Site 3 next week."[99]
29. Cypress Island Weekly Production Report June 11 to June 17[, 2017]: "***Stingray down today, should have repaired tomorrow/Wednesday. Idema ran great last week and through the weekend, would not start today – investigating issue. MPI expected back on site this week.***"[100]
30. Cypress Island Weekly Production Report June 18 to June 24[, 2017]: "All net washers up and running; ***attempting to catch up on net hygiene***."[101]
31. Cypress Island Weekly Production Report June 25 to July 1[, 2017]: "***Stingray is down***, MPI and Idema running well. ***Continuing to catch up on net hygiene***."[102]
32. Cypress Island June 2017 results: "MPI, Stingray and Idema all running. ***Almost caught up on net hygiene***, will be starting on floors with the Idema and MPI in July."[103]
33. Cypress Island Weekly Production Report July 16 – July 22[, 2017]: "Began washing walls and floors on site 2. Net Hygeine [sic] on site 1 and 3 good. Stingray is chewing through mussel sets on site 3 net walls."[104]

In interviews, Cooke staff stated that the biofouling on stock nets in net pen #2 was worse than usual when they began cleaning after the July incident. One staff used a ten-point scale with "1" being "No fouling," "5" being "40% of net space is blocked by fouling," and "10" being "90-100% of net space is blocked by fouling." This scale and associated percentages was posted at the Hope Island farm as observed by state staff on November 27, 2017 but a different chart, without percentages, was at the Cypress crew quarters (Figure 13).[105] According to one worker, typical fouling on nets at this time of year would have been about a "4" ("30% of net space is

blocked by fouling"), but as of mid-August 2017 fouling was at a "7" (60% of net space is blocked by fouling").[106] The Cypress farm manager said that a "2" or "3" is ideal but was probably around an "8" after July. He also noted mussel build up on the bottom of the nets.[107]

Figure 13. Photograph of photos showing relative biofouling. Displayed on office wall at Hope Island salmon farm office on November 27, 2017.

Interviews with Cooke staff confirmed what the weekly and monthly reports summarized, namely that the broken net washers affected the cleaning schedule.[108] [109] The Cypress farm manager summarized that prior to July, there was only one functioning unit for all three net pens, with the other two machines not functioning for about a month.[110] The Cooke maintenance supervisor, who maintains the cleaning machines, noted that obtaining replacement parts in a timely manner was a challenge.[111] The manufacturer of the MPI reportedly could not be reached for a month. The maintenance supervisor said the lack of functioning machines at Cypress led him in June to bring in an MPI washing machine from Clam Bay (Rich Passage farm).[112]

The maintenance supervisor attributed the cleaning machine breakdowns, at least in part, to inadequate care by workers. The machines should be flushed once a week to make sure salt does not build up in them, for example. He said the machines were "not easy to maintain."[113] The cleaning machines reportedly have hour clocks that are used to schedule routine maintenance.

No documentation was provided by Cooke regarding the effectiveness of cleaning through net washing. As discussed above, net washing occurred but, given the condition of the nets when removed from the water, the nets were heavily fouled. No quantitative or qualitative assessment of net cleanliness – as opposed to net cleaning efforts – was provided or is found in Cooke documents on the effectiveness of net washing efforts.

At the time the stock nets were removed from net pen #2 in late August/early September following the collapse, the weight of the biofouling was 110 tons for the 10 nets, averaging 11 tons per net (see Appendix 3: Weight of Stock Nets Landed in Anacortes Following Salvage in September 2017).[7] A clean net weighs 3,620 pounds.[114] The weight of the biofouling was over 600% of the weight of a clean net.

No information is available for weight of nets removed from net pen #2 at other times. However, an Excel spreadsheet provided by Cooke to DNR in November 2017 titled "2016 Debris Log for Washed Nets," reportedly for Hope Island, shows the weight of debris removed from each net was less than 300% of the weight of a clean net. The Hope Island nets were either the same size as those used at Cypress net pen #2 or somewhat smaller (several were not as deep).

During the salvage and then when the stock containment nets were landed in Anacortes, state staff photographed and filmed biofouling on the stock nets. Photos/video of the nets being removed from the failed pen were made on August 28, August 29, and August 31. Photos/video of all ten stock containment nets being landed at the Curtis Wharf in Anacortes were made on September 1, September 8, and September 19 (Figure 14). As the nets were unloaded into disposal containers, the weight was recorded by staff of the marine construction contractor that operated the crane.

During the September 8 landing of stock nets, a Cooke representative and state staff took "split samples" of stock net mesh with mussel growth. A swath of net was cut into four equal sections approximately 18" square. Cooke, ECY, DFW, and DNR each received a section (Figure 7 and Figure 15).

[7] By letter dated January 29, 2018, Cooke asserted that the amount of biofouling on the nets increased from August 19, 2017 until the nets were removed from the water. The Panel acknowledges this is likely but does not believe this warrants changing its conclusions. Cooke provided no documentation or calculations of what this would have added to the mature plants and animals observed on the nets during salvage.

Figure 14. Stock net retrieved following August failure, photographed on September 1 in Anacortes. Note heavy fouling by mussels.

Figure 15 Salvaged stock nets on barge in Anacortes on September 8. Cooke staff (on left) and DNR staff are identifying a swath of net from which to take a sample. Note pile of loose mussels on deck of barge in foreground.

All stock nets removed from net pen #2 showed biofouling. During the removal, state staff observed the outside of the stock nets because of how they were lifted out of the water (Figure 16) and then loaded into the disposal containers (Figure 17). Because each stock net typically was lifted as a whole mass, it was not possible to see an entire side panel or bottom panel of a given stock net. However, given the observation and documentation of all stock nets, it is possible to generalize that the stock nets had substantial accumulations of biofouling organisms. Patterns ranged from spotty to heavy coverage. Mussel growth was particularly obvious. During the lifts of the nets, the videos document a “rain” of mussels falling from the nets. Loose mussels were swept in piles about three feet high on the deck of the crane barge. Cooke did not provide any information that would allow the Panel to compare these qualitative assessments to biofouling on other nets at other times.

Figure 16. Stock net 212 minutes after being lifted from collapsed net pen on August 31. Biofouling by animals (mussels) and plants (algae) is visible. Image is believed to show outside of stock net.

Figure 17. First stock landed in Anacortes, being loaded in disposal container on September 1. Note two railings from net pen platforms entangled at top of net. Aviary (bird exclusion) netting hangs from railing on right; it has no biofouling.

Within a week of the July incident, Cooke staff attributed it to biofouling. The Cypress Island farm manager stated in an internal Cooke email dated July 31, 2017: “On Monday 7/24 at

approx. 7 p.m. the overnight staff alerted me of moorage failure on site 2. Once we arrived on site and inspect it was found that 10 anchors had broken and numerous anchors had drug and the site shifted considerably. *This was the result of* ***fouled nets*** [emphasis added] and weak mooring points."

Upon further consideration, Cooke staff affirmed their initial assessment of the causes of the July incident. At an August 9 meeting involving the Puget Sound General Manager and the managers of each of the four farms, there was detailed (by the standards of the monthly notes) discussion on biofouling and its contribution to the July incident:

> *Clean nets = less drag and stress on systems. . . .*
>
> ***Net cleanliness-***
>
> *Problem- Failure and unreliability of net washing systems was a factor in both instances of Clam Bay and Site 2 breaking moorings.[*] Both farms fell behind in keeping up with net hygiene. Increased drag during extreme tides snapped moorings.*
>
> *Keeping nets clean especially during spring summer rapid fouling growth periods and hard tidal exchanges is critical.*
>
> *—Are the net washers functioning at all times? No.*
>
> *—What can we do to correct that problem?*
>
> ***Solutions:***
>
> - *Have common breakdown replacement parts available on site. Keep extra 2 to 3 of each part available at each of the sites in inventory.*
>
> ***Other Solutions:***
>
> - *Spare nets for Grow Out rotation and Local land based net washing facility.*
>
> *Short-term – Have available in the site inventory from 2 to 6 nets for emergency net swaps and rotation. Is it economical to do net swaps for the last 6 months of growth into larger mesh nets.*
>
> *Long-term – Look into the feasibility of starting a local net washing facility that can handle our nets . . .*[115]

[*] After seeing the company meeting notes for August 9, 2017, which were sent by Cooke on December 22, 2017, the Panel requested information from Cooke regarding what happened at Clam Bay. By letter on January 19, 2018, Cooke stated that there was a failure of a mooring line between the feed barge and the net pen on May 26, 2017. Cooke stated in its letter that "Net hygiene is not believed to have played a role in the failure of the feed barge attachment points on May 26." Cooke did not explain in its letter why the company thought on August 9 that falling "behind in keeping up with net hygiene" was a factor behind the Clam Bay incident but now does not.

Actions by Cooke since the August failure are consistent with discussion above. State staff observed a new Trimara AutoBoss net cleaning machine at the Fort Ward dock on December 11. Cooke staff expect it to be faster and more reliable than existing machines. At the end of December 2017, Cooke established a stock of spare parts for the existing net washers, as proposed at the August 9 meeting.[116]

Analysis/discussion

The Panel twice asked Cooke for a causal analysis regarding the cause(s) of the July incident and August failure.[117] [118] Cooke did not directly provide its conclusion regarding the cause(s) and contributing factor(s) beyond what is stated in the documents referenced above.

Given the fouling observed on the nets during their recovery at the end of August/early September, the cleaning that was done was relatively ineffective. The main contributor to the excess net biofouling was, per Cooke's own internal documents and interviews with staff, breakdowns of the mechanical cleaning devices. These breakdowns allowed biofouling, most obviously mussels, to become well-established and widespread. When the machines were repaired and/or replaced and cleaning resumed, the mussels were too established to be removed despite continued washing efforts.

The biofouling created considerable amounts of drag in tidal currents and, by blocking the mesh of the stock net, further increased drag. It is unlikely that the weight (vertical pull) of the biofouling contributed significantly to the July incident and August failure; rather, it was the great amount of lateral drag in the tidal currents that was instrumental in the collapse.

Biofouling on the predator exclusion net was relatively less critical because the mesh size is so much larger that complete blocking of the openings is unlikely. Moreover, observations of the predator net during salvage suggested that cleaning had been relatively effective in managing mussel growth.

Biofouling also was examined in Appendix 1: Cypress Island Net Pen Failure Engineering Review. That review concluded that "due to large currents, the forces and corresponding movements of nets may have been very high due to higher than normal amounts of fouling."[119]

Based on the facts above, the Panel concludes:

- Excess biofouling (reported by Cooke staff as a "7" or "8" on a 10-point scale) of the stock containment nets created more drag than usual;
- The higher-than-normal drag exceeded the capacity of the mooring system on July 24 and July 25;
- The excess biofouling was a result of insufficient net cleaning;
- Insufficient net cleaning was a result of breakdowns in the cleaning machines;
- Net cleaning between late July and August 19 was relatively ineffective in reducing biofouling as evidenced by the 110 tons of biofouling on the ten stock nets at the time of their removal from the failed structure; and
- The higher-than-normal drag again, as in July, exceeded the capacity of the mooring system on August 19.

Therefore, the probable cause of the July incident and the August failure was Cooke's inadequate cleaning of the nets, which led to excessive biofouling and increased loading of the net pen #2 structure.

Badly fouled nets can be removed before harvest is completed. This idea was discussed in Cooke's August 9 meeting as a possible approach to the removal of biofouling: "Short-term – Have available in the site inventory from two to six nets for emergency net swaps and rotation." Cooke provided no information suggesting this idea was developed further between August 9 and August 19.

After the July 2017 incident (see next chapter), Cooke was aware that biofouling at net pen #2 was so extensive as to have caused the pen to go adrift and almost collapse. Yet the portion of the response focused on biofouling was simply more (ineffective) net washing. By failing to adequately address biofouling after the July incident, Cooke missed an opportunity to reduce the risk of recurrence of net pen movement and structural and mooring point overload. The most effective way to quickly and markedly reduce drag caused by biofouling would have been swapping fouled nets for clean nets. While Cooke discussed this possibility, they did not choose to exercise the option.

Events of July 2017

Facts

On Monday, July 24, 2017, net pen #2 crewmembers returned to shore after the workday, with one crewmember remaining on net pen #1 overnight. At approximately 7 p.m., the crewmember called the Cypress Island Site Manager and net pen #1 Raft Supervisor and reported that it looked like an anchor or anchors had broken, and there was significant movement of net pen #2 toward net pen #1. [120, 121]

The Site Manager called the General Manager, a Cooke vessel operator, the Cypress Island Assistant Manager, and the net pen #1 Raft Supervisor, and then went to the site, arriving within an hour of the initial call. The vessel operator went to the site approximately 30 minutes after receiving the Site Manager's call.[122]

The General Manager texted the Hope Island Manager and Assistant Manager to report an anchor line may have broken at net pen #2 and asked them to take a look. The Hope Island Manager went to the Hope Island net pen facility and took a picture of the contacts list, which included tug operators, and sent it to the Cypress Island Manager before proceeding to net pen #2 by boat.[123]

Numerous mooring system failures were observed to have occurred on the north side of net pen #2. Pad eyes broke and anchors dragged. The flood tide current pushed net pen #2 south, causing the structure to drift and come to rest on the south/southeast anchors. The vessel operator was ordered to push on the net pen from the south.

Through counsel, Cooke reported that inspection of the site on the evening of July 24, revealed that ten mooring points (pad eyes) had broken, and numerous other anchors had dragged, shifting the position of the site considerably.[124] Mooring points 1, 2, 3, 4, and 17 through 22 all failed at the pad eye.[125] This information was clarified in a telephone call of January 4, 2018 with Cooke's General Manager (Figure 18).

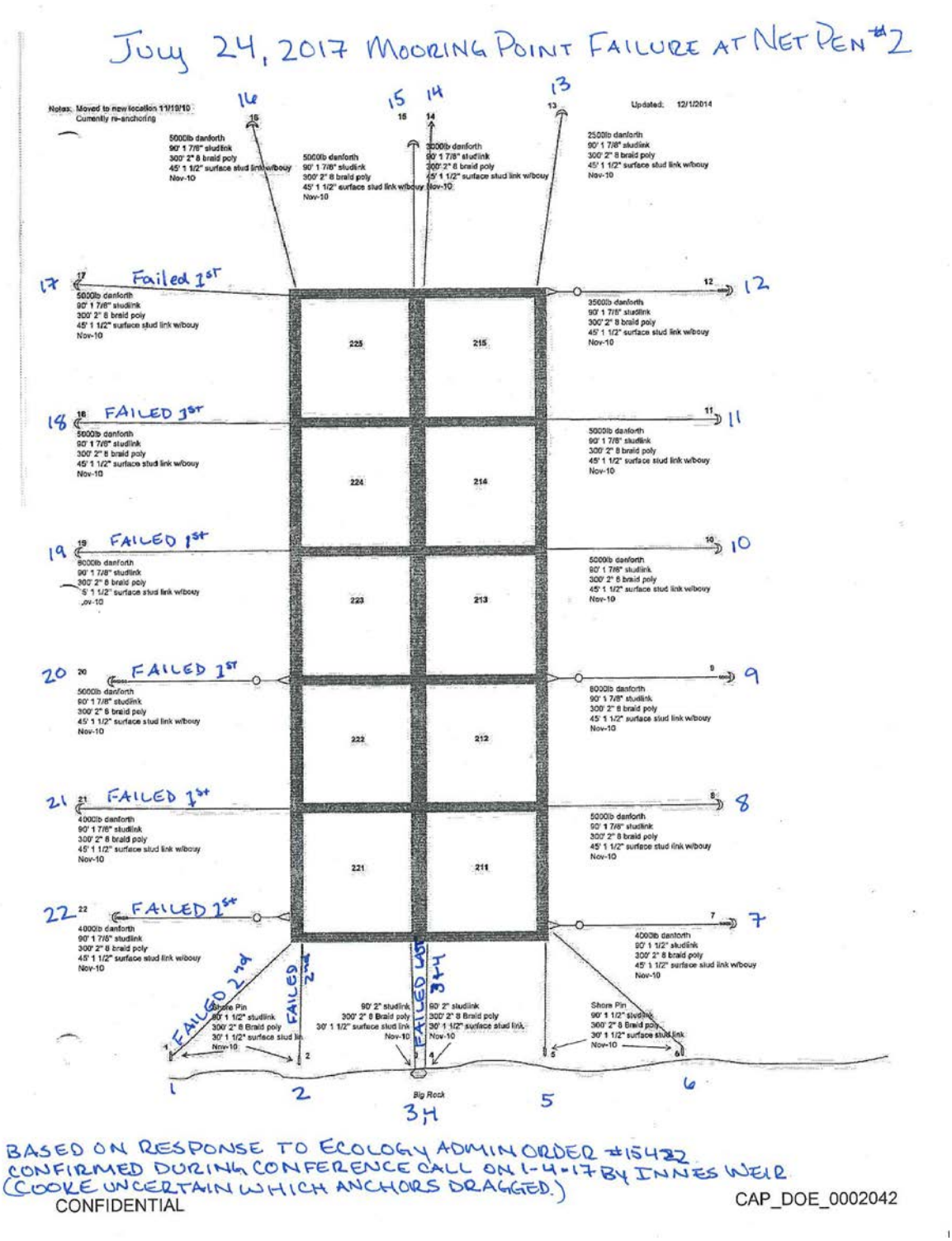

Figure 18. Configuration of net pen #2 on July 24, 2017 annotated with the moorings that failed.

The Site Manager contacted tug agencies and contract vessels. The tugboat MILLENNIUM STAR was dispatched to net pen #2 at 9:30 p.m., departing Dakota Creek Shipyard in Anacortes for Deepwater Bay at 10 p.m. and arriving on the site at 10:30 p.m. The Captain observed that

net pen #2 was low in the water, and small horsepower tugs (500-700hp) were already on site. Two Cooke staff approached the MILLENNIUM STAR in a skiff and asked if the tug could push on the pens. The MILLENNIUM STAR Captain was skeptical about pushing due to the low freeboard of the pens and the power of the tug, which he felt would damage the pen structure.[126] The Captain sent the Junior Captain in the Cooke skiff to net pen #2 to assess the situation. The Junior Captain radioed from the site and suggested that a bridle could be rigged to the pen structure and attached to the MILLENNIUM STAR bow line, enabling the tug to pull on the pens. Cooke staff ran double poly line through shackles and hooked it up to the MILLENNIUM STAR—this process took until 3:30 a.m.[127]

Cooke staff worked through the night of July 24, replacing broken pad eyes, and divers recovered anchor lines to be attached to new or undamaged pad eyes. Existing anchors that had dragged were retrieved when possible, and new anchors from Cooke's pier facility were set. Cooke also began removing machinery and feed from net pen #2 to net pen #1.

Cooke divers inspected the site during the morning of July 25, and confirmed no containment had been breached and stock had not been lost.[128] The General Manager arrived early on the morning of July 25 and observed that the staff had reattached the moorings, there was no apparent structural damage or containment issues at that time, and the MILLENNIUM STAR was onsite.[129]

At 5:45 p.m., the flood tide current increased, the replaced pad eyes failed, and the net pen structure began folding and buckling. The center of the structure was pushing south, with the MILLENNIUM STAR pulling from the north attempting to hold it, and other vessels pushing from the south. Cooke staff were removing equipment when the structure began buckling severely and the staff evacuated.[130] The Captain of the MILLENNIUM STAR rang the general alarm, concerned that Cooke staff might need to be rescued from the water.[131]

The General Manager made calls to the company owner, and staff were called in from Canada and Maine to help and advise. The General Manager also reported in an email at 11:00 p.m. on July 25 that net pen #2 was "approximately 200 feet from site 1."[132]

On July 25 at 11:30 p.m. the MILLENNIUM STAR got a poly line caught in its starboard propeller while moving from one end of the net pens to the other. Cooke divers freed the line at 8:10 a.m. on July 26, and divers began coiling anchor lines to get them out of the way of the tugs. At 9 a.m. the MILLENNIUM STAR got a line in its port propeller; divers cleared it within 15 minutes. While the MILLENNIUM STAR had lines in its propellers, a Foss tug was on site to assist. At noon on July 26, the MILLENNIUM STAR began towing again and the Foss tug was released.[133]

When the tidal current slowed, the structure was moved back into position. Two tugs were needed overnight to hold net pen #2 in position. On Wednesday, July 26, Cooke divers inspected the stock nets and found no breaches, holes, or escapements. Staff worked to replace anchors and damaged pad eyes.

At one point on July 26, Cooke started to turn the net pen so that the short end would face the current rather than the broadside, but abandoned this plan as it would require cutting more anchor lines.[134] Cooke staff again worked overnight to reconnect pad eyes and reset anchors.

Cooke's Permit Coordinator called the DNR, DFW, and ECY on July 26 and reported that a large flood tide surge had caused some anchors to drag at net pen #2. Cooke reported no fish escapes or spills had occurred, fuel had been removed, and resources were on site to assist. The Permit Coordinator emailed the DNR on July 27, and reported that "strong flood tides caused some movement of the Site 2 anchors and the fish pen structures." The email stated the site was "back into the correct orientation now and we will keep extra boats on site to assist in connecting anchors and properly tensioning the mooring lines."[135]

Thursday, July 27, pad eyes were replaced and more anchors were set. All available net washing equipment was brought to the site to wash nets. The Cypress Island Site Manager stated in an interview that they were washing nets, doing "anything to reduce drag."[136]

Friday, July 28, Cooke reported 80 percent of the nets were cleaned. The site was in a slightly different location than its original position. Cooke began reinforcing the structure with additional pad eyes, chains, and shackles. Additional pad eyes were put alongside existing pad eyes. Chains were put across outrigger sections and along the main central walkway and attached to shackles, with the intention of redistributing the load and reducing strain on the net pen components. This work continued into the following week.

When Cooke deemed the net pen secure, the Site Manager was instructed to resume normal operations. Equipment was returned to the site and feeding was resumed.[137] The MILLENNIUM STAR was released at 8 a.m. on July 28.[138]

The Site Manager summarized the July incident in an email on July 31 to multiple Cooke staff, stating in part that, "…it was found that 10 anchors had broken and numerous anchors had drug and the site shifted considerably. This was the result of fouled nets and weak mooring points."[139]

Analysis/discussion

The Panel twice asked Cooke for a causal analysis regarding the cause(s) of the July incident and August failure.[140, 141] Cooke did not directly provide its conclusion regarding the cause(s) and contributing factor(s) beyond what is stated in the documents referenced above.

Staff accounts of net cleaning issues before and immediately after the July incident make clear that Cooke blamed net hygiene for the incident in combination with "weak mooring points." The incident at net pen #2 in July appears to have been catalyzed by a flood current occurring at a time when inadequate net cleaning resulted in excessive biofouling on the nets.[142] This excessive biofouling created increased drag on the structure. The combination of tidal currents and excess drag on the nets, caused pad eyes to fail on the north side of net pen #2, pushing the structure south toward net pen #1.

The Panel concludes that Cooke's reporting of the July incident did not accurately convey the magnitude of the incident. Accounts from staff, eyewitnesses, and Cooke's internal emails differ substantially from the report of the event to the state as discussed in the next chapter.

The state was not notified that reinforcing chains and welded steel sections were being added to the structure following the July incident, so the state agencies had no opportunity at that time to inquire whether these modifications were being done in consultation with an engineer.

Response by State Agencies to July 2017 Incident

Facts

Cooke initially notified the state agencies by telephone of the July 24 incident and response on the morning of July 26.

The Cooke Permit Coordinator told the DNR Land Manager that net pen #2 experienced several mooring failures the previous day (July 25; in actuality, the incident began July 24). Cooke said they were able to get several tugboats on site to secure the net pen to keep it from moving. Fish escapement did not occur and all of the portable equipment (generator and air compressor) and fuel were removed from net pen #2. Cooke intend to re-secure the net pen at the next available slack tide.

The Cooke Permit Coordinator left a voicemail for DFW that stated that net pen #2 "broke some mooring points." Cooke was securing the net and getting it re-anchored. Cooke had two tugs "basically holding it in position." Outside resources were being called in. There were no fish escapes and no spill of fuel. Cooke intended to "drop some more anchors." He summarized, "so far so good." The following week, DFW staff followed up with the Cooke Permit Coordinator. Based on the information provided, DFW staff concluded that the pen was secure and no fish escaped.[143]

The Cooke Permit Coordinator notified ECY the same day, saying net pen #2 had experienced mooring point failures. Cooke was working to get the pen re-anchored. There were no fish escapes and no spill of fuel. The Permit Coordinator followed up with ECY the following day, July 27, saying the net pen was secure and back in position, with anchors being tensioned.

In the evening of July 27, Cooke sent an email -- the only information in writing regarding the issue -- to DNR:

> *Update on the repairs to the Cypress Site 2 mooring system as of 5:00 PM Thursday[, July 27]*.
>
> *We were challenged by the strong tides over the past few days and our crew has been working very hard to secure the farm and the fish.* ***The strong flood tides caused some movement of the Site 2 anchors and the fish pen structures*** [emphasis added]. *The site is back into the correct orientation now and we will keep extra boats on site to assist in connecting anchors and properly tensioning the mooring lines. Divers have been in the water and checked containment nets and there was no damage to the nets or loss of fish.*
>
> *As we discussed on the phone, Site 2 currently sits "broadside" to the strongest ebb and flood currents in Deepwater Bay. We have applied for the permits to both replace the old cages with brand new ones of similar design, and to re-orientate them such that the narrowest ends of the farm will be facing the strongest currents. These changes will both greatly improve the floating steel structure and considerably reduce the drag loads exerted on the equipment, nets and moorings.*

The DNR response to this information is summarized in an internal DNR email sent the following day:

> *We've looked to confirm that the tenant is complying with the contract [lease] with regard to this incident. Section 12(a) applies in this instance, requiring prompt notification to the state of damage or destruction to the Improvements and prompt reconstruction/repair.* ***Based on what has been reported*** [emphasis added]*, we believe tenant is in compliance with that provision. Section 11.2 requires tenant to keep Improvements in good order and repair and in a safe condition. A moving net pen is not safe and could reflect insufficient attention to inspection and maintenance (although it could also reflect other decisions that don't fall under 11.2). The problem was detected quickly, however, and the tenant apparently managed the situation to avoid substantial damage or fish release. Also, the tenant also told [Land Manager] Sean [Carlson] that fuel for the generator and, I believe, the generator itself were removed from #2 during the incident to reduce the risk of spill/loss. We did compliance on #2 just last September and the surface part of the operation appeared to be in good order and repair; we have no basis for speculating one way or the other on condition of Improvements below the surface where the anchor drag/failure occurred. If #2 is reconfigured/replaced, all the tackle and at least some anchors would be replaced/redeployed. Tenant has also reported that they are keeping our sister agencies WDFW and DOE informed as required.*

Based on the information provided by Cooke, the state agencies did not investigate further.

Analysis/discussion

The state response was hampered by the lack of complete, accurate, and timely information received from Cooke. The state agencies were not notified until July 26, two days after the incident began.

The characterization of the incident by Cooke staff who reported to the state agencies downplayed the seriousness of the incident and did not contain important information. Instances include:

> Cooke's characterization of incident to state: "The strong flood tides caused *some movement* [emphasis added] of the Site 2 anchors and the fish pen structures."
>
> What Cooke knew or said internally:
>
> - "We nearly lost the farm."[144]
> - "10 anchors had broken and numerous anchors had drug and the site shifted considerably."[145] At one point, net pen #2 had drifted to within 200 feet of net pen #1 when before the incident it was 800 feet away.[146]
> - The initial effort to re-secure the pen failed when replaced pad eyes again broke, indicating tremendous forces were being imparted to the net pen.

How Cooke summarized its incident response to state in writing: “We were challenged by the strong tides over the past few days and our crew has been working very hard to secure the farm and the fish.”

Cooke’s actual response, showing the considerable effort expended to respond:

- Ten anchor attachment points (pad eyes) failed completely on July 24
- The steel walkways on the north side of the net pen were bent downward by the strong forces imparted by the incident
- Multiple tugs were called initially and at one point, two tugs were on site (mentioned in voicemail to DFW only)
- The initial effort to secure the pen failed on July 25 when replacement pad eyes failed
- Five staff were sent from Canada and Maine to help (voicemail to DFW only referred to “outside help”)
- Rotating the net pen so it would no longer be perpendicular to the flood tidal current was considered
- Some anchors were replaced with heavier versions
- All or nearly all mooring lines were replaced
- $282,290 was spent on the contract for the tug MILLENIUM STAR

Cooke’s statement to state of planned follow up after July 27: “The site is back into the correct orientation now and we will keep extra boats on site to assist in connecting anchors and properly tensioning the mooring lines.”

Cooke’s actual follow up after July 27:

- “Catching up” on net washing by bringing in net cleaning machines from other farms (see chapter on “Biofouling”)
- Affixing steel beams and plates to bent steel walkways
- Installing chain “exoskeleton”
- Considering the incident – along with an apparently similar incident at Clam Bay – as a sign they needed to improve net hygiene at all Puget Sound farms

What Cooke told the state (DNR) was the cause: “strong flood tides.”

What Cooke stated internally was the cause: “fouled nets and weak mooring points.”[147]

Events of August 2017

Facts

Subsequent to the near-loss of net pen #2 in July 2017[148], local Cooke management continued to discuss its status in meeting notes such as:

> *Site 2 is holding up well with continued efforts to reinforce weak and compromised welds.*[149]
>
> and,
>
> *Reinforce walkways on Site 2 should be done on Wednesday.*[150]

New mooring diagrams were also prepared to reflect the updated configuration of anchor points, reinforcing chain, and anchor gear (Figure 19).[151]

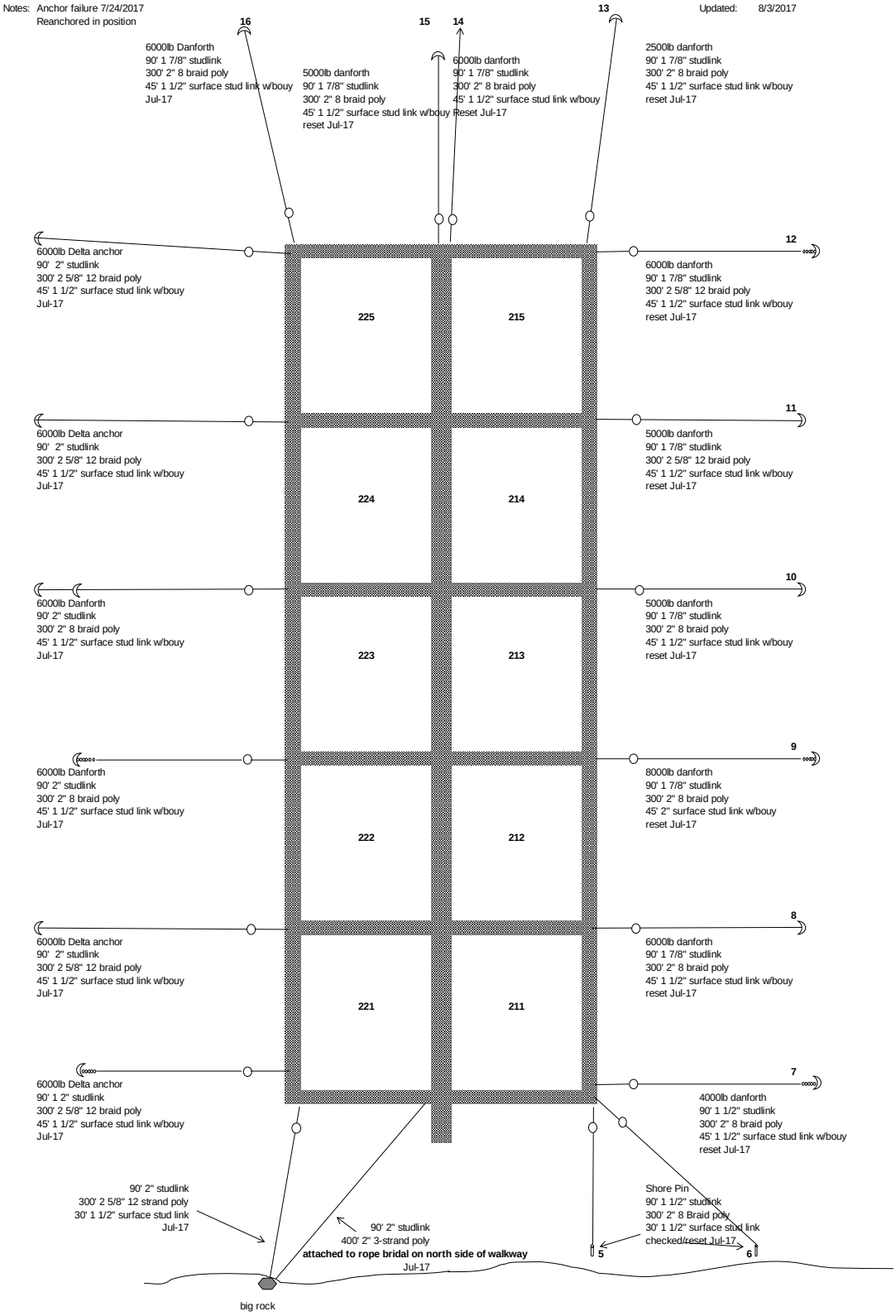

Figure 19. Revised mooring arrangement for net pen #2 following the July 2017 incident.

But a broader discussion of farm site management, led by Cooke's General Manager, was also occurring, as reflected in the following notes from a Cooke meeting of August 9:

> ***Net cleanliness-***
>
> *Problem- Failure and unreliability of net washing systems was a factor in both instances of Clam Bay and Site 2 breaking moorings. Both farms fell behind in keeping up with net hygiene. Increased drag during extreme tides snapped moorings.*
>
> *Keeping nets clean especially during spring summer rapid fouling growth periods and hard tidal exchanges is critical.*
>
> *—Are the net washers functioning at all times? No.*
>
> *—What can we do to correct that problem?*
>
> ***Solutions:***
>
> - *Have common breakdown replacement parts available on site. Keep extra 2 to 3 of each part available at each of the sites in inventory.* [152]

However, this farm site management introspection and corrective action was interrupted by the events of Saturday, August 19, 2017, at the Cypress Island net pen #2 site.

No Daily Site Logs for net pen #2 for August 2017 were available from Cooke, reportedly having been lost during the collapse[153], so contemporaneous notes of what occurred at site #2 in the days since the July 2017 near-loss were not available. However, a description of events, as well as photos and videography, of the August 19, 2017 failure at site #2 was provided by a boater who happened to be in Deepwater Bay. She described what she saw:

> *…my family and I were setting crab pots near the middle and south fish pens on August 19 when we heard odd noises coming from the middle pen. The first distinctive thing we could see was a chain attached to one of the southeast corner buoys dragging on the fish pen deck, followed by the buoy jumping over the deck. That was about 3:30 pm. At first we thought workers were moving things around. After a bit, when the underside of the southeast corner of the pen was showing, it became clear something was seriously wrong. Because we couldn't see any workers around, we called 911 (about 3:45 pm). That was about the same time we started taking pictures. Thereafter, things just kept changing; albeit slow and unpredictably enough that we couldn't catch anything on video. After making our call to 911, we spotted one worker on the south pen and made contact with him. He said he had called his boss and three guys in a boat arrived on scene about 20 minutes thereafter. They docked their boat on the west side of the pen and walked around on the pen. The workers were able to remove two portions of the pen which looked to be stand-alone docks (for lack of a better description). One of the docks was located on the west side of the pen and looked to contain a generator and fuel tank. The other dock was on the northeast side of the pen and contained, among other things, a storage building (the removal is captured in one of the photos…You can see the boat to*

the left of the storage building in the photo. For reference, the dock's original location was on the northeast side of the pen. The photo was taken as the boat and dock neared the northwest side of the pen. They towed the dock to the east side of the south pen). A tug with a boom arrived on scene about 5:00 pm and made contact with the south side of the pen. We thought they might try to recover the forklift on the deck but they did not while we were there. A tug boat also arrived a bit later. We were by the pens until 7:00 pm or so. By that point, it looked to us that nothing could be done to save the pen. [154]

As part of their Agreed Order with ECY, Cooke, through counsel, provided the following account of the August 19 events:

…at approximately 3:40 in the afternoon, Cypress Island staff reported that a mooring failure had occurred at the site. Again, we have some reason to believe this failure may have coincided with the afternoon flood tide. The failure resulted in major damage to the east end of the site (adjacent to pens 215 and 225). Two anchors on the northern outside end of the net pen complex failed, three other anchors were dragged, and one anchor on the shore side of the net pen complex (adjacent to Pen 211) had a broken pad eye, broken safety chain, and broken cleat. Two above-surface holes in pens 215 and 225 were visible, but there were no signs of fish escape at this time. Staff worked to secure fuel cells, generators, and other equipment and chain broken walkways and secure the site. A Foss tug was called, bridle equipment was installed, and overnight staff monitored the situation after sunset. [155]

Multiple Cooke employees were interviewed regarding the August 19 events at site #2. Notes of the interviews reflect the following:

- From net pen #1, the walkways were seen buckling and the structure bending and twisting. Sea state was flat (no waves) with a strong current running. The Cypress Island Farm Manager was notified.[156]
- Conditions were worse than the July incident. Tides were moving the structure around. Some net pen cages initially still had structure, but eventually those started to collapse and warp too. When the tide (current) eased Cooke employees focused on removing fuel and equipment to net pen site #1.[157]
- Net pen #2 was starting to drift towards net pen #1 (south). The chains run in July (across net pen #2) popped. When tugs arrived they were pushing and pulling to counter the folding structure.[158]
- The incident happened on the flood tide. Lines broke on the northeast side of net pen #2 (side towards net pen #3). Net pen #2 had moved close to net pen #1 (to the south). The General Manager and Director of Saltwater Operations were directing the operations.[159]
- Net pen #2 was bent, nets were going underwater and fish were escaping (on Saturday). The west side walkway had broken free and was just held by the nets and lines. A workboat was used to remove heavy equipment. The chain, run from each anchor point across the walkway in July, held in August but “sawed” back and forth contributing to the damage.[160]

- Net pen #2 began to collapse near where it was originally anchored, but got very close to (a stone's throw away from) net pen #1.[161]
- East end anchor points on net pen #2 came apart. The chains detached from the structure and the whole structure was sliding under the chains. Harvest was attempted on Sunday, but the structure was too unstable.[162]
- There was extensive damage to net pen #2 which was moving towards net pen #1 (south/southeast). The situation was very dynamic, so no staff were put aboard out of safety concern. The tide was flooding and the north and shore side (west) anchors failed (broken or dragged). The east end walkways were buckling. The main bridge (center spine of net pen #2) had disconnected from the east walkway and the pens 215 and 225 (on southeast side of net pen #2) were disconnected and failing. After the tide (current) slowed the structure settled into a location over the south anchors. Tugs and other vessels were summoned to assist. The General Manager arrived Saturday evening and was in charge from that point on. Things got worse over the next couple of days.[163]
- The General Manager reported on Sunday morning that the tops of the nets were in the water, and that while he did not see fish escaping, he thought it was possible that some had escaped. By later, walkways were going under and fish were escaping from at least two pens. Vessels were contacted to assist in harvesting the remaining fish.[164]
- The General Manager was notified at 3:30 p.m. of the mooring failure at net pen #2. He was on site at 5 p.m. The site was buckling and there was stress on the hinges. Two moorings were broken, one shoreward, and safety chains were also broken. At tug was called to the site. Two cages were in bad shape and they tried to remove fish from them. At the tide change net pen #2 was too dangerous to board. By Tuesday morning Cooke suspended diving operations and the focus became fish removal and site stabilization.[165]

Review of AIS data for August 19, 2017 indicates that the Foss tug LINDSEY FOSS arrived at the site of net pen #2 at about 9:20 p.m. to help stabilize the structure.[166] Any Cooke vessels on scene to assist were not specifically identified and did not have an AIS signal.

Cooke described events on subsequent days as the condition of net pen #2 continued to deteriorate:

- *Monday, August 21, 2017: Strong tides and surge continued to inhibit Cooke's efforts to secure the site. Nonetheless, Cooke personnel were able remove from the site a small number of fish. It was observed that walkways providing access to cages 214 and 224 were continually twisting and this twisting compromised the integrity of net-pens 214 and 224. Ecology, DNR, and WDFW were called again to report an estimate of fish loss based on the conditions at that time.*
- *Tuesday, August 22, 2017: Attempts to remove fish from the facility were again hampered by strong tidal currents and unsafe conditions, and diving operations were suspended due to unsafe conditions. Assessments of cages were not safe to perform at this point.*

- *Wednesday, August 23, 2017: The site was now a total loss. Attempts to remove fish from the collapsed net pens were again unsuccessful. Efforts remained focused on securing the site.*
- *Thursday, August 24, 2017: Site stabilization efforts continued.*
- *Friday, August 25, 2017: Site stabilization efforts continued. Chains were secured around the main walkway between cages 211 and 221 to create an attachment point for anchors. A safety chain was secured running the length of the main walkway. Crews used seven shots of two-inch chain and doubled two 5/8 lengths of braided rope, to make an anchor line to the large rock ashore. Additionally, at the main walkway adjacent to cages 223 and 223* [sic]*, a similar system of two shots of chain to 600' of double 5/8-inch rope was secured to the Foss tug.*
- *Saturday, August 26, 2017. The site was stabilized on Saturday and remained stable until removed from the water in September. Once the structure was stabilized efforts turned to removal of fish mortalities from the net pens, and deconstruction efforts. Both of these classes of activities are detailed in the daily reports provided to Ecology, DNR, and WDFW, which are incorporated by reference in this Response.* [167]

Based on the information they reviewed, Mott MacDonald's (Mott) engineers, working under contract for DFW, concluded the following regarding the circumstances of August 19, 2017 collapse of net pen #2:

- *Similar to what was reported in the July incident, anchors dragged on the north side of the net pen facility.*
- *Based on eyewitness accounts and interview notes, the mooring brackets and the connections between the floats (intermediate and outrigger floats) on the outer edges of pens 215 and 225 failed first, leading to a progressive collapse of the facility.*
- *Although the first point of failure cannot be definitively identified, some combination of anchors dragging, mooring brackets failing, and structural float framing members failing contributed to the collapse of the net pen #2 structure.* [168]

Information provided by Cooke[169], clarified in a conference call with Cooke's General Manager, provided a clearer picture of the mooring and structural failures that occurred on August 19 (Figure 20). However, while Cooke's General Manager stated that only the central walkway separated from the east end, another Cooke employee at the scene during the early stages reported that the east end separated at the northeast corner of pen 225 as well (Appendix 1: Cypress Island Net Pen Failure Engineering Review - Section 7.4).

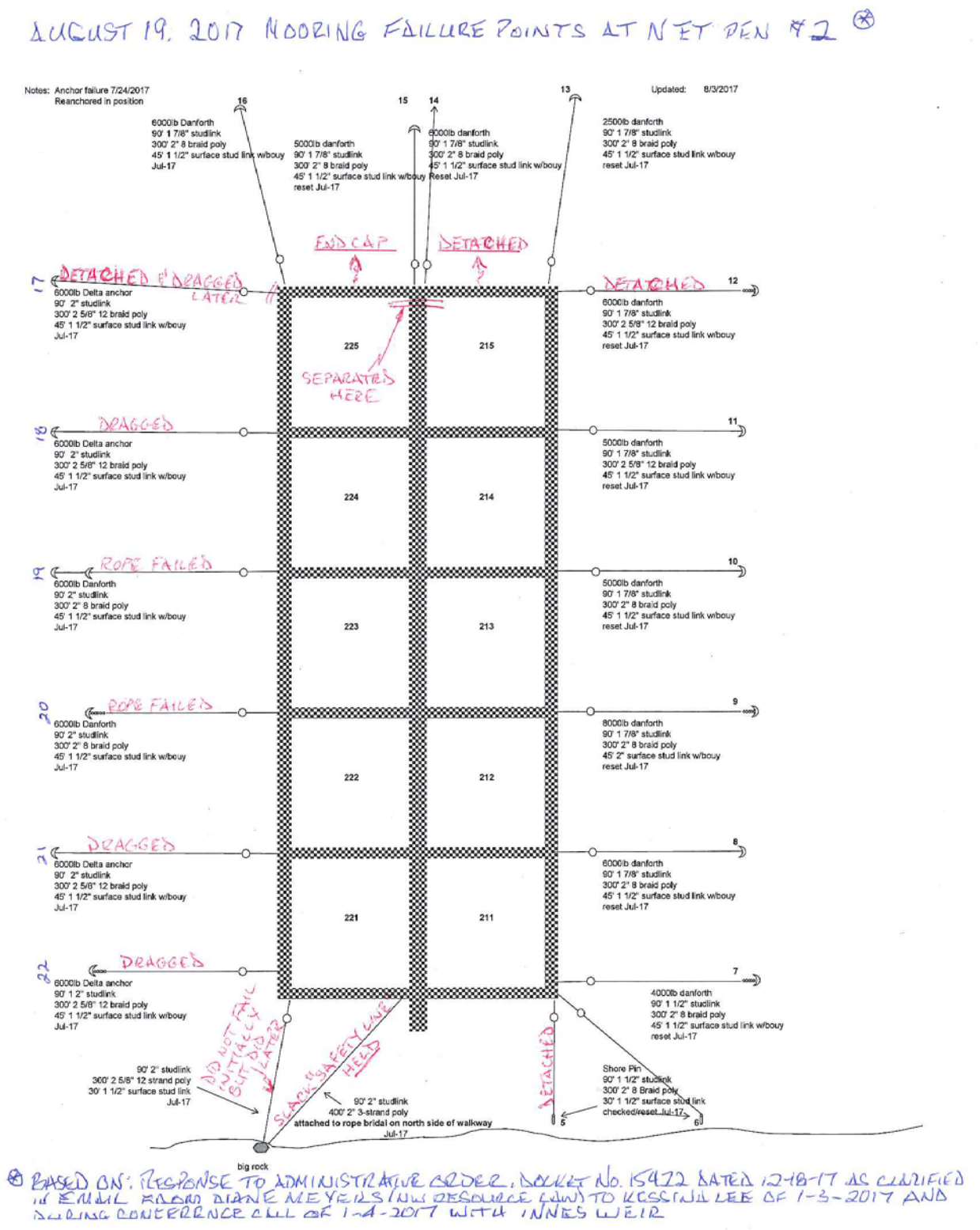

Figure 20. Configuration of net pen #2 on August 19, 2017 annotated with the moorings that failed.

Analysis/discussion

The Panel twice asked Cooke for a causal analysis regarding the cause(s) of the July incident and August failure.[170] [171] Cooke did not directly provide its conclusion regarding the cause(s) and contributing factor(s) beyond what is stated in the documents referenced above.

The energy of Cooke staff during the interval between the July incident and August failure appeared to have been focused on re-mooring net pen #2, getting back to normal operations to facilitate the remainder of the grow out, and introspection over addressing net hygiene issues in the future.

Cooke's actions included replacing anchors and resetting moorings (and in the process reducing moorings from 22 to 19), making un-engineered repairs to damaged net pen components, and adding chains across the structure. While Cooke documents indicate that they believed they had "caught up" on net washing by early August, each stock net had at least 11 tons of plant and animal life on it. The weight of the biofouling was over 600% of the weight of a clean net. Mussels, in particular, were prolific and well-established on the stock nets, which would have been evident to Cooke's divers. At a meeting on August 9, the potential for a net swap was discussed by Cooke managers, which would have reset the biofouling to zero, but no such action was taken.

Based on interviews and review of documentation provided by Cooke, what appeared to be absent was contingency planning for the next predicted period of larger than average tides and the associated higher tidal currents predicted for August 19-21. This is notable given the apparent ineffectiveness of net washing and the reduced number of moorings.

On Saturday, August 19, there were no additional personnel on site or staged to closely monitor the structure, respond to problems, and call for help. No commercial tug with appropriate towing connections to prevent drift of net pen #2 was on standby status.[8] The single item apparently acknowledging the possibility of another failure of the pen structure following the July incident was the inclusion of a slack "safety line" to the "big rock" (Figure 20) that stood in place of three tensioned mooring lines that were not replaced following the July incident. The appearance given overall is that, despite the warning inherent in the July incident, operations had largely returned to normal and Cooke personnel returned to a reactive posture.

[8] This precaution was taken following a May 26, 2017 incident at Cooke's Clam Bay net pen facility. According to January 19, 2018 Cooke correspondence with ECY through Cooke's counsel: "As a precaution, Cooke retained the tug to return on June 24 during the strong ebb tide, but the tug was not necessary or used on that day."

Response by State Agencies to August 2017 Failure

Facts

Three Washington State agencies responded during and after the August 2017 failure.

- Washington Department of Ecology (ECY)
- Washington Department of Fish & Wildlife (DFW)
- Washington Department of Natural Resources (DNR)

Please see Appendix 2: Atlantic Salmon Cypress Island Net Pen Break Response Timeline for a detailed timeline of the incident and the response by the state agencies.

Initial Agency Response (August 19 – 24)

On Saturday, August 19, a citizen boating in Deepwater Bay called Skagit County 911 to report the incident. Skagit County relayed the information to U.S. Coast Guard. USCG relayed this information to ECY after hours spill responders (Northwest Regional Office) at 5:09 p.m. ECY after-hours responder contacted the citizen by telephone 11 minutes later. The two spoke again by telephone less than an hour later. At the time of the second call, the citizen reported there were tugs assisting on scene. The ECY after after-hours responder attempted to contact Cooke's office but received no answer. The ECY after-hours responder made a note to follow up with Cooke on Monday morning.

Cooke attempted to notify by telephone representatives of the three state agencies in the morning of Sunday, August 20, about the incident. As of the end of the day, Cooke was reporting "damage" to the net pen and that 4,000 to 5,000 fish were believed to have escaped. Cooke spoke with ECY staff on Sunday and left voice messages with DFW and DNR. On Monday morning, agency staff specializing in net pen management began active response.

The net pens at Deepwater Bay cannot be easily viewed from public areas on the shoreline. Effective observation was only possible by boat or air. All three state agencies have boats they can use but time is required to mobilize these resources. Consequently, state agencies relied on reports from Cooke on the condition of the net pen through Tuesday, August 22.

Actions by state agencies during this period included:

- Monday, August 21: DFW provided Cooke an Emergency Fishery Permit to seine for Atlantic salmon in Deepwater Bay.

- Tuesday, August 22: DFW authorized retention and sale of Atlantic salmon taken in Puget Sound commercial salmon fisheries. DFW notified the Fraser River Panel, an international management body of the Pacific Salmon Commission that oversees this area during sockeye and pink salmon directed fisheries, that Cooke had been issued an Emergency Fishery Permit. The Fraser River Panel authorized Treaty Tribal fisheries targeting Fraser River origin pink salmon in the Strait of Juan de Fuca (Marine Areas 4B, 5, and 6C).

- Wednesday, August 23: State began daily site monitoring, which continued through Saturday, September 2. ECY and DNR staff jointly conducted the first site visit to net pen #2. The visit occurred on a Cooke vessel. Cooke staff described what had happened to the pen and how they were attempting to stabilize and secure the pen. State staff observed Cooke staff beach seining for escaped fish.

- Thursday, August 24: DNR staff visited twice to photograph efforts to stabilize the pen. The Fraser River Panel authorized Treaty Tribal fisheries targeting Fraser River-origin pink salmon in the area of the eastern Strait of Juan de Fuca (Marine Area 6) and the San Juan Islands north to the U.S – Canada border (Marine Areas 7 and 7A) August 25 to August 26 and also authorized an all-citizen's fisheries in Marine Areas 7 and 7A on August 26. Directed Atlantic salmon fishing by Treaty Tribes using beach seine and gillnet gear was authorized in Deepwater Bay from August 24 through August 28. DFW reduced the minimum size required for the all-citizen's gillnet fisheries from 7 inches to 5 inches in Bellingham and Samish bays to facilitate the harvest of Atlantic salmon.

State Agency Unified Incident Command (August 25 – September 5)

On Friday, August 25, DNR's Commissioner of Public Lands Hilary Franz, ECY Director Maia Bellon, and DFW Director James Unsworth signed a memorandum of agreement and associated delegation of authority to form a Unified Incident Command (UIC) to coordinate the state response. A UIC is a way for the incident command role in the Incident Command System to be shared by two or more agency representatives. Each agency remained responsible for covering its own staff and other costs associated with the incident.

On Saturday, August 26, the three agencies established an incident command post at the Port of Anacortes Commission meeting room on the waterfront in Anacortes, five miles from the site of the net pen collapse at Cypress Island. From this location, staff were able to deploy directly to vessels that pulled alongside or from the nearby Cap Sante Marina. From the pier, it was an approximately 15 minute boat ride to Deepwater Bay. The agencies also established a virtual information center to coordinate and disseminate incident information to fishery co-managers, stakeholders, and the public. The DNR web site (https://www.dnr.wa.gov/atlanticsalmon) was used to provide consolidated information from and for all three agencies and links were established to that page from ECY and DFW web pages. The UIC immediately established the following objectives (agency work priorities):

- ECY
    - Protecting water quality while scene was secured and net pen #2 was removed
    - Investigating the cause and extent of water quality permit violations
    - Corrective action and future prevention
- DFW
    - Fish recovery
    - Strengthen Tribal engagement/respond timely
- DNR
    - Secure the scene/recover the fish/remove net pen #2

- Investigate what happened/why
- Evaluate existing facilities to ensure structural integrity

The delegation charged the Unified Incident Commanders to "manage a coordinated state response to the on-going efforts by Cooke Aquaculture to stabilize, clean-up and remove the net pen in a safe, effective, and efficient manner [and to] document salvage material and biomass of fish, recover applicable written records and documents." The Unified Incident Commanders were to "form a Joint Information Center to coordinate and manage consistent, timely and unified messages to tribes, stakeholders, affected agencies, and the public regarding plans and on-going actions to address the incident."

From the agency work objectives, the Unified Incident Commanders distilled four objectives for the daily Incident Action Plans used through the UIC response:

1. Secure the scene to ensure safety,
2. Recover fish and remove net pen #2,
3. Ensure water quality, and
4. Communicate with state, local and federal government and tribal governments.

Outside legal counsel for Cooke worked with the Unified Incident Commanders and was in the Incident Command Post daily. During August 24 – September 8 and periodically thereafter through September 24, Cooke provided daily short written summaries of their activities and plans (available at the DNR website).

Tribal representatives were invited to observe and participate as they chose. Representatives of the Lummi Nation, Samish Indian Nation, Sauk-Suiattle Tribe, and Swinomish Indian Tribal Community participated at various times.

On a daily basis, the Unified Incident Commanders held separate conference calls with 1) Tribes/First Nations and 2) counties, state and federal agencies, and Department of Fisheries and Oceans Canada (DFO-C). These calls summarized activities by Cooke and actions by the state agencies. Information was also received from call participants, most often fishing reports from Tribes/First Nations and DFO-C. Complementing the conference calls were daily written Incident Status Summaries distributed at the end of the day.

Other significant activities of the UIC included:

- Monitoring and documenting on-site work by Cooke and their contractors, including the use of a DNR drone on August 28 to photo-document the collapsed net pen and establish its shifted location,
- Monitoring Cooke's fish recovery and extraction efforts, tribal and recreational fishers success in recovering fugitive fish, and the physical condition of recovered fish,
- Liaising with fishery co-managers and tribal representatives, including meeting with Tribes on Monday, August 28,
- Responding to information requests from the media,
- Working with the USCG Sector Puget Sound to establish an enforceable safety zone around the collapsed net pen in Deepwater Bay. This safety zone was put in place on

Monday, August 28, coinciding with the arrival of USCG personnel in the Incident Command Post. The zone was enforced by USCG, with logistical support provided by DFW and DNR on-water personnel,

- Developing daily incident action plans to set priorities and coordinate activities,
- Requesting Cooke to provide a water quality monitoring plan and reviewing Cooke's water quality monitoring results taken during salvage operations,
- Requesting Cooke and their salvage contractor to document, to the extent safe and possible, the condition of the net pen and mooring system as it was removed from the water in Deepwater Bay, Cypress Island,
- Ensuring that Cooke had oil spill response equipment on scene in case of a release during salvage operations,
- Identifying area facilities interested in accepting salmon carcasses for rendering or other uses,
- Supporting Cooke's application for a Section 10 permit waiver with USACE, and
- Standing up an Investigation and Review Branch of the UIC to begin the investigation process.

By Tuesday, September 5, Cooke had secured the failed net pen, extracted all fish from the pen, and had salvaged much of the structure. Meanwhile, catch rates of escaped fish dropped significantly. As the tempo of operations slowed and patterns of interagency cooperation became established, the UIC stood down and incident management transitioned to DNR single unit incident command. Single unit incident command continued the mission established by the delegation order and the pattern of close cooperation between state agency staff established continued. Conference calls and Incident Status Summaries were continued, albeit shifting to once every two or three days from daily.

From Friday, August 25 through Saturday, September 2, state staff were on site from between one and five hours per day. This period of observation includes the days of peak fish extraction from the nets (August 26-30). Thereafter, DNR or DFW staff visited the site several times a week through the end of surface salvage on September 24.

In an effort to develop lessons-learned from the use of a UIC to respond to this net pen collapse, the UIC agencies convened an after-action review that was held at ECY headquarters in Lacey on Wednesday, September 27. Tribal fishery co-managers also participated in this review. The UIC's work was reviewed and ideas for improved coordination for future incident command situations were captured.[172]

The incident was deemed concluded and DNR demobilized its command on October 3. On that date, the Investigation and Review Branch became the Investigation and Review Panel. (Please see chapter "How to Read and Understand this Report" for information on the Panel.)

Individual State Agency Responses

Complementing the Incident Command Structure response, each agency carried out its statutory responsibilities and employed its resources.

ECY
Environmental impacts

Figure 21. Incidence of turbidity during fish extraction August 27, 2017.

Protecting water quality in the aftermath of the August failure was an agency work priority and was adopted as a UIC priority. On August 26, DNR staff on site observing fish extraction at net pen #2 informed ECY that removal of nets containing decomposed fish was creating turbidity as a milky liquid escaped from the net openings. ECY communicated to Cooke, both directly and through Cooke's representative at the UIC, the necessity of establishing water quality monitoring during the fish extraction and subsequent salvage.

On August 27, ECY, through the UIC, submitted a written request for water column sampling at and around net pen #2. The request set parameters, frequency, and locations for monitoring, and contained a provision that if dissolved oxygen (DO) dropped below 4 parts per million (ppm), the UIC on site could request operations pause and/or aeration be done until DO levels recovered to ~6 ppm.

On August 27, ECY's UIC representative on site observed a turbid plume adjacent to the tender vessel during extraction, possibly due to spilled feed from a feeder that had fallen into the water during the structural failure. The UIC worked with Cooke and Global Diving & Salvage to adjust existing best management practices on tenders and vessels, deploying extra screens and booms, to mitigate the discharge of pollutants caused by the extraction.

On August 28 and 29, Cooke took limited monitoring samples at net pen #2 that showed results within water quality standards. ECY continued to work with Cooke to establish protocols for ongoing monitoring during fish extraction and the subsequent salvage of the structure.

On August 30, Cooke began monitoring twice daily according to agreed-upon protocols. The monitoring plan included:

Parameters

- Dissolved oxygen at 1 meter and 12 meter depths (duplicate readings at both depths)
- Temperature
- Turbidity

Frequency and timing:

- Minimum of two full sampling routines per day.
- Attempt sampling routine during the fish pumping process (preferably).
- If no fish recovery is occurring on that day, two sampling routines will be performed during other salvage operations.

Locations:

- Approximately 300 feet upstream (up current) of the structure
- Approximately 100 feet downstream of the structure.
- Approximately 300 feet downstream of the structure.

Daily monitoring continued through September 22, and on September 28, ECY and Cooke formally agreed to cease monitoring related to the net pen #2 salvage.

The terms of Cooke's National Pollutant Discharge Elimination System (NPDES) permit require closure monitoring when a net pen is moved or removed, to ensure recovery of the benthos at the pen's former location. As of the writing of this report, ECY is working with Cooke on a Sediment Sampling and Analysis Plan that will include the original location of net pen #2 as well as the area the pen moved to and where the fish extraction and salvage took place.

As part of ECY's agency priority to investigate the cause and extent of water quality permit violations, on August 25, an email was sent to Cooke and Cooke's legal counsel requesting information on maintenance policies, procedures, and schedules, documentation of inspections, maintenance, and repairs, a detailed timeline of the July incident and August failure, a description of the repair work on net pen #2 following the July incident, and an inventory of cage breaches and number of fish lost from each cage due to the August failure.

On September 3, ECY's representative at the UIC informed Cooke's legal counsel that ECY would be issuing an Administrative Order for a full engineering report for net pen #2, based on ECY's authority under the Clean Water Act, chapter 90.48 of the Revised Code of Washington, and Cooke's NPDES permit. The Order would replace the August 25 request and would incorporate the elements of that request, and would be in addition to any follow-up reporting required by the NPDES permit. On September 11, ECY emailed Cooke's legal counsel, clarifying what the contents of the Administrative Order would be, and offering the option of issuing an Agreed Order, which would state that Cooke agrees to undertake all actions required by the terms and conditions of the Order without contesting ECY's jurisdiction and authority to

administer the Order, or contesting the Order itself. Cooke accepted the option of an Agreed Order, and on September 15 ECY issued Agreed Order docket #15422. The Order included Findings of Fact based on ECY's determination that violations of state water quality standards and the NPDES permit had occurred.

On October 30, ECY received Cooke's initial response to the Agreed Order, and the response became part of the information available to the Panel. The Panel found Cooke's response to several elements of the Order incomplete, and on December 8, ECY sent a letter to Cooke specifying what was still needed to comply with the terms of the Order. On December 18, 20, and 22, Cooke, through legal counsel, provided several hundred additional documents in response to the Agreed Order, which were reviewed by ECY and the Panel.

DFW

Fishery management

As co-managers of Washington fisheries, DFW focused on supporting and encouraging the capture of Atlantic salmon from Puget Sound waters. This incident occurred within waters home to native and Endangered Species Act listed salmon stocks. The native salmon stocks are vital to Puget Sound tribes and fishing for native salmon is a reserved tribal treaty right. Native salmon are also an important commercial and recreational resource to the citizens of Washington. The Atlantic salmon were spilled into an area of complex fishery regulations overseen by the Fraser River Panel, described above.

Fishery management actions by DFW following establishment of the Unified Incident Command included:

- August 28: Treaty Tribal and all-citizen's fisheries targeting Atlantic salmon using beach seine and gillnet were authorized from 6 p.m. August 28 through 6 p.m. September 4 in the waters around Cypress Island and to the east from Fidalgo Head in the south to the southern tip of Lummi Island in the north. The Fraser River Panel authorized all-citizen's fisheries targeting pink salmon in Marine Areas 7 and 7A, for August 30, 2017 and Treaty Tribal fisheries in Marine Areas 4B, 5, 6, 6C, 7, and 7A on September 1. DFW created web-based voluntary reporting tool for recreational anglers to report catch of Atlantic salmon.

- August 29: DFW authorized Puget Sound forage fish and Puget Sound herring, anchovy, and smelt drag seine fishers to retain and sell Atlantic salmon taken in the operation of their fishery.

- August 30: The Fraser River Panel authorized Treaty Tribal and all-citizen's fisheries targeting pink salmon in Marine Areas 7 and 7A, and Treaty Tribal fisheries in Marine Areas 4B, 5, 6, and 6C from September 1 through the remaining total allowable catch of Fraser River origin pink salmon; the fishery closed at midnight Sunday, September 4.

- September 5: The Fraser River Panel agreed to allow Treaty Tribal and all-citizen's fisheries using beach seine and gillnet in the waters around Cypress Island and to the east

from Fidalgo Head in the south to the southern tip of Lummi Island in the north to extend through September 12, and added the embayments around the southern portions of San Juan and Lopez islands, Burrows Bay on Fidalgo Island, and Birch Bay near the Canadian border to the area open for targeting Atlantic salmon.

Fish health data
DFW needed to answer two questions immediately:

1) Were the fish safe to eat?

2) Was the health of the escaped fish an immediate threat to native salmon stocks?

DFW worked with the Northwest Indian Fisheries Commission to test and monitor the recovered fish and determined that the fish were healthy at the time of release and therefore safe to eat and that they were not carrying diseases that would impact native salmon stocks.

Ecological effects of escaped fish
DFW established a Puget Sound wide monitoring plan with the Northwest Indian Fisheries Commission to monitor fish in the commercial fisheries and to monitor rivers for the presence of Atlantic salmon. Please see the chapter on Fish Accounting for additional information.

Fish accounting
Atlantic salmon from the incident that escaped into Puget Sound were accounted for differently depending on the fishery in which the fish was caught. Atlantic salmon captured in Tribal or commercial fisheries were accounted for through a fish ticket system. The use and reporting of fish on fish tickets is the standard procedure for documenting catch by both tribal and non-tribal commercial fishermen. The fish ticket system and data sharing agreements between the co-managers allowed DFW to know fairly quickly how many Atlantic salmon were captured through the tribal and non-tribal commercial fishing fleets. Recreational fishers were encouraged to self-report fish through a website developed by DFW in the first days of the incident. Fish extracted from the net pen were reported by a Cooke representative each night. Please see the chapter on Fish Accounting for additional information.

DNR
DNR focused on lease compliance. The lease contract established the responsibilities of the lessee (Cooke).

The main question DNR sought answers to was whether the lessee was maintaining the net pen in “good order and repair, in a clean, safe, and attractive condition,” standard language in DNR leases. Therefore, DNR sought to verify statements and documentation by Cooke that would allow the agency to answer that question.

Actions that DNR took included:

- Notifying Cooke that it was in default of its lease 20-B12517 twice:
    - August 25: failure to maintain net pen #2 in good order and repair, in a clean, safe, and attractive condition

    - September 19: anchor chains, concrete blocks, and debris located outside the leasehold
- Conducting a bathymetric survey on October 26 and a remotely operated vehicle (ROV) survey on October 27 of the bottom of the Deepwater Bay to confirm whether all debris from net pen #2 had been removed. The surveys revealed considerable debris. DNR notified Cooke by letter on November 17 that the August 25 default had not been cured. In January 2018, Cooke conducted further removal operations to address this failure.
- Conducting lease contract compliance visits to all remaining eight net pens. ECY and DFW staff joined DNR on several of these visits.
- Contracting for an engineering inspection of all remaining eight net pens in Puget Sound, including Cypress net pen #1 and Cypress net pen #3. The purpose of the inspections was to evaluate the structural integrity of the facilities. These inspections were completed in mid-January 2018.

The contract compliance visits and engineering inspections helped DNR staff better understand net pen operations generally, which helped them in conducting the Cypress net pen #2 investigation and review.

Analysis/discussion
Priorities of the Unified Incident Command (UIC) were largely achieved:

- The safety zone enforced and no persons were harmed,
- Cooke stabilized the net pen, extracted fish, and salvaged the net pen,
- The agencies monitored and verified what Cooke did and reported,
- Water quality was monitored,
- Fish health was ascertained,
- A reporting system for recovered fish (fish that were caught in the Puget Sound and beyond) was developed quickly and worked well, and
- Information was conveyed between Cooke, the state agencies, and USCG.

Several priorities of the UIC were only partly achieved:

- Communication and collaboration with Tribal co-managers got off to slow start and
- 186,100 – 205,800 fish were not harvested, extracted, or recovered and thus escaped to Puget Sound and beyond.

Determining ecological impacts/impacts to threatened salmon species was a UIC priority. Given the substantial number of fish that escaped, it remains an on-going priority for the state.

The Panel concluded that:

- The state agency response to the August 19 incident was hampered by lack of information and understanding of magnitude of the problem at outset caused by:
    - Early information received from Cooke suggesting escaped fish numbers 4,000-5,000,
    - Lack of easy shoreline access that would have allowed direct observation by state staff, and
    - Not conducting the first site inspection until Wednesday, August 23.
- Numbers of escaped fish are not a sufficient criterion for determining level of response. This is because numbers are likely to be unknown or underestimated and because the number of escaped fish may not be an indicator of the stability of a net pen and potential for future escapes.
- The Fraser River Panel was responsive, met in a timely fashion, and was the right venue for conversation because it included Tribal co-managers and Canadians.
- If the magnitude of the numbers of escaped fish had been better understood, different options could have been considered such as:
    - Setting a net across outside of Deepwater Bay and
    - Not activating recreational fishers because their presence hindered effective net fishing
- Water quality monitoring could have begun sooner. Cooke had personnel trained to conduct sampling but the sampling protocol had to be developed after the incident and was limited to shallower depths. In the future, it may be necessary to be able to monitor at depth.
- ECY did not have its own water quality monitoring assets to employ to verify Cooke monitoring.

Accounting for Fish

Facts

Overview

Cooke reported a total of 305,000 fish in Net Pen #2 on August 19. Following the collapse, Cooke reported 5,166 live fish were harvested and sent for processing in Seattle and 388 were caught in beach seines by Cooke. Cooke reported extracting 139,897 fish from the collapsed net pen. Thus, Cooke reported accounting for a total of 145,451 fish. If the numbers reported by Cooke were accurate, then 159,549 fish escaped into Puget Sound (159,937 if the 388 fish immediately caught in beach seines by Cooke are included), of which 56,465 were caught by people other than Cooke, leaving 103,084 unaccounted for. This chapter documents and discusses this accounting.

For clarity, the following terms are used in this chapter:

- "Harvested" is defined as live fish taken from the net pens using the normal harvest practices. Harvest occurred on August 20 and 21.
- "Extracted" is defined as fish removed from net pens, except those harvested. Most of these fish were dead. Extraction occurred from August 26 to September 4
- "Recovered" is defined as all fish captured from Puget Sound waters outside the net pen. Recovery began on August 19 and recovery numbers continue to be updated as fish are reported to DFW. The fish recovery period for the purpose of this report ended on January 15, 2018.

Fish numbers and weight per fish on August 19

Atlantic salmon were moved to Cypress net pen #2 from Cooke's Rochester, Washington, facility during May 12 – May 23, 2016. A total of 369,312 fish were reported by Cooke to have been moved into the net pen. The day before the August 19 failure, Cooke reported an estimated biomass at net pen #2 of 2,844,131 pounds.[173] At the time of the incident, Cooke reported there were 305,000 fish in net pen, a result of mortality over the grow out period. The reported biomass and fish numbers indicates a weight of 9.3 pounds per fish.

The Cooke Puget Sound General Manager stated that once net pen #2 had been stabilized after the July incident, he expected to begin harvest in September because "the fish were larger than expected," and continue through October, possibly November.[174] Cooke's Permit Manager said marketable size is 6 – 18 pounds.[175] Ideally, fish are graded in the pens initially to harvest fish 10-12 pounds or larger and that some weeks later, the remainder are harvested.

The 5,166 fish harvested from the failing net pen on August 20-21 weighed 7.9 pounds each based on the document provided by Cooke, presumably from International Packing Corp (see below).

In the weeks after August 19, the Lummi Nation recovered 44,239 Atlantic salmon with a total weight of 392,913 pounds, resulting in an average weight of 8.9 pounds per fish. Tribal fishery managers recommended excluding fish significantly lighter or heavier (outliers) before calculating the average, producing an average weight of 8.5 pounds per fish.[176] Because there is

no evidence that the fish fed after August 19 and because they were expending energy (metabolizing fat), the average weight of the fish recovered must be equal to or less than the weight of the fish on August 19.

Fish harvest and extraction

In the first two days following the August 19 incident, fish were harvested by Cooke staff essentially following normal harvest practices (see chapter on "Net Pen Operations"). Seine nets were used to gather live fish, which were pumped into the hold of the harvest vessel, F/V HARVESTOR. Cooke reported harvesting a total of 5,166 live fish, 3,098 fish from pen 221 on Sunday, August 20, and 2,068 fish from pen 212 on Monday, August 21.[177] Cooke reported that HARVESTOR transferred these fish to F/V POLAR LADY and that POLAR LADY offloaded these fish on August 22 at Pier 91 in Seattle.[178]

Cooke provided a PDF titled "Product overview, pieces" to document the fish extracted on August 20-21. It summarizes 5,166 "pieces" weighing 40,806 pounds and lists a "total average weight" of 7.9 pounds. "Pieces" is not defined but is assumed to be individual fish. The source of this document is unknown but is assumed to be International Packing Corp, which reportedly processed these fish in Seattle.[179]

The harvest operation ended on Monday, August 21 as the net pen become increasingly unstable with each tidal cycle.

The net pen was stabilized on Friday, August 25, and Cooke began extracting fish from the net pen on August 26. By this time, most fish were dead, likely due to trauma and asphyxiation. Because the fish were mostly dead and lying on the bottom of the net pen cages and because of damage to the pen, normal harvest practices were impossible. Global Diving & Salvage (Global) salvage divers had to enter each cage, descend to the bottom, and guide a suction nozzle to remove fish.[180] From August 26 to August 30, the extracted fish were deposited on a counting table on HARVESTOR. Cooke employees pushed the fish across a flat metal table while another employee counted the fish (Figure 22). Cooke did not provide documentation or tally sheets of this counting. At the end of each day, the employee counting the extracted fish would report the total number of fish electronically or verbally over the phone to Cooke management.[181] On or before August 31, HARVESTOR left Deepwater Bay and spent August 31-September 2 unloading in Anacortes. Dead fish that were extracted from the net pen from September 1 to September 4 were placed in plastic totes and brought to Anacortes on Cooke vessel F/V CLAM DIGGER. Table 1 shows Cooke's accounting of fish extracted by individual net, with estimated number of escaped fish. Table 2 shows Cooke's accounting of fish extracted by day.

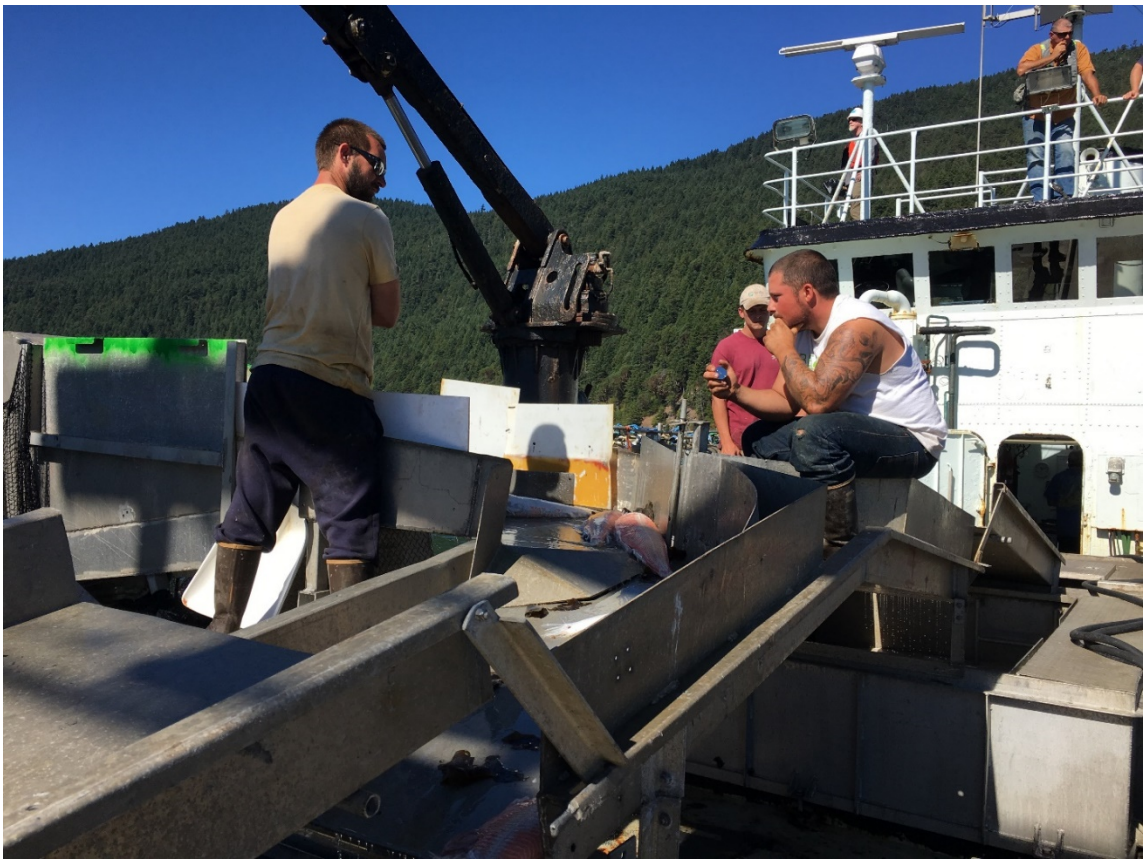

Figure 22. Fish counting on F/V HARVESTOR during extraction of dead fish from net pen on Sunday, August 27. Note blue tally clicker in hand of worker at right. After being counted, fish were slid into hold at left-center bottom of photo.

Table 1. Account of dead fish extracted from net pen #2 from August 26 to September 4, 2017. (From 12.14.17 Fish Recovery and Response Report provided by DJ Steding for Cooke.)

Cage Number	Mortality Count (extracted from cages during salvage)	Escape Count (based on inventory prior to failure)	Notes from Global Diving & Salvage report
211	28,950	6,386	No holes observed, large amounts of mortality, lots of fish swimming
212	29,162	-	Significant mortality, no holes observed
213	-	32,378	Large hole in base, with no fish observed
214	19,600	11,400	Significant mortality, no swimming fish reported, no holes reported
215	2,800	23,814	Unsafe and unable to assess
221	26,600	2,953	Holes observed in net, significant mortality, not many swimming fish
222	250	24,802	No fish observed, with the cage net pinched and very narrow at the base
223	-	31,418	Possible holes, with no fish observed
224	26,310	4,443	Significant numbers of swimming and dead fish
225	6,225	22,513	Complete mortality, no swimming fish observed
	139,897	160,107[9]	

[9] The sum of the totals in the two columns plus 5,166 fish (harvested on August 20-21) equals 305,170, not 305,000. These figures were provided by Cooke.

Table 2. Account of fish harvested and extracted by day and means of disposal. Various Cooke sources.

Date	Number Harvested and Extracted	Vessel(s) Used	Location/Date Offloaded
Sunday, August 20	3,098	HARVESTOR, then transferred to POLAR LADY	Seattle, August 22
Monday, August 21	2,068		
Subtotal	5,166		
Saturday, August 26	62,100	HARVESTOR	Anacortes, August 31 – September 2
Sunday, August 27	51,712[10]		
Monday, August 28	2,500		
Tuesday, August 29	19,810		
Wednesday, August 30	600		
Subtotal	136,722		
Friday, September 1	125	Unknown	Offloaded in totes by F/V CLAM DIGGER in Anacortes on September 4 and September 6
Saturday, September 2	250		
Sunday, September 3	2,550		
Monday, September 4	250		
Subtotal	3,175		
TOTAL	**145,063**		

The fish extracted from August 26 to August 30 were stored in the holds of HARVESTOR until August 31 and kept cool with refrigerated seawater to reduce the rate of decomposition (Figure 23).[182] The extracted fish and some seawater were discharged into Lautenbach Industries containers over a three-day period from August 31 to September 2.[183] The containers were transported to energy digester plants where the offloaded material was turned into biofuel and fertilizer products. The Lautenbach invoice shows 253.62 tons (507,240 pounds) of material offloaded during this period.[184] Cooke affirmed that tonnage figure was correct.[185] The Cooke Permit Coordinator said that fish that were disposed of with Lautenbach were 4-8 pounds.[186]

(The Lautenbach invoice also contains two line items dated September 5 totaling 52.34 tons. These fish were from net pen #3, mortalities caused by an act of vandalism.)

[10] Reported to UIC as 52,500 on August 27. Adjusted downward to 51,712 by Cooke by letter from Doug Steding to Eric Kinne, DFW, dated December 8, 2017.

Figure 23. Extracted fish in hold of HARVESTOR on August 27, 2017. Note presence of water; refrigerated seawater was used to slow decomposition during the fish extraction period August 26 – 30.

Cooke reported that HARVESTOR was filled to capacity at the time it left Deepwater Bay. While other vessels had been called to take on extracted fish, they were not needed.[187]

Capacity of F/V HARVESTOR

F/V HARVESTOR is not owned by Cooke but is contracted. The vessel has the following identification numbers: USCG Doc. No. 618129; IMO No. 8034875; call sign WUT3895; AFIS No. WDC8229; MMSI 367083650. NOAA Fisheries Vessel Documentation lists the following specifications:[188]

Gross tonnage 199 tons

Net tonnage 148 tons

Length 112.7 feet

Beam 26 feet

Hull depth 8.4 feet

Cooke reported the hold capacity of HARVESTOR as 208 cubic meters, which is 7,340 cubic feet.[189]

Video/photos of HARVESTOR during the period of fish extraction show changes in the HARVESTOR's forward draft. Draft would have been affected by fish taken on board and ballast water pumped on and off. Fuel consumption also would be a factor but fuel consumption rates are not known. The draft readings forward also could have been affected by the fore and aft trim of the vessel. Figure 24 to Figure 27 below, show the HARVESTOR's forward draft at various times.

Figure 24. F/V HARVESTOR on August 26, 10:31 a.m. First day of fish extraction onto vessel. The forward draft is about 4 feet.

Figure 25. Close up of bow of F/V HARVESTOR on August 26, 2:00 p.m. First day of fish extraction onto vessel. The forward draft reading is about 5 feet, 3 inches.

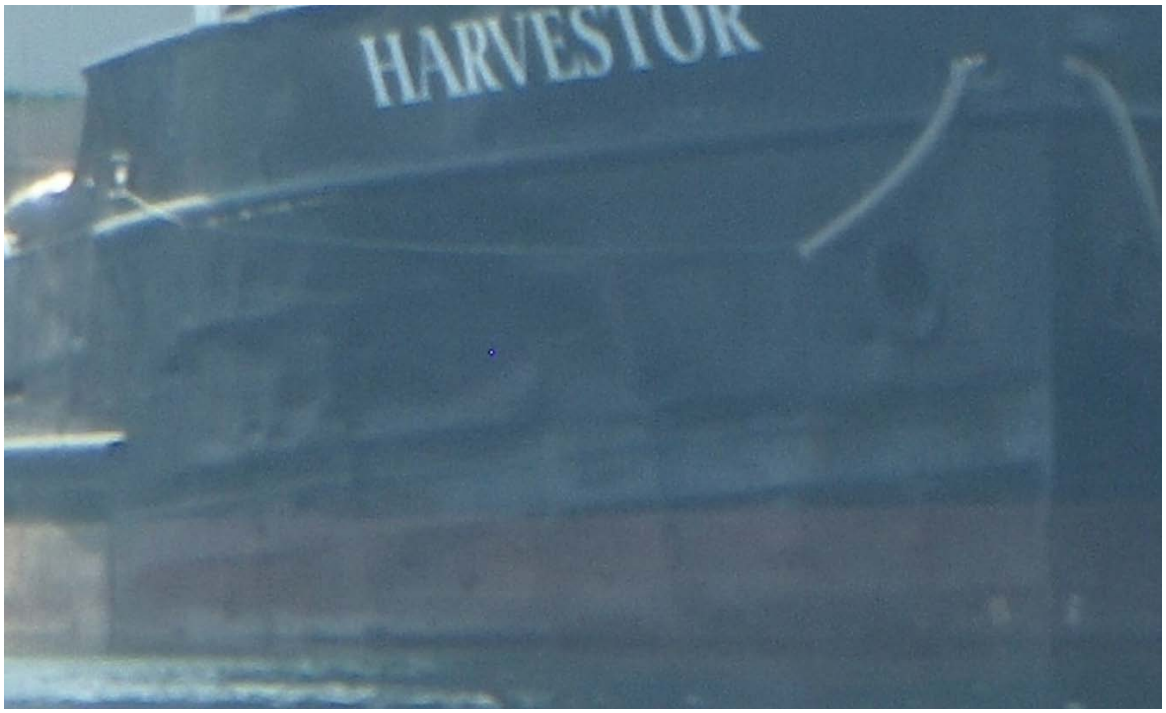

Figure 26. F/V HARVESTOR on August 29, 1:43 p.m. Last day of significant fish extraction onto vessel reported by Cooke. The forward draft reading appears to be at draft mark 5 feet 3 inches, unchanged from August 26, 2 p.m.

Figure 27. Close up of bow of F/V HARVESTOR on August 31, 1:49 p.m. Vessel is alongside Curtis Wharf in Anacortes, preparing to unload fish to disposal containers. The waterline is at draft mark 6 feet 3 inches.

Overall, between Saturday, August 26 and Friday, August 31, when the vessel took on a reported 136,722 fish (Table 2), the forward draft increased from 4 feet to 6 feet 3 inches.

Fish recovery

In the January 2017 Updated Fish Recovery and Response Plan, Cooke identified actions for recovery and response efforts for any accidental release of more than 3,000 fish. The focus of the following section is the implementation of the Recovery and Response Plan and the effectiveness of that plan. There were three specific elements of recovery outlined in the 2017 Recovery and Response Plan, which Cooke implemented.

1. Procedures for determining medicated feed usage in escaped fish
    a. Cooke provided DFW information that the most recent antibiotic given to Cypress net pen #2 fish was in summer 2016.
    b. Administration of antibiotics is reported to ECY as part of the National Pollutant Discharge Elimination System reporting requirements.
2. Emergency procedures to minimize fish releases
    a. Cooke began immediately trying to stabilize net pen #2 with the use of barges, divers, and other means.
3. Recovery procedures outlined in the plan were broadly worded. The implementation of those broad procedures included the following:

a. Cooke received approval from DFW to beach seine in Deepwater Bay. Beach seining on August 22-25 and 29 occurred at the eastern shoreline of Cypress Island, primarily shorelines of Deepwater Bay and Secret Harbor and resulted in 390 fish reported recovered. Cooke did not employ any outside contractors for the beach seining recovery efforts.
b. DFW worked with Washington State co-managers and fishery managers in Canada to revise the fishing regulations to allow for recovery of Atlantic salmon from Puget Sound. This included changes to allowed fishing gear and the expansion of areas for fishing. DFW also encouraged recreational fishers to retain an unlimited number of Atlantic salmon if the fisher had a valid fishing license and did not exceed his or her limit for native salmon. The additional commercial salmon fishing effort (using gillnet, purse seine, and reef net gears) required the engagement of the international management body (the Pacific Salmon Commission's Fraser River Panel) that oversees this area during sockeye and pink salmon directed fisheries.
c. The Lummi Nation declared an emergency and activated their fishing fleet.
d. The smelt fishery also caught 2,261 fish in the San Juan Islands through beach seining efforts.

Fish health

DFW asked five questions relative to fish health:

1. Were the recovered Atlantic salmon recovered from the Cooke facility (rather than net pens in British Columbia)?
2. Were the recovered fish healthy at the time of release?
3. Were the recovered fish eating as they dispersed into the ecosystem?
4. Were the recovered fish able to reproduce?
5. How did the recovered fish's health change over time since incident?

To answer these questions, DFW developed a health assessment plan for recovered Atlantic salmon. This plan included a survey of specimens at or near the time of release and in the direct area around the release. A minimum of 15 fish recovered soon after their release were evaluated. Additional fish were examined on an ad hoc basis, as the fish became available, to evaluate changes in the status of the fish over time. All samples received a complete necropsy and laboratory evaluation. Post release samples were taken at different dates in multiple locations from multiple sources to get a survey of how the fish fared by time and by location as they were available. All examinations post initial release included native species of Pacific salmon as a comparison for disease endemic to a given location where the Atlantics were harvested. DFW tested the Atlantic salmon for endemic pathogens using the same methods as the agency uses in DFW-operated hatcheries.

Assessment:

All fish examined were confirmed to have originated from a Cooke facility, presumably Cypress net pen #2 as no other escapes were reported. Veterinary assessment of released Atlantic salmon specimens indicated that the escaped population was healthy at time of release. No endemic bacterial, viral, or parasitic (such as sea lice) pathogens were detected in the group of fish sampled immediately after release.

Cooke reported that it did not appear that mortality was excessive or abnormal at time of release.[190] Specimens caught at the Cypress site at the time of release were deemed healthy by general necropsy, culture for endemic pathogens, and by histopathology.

Atlantic salmon stocks employed by Cooke are highly domesticated with over eight generations (32 years) in captivity and dependent on artificial diets. Of 138 specimens evaluated post release in this study, no specimen showed evidence of eating. Gastrointestinal tracts were empty with the exception of yellow pellets and mucus typically seen in anorexic adult fish found in saltwater, which are a combination of mucus, epithelial cell remnants, and other debris. Anorexia was clinically determined by increased gall bladder size and by gross histological examination of the gastrointestinal tract. Body condition factors declined over time in captured specimens due to a loss of abdominal fat and weight.

Stress was difficult to evaluate as fish samples were presented post mortem so standard methods of evaluation such as behavioral or clinical impressions; complete blood counts including numbers of lymphocytes and neutrophils; and blood chemistries such as glucose or cortisol were unavailable. Still, DFW did acquire interviews of behavior from recreational fishers and histopathology indicated alarm cells in skin and gills and necrosis of intestinal epithelial cells in the gastrointestinal tract. The declining condition and weight also indicate that stress was an important factor post-release in decreasing survival and poor health of Atlantic salmon in Puget Sound.

Post release groups had evidence of a systemic inflammatory response by gross necropsy and histopathology. It was not clear as to the specific etiology, but evidence points to damage to the epithelial cells lining the gastrointestinal tract and the release of bacteria possibly lipopolysaccharides or endotoxins systemically causing a systemic immune response. Salmonids do not normally carry heavy loads of bacteria in their gastrointestinal tract, in contrast to mammals. Findings of large amounts of bacteria in the gastrointestinal tract in these fish is significant.

Testing was performed for infectious disease organisms endemic to Puget Sound in cooperation with the Northwest Indian Fish Commission (NWIFC) and Fish Vet Group. Tests for endemic viral pathogens sampled at the 95% confidence interval were all negative except for the positive results for Piscine Orthoreoviros (PRV) in all four of the study fish sampled for that pathogen. Samples that tested positive for PRV showed no histopathological evidence of HSMI. Tests for *Renibacterium salmoninarum* and Salmon Rickettsial Syndrome (RSV) were negative. Bacterial cultures early in the investigation were negative by culture on multiple agars, with tests conducted by NWIFC, DFW, and Fish Vet Group. As time went on post release a mixture of bacterial pathogens endemic to Puget Sound began to appear; agents such as *Vibrio anguillarum*

were observed by culture. There was not a single bacterial pathogen found in large numbers, and the inconsistency of the types of infection indicated that the bacterial infections were secondary or opportunistic. DFW concludes that the fish became susceptible to bacterial infection following anorexia and stress.

The health findings associated with the escaped Atlantic salmon are consistent with results from Pacific salmon sampled at the same time as the Atlantic salmon. That is, necropsy and lab tests of Pacific salmon indicated that senescent, anorexic returning adult Pacific salmon had similar inflammatory responses, degradation of the intestinal tract, and mixed bacterial infections as the Atlantic salmon, although to a lesser degree.

The stress of an unfamiliar environment (i.e., outside of net pen) and lack of regular feedings resulting in a decreasing nutritional profile likely played a significant role in reducing survival of the escaped Atlantic salmon. Disease activity observed in the Atlantic salmon are bacterial diseases endemic to Puget Sound maintained by native populations of Pacific Salmon and invertebrates. There was no clinical or histopathological evidence of any exotic diseases such as HSMI, CMS, or Salmonid alpha virus disease in any specimen examined. DFW observed a steady decline in numbers of Atlantic salmon in both the commercial and recreational catch as fish succumbed to the effects of malnutrition and stress post-incident.

All the fish collected in Puget Sound from Marine Area 7, Point Roberts and Bellingham Bay, had terminal lesions to the gastrointestinal tract and a systemic inflammatory response that was damaging to other organ systems. Similar findings were found in Marine Area 10. DFW estimated that the majority of the fish that remained in saltwater were dead by November/December 2017. However, small numbers of fish could remain alive in salt water for limited period of time.

Health of fish recovered in freshwater was noticeably different than that recovered in saltwater. Relatively healthy Atlantic salmon were recovered in November and December 2017 in the Skagit River by the Upper Skagit Tribes. It is not uncommon for returning adult Pacific salmon to go upwards of six months without eating. DFW speculated that the recovered Atlantic salmon entered the Skagit River soon after the release in August. Given the decreased muscle pigmentation and lower body condition factor scores, it is likely that these fish had not eaten in a long time, similar to the Atlantic salmon recovered in salt water. At the time of sampling, the fish found in the Upper Skagit had no significant lesions, no infectious organisms, and were healthy with normal gross necropsy. Blood profiles were normal, and histology results were within normal limits. Gametes were immature and gastrointestinal tracts were empty with the exception of some wood chips about the size of pelleted fish food observed in one fish. Fish remaining in the rivers may survive for some time further unless caught. The long-term impact of escaped Atlantic salmon in the rivers is not known at this time.

Analysis/discussion

Analysis of extracted fish numbers and fish escape numbers

The number of escaped fish reported by Cooke during the August failure likely significantly underrepresents the number that actually escaped from net pen #2. There are four lines of

evidence that support this conclusion. All four are associated with lack of certainty about the number of fish extracted from failed net pen #2:

- Tonnage of fish/water accepted by the waste disposal company does not support the reported numbers of fish extracted,
- Hold capacity of F/V HARVESTOR is not sufficient to carry the tonnage calculated for the reported numbers of fish extracted,
- The observed changes in displacement of F/V HARVESTOR do not appear consistent with the tonnage calculated for the reported numbers of fish extracted, and
- Rate of fish extracted from the stock nets as seen in the diver and topside video footage does not support reported numbers.

Tonnage of disposed material

Based on Cooke's accounting, HARVESTOR discharged 136,722 fish and refrigerated seawater weighing 253.62 tons (507,240 pounds) from August 31 to September 2 in Anacortes. This produces a figure of 3.71 pounds per fish and associated seawater. In contrast, the weight per fish reported for the 5,166 fish harvested on August 20 and 21 was reported as 7.9 pounds—about twice the per fish weight disposed of to the containers. While the fish continued to decompose and thus lose weight between August 21 and the end of fish extraction on August 30, the 7.9 pound/fish figure from August 20-21 was presumably fish weight only and did not include any seawater used to chill the fish. As the pen failed on August 19, the fish extracted August 20-21 probably had not decomposed to any measurable degree. Cooke reported that the fish discharged to the Lautenbach containers were in water used to slow decomposition (Figure 23 and Figure 28).[191] So while the average weight per fish extracted from August 26 to 30 may have been lower than 7.9 pounds, that lower weight was likely offset – in whole or in part – by the seawater used to chill the fish. In short, either the fish were even lighter than 3.71 pounds per fish, or there were fewer fish extracted and delivered to the Lautenbach containers than Cooke reported.

Figure 28. Hold on F/V HARVESTOR receiving extracted fish on August 30, 2017, the final day of fish extraction. Note presence of fluids.

Assuming the average fish/water weight of 7.9 pounds at extraction, then the total weight of fish extracted August 26-30 should equal 1,080,104 pounds, or 540.1 tons (136,722 fish x 7.9 pounds/fish). The total tons of fish removed from the facility, as recorded on the Lautenbach receipt, was 253.62 tons (507,240 pounds). Thus, the total amount of fish disposed of weighed no more than 47% of the expected tonnage.

Fish extracted based on hold capacity of vessel F/V HARVESTOR

Extracted fish were placed in four holds on F/V HARVESTOR, which together had a volume capacity of 7,340 cubic feet. The number of fish that could be held is a function of packing density and average weight of fish. Neither the packing density of the extracted fish nor the normal packing density during normal harvest practices is known. The packing density likely used would have been higher in this situation than in normal harvest procedures because quality control would not be a consideration. A cubic foot of seawater weighs approximately 64.1 pounds. Fish are slightly heavier than saltwater: 65.8 pounds per cubic foot.[192]

- If the extracted fish/water mix weighed 64.1 pounds per cubic foot, HARVESTOR could hold 235 tons ([7,340 cubic feet x 64.1 pounds per cubic foot]/2,000 pounds). At 7.9 pounds per fish, the maximum fish number that HARVESTOR could carry would be 59,500 fish.
- At 65.8 pounds per cubic foot, HARVESTOR could hold 241 tons. At 7.9 pounds per fish, the maximum fish number that HARVESTOR could carry would be 61,100 fish.

- Cooke reported that HARVESTOR unloaded 253.62 tons to disposal containers. This would have require a packing density of 69 pounds per cubic foot to fit this tonnage in the holds. At 7.9 pounds per fish, the maximum fish number that HARVESTOR could carry would be 64,200 fish. It is unknown what fraction of the tonnage was seawater.

The above calculations make no allowance for the seawater reportedly used to chill the fish to slow decomposition. Using the most conservative estimates, the most that HARVESTOR could have carried was 47% of the 136,722 fish reported delivered to Anacortes. The only alternative explanation is that *all* fish extracted after August 21 would have had to lose over half their total body weight between August 22 and August 30, the final day of extraction. Note that this is the same percentage as calculated by different means in the previous subsection.

Fish extracted based on observed changes in displacement of vessel F/V HARVESTOR

An increase in draft of 2 feet 3 inches corresponds to an increased weight of cargo. Usually the increased weight would be calculated using the vessel's tons per inch immersion table, and amidship or average draft, but those were not available. Ignoring diesel fuel usage and any trim by the stern, and assuming a rectangular volume of 112 feet by 26 feet by 2.25 feet (the ship's dimensions multiplied by the change in draft) containing the weight of seawater (about 64.1 pounds/cubic foot) that calculated weight is 419,983 pounds (210 tons). Assuming a rectangular prism overestimates the weight taken aboard the HARVESTOR since the vessel is tapered at the ends, but any trim by the stern would cut into the overestimate.

This figure is less than the 507,240 pounds (253.62 tons) that HARVESTOR reportedly delivered to Anacortes. In addition, 419,983 pounds divided by 136,722 fish yields an average per fish weight of 3.1 pounds, less than half of the average per fish weight (7.9 pounds) for the 5,166 fish extracted on August 20 and 21.

Rate of fish extracted based on diver cam footage

As described above, the fish were extracted by divers using a suction tube lowered into the net pen from HARVESTOR. Dive logs for all the dives were provided to the Panel. Every dive was also recorded by video cameras mounted to the diver's helmet. The videos provided to the Panel are referred to as "dive cam footage." DFW provided experts to review the videos and count fish as they were sucked into the vacuum pipe by the Global divers. Table 3 shows the total dive time (technically, "bottom time"), the time the extraction pump was on, and the number of fish reported to have been extracted.

Table 3. Extraction pump times, fish extraction reported by Cooke, and fish extraction calculated by Panel for August 26 – 30, 2017.

Date	Time Extraction Pump Was On	Rate Required to Achieve Cooke-Reported Numbers (Fish per Minute Pump Was On)	Cooke Report of Fish Extracted	*Highest* Rate Observed by DFW on Dive Video (Fish per Minute)	Panel Estimate of Fish Extracted Using Rate from Dive Video
August 26	118 minutes	526 fish	62,100	132 fish	15,576
August 27	127 minutes	407 fish	51,712		16,764
August 28	7 minutes	357 fish	2,500		924
August 29	0 minutes	No fish extracted during diving; see discussion below	19,810	No fish extracted during diving; see discussion below	19,810 (Cooke figure; not verified)
August 30	14 minutes (approx.)	42 fish	600	Not used (Cooke figure; realistic)	600
TOTAL	**Total: 266 minutes (4 hours, 26 minutes)**	**Average: 440 fish per minute** (excludes August 29; see discussion below)	**Total: 136,722 fish**		**Total: 53,674 fish (39% of reported figure)**

Fish extraction on August 29 requires special discussion. Both dive logs for that date and repeated reviews of the dive cam footage demonstrated that *no* fish extraction occurred during those dives. This assessment is further confirmed by the fact that the final of the three dives on that date, Dive 28, ended at 12:39 p.m. HARVESTOR did not moor next to the failed net pen until about 1:20 p.m., as confirmed by DNR photographs and AIS vessel tracking. Only HARVESTOR had a pump that could extract fish from the bottom of the nets. Although Cooke said that all fish extraction was conducted by divers in the pens guiding fish into the suction hose, a close inspection of photos taken by DNR suggests that Cooke likely employed an alternative extraction technique on the afternoon of August 29. Photos show the stock net lifted high above the failed net pen, a procedure not employed at other times fish extraction was observed. This action could have concentrated dead fish in a pocket lifted to the surface. If so and if the pocket of fish was relatively free of debris, then extraction might have been possible without use of a diver, similar to standard harvest practices. DNR photos show the pump hose on the deck of the crane barge, apparently extending from the pump on the HARVESTER south to

the southern end of the crane barge. This would place the opening of the hose next to where the bottom of the stock net would be near the surface (Figure 29 and Figure 30). The pump was not on before 2:21 p.m. at the earliest.[193, 194] At 3:16 p.m., DNR observed water was flowing from the de-watering table and inspected turbidity in the water, indicating the pump was on and suctioning fish.[195] AIS information shows HARVESTOR departed the net pen at 4:24 p.m. Thus extraction could not have occurred for more than two hours at the most. This duration would have required extracting fish at an average rate of *at least* 165 fish per minute (19,810 fish/120 minutes). In contrast to most other times when extraction occurred, state staff were on neither the HARVESTOR nor the salvage vessel M/V PRUDHOE BAY. State staff viewed the operation from afar because they were prioritizing scene safety by communicating with boaters in Deepwater Bay. Whereas the Panel had diver cam and topside video footage to evaluate the validity of fish numbers extracted on August 26, 27, 28, and 30, it had no information with which to evaluate the number claimed for extraction on August 29 or re-calculate that number.[11]

[11] By way of letter from Cooke legal counsel dated January 29, 2018, Cooke suggested the approach to fish extraction without divers used on August 29 was used on other days as well. Cooke provided no dates or times when this occurred. The Panel's review of vessel location information, dive logs, and photographs lead the Panel to reject this assertion.

Figure 29. Image possibly showing preparation for fish extraction not using divers at 1:53 p.m. on August 29. Stock net has been raised mostly out of the water. Gray pipe used to vacuum fish can be seen at foot of three men standing next to net.

Figure 30. Image possibly showing preparation for extraction not using divers at 2:24 p.m. on August 29. Note gray 12-inch hose lying on deck of crane barge and elevated toward the stern of HARVESTOR (at right), apparently stretching from the vacuum pump.

Based on the review of the dive cam footage, some portion of each of the dives was spent assessing the net, checking for holes and scanning the area for dead fish. Some of the dive time was spent suctioning fish. In an effort to confirm the reported extracted numbers, DFW staff reviewed the dive cam footage and counted the number of fish suctioned. (Please see Appendix 4 for full DFW report on this analysis.) The video cam footage presented three key challenges to getting a precise count of fish for the entire time the suction pump was on: 1) the operator looked away from the suction device while suctioning fish, 2) reduced visibility due to debris in the water, and 3) the fish were not always whole (Figure 31). Given that the fish were not being suctioned the entire dive, the reviewers identified just those times when the fish suction pumps were on and fish were being suctioned. The reviewers identified a total of 4 hours, 19 minutes, 45 seconds (259 minutes) when the pump was on. Of these 259 minutes, the diver was only suctioning fish for 4 hours, 9 minutes, 35 seconds (249.5 minutes). The reviewers were not able to get a precise count of fish for the entire time the suction pump was on due to the three factors described; rather, the reviewers segmented the videos into 30-second blocks when fish were countable. Reviewers then counted the number of fish suctioned within each 30-second blocks.

This resulted in counts as high as 65 and 66 and as low as 11 and 8 fish with an average of 27.4 and 28.7 for each reviewer, respectively.

The lead reviewer summarized the condition of the fish:

> *8/27 would be the day when fish body condition looks to have deteriorated the most. Pen 14 was cleared on 8/26 and most of the fish look pretty good. Pen 21, also cleared on 8/26, has fish that appear to be in worse condition mixed with those that look like the image from pen 14. By the next day, the fish in pens 12 and 22 look consistently worse, and on 8/30, most of the fish in pen 25 have no skin and occasionally break apart when disturbed.*[196]

Figure 31. Screenshot from Dive 5 on August 26. This shows optimal conditions for obtaining an accurate count of fish extracted: camera is pointed directly at opening of suction pipe, fish are whole, and there is little debris (decomposing fish) in the water.

To estimate how many fish Cooke could have extracted when divers were involved, the reviewers recommended to the Panel a very conservative approach of using the *highest* rate ever observed in a 30-second block and applying it to the *entire time* when fish were being suctioned. The highest rate observed was 66 fish per 30-second block (132 fish per minute). According to the dive videos, the total time the pump was on and fish were being suctioned on August 26, 27, 28, and 30 was 4 hours, 9 minutes, 35 seconds (249.5 minutes). (As noted previously, diver-managed fish extraction did not occur on August 29.) This approach will ensure the resulting estimate errs on the side of over-counting. There were 513 30-second segments of suction time (4 hours, 9 minutes, 35 seconds + 7 minutes from the DNR topside video that replaced the missing dive video). To perform the calculation, 513 is multiplied by the highest count of fish for a 30-second period of 66 fish, equaling 33,858 fish. If the 19,810 fish reported extracted on

August 29 (see above) is accepted without adjustment and added, the total is 53,668.[12] This is 39% of the 136,722 fish reported by Cooke during August 26-30.

The 53,668 fish resulting from this methodology multiplied by an estimated per fish weight of 7.9 pounds produces an estimated weight of 212.0 tons (423,977 pounds). This is 84% of the 253.62 tons (507,240 pounds) documented in the Lautenbach receipt. The difference could be composed of cooling water.

The use of different assumptions produces different estimates of fish extracted. For example, using the *average* count of 28 fish suctioned during a 30-second segment – rather than the highest count – produces an estimate of 34,174 fish extracted ([513 x 28] +19,810). This is 25% of the 136,722 fish reported by Cooke during August 26-30. When multiplied by an estimated per fish weight of 7.9 pounds, it produces an estimated weight of 135.0 tons (269,975 pounds). This is 53.2% of the 253.62 tons (507,240 pounds) documented in the Lautenbach receipt. Again, the difference could be composed of cooling water. The Panel discusses these two different approaches to demonstrate various assumptions and the results of those assumptions.

Complementing the helmet cam footage was video by state staff of operations on HARVESTOR during the entire time the pump was operating during the final extraction dive, Dive 32, on August 30. Shot from the top of the wheelhouse, the video covers the entire 7 minutes when the pump is on and shows nearly all fish that passed across the dewatering table and were placed in the hold. The view in these "topside videos" was not affected by the three challenges associated with viewing dive cam footage discussed in the paragraph above (Figure 32). DFW staff counted 239 fish during this period. This is equivalent to 16 fish per 30-second period or 32 fish per minute that the pump was on. These figures are considerably less than the average rates counted using the dive cam footage on August 26-28. State staff also filmed two minutes of fish extraction during Dive 31 and narration on that video reports the pump was on for about the same duration, 7 minutes. Cooke reported extracting 600 fish on August 30, which included these two dives.

August 30 was the only date when state personnel observed the entire duration of fish extraction close up, on board HARVESTOR. The reported number of 600 is commensurate with what would be concluded from state observations (239 fish x two 7-minute pump durations = 478, 80% of the 600 fish reported).

[12] For simplicity's sake, these calculations include the estimated 14 minutes of suction time for August 30. However, Cooke's reported figure of 600 can be used alternatively, as shown in Table 3. By coincidence, the two approaches produce similar results: 53,668 fish versus 53,674 fish.

Figure 32. Screen shot from video of fish counting on F/V HARVESTOR during Dive 32 on August 30, 2017. Note that on the final date of fish extraction, the fish were in an advanced state of decomposition. Cooke reported extracting 600 fish on this date.

While there are significant assumptions in both videography approaches employed to verify the number of fish disposed of by Cooke resulting in disparate estimates, each of the methods indicates that many fewer fish were extracted from net pen #2 than reported. If Cooke had extracted the number reported, then during the total suction time of 4 hours, 16 minutes, 35 seconds (256.5 minutes = 4 hours, 9 minutes, 35 seconds of suction time + 7 minutes from the DNR topside video that replaced the missing dive video), they would have needed to extract an average of 456 fish per minute (228 per 30 seconds) to reach the reported 116,912 extracted Atlantic salmon reported for August 26, 27, 28, and 30 ([136,722-19,810 for August 29]/256.5 minutes). The review of video footage does not support such a high extraction rate.

Panel's accounting of 305,000 fish from net pen #2

To arrive at a final accounting of the fate of the 305,000 fish that were reportedly in net pen #2 at the time of the collapse, it is necessary to estimate how many fish were extracted from the failed net pen during August 26-30. As discussed above, the Panel does not accept the reported figure of 136,722 fish.

The Panel estimates that the number of fish extracted from net pen #2 during August 26-30 was in the range of 34,000 – 53,700 fish. The Panel has added this range to other figures to arrive at an accounting of the 305,000 fish that were reportedly in net pen #2 on August 19 in Table 4.

The Panel considered the following in developing its estimate (estimates are rounded to the nearest hundred):

- Number-based estimates rely primarily on verified information (fish rates and durations the pump is on) and require only a decision about which fish count rate per 30-second period to use.
- Weight- and volume-based estimates require use of assumed figures for multiple variables (average weight per fish, amount of cooling water, packing density, vessel displacement, vessel trim, and fuel consumption).
- Information on the Lautenbach disposal receipt indicates that the number of fish disposed of cannot be greater than 84,500 if fish/cooling water are assumed to have weighed as little as 6 pounds per fish or 64,200 if the fish/cooling water weighed 7.9 pounds per fish. A weight of 6 pounds per fish represents a midpoint between the 3.71 pound figure that would be necessary based on tonnage figures (see subsection "Tonnage of disposed material") and the 7.9 pound average for fish harvested August 20-21. The Panel does not consider plausible a figure of less than 6 pounds per fish due to information regarding biomass/reported fish numbers for August 18, the size of fish at harvested August 20-21, the weight of fish recovered by the Lummi Nation, and observations of decomposition from the dive cam footage during extraction.
- The dive cam footage demonstrates clearly that a rate of 29-66 fish per 30-second period is reasonable to assume. Using this range, the number of fish extracted August 26-28 and 30 was 14,400 - 34,000 fish. If the full 19,810 fish reported by Cooke for August 29 is accepted at face value, the range of fish extracted August 26-30 was 34,000 - 53,700.
- The Panel concludes that the strongest lines of evidence, relying on the fewest assumptions are based on the dive cam/topside video footage. Therefore, the Panel gives greater weight to estimates based on analysis of that information. For these reasons, the Panel concludes that the range of extracted fish was 34,000 – 53,700, as described in the preceding bullet. The Panel believes there is no possibility the number of fish extracted is greater than the upper end of the range. It is possible that the number of fish extracted was less than the lower end of the range.

Table 4. Panel's accounting of 305,000 Atlantic salmon in net pen #2 following August 19, 2017 failure through January 15, 2018.

Location	Number of Fish	Source of Number	Rationale for Using Source
Harvested/extracted by Cooke (*Not* Released into Puget Sound)			
Harvest from net pen August 20-21	5,166	Report by Cooke	Additional documentation from Intl. Packing Company; reported numbers are realistic
Extracted from net pen August 26-30 by HARVESTOR	34,000 – 53,700	Estimate by Panel	See discussion above regarding how Panel arrived at this estimate
Extracted from net pen September 1-4 and transported by CLAM DIGGER	3,175	Report by Cooke	Although not documented by company or others, Panel sees no alternative to using these figures; reported numbers are realistic
Fish that Cooke Harvested or Extracted from Failed Net Pen 42,341 – 62,041			
Fish Released into Puget Sound 242,959 – 262,659			
Recovered by Cooke			
Recovered by beach seining	**388**	Report by Cooke	Although not documented by company or others, Panel sees no alternative to using these figures; reported numbers are realistic
Recovered by Tribes			
Marine	51,300	Fish tickets	
Rivers	233	Tribal reports	
Subtotal	**51,533**		
Recovered by Public			
Non-Tribal commercial	2,931	Fish tickets	
Recreational (includes Canadian reports)	1,958	Self-reporting to DFW webpage	
Subtotal	**4,889**		
Fish Recovered 56,810			
Fish Not Recovered 186,149 – 205,849			

What were the implications of Recovery Plan implementation on fish recovery?

1. Implications of the recovery process
    e. A pre-planned recovery effort was absent and the recovery lacked a coordinated response.
    f. Recovering fish from Puget Sound required a detailed understanding of co-management, fish regulations, fish science and an existing relationship with the fishing fleets. In the future, it may be more effective for DFW and co-managers to work together to design and implement recovery efforts with input and support from the net pen operator. The combined recovery effort could be tested and refined similar to the preparations for oil spill response.

2. Rapid response by fishery managers was necessary to allow Atlantic salmon-targeted fisheries.
    a. Fisheries were expanded to the extent practical within constraints associated with the federal Endangered Species Act (ESA) and the Pacific Salmon Treaty.
    b. The Fraser River Panel was responsive and met in timely fashion to increase fishing pressure in the area in a way that did not result in unacceptable increases to take of ESA-listed salmon stocks.
    c. The all-citizens commercial salmon fleet experienced a limited amount of effort. The all-citizens smelt drag seine fishery was mobilized in the area and was able to harvest a portion of the Atlantic salmon that were taken in fisheries.
    d. The recreational fishery self-reporting tool on the DFW website was useful to understand dispersal rate and locations.
    e. Recreational fishers were notified of current regulations allowing unlimited retention of Atlantic salmon, and as a result, recreational effort increased moderately in the area.
    f. The daily calls by the Unified Incident Command with governments and Tribes/First Nations were useful in understanding the effectiveness of the recovery efforts and where the fish were being recovered. In particular, the engagement of the Canadian government was helpful in understanding the northern extent of the Atlantic salmon dispersal.

3. Tribal fishers mobilized their fleets in response to fishing opportunity provided within constraints previously described. Tribal fishers did an excellent job mobilizing their fleet. It is not clear if the activation of the recreational fishery resulted in increased recovery of fish or hindered the more efficient use of nets employed by the Tribes.

4. The recovery response plan was not adequately detailed and future response plans need to be tailored to the site such that they reflect site-specific conditions, geography, currents and best approaches for recovery given those specifics. Initial recovery efforts were successful as the fish kept close to shore and were within the immediate area. As the recovery period moved past the first few weeks, however, the fish became widely dispersed or died and recovery became very difficult. In the future, recovery efforts should be immediate and comprehensive prior to dispersal.

What were the implications for the Puget Sound ecosystem from the Cypress Island Atlantic salmon net pen failure?

1. To date, there is no evidence that the escaped Atlantic salmon were eating native fauna nor is there evidence that they were sexually mature.

2. Over time, the fish in the marine system contracted native pathogens and have shown decreasing health status.

3. Atlantic salmon have been found in a limited number of rivers in Puget Sound (Skykomish and Skagit rivers). Atlantic salmon have not been seen at any DFW hatchery despite monitoring. There is no indication that Atlantic salmon have been caught in Nooksack drainage or at Whatcom Creek Hatchery drainage. DFW was present at the chum spawns in late fall at Bellingham Technical College and did not see any Atlantic salmon in Whatcom Creek.

4. The limited numbers of Atlantic salmon found in the freshwater system appear healthy. There is no evidence that they were feeding in the freshwater system nor were they sexually mature. The Atlantic salmon in freshwater may survive for some time.

Monitoring through the winter and the subsequent fall will be critical to know if the Atlantics remain in the freshwater systems and if they are reproducing.

"Lessons Learned" for State Agencies

The Panel developed a list of "lessons learned" by state agencies to prevent recurrence and improve regulation and oversight of Atlantic salmon net pen aquaculture as long as it occurs on the land and waters of Washington State. The list includes steps the state agencies are already taking, things that the agencies can begin doing that do not require substantial changes in funding or staffing, and steps that would require additional/reallocated funding and staffing to implement. Please also see Analysis/discussion section of chapter "Regulatory Environment."

The state agencies have already:

- Provided Cooke with *multiple* off-hours contacts for all three agencies.
- Determined that numbers of escaped fish will not be the sole or primary criterion for determining response to future incidents and that responses will assume under-reporting of numbers.
- Committed to get agency staff on-scene faster, especially for Cypress and Hope Island sites.
- Committed to a response mindset that will be more aggressive and forward leaning, using the models of oil spill and wildfire response. The agencies will repeat successful use of Unified Incident Command, expanding it to include NOAA. Similarly, the agencies will repeat use of the single point of contact for Tribal collaboration and single point of contact for media communications that worked well in response to the August failure.

The state agencies think the following steps can be taken going forward. These steps do not require substantial changes in funding/staffing but will require time to develop:

- Include in National Pollutant Discharge Elimination System (NPDES) permit renewals and in any future permits/leases greater emphasis on structural safety/stability and net biofouling management to prevent recurrence of July incident and August failure. Require documentation of actions.
- Require under DFW and NPDES permit-required site-specific Fish Escape Response Plan emphasis on recovery of escapees, possibly including:
    - Faster fishing response to mass escapes including use of vessels of opportunity;
    - Contact info for area Tribes to coordinate fishing response;
    - Planning based on site attributes, what type of fishing gear would be effective, and seasonal considerations; and
    - Require tabletop and deployment drills to maintain recovery plan readiness.
- Establish procedure for renting aircraft response for Cypress Island and Hope Island sites to assess damage to facilities and organize fishing response, billing back to lessee/permittee.

- Prepare in advance a post-incident water quality monitoring plan including monitoring at depth.

Finally, the state agencies could do the following if there was greater funding/staffing focused on managing Atlantic salmon aquaculture:

- Conduct periodic independent (contracted) review of operator-developed net pen mooring plans, site risk analysis, and inspection reports.
- Conduct periodic independent (contracted) inspection of net pens, as has been done by DNR during September 2017 – January 2018 at cost of $460,000.

Endnotes: References

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[190] Email from Kevin Bright, Permit Manager, to Eric Kinne, DFW, of August 28, 2018.
[191] Notes of interview with Kevin Bright, Permit Manager, of December 6, 2017.
[192] Food and Agriculture Organization of the United Nations:
http://www.fao.org/wairdocs/tan/x5898e/x5898e01.htm
[193] Photo IMG_1602.JPG taken by Police Officer Greg Erwin, DNR, on August 29, 2017.
[194] Photo IMGP0085.JPG taken by Sean Carlson, DNR, on August 29, 2017.
[195] Photo IMGP0092.JPG taken by Sean Carlson, DNR, on August 29, 2017.
[196] Email from Andrea Hennings, DFW, to Dennis Clark, DNR, of January 22, 2018.