DECLARATION OF TODD SANDELL, M.S., Ph.D.
IN SUPPORT OF NOTICE LETTER FOR VIOLATIONS OF THE ENDANGERED SPECIES ACT RELATING TO ESA CONSULTATION ON PUGET SOUND COMMERCIAL SALMON FARMS

I, Todd Sandell, declare the following on the basis of personal knowledge to which I am competent to testify:

1. My current address is 4021 NE 196th St., Lake Forest Park, WA, 98155.

PROFESSIONAL QUALIFICATIONS

2. I am a senior ecologist for the Wild Fish Conservancy, which position I have held since December 2010. I have a BS degree in Biology from Bowdoin College (Brunswick, ME). In 2001, I received a master's degree in Microbiology from Oregon State University in Corvallis, Oregon. I earned a Ph.D. from Oregon State University in 2010 in Pathogenic Microbiology. I have substantial knowledge and experience in parasitology, immunology and the disease ecology of Pacific salmon (how pathogens and parasites influence and regulate populations).

3. My undergraduate work at Bowdoin College (Brunswick, ME) included a focus on immunology. In my senior year I completed an independent study project isolating the cymbidium mosaic virus and generated a rabbit polyclonal antibody to that virus for use in future research. Later I worked at the Barbara Davis Clinic for juvenile (Type I) diabetes at the University of Colorado Health Sciences Center (Denver, CO) where I studied the interactions of the immune system as autoimmunity arose, leading to diabetes in humans and a mouse model. Our work focused on the role of macrophages in triggering the autoimmune cascade and on the development of a synthetic insulin molecule that would not trigger an autoimmune response.

4. After this I attended Oregon State University (OSU; Corvallis, OR) where I initially studied the salmonid immune system response to the pathogen *Renibacterium salmoninarum*; the research focused on macrophages, which harbor the bacterium, and their potential to clear this intracellular pathogen when activated. The lab in which I studied also focused on the human parasite *Schistosoma mansoni*, and as a result I learned much about comparative immunity and the unique aspects of the teleost (bony fishes, which includes salmon) immune system.

5. Later I moved to the Microbiology department and OSU's Salmon Disease Laboratory, where I studied the dynamics of an exotic parasite, *Myxobolus cerebralis* (which causes Whirling Disease in susceptible salmonids), on the salmon and trout populations in the Lostine River, Oregon. This work investigated the role of the environment on parasite transmission with histology, fluorescent antibody techniques and PCR, and identified factors increasing the density of the alternate host and on infection and disease risk.

6. I then spent 7 years at the Hatfield Marine Science Center investigating how pathogens affected the growth and survival of juvenile salmon shortly after marine entry, as well as during their emigration through the Columbia River estuary.

7. Interest in this work led me back to graduate school at OSU, where I studied the disease ecology of juvenile salmon in nearshore marine waters of the northeast Pacific Ocean, utilizing polymerase chain reaction (PCR) and quantitative PCR (qPCR), among other techniques, to detect and quantify bacterial, viral and parasitic organisms and model their effects on growth and survival. I defended my dissertation in

2010 and continue to publish findings from that research. A list of relevant publications is included in with my *curriculum vitae* attached hereto.

SUMMARY OF OPINIONS

8. In summary, it is my opinion that the commercial salmon farms in Puget Sound likely have some adverse effects on native salmonids protected under the Endangered Species Act ("ESA"). It is further my opinion that the outbreak of the infectious hematopoietic necrosis virus ("IHNV") in May of 2012, at net pen complexes near Rich Passage at the southern end of Bainbridge Island, likely led to increased infection levels (and potential mortality) in native stocks of wild, juvenile Pacific salmon within Puget Sound, Washington with IHNV.

ESA-LISTED SALMONIDS IN PUGET SOUND

9. The Puget Sound Chinook salmon evolutionary significant unit ("ESU") was listed as a threatened species in 1999.

10. The Puget Sound distinct population segment ("DPS") of steelhead was listed as a threatened species in 2007.

11. The Hood Canal summer-run chum salmon ESU is listed as a threatened species.

THE MAY 2012 IHNV OUTBREAK

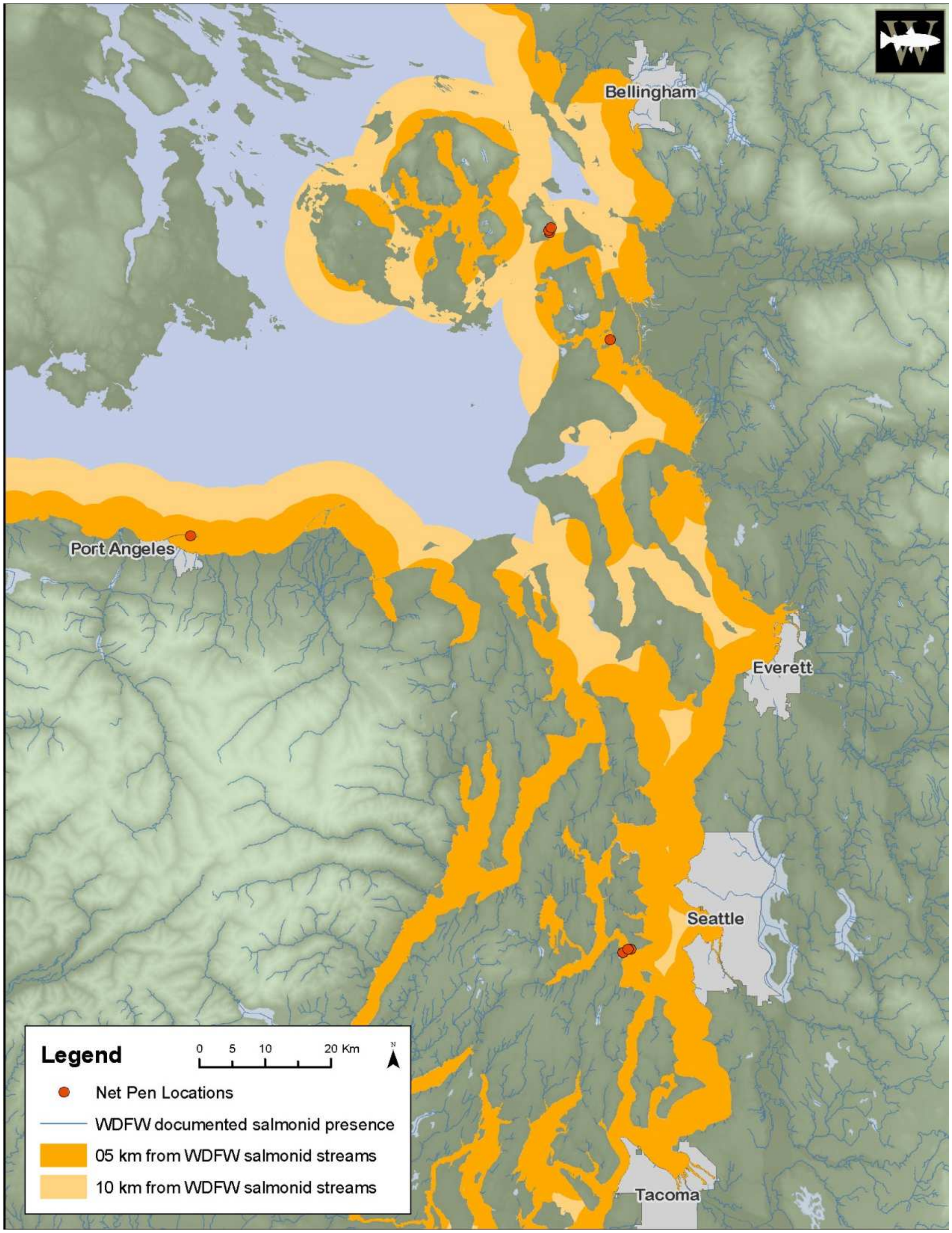
12. IHNV is among the most virulent pathogens of salmonids, and for this reason is listed as a "reportable disease" by the World Organization for Animal Health (OIE), the international body charged with controlling the spread of animal diseases. In 2012, a major outbreak of IHNV occurred at three Atlantic salmon net pen feedlots in Puget Sound, just minutes from downtown Seattle: Fort Ward, Clam Bay, and Orchard

Rock. This outbreak is concerning because of the speed at which the disease spread; the close proximity of the net pens led to a rapid disease progression that exposed native salmonids to elevated levels of the IHN virus and likely caused harm to two threatened species (Puget Sound Chinook salmon and steelhead trout). While it is likely that the net pen infections arose from wild salmon, the high densities of Atlantic salmon, which are highly susceptible to IHNV, artificially elevated ("bioamplified") the number of viral particles present in South Puget Sound, increasing the infection risk for native juvenile salmon.

13. At present the State of Washington and the federal agencies concerned do not stipulate minimum distances between the pens and do not take factors like tidal flow (affecting pathogen plumes emitted from the pens) and proximity to salmon bearing streams into consideration, despite decades of work (and catastrophic disease outbreaks costing billions of dollars in the Norwegian and Chilean Atlantic salmon farming industries) that led to the development of guidelines to reduce disease transmission. While international (OIE) guidelines suggest a minimum of 5km between pens, a study in Chile (Mardones et al. 2011) suggested that 10km between pens might be a safer guideline (note that there are no native salmon in Chile; this guideline was meant only to protect one salmon farm from infection by an adjacent farm). In those countries, the guidelines were put in place to limit the spread of disease between farms or between farms and wild fish, and *were developed to assist the salmon farming industry in protecting their investments*.

14. The placement of these net pens is also a concern; floating between two Washington state parks, the Orchard Rocks marine reserve (two of the net pens are

actually within part of the reserve's boundaries), and the Northwest Fisheries Science Center's Manchester Research Station (NOAA), where several endangered salmon stocks have broodstock rearing to assist in recovery efforts. These net pens are also in the middle of wild salmon habitat (see map, below), including that of ESA listed Puget Sound Chinook salmon and steelhead stocks. Juvenile salmonids, the life stage most susceptible to IHNV (Lapatra 1998), must emigrate past these pens and the pathogen plumes they generate on their way to sea. A map showing the distance from the existing net pens in Puget Sound to the mouths of salmon bearing streams is below (data from WDFW: http://apps.wdfw.wa.gov/salmonscape/); the different shades of orange show proximity to salmon bearing streams at 5 and 10 km distances; the grey shading highlights urban areas. Note that there are few areas within the main basin of Puget Sound that are outside of the 5km buffer (land is shaded green);



15. Despite a declared "quarantine" of the infected pens (which does nothing to prevent the virus being shed from infected Atlantic salmon into the water flushing through the pens), the virus quickly spread to open water facilities at two other locations

in South Puget Sound, including one near the Orchard Parks Marine Reserve and one in Clam Bay. The outbreak may also have affected nearby tribal salmon pens off Squaxin Island. At the time, Bruce Stewart, fish health program manager for the Northwest Indian Fisheries Commission, voiced concern over the delay in removing the infected salmon: "We are concerned about the virus amplification that is occurring from the affected pens, and the length of time the amplifying event is occurring over …American Gold reported increased mortalities starting in April. We now are at end of May and infected fish are still in those pens shedding virus." (http://nwifc.org/2012/05/ihn-virus-detected-in-atlantic-salmon-farm-near-bainbridge-island/).

16. A recent study of IHNV viral shedding and persistence in British Columbia (Garver et al. 2013) reported:

> "Using the laboratory estimates of IHNV shedding capacity of Atlantic salmon as derived herein, it is possible to quantify virus amplification potential from infected sites. For instance if 1% of 500,000 Atlantic salmon contained in an open net-pen site are undergoing acute IHN disease there is a **potential for this outbreak to generate upwards of 1.6 X 10^{11} plaque forming units (PFU) in one hour** during peak virus shedding" (Garver et al. 2013).

That estimate is derived from one pen (500,000 fish) if only 1% (5,000) fish were acutely infected. The number of viral particles released from each infected fish is equal to (1.66 X 10^{11} PFU/5,000 fish) = **32,000,000 PFU released per acutely infected fish per hour**.

17. A May 26, 2012, Associated Press article carried in the Seattle Times reported: "Seattle-based American Gold Seafoods plans to remove more than a million pounds of Atlantic salmon from infected net pens in Rich Passage. In April, the company noticed fish were dying off at a fast rate. Test

results this month confirmed the virus." (http://www.seattletimes.com/seattle-news/wash-fish-farm-kills-stock-after-virus-found/).] If an average Atlantic salmon weighs 7 lbs. at harvest, one million pounds of fish culled equates to 142,857 fish.

18. The net pens in question held infected Atlantic salmon (almost certainly more than 1% infected given the high mortality rate) for an estimated 60 days (1,440 hours). Using the conservative estimate of 142,857 fish culled by American Gold Seafoods, this would have resulted in **65,848,320,000,000** viral PFU being released from the infected Atlantic salmon into South Puget Sound during the course of the outbreak [(= 142,857 *1%= 1,429 fish acutely infected at peak shedding); ((1,429 fish) *(1,440 hours)*(33,200,000 PFU per fish per hour)) = **65,848,320,000,000 (** 6.58483×10^{13}**, or 65 *Tera***)].

19. The volume of South Puget Sound is roughly 9% of the 168 cubic kilometer (km^3) total volume for all of Puget Sound (http://www.cev.washington.edu/lc/CLFISH497/Web5.html#PHYS), which equals 15.1 km^3 or 1.51×10^{10} cubic meters. Applying the calculation from 1,429 infected fish to the estimated volume of 15.1 km^3 means that **3,024,338,624 (3.02×10^9) viral PFUs were released per hour per km^3 of water into South Puget Sound**.

20. The IHN virus may remain viable for up to five days in seawater (depending on UV exposure and other factors; (Garver et al. 2013); assuming a 5-day viable lifespan for a viral particle, **3.02×10^9** PFU per hour per km^3 equates to **an instantaneous concentration ((5 days)*(24 hours)=120 hours) of 3.62921×10^{11} total PFU per km^3 (=363 per m^3) during an outbreak**. Given that a dose of 10 plaque

forming units (PFU) may initiate active infection in exposed juvenile Atlantic salmon, the risk of disease transmission to native salmonids – even if they are more resistant to infection – during such an outbreak becomes obvious. While additional experiments and analyses are needed to accurately define the likelihood of transmission, it is my opinion that it is highly likely that at least some ESA-listed salmonids were infected as a result of this outbreak.

21. Note that the IHNV viruses released into Puget Sound in 2012 from the commercial net pens were almost certainly not evenly distributed throughout the water column - it is likely that due to thermal and density layers (e.g. pycnoclines) that inhibit vertical mixing, viral particles would have remained concentrated in the upper water layers near the surface where juvenile salmonids reside. In addition, the viral concentrations near the net pens would have been significantly higher due to proximity to the source (the net pens). This indicates that the concentration of viral particles was almost certainly higher (potentially many times higher) than the conservative estimate given above, although this point should be a topic of further research. In addition, the outbreak occurred in April and May- when juvenile Chinook and coho salmon emigration nears its peak; the location of these net pens in nearshore waters means that juvenile Pacific salmon must migrate past them, and their pathogen plumes, while emigrating to the ocean.

22 IHNV is a highly virulent member of the Rhabdoviridae family, is naturally occurring from the Pacific Northwest to Russia (Kamchatka), Japan and Korea, and infects most salmon species and rainbow trout (and steelhead) to varying degrees. The virus is also found in Europe, presumably as a result of the transfer of infected

rainbow trout from North America (Johansson et al. 2009). Salmon lice (*Lepeophtheirus salmonis*) have been identified as a mechanical vector for the virus (meaning they introduce the virus to new hosts by piercing the skin, but are not internally infected) (Jakob, Barker, and Garver 2011);

23. There are three clades of IHNV, each typically found in a specific geographic area. The "U" clade (most pathogenic for sockeye and kokanee, as well as Chinook salmon and rainbow trout/steelhead) is common in B.C. and Alaska, the "M" clade (most pathogenic for steelhead/rainbow trout, as well as Chinook salmon) is found in the Columbia River basin and the Olympic Peninsula (including the Chehalis River basin), and the "L" clade (most pathogenic for Chinook salmon) is typically found in southern Oregon and California. Preliminary reports are that the recent outbreaks are in the U clade, and thus pose the greatest risk to sockeye and steelhead, but the virus appears to also have infected farmed coho salmon in B.C. *Juvenile salmon are at the highest risk of mortality from IHNV infection* (Lapatra 1998), although survivors may also act as carriers of the virus and may begin shedding viral particles when stressed; in some cases adult fish have been reported to succumb to the infection.

24. In summary, given the magnitude and duration of the IHNV outbreak, the proximity of the infected net pens to nearshore habitats utilized by juvenile Pacific salmon, and the proximity of the pens to salmon bearing streams in South Puget Sound, it is highly likely that ESA-listed Chinook salmon and steelhead trout were harmed.

OTHER POTENTIAL EFFECTS THAT ARE OF CONCERN

25. In addition to several concerns about the effects of net pens widely noted in the literature (e.g. release of chemicals, heavy metals, antibiotics released from fish

farms leading to antibiotic resistance (Goa et al. 2012), the use of baitfish in feed pellets which may deplete food supplies for wild salmon, etc.), the several points discussed below deserve further consideration with regard to the net pens in Puget Sound.

26. It is widely acknowledged that salmon net pen operations have unintentionally released Atlantic salmon into the waters of the Salish Sea since the introduction of marine net pens in the 1980's, though the number of escapees has declined as netting and other practices have improved. However, concern over the introduction of self-sustaining Atlantic salmon populations derived from net pen escapees has been downplayed over the years, due in part to the failed attempts by state fish and wildlife departments to intentionally introduce the species into the Pacific Northwest from 1904 to 1991 (Waknitz et al. 2002). However, a study in the Tsitika River (a moderate-sized (42-km mainstem length) remote river system on the northeast coast of Vancouver Island, Canada) published in 2000 (Volpe et al. 2000) found juvenile *Atlantic* salmon of two size classes present. That they were Atlantics salmon was confirmed by genetic analysis, and scale analysis suggested that they were the naturally produced offspring of adult Atlantic salmon that had spawned in the river. The study also reported that their dietary intake overlapped almost completely with that of native salmonids in the river, implying that they were competing for resources with the native, wild fish.

27. A more recent study (Fisher, Volpe, and Fisher 2014) found that Atlantic salmon offspring were present in 36.6% of the 41 rivers surveyed over a three year period, and occupancy models (models were used because detection frequency of species at low abundance is imperfect) suggested that Atlantic salmon were present in 97% of those rivers and streams occupied by diverse assemblages of native Pacific salmon. The

authors concluded that the continued low-levels of escaped Atlantic salmon in British Columbia (where salmon farms are numerous and of a much larger scale than in Puget Sound) posed a threat for the establishment of this foreign species in waters of the Pacific Northwest, ending "Their [Atlantic salmon] current distribution, and the potential effects on Pacific ecosystems and native Pacific salmon, is a conservation priority that has been neglected in the push for economic return" (Fisher, Volpe, and Fisher 2014, pg. 2145). The authors also pointed out that the habitats encountered in British Columbia are common from the Oregon coast through southeast Alaska.

28. A very recent Scandinavian study detailed the capture of farmed Atlantic salmon infected with two different viruses (salmon alphavirus and piscine reovirus) in a nearby river after they had escaped from their net pen, highlighting the ability of escapees to also transmit pathogens directly to the spawning grounds of wild fish (Madhun et al. 2015).

29. Sea lice, a problematic parasite in British Columbia (little data is available for Puget Sound), have also been a major source of farmed Atlantic salmon loss in Norway. Despite intensive research and the development of therapeutic drugs to address the issue, sea lice control measures are failing in Norway: http://www.worldfishing.net/news101/industry-news/norway-to-slaughter-sea-lice-infected-salmon (10/2013). "The Norwegian authorities have recently ordered that some two million sea-lice infested farmed salmon in the Vikna district of Nord Trondelag be slaughtered with immediate effect after becoming resistant to chemical treatments against the sea-lice parasite. The action has been prompted specifically to protect wild young salmon (smolts) migrating through the fjords to the open sea next May and June from

huge numbers of juvenile sea-lice being produced on and released from particular salmon farms that have been unable to control their lice numbers."

30. Native juvenile salmon (and other fish species) have been shown to congregate around net pen farms due to food availability and shelter from currents, among other reasons (Fernandez-Jover et al. 2008; Dempster et al. 2009). This has the potential to increase their exposure to pathogens, and infected fish may then serve as a disease "vector" (a route of disease transmission) over long distances as juvenile salmon migrate to and from the ocean.

31. In addition to bio-amplifying viruses (and potentially other pathogens), an impact of salmon farming which has only recently gained attention is the potential for salmon raised in net pens to generate more virulent pathogens. The high rearing densities, continuous introduction of native hosts into the net pens, stress, and lack of selection for resistance (all fish are harvested, rather than breeding those that have a higher natural resistance) found in salmon farming operations result in ideal conditions for viral amplification and the evolution of increasingly pathogenic strains. This has been reported both for exotic (foreign to the Pacific Northwest) pathogens like Infectious Salmon Anemia Virus (ISAV; Christiansen et al. 2011; Are Nylund et al. 2003; A Nylund et al. 2007) and native (endemic) pathogens like infectious hematopoietic necrosis virus (IHNV; Troyer and Kurath 2003) and viral hemorrhagic septicemia virus (VHSV; Einer-Jensen 2004).

32. NOAA's stated mandate to expand U.S. aquaculture production may undermine adequate supervision of the finfish aquaculture industry:

> "The US Government advocates a strong policy for national aquaculture development. The Department of Commerce (DOC) has set specific 25-

> year goals to offset the annual $7 billion imbalance in seafood trade, and to double employment and the export value of goods and services. The policy is reflected in strategies proposed by the National Oceanic and Atmospheric Administration (NOAA) and its three line agencies responsible for certification of aquaculture-related activities. With its broad mandate for stewardship of the nation's marine and coastal living resources, NOAA recommends that aquaculture development and environmental protection proceed hand in hand to meet public needs. Thus, in keeping with the Government's firm commitment to the United Nations Food and Agriculture Organization's (FAO) Code of Conduct for Responsible Fisheries, the line agencies of NOAA are encouraging the fisheries and aquaculture sectors to develop national Codes of Conduct, and their sub-sectors to develop and abide by Best Management Practices (BMPs)." (Nash 2001)

33. Promoting aquaculture poses risks to the existing fishery for Pacific salmon, the associated economic impact, and job creation within the fishery, which were estimated in a press release by Senator Maria Cantwell (2011) following reports of detection of Infectious salmon anemia virus (ISAV) in BC:

> "We should not rely on another government – particularly one that may have a motive to misrepresent its findings-- to determine how we assess the risk ISA may pose to American fishery jobs… **One recent study of Pacific salmon estimated the wholesale value of the annual catch at least $2.2 billion dollars, supporting 35,000 harvesting and processing jobs**…With so much at stake, a rapidly spreading virus that causes disease in wild Pacific salmon could be economically and ecologically devastating…While a few scientists may downplay the threat to wild Pacific salmon posed by the ISA infections recently detected in British Columbia, we believe the lessons learned from other recent fish disease outbreaks suggest that ISA should be cause for considerable concern now." [emphasis added]

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct to the best of my knowledge.

Executed this 19th day of August, 2015.

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Todd A. Sandell, M.S., Ph.D.

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