FISH POPULATIONS IN THE VICINITY OF THREE PROPOSED FINFISH AQUACULTURE SITES IN SHELBURNE COUNTY, NOVA SCOTIA

Context

On May 31, 2011, Fisheries and Oceans Canada's (DFO) Habitat Management Division, Maritimes Region, requested that DFO Science, Maritimes Region, provide advice regarding wild salmon and other fish populations in the vicinity of three proposed finfish aquaculture sites at Middle Head, Jordan Bay and Blue Island in Shelburne County, Nova Scotia. The impact of the proposed development project on wild salmon populations and the likelihood of negative effects on the wild salmon populations and their habitat are provided to enable DFO Aquaculture and Habitat managers to assess the risk of these proposals with respect to wild salmon. A list of the fishery resources to be considered in assessing the risk to other fish populations is also documented. The request for advice is in support of Habitat Management's review of an environmental assessment (EA) of a proposed aquaculture development project pursuant to the *Canadian Environmental Assessment Act*. Specifically, Habitat Management asked:

Wild Salmon Populations

1) To determine the risk of genetic impacts or parasite or disease transmission to wild salmon populations (and their lifecycle stages) from the proposed aquaculture sites, Habitat Management is requesting Science advice regarding the salmon populations that are known to be or are potentially present in the vicinity of the proposed finfish aquaculture sites at Middle Head, Jordan Bay and Blue Island, Nova Scotia and their relative abundance.

2) To determine the extent and duration of the potential impacts to wild salmon populations, Habitat Management is requesting Science advice on the times of the year and the duration that wild salmon would be expected to be in the vicinity of the proposed aquaculture sites.

3) To determine the impacts of escaped fish on salmon reproduction, Habitat Management is requesting Science advice on which freshwater systems in the vicinity of the proposed sites currently have successful salmon spawning that could be impacted by the escaped fish and what those potential impacts might be.

Other Fish Populations

4) Within the general vicinity of the proposed aquaculture sites, are important fishery resource species missing from the attached table, and is there any critical or valuable habitat for these species in the area.

DFO's Science Special Response Process was used to respond to this request due to the short deadline for advice of August 31, 2011. This Science Response report was developed and reviewed through email correspondence. No review meeting was held. The conclusions of this Science Response are:

1. The proposed aquaculture sites are in the Atlantic Salmon Southern Upland Designatable Unit (DU). This DU was assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2010. The 2008 Conservation Status Report conclusion that there: "is no scope for additional harm in the southern most CUs (Conservation Units)," places Southern Uplands DU salmon in the Extreme Impact category (5) and is consistent with the statement: "Species, stock, or population is already threatened or endangered: further impact may lead to permanent loss" (Appendix 1).

2. Genetic effects have been clearly demonstrated to occur in the conditions existing in the Southern Upland DU. Thus, likelihood in a plausible range of 2 – 4 is warranted, i.e., "has occurred infrequently before to others in similar circumstances," to: "has occurred more than once, or is occurring to others in similar circumstances" (Appendix 2).

3. Redd disturbance and competition occurs among wild salmonids; the establishment by escaped farmed fish in wild rivers indicates that the likelihood of competition and disturbance effects is expected. Therefore, the likelihood that these will occur is at least 2: "has occurred infrequently before to others in similar circumstances" (Appendix 2). There is not enough known about these effects to describe a plausible range for the circumstances considered in this document.

4. The likelihoods that wild migrating salmon will encounter the sites and that if escapes occur they will encounter wild salmon have been identified as ranging from 2 – 4. That is, likelihoods range from: "has occurred infrequently before to others in similar circumstances," to: "has occurred more than once, or is occurring to others in similar circumstances" (Appendix 2). In the absence of a direct link, no advice can be offered on the likelihood of effects on disease transmission when these encounters occur. The risk assessor must balance the likelihood that an encounter will occur with the circumstantial evidence associated with suspected cases of disease transmission and pathogen or parasite transfer.

5. The likelihood of wild/farmed salmon interaction effects will increase as the number of sites and total individuals among sites increases.

Background

Habitat Management, Maritimes Region, is reviewing an EA for three finfish aquaculture sites located in Shelburne County, Nova Scotia, to determine the risk of negative impacts to fish and fish habitat. One component identified in the Habitat Management risk assessment of the proposed aquaculture development project is the risk of the proposed development on wild salmon populations and the presence of other fishery resources in the vicinity of the proposed development sites. As part of the Federal EA process, if requested, DFO provides advice to Transport Canada and the Nova Scotia Department of Fisheries and Aquaculture regarding any impacts from the proposed sites that are within DFO's mandate. Refer to Canadian Environmental Assessment Registry reference number 11-01-61095 for more information regarding the EA of the proposed development project.

Analysis

There is considerable overlap in the material that is used to address each of the questions posed by Habitat Management. To avoid repetition of information, this response is organized by source of the concern creating the interaction between wild and farmed salmon (aquaculture escapes, migration routes of wild salmon, and combination of these sources), rather than an individual response to each question.

A DFO risk based framework is used to identify the impact and likelihood associated with the ecological effects expected on wild and farmed fish interactions. Impact and likelihood are defined in the context of the DFO risk assessment framework for science advice. Biological impact is scored from 1 to 5 indicating the severity of impact and largely depends on the status of the populations considered (Appendix 1). The likelihood of the impact occurring is also scored from 1 to 5 indicating the relative certainty of a particular effect occurring (Appendix 2).

The pathways for the effects of concern associated with wild and farmed fish interactions have been well described in Leggatt et al. (2010). Published information in Leggatt et al. (2010), other relevant documents, and published information specific to the site areas are used to assess the impact, likelihood and subsequent risk from the effects of concern.

Response

Wild Salmon Populations

Atlantic Salmon show high, but not complete, fidelity to their natal river. Consequently, rivers in close geographic proximity are treated as uniform units for management and assessment purposes. When evaluating the extinction risk of Atlantic Salmon in Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), identified four of these geographic groups or designatable units (DU) for evaluation. The proposed aquaculture sites are located within the Atlantic Salmon Southern Upland DU. Southern Upland Atlantic Salmon were designated as Endangered by COSEWIC in November 2010.

The COSEWIC Endangered designation was based on declines of over 50% in the previous three generations at the two index sites for the Southern Upland DU, Morgans Falls and the St. Mary's River. This designation was also supported by declines in juvenile salmon surveys which, in the past, found salmon in 63 rivers. A recent electrofishing survey for juvenile salmon in 2008 found salmon in 21 of 50 rivers surveyed, a decline over a previous survey in 2000. Forty-two of the rivers surveyed in 2008 were identical to those surveyed in 2000 (Figure 1, Gibson et al. 2010).

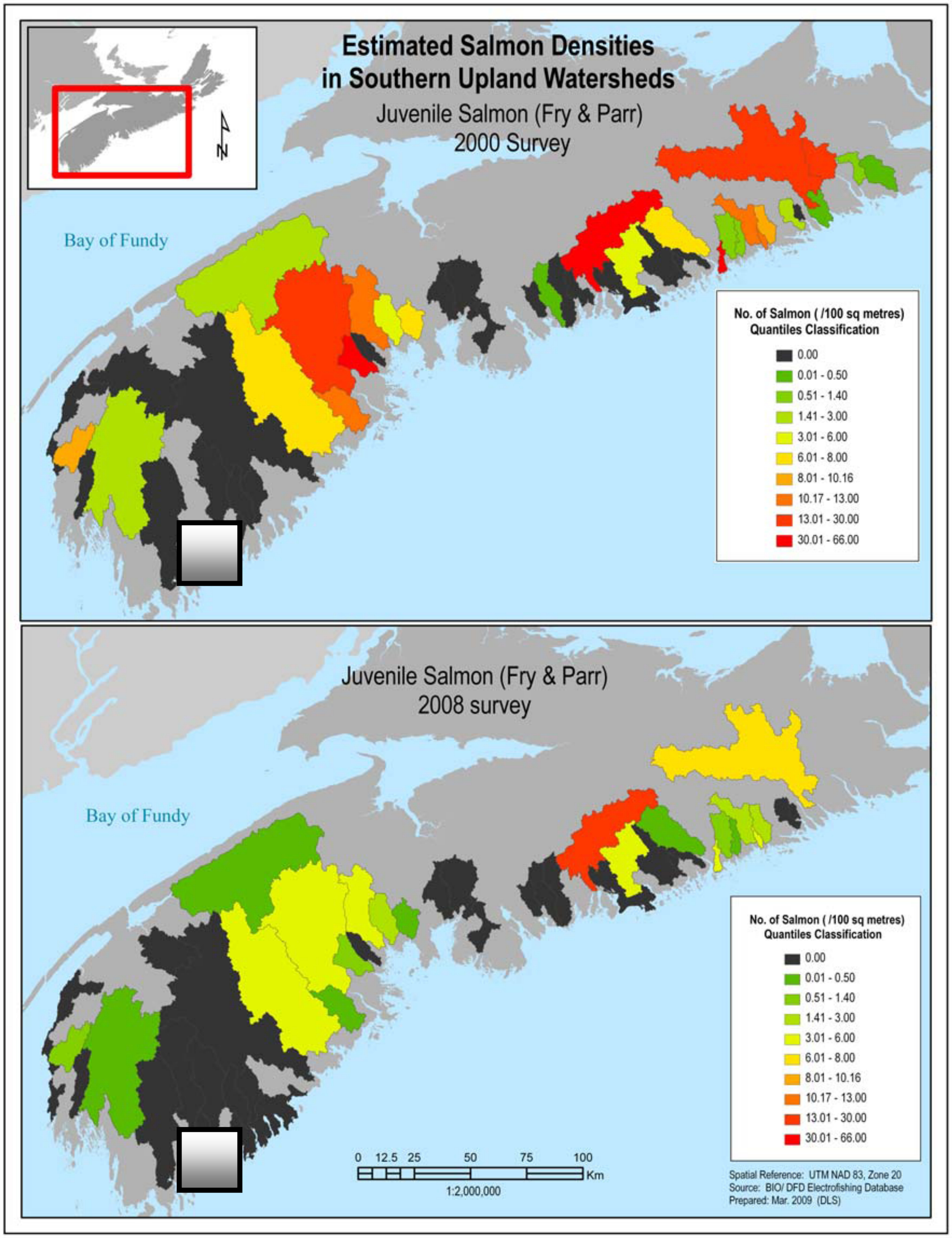

Figure 1. A comparison of the mean juvenile densities (all age classes combined) in watersheds throughout the Southern Upland in 2000 and 2008. Watersheds in which no salmon were captured are shown in black (Gibson et al. 2010). The box shows the general area of the proposed sites.

Salmon were not observed in the electrofishing surveys in rivers within 25 – 50 km of the proposed sites (Figure 1). These rivers have not had appreciable numbers of angling catches or effort since 1983 (Gibson et al. 2010), though catches of salmon in commercial fisheries historically occurred in this area (Cutting 1984).

Rivers within 50 – 100 km of the proposed sites had appreciable declines in juvenile density from 2000 to 2008. The LaHave River had returns of 4,000 to 5,000 salmon during the 1980s and now has returns less than 1,000 salmon. These returns are in comparison to a spawning requirement of about 2,000 salmon (Gibson et al. 2010). The St. Mary's River, which is within 300 km of the proposed sites, has declined from about 1,000 salmon in the mid 1990s to less than 400 since 2005 (Gibson et al. 2010).

Threats to Species Recovery

Two main threats are currently acting to increase the threat to recovery of Atlantic Salmon in the Southern Upland DU. The first is reduced marine survival. Like other salmon populations identified as Endangered by COSEWIC (i.e. Inner Bay of Fundy Salmon), the factors are poorly understood (Amiro et al. 2008, Gibson et al. 2010). While the marine mortality rates are not as high as Inner Bay of Fundy Salmon, they nevertheless are limiting current and future population recovery (Gibson et al. 2010). Secondly, acidification in freshwater has greatly reduced the freshwater productive capacity of Southern Upland rivers. Estimated loss of productive potential ranges from 24% to 50% and only remnant populations are able to persist at current acidification levels over much of the Southern Upland (LaCroix 1985, Watt 1987, Amiro 2000, Amiro et al. 2000).

The loss of productivity related to acidification, the negative effects of low marine survival, and the occurrence of cumulative effects from multiple threats further increases the vulnerability of Atlantic Salmon in the Southern Upland DU to extirpation (Gibson et al. 2010). Thus, a recent Conservation Status Report (DFO and MNRF 2008) concluded that there: "is no scope for additional harm in the southern most CUs (Conservation Units)."

A species, stock or population that is assessed as Threatened, Endangered or Extirpated by COSEWIC is placed in a level 4 category with respect to Environmental / Biological / Human Risks identified by the DFO Risk Framework. However, the 2008 Conservation Status Report conclusion that there: "is no scope for additional harm in the southern most CUs (Conservation Units)" places Southern Uplands DU salmon in the Extreme Impact category (5) and is consistent with the statement: "Species, stock, or population is already threatened or endangered: further impact may lead to permanent loss" (Appendix 1).

Likelihood of Effects

The likelihood of effects on wild Atlantic Salmon populations by farmed salmon will occur either by interaction in the immediate vicinity of the site or through the interactions of escaped aquaculture salmon with wild salmon (Leggatt et al. 2010). Aquaculture escapes, migration of wild salmon to or past aquaculture sites, and a combination of escapes and migration can potentially result in predator attraction, disease and pathogen exchange, redd (reproductive site) competition, food competition and genetic interaction.

Information on likelihood will be presented in the context of a previous occurrence of an effect in a similar situation or an experimental result that indicates the effect occurs.

Likelihood of Effects from Aquaculture Escape Survival

Several studies indicate that the likelihood of survival of net-pen escapes would be relatively lower than for wild salmon in similar situations (summarized in Weir and Fleming 2006). Nevertheless, appreciable numbers of farmed salmon have been found entering rivers at spawning time. In Norway, farmed salmon entering rivers increased as the number of farms increased (Lund et al. 1991, Fiske et al. 2006). Fiske et al. (2006) also observed that salmon do not always enter rivers in the first year of escape. In Scotland, from some 184,000 escapes up to 500 were observed in nearby rivers (within 30 km) (Webb et al. 1991). Similarly, on the Magaguadavic River in New Brunswick, Canada, Carr et al. (1997) found an increasing number of farmed salmon escapes from nearby farms contributing to spawning as aquaculture sites increased. In experiments removing salmon up to 50 km; Whoriskey and Carr (2001) found that 1 - 25% of observed escaped farmed salmon migrated to local rivers. However, return rates were variable and unpredictable. In Scotland, farmed salmon did not spawn as far up in the river systems as wild fish, and male farmed fish were more successful than females (Webb et al. 1991).

Morris et al. (2008) reviewed the prevalence of aquaculture escapes in North American rivers and found that escapes were reported in 54 of 62 (87%) rivers investigated within a 300 km radius of the aquaculture industry since 1984. The proportional representation of farmed salmon among adults entering the rivers from the sea was 9.2% (range 0% to 100%). Like those cited above they found that escape events were episodic in nature, unpredictable, and occurred at changing and irregular intervals. They concluded that: “escaped farmed salmon are sufficiently prevalent in eastern North American rivers to pose a potentially serious risk to the persistence of wild salmon populations, especially in those rivers that are adjacent to existing aquaculture sites” (p. 2807).

The likelihood associated with survival of escapes differs depending on geographic location and status of wild salmon rivers. Within rivers 50 km of the proposed sites, the likelihood of direct interaction from escapes at current population levels would be close to 0 or, “guaranteed never to occur”. However, any escapes to these areas would add to any cumulative effects already existing that are inhibiting recovery. Within a range of 300 km including those outside the area of the immediate vicinity of escape sites, a range of 2 – 4 on the likelihood scale is plausible. That is, likelihood ranges from: “has occurred infrequently before to others in similar circumstances,” to: “has occurred more than once, or is occurring to others in similar circumstances” (Appendix 2). This likelihood would change depending on the number of salmon cultured, the frequency and magnitude of escape events, and the occurrence of specific effects that are dependent on aquaculture escapes (described below).

Likelihood of Effects from Wild Salmon Migration

The likelihood of impact will also depend on encounters that salmon migrating to and from natal rivers have with the proposed sites. This likelihood is assessed using a previous tagging study when the commercial fishery was active. For example, Districts 30/31/32 (the proposed sites are within and adjacent to these districts) were 39% dependent on salmon stocks originating in Districts 26/27/28 and 16/17/19 (districts accounting for a large proportion of home water salmon production in the Southern Upland DU). The mechanism proposed is that salmon approach the coast on return migrations and make contact in southeast Nova, southwest Nova Scotia, and Halifax. Migration then proceeds from, “headland to headland enroute” to home waters (Marshall 1982). As a result, the likelihood of impacts resulting from interactions of wild migrating salmon from rivers currently supporting low populations of Southern Upland DU salmon with the proposed sites ranges from 2 – 4 on the likelihood scale. That is, likelihood ranges from: "has occurred infrequently before to others in similar circumstances," to: "has occurred more than once, or is occurring to others in similar circumstances" (Appendix 2).

Ritter's (1989) work on marine migration indicates that adult encounters with aquaculture salmon on headland to headland migration will most often occur in June and July. Smolt emigration occurs primarily in May (Gibson et al. 2010) and post-smolt encounters on migrations, based on tag recoveries, are also expected to occur primarily in June in Nova Scotia areas and July in Newfoundland areas (Ritter 1989).

Likelihood of Effects Solely from Aquaculture Escapes

Effects on genetics, redd competition, and redd disturbance will result from escapes surviving and spawning and/or attempting to spawn with wild salmon. The effects are expected to increase as the ratio of escapes to wild salmon increases (Hindar et al. 1991, Wang et al. 2002, Houde et al. 2010a).

Genetics

The main genetic effect resulting from wild and farmed salmon interactions is a reduction in fitness caused by erosion of local adaptations, which reduces population growth and lowers resiliency to environmental perturbations. This effect occurs first by hybridization which is the mixing of genes from wild and farmed fish in the first generation.

Effects from reduction in fitness secondarily occur by incorporation of the farmed fish genetics into the wild population genome. This effect occurs in the second and subsequent generations, when hybrids mate with wild salmon and is called introgression (Leggatt et al. 2010). Introgression shifts traits toward those of the farmed fish and leads to a loss of local adaptation and genetic variation that buffers against change (Schindler et al. 2010, Fraser et al. 2010a, Fraser et al. 2010b).

Experiments in Irish rivers (McGinnity et al. 2003) and Norwegian rivers (Fleming et al. 2000) demonstrate the occurrence of these effects. Increases in genetic difference between the farmed and wild salmon and increases in the degree of domestication of the farmed salmon will also increase the likelihood of effect (Hindar et al. 2006). If local broodstock were used, the likelihood of effects would be reduced; if non-local broodstock is used, it would increase the likelihood of effects.

Genetic effects have been clearly demonstrated to occur in the conditions existing in the Southern Upland DU. Thus, there is no reason to alter the likelihood from the plausible range of 2 – 4 provided above, i.e., "has occurred infrequently before to others in similar circumstances," to: "has occurred more than once, or is occurring to others in similar circumstances" (Appendix 2). The low level of Southern Upland populations is expected to continue and the effects on reproductive capacity are expected to vary relative to the number of escapes.

Redd Competition - Disturbance

The main effect created by the use of preferred redd sites or the disturbance of redds constructed by local salmon by escaped aquaculture fish would cause a reduction in the number of wild mating pairs. A reduction in number of wild pairs would increase the likelihood of farmed-wild salmon hybrids occurring.

Intentional stocking of Atlantic Salmon in non-native habitat has generally resulted in poor spawning (<30%) (Volpe et al. 2001) or by failure to establish self-sustaining populations (MacCrimmon and Gots 1979). However, juvenile Atlantic Salmon have been identified in 3 British Columbia rivers, including 2 year classes in one river (Volpe et al. 2001, Leggatt et al. 2010). In addition, self sustaining populations of wild salmonids have resulted from intentional stocking in non-native habitat in Argentina and New Zealand (MacCrimmon and Gots 1979). Enhancement efforts in native habitat has a long-history for Atlantic Salmon (MacCrimmon and Gots 1979).

Despite poor reproductive success, the large number of salmon escapes in some areas in Canada has resulted in a report of significant numbers of these salmon reproducing (20% of redds in the Magaguadavic River, New Brunswick, were thought to be of maternal farm origin in the 1992/1993 spawning period (Carr et al. 1997)). Extensive reproduction of escaped Atlantic Salmon has been noted in Europe (e.g., 14 of 16 rivers examined in Scotland had fry with maternal farm origin, ranging from 0-17.8% of the population (Webb et al. 1993)).

Redd disturbance and competition occurs among wild salmonids (Witzel and MacCrimmon 1983); the establishment by escaped farmed fish in wild rivers indicates that the likelihood of competition and disturbance effects is expected, though these effects can occur without any interaction between wild and farmed salmon. Therefore, the likelihood that these will occur is at least 2: “has occurred infrequently before to others in similar circumstances” (Appendix 2). There is not enough known about these effects to describe a plausible range for the circumstances considered in this document.

Food Competition

A large number of escapes would reduce body size and marine survival of wild salmon if marine density of salmonids leads to food competition.

In the western Atlantic Ocean, food supply does not appear to limit post-smolt growth or survival of wild Atlantic Salmon in the Bay of Fundy and the Gulf of Maine (Lacroix and Knox 2005). In Atlantic Canada, growth of post-smolt Atlantic Salmon appears to be constrained by intraspecific competition in the Miramichi River, Gulf of St. Lawrence, in the first 1-2 months of marine inhabitation, but not at later stages (Friedland et al. 2009).

Consequently, competition from escaped salmon or their offspring in the Atlantic marine environment is expected to have little or transient impact on productivity of wild populations (Leggatt et al. 2010).

These observations indicate that the likelihood of food competition effects at current wild salmon population levels is 0: “guaranteed never to occur” (Appendix 2).

Likelihood of Effects Solely from Wild Salmon Migration

Predator Attraction

The primary effect associated with predator attraction is direct mortality. Direct links to increased mortality of wild fish stocks has not been shown even though predators of several types are attracted to aquaculture sites (Dempster et al. 2002, Leggatt et al. 2010, Sanchez-Jerez et al. 2008). Predator interactions are important to consider because Houde et al. (2010b) found that wild – farmed hybridization reduces anti-predator responses. If this predator attraction occurs at these sites, then the likelihood that wild migrating salmon will encounter predators would be consistent with the general likelihood range of 2 – 4 identified above. In the absence of a direct link, no advice can be offered on the likelihood of effects from predator attraction.

Likelihood of Effects from Aquaculture Escapes and Wild Salmon Migration

Impacts occurring from the effects resulting from escapes and/or migration would have two sources of origin. This dual origin would have to be considered in any mitigative strategies and likelihood considerations.

Disease Transmission, Pathogen Transfer, and Parasites

Direct mortality and indirect effects on survival because disease symptoms reduce body size and fish condition are the most important effects resulting from disease transmission, pathogen transfer, and parasites (Leggatt et al. 2010, Miller et al. 2011).

While there are suspected cases where disease has been transferred from farmed salmon to wild salmon, there are no known cases in Canada, where escaped farmed fish have been directly implicated in disease transfer to wild fish (Leggatt et al. 2010) and the transfer of sea-lice to wild fish (Brooks and Jones 2008).

The likelihoods that wild migrating salmon will encounter the aquaculture sites and that, if escapes occur, they will encounter wild salmon have been identified as ranging from 2 – 4. That is, likelihoods range from: “has occurred infrequently before to others in similar circumstances,” to: “has occurred more than once, or is occurring to others in similar circumstances” (Appendix 2). In the absence of a direct link, no advice can be offered on the likelihood of effects on disease transmission when these encounters occur. The risk assessor must balance the likelihood that an encounter will occur with the circumstantial evidence associated with suspected cases of disease transmission and pathogen or parasite transfer.

Summary

An Endangered designation by COSEWIC and the 2008 Conservation Status Report conclusion that there: “is no scope for additional harm in the southern most CUs (Conservation Units),” for Atlantic Salmon (DFO and MNRF 2008), places Southern Uplands DU salmon in the Extreme Impact category (5) and is consistent with the statement: “Species, stock, or population is already threatened or endangered: further impact may lead to permanent loss” (Appendix 1).

While poor survival, disrupted migration patterns, and low reproductive success of farmed Atlantic Salmon limits their ability to become reproductively established, the large numbers of escaped fish in both Atlantic and Pacific Canada have resulted in successful reproduction of some individuals on both coasts (Leggatt et al. 2010). It is not possible to precisely define the level of likelihood in each case. The level is dynamic depending on the mitigative measure, environmental events, and local practices. As a result, a range of plausible likelihoods has been defined for most situations based on experimental results identifying the conditions under which a particular effect will occur and/or field observations that a particular effect has occurred.

The general observations in the literature that the likelihood of wild/farmed salmon interaction effects will increase as the number of sites and total individuals among sites increases contributes to a dynamic interpretation of likelihood. In general, if an effect has been shown to occur then it is clear that the likelihood in these cases is between 2 – 4. That is, likelihoods range from: "has occurred infrequently before to others in similar circumstances," to: "has occurred more than once, or is occurring to others in similar circumstances" (Appendix 2).

A final risk assessment using the DFO framework will combine likelihood and impact to determine risk. Extreme Impact (5) likelihoods from 2 – 4 will produce high or very high risks. Mitigation and acceptance of these risks will depend on management regimes and risk associated with other factors that are outside the scientific elements discussed in this document.

Other Fishery Resources

Appendix 3 provides a list of fishery resources within the vicinity of the aquaculture; however, a number of species were considered absent from the list.

It is suggested that American Shad, Atlantic Sturgeon and Stripped Bass be added to the list of species, with the latter of the two species expected to frequent the proposed aquaculture sites as seasonal migrants. Atlantic Whitefish, classified as Endangered, is also considered missing. It is recommended that all Schedule 1 *Species at Risk Act* species that occur in areas slated for development be included in the assessments.

Gaspereaux which appear under the pelagics should appear under diadromous species and be replaced with specific reference to Alewife and Blueback Herring.

American Eel, which appears on the list as a demersal species should be considered a diadromous species.

It is recommended that the assessment also consider both commercial and non-commercial species as well as species that support the ecosystem.

Conclusions

The proposed sites are in the Atlantic Salmon Southern Upland Designatable Unit (DU). This DU was assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada in November 2010. The 2008 Conservation Status Report conclusion that there: "is no scope for additional harm in the southern most CUs (Conservation Units)," places Southern Uplands DU salmon in the Extreme Impact category (5) and is consistent with the statement: "Species, stock, or population is already threatened or endangered: further impact may lead to permanent loss" (Appendix 1).

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The likelihoods that wild migrating salmon will encounter the sites and that, if escapes occur, they will encounter wild salmon have been identified as ranging from 2 – 4. That is, likelihoods range from: “has occurred infrequently before to others in similar circumstances,” to: “has occurred more than once, or is occurring to others in similar circumstances” (Appendix 2). In the absence of a direct link, no advice can be offered on the likelihood of effects on disease transmission when these encounters occur. The risk assessor must balance the likelihood that an encounter will occur with the circumstantial evidence associated with suspected cases of disease transmission and pathogen or parasite transfer.

The likelihood of wild/farmed salmon interaction effects will increase as the number of sites and total individuals among sites increases.

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Appendices

Appendix 1. Degree of impact given the nature and magnitude of possible Environmental / Biological change.

<u>Risk Area Criteria</u>

Impact	Environmental / Biological Risks:
5. Extreme	• Harm to an aquatic ecosystem (e.g. disease, parasites, introductions) resulting in a substantial impact on human health (e.g., domoic acid, paralytic shellfish poisoning, tsunami, oil spill). • Species, stock or population is already threatened or endangered; further impact may lead to permanent loss. • Permanent and spatially significant loss of critical fish habitat or ecosystem component.
4. High	• Harm to an aquatic ecosystem (e.g. disease, parasites, introductions, invasive species) resulting in a substantial impact on human activities (including fisheries, aquaculture, tourism, infrastructure, etc.). • Limit reference point for a stock has been reached • A species, stock or population is assessed as Threatened, Endangered or Extirpated by the Committee on the Status of Endangered Wildlife in Canada. • Substantial damage to fish/fish habitat that results in damage with longer term for recovery (>5 years).
3. Medium	• A species, stock or population is under moderate pressure; further impact would result in reaching its limit reference point. • A species, stock or population is assessed as of Special Concern by the Committee on the Status of Endangered Wildlife in Canada. • Moderate impact to fish/habitat with medium term for recovery (3-5 years).
2. Low	• Species, stock or population is currently stable, but additional impact could be lead to decline. • Minor, recoverable short term changes to an aquatic species, stock or population or their habitat (e.g., seasonal or changes <1 year).
1. Negligible	• Minimal change or impact to the species, stock, population; or minor alteration to an ecosystem in question. • Species, stock or population is doing well; additional impact would not cause changes outside the normal range of variation. • Habitat alteration within acceptable guidelines. • Species, stock or population is at healthy abundance level; impacts at current level would not cause changes outside the normal range of variation.

Appendix 2. Scale of likelihood as described by the DFO framework.

Likelihood	Description
0	Guaranteed to never occur.
1	Rare (<5%): Almost never observed – may occur only in exceptional circumstances.
2	Unlikely (5% - 24%): Has occurred infrequently before to others in similar circumstances, but not here.
3	Moderate (25% - 75%): Has occurred here before, or has been observed in similar circumstances
4	Likely (76% - 95%): Has occurred here more than once, or is occurring to others in similar circumstances.
5	Almost Certain (>95%): Occurs regularly here.

Appendix 3. List of species assessed for impacts from proposed aquaculture sites at Jordan Bay, Middle Head and Blue Island, Shelburne County, Nova Scotia.

SPECIES ASSESSED
Aquatic Vegetation
Moss
Seaweed
Kelp
Algae
Eelgrass
Crustaceans
Lobster
Benthic Infauna
Shellfish
Scallop
Clam
Quahog
Pelagics
Herring
Gaspereaux
Bluefin Tuna
Groundfish (Demersal)
American Eel - Special Concern*
Haddock
Atlantic Cod - Southern Population - Endangered*
Cusk - Threatened*
Pollock
Flounder
Diadramous
Atlantic Salmon - Southern Uplands - Endangered*
Marine Mammals and Reptiles
Harbour Porpoise - Northwest Atlantic Population - Special Concern*
Atlantic Walrus - Atlantic Population - Special Concern*
Loggerhead Sea Turtle - Endangered*
Plankton
Aquatic Species at Risk (SARA Schedule 1)
Leatherback Sea Turtle - Endangered
North Atlantic Right Whale - Endangered

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