

Atlantic Salmon in Washington State: A Fish Management Perspective

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Executive Summary

Atlantic salmon (*Salmo salar*) are commercially reared in marine net pens in Washington State. The industry produces over ten million pounds of salmon each year with a total annual economic value which exceeds \$40 million. The salmon net pen industry in British Columbia, Canada, is ten times larger than Washington.

One aspect of fish farming which concerns fishery managers is the escape of farmed fish and the impact escapees might have on native salmon stocks. This is of particular interest because of the recent listing of many salmon stocks in Washington as *endangered* or *threatened* under the Endangered Species Act (ESA). Annual escapes of salmon from pens in British Columbia are estimated to be approximately 60,000 fish (*Salmon Aquaculture Review*, British Columbia). Annual escapes in Washington prior to 1996 are not recorded, however, in 1996, 1997, and 1999, catastrophic events resulted in the escape of 107,000, 369,000, and 115,000 Atlantic salmon, respectively.

The scientific evidence available prior to the summer of 1998 suggested escaped Atlantic salmon were not colonizing local watersheds and were not significantly impacting native fish. However, in 1998 and in 1999, naturally-produced Atlantic salmon were discovered in streams on Vancouver Island, British Columbia. This evidence indicates escaped Atlantic salmon are capable of successfully producing offspring in the wild. To date, there is no evidence of a naturally-produced Atlantic salmon surviving in the wild to maturity and spawning. Much is still unknown about escaped Atlantic salmon in Washington.

The Washington Department of Fish and Wildlife (WDFW), the state agency with the mandate to manage the fish and wildlife resources of the state, has limited authority over private aquaculture. The authority of WDFW is limited to disease prevention and control. The Departments of Agriculture and Ecology are the agencies in Washington which regulate the industry and the escape of fish. Only after the fish have escaped does WDFW have authority to take action to manage the outcome.

Recommended actions to address the management of escaped Atlantic salmon include: 1) re-establish the authority of WDFW or other appropriate state agencies to manage most aspects of aquaculture, excluding marketing and commodity boards, which should remain with the Department of Agriculture, 2) provide adequate resources to WDFW to evaluate the impact of escaped Atlantic salmon on fish stocks in Washington and provide the resources necessary to manage the additional aquaculture regulatory authority being requested for WDFW or other appropriate state agency, 3) actively work with the fish management agencies in British Columbia, both federal and provincial, and the aquaculture industry, to ensure aquaculture regulations and management policies are consistent throughout the region, 4) actively pursue the implementation of an Atlantic salmon breeding program which requires the use in production of fish that are unable to reproduce in the wild (such as mono-sex or triploid fish) and, 5) institute a comprehensive code of practice for commercial salmon aquaculture administered by WDFW to ensure environmentally-sound fish culture. The code of practices should be implemented within a management framework jointly developed with the Ministry of Fisheries (BC) and the aquaculture industry.

Introduction

The Atlantic salmon (*Salmo salar*) is an anadromous ⁽¹⁾ species of trout native to the regions surrounding the northern Atlantic Ocean. This fish has gained notoriety through the centuries for its desirability in recreational fisheries. Attempts have been made by fish and wildlife agencies during the twentieth century to introduce and establish this species in Washington without success. Within the last thirty years, Atlantic salmon have become the mainstay of commercial net pen aquaculture in Washington as well as throughout North America, Europe, South America, and Australia. The Atlantic salmon is the favored species for aquaculture in cold marine waters because of its consistent growth performance, resistance to disease, and appeal to consumers. Since salmon net pens are sited in open marine waters, consideration must be given to impacts of operations on the environment. Of particular interest to fishery managers is the potential impact of Atlantic salmon on wild salmon should they escape from the pens and co-mingle with other fish and wildlife in waters of the state.

This paper will review the issue of escaped Atlantic salmon and their potential impact on native fish stocks. Consideration will be given to: 1) the history of Atlantic salmon in the Pacific Northwest, including attempted introductions, 2) the establishment of the commercial aquaculture industry, 3) fish management concerns revolving around Atlantic salmon, particularly in light of the listing of several stocks of Pacific salmon under the Endangered Species Act (ESA) by the United States Department of Commerce, National Marine Fisheries Service, and, 4) the regulatory roles and responsibilities of local, state, federal, and tribal authorities.

The issues of escaped Atlantic salmon and the consequence of the escapes will also be discussed. These issues include the impacts of competition, predation, disease transfer, hybridization, and the possibility of colonization. Authorities and sources of information for this report include the final programmatic environmental impact statement on net pen aquaculture (*Fish Culture in Floating Net Pens*, Washington Department of Fisheries, 1990), proceedings of the *Pollution Control Hearings Board* of Washington State (hearing the appeal of the issuance of discharge permits for marine net pens by the Department of Ecology), and the *Salmon Aquaculture Review* prepared by the Environmental Assessment Office, provincial government of British Columbia , Canada (to be referred to as the *B.C. Review*).

After a historical review of Atlantic salmon culture and an examination of potential impacts of escaped fish, we will propose management strategies for Atlantic salmon from the perspective of the Washington Department of Fish and Wildlife (WDFW) - the agency responsible for the management of fish and wildlife in the state. Resources needed to manage Atlantic salmon will also be identified. Finally, legislation will be discussed which would improve management of Atlantic salmon in Washington and make it consistent with strategies in place in Canada.

Historical Background

Atlantic salmon have played an important role in recreational fisheries in North America and Europe. Because this sea-going trout grows to a large size, willingly takes flies or lures in fresh water, and has excellent flavor, it is eagerly sought by anglers. It is similar in many ways to the steelhead trout which is native to Northwest waters. For these reasons, state fishery managers in the past have imported, cultured, and stocked Atlantic salmon with the hope of establishing wild populations which would provide additional and unique fishing opportunities in the state. The release of Atlantic salmon smolts for the purpose of establishing runs in Washington by the department occurred in 1951, 1980, and 1981. Additionally, many releases were made in lakes for the purpose of establishing a fishery in those lakes (Table 1). None of these releases resulted in the return of adult Atlantic salmon. Attempts throughout the United States and world to introduce and establish Atlantic salmon outside the Atlantic Ocean have failed.

Research to develop marine net pen aquaculture was conducted in earnest in the late 1960's and early 1970's. Some of the preliminary research was conducted in Puget Sound near Manchester, Washington,

by the National Marine Fisheries Service (NMFS). Both Pacific and Atlantic salmon were grown in marine net pens. As a result of this research, captive broodstocks were developed which could be used to restore depleted salmon runs. Many of the research efforts of NMFS were focused on helping to restore Atlantic salmon runs in the northeastern United States where native runs had been depleted due to over-harvest and habitat degradation. As the technology proved successful, the use of pens in commercial aquaculture flourished world-wide. Norway made a significant national effort to develop the industry utilizing Atlantic salmon as the primary species. Initial efforts in commercial net pen culture in the Pacific Northwest utilized Pacific salmon. Intensive breeding programs have selected traits of the Atlantic salmon which make them highly domesticated and amenable to culture. It is these traits which make the Atlantic preferred over the Pacific salmon for most aquaculture situations. Today, virtually all of the commercial marine net pen industry in Washington and approximately 80% of the industry in British Columbia (B.C.), produce Atlantic salmon.

The Washington State Legislature and Governor Booth Gardiner recognized the similarities of commercial aquaculture to farming and proclaimed "aquaculture is agriculture" in 1985. Legislation was passed which designated the Department of Agriculture as lead agency in the state for the promotion and marketing of cultured salmon. WDFW (then the Department of Fisheries) was designated in the act to be responsible for administering fish disease control and prevention regulations which were to be jointly developed with the Department of Agriculture.

In the 1980's, the Washington State Legislature directed WDFW to conduct a programmatic environmental impact statement (PEIS) of net pen aquaculture. The purpose of the PEIS was to "assist state, county, and local decision makers in evaluating proposals for fish farm sites by compiling existing knowledge regarding potential significant environmental impacts of siting fish farms in Puget Sound". The final report was prepared under contract by Parametrix Inc. and was published in January, 1990. Issues considered in the PEIS included the import of new fish species, genetic issues, disease issues, and other factors which might affect the environment.

Since the beginning of marine aquaculture in the early 1970's, including both commercial and public/tribal operations, fishery managers have been aware of the potential for net pen fish to impact native fish stocks in the Puget Sound region. These concerns encompassed the biological impacts (competition, disease transfer, hybridization) of both escaped aquaculture fish and salmon released from enhancement projects operated by the state. The best available knowledge indicated that the impacts were insignificant and could be managed. To manage the potential impacts of disease, policies and regulations were implemented by WDFW in 1987. These rules were developed in a collaborative process with state, federal, tribal and industry representatives. The only legal authority granted WDFW by the legislature in 1985 over commercial aquaculture was the prevention and control of fish diseases. Escaped fish did not appear to present risk as the literature did not indicate a single example of Atlantic salmon being successfully established in a new area. There was not a concern for the establishment of the Pacific salmon released from the enhancement projects as these species were native to Puget Sound.

Before 1996 in Washington, there were no significant escapes of Atlantic salmon reported in the state. In the summer of 1996, failure of an anchor line on a pen system resulted in the escape of 107,000 Atlantic salmon. Towing of a pen to avoid a toxic algae bloom resulted in the escape of approximately 369,000 fish in July, 1997. In June, 1999, 115,000 fish escaped during another pen system failure during an extreme tidal exchange. It is estimated in the *B.C. Review* that escapes of Atlantic salmon from their commercial pens in 1994-1995 were approximately 60,000 fish, but may be double that number annually due to "leakage". The impacts of these escapees will be discussed in detail in the "management issues" section to follow.

The issue of escaped Atlantic salmon is further complicated by the recent NMFS listing of many stocks of Pacific salmon as threatened or endangered under the Endangered Species Act (ESA). The ESA listing causes us to once again examine all factors which might impact the listed species and recommend actions to decrease any known negative impacts. One important point that needs to be considered in all deliberations is that the industry in British Columbia has the potential to impact the resources in

Washington, even if all production in Washington were to cease. Therefore, it is important that policies and regulations being considered for adoption in Washington are consistent with those of British Columbia.

Current Status of Atlantic Salmon Aquaculture

Atlantic salmon aquaculture is a significant industry in the state. Over the years, many companies have held permits for net pen sites and produced salmon. In Washington, all the former companies are now consolidated into one holding company - the Omega Group. The Omega Group also has holdings in British Columbia and is a subsidiary company of one of the largest Atlantic salmon rearing companies in the world, Panfish Incorporated. The Omega Group produces over ten million pounds of Atlantic salmon annually from its net pens in Washington. The gross value of this product to the company is \$25 million. Additionally, salmon smolt and eggs are produced by other companies which sell directly to Omega Group. The value of smolt and eggs produced, in addition to those produced by the Omega Group, is estimated to be \$5 million. A variety of companies in Washington, which are not actual fish culture operations, provide support for the industry. This includes net manufacturers, fish processors, tugboat operators, and mechanical support. The total value to the state's economy for activities which are related to the production of Atlantic salmon is over \$ 40 million per year. Over 200 people in Washington are directly employed by the Atlantic salmon industry (Dan Swecker, Washington Fish Growers Association, personal communication).

The marine fin fish aquaculture industry in British Columbia (B.C.) is ten times larger than that of Washington. Approximately 100,000,000 pounds of salmon are produced in pens in B.C., 80% of which are Atlantic salmon (Ministry of Fisheries, B.C.). On the world scale, British Columbia is considered small as it produces only 4% of the world's total of cultured Atlantic salmon product.

Regulatory Authority in Washington State: Roles and Responsibilities

Washington Department of Fish and Wildlife

The authority of the department to regulate Atlantic salmon covers two areas. First, the Fish and Wildlife Commission and the Director of WDFW have extensive authority over Atlantic salmon when they are considered "food fish". This authority is consistent with the responsibility that the Commission and agency have to manage all fish and wildlife in the state. Specifically, the chapters in Revised Code Washington (RCW) which give this authority are as follows: **Chapter 75.08.012 RCW Mandate of the department** - WDFW has the mandate to "preserve, protect, perpetuate, and manage the food fish and shellfish in state waters and offshore waters"; **Chapter 75.08.080 RCW - Scope of commission's authority to adopt rules** - the commission specifies the time, place, and manner at which food fish may be harvested; **Chapter 75.08.255 RCW - Director may take or sell fish or shellfish** - "the director may take or remove any species of fish or shellfish from the waters or beaches of the state"; **Chapter 75.08.285 RCW - Prevention and suppression of disease and pests** - "The commission may prohibit the introduction, transportation, or transplanting of food fish, shellfish, and other organisms, material, or other equipment which in the commission's judgement may transmit disease or pests affecting food fish or shellfish"; **Chapter 75.08.295 RCW - Planting food fish or shellfish - Permit authorized by rule** - "The commission may adopt rules to authorize issuance of permits to

release, plant, or place food fish or shellfish in state waters"; **Chapter 77.15.250 RCW - Unlawful release of fish or wildlife** - "A person is guilty of unlawfully releasing, planting, or placing fish or wildlife if the person knowingly releases, plants, or places live fish, wildlife, or aquatic plants within the state except into private waters for which a game fish stocking permit

has been obtained or the planting of food fish or shellfish by permit of the commission". The intent of the regulations is clear. The commission and the director shall have the authority to regulate all aspects of Atlantic salmon when they are in the waters of the state and are classified as "food fish".

The other authority WDFW has over Atlantic salmon is when they are classified as "private sector cultured aquatic products" (Chapter 15.85.020 RCW - see jurisdiction of the Department of Agriculture, below). This is the designation which Atlantic salmon have when that are in

captivity and are being reared by an "aquatic farmer" in a commercial fish farm. The authority granted by the Legislature in 1985 to WDFW is quite limited when Atlantic salmon are in the status of private cultured products. **Chapter 75.58.010 RCW - Disease inspection and control for aquatic farmers** - "(1) The director of agriculture and the director (WDFW) shall jointly develop a program of disease inspection and control for aquatic farmers as defined in RCW 15.85.020. The program shall be administered by the director (WDFW) under rules established under this section", and, (2) ".....The authorities granted the department (WDFW) by these rulesconstitute the only authorities of the department to regulate private sector culture aquatic products and aquatic farmers as defined in RCW 15.85.020" (Attachment 1 - legal opinion from the Office of the Attorney General on the authority of WDFW over private aquaculture). WDFW is also responsible for issuing hydraulic permits (HPA) when work is being conducted in the waters of the state. It is unclear if the limited authority granted to WDFW to regulate aquaculture in Chapter 75.58 excuses commercial aquatic farmers from obtaining an HPA when conducting work in or on their fish or shellfish farms.

In summary, when Atlantic salmon are in captivity and classified as private aquaculture products, the authority of WDFW is restricted to the development and administration of disease control regulations as specified under Chapter 75.58 RCW . However, if an Atlantic salmon escapes from captivity, it immediately becomes classified as a food fish and at that point, WDFW has full authority to regulate the fish. Only when Atlantic salmon, which have been in captivity as private aquatic products, are stocked or released purposely without a permit, does the agency have ability to take action against the party releasing the fish. The accidental release of fish does not constitute a violation of the fish and wildlife code.

Outside the scope of legislative directives, WDFW has other legally mandated activities in regard to the management of Atlantic salmon. WDFW operates a number of marine net pens in Puget Sound. These pens culture native salmon species for a variety of management purposes. In order to operate these pens, WDFW secured from the Department of Ecology (DOE), *National Pollution Discharge Elimination System* (NPDES) permits. The issuance of the NPDES permits by DOE to WDFW were appealed and DOE and WDFW became respondents in a legal action. An agreement was negotiated in 1998 between WDFW and the appellants, which then removed WDFW as a party in the litigation. WDFW agreed to monitor weirs, traps and streams for Atlantic salmon during their usual course of business. Upon interception of Atlantic salmon, they would be killed and sampled for biological information. The scientific information collected includes information on the general health of the fish, contents of the stomach, and development of the gonads. WDFW agreed to collate this information and provide it to the appellants on an annual basis.

Pollution Control Hearings Board

The Pollution Control Hearings Board (PCHB) is the administrative body established to adjudicate appeals to actions taken by the Department of Ecology. The issuance by DOE of NPDES permits to WDFW and commercial net pen operations was appealed by the *Marine*

Environmental Consortium, Washington Environmental Council, Protect Our Waters and Environmental Resources, and, Washington Trout. Extensive testimony was given at the board hearings on the potential impacts of escaped Atlantic salmon on the native stocks. One issue determined by the board was the definition of Atlantic salmon, in the context of the appeal. The PCHB (PCHB # 96-257, First Order Summary Judgement, May, 1997 - Attachment 2), assigned Atlantic salmon to yet another legal classification (beside "food fish" and "private sector cultured aquatic products"), the classification of "pollutant". This designation by the PCHB of escaped Atlantic salmon as pollutants puts this biological entity also under the jurisdiction of the Washington State Department of Ecology (DOE). The basis for the classification by the PCHB was that Atlantic salmon : 1) escaped from a "point source", i.e. the net pen, 2)

they constituted biological material, as defined by *Webster's New World Dictionary*, 3) are "agricultural or industrial waste", in the sense that " escapement of Atlantic salmon is a commercial loss, escaping salmon are a 'waste': that they become...fewer by gradual loss.' *Webster's*", and 4) are a species not native to Puget Sound.

Department of Agriculture

The authority granted to the Department of Agriculture to regulate Atlantic salmon, and other aquatic animals began in 1985 when legislation was enacted that recognized "aquaculture is agriculture". As such, Agriculture was given the following jurisdiction: **Chapter 43.23.040 RCW, Powers and duties of director.** These duties shall include development of markets for agriculture commodities...and the sale and distribution of agricultural commodities, including private sector cultured aquatic products as defined in RCW 15.85.020. **Chapter 75.58.010 (1) RCW - Disease inspection and control for aquatic farmers.** The director of agriculture and the director (WDFW) shall jointly develop a program of disease inspection and control for aquatic farmers.....**(2)** the directors of agriculture and of fish and wildlife shall jointly develop by rule, in a manner prescribed in RCW 75.58.010(2), a schedule of user fees for the disease inspection and control program established under RCW 75.58.010...**Chapter 15.85.030 RCW - Department principal agency for aquaculture marketing support.** The department is the principal state agency for providing state marketing support services for the private sector aquaculture industry. **Chapter 16.36.005 RCW - Definitions of Chapter RCW 16.36.** "Animal" means all members of the animal kingdom except humans, fish and insects. "Farm-raised fish" means fish raised by aquaculture as defined in RCW 15.85.020. Farm-raised fish are considered to be part of animal agriculture, however, disease inspection, prevention, and control programs and related activities for farm-raised fish are administered by the department of fish and wildlife under chapter 75.58 RCW.

Department of Ecology

The Department of Ecology (DOE) is responsible for writing and issuing NPDES permits for marine net pens in Washington State. The authority for this responsibility is found in **Chapter 90.48 RCW**. It is within the purview of DOE to condition these NPDES permits on the operating conditions and procedures for the pens which minimize or eliminate the discharge of pollutants. As a result of the PCHB decision previously mentioned, escaped Atlantic salmon are regulated as "pollutants" under both the state *Water Pollution Control Act* and the federal *Clean Water Act*. In response to the release of approximately 369,000 Atlantic salmon in July, 1997, DOE issues an Administrative Order to Global Aqua Inc., the owner and operator of the net which failed. The Administrative Order required Global Aqua to develop a "fish release prevention plan" and an "accidental fish release response plan". The accidental fish release plan requires the grower to notify WDFW and DOE within two hours of an accidental release of significance. DOE has issued a Notice of Violation to Northwest Sea Farms, Global Aqua's successor, for the June, 1999, accidental release of an estimated 115,000 Atlantic salmon.

In developing NPDES permits for net pens, DOE relies on WDFW for input in areas related to fish management. It is anticipated that DOE will work closely with WDFW in the renewal of the current marine net pen permits when they expire in September, 2001.

Department of Natural Resources

The Department of Natural Resources is responsible for issuing leases covering the aquatic lands that the net pens "occupy".

Counties of Washington State

The counties of Washington are responsible for issuing *Substantial Development Shoreline Permits*. All net operations must secure this permit before constructing or operating an aquaculture net pen facility.

Treaty Tribes of Washington State

The treaty tribes of Washington are recognized as co-managers of the fishery resource. The tribes actively co-manage fish stocks, including escaped Atlantic salmon. The tribes also participate in the development of disease control regulations and polices which are administered by WDFW.

National Marine Fisheries Service

The United States Department of Commerce, National Marine Fisheries Service (NMFS), is responsible for making a determination as to whether an activity, constitutes a "taking" of a listed species (as endangered or threatened under the Endangered Species Act (ESA), under their control. Escaped Atlantic salmon co-mingle in Puget Sound with salmon species that are listed under ESA. If it is determined that co-mingling constituted a "taking" of the listed species, then it would be within the authority of NMFS to require net pen operators to obtain a "take" permit to continue operation.

United States Army Corps of Engineers

The Army Corps of Engineers issue "404" permits. These permits are required for any structure which is determined to impact navigation of the waterways. Marine net pens are required to obtain this permit prior to installation of the net pen structure.

Fish Management Issues of "Escaped" Atlantic Salmon

Atlantic salmon which escape from marine net pens have the potential to impact native fish stocks if the escapes are large and occur on a regular basis. Many factors determine if any impact will occur and whether the impact will be significant. Factors considered include; the number, size, and location of escape, the time of the escape, and the fisheries which are occurring in the vicinity of the escape. The process by which the risk factors are evaluated and considered with the existing knowledge base is called an "environmental risk assessment". Such an assessment was recently completed in British Columbia, Canada (*B.C. Review*). Issues discussed in the *B.C. Review* and which this report will examine further include the potential impacts due to competition, predation, disease transfer, hybridization, and colonization. Based on the observations of biologists in B.C. and Washington and the findings of the PCHB and the *Salmon Aquaculture Review*, it is believed that escaped Atlantic salmon do not pose a significant risk to native fish populations. However, it is unknown if the findings of naturally-produced Atlantic salmon juveniles in streams on Vancouver Island or the recent large escapes of Atlantic salmon from pens in Washington will, in the future, significantly impact ESA-listed salmon stocks in Puget Sound. As new data become available, the opinions of fishery scientists may change. Below is more detailed discussion on the biological issues of concern.

Competition - One concern is that escaped Atlantic salmon will compete with local fish stocks for food and space. Also, the potential exists for Atlantic salmon, which migrate from marine to fresh waters, to compete with salmon for space on the spawning grounds . This event is more likely if a niche is available for the Atlantic salmon to spawn and for its offspring to grow (Chapman, D.W., 1966). The information provided in Table 2 illustrates the observations of Atlantic salmon in fresh and marine waters in Washington in recent years. Increased observations of Atlantic salmon in the fisheries in 1997 can be attributed to a significant escape which occurred that summer. As technology has improved in the industry, the incidental "leakage" of Atlantic salmon has decreased substantially over that which occurred in the 1980's (*B.C. Review*). Because of their highly domesticated nature, it is likely that many of the Atlantic salmon succumb soon after escape due to their failure to find food or to being eaten by a variety of marine predators. Of the escaped Atlantic salmon recaptured and analyzed in Washington, all had empty stomachs and swollen gall bladders (swollen gall bladders are indicative of not eating). Observations of Atlantic salmon captured in marine waters in B.C. and Alaska indicate that approximately 2-4% had herring in their stomachs, 2-4% had commercial fish food pellets, and 1-5% of the Atlantic's captured had wood chips, kelp, or other material not recognized as food. The number of Atlantic salmon

analyzed annually ranged between 160 and 240 fish (Thomson et al., 1993-1997). The evidence indicates that some Atlantic salmon are successful at capturing and ingesting food but most of the escaped fish are not eating.

Another aspect of competition is the occupation and use of spawning sites by Atlantic salmon that might also be used by native salmonids. Of the limited observations of Atlantic salmon captured in fresh water in Washington, approximately 10% have had mature gonads. The

mature fish observed have been males and appeared to be recent escapees from the pens. No spawning activity has been observed in the waters of Washington. Evidence in British Columbia indicates that Atlantic salmon have occupied spawning space and have successfully reproduced in the wild. This information will be discussed in more detail in the "colonization" section below. Any impact the spawning adult Atlantic salmon in British Columbia have had on other fish species that also were utilizing spawning areas in the streams where Atlantic salmon spawning activity occurred (Tsitika River and Amor de Cosmos Creek, Vancouver Island, B.C.) has not been reported.

It is well established by fisheries research that intra and inter-species competition by salmonids is an on-going process in the streams of the Pacific Northwest. The evolutionary process favors the fish species which has adapted to the conditions and has made "choices" which make it successful in perpetuating its stock. Data suggests when species which are native to one watershed are transported out of their "normal" residence to another watershed they have difficulty in surviving and displacing the local stock. An example of this is steelhead trout in the Skagit River, Washington. The native steelhead to the Skagit River is the "winter-run" which spawns in early spring. For management purposes (primarily for harvest), hatchery stocks of Chambers Creek winter steelhead have been annually released into the Skagit River. The Chambers Creek stock spawns in the winter. The annual releases of the Chamber Creek stock into the Skagit River have exceeded 250,000 smolts. Even with these large annual releases and subsequent return of mature adults to spawn, genetic analysis of juvenile wild steelhead indicate they are from the native Skagit stock and not the introduced Chambers Creek stock. This example and many similar ones suggest it is unlikely exotic Atlantic salmon would compete well against native salmon stocks.

Predation - Another concern is the potential for escaped Atlantic salmon to prey on other fish species, particularly juvenile wild salmon or wild salmon eggs. Atlantic salmon are fed large pellets in the marine net pens so it is not within their normal behavior pattern to capture and feed on live prey. The evidence indicates, as mentioned above, that the escaped fish in marine areas have been found with material in their stomachs to include feed pellets, kelp and a few with herring. No data exists on stomach contents of Atlantic salmon caught in marine waters of Washington. Of all the Atlantic salmon escapees from fresh water in B.C. or Washington that were examined, none of them have had any fish or fish eggs in their stomachs. The evidence indicates that escaped Atlantic salmon have little success in preying on fish in marine waters and have no success or desire to prey on fish or fish eggs in fresh water (Thomson et al., 1993-1997).

Disease Transfer - The transfer of infectious diseases from farmed Atlantic salmon to native fish stocks, particularly salmonid species, is a potential impact that must be considered. Infectious diseases are caused by fish pathogens including bacteria, virus, parasites, and fungal infections. Certain fish pathogens can cause serious disease outbreaks and it is required by law to report occurrences to WDFW - these are known as "regulated" pathogens. Transfer of pathogens from escaped net pen fish to wild salmon could occur in the marine waters of the Pacific Ocean or Puget Sound and/or in the rivers and streams. Likewise, transfer of fish pathogens could occur from indigenous fish stocks to Atlantic salmon in either fresh or marine waters.

Before further consideration is given to how the transfer might occur, we need to examine the health status of the fish in question. Local Atlantic salmon originated either from the east coast of North America or Europe. Originally, all were imported as eggs. All broodstock which were the original source of Atlantic eggs were extensively screened for pathogens. If a regulated pathogen is detected during the screening process, the eggs are not allowed into B.C. or Washington. Currently, all eggs in Washington are

obtained from local broodstock. There has not been an import of Atlantic salmon eggs from outside North America authorized for nine years. The last import was in the summer of 1990 from Tasmania, Australia.

The stocks in Washington are extensively screened annually for regulated pathogens, as well. There has never been a finding of a fish pathogen exotic to Washington or B.C. in Atlantic salmon. There has not been a finding of a regulated pathogen in Atlantic salmon from a freshwater site in either Washington or British Columbia. The only finding of a regulated pathogen in Washington was the reported isolation of viral hemorrhagic septicemia virus (VHSV) from a group of Atlantic salmon in one net pen. The isolation was made by a commercial laboratory in British Columbia. A disease outbreak was not occurring at the time of the finding. This VHS virus is known to occur naturally in stocks of herring and pilchard in Puget Sound and has caused disease outbreaks in the wild in these species (Amos et al., 1998). Subsequent testing of salmon in the pen in question by WDFW pathologists failed to re-confirm this finding of VHSV. All the fish pathogens that have been isolated from Atlantic salmon in Washington appear to have historically existed in wild fish species in the state. The evidence would suggest that the source of pathogens which infect both Pacific and Atlantic salmon originated from wild fish (both salmonids and non-salmonids) which occur naturally in Washington State.

Hybridization - Hybridization is the event that occurs when two individuals, either of the same species and different race or of similar but distinct species, mate and produce offspring which have genetic characteristics from both parents. The concern is that an Atlantic salmon adult will successfully mate with a Pacific salmon adult and produce offspring which contaminate the integrity of the gene pool of the native Pacific salmon. This has been determined to be an unlikely event. First, the process of mate selection by Pacific salmon would tend to exclude an Atlantic salmon. Second, laboratory studies conducted under ideal conditions have had great difficulty in producing offspring from such a mating. Finally, even if a successful mating were to occur and offspring were produced, the offspring would be sterile and unable to reproduce themselves. The risk of escaped Atlantic salmon hybridizing with native salmonids and causing any impact is very low.

Colonization - Colonization, or the establishment of Atlantic salmon in the waters of the northeastern Pacific Ocean region, is perhaps the risk factor which receives the most attention. The reason for this attention is that if Atlantic salmon populations became established in coastal rivers and streams, they could directly compete with native salmon stocks for food and space. To become permanently colonized or established, the Atlantic salmon would need to be successful in each step of a complicated life history and complete the life history in numbers sufficient to perpetuate the stock. The steps are as follows: First, a significant number of Atlantic salmon smolts would need to migrate from freshwater to salt water for an extended rearing period (two or more years). The source of these smolts could potentially be from three sources: a) stocking activities by conservation agencies, b) accidental escapes of juvenile Atlantic salmon from commercial smolt farms, and/or c) offspring from sexually mature, pen-reared salmon which escaped from the pens, migrate to fresh water, successfully spawn, and produce juveniles which survive to the yearling or smolt stage. The second step for colonization is the growth of the Atlantic salmon smolts in marine waters to maturity. In this stage of its life history it would need to compete with native fish and wildlife and be successful in capturing food, avoiding predators, and resisting infectious processes (pathogens) and non-infectious processes (fishers or environmental hazards). Finally, the mature adult Atlantic salmon must migrate back to freshwater, find a mate, spawn, and produce juveniles in sufficient numbers which survive again to the smolt stage in numbers sufficient to repeat the cycle. The life history outlined is identical to that of native salmon and steelhead.

The evidence presently available suggests that colonization is unlikely. First, many attempts have been made throughout the world to establish Atlantic salmon into non-native waters via the release of smolts. Data indicate none of these attempts have been successful. On the west coast of North America in the 20th century over five million smolts have been released with no evidence of returning adults. In Washington State alone, since the 1950's, WDFW has released thousands of smolts with the intent of establishing runs without success (this practice has not taken place in anadromous waters in Washington since 1981 - see Table 2). The intentional release of Atlantic salmon smolts by conservation agencies failed to establish runs.

Fish biologists from WDFW monitor streams and rivers each spring in order to count the out-migration of salmon smolts. Likewise, the same biologists install adult salmon traps on the same rivers to monitor the return of spawning salmon adults in the fall. Over the years, a few Atlantic salmon smolts which escaped from fish farms have been captured in the smolt traps operated by WDFW. The fry were confirmed to have originated from fish farms based on fish scale growth patterns. Though this "leakage" of juvenile salmon from farms has not been large compared to the volitional releases by conservation agencies, no adult Atlantic salmon have been recaptured in the adult traps in the river in question nor has there been any adult Atlantic salmon observed spawning in Washington rivers (Dave Seiler, WDFW, personal communication). This evidence suggests that the smolts did not survive to adulthood.

Atlantic salmon are known to have escaped from marine net pens, entered fresh water streams, and have successfully spawned in British Columbia. Juvenile Atlantic salmon have been found in the Tsitika River and Amor de Cosmos Creek on the east side of Vancouver Island. These streams are near the town of Campbell River and are proximate to marine net pen operations. Two age classes of juvenile Atlantic salmon were found in the Tsitika River last year, eight from one year class and four from another. Based on scale analysis and otolith bone analysis, these juveniles were determined to be of "wild" origin. More recently this summer, 42 juvenile Atlantic salmon (6, 0-age and 36, 1 +age) were captured in Amor de Cosmos Creek (a total of 113 were observed). It has not been determined if they are of wild or hatchery origin. Though two adult Atlantic salmon were observed in the stream in October, 1998, there is also a commercial smolt hatchery in Pye Creek which is adjacent to Amor de Cosmos Creek. To date, no juvenile "wild" Atlantic salmon have been found in Washington.

One management technique that could be implemented to reduce or eliminate the risk of colonization is requiring the use of "non-reproducing populations" for all production fish. This may be accomplished by using either "mono-sexed" or "triploid" fish. Through physical or chemical manipulation of fish eggs or very young fish, the ability of the fish to reproduce can be controlled. Mono-sexed or all-female fish are produced by exposing very young female fish (having 2, X chromosomes) to male hormones. This treated female, when it reaches sexual maturity, will be capable of generating sperm, but the sperm will contain only female chromosomes and the resultant offspring will be all females. If these mono-sexed fish were to escape from pens and migrate to fresh water for spawning, there would be no males that could fertilize their eggs. Triploid fish contain an extra set of chromosomes and also are unable to reproduce. Triploid are produced by heating or exposing eggs to pressure soon after fertilization. Research indicates growth and performance of mono-sexed fish is better than triploid fish and is similar, in most cases, to regularly sexed Atlantic salmon. Currently, some Atlantic salmon growers are utilizing all-female fish.

In summary, the scientific evidence indicates that escaped Atlantic salmon, due to their behavior and domestication, are not likely to compete on par with native salmon. Atlantic salmon do not appear to prey on native salmon and appear to make limited utilization of natural food. The infectious diseases found in Atlantic salmon have originated from natural reservoirs, i.e. other fish, and are not likely to represent the threat of a new exposure to native fish. The likelihood of an Atlantic salmon successfully spawning with a native salmonid is remote, however, if it were to occur, the offspring would be unable to reproduce. Finally, in reference to colonization, even though it is possible for an Atlantic salmon juvenile to grow to the smolt stage, emigrate to the ocean, mature, and return to spawn, no evidence exists of a naturally-produced Atlantic salmon adult spawning in the state's waters. Even if this event were to occur, it is not clear as to the numbers of returning adults that must continue to return annually to maintain a run. We know in the case of Pacific salmon, a stock that is unable to return a significant number of adults annually to the spawning grounds is likely facing the threat of extinction. The conclusion of the *B.C. Review* and the PCHB in Washington is that unless there are annual escapes of significant numbers of Atlantic salmon, the risk of colonization is low. It is unknown at this time what constitutes an escape "significant" enough to facilitate colonization. The largest escapes recorded in Washington or B.C. have occurred within the last three years so the impact of those events is still unknown. Prior to 1998, there was no evidence of escaped Atlantic salmon producing "wild" Atlantic juveniles. We now have evidence to show this occurs. We have yet to obtain evidence that indicates a "wild" Atlantic salmon has successfully spawned in the wild in B.C. or Washington, completing the life history necessary for colonization. However, as scientists we know, "absence of evidence is not evidence of absence". Requiring the use of

non-reproducing populations in production pens would virtually eliminate the risks associated with colonization.

Future Management of Atlantic Salmon

The basis for an environmentally-sound fishery management scheme is scientifically valid data and the ability to manage the data for a desired outcome. There are no resources in WDFW allocated for the management of Atlantic salmon, either in the pens or as escapees. A small portion of one person's time is utilized to review fish transfer permits and review the results of pathogen testing of captive Atlantic salmon broodstock. At least the equivalent of eight full-time positions in British Columbia are allocated to the resource management issues associated with commercial net pen aquaculture. Some information is gathered by WDFW fish biologists incidentally as they gather data on Pacific salmon, but it is relatively sparse compared to the methods and the data bases established by Canada. Even if the data were available, there are no resources identified for the purpose of collation and analysis. As the commercial Atlantic salmon industry continues to operate (and potentially grow) in Washington and British Columbia and the recovery of Pacific salmon remains a high priority for all citizens of the state, it is critical for WDFW to have the resources and opportunity to collect data which can be used to determine if Atlantic salmon are impacting Pacific salmon and take management actions as necessary.

WDFW has the current responsibility for the management and stewardship of the fish and wildlife resources of the state. The expertise for the management of fish, both in captivity and in the wild, lies in WDFW. Prior to 1985, the Departments of Fisheries and Game had control over all fish and shellfish in the state, both public and private. Due to the actions of the Legislature in 1985, the remaining authority of the department, which is shared with the Department of Agriculture, is for disease control. If there were no interaction of private fish and shellfish with public fish/shellfish, perhaps this would not be an issue. However, interactions do occur and will continue to occur. For this reason it is necessary to re-examine the role that is to be played by WDFW in the management not only of Atlantic salmon, but of all species commercially reared in the state.

The Ministry of Fisheries of the provincial government in British Columbia, is playing an active role in Atlantic salmon farming. The ministry not only regulates the farmers to prevent fish management problems, it also helps the salmon farmers through extension and education programs which in turn help the farmers to be more effective and efficient in their trade. This service and oversight is available on a limited basis in Washington. Perhaps, the large escapes from the net pens in 1996, 1997, and 1999 would not have happened had the appropriate responsibility and resources been placed under the auspices of WDFW or other appropriate state agency.

The following recommendations are being put forth in order to better manage Atlantic salmon aquaculture and at the same time protect the fish and wildlife resources of the state:

1. Re-establish the authority of WDFW or other appropriate state agency to regulate most aspects of commercial aquaculture, excluding marketing and commodity boards which should remain with the Department of Agriculture. New authority would include: ability to determine the appropriate specie(s) or stocks to be cultured in a specific geographic area; ability to inspect farms and ensure appropriate practices and procedures are being followed to prevent escapes; ability to provide educational opportunities to fish culturists throughout the state which would improve the performance of the farms and improve protection of natural resources; and, the establishment of an *Atlantic Salmon Watch* program similar to B.C., to be a focal point for gathering data on Atlantic salmon in Washington State.
2. Provide adequate resources to WDFW to evaluate the impact of escaped Atlantic salmon on fish stocks in Washington and provide the resources necessary to manage the enhanced aquaculture regulatory authority requested by the department;

3. Actively work with the fish management agencies in British Columbia, both federal and provincial, and the commercial industry to ensure aquaculture regulations and management policies are consistent throughout the region;
4. Actively pursue the implementation of an Atlantic salmon breeding program which requires the use of non-reproductive populations (either mono-sex or triploid fish).
5. Institute a comprehensive code of salmon aquaculture practices to be administered by WDFW which promote environmentally-sound fish culture.

Potential Legislative Actions

The Washington Department of Fish and Wildlife hopes to re-establish its position of actively managing all fish and shellfish of the state, including private sector aquaculture products. If requested, WDFW will submit legislation to amend the Aquaculture Act of 1985, codified as Chapter 75.58 RCW. While marketing, commodity boards, and promotion of agriculture products appropriately resides in the Department of Agriculture, all aspects of fishery management of live commercial aquaculture products should be reassigned to WDFW. Further, the resources necessary to operate the appropriate management programs must accompany the authority. The mandate of the department has not changed over the years, WDFW still has the responsibility to preserve, protect, and perpetuate the fish and wildlife resources of the state. We also believe it is important to maintain a viable finfish and shellfish industry in the state. However, it is imperative that commercial aquaculture in no way jeopardizes the natural resources of the state. Only by joining the responsibility of managing both aquaculture and wild resources under one agency do we believe our management goals can be achieved.

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1. "Anadromous" defines the life history of salmon which includes spawning and early rearing in fresh water, migration to salt water to grow to maturity, then returning again to fresh water as a sexually mature adult to spawn.