To: Maine Department of Marine Resources
21 State House Station, Augusta, Maine 04333
From: John Krueger, Northport, Maine, Representing UpStream Watch.org
Date: February 28, 2020
RE: Nordic Aquafarms Permit Application Public Comments

The Maine Department of Marine Resources (DMR) intends to provide the Maine Department of Environmental Protection (DEP) with an assessment of the potential impacts of a project proposed in connection with a pending Natural Resource Protection Act permit application filed by Nordic Aquafarms Inc. of Belfast, Maine (Nordic).

My name is John Krueger[1]. In this testimony I will represent Upstream Watch. Upstream Watch is a loosely bound but tightly focused group of small business people, educators, scientists, historians, and citizen activists, together with current and former civil servants from local, state, and national government. The purpose of Upstream Watch is to advocate for the health of Midcoast Maine rivers and watersheds through science, education, and public action. More generally Upstream takes the position that now is the time to Conserve, Protect and Restore (CPR) Penobscot Bay and the Gulf of Maine.

Upstream has been an intervenor in the DEP permit review process regarding Nordic. Upstream seeks opportunities to provide information that might be helpful to the DMR review. As such, this testimony also includes numerous exhibits, (some have been shared with the Maine DEP). These exhibits are provided electronically to the DMR formal email: dmr.rulemaking@maine.gov.

Nordic has chosen a pristine green field and, if permitted, may be the 2nd largest land based salmon farm in the world. This is large for our small community (Size Matters). Upstream wishes to highlight more specifically the following areas for DMR to consider. Specifically - have these topics been reviewed as complete and adequate to protect the marine environment and fisheries interests?

1. **RAS Technology**
2. **Thermal Load and Contribution to Temperature Increase in the Bay**
3. **Currents in the Bay and Their Effect on Penobscot Bay Water Quality**
4. **Virus and Disease Introduction to the Bay.**
5. **Sea-Run Fisheries Status and Potential**

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[1]Experience/Background:
BS/MS Massachusetts Institute of Technology in Chemical Engineering
Director of Licensing & Enforcement and Director of Field Services at Maine DEP Director of the DHS Health and Environmental Testing Laboratory (HETL)
Consultant for the Association of Public Health Laboratories, Biomonitoring, Laboratory Data Interoperability.
Consultant for EPA Emergency Response Laboratory Network, through Computer Science Corporation

6. **Assessment of the Nordic Aquafarms Permit to Satisfy Clean Water Act Requirements and Provide Safe Effluent to the Bay.**
7. **Effects on the Bay Caused by the Construction and Existence of the Three Pipes**
8. **Finances and Lack of Exit Plan**
9. **Threats to Marine Resources**

1. **RAS Technology**

First, by providing a technology based effluent standard, the applicant can take little responsibility in setting any kind of water quality based standard to uphold and protect the environment and fisheries. Maine has few if any water quality based standards. The legislature has suggested that there is a need to create effluent standards. This might be a good time to begin this process.

As a side consideration, some dialogue has existed regarding Maine's own IF&W fish hatcheries and how their treatment system contrasts to Nordic's RAS system. Maine's hatcheries are essentially flow through systems and their treatment systems are certainly significantly less capable than Nordic's RAS system. This discussion should not conclude that Nordic's treatment system is therefore extremely adequate. Review of Department of Environmental Protection Environmental Graphical Analysis Data Base suggests that many of Maine's hatcheries may be discharging levels of organic/ammonia well in excess of recommended freshwater acceptable standards. Total kjeldahl nitrogen (organic and NH_3) as nitrogen minus the nitrate/nitrite levels represent the potential for high ammonia. Also there are situations of high Total Phosphorous as well. There is little if any monitoring data regarding disease management, though Maine's native sourced eggs do provide significant assurances. Flow through systems would not be appropriate in this pristine location.

Lacking these standards is why there is so much interest now in evaluating the Nordic version of RAS and determining if it is really the Best Available Technology. Recirculating tank aquaculture (RAS) is a great choice, but the choice of what type of RAS to use can make a difference. Those who choose **CLOSED** RAS, meaning no effluent out into a river or bay, yields all the benefits of growing fin-fish on land without the environmental risks. Those risks can be significant. **Partially OPEN RAS,** such as what Nordic is proposing, allows the discharge of millions of gallons of effluent a day into the bay.

There are concerns about nutrients, pathogen, viruses, pharmaceuticals etc. being released. **Fully CLOSED RAS i**s now in various stages of development in the US, Canada, Europe and the Middle East. These are often referred to as Minimum liquid discharge and Zero discharge systems. Aquifer based water supplies and hydroponic outputs to utilize nutrients are examples of ways these companies are assuring sustainability. Examples of companies include Aquamaof Aquaculture, Superior Fresh and Sustainable Blue. Many in the scientific community are behind the use of Closed RAS and its benefits. Large scale land based fin-fish aquaculture is in its infancy in Maine. If closed RAS systems are where the industry, and investors, are headed, it is important to focus on details now to insure Maine gets this right from the start.

As an unproven production process, RAS carries its own risks. The largest RAS facility right now is Atlantic Sapphire's operation in Florida. It is also a Norwegian enterprise. Just last year Atlantic Sapphire CEO and Chairman, Johan E. Andreassen was quoted as saying: "disease outbreaks, algae outbreaks, parasites and toxins are common problems in farming. While land plants have obstacles to stop most of these problems, there is no absolute guarantee." Do we want to be the site of a giant science experiment?

One way to assure that the Nordic RAS system adequately addresses environmental concerns would be to perform a "check point" review of the small sister RAS system in Fredrickstad and require 3rd party reviews of the facility using industry groups such as Nofitech.

2. **Thermal load and contribution to temperature increase in the Bay**

Temperature is a unique kind of pollutant, it is considered a "non-conservative" pollutant. It is not measured as concentration, but is instead a property of water. Thermal energy is not "in" the water in the same sense that copper atoms and ammonium ions are in water. Thermal energy is absorbed by the water molecules, which is manifested as temperature and a property of the water. Nordic has implied only a small increase in bay temperatures. Their calculations and models used lower temperatures for their effluent output (13 degrees C) and higher extremes of bay temperature (70 degrees F) and have painted a picture of a small 0.2 degree C increase in the bay. I believe we can safely dispute the 70 degree high temperature by using data collected by the Northeastern Regional Association of Coastal Ocean Observing Systems, NERACOOS. Their data at buoys in our area is collected 24/7 for several years, typically thousands of readings a year. The highest reading for 2018 for example was 64.3 degrees F.

One way to look at the effect of effluent discharge into a generally lower temperature body of water is to calculate the amount of thermal energy that is transferred from the Nordic discharge to the bay. This thermal energy can be calculated by looking at the specific heat of water, which is defined in joules needed to raise 1 kg of water by 1C. The heat capacity of water is 4179.6 $J \cdot kg^{-1} \cdot C$. Let's do the calculation.

First a few figures. As has been established in previous testimonies, we know the estimated temperature of the Nordic Effluent to be 18 degrees C (64.4 F) and the estimated average bay temperature over an entire year, derived from NERACOOS buoys, is 7.9 degrees C (46.2 F). Knowing the number of gallons of water (7.7 million gallons/day) we can calculate the kg of water that will be on average cooled from 18 to 7.9 degrees C (10.1 degrees) multiply this number by the specific heat of water, 4179.6 $J \cdot kg^{-1} \cdot C$. Thus we can calculate the joules of energy transferred to the bay in one day. I performed this calculation.

=1.23193e+12 Joules or 342,202.7 kwh, or 1,167,644,082.5 BTU's

To put these numbers in perspective this thermal loss to the bay is the equivalent in one day of burning 10,000 gallons of gasoline or the electricity used by 10,000 homes a day. This is a lot of heat going to a relatively shallow and small bay. Unfortunately, I cannot currently calculate what this might mean as a temperature increase and where the temperature increase might take place. Some of the heat may go to the bottom or to the atmosphere. Again, and maybe unfortunately, we are currently at the mercy of models and the need for more data.

If this project gets built, I hope that the Nordic prediction of 0.2 degrees C is accurate. If it is not, we are looking at a tremendous amount of heat that is being transferred. We do not want to create a permit that might exceed one of the few regulatory standards. Accurate modeling is very critical coupled with verified data. Nordic's Ramboll consultants recommended over a year ago that Nordic collect more data to support their modeling. If that had been done, we would be in a better position to model characteristics of their discharge.

The rate of mixing of the discharge plume with the water column will determine the rate at which heat is dissipated. We need to better define the so called mixing zone. Heat transfer, just like nutrients, can be exacerbated by stratification where heated effluents can be entrained in distinct layers in the water column, and subject to different forces such as wind and weather. We also need to take into consideration secondary circulations that can create isolated pockets of plumes distinct from an average dispersal.

So why so much discussion about thermal effects? This omission is surprising, especially since it is so well understood in environmental science that thermal pollution has profound impacts on the ecosystems where it occurs. Indeed, we are learning though climate change research that for some species single-digit changes in temperature can result in profound changes to their distribution, abundance and behavior. Therefore, it is vitally important and relevant to this project to fully understand the impact of the thermal anomaly - it will directly impact water column species, such as phyto- and zooplankton, larval fish and invertebrates and thereby the benthos and other species in the food chain that depend upon the water column. Similarly, if the benthos experience impacts in the vicinity of the thermal discharge, so too will the fish, waterfowl and human livelihoods that depend on it.

3. Currents in the Bay and their effect on Penobscot Bay Water Quality

A central component of rationally evaluating potential environmental impacts at the proposed site is the release of nutrients into the water column and their dispersal and dilution thereafter. Three important factors exist for evaluating the discharge into the local environment: local physical oceanographic conditions, local background water quality and waste-water composition. I refer you here to Exhibit 1, the December 13, 2019 testimony of Dr. Kyle Aveni-Deforge. Based on his understanding of the currently available data, these parameters have not been well enough described to make a confident risk assessment for water quality near the project site. Because the proposed project will operate

continuously throughout the year and possibly for decades, collecting a thorough data set that describes the background environmental and ecological conditions is crucial.
(space)
NAF has proposed monitoring programs for their facility once it is operational. Dr. Aveni-Deforge's testimony asserts that existing knowledge of site water quality and physical oceanography is insufficient to have confidence in our understanding of baseline environmental conditions or how the processed waste-water will interact with the environment. Consequently a rational, evidence based decision on the impacts of the proposed action cannot be made. Similarly, the future monitoring program proposed by NAF would not have enough baseline data from the pre-project environment at and near the project site to evaluate environmental impacts.

Exhibit 2 is the December 2019 testimony of Dr Neal Pettigrew. Dr. Pettigrew asserts that Nordic's Ransom modeling report acknowledges the need for significant data collection efforts before substantial model validation is possible. I agree strongly with this position, and suggest that a yearlong oceanographic observing effort should be fielded at least at the discharge and intake locations. These observations need to be combined with a full 3 dimensional ocean numerical model that can dynamically simulate the Penobscot Bay circulation and particle tracking. More specifically, the 2D ADCIRC model was implemented in a limited manner, *forced only by astronomic tides along the open boundary and a constant freshwater discharge from the Penobscot river* to the north of the study domain. Point-sourced validation of water levels were performed under idealized summer conditions. No additional validation was performed. The particle tracking model was forced solely by the velocity fields produced by the 2D ADCIRC model under several major assumptions. Currents were vertically averaged and did not agree with known observations, *constant values* were prescribed for effluent flow rate and horizontal eddy diffusivity, while wind fields and waves were excluded entirely.

4. Virus and Disease Introduction to the Bay

Exhibit 3 is from Bill Bryden of Newfoundland. His concerns can be summarized to state that large mortalities will exist and that these mortalities are primarily from: 1) local external known contagions entering the facility, 2) contagions entering the tanks via the eggs, 3) unknown causes at least in part due to unknowns to science pathogens. Recommendations include:

a) 1) reduce water use to aquifer only water, 2) use only local salmon genetics as per the Williamsburg Treaty recommendations, 3) require third party testing of effluent samples taken off Nordic's land such that chain of custody is maintained for legal purposes.
b) Native salmon will be drawn to the warmer effluent so there is a need to reduce temperature difference by cooling the water before discharge. Reduce pathogen creation by only allowing aquifer water be used.
c) Nordic should comply with the Williamsburg Treaty and only use native genetics and rapidly develop its own broodstock.
d) Cap antibiotics with serious fines as a deterrent, public reporting of amounts used on a weekly basis. Include a year around survey for contagions in source water before a permit is issued. Limit use to aquifer only water (town and nordic wells). Monitor for ingress of surface water

that can carry contagions.

e) Require weekly public disclosure of mortalities, disease events, diagnoses, antibiotic usage, and mass mortalities.
f) Long term monitoring of sturgeon for contagion loads. Challenge Sturgeon with salmon RAS contagions in a lab setting to determine transmissible contagions and required numbers of contagions per litre of water to facilitate infection.
g) Require any permit to state that a fishway will be installed if the dams need any alterations or removal.
h) Gather the required Antimicrobial Resistance (aka AMRs) Baseline Data and Testing by USA and Maine of Effluent for fish fungus and bacteria before the project starts as well as zoonotics. This is required to monitor for effects from the project after start-up.
i) Provide Mitigation and remedy bonds.

Exhibit 4 is the testimony of Brian Dixon, PhD Professor of Biology Canada Research Chair in Fish and Environmental Immunology. Dr Dixon's expertise lies in fish diseases. No filter is stringent enough to filter out viral particles. A 0.1 um filter would not filter viruses, which are nanometers in diameter, and filters this size would clog even more frequently. Once a pathogen entered a larger recirculating system, it would be extremely difficult to clear it out and would probably involve, at a minimum, euthanizing all the animals and bleaching the system. Dr Dixon provides significant information on the types of systems needed to manage diseases and on the effects some of these have on the RAS ability to treat waste.

5. Sea-Run Fisheries Status and Potential

Exhibit 5 is Upstream's Doug Watts' report on sea-run fisheries status and potential. DMR is the principal advocate in state government for promoting fish passage. We make the case that Nordic's plan to draw a portion of its fresh water supply from the Little River will make anadromous fish passage very difficult to achieve. Watts' report makes the case for the value of restoring fish passage to the Little River (i.e. sea run brook trout, smelt, tom cod, river herring, and salmon).

6. Assessment of the Nordic Aquafarms Permit to Satisfy Clean Water Act Requirements and Provide Safe Effluent to the Bay

The Nordic effluent can discharge chemicals, biologics, vaccines, medicines, and industrial cleaners. Nordic lists four industrial detergents, four disinfectants, four therapeutants, and five "emergency" compounds for disease control. All may appear in waste flows from the plant. Exhibit 6 is the December 2019 testimony of John Krueger and Gary Gulezian: **Assessment of the Nordic Aquafarms Permit to Satisfy Clean Water Act**. Documented is the inadequate evaluation of baseline stratification of temperature, oxygen and nitrogen, and inventories of fauna and flora in the bay.

Nitrogen pollution is likely. Nordic's factory will discharge 1,484 pounds of nitrogen daily. Excess nitrogen in seawater can cause algal blooms that lower the dissolved oxygen for marine life, leading to fish-kills and possible damage to the Bayside Mussel Farm, one of several small-scale aquaculture operations to the south. Other concerns are: providing enforceable water quality based standards, enforceable concentration based standards, multi-parameter monitoring program, contingency plans, feed analysis, and bay audiological analysis.

What the salmon eat, they will excrete. Nordic calculates it will need 216,758 pounds of fish food a day, but has not decided exactly what will be in it. If we do not know what they will be fed, we do not know what will bio-accumulate in their flesh or concentrate in the solid and liquid wastes produced.

7. **Effects on the Bay Caused by the Construction and Existence of the Three Pipes**

Mercury-laden sediments may be disturbed. Dredging required to bury Nordic's three pipelines may stir up and re-suspend mercury deposited 50 years ago by HoltraChem. Sediment samples taken found at least one with a mercury concentration of 239 nanograms/gram (ng/g). Concentrations over 200 ng/g justify closing an area to lobster and crab harvest.

An underwater seawall will change currents and habitats. Burying the pipelines will create a 5.5-foot high, ½-mile long underwater seawall off Northport. Lobster migration may be affected, currents will change, and shoreline erosion may increase.

8. **Finances and Lack of Exit Plan**

Nordic Aquafarms has submitted no evidence that they have the financial capacity to successfully and responsibly construct and operate this facility; no evidence of committed or available funding, and no financial projections. The RAS industry is young, untested, and overwhelmingly reporting losses and failures, and thus requires a high level of scrutiny. NAS has not demonstrated adequate funding to prevent serious risk to natural resources from ineffective maintenance and control of pollution mitigation systems or insufficient response to environmental emergencies. Exhibit 7 is a list of failed RAS systems.

Whatever short-term benefits Nordic may claim, the long-term impacts on native Atlantic salmon, cod, halibut, bivalves, elvers, herring, grasses, and seaweeds will be negative. Efforts to restore native marine populations will suffer, and so will the communities that live off them.

Nordic has no exit plan. Nordic representatives have said that their proposed factory has a 30-year economic life. NAF has dismissed the need for a closure plan to remove concrete and restore or reuse the land at the end of their tenure. It declined to entertain the setting of a performance bond to protect Belfast (and Northport) if the experiment fails.

9. **Threats to Marine Resources**

For a project that is as ambitious and impactful as Nordic's, with short, long term, and permanent impacts to uplands, wetlands, intertidal, subtidal and water column habitats, it is my opinion that direct, field observations and quantitative assessments of the biological resources should be performed in every season, and in every habitat, that will experience impact from project activities. There are real consequences and implications in failing to properly characterize the ecological communities in the project area. Simply put, this failure opens doors for unintended consequences and the potential for harm to important and protected natural resources both on land and in the water.

Specific evaluations of marine resources should be evaluated:

a) The applicant analysis should point out and discuss the fact that to get to and from the open Gulf of Maine and into the Little River or up the Passagassawaskeag River, some elvers would have to pass through anomalous water discharged by Nordic.
b) Though alewives and blueback herring do not presently use the Little River, adults could be moving through the project area on their way to the mouth of the Penobscot River.
c) The project area, with its mainly soft bottom, would likely be suitable habitat for winter flounder spawning and nursery habitat. Yet again, no mention of what impact might be experienced by winter flounder from exposure to project-caused anomalies or indirectly to them from the impact to their food sources.
d) Rainbow smelt after hatching larvae may not drift to estuarine waters if there is any impact from the permanent presence of a thermal/chemical plume while they reside in or move through the impact area.
e) In regards to the very important endangered Atlantic salmon, while juveniles are documented to use Belfast Bay as a western corridor of Penobscot Bay to get from their natal waters within the Penobscot River to the ocean, Atlantic salmon who come into contact with Nordic discharge waters might reasonably be exposed to biological agents, such as fish-borne diseases, not removed by Nordic's Effluent/Wastewater treatment technology. Any Atlantic salmon so exposed might become vectors for diseases at a time when this imperiled population is in a vulnerable, rebuilding phase.
f) Both species of sturgeon in the affected area, which are federally listed, may be affected by the large and permanent offshore thermal anomoly, chemical and possibly biologically active plume covering 1 or more square miles of Belfast and west Penobscot Bays.
g) Regarding American lobster, there is no mention at all about the large, thermal anomaly and what impacts it might have on the distribution and abundance of American lobsters in an area of Belfast Bay, that may be as large as between 700 and 1500 football fields in size. Current research indicates that even a few single degrees of warming in Gulf of Maine waters may be sufficient to compel lobsters to relocate en masse to colder waters in Canada.
h) Finally, there is concern that scallops, blue mussels, and soft shell clams will not be able to modify their behavior to endure the change in water conditions when the entire benthic region and the water column upon which these filter-feeders depend will host a permanent, chemical and thermal anomaly.

As with the benthos, the full evaluation of effects to fin-fish, molluscan and arthropod fisheries from project impacts can only be understood vis-à-vis robust baseline ecological studies within the project area, throughout the year, and inclusive of areas both near the discharge as well as areas within the modeled receiving area. No such surveys were done, and no such approach was taken. Exhibit 8 is testimony from Richard Harris Podolsky, Founder and CEO of Ecology And Technology, an environmental science consulting company based in Camden, Maine.

In summary, this testimony identifies a number of deficiencies in the Nordic application. These deficiencies are particularly concerning given the fact that the project would have profound and permanent impacts to uplands, wetlands, inter and subtidal and water column habitats and to the biological food chains upon which so many species, including human livelihoods, depend.

Attachments Provided Electronically

Exhibit 1 Dr. Kyle Aveni-Deforge
Exhibit 2 Dr Neal Pettigrew
Exhibit 3 Bill Bryden of Newfoundland
Exhibit 4 Brian Dixon, PhD Professor of Biology Canada Research Chair in Fish and Environmental Immunology
Exhibit 5 Doug Watts
Exhibit 6 John Krueger and Gary Gulezian
Exhibit 7 List of Failed RAS projects
Exhibit 8 Testimony of Richard Harris Podolsky