Surveillance Plan For ISAV, IPNV, and IHNV In Anadromous Salmonids in British Columbia

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1. Introduction

1.1. Background

CFIA Aquatic Animal Health Surveillance and Epidemiology Program is a support program of the NAAHP designed to facilitate domestic disease control, import control and export certification, while meeting international standards as set out by the OIE. Its primary output deliverables include the

- substantiation of disease freedom[1] in aquatic animal populations at different levels (i.e., country, region, population, premises level);
- development of survey designs and sampling plans and associated communication plans required to support domestic and international trade and movement requirements;
- ongoing coordination and communication with the Department of Fisheries and Oceans for surveillance program delivery;
- development and maintenance of surveillance procedures for field delivery; and
- development of disease or commodity specific surveillance approaches that ensure Canada has an integrated program for aquatic surveillance in Canada.

Developing and conducting active surveillance for one or several diseases can be a costly endeavour. To ensure that maximum benefit is achieved from surveillance activities to meet the overall mandate of the National Aquatic Animal Health Program (NAAHP) this proposal focuses on prioritising the diseases and specific regions to be included in an active surveillance program to meet the needs of the NAAHP with respect to surveillance in British Columbia. Criteria for prioritization of activities outlined in this proposal are based on the needs to provide assurance of disease status in British Columbia to support import and/or domestic and international trade requirements to prevent of the introduction and spread of disease.

The *Health of Animals Act* sections 35, 38, 39 and 41and *Regulations* provide the legal power to the Agency to access farms and processing plants and to collect aquatic animals from farms and processing plants. *The Act* is found on the Department of Justice Website at http://laws-lois.justice.gc.ca/eng/H-3.3/index.html. The Department of Justice is responsible for maintaining the Consolidated Statutes and Regulations for the Government of Canada.

[1] A designation applied to zones or compartments that can demonstrate, with an accepted statistical level of confidence, a negligible likelihood of the presence of a certain disease or pathogen.

ISAV and IPNV are diseases ~~for which the~~ not currently known to be present in British Columbia. IHNV is considered endemic to British Columbia but only known to occur in certain wild species and populations and manifests as disease during specific life stages (freshwater primarily). Due to the considerable size of the industry on the west coast both with respect to the salmonid aquaculture industry, the recreational and commercial fisheries; substantiation of absence of ISAV and IPNV in the region and IHNV in certain species and populations, is considered a surveillance priority of the CFIA. Scientific evidence indicates that the species of wild aquatic animals present in BC waters can be considered as susceptible to natural infection or disease caused by ISAV, IPNV and/or IHNV. In addition, these species of aquatic animals are considered valuable to recreational and commercial fisheries. As a result, these species are considered the target animals in the surveillance plan. Other species, although not scientifically considered at high risk for the diseases, will be sampled to establish disease freedom, due to their importance to commercial fish trade.

The species targeted in this plan an are anadromous salmonid species that are i) considered highly or moderately susceptible to at least one disease of concern, or ii) commonly traded in and out of British Columbia.

Targeted means the selection of sites or fish that are likely to exhibit a higher prevalence (relative risk) of infection if it is present. Such selection reduces the sample size requirements necessary to demonstrate disease freedom at a pre-determined prevalence level.

The implementation of the plan will be based on internationally accepted guidelines and provide scientific evidence of the health status of animals and products originating from the west coast of Canada. The international guidelines are outlined by the World Animals Health Organization (OIE) in the Aquatic Animal Health Code and in the Manual of Diagnostic Tests for Aquatic Animals, 2011. The plan will be reviewed annually. Following the evaluation, diseases and species may be added or deleted from the plan to accommodate to burgeoning needs and pressure.

The absence or presence of diseases of concern in wild fish stocks will be evaluated through field surveillance of a representative selection of species, and areas of interests. Therefore, risk factors associated with the surrounding environment will be used to direct field surveillance efforts to time of the year and life stages with higher potential to infection and disease.

The Surveillance and Epidemiology section, AAHD of the CFIA has evaluated the most scientifically valid and efficient approach to ensure that the surveillance meets international standards for determination of absence of aquatic animal diseases.

The Canadian Food Inspection Agency (CFIA) proposes to undertake the development and subsequently the implementation of the proposed plan in partnership with Fisheries and Oceans and via a series of consultation with industry, provincial stakeholders and rights holders.

1.2. Goal and Objectives

The goal of this surveillance effort is to effectively determine the absence or presence of three diseases of significance in both cultured and wild marine anadromous fish populations off the west coast of Canada.

Implementation of an official surveillance program in British Columbia for ISAV, IPNV and IHNV is an essential part of CFIA's mandate as a science-based agency. This evidence is required to ensure that CFIA meets its mandate for prevention of the introduction and spread of aquatic animal diseases and provides support for Canada's market access of for aquatic animals and their products.

The CFIA and other regulatory agencies in Canada also have a vested interest in protecting aquatic animal health by minimizing the spread of this virus throughout the aquatic ecosystem. Infectious Salmon Anemia Virus (ISAV), Infectious Pancreatic Necrosis Virus (IPNV) and Infectious Hematopoetic Necrosis Virus (IHNV) are highly contagious viruses which can cause significant mortality in both wild and aquaculture salmon. There is no evidence to support that ISAV and IPNV occur in either wild or cultured salmon in B.C. IHNV, ISAV, and IPNV are federally regulated diseases, reportable to the CFIA. ISAV and IHNV are also diseases reportable to the World Organization for Animal Health (OIE). Section 7.1 (Appendices) provides technical fact sheets that were developed for each one of those three diseases. The fact sheets are also available on line http://merlin/english/anima/aqua/disease/dccpe.asp

The evidence put forward through this surveillance plan will

i) Provide support for the protection of aquatic resources.

Provides evidence to support science based decision-making for CFIA domestic disease control policy such as disease response measures in cultured salmonids, and support for science-based geographic delineations on the occurrence of specific diseases of both wild and cultured salmonids in British Columbia (as per the *Health of Animal Act*).

ii) Support international trade negotiations.

Expected outcomes include the provision of scientific evidence to support import measures and arrangements with trading partners

iii) Support the risk-based compartmentalization program.

Compartmentalization requirements are established based on the estimated risk for disease introduction through the anthropogenic (man made) sources and from the surrounding environment. Establishing the health status of BC with respect to the diseases of concern in this plan provides valuable data used to determine the frequency of disease testing in compartments.

1.3. Documentation for Delivery

A short description of the documents and tools provided to CFIA operational arm for delivery of survey and on going surveillance programs are provided below.

1.3.1. Finfish Field Survey Protocols

Field survey protocols have been developed for the collection of finfish samples (whole animals) and specimens (parts of animals). They apply to the collection of surveillance samples for diagnostic purposes from various collection points where the animals are under care, control and possession. These protocols contain the procedures required to collect samples and specimens for surveillance testing.

The procedures included in these protocols are:

- Planning for the Inspection
- Determining Number of Populations and Sample Sizes
- Biosecure Entry and Movement within a Premises
- Collection of Finfish
- Euthanasia of Finfish
- Finfish Dissection and Specimen Collection
- Filling in the NAAHP Laboratory Submission Form
- Biosecure Exit from a Premises
- Packaging and Shipping

The purpose of these protocols is to establish a uniform methodology for the collection of samples and specimens for surveillance purposes. The procedures within this protocol are designed to ensure that aquatic animals are sampled in a way that maintains diagnostic quality and chain of custody required.

Not all of the procedures are required for every collection event. For example, the "Finfish Dissection and Specimen Collection" procedure is not required if whole finfish will be sampled and sent to the laboratory.

1.3.2. Survey Designs and Sampling Plans

Sampling plans are designed by the Surveillance and Epidemiology Section of Programs Branch and provided to the CFIA Operations Branch or DFO for delivery. They are tailored to the purpose and objectives of the sampling event being planed. There are three different types of sampling plans; commodity specific, disease specific and general survey. Commodity specific surveys target particular species in which disease freedom is being sought, common for export purposes.

General and disease specific information provided in the OIE aquatic manual http://www.oie.int/en/international-standard-setting/aquatic-manual/access-online/, as well as provided in CFIA disease specific hazard specific plans and hazard characterizations, are used as reference material for the targeted selection of populations, individual samples and specimens.

The determined level of sampling is determined as a function of the assigned design prevalence, the level of certainty, level of clustering in the sampled population, and the assumed sensitivity and specificity of the diagnostic test. The implementation and proper analysis and interpretation of results of structured, population-based, targeted statistical surveys meet the international standards as recommended by the OIE to generate evidence for freedom from infection for aquatic diseases http://www.oie.int/index.php?id=171&L=0&htmfile=chapitre_1.1.4.htm

Examples of survey designs that have been developed to carry out sampling of both wild and cultured populations to substantiate freedom for listed aquatic animal diseases of both national and international concerns can be viewed on CFIA web page http://www.inspection.gc.ca/english/anima/aqua/disemala/surve.shtml

2. Surveillance System and Freedom Evaluation

2.1. Concept and Approach

The quantification of i) the sensitivity of existing surveillance activities, and subsequently ii) the estimation of the probability that British Columbia is free from ISAV, IPNV and IHNV will be assessed by stochastic scenario tree modelling.

This methodology allows the quantitative analysis of complex surveillance activities, as well as the combination of evidence of freedom from multiple sources. Section 7.2 describes testing activities that took place within the last 10 years in BC. Most of these activities will be included in the surveillance system evaluation as surveillance components. The approach is based Bayesian analysis. These estimates (of system sensitivity based on historical activities) will be used as prior estimates of surveillance system sensitivity in both cultured and wild populations. Such estimates (i.e., prior

surveillance plan implementation estimates) will be refine post the implementation of this surveillance plan (i.e., post implementation estimates),

Scenario tree are used to calculate the sensitivity of a component (i.e., activity) of a surveillance system (SSC). Sensitivity is the probability that the surveillance system component will detect at least one infected animal, if the population is infected at the design prevalence. The scenario tree divides the population into smaller groups, within which each individual unit) has the same probability of being detected as diseased, given that the population is infected. It does this by describing both the structure of the population and all events within a SSC that influence the probability that a disease or disease agent, if present, will be detected by that SSC. At each branch of the tree, probabilities are estimated for each possible outcome. Required values to built scenario trees include design prevalence at the animal and cluster level, sensitivity of diagnostic tests, relative risk, population proportion and surveillance system component proportion.

Low probabilities of disease can result from a minimal presence of risk factors combined with historical negative test results and/or from current negative surveillance results. The maintenance of that status would require assurance of regional biosecurity and/or ongoing surveillance. As regional biosecurity can not be assured in such areas, regional disease freedom claim can only be achieved via an official surveillance program. Such programs are described in chapter III and IV.

2.2. Model Description

2.2.1. Computation of the sensitivity of surveillance system components - Scenario tree

A stochastic scenario tree model will be developed in Microsoft Office Excel (Microsoft Corporation) using the add-in @RISK Version 4.5 Professional (Palisade Corporation). The scenario tree will be constructed so that all possible paths for a single tested "unit" (here, a fish) to record a positive outcome could be travel along the limbs of the tree. The system will be assumed to have perfect specificity; that is, that all units with positive outcomes would be true positives. Nodes, which are the branching points in the tree structure, are factors that affect the probability of either infection or detection of a unit. Probabilities or proportions will be applied to the branches at each node. Theses are conditional on all preceding nodes in the tree, and will be described as distributions to reflect underlying variation in and uncertainty about the estimates, or as point estimates.

2.2.2. Combination of surveillance system components

Normally, a surveillance system is made of a number of different components that provide different types of evidence that the disease is not present. Each of these systems is a component of an overall surveillance system, and each has a different capacity to detect the presence of the disease. Using scenario trees we are able to estimate the

sensitivity of each of the components. However, we are also interest in the system as a whole.

The surveillance system sensitivity (SSe) is considering each of the components together. It is the probability of detecting at least one infected farm by any of the surveillance system components will be calculated as $SSe = 1 - \prod_{i=I}^{I}(1 - CSei)$ when the surveillance components are independents.

2.2.3. Accounting for lack of independence between surveillance system components

The lack of independence between system will be accounted for by using the posterior P(farm infected) from the first system as the prior P(farm infected) from the second system

2.2.4. Confidence in disease freedom

The lack of any positive surveillance results, given the documented capacity of the surveillance system to detect disease if it were present, provides us with a certain confidence in disease freedom.

The estimate of the probability (confidence) in disease freedom, given the negative test results, will be calculated for a given time period as

$$P(free) = \frac{1 - \Pr ior}{1 - (\Pr ior \times SSe)}$$

2.2.5. Temporal discounting

Temporal discounting is a technique used to capture the value of ongoing negative surveillance results while taking into account the possibility of disease introduction, the key reason for erosion of confidence in historical results.

The calculation is as follows:

$$PostPFree_{tp} = \frac{1 - \Pr iorPInf_{tp}}{1 - \Pr iorPInf_{tp} \times SSe_{tp}}$$

2.3. Input Parameters

The quantitative evaluation of the sensitivity of the disease surveillance systems is using many parameters. Such parameters are described below. Sensitivity analysis will also be used to identify the input parameters that have the greatest impact on the model outcomes (sensitivity and confidence in disease freedom).

This section describes how those figures will be estimated.

- *Relative risk*: The relative risks describe how some parts of the population are at higher risk than others. There are a number of approaches to select this figure, and these are listed below, in order of preference
    - Published estimates of relative risks
    - Expert opinion through a formal approach to gathering and analysing expert opinion
    - Expert opinion through an informal approach
    - Personal opinion based on the epidemiology of the disease and the characteristics of the environment and population involved
- *Population proportion*: Industry
- *Diagnostic sensitivity*: Sensitivity is the probability of getting a positive test result if the animal tested truly is infected. There are a number of approaches to select this figures, and these are listed below, in order of preference
    - Published studies in which a laboratory test has been validated, and the sensitivity and specificity calculated
    - Expert opinion through a formal approach to gathering and analysing expert opinion
    - Expert opinion through an informal approach
    - Personal opinion
- *Design prevalence*: Design prevalence values are normally assigned at the unit level indicating the proportion of diseased units in the population. They may also be assigned at one or more higher levels in order to capture the concept of disease clustering. There are a number of approaches to select this figure, and these are listed below, in order of preference
    - International Standard
    - Trading partner requirements
    - Experts opinion through formal and informal approaches
    - Biological plausibility
    - Resources and political considerations

- *Risk of introduction of disease*: It is the probability that disease will enter the herd during a certain time period (the time period of the analysis). There are a number of approaches to select this figures, and these are listed below, in order of preference
    - Quantitative risk analysis is a well defined methodology that enables us to estimate the risk of introduction. However performing a thorough quantitative risk analysis can be very challenging and time consuming task
    - Expert opinion through an informal approach
- *Initial probability of freedom*: This value will be 50%
- *Time period of analysis*: It is better to analyse the data as multiple relatively short time period rather than a single long time period. The length of this time period should depends largely on the nature of the disease. For rapidly spreading diseases with short incubation periods short period of analysis is appropriate – normally a month. For slow diseases a period of analysis of a year is usually used

3. Active Surveillance of Wild Fish Populations

3.1. Survey Design

This proposed survey describes the species, collection points and time of year for collection of animals within the first 2 year of the survey. Targeted species are anadromous salmonids found in the wild in BC and known to be susceptible to one or more of the three reportable diseases of concern (Table 1 Section 7.4). Note that there are more than 9600 stocks of salmon in BC. When fish return to spawn is highly variable within species and runs (variable run-time). Data on migratory routes is scarce.

Criteria for determining the species to be targeted are i) that species must be of trade significance and or regional freedom significance and ii) considered susceptible to at least one of the three reportable diseases of concern. Pacific salmonids including coho (*O. kisutch*), chum (*O. keta*), Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and pink salmon (*O. gorbuscha*) are targeted because they are of major trade significance as well as being susceptible to at least one of the three reportable viruses. Steelhead (*O. mykiss*) are known to be susceptible to all three diseases, therefore provide strong evidence towards regional freedom. The species is also currently listed by Committee on the Status of Endangered Wild Life in Canada (COSEWIC) as high priority in BC.
Other salmonids, including Lake trout (*S. namaycush*), brook trout (*S. fontinalis*), Kokanee (*O. nerka*), rainbow trout in fresh water (*O. mykiss*), and cutthroat trout (*O. clarkii*) are not considered of trade significance and are not valuable evidence for establishing regional freedom, therefore not included the first 2 year of sampling. Sea trout/.brown trout (*S. trutta*) are limited in distribution in BC and will not be considered for sampling in the first 2 year even though they are susceptible to the three diseases.

In general, IHN and IPN are considered freshwater diseases, although animals which contracted the disease in freshwater may continue to harbour the disease (and/or shed virus) when in seawater. Because of the etiology of the pathogens, the number of samples has been determined based on determination of populations.

In order to get an idea of the size of populations in fresh water and seawater for each species, stock reports, catch data, and escapement data were reviewed (Table 2 and 3 Section 7.3). The proposed sampling requirements are based on known stocks based on Stock Reports and Escapement data available from DFO and Freshwater Fisheries Society of BC (http://www.gofishbc.com/default.htm).

For wild (which include enhancement fish) populations, this initial surveillance effort is proposed to occur over a 2-year period. Further surveillance needs will be based upon the initial evaluation of the initial CFIA-led surveillance effort and resultant diagnostic findings. This survey plan, after completion, will enable disease status conclusions to be drawn at either the regional level of British Columbia and/or population level (e.g. specific commodity, species, and life stage).

It is important to note that an enhancement hatchery is a fish culture facility that is managed by Federal or Provincial governments, a government-public partnership, or by the public. These establishments are not businesses. For the purpose of this plan, wild fish are fish living in natural water bodies or drainages that are not considered a part of fish culture or aquaculture facilities, which include feral fish residing in natural waters, even if a portion of their life cycle was, or is, managed in a farmed setting.

The proposed sampling requirements are 3850 fish per year for a minimum of two consecutive years, which is comprised of 6 pacific anadromous species, 350 animals per species and per population (details provided in section 3.3.1.3).

Laboratory testing of fish sampled for surveillance purposes will be based on DFO's official disease specific Test Method Agreement, that is for apparently healthy populations, screening by reverse-transcriptase polymerase chain reaction (RT-PCR) or QRT-PCR with subsequent confirmation of positive findings by an independent test (preferably virus isolation). Tests will be conducted at either one of Canada's National Reference Laboratory, or any federally approved laboratories for ISAV and other regulated diseases using approved protocols established through the Department of Fisheries and Oceans. The screening techniques used will detect and differentiate all known strains of ISAV.

It is proposed that fresh water life stages considered most susceptible (spawning fish and fry) be primarily collected at federal enhancement facilities, whereas saltwater life stage of interest (mature returning fish going to market) be collected primarily at processing plants. As all fish collected will be under care, control and possession, all sample collection and submission will be done under the auspices of the CFIA. Procedures and training will be required to those collecting on behalf of the CFIA to ensure chain of custody and that samples arrive at the laboratory in good quality. Any wild collection (i.e., fish sampled in the wild), will require to be conducted under the auspices of the Department of Fisheries of Oceans.

3.2. Specific Considerations and Assumptions

When developing this surveillance plan, many considerations and some assumptions had to be made.

3.2.1. Targeting of Species and life Stages

Species were chosen based on two factors: i) these species are known to be present in the wild environment in BC, and ii) targeted animals are known to be susceptible to the diseases of concern (ISA, IHN, IPN). The lifestage of an animal influences the susceptibility to disease (and detection if infected). Hence stages of development was a factor in determining what life stage to target for sampling to ensure that if present the pathogen would most likely be detected. This approach presents some challenges with respect to ISAV as most of the research to date has been done on Atlantic salmon (*Salmo salar*). The current scientific evidence on the susceptibility of Pacific salmon species with

respect susceptibility to ISAV is limited. Thus, when choosing which life stages of Pacific salmon to target, the assumption was that Pacific salmon would be susceptible at the same lifestage as Atlantic salmon.

3.2.2. Collection points

When determining the collection points, the variation and complexity of salmonid life history were considered since this determines what time of year certain species are returning to river systems. Moreover, several types of hatcheries had to be considered to be able to acquire the required species in the first year of sampling.
However, it is proposed that collection focus on federal salmonid enhancement hatcheries with the acknowledgement of the contribution from PIP and CEDP hatcheries.

To determine the sampling frame, information from many sources was considered. For example, catch data (counts and locations of catch) were evaluated, as well as processing plant information (including species, time of year, commercial fisheries area).

3.2.2.1. Enhancement facilities

Enhancement facilities provide an invaluable point of collection, keeping in mind that enhancement facilities can include hatcheries, spawning channels and cages. Additional information on other locations where and when to see species is provided at http://www.pac.dfo-mpo.gc.ca/publications/docs/salmon-saumon-eng.htm#Map. DFO hatcheries are targeted collection points in this plan. Refer to Table 4 (Section 7.4) for a description of all types salmonid enhancement hatcheries in BC) based on current licenses. There are 18 DFO run hatcheries and spawning channels (http://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/docs/sep-pmvs-eng.htm). Community and economic development program (CEDP) has 21 projects mostly hatcheries and/or counting fences. 13 projects are operated by Aboriginal bands, the rest community organizations. Fish culture is the primary project.

3.2.2.2. Processing plants (Commercial anadromous salmonid fishery)

Catch data is available for all species of anadromous salmon (Table 3 Section 7.4). Figure 1 (Section 7.4) shows commercial salmon harvesting areas. Harvesting by species and area, which is a reflection of gear type, is also available on line (http://www.pac.dfo-mpo.gc.ca/fm-gp/maps-cartes/salmon-saumon/index-eng.htm). Each Salmon License Area is made up of sub-areas. Licenses are issued as A, N (Northern Native Fishing Corporation) or F (communal commercial). Most commercial licenses are A, and are issued to the vessel not the operator, and those are targeted for collection in this plan. Animals sent to plants whole and fresh will be targeted for collection. Therefore, only animals collected by seine and gillnet will be considered (troll fisheries does the processing directly on their vessels).

3.2.3. Sample size determination

Sample size calculations for disease freedom investigations involve several assumptions. The chosen diagnostic test protocol was assumed 85 percent sensitive and 100 percent specific at the level of the fish, based on using RT-PCR or QRT-PCR as the screening test. Since two tests are required for confirmation (see case definition[2] Section 7.3), specificity is assumed to be 100 percent.

Following OIE guidelines, the detection threshold for proportion of infected fish in a given population is set at 1 percent. Targeted selection of more susceptible life stages and time of the year that would increase the likelihood of detection (increased pathogen load and prevalence) further justifies the chosen design prevalence for wild populations.

The l% design prevalence presumed that several factors such as loss of diseased fish from the general population (e.g., shortened survival of moribunds due to predation, failure to school, harsh environmental conditions, etc) and/or capture methodologies biased toward healthier animals would likely lower the prevalence of disease, and necessitate greater sampling effort, in the harvested subset of the population. These assumptions result in a sample size of 350 animals per selected population. This is similar to OIE guidelines for sampling of 150 fish from wild or mixed populations (presumably based on 2% design prevalence). The chosen design prevalence of 1% was to account for a sampling frame that consists mainly of species not considered highly susceptible to all the diseases screened for.

Using a Bayesian model of infection probability, demonstration of disease freedom at these detection thresholds can be achieved pending negative results on surveillance.

3.3. Implementation

A sampling plan is presented in section 3.3.1.3. It is proposed that approximately 3850 animals be collected per year for a minimum of two consecutive years. Options for collection points and times of year to collect are provided in the sampling plan for each life stage of the targeted species. Recommendations are made for each species as to which collection point to target and at what specific times of year. Requirements for on going surveillance in anadromous species will be determined upon the review of the first two year of sampling.

Collection of wild pacific salmonids in year 3 and 4 is strongly recommended for a complete picture of salmonids health on west coast of BC. This continued sampling is strongly recommended due to the life cycle of the Pacific anadromous salmon being

[2] A case definition sspecifies the criteria that define a positive fish, fish culture facility, watershed, zone, or compartment.

highly variable between and within species. Significantly reduced level of testing and opportunistic sampling is proposed.

3.3.1. Operational Requirements

3.3.1.1. Collection, dissection, packaging and shipping

Human resources and the time required to complete the first year of sampling is provided. These resources include collection tasks (collection, dissection, packaging and shipping), costs associated with travel and accommodations. The table below provides an indication of the time and people it will take to complete a collection targeting 175 animals (recommended sample submission).

Sample	**Requirements***	**Sampling Conditions**	Time	# of Samplers
175 animals	Collection, packaging and shipping	Ideal – assistance provided, equipment present, and environmental conditions favourable.	½ day	2
175 animals	Collection, packaging and shipping	Adverse conditions – no assistance, shelter set up, environment unfavourable	1 day	2
175 animals	Collection, **dissection**, packaging & shipping	Ideal – assistance provided, equipment present, and environmental conditions favourable.	1 day	2
175 animals	Collection, **dissection**, packaging & shipping	Adverse conditions – no assistance, shelter set up, environment unfavourable	2 days	2

Ideal conditions for sampling in the plan are defined as those in which the Sample Collectors have assistance from another person on the premises/location; and immediate and easy access to equipment like buckets, dip nets; decent environmental conditions such as a roof overhead (out of the elements). An example of ideal conditions would be collecting animals from a heated hatchery facility with a hatchery staff person available to provide assistance.

Adverse conditions are those open to the environment and weather with no assistance from site personal. Such conditions may require staff to set up their own shelter to create an acceptable place to dissect animals if required.
An example of adverse conditions is collecting animal from a spawning channel on a rainy cold day. A shelter set up would be required in this situation.

Table 5 (Section 7.4) describes the person time requirement to complete the first year of sampling. That is for the collection targeting a total 3850 animals. Of those 3850, approximately 2500 will require to be dissected under the auspices of the CFIA. Based on time required to collect, package and submit 3850 animals to the laboratory including

the dissection on site of 2500 of those animals, under ideal conditions an estimated total of 277.5 people hours was estimated. For example, for collection involving two collectors (recommended) that will amount to 18.6 work days (based on a 7.5 hr/day).

The sampling period will be from early spring to late fall. Table 6 (Section 7.4) provides a complete breakdown of collection time by species and life stages. Spring collection will target fry[3] as well as steelhead spawners. Summer and fall collection will target spawning pacific salmon[4] and returning adult[5]. As only adults and spawners will be dissected, and that 2/3 of the targeted animals is adults and spawners, approximately 80% of the collection will be done in the summer and fall (June through November collection depending on the species).

Below is a cost breakdown for Year 1 Sampling based on the number of week required to carry out the plan (# of weeks is based on the estimated 277.5 person hours) and the work being carried out by CFIA. These estimates are for sample collection tasks (i.e., collection, dissection, packaging, and shipping), shipping costs, travel and accommodations (including per dium), and equipments and supplies. The figures estimated are based on the upper end of the EG-3 pay scale ($48,575 - $61,459). This work will be carried out over a period of months, and not consecutively. The costs for travel and accommodation, shipping and equipments and supplies is based on a total of 25 laboratory submissions (175 animals/specimens per submission) and half the collection on Vancouver Island and half from the mainland.

Option	**Requirements***	**# of weeks*****	**Cost/day**	**Cost**
CFIA - 1 FTE* (EG)	37 days @7.5 hrs per day	5.23	$167.06/day	$6181.35
CFIA –Contractor	37 days @7.5 hrs per day	5.23	$350/day	$12, 950
Shipping	25 sample submissions			$1,500
Travel and accommodations	25 sample submissions			$7,500
Equipments and supplies	25 sample submissions			$3,000
TOTAL				$18,185

[3] Refers to juveniles within their first year of life in freshwater enhancement facilities
[4] Refers to animals which are at their spawning grounds (i.e., spawning channels, hatcheries).
[5] Refers to at-sea sampling of non-spawning individuals which are caught by vessels and brought to a processing plant

3.3.1.2. Testing

The table below shows the number of tests per disease, and species considering life stage that will be required for year 1 of sampling. A total number of 9800 tests will be required, which is comprised of 3850 tests for ISAV and IHNV, respectively, and 2100 tests for IPNV. For ISAV, this number of tests is based on the assumption that the same test can be used for the detection of both HPR0 and ISAV virulent strains (i.e. homogenates of gills, heart, kidney, and liver).

Species	# animals per SW population	# animals per FW population	Fry (FW)			Adult (SW)			Spawning (FW)		
			IPN test	ISA Test	IHN test	IPN test	ISA test	IHN test	IPN test	ISA test	IHN test
Coho salmon	350	350	175	175	175	0	350	350	175	175	175
Chum salmon	350	350	175	175	175	0	350	350	175	175	175
Chinook salmon	350	350	175	175	175	0	350	350	175	175	175
Sockeye salmon	350	350	175	175	175	0	350	350	175	175	175
Pink salmon	350	350	175	175	175	0	350	350	175	175	175
Steelhead	0	350	175	175	175	0	0	0	175[6]	175[7]	175[7]
Totals	2100	2100	1050	1050	1050	0	1750	1750	1050	1050	1050
	3850 animals sampled (175 sampled non-lethally; 3775 sampled lethally)		3150 tests			3500 tests			3150 tests		
	3850 animals										

3.3.1.3. Sampling plan year 2012-2013

Finfish will be collected at specific times of the year as they become available at the selected points of collection. Collection of samples is to be done in accordance with i) CFIA's Surveillance Protocol for Finfish Collection from Premises other than Processing Plans and ii) Surveillance Protocol for Finfish Collection from Processing Plants.

[6] Reproductive fluid only due to value of animals. With small populations, non-lethal sampling methods are required.

Samples and specimens are to be submitted to the National Aquatic Animal Health Laboratory System (NAAHLS) Laboratories. Official diagnostic protocols for detection and confirmation of the listed finfish pathogens are being developed and validated by DFO National Aquatic Animal Health Laboratory System (NAAHLS) in accordance with the requirements of the OIE for the certification of diagnostic tests as validated fit for specific purposes.

It is assumed that all gillnet caught fish will be suitable for sampling for this initial sampling plan. It is therefore recommended that samples for Adult (SW) be derived from DFO salmon harvest areas (Table 2 and 3 Section 7.4). The specific sub-areas are to be determined after consultations with individual processors prior to harvest.

The table below presents the proposed sampling plan for 2012-2013. Location, number of samples and an estimate of when fish are present at a facility is provided. Specifics such as the processing plants that will be used for collection will be determined through further consultation. Hatcheries listed in the sampling plan below for each species are based on their production data for that given species (refer to Table 7 to 12 Section 7.4). Figure 2 (Section 7.4) shows the location of each DFO fish hatchery. It is intended that hatcheries which are chosen to sample on category (fry/spawning) should not be used for the other category (fry/spawning) to increase representation. Sample numbers are based on 350 freshwater (FW) and 350 saltwater (SW) per year/species, with the exception of steelhead as the likelihood of getting samples from the marine environment is poor.

Species	Fry (FW)	Adult (SW)	Spawning (FW)
Coho salmon (*O. kisutch*)	• Chilliwack River Hatchery • N=175 • Fish present all year round	• Area A (processing plants) • N= 117 • Oct-Nov	• Chehalis River Hatchery • N= 58 • June-Nov
	OR	**AND**	**AND**
	• Quinsam River Hatchery • N=175 • Fish present all year round	• Area B (processing plants) • N= 117 • Oct-Nov	• Big Qualicum River Hatchery • N=58 • June-Nov
		AND	**AND**
		• Area D (processing plants) • N= 117 • Oct-Nov	• Puntledge River Hatchery • N=58 • June-Nov
		ADDITIONAL	
		• DFO vessel • N= TBD • Date= TBD	
Chum salmon (*O. keta*)	• Nitinat River Hatchery	• Area B (processing plants)	• Chehalis River Hatchery

	• N=175 • April-May	• N= 117 • Oct-Nov	• N=58 • Sept-Nov
	OR	**AND**	**AND**
	• Big Qualicum River Hatchery • N=175 • April-May	• Area C (processing plants) • N= 117 • Oct-Nov	• Kitimat River Hatchery • N=58 • Sept- Nov
		AND	**AND**
		• Area D (processing plants) • N= 117 • Oct-Nov	• Puntledge River Hatchery • N=58 • Sept-Nov
		ADDITIONAL	
		• DFO vessel • N= TBD • Date= TBD	
Chinook salmon (*O. tshawytscha*)	• Robertson Creek Hatchery • N=175 • Feb-June	• Area C (processing plants) • N= 175 • Oct-Nov	• Big Qualicum Hatchery • N=58 • Oct-Nov
	OR	**AND**	**AND**
	• Quinsam River Hatchery • N=175 • Feb-June	• Area E (processing plants) • N= 175 • Oct-Nov	• Nitinat River Hatchery • N=58 • Oct-Nov
		ADDITIONAL	**AND**
		• DFO vessel • N= TBD • Date= TBD	• Little Qualicum Hatchery • N=58 • Oct-Nov
Sockeye salmon (*O. nerka*)	• Fulton River Spawning Channel • N=175 • Feb-May	• Area B (processing plants) • N= 117 • Sept-Oct	• Weaver Creek Spawning Channel • N=88 • Aug-Oct
	OR	**AND**	**AND**
	• Pinkut Creek Spawning Channel • N=175 • Feb-May	• Area D (processing plants) • N= 117 • Sept-Oct	• Nadina Spawning Channel • N=88 • Aug-Oct

		AND • Area E (processing plants) • N= 117 • Sept-Oct **ADDITIONAL** • DFO vessel • N= TBD • Date= TBD	
Pink salmon (*O. gorbuscha*)	• Quinsam River Hatchery • N=175 • Feb-April **OR** • Puntledge River Hatchery • N=175 • Feb-April	• Area A (processing plants) • N= 117 • Sept-Oct **AND** • Area B (processing plants) • N= 117 • Sept-Oct **AND** • Area D (processing plants) • N= 117 • Sept-Oct **ADDITIONAL** • DFO vessel • N= TBD • Date= TBD	• Chehalis River Hatchery • N=88 • Sept-Oct **AND** • Tenderfoot Hatchery • N=88 • Sept-Oct
Steelhead (*O. mykiss*)	• GoFish BC Hatchery A • N=175 • All year round **OR** • GoFish BC Hatchery B • N=175 • Fish present all year round	No sampling	• Robertson Creek Hatchery • N=58 • March-April **AND** • Chilliwack River Hatchery • N=58 • March-April **AND** • Chehalis River Hatchery • N=58 • March-April

3.3.2. Roles and Responsibilities

CFIA
CFIA is responsible for the consultation, development, implementation, and review of the plan and reporting of findings. It is also responsible for sample collection from collections points where the targeted species are under the care, control and possession of an owner/operator.

DFO
DFO is responsible for providing scientific advice on the wild fish sampling plan, NAAHLS laboratory testing, and collection of animals directly from the wild. CFIA is also responsible for the role of diagnostic coordination of all sample submissions to a NAAHLS laboratory.

Provincial Ministry
The British Columbia provincial ministries will play a role in providing input to the plan and access to specific collection points such as certain hatcheries (Gofish BC).

Industry
The industry such as the commercial fisheries will play a role in providing harvest information and access to specific processing plants for collection.

3.3.3. Required Training

Basic Training for National Aquatic Animal Health Program (NAAHP) Delivery is required for Inspectors and Officers collecting samples on behalf of CFIA. Basic training for NAAHP is a five course series including an Introduction to NAAHP, Aquatic Animal Industries, Disease Recognition, Aquatic Animal Species Identification, and Introduction to sampling Aquatic Animals. These courses are available as online e-learning courses to CFIA staff through My Account (formerly known as Campus direct).

I. Introduction to the NAAHP
   Recognize the CFIA mission statement, the NAAHP objectives, and regulatory authority
   - Identify the NAAHP structure and federal roles
   - Recognize the program elements and supporting activities

II. Aquatic Animal Industries
   Recognize the aquatic animal production types, processing plants, and other aquatic animal industries

III. Aquatic Animal Disease Recognition
   - Recognize Reportable Diseases in susceptible aquatic animal species

- Distinguish between normal and abnormal appearances of aquatic animal species

IV. Aquatic Animal Species Identification
- Identify and recognize aquatic species of concern

V. Introduction to Sampling Aquatic Animals
- Identify the basic principles of biosecurity
- Describe the basic procedures for aquatic animal sample and specimen collection
- Describe the basic procedures for packaging and shipping samples and specimens to the laboratory.

4. Active Surveillance of Cultured Fish

4.1. CFIA oversight program

A fish culture facility in this plan refers to one that is privately owned and operates as a business. For cultured fish populations, following its quantitative sensitivity evaluation of on going programs, CFIA will provide each company assessed a list of gaps for each diseases assessed with respect to their likelihood of detection along with recommendations for their remediation.

There are 3 main salmonid aquaculture companies in British Columbia: Grieg Seafood BC Ltd., Marine Harvest, and Mainstream Canada. Grieg Seafood BC Ltd. is a Canadian salmon farming company based in Campbell River, British Columbia. Its farm Operations is comprised of 9 sites based in four areas; Esperanza Inlet and Nootka Sound on the west coast of Vancouver Island, and on the east side of Vancouver Island in Clio Channel and Okisollo Channel. Marine Harvest is the world's largest aquaculture producer and supplier of farmed salmon. Marine Harvest Canada is a fully integrated business having freshwater and saltwater production facilities from Duncan to Klemtu and its own processing plant in Port Hardy. Marine Harvest is the largest producer of Atlantic Salmon on the Canada's west coast. Mainstream Canada is another leading company in the Canadian salmon industry. Information on each company is provided on the association's website http://www.salmonfarmers.org/salmon_farmers.php

It is proposed that CFIA, as Canada's veterinary competent authority, will provide an oversight function to industry-led surveillance effort, which will include an annual visit to sites (i.e., physical and documentation inspection, and optional animal sampling/testing as indicated by inspection findings).

A Veterinary Competent Authority (OIE Aquatic Animal Health Code) refers to the Authorities of a Member Country that have the responsibility and competence to ensure or supervise the implementation of aquatic animal health measures or other standards in the OIE Aquatic Code.

Administrative animal health regulations and oversight by the competent authority will help resume or maintain trading partner confidence for either specific commodity groups or the entire region. This approach is based on OIE guidelines for surveillance of aquatic animal diseases.

4.2. Operational Requirements

There are approximately 150 individual leases in BC that grows anadromous salmonids. Each site will be risk profiled based on a semi-qualitative evaluation of introduction risk of diseases of concern. It is proposed that 10% of sites be visited by the CFIA on an annual basis (approximately 15 sites visited annually). A greater proportion of sites will be selected from higher risk categories (i.e., likelihood of selection for an inspection

proportional to risk). From each risk category, facilities will be selected at random. CFIA veterinary inspector will visit each selected site to perform a veterinary inspection (see section 4.2.2.1.).

4.2.1. Roles and Responsibilities

CFIA
The Surveillance and Epidemiology Section of the Aquatic Animal Health Division is responsible for:

- Providing information on the health status of the region
- Reporting on system quantitative evaluation and providing recommendations
- Conducting the sites introduction risk profiling
- Participating in performance review of oversight program as required

The CFIA Veterinary Inspector will be responsible for:

- Providing information to premises selected for a veterinary inspection.
- Reviewing the premises biosecurity plan and verifying that it complies with CFIA Program Standards.
- Conducting the inspections of premises and initializing the premises profile.
- Collecting samples/specimens if required (i.e., signs or suspicion of a reportable diseases).
- Communicating inspection findings to the premises biosecurity manager or owner/operator in a professional manner using the correct documentation
- Enforcing the Health of Animals Act and associated Regulations if required
- Maintaining equipment for inspection including biosecurity and sampling
- Verifying gaps are addressed and have been corrected.
- Maintaining complete records of inspection (some records exist only electronically, others are available as hard copy)

The CFIA Inspector is responsible for:

- Performing any duties as assigned by the veterinary inspector that is responsible for the oversight of the premises.
    - Conducting premises inspections;
    - Collecting samples/specimens;
    - Conducting enforcement activities

DFO
Fisheries and Oceans Canada (DFO) oversees the National Aquatic Animal Health Laboratory System (NAAHLS) to support CFIA's delivery of the regulatory mandate of the NAAHP.

The responsibilities of the NAAHLS are to:

- Receiving, analysing and providing reports of the findings for all samples submitted by CFIA as a requirement of the surveillance oversight program.

DFO will play a role in providing information and access to specific data such as laboratory data

Provincial Government
The British Columbia provincial ministries will play a role in providing technical input to the proposed approach and access to specific data such as laboratory data.

Industry
The industry (farm companies and the BC Salmon farmers Association) and association will play a role in providing information and access to specific farm-level data.

The premises owner/operator, veterinarian and other health staff will be responsible for

- Providing specimens and samples for diagnostic evaluation as required
- Training staff in the implementation of biosecurity plan and other CFIA standards and requirements
- Providing the CFIA and designated inspectors with access to all premises, records, animals, and any and all other documentation required to verify the status of the compartment; and
- Compliance with all other regulatory requirements under the *Health of Animals Act* and *Regulations* and the *Reportable Diseases Regulations*.
- Reporting to CFIA any reportable or immediately notifiable pathogen detections

4.2.2. Required Training

Area Program Specialists - Aquatic and Veterinary Inspectors who are responsible for inspecting premises will require the following training:

- NTI-D- 01 Basic Training for National Aquatic Animal Health Program (NAAHP) Delivery
  Course 1: Introduction to the National Aquatic Animal Health Program (NAAHP)
  Course 2: Aquatic Animal Industries
  Course 3: Aquatic Animal Disease Recognition
  Course 4: Aquatic Animal Species Identification
  Course 5: Introduction to Sampling Aquatic Animals

- NTI-D-02: Completion of the Aquatic Premises Questionnaire Part A
- NTI - D-05a Aquatic Animal Knowledge
- NTI - D-05b Site Practical Procedures
- On the job mentorship

5. Reporting, Consultation and Communication

5.1. Consultation and Outreach

Consultation and outreach is required at different levels:

i. Plan review and meetings with stakeholders, Federal and Provincial authorities to explain the surveillance plan, garner support and assistance, and clarify roles and responsibilities.

ii. Technical training will be provided for individuals designated to conduct the various components of the surveillance plan.

iii. Outreach education, field sampling and laboratory coordination are critical first steps in the implementation of wild fish surveillance. Necessary resources for implementation are described in section III and IV.

iv. As part of its proposed oversight program on farms, the CFIA will be conducting a series of outreach/education sessions to staff on CFIA's aquatic animal health standards (e.g., premises biosecurity and active observational surveillance) and regulatory requirements.

5.2. Reporting of findings and results

The dissemination of negative and positive test results resulting from surveillance samples is done via prompt e-notification to selected stakeholder and industry groups and via the posting of annual survey reports on CFIA internal and external web pages.

Use of findings and recommendations derived from official evaluation will occur at several levels: industry and provincial level for management decisions; federal level for regulatory purposes, performance evaluation and validation.

6. Program Review and Performance Evaluation

The measures of success of this proposed surveillance program under the NAAHP include the integration of available resources across different level of governments for aquatic animal health surveillance, the maintenance or increased opportunities for safe trade, meeting Canada's international disease reporting obligations to OIE (World Organisation for Animal Health), and the provision of timely and effective dissemination of aquatic animal health information to NAAHP stakeholders in order to maintain and enhance welfare, productivity, and economic viability of aquatic animal industries in Canada.

The plan will be revised annually and adjusted accordingly. Historical data and activities as described in Chapter II will supplement test-based surveillance requirements for wild populations as outlined in Chapter III. Requirements for test-based surveillance will be revised annually, discounting historical data by introduction risk, incorporating new findings, and re-visiting risk factors as needed. Areas (either geographic or population based) with cumulative negative test results sufficient to support a disease freedom claim will maintain that status through a variety of options. For consistently low calculated disease probabilities of introduction, alternative surveillance, such as active observational surveillance, may provide acceptable options to minimize costs of ongoing surveillance.

Specific needs for ongoing surveillance, in farm and wild fish independently, including revision of risk factors, as well as alternative means of early detection systems such as AOS and mandatory notification, will be detailed following a performance review of the first year of the plan implementation.

An evaluation of the proposed initial surveillance in wild fish will be conducted by the CFIA as per their validated model on evaluation of animal health surveillance systems in order to provide recommendations on surveillance plan updates or modifications. This review will include stakeholder feedback. Following the first year of implementation of the plan, diseases and species may be added or deleted from the plan to accommodate to burgeoning needs and pressure.

7. Appendices

7.1. Finfish Fact Sheets for IHN, ISA and IPN

7.1.1. Infectious haematopoietic necrosis (IHN)

Causative agent: Infectious Haematopoietic Necrosis Virus (IHNV) (Family Rhabdoviridae, Genus Novirhabdovirus).

There are three genotypes (U, M, L) based on sequencing of the G gene. The U genotype predominates in British Columbia (BC); however, the three genotypes and associated subtypes do overlap geographically to some extent, and therefore IHNV will not be regulated at this time, according to strain.

Distribution in Canada: IHNV has been reported in the Pacific Ocean watershed of BC.

Global distribution: IHNV is endemic in salmonid populations of the Pacific Ocean watershed of the United States of America, from Alaska to California. IHNV has been reported from most countries in Europe, as well as from Bolivia, China, Iran, Japan, Kuwait, Republic of Korea, Russia, and Taiwan.

Susceptible species: Susceptible species means a species of aquatic animal in which infection or infestation has been demonstrated by natural cases or by experimental exposures to the disease agent that mimic the natural pathways for infection or infestation. This includes animals denoted as “carriers” (an aquatic animal of a susceptible species that shows no clinical signs of disease but carries the infectious agent of disease and is capable of transmitting the agent to others because of active shedding of the disease agent).

IHNV infection and disease can occur in both freshwater and seawater. Tables 1 and 2 list the species known to be susceptible to IHNV.

Affected life stages: All life stages of fish can be infected and can express disease, except germplasm or fertilized eggs. IHNV, however, can adsorb to sperm and the surface of eggs.

Signs of disease:

Clinical signs, post-mortem findings, and mortality statistics are reported for finfish reared in freshwater hatcheries and for Atlantic salmon reared in net pens in seawater.

Aquatic animals with disease may show one or more of the signs below; disease may still be present in the absence of any signs.

Aquatic animals not previously identified as susceptible to this disease may show one or more signs that differ from the signs noted below.

Signs in the population:

IHN can manifest as a peracute disease in young finfish reared in freshwater hatcheries or when Atlantic salmon smolts are recently introduced into seawater.

Mortality:

- In the freshwater hatchery, rapid high mortality occurs in young juveniles, often reaching 100% over a short time period.
- In marine net-pen sites, cumulative mortality can range from < 20%–100% and can occur over a protracted period of time (months).

Morbidity (behaviour):

In the freshwater hatchery:

- Inappetence
- Abnormal swimming pattern: slow spirals, flashing, or bouts of erratic swimming
- Float "belly up"

In the marine net-pen site:

- Abnormal swimming pattern: slow swimming at the surface

Signs in an infected animal:

In the freshwater hatchery:

- Exophthalmia
- Pale gills
- Petechial hemorrhages at base of fins, in mouth, head, anus, and yolk sac
- Hyperpigmentation in younger fish (dark skin discolouration)
- Distended abdomen
- Trailing fecal casts that may be present in young finfish
- Scoliosis, which can occur in survivors of an epidemic (< 5%)

In the marine net-pen site:

- Hyperpigmentation (dark skin discolouration)
- Pale brown gills

Gross necropsy signs in an infected animal:

In the freshwater hatchery:

- Ascites (fluid type not described)
- Stomach and intestines may contain white to yellowish fluid
- Swelling of kidney
- Petechial or ecchymotic hemorrhages in skeletal muscle and visceral tissue

In the marine net-pen site:

- *Ascites (fluid type not described);*
- *Petechial hemorrhages on peritoneal surfaces, in adipose tissue surrounding pyloric cecae, and in skeletal musculature.*

Epidemiology:

- Water temperature during an outbreak is generally between 8˚C and 15°C
  - Outbreaks rarely occur above 15°C.
- In bath water, challenges occur at 15˚C; the incubation period is approximately 4 days (to first mortality).
- Concurrent infections with other finfish viruses, such as infectious pancreatic necrosis virus (IPNV) and viral hemorrhagic septicemia virus (VHSV), have been reported.

Transmission:

- Transmission is horizontal and direct or indirect:
  - exposure to contaminated water
  - feeding upon infected fish.
- Vertical transmission has not been demonstrated, but egg surface-associated transmission does occur:
  - IHNV adsorbs to sperm; sperm-associated infection of eggs upon fertilization has not been demonstrated.
- The route of virus entry has not been definitively determined; there is evidence of internalization of virus by the esophagus and cardiac region of the stomach.
- Water becomes contaminated when infected fish shed virus in reproductive fluids; other shedding routes have not yet been demonstrated.
- The role of mechanical vectors, such as gill copepods, leeches, and mayflies, remains unclear.

Survival of IHNV in the environment:

- IHNV will survive in
  - untreated freshwater at 15˚C for 3 to 25 days.
  - untreated seawater at 15˚C for 3 to 14 days.
  - untreated sediment at 15˚C for < 3 days.

Differential diagnosis:

Note: Only those diseases that are regulated by the National Aquatic Animal Health Program (NAAHP) are referenced in these lists.

Reportable diseases

- Infectious salmon anaemia (regionally enzootic in Canada)
- Viral hemorrhagic septicaemia (regionally enzootic in Canada)
- Infectious pancreatic necrosis (regionally enzootic in Canada)
- Whirling disease (exotic to Canada)
- Epizootic haematopoietic necrosis (exotic to Canada)

Annually Notifiable diseases

- Enteric red mouth disease (*Yersinia ruckeri*) (enzootic in Canada)
- Furunculosis (*Aeromonas salmonicida*) (enzootic in Canada)

Table 1: Species susceptible to IHNV that **occur** in the natural environment in Canada. Finfish may have several common names, but this list refers to only one.
Note: Species coloured in blue have not been confirmed as susceptible to IHNV.

Scientific Name	Common Name	Scientific Name	Common Name
Acipenser transmontanus	White sturgeon	*Oncorhynchus kisutch*	Coho salmon
Aulorhynchus flavidus	Tube-snout	*Oncorhynchus mykiss*	Rainbow trout
Clupea pallasii	Pacific herring	*Oncorhynchus nerka*	Sockeye salmon
Cymatogaster aggregata	Shiner perch	*Oncorhynchus tshawytscha*	Chinook salmon
Esox lucius	Northern pike	*Salmo salar*	Atlantic salmon
Gadus morhua	Atlantic cod	*Salmo trutta*	Sea trout
Lota lota	Burbot	*Salvelinus alpinus*	Arctic char
Oncorhynchus clarkii	Cutthroat trout	*Salvelinus fontinalis*	Brook trout
Oncorhynchus gorbuscha	Pink salmon	*Salvelinus namaycush*	Lake trout
Oncorhynchus keta	Chum salmon	*Thymallus arcticus*	Arctic grayling

Table 2: Species susceptible to IHNV that **do not occur** in the natural environment in Canada. Finfish may have several common names, but this list refers to only one.
Note: Species coloured in blue have not been confirmed as susceptible to IHNV.

Scientific Name	Common Name	Scientific Name	Common Name
Oncorhynchus rhodurus	Amago salmon	*Plecoglossus altivelis*	Ayu sweetfish
Oncorhynchus masou	Masu salmon	*Salvelinus leucomaenis*	Whitespotted char

7.1.2. Infectious salmon anaemia (ISA)

Causative agent: Infectious Salmon Anaemia Virus (ISAV) (Family Orthomyxoviridae, Genus Isavirus). There are pathogenic and non-pathogenic strains of ISAV. Pathogenic strains include strains that are highly pathogenic and those that are of low pathogenicity. All strains are reportable.

Distribution in Canada: Outbreaks of ISA have occurred in Atlantic salmon cultured in New Brunswick in the Bay of Fundy. However, the last detection of a pathogenic strain of ISAV in this area occurred in 2007. Since then, only a non-pathogenic strain of ISAV has been periodically detected. Single, small outbreaks have also been reported in the past in Nova Scotia and PEI but the occurrence of non-pathogenic strains of ISAV has not been reported from these 2 provinces since the outbreaks occurred.

Global distribution: Outbreaks and detections of ISAV have been reported in cultured Atlantic salmon or Rainbow trout in Chile, Faroes Islands, Ireland, Norway, Scotland (including Shetland Islands), and the Cobscook Bay area of Maine in the United States of America.

ISAV has been detected by PCR methodology in wild Atlantic salmon, Atlantic cod, brown trout and pollack harvested from European or North American (Maine, USA) waters but not confirmed.

Susceptible species: Susceptible species means a species of aquatic animal in which infection or infestation has been demonstrated by natural cases or by experimental exposures to the disease agent that mimics the natural pathways for infection or infestation. This includes animals denoted as “carriers” (an aquatic animal of a susceptible species that shows no clinical signs of disease but carries the infectious agent of disease and is capable of transmitting the agent to others because of active shedding of the disease agent).

Table 1 lists the species known to be susceptible to ISAV.

Affected life stages: ISAV is infectious for all life stages in Atlantic salmon (except eggs). ISAV has been reported in Atlantic salmon fry and parr in freshwater hatcheries. Life stage susceptibility in other species is not well documented.

Signs of disease:

Mortality statistics, clinical signs, and post-mortem lesions are described for cultured Atlantic salmon (*Salmo salar*).

Aquatic animals with disease may show one or more of the signs below; disease may still be present in the absence of any signs.

Aquatic animals not previously identified as susceptible to this disease may show one or more signs that differ from the signs noted below.

Signs in the population:

Mortality:

- Initially, mortality rate is low and may occur over a prolonged period.
- Cumulative mortality can be up to 90% (varies with strain).

Morbidity (behaviour):

- Inappetence (decrease in feed conversion ratio)
- Abnormal swimming patterns: slow swimming; swim slowly at the surface
- Congregation at edges or outlets of holding units
- Fish gasp at the surface

Signs in an infected animal:

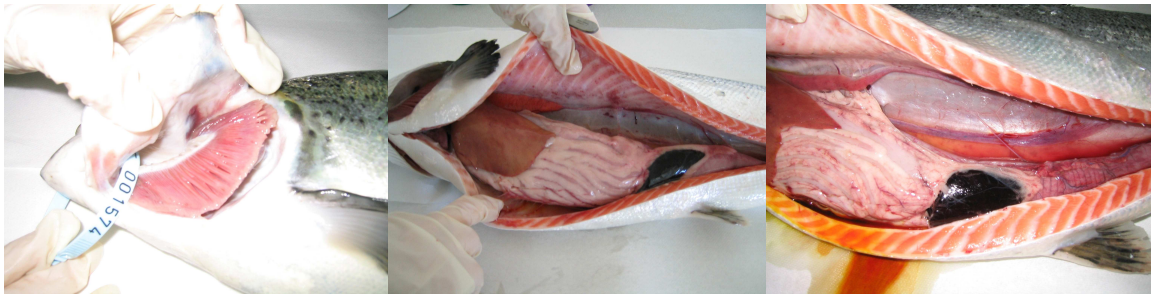
- Grey gills
- Distended abdomen
- Ecchymotic and petechial hemorrhages may be present ventrally

Gross necropsy signs in an infected animal:

- *Kidney, liver, and spleen are swollen and dark*
- *Petechial hemorrhages in visceral fat*
- *Hemorrhages in pyloric cecae and intestines (Figure 1)*
- *Hemorrhages in liver*
- *Pale heart*
- *Ascites: serosanguinous*
- *Pericardial fluid: serosanguinous*

Epidemiology:

- ISA occurs in spring or early summer in water temperatures from 3˚C to 15˚C.
- Severity of infection in the population:
    - in enzootic areas, infection severity relates to farm local husbandry (moving fish between pens) and frequency of removal of infected fish; and
    - strain of virus.
- Risk of infection is increased with
    - proximity to infected farms
    - multiple year classes held on the same site.



An adult Atlantic salmon (*Salmo salar*) with typical signs of ISAV. Left: Pale gills; Center and Right: Petechial hemorrhaging of the musculature, a swollen/irregular kidney, an enlarged liver with hemorrhaging, enlarged spleen; (Photos: V. Pederson).

Transmission:

- Transmission of ISAV is horizontal and indirect via contaminated water:
  - The virus is shed in epidermal mucus, urine, feces, and reproductive fluids.
  - Primary portals of entry are unknown, but the gills are suspected.
  - Direct transmission has not been thoroughly investigated.
- Vertical transmission has not been demonstrated; egg surface-associated transmission does occur.
- Spread of ISAV via fomites can occur during
  - movement of equipment between farms.
  - discharge of organic waste from fish-processing plants, without effluent treatment, into the marine environment.
- The role of vectors in ISAV transmission is unknown.

Survival of ISAV in the environment:

- ISAV can survive in 6˚C seawater for at least 20 hours.
- ISAV can survive in carcasses for at least 4 hours at 6˚C.
- Survival of ISAV in freshwater has not been reported.

Differential diagnosis:

Reportable diseases

- Viral haemorrhagic septicaemia (regionally enzootic in Canada)
- Infectious haematopoietic necrosis (regionally enzootic in Canada)
- Infectious pancreatic necrosis (regionally enzootic in Canada)

Annually Notifiable diseases

- Enteric red mouth disease (*Yersinia ruckeri*) (enzootic in Canada)
- Furunculosis (*Aeromonas salmonicida*) (enzootic in Canada)

Table 1: List of species susceptible to ISAV that **occur** in the natural environment in Canada. Finfish may have several common names, but this list refers to only one.
Note: Species coloured in blue have not been confirmed as susceptible to ISAV.

Scientific Name	Common Name	Scientific Name	Common Name
Alosa pseudoharengus	Alewife	*Pollachius virens*	Pollack
Clupea harengus	Atlantic herring	*Salmo salar*	Atlantic salmon
Gadus morhua	Atlantic cod	*Salmo trutta*	Sea trout
Oncorhynchus kisutch	Coho salmon	*Salvelinus alpinus*	Arctic char
Oncorhynchus mykiss	Rainbow trout		

7.1.3. Infectious pancreatic necrosis (IPN)

Causative agent: Infectious Pancreatic Necrosis Virus (IPNV) (family Birnaviridae; genus Aquabirnavirus)

Distribution in Canada: IPNV is enzootic in Canada; however, IPNV has not been reported from British Columbia.

Global distribution: IPNV has been isolated in most of the major salmonid farming countries worldwide, including Chile, Iran, Japan, Republic of Korea, South Africa, Taiwan, Thailand, United States of America, and most of eastern and western Europe.

Susceptible species: Susceptible species means a species of aquatic animal in which infection or infestation has been demonstrated by natural cases or by experimental exposures to the disease agent that mimics the natural pathways for infection or infestation. This includes animals denoted as "carriers" (an aquatic animal of a susceptible species that shows no clinical signs of disease but carries the infectious agent of disease and is capable of transmitting the agent to others because of active shedding of the disease agent).

The virus infects freshwater, marine, and anadromous finfish. Tables 1 and 2 list the species known to be susceptible to IPNV.

Affected life stages: IPNV may infect all life stages of susceptible finfish. Generally, finfish populations older than 6 months experience subclinical infection without serious mortality.

Signs of disease:

Aquatic animals with disease may show one or more of the signs below; disease may still be present in the absence of any signs.

Aquatic animals not previously identified as susceptible to this disease may show one or more signs that differ from the signs noted below.

Signs in the population:

Mortality:

- Cumulative mortality can vary from 10%–90%.

Morbidity (behaviour):

- Inappetence
- Fish tend to lie still on the bottom of the holding unit
- Abnormal swimming patterns: spiral (corkscrew) swimming pattern

Signs in an infected animal:

- Pale gills

- Trailing white fecal casts
- Abdominal distension
- Hyperpigmentation (darkening of body colour)
- Exophthalmus

Gross necropsy signs in an infected animal:

- Hemorrhages sometimes present on ventral area, including ventral fins
- Ulcers in esophagus and stomach
- Stomach and intestines empty or filled with clear or milky mucus
- Spleen, kidney, liver and heart are pale in fry
- Petechial hemorrhages on pyloric caecae and abdominal adipose tissue

Epidemiology:

- Cumulative mortality can vary depending on species, age, and temperature of the water:
    - Highest mortalities are experienced by fry and fingerlings classes (1 to 4 months of age).
    - Mortalities at 5˚C are minimal, whereas at 10˚C, 15˚C, and 20˚C, 80%–100% mortality can occur.
    - Low temperatures have a protective effect on the mortality rate with IPN.
    - High, rapid mortality occurs at temperatures of 10˚C to 14˚C.
    - IPNV affects post-smolt Atlantic salmon 7 to 12 weeks after transfer from freshwater to seawater (noted as a sudden and progressive increase in mortality).

Transmission:

- Transmission is horizontal, and either direct or indirect, through contact with secretions and excretions from clinically infected fish, such as feces, reproductive fluids, and urine.
- Vertical transmission has not been demonstrated; egg surface-associated transmission does occur.
- The role of vectors has not been clearly established:
    - Invertebrates are considered potential mechanical vectors of fish pathogens, and uptake of IPNV has been shown in both crustaceans and bivalve molluscs

Survival of IPNV in the environment:

- IPNV remains viable for several months in filtered water at 4˚C.
- IPNV can survive for several weeks in sediment at 10˚C.
- IPNV can survive 71 days at 20˚C.
- IPNV can survive 2 hours at 60˚C.

Differential diagnosis:

Note: Only those diseases regulated by the National Aquatic Animal Health Program (NAAHP) are referenced in these lists.

Reportable diseases

- Infectious haematopoietic necrosis (regionally enzootic in Canada)
- Infectious salmon anaemia (regionally enzootic in Canada)
- Viral haemorrhagic septicaemia (regionally enzootic in Canada)

Annually Notifiable diseases

- Enteric red mouth disease (*Yersinia ruckeri*) (enzootic in Canada)
- Furunculosis (*Aeromonas salmonicida*) (enzootic in Canada)

Table 1: List of species susceptible to IPNV that **occur** in the natural environment in Canada. Finfish may have several common names, but this list refers to only one.

Scientific Name	Common Name	Scientific Name	Common Name
Anarhichas minor	Spotted wolffish	*Oncorhynchus keta*	Chum salmon
Carassius auratus	Goldfish	*Oncorhynchus mykiss*	Rainbow trout
Catostomus commersonii	White sucker	*Phoxinus phoxinus*	Eurasian minnow
Cyprinus carpio	Common carp	*Pollachius virens*	Pollack
Gadus morhua	Atlantic cod	*Salmo salar*	Atlantic salmon
Hippoglossus hippoglossus	Atlantic halibut	*Salmo trutta*	Sea trout
Melanogrammus aeglefinus	Haddock	*Salvelinus alpinus*	Arctic char
Morone saxatilis	Striped bass	*Salvelinus fontinalis*	Brook trout
Oncorhynchus clarkii	Cutthroat trout	*Salvelinus namaycush*	Lake trout

Table 2: List of species susceptible to IPNV that **do not occur** in the natural environment in Canada. Finfish may have several common names, but this list refers to only one.

Scientific Name	Common Name	Scientific Name	Common Name
Abramis brama	Freshwater bream	*Microstomus kitt*	Lemon sole
Anguilla anguilla	European eel	*Oncorhynchus rhodurus*	Amago salmon
Anguilla japonica	Japanese eel	*Paralichthys lethostigma*	Southern flounder
Barbus barbus	Barbel	*Perca fluviatilis*	European perch
Ctenolabrus rupestris	Goldsinny-wrasse	*Platichthys flesus*	European flounder
Eutrigla gurnardus	Grey gurnard	*Pleuronectes platessa*	European plaice
Hucho hucho	Huchen	*Psetta maxima*	Turbot
Lampetra fluviatilis	River lamprey	*Sparus aurata*	Gilthead seabream
Limanda limanda	Common dab	*Symphysodon discus*	Red discus
Merluccius merluccius	European hake	*Thymallus thymallus*	Grayling

7.2. Description of historical and on going testing activities

The following are a list of surveillance activities that screen for one or several of the diseases targeted in this plan. Some of those activities were one-off (historical) while the majority are still ongoing. Only programs that were initiated within the last 10 years are described below.

Organization: **Freshwater Fisheries Society of BC**
Activity: **Fish Stocking Program and Conservation Fish Culture Services**
Disease(s): **Viruses and bacterial pathogens of finfish**
Species (2010): **Cutthroat Trout (anadromous and coastal)**
Brook trout
Kokanee
Rainbow trout
Steelhead Trout
Westslope cutthroat
White Sturgeon
Geo Area: **BC**

The Freshwater Fisheries Society of BC (FFSBC)[7] is a non-profit organization that works closely with the Ministry of Environment and other public and private sector partners in the delivery of programs and services. The purposes of the FFSBC are to provide fish culture and stocking services that support freshwater recreational fishing and the conservation and restoration of wild freshwater fish; to promote and market recreational sport fishing; and to inform and educate the public about fish, conservation and fishing.

In cooperation with the British Columbia provincial Ministry of Environment, the FFSBC cultures and stocks trout, char and kokanee into lakes and streams throughout BC to support recreational fisheries. It also provides special conservation fish culture services to assist with the recovery of fish species at risk, such as white sturgeon. The FFSBC currently supports three conservation fish culture programs working towards the restoration of endangered white sturgeon in the Kootenay, Columbia and Nechako rivers.

The FFSBC advises and supports Provincial freshwater fishery managers on initiatives to improve fishery performance and angler satisfaction in stocked waters. Applied research is conducted by the FFSBC to continuously improve cultured fish performance, technical service delivery, and the assessment of fish populations and angling impact.

The Science Division of the FFSBC provides professional support, program evaluation, applied research, planning, product and technology development needed to support the partnership in the Ministry of Environment's fisheries program and for delivery of FFSBC services. The division is supported by specialists in the fields of fish culture, fish health, genetics, fish biology, and sport fisheries management.

[7] All of the information on the Freshwater Fisheries Society of BC was sourced and modified from the gofishbc.com website and is copyright of GO FISH BC, the Freshwater Fisheries Society of BC.

A new Fish Health Lab was established by the FFSBC in Duncan, BC in 2008-2009. Lab staff worked with Operations staff at all the facilities to try and reduce the incidence of *Flavobacterium psychrophilum*. Some of the initiatives implemented appear to have been effective in reducing the incidence of this bacteria, in particular the replacement of smaller rearing containers with larger more efficient containers. As a result in 2009–2010 we saw a marked reduction in the incidence of *Flavobacterium* in early rearing stages. A continued emphasis will be placed on bio-security and fish husbandry techniques to better manage *Flavobacterium psychrophilum* in the rearing facilities.

The Fish Health Unit maintains year round diagnostic assessments on all hatchery-reared fish to ensure that all fish health standards established by federal and provincial regulatory agencies are met. The Fish Health Unit maintains 6 cell lines year round to conduct virology assays. Three of these lines are salmonid, but the other 3 lines are white sturgeon. These cell lines are used in monitoring the ongoing health of the sturgeon and meeting regulation requests for the Society's conservation culture programs for white sturgeon.

The fish health lab is capable of performing a number of other disease screening techniques. The most recent addition is the PCR test to confirm the presence or absence of certain pathogens. The lab performs bacteriology isolation and basic identification of some common bacterial pathogens. A full histology lab allows for the preservation and processing of tissues in order to look for microscopic changes within the tissue which may be the result of pathogenic infections or environmental changes.

Organization: **British Columbia Salmon Farmers Association (BCSFA)**
Activity: **British Columbia Salmon Farmers Association Fish Health Database**
Disease(s): **All proposed listed salmonid diseases**
Species: **Pink salmon**
Chinook salmon
Coho salmon
Atlantic salmon
Sockeye salmon
Rainbow trout
Cutthroat trout
Steelhead
Geo Area: **BC**

The British Columbia Salmon Farmers Association (BCSFA) has operated and maintained the BCSFA Fish Health Database for six years. The majority of salmonid growers in BC report to the BCSFA fish health database. The Grower Fish Health Representative is responsible for entering the data and the complete BCSFA Fish Health Database. BCSFA maintains quality control and quality assurance of the data and a report is generated from this data quarterly.

The purpose of this activity is to provide evidence for the absence of disease(s) relevant to domestic (inside Canada) and/or international movement of aquatic animals and to obtain a description of the geographic distribution and occurrence of disease(s). The mechanisms by which the information is acquired is through voluntary or mandatory reporting, and from animal health data from sentinel surveys, aquatic animal health personnel or diagnostic laboratories.

Sites are inspected by a private or corporate aquatic animal health specialist; a provincial government official; or a provincial official acting as an audit of the industry Monitoring and Reporting System. The BCSFA does not perform fish health visits.

Animals are collected by a private or corporate aquatic animal health specialist. The BCSFA does not perform fish health visits.

The BCSFA fish health database holds data on culture species including pink salmon, Chinook salmon, Coho salmon, Atlantic salmon, sockeye salmon, rainbow trout, cutthroat trout, and steelhead.

Organization: **Freshwater Aquaculture Association of British Columbia (FAABC)**
Activity: **BC freshwater farmers disease monitoring and control systems used within the group.**
Disease: **IHNV, ISAV, IPNV (as well as Whirling Disease, Ceratomyxosis, Furunculosis, Enteric Red Mouth Disease)**
Species: **Coho salmon, Tilapia, Sturgeon, Rainbow trout (farmed), Sockeye salmon (farmed)**
Geo Area: **British Columbia**

The purpose of this activity is for diagnosis/detection of exotic (to the province) and/or emerging infectious diseases, diagnosis/detection of endemic infectious diseases, to provide evidence for the absence of disease(s) relevant to domestic (inside Canada) and/or international movement of aquatic animals, to describe the geographic distribution and occurrence of disease(s) and to assess the success of disease control programme(s). These are the reasons why the BC freshwater farmers developed the disease monitoring and control systems in use within the group. Three years ago, an independent aquatic veterinarian surveyed the diseases of the commercial freshwater finfish aquaculture of FAABC and the Introductions and Transplant Committee. The report shows that with regard to the history and the current status (at that time) of the salmonid freshwater culture industry, diseases and disease organisms were not prevalent. The situation is the same today.
The salmonid culture portion of the fresh water industry may have the occasional incident of gill disease, occasional flavobacterial coldwater disease and 1-2 farms have gill flukes (Salmonicola sp.) on the rainbow trout gills and some of the salmon may have had Bacterial Kidney Disease (*Renibacterium salmonicida*). Other than the above, no other diseases have been found in the past five years. FAABC attributes the largely disease-free status of the salmonid culture industry to the fact that the majority of their salmonid ova come from the four DFO-certified Schedule II Disease-free freshwater farms in BC. These farms are on spring water as the water sources. Most of the salmonids are subsequently cultured at grow-out sites that use spring water. The FAABC are experienced in recognizing common signs of disease and immediately ask for the help of DFO-Nanaimo or BCMAL-Abbotsford for disease analyses of the suspected moribund fish. The industry largely uses disease-free rainbow trout stocks from certified disease-free. Suspected diseased fish are voluntarily sent to one of DFO or BCMAL labs for analysis.

DFO personnel inspect the four certified DFO Disease-free farms. BCMAL personnel occasionally do surveys of all freshwater farms in BC. All of the BC freshwater farms are extremely vigilant and the farmers do self-reporting immediately when disease is noted. DFO or veterinarians collect the samples for certification purposes.
Bi-annual inspections are conducted for certified disease-free farms and inspections are conducted as warranted for all other farms. The sites selected for inspection and/or sampling are based on outbreak investigations, certification programs, and targeted sampling. The number of sites selected include the four disease-free sites are sampled twice annually, the others as warranted at the invitation of the farmer.

Animals are shipped to the DFO Pacific Biological Station laboratory or the BC MAL Laboratory live, whole on ice, or as directed by DFO or BCMAL.

Organization: **Fisheries and Oceans Canada (DFO) Pacific Biological Station (PBS), Nanaimo**
Activity: **IHNV monitoring in sockeye in Lower and upper Fraser River and Skeena river/Babine Lake (man made DFO spawning channels) for 20 years.**
Disease(s): **IHN**
Species: **Sockeye salmon (wild)**
Geo Area: **BC including the lower and upper Fraser river and Babine Lake (Skeena River system)**

The purpose of this activity is the diagnosis/detection of endemic infectious diseases by conducting structured surveys.

Sites are inspected during spawning and at the fry stage by a federal government official. Animals are collected biannually at spawning time and at the fry stage by a federal government official. Sites were selected by targeted sampling utilizing DFO man-made spawning channels. Two spawning channel facilities are surveyed on the Fraser system (Weaver Creek and Nadina River) and two facilities are surveyed on the Skeena System (Fulton River and Pinkut Creek). Freshly dead and moribund fish are collected by hand. The remainder of the sample is selected randomly. The number of animals collected is estimated to be 100-150 animals per spawning channel facility.

Animals are shipped whole on ice to the DFO PBS laboratory. Tests performed are viral culture followed by RT-PCR.

Organization: **Fisheries and Oceans Canada (DFO) Pacific Biological Station (PBS), Nanaimo**
Activity: **Outbreak investigation by Public and Industry of VHS suspects**
Disease(s): **VHS**
Species: **VHSV (IVa) known susceptible species**
Geo Area: **BC**

The purpose of this activity is the diagnosis/detection of endemic infectious diseases through outbreak investigations.

The site is inspected by a private or corporate aquatic animal health specialist and animals are collected by a private or corporate aquatic animal health specialist as warranted. Sites are targeted based on location of mass mortality events. Animals are collected by diving (for dead or moribunds) and by dip net (for dead or moribunds). Animals are selected by targeted sampling. Fresh mortalities or fish showing signs of disease are selected. A total of 5-20 fish are collected per sampling, depending on severity of the disease.

Animals are shipped whole on ice to the DFO PBS laboratory. Tests performed are viral culture followed by molecular assay, qRT-PCR, or RT-PCR.

Organization: **Fisheries and Oceans Canada (DFO) Pacific Biological Station (PBS), Nanaimo**
Activity: **Fish health assessment of Okanogan river sockeye (investigating occurrence of BKD, IPNV and IHNV)**
Disease(s): **BKD, IPN, IHN**
Species: **Sockeye salmon (wild)**
Geo Area: **BC - Okanagan River, a tributary of the Upper Columbia River.**

The purpose of this activity is the diagnosis/ detection of exotic (to the province) and/or emerging infectious diseases, the diagnosis/ detection of endemic infectious diseases, and to obtain a description of the geographic distribution and occurrence of disease(s), through disease management.

The site is inspected by a private or corporate aquatic animal health specialist or a federal government official annually, during the egg take. Animals are collected by a private or corporate aquatic animal health specialist or a federal government official, biannually, during spawning and at the fry stage. One site on the Okanagan River has been selected by targeted sampling. Over 250 ripe females are selected and collected by seine.

Animals are shipped whole on ice to the DFO PBS laboratory. Frozen ovarian fluid and kidney tissue transported on dry ice. Tests performed are viral culture followed by RT-PCR and BKD ELISA.

Organization: **DFO Pacific Biological Station Aquatic Animal Health, Nanaimo, BC**
Activity: **Fish Health Protection Regulation (FHPR) Certification Program**
Disease(s): **Schedule 2 diseases listed in Manual of Compliance (ISA,VSH, IHN, IPN, Whirling Disease, Ceratomyxosis, Furunculosis, Enteric Red Mouth Disease)**
Species: **Rainbow trout**
Sockeye salmon
Atlantic salmon
Arctic char
Geo Area: **BC, YT**

The intent of the FHPR certification program is to provide certification for salmonid inter-provincial movement and international equivalency. The purpose of this activity is for diagnosis/ detection of exotic (to the province) and/or emerging infectious diseases, diagnosis/ detection of endemic infectious diseases, and to reduce the likelihood of pathogen dissemination through certification.

Sites are inspected by a federal government official as warranted. Sites are selected based on the certification program. Participation in the certification program is voluntary. In total there are 10 participating farm sites. The design indices used is a 95% confidence for all age classes per farm.

Animals are collected by a federal government official biannually. Animals are collected by dip net and are selected by targeted sampling and random selection. Usually 57 animals/ age class are sampled and usually 4-5 lots per farm per visit are collected.

Animals are shipped live, whole on ice, and as tissues and/or of fluids to the DFO PBS laboratory. Diagnostic tests used for FHPR include virology, bacteriology, microscopy and histology.

Organization: **DFO Oceans Habitat and Enhancement Branch, Nanaimo BC**
Activity: **Broodstock screening for IHNV**
Potential enhancement stocks (60 fish minimum by opportunistic sampling)
Egg segregation and culling program for OHEB facilities and affiliated hatcheries
Disease(s): **IHN**
Species: **Sockeye salmon (*O. nerka*)**
Chinook salmon (*O. tshawytscha*)
Enhancement stocks only: returning salmon (wild or hatchery-released) spawned at a hatchery with juveniles released to the wild.
Geo Area: **BC, YT, and Trans-boundary on request**

The purpose of this activity is to obtain a description of the distribution and occurrence of diseases.

The sites are inspected by a federal government official annually and as warranted depending on historical incidence/recent clinical disease. Sites are selected by targeted sampling based on historical incidence level and/or recent clinical disease. In 2007, 632 ovarian fluid samples from 13 stocks (10 Sockeye, 1 Chinook and 2 Coho research stocks) were screened for IHNV using cell culture. This included 3 of 17 federal hatcheries and 2 federal spawning channels that enhance sockeye stocks. At least 8 of 134 CEDP and PIP hatcheries enhance sockeye. Any new stocks considered for enhancement undergo screening of at least 60 fish annually for two spawning seasons, to assess IHNV status prior to making the decision to enhance. New facilities will be strongly encouraged by DFO OHEB to screen the first several years of culture to establish disease awareness and baseline risk.

Screening is done on request. Technical advice from DFO Science virologist Garth Traxler indicated poor correlation between ovarian fluid levels of IHNV and occurrence of disease outbreak. Suboptimal husbandry and biosecurity protocols appear to be more reliable predictors of the risk of disease expression. Virus is readily destroyed by povidone iodine egg disinfection. Sites with successful sockeye culture history, IHNV-free water source, documented egg disinfection and biosecurity measures, capacity for early detection and willingness to destroy stocks suspected of undergoing an IHNV outbreak may not be screening for IHNV.

Hatchery fish culture staff collects animals annually, however, sampling has decreased in frequency and sites in the past several years. Brood and hatchery fry are collected for sampling, as well as animals at the counting fence on entry to spawning channel. All brood females are sampled if segregating eggs and culling is based on IHNV levels in ovarian fluid. Also, 60 animals are sampled for the survey assessment, as well.

Animals are shipped to the DFO PBS Laboratory as tissues and/or fluids. Cell culture (EPC and CHSE-214) is conducted for presumptive testing, followed by RT-PCR for confirmation.

Organization: **DFO Oceans Habitat and Enhancement Branch, Nanaimo BC**
Activity: **Suspected disease outbreak investigation**
Disease(s): **Diagnostic test selection is based on historical incidence of disease, clinical signs, mortality distribution and rate, response to treatment**
Species: **Sockeye salmon (*O. nerka*)**
Chinook salmon (*O. tshawytscha*)
Coho salmon (*O. kisutch*)
Pink salmon (*O. gorbuscha*)
Chum salmon (*O. keta*)

Enhancement stocks only: returning salmon (wild or hatchery-released) spawned at a hatchery with juveniles released to the wild.

Infrequently, stocks under Provincial jurisdiction are reared at DFO facilities on request: Steelhead trout (*O. mykiss*) and Cutthroat trout (O. *clarkii*)
Geo Area: **BC, YT, and Trans-boundary on request**

The purpose of this activity is diagnosis detection of new and exotic infectious diseases in aquatic animals.

Sites are inspected by a federal government official as warranted and when there is an increase in mortalities or other clinical signs of disease. Sites are selected based on outbreak investigations. There are 17 federal hatcheries, 1 CEDP hatchery, and 113 PIP hatcheries operated by volunteer or community organizations which can access technical support from DFO by request. Annual caseload for disease investigation is roughly 60-80. Thresholds for diagnostic submission include: improved husbandry and monitoring if mortalities per day exceed 0.1%, sample submission for diagnostic workup if mortalities per day reach 0.5 % and pre-release disease check if mortalities exceed 5% in final 3 months of rearing before release as smolts.

Animals are collected by hatchery fish culture staff as warranted by dip net. Moribund animals or fresh mortalities are targeted for sampling. For disease investigations, 6-8 moribund fish are sampled, plus 10-20 random, apparently healthy fish to make up a total sample of 16-28 fish. Recent fresh mortalities are selected, if moribund fish are in low numbers.

Animals are sent to the DFO Fish Pathology Laboratory at the DFO Pacific Biological Station live, whole on ice, and as tissues and/or fluids. Tests performed include necropsy and microscopy (impression smears, gill mounts, skin scraping, leading edge of external lesion preps, etc.; Gram stains, methyline blue); bacteriology (oxidase test, motility, etc. - potential media: HS, TSA, TSA with salt; API; antibiotic sensitivity); serology (agglutination, dfat, ELISA); virology (cell culture on EPC and CHSE-24); histology (H+E, Giemsa, PAS); and PCR if indicated.

Organization: Pfizer
Activity: **Conducting Schedule II testing as outlined in the current Fish Health Protection Regulations**
Disease(s): **ISA, VSH, IHN, IPN, Whirling Disease, Ceratomyxosis, Furunculosis, Enteric Red Mouth Disease**
Species: **Atlantic salmon, *Salmo salar* (farmed)**
***Oncorhynchus spp* (farmed)**
***Salvelinus spp* (farmed)**
Geo Area: **BC**

Schedule II testing under the FHPR involves screening a population by sub sampling 60 animals from the population for the presence of whirling disease, ceratomyxosis, furunculosis, and enteric redmouth disease, and filterable replicating agents causing cytopathic effects in fish cell lines. The purpose of this activity is to provide evidence for the absence of disease(s) relevant to domestic (inside Canada) and/or international movement of aquatic animals and to obtain a description of the geographic distribution and occurrence of disease(s) through mechanisms such as structured surveys and certification. Certification is required for the application of a transplant permit for moving animals between designated zones.

Animals are inspected by a federal government official as warranted and collected by a private or corporate aquatic animal health specialist usually prior to transporting the animals between provincial boundaries. Currently, Microtek International Inc does the testing for four active farm sites. Animals are collected by dip net and seine and are selected by targeted sampling and random selection. A total of 60 animals are collected per sampling at a 95% confidence level and a detection prevalence of 5%.

Animals are shipped whole on ice and as tissues and/or fluids to the Microtek International Inc. Tests performed include virus screening using 2 cell lines (EPC and CHSE) as outlined in the FHPR Section X, digestion method for detecting *Myxosoma cerebralis* as outlined in the FHPR Section XI, dried smears for detecting *Ceratomyxa shasta* as outlined in the FHPR Section XI C, and culture methods for detecting *Aeromonas salmonicida* and *Yersinia ruckeri* serotype 01 or 02 as outlined in the FHPR Section IX.

Organization: **British Columbia Ministry of Agriculture and Land (BCMAL)**
Activity: **Routine Fish Health Audit and Surveillance Program (FHASP)**
Disease(s): **Mouth Myxobacteriosis**
Bacterial Kidney Disease
VHS (NA strain)
Rickettsiosis
Furunculosis
Enteric Red Mouth
Net Pen Liver Disease
Peritonitis
Piscirickettsia salmonis
Infectious Hematopoietic Necrosis Virus (IHNV)
Infectious Pancreatic Necrosis Virus (IPNV)
Infectious Salmon Anemia (ISAV)
Viral Hemorrhagic Septicemia (VHSV, North American strain)
Sea Lice
Species: **Atlantic salmon (farmed, marine)**
Coho salmon (farmed, marine)
Chinook salmon (farmed marine)
Sable fish (farmed, marine)
Geo Area: **BC, all coastal zones (except northernmost area) = 8 sub-zones**

The Routine Fish Health Audit and Surveillance Program (FHASP) under the BCMAL was in place from 2002 to 2010. With the promulagation of the Pacifc Aquaculture Regulations in 2010, parts of the program moved over to DFO.

Under BCMAL, the purpose of this activity was the diagnosis/ detection of an exotic disease (to the province) and/or emerging infectious diseases. Sites were selected by random sampling and targeted sampling. Sampling was aimed at achieving a 95% confidence of detection of 2% disease prevalence among farmed fish during a quarter. The total number of dead fish sampled varies at each farm because the availability of fresh silvers is often limited. The number of carcasses tested annually ranged between 500 and 1000 animals. Animals were collected by a private or corporate animal health specialist or a provincial governmental official quarterly. Animals were collected by diving and selected by targeted sampling (i.e., Carcasses to be sampled were those that had grown well prior to death and have red or pink gills - these are fish that have died most recently and may or may not show signs of disease). This group of animals provides the greatest diagnostic value, is most reflective of active disease, and is representative of the robust living population. Typically, six to eight silvers per farm were collected to a maximum of 20. Sampling was aimed at achieving a 95% confidence of detection of 2% disease prevalence among farmed fish during a quarter.
The total number of dead fish sampled varies at each farm because the availability of fresh silvers is often limited. The typically number of fish collected is 6 to 8 silvers to a maximum of 20 per farm for FH audits.

Animals were shipped as tissues and/or fluids to the BC Animal Health Centre (AHC) in Abbotsford. Samples were assessed by bacteriology, virology, histopathology, and molecular diagnostics. Samples were pooled to a maximum of five fish per pool and screened using Polymerase Chain Reaction (PCR) techniques for the following pathogens of concern: IHNV,IPNV, ISAV, VHSV (North American strain), and *Piscirickettsia salmonis*. If PCR findings are positive, individual samples are subsequently transferred to appropriate cell lines for confirmation. All tissue samples for histology were examined for signs of inflammation and abnormality and, if possible, to determine the cause of the mortality.

Organization: British Columbia Ministry of Agriculture and Lands (BCMAL)
Activity: **Wild Pink Salmon joint assessment**
Disease(s): **Bacterial Kidney Disease, Loma, Rickettsiosis, Marine Anaemia, Enteritis, *Piscirickettsia salmonis*, IHNV, IPNV, ISAV, VHSV (NA strain), and sea lice**
Species: **Pink salmon (wild)**
Geo Area: **BC**
All coastal zones (except northernmost area) = 8 sub-zones
See chart page 7 and map page 55, FH Report

The Wild Pink Salmon project has been in place from 2005 to 2007 and was a joint effort by a private researcher, DFO and BCMAL. Beach and open-water seines were conducted 4-6 times between April and July to collect wild pink salmon fry. Lengths and weights were taken, sea lice counts were conducted and necropsies and/or histology were performed to assess concurrent infection/pathology.

The purpose of this activity was the diagnosis/ detection of an exotic disease (to the province) and/or emerging infectious diseases, the diagnosis/ detection of endemic infectious diseases, to provide evidence for the absence of disease(s) relevant to domestic (inside Canada) and/or international movement of aquatic animals, to obtain a description of the geographic distribution and occurrence of disease(s), and to assess the success of disease control program(s) through mechanisms such as outbreak investigations; voluntary or mandatory reporting; animal health data from sentinel surveys, aquatic animal health personnel or diagnostic laboratories; and disease management.

A private or corporate animal health specialist (veterinarian or biologist) or a provincial governmental official (veterinarian or biologist) inspected the sites quarterly. Sites were selected by random sampling and targeted sampling. Targeted sampling only arose during outbreak investigation or for sea lice information (if ENGO controversy is anticipated).

Animals were collected by a private or corporate animal health specialist (veterinarian or biologist) or a provincial governmental official (veterinarian or biologist) quarterly by seine and dip net. Animals were selected by targeted sampling. Samples were taken 4-6 times between April and July.

No samples collected during sea lice assessments. When samples were collected, they were shipped as tissues and/or fluids to the BC Animal Health Centre (AHC) in Abbotsford. Necropsy and/or histology were conducted to assess concurrent infection/pathology.

Organization: **Canadian Co-operative Wildlife Health Centre (CCWHC)**
Activity: **National program of general disease surveillance in wild vertebrate**
Disease: **General disease surveillance to identify any/all diseases**
Recent diseases of importance detected include VHS and KHV
Species: **All wild vertebrates in Canada including fish**
Geo Area: **National (Canada-wide)**

The National Wildlife Disease Surveillance Program of the Canadian Cooperative Wildlife Health Centre has carried out a national program of general disease surveillance in wild vertebrate animals since 1992. This disease program included surveillance of diseases of wild finfish. CCWHC utilizes laboratories in Charlottetown, St-Hyacinthe, Guelph, and Saskatoon. Saskatoon accepted samples of diseased fish provided by fish and wildlife agency personnel and/or the public. The laboratories use standard methods of necropsy and laboratory diagnosis to determine the pathogens and diseases causing death or illness in each specimen. The purpose of this activity is diagnosis/detection of exotic (to the province) and/or emerging infectious diseases, diagnosis/ detection of endemic infectious diseases and to obtain a description of the geographic distribution and occurrence of disease(s). Mechanisms used to obtain data are outbreak investigations; animal health data from sentinel surveys; aquatic animal health personnel or diagnostic laboratories; and structured surveys.

Animals are collected by a provincial government official, a federal government official, and/or researchers. Samples were accepted year round, hence no set frequency. Fish samples from remote areas are infrequently received.

7.3. ISAV, IHNV, IPNV Case Definition

a) Case Definitions for presumptive and confirmed test results[8]

Pathogen	Presumptive	Confirmed[9]
Generic for virus	• Detection of the virus using one or more tests by a non-CFIA approved laboratory • Detection of the virus by a NAAHLS laboratory or approved network laboratory that do not meet all listed criteria for confirmation	• A NAAHLS laboratory or approved network laboratory reports 1) at least one positive result of any lineage/sub-lineage of the virus by isolation and identification of the virus by RT-PCR [A] OR 2) at least 2 positive results using 2 independent[10] assays, each one using the original unprocessed test specimen
[A] Nuclear acid detection methods must always be followed up by sequencing if strain typing is required		

[8] These case definitions have been used for the creation of disease maps for enzootic reportable diseases

[9] Effective December 2010, when regulations under HAA got promulgated

[10] Confirmatory testing needs to be performed on material derived from the original unprocessed sample or specimen. The analyte target of confirmatory testing is required to be sufficiently different from that of the screening test so as to ensure that the tests results can be considered independent of each other. Examples include the detection of different genomic regions, different antigenic epitopes, or antibodies of different antigen specificity.

7.4. Tables and Figures

7.4.1. Salmonids of BC and their susceptibility to ISA, IPN, and IHN.

Species known to be present in the wild in BC	ISA	IHN	IPN
Coho salmon (*O. kisutch*)	X	X	
Chum salmon (*O. keta*)		X	X
Chinook salmon (*O. tshawytscha*)		X	
Sockeye salmon (*O. nerka*)		X	
Pink salmon (*O. gorbuscha*)		X	
Steelhead (*O. mykiss*)	X	X	X
Sea trout (*S. trutta*)	X	X	X
Kokanee (*O. nerka*)			
Rainbow trout (*O. mykiss*)	X	X	X
Cutthroat trout (*O. clarkii*)		X	X
Brown trout (*S. trutta*)	X	X	X
Lake trout (*S. namaycush*)		X	X
Brook trout (*S. fontinalis*)		X	X

7.4.2. 2010 commercial salmon retained for April 1 2010 to March 30, 2011.

Area	Sockeye	Coho	Pink	Chum	Chinook	All Species	Estimates
Seine							
Area A	5278	362	501722	9249	0	516611	complete
Area B	6302503	574	84399	38946	87	6426509	complete
Seine total	**6307781**	**936**	**586121**	**48195**	**87**	**6943120**	
Gillnet							
Area C	131431	100	47154	29534	3325	211544	complete
Area D	1246226	742	108382	35901	1772	1393023	complete
Area E	2120369	51	57	165	6385	2127027	complete
Gillnet total	**3498026**	**893**	**155593**	**65600**	**11482**	**3731594**	
Troll							
Area F	523	138295	27141	92	84444	250495	complete
Area G	0	458	47	402	79123	80030	incomplete
Area H	381665	217	3809	394	7	386092	complete
Troll total	**382188**	**138970**	**30997**	**888**	**163574**	**716617**	
Species total	**10187995**	**140799**	**772711**	**114683**	**175143**	**11391331**	

7.4.3. Percentage of returning adult sample by DFO salmon harvest area.

% sample (by species) derived from adult (SW) category

Area	Sockeye salmon	Coho salmon	Pink salmon	Chum salmon	Chinook salmon
A		33	33		
B	33	33	33	33	
C				33	50
D	33	33	33	33	
E	33				50

7.4.4. Information on species licensed for culture at federal salmonid enhancement facilities.

		Species licensed for culture (common name)							
License holder	**Site common name**	**Chinook**	**Chum**	**Coho**	**Pink**	**Sockeye**	**Cutthroat trout**	**Steelhead**	**None**
Watershed Manager, Big Qualicum River Project	Big Qualicum River	x	x	x					
Watershed Manager, Big Qualicum River Project	Little Qualicum River	x	x						
Watershed Manager, Big Qualicum River Project	Rosewall								x
Watershed Manager,Capilano River Hatchery	Capilano River	x	x	x				x	
Watershed Manager, Capilano River Hatchery	Sandy Cove net pens	x							
Watershed Manager, Chehalis River Hatchery	Chehalis River	x	x	x	x		x	x	
Watershed Manager, Chilliwack River Hatchery	Chilliwack river	x	x	x	x			x	
Watershed Manager, Conuma River Hatchery	Conuma River	x	x	x					
Watershed Manager, Conuma River Hatchery	Burman R (Matchlee Bay) Estuary	x							
Watershed Manager, Conuma River	Conuma R Estuary	x	x	x					

Hatchery									
Watershed Manager,Conuma River Hatchery	Gold R (Muchalat Inlet) Estuary	x							
Watershed Manager,Conuma River Hatchery	Sucwoa R (Headbay) Estuary	x	x						
Watershed Manager,Conuma River Hatchery	Tlupana R (Nesooke Bay) Estuary	x	x						
Watershed Manager, Inch Creek Hatchery	Inch Cr		x	x				x	
Watershed Manager, Inch Creek Hatchery	Inch Sock Sat					x			
Watershed Manager, Inch Creek Hatchery	Cultus					x			
Watershed Manager, Kitimat River Hatchery	Kitimat R	x	x	x			x	x	
Watershed Manager, Nitinat River Hatchery	Nitinat R	x	x	x				x	
Watershed Manager, Nitinat River Hatchery	Nitinat Lake Net Pens	x							
Watershed Manager, Puntledge River Hatchery	Puntledge R	x	x	x	x				
Watershed Manager, Puntledge River Hatchery	Comox Bay Sea Pens	x							
Watershed	Quinsam R	x		x	x		x		

Manager,Quinsam River Hatchery									
Watershed Manager, Quinsam River Hatchery	April Point Boat Dock Net Pens	x							
Watershed Manager, Quinsam River Hatchery	Coast Discovery Marina Net Pens	x							
Watershed Manager, Quinsam River Hatchery	Discovery Harbour Marina Net Pens	x							
Watershed Manager, Quinsam River Hatchery	Fisherman's Wharf Net Pens				x				
Watershed Manager, Quinsam River Hatchery	Hidden Harbours Net Pens	x			x				
Watershed Manager, Robertson Creek Hatchery	Robertson Cr	x		x				x	
Watershed Manager, Robertson Creek Hatchery	MacTouch Bay Net Pens	x							
Watershed Manager, Robertson Creek Hatchery	Nahmint Site #1 Net Pens	x							
Watershed Manager, Robertson Creek Hatchery	Nahmint Site #2 Net Pens	x							
Watershed Manager, Robertson Creek Hatchery	Old Log Dump Net Pens	x							
Watershed Manager, Robertson Creek	Upper Inlet Net Pens	x							

Hatchery									
Watershed Manager,Shuswap River Hatchery	Shuswap R	x		x		x			
Watershed Manager, Snootli Creek Hatchery	Snootli Cr	x	x	x		x			
Watershed Manager, Spius Creek Hatchery	Spius Cr	x		x					
Watershed Manager, Tenderfoot Creek Hatchery	Tenderfoot Cr	x	x	x	x				
Watershed Manager, Tenderfoot Creek Hatchery	Porteau Cove Net Pens	x							

7.4.5. Human Resource Requirements for Year 1 (2012) Proposed Sampling[11].

Species	Total Animals	Life stage	# animals required per life stage	Dissection Required (likelihood)	Sampling tasks*	Person Hours
Coho salmon (*O. kisutch*)	700	Fry (FW)	175	no	Collection, packaging and shipping	7.5
		Adult (SW)	350	yes	Collection, dissection, packaging and shipping	30.0
		Spawner (FW)	175	yes	Collection, dissection, packaging and shipping	15.0
Chum salmon (*O. keta*)	700	Fry	175	no	Collection, packaging and shipping	7.5
		Adult	350	yes	Collection, dissection, packaging and shipping	30.0
		Spawner	175	yes	Collection, dissection, packaging and shipping	15.0
Chinook salmon (*O. tshawytscha*)	700	Fry	175	no	Collection, packaging and shipping	7.5
		Adult	350	yes	Collection, dissection, packaging and shipping	30.0
		Spawner	175	yes	Collection, dissection, packaging and shipping	15.0
Sockeye salmon (*O.*	700	Fry	175	no	Collection, packaging	7.5

[11] Those estimates are based on idea conditions for sampling.

nerka)					and shipping	
		Adult	350	yes	Collection, dissection, packaging and shipping	30.0
		Spawner	175	yes	Collection, dissection, packaging and shipping	15.0
Pink salmon (*O. gorbuscha*)	700	Fry	175	no	Collection, packaging and shipping	7.5
		Adult	350	yes	Collection, dissection, packaging and shipping	30.0
		Spawner	175	yes	Collection, dissection, packaging and shipping	15.0
Steelhead (*O. mykiss*)	350	Fry	175	no	Collection, packaging and shipping	7.5
		Adult	0	n/a	n/a	0
		Spawner	175	no	Fluid collection, packaging and shipping	7.5
Totals	**3850**					**277.5 people hours**

7.4.6. Collection time by species and location type.

Stage	Points (locations)	When fish are on-site
Adult Chinook (spawning)	Enhancement facilities	Oct-Nov
Adult chum (spawning)	Enhancement facilities	Sept-Nov
Adult pink (spawning)	Enhancement facilities	Sept-Oct
Adult sockeye (spawning)	Enhancement facilities	Aug-Oct
Adult coho (spawning)	Enhancement facilities	June-Nov
Adult steelhead (spawning)	Enhancement facilities	March-April
Juvenile Chinook	Hatchery	Feb-June
Juvenile sockeye	Hatchery	Feb-May
Juvenile chum	Hatchery	April-May
Juvenile pink	Hatchery	Feb-April
Juvenile coho	Hatchery	All year
Juvenile steelhead	Hatchery	All year (preferably June-May)

7.4.7. Chinook salmon production from DFO salmonid enhancement facilities

				Production/year			
ID	**Project Name**	**Type**	**Production Area**	**Chinook 09**	**Chinook 08**	**Chinook 07**	**Average**
104	Robertson Creek	Hatchery	SW Vancouver Island	6179993	6242997	6542778	6321923
106	Quinsam River	Hatchery	Johnstone St	4018227	4064914	4287093	4123411
100	Big Qualicum	Hatchery/channel		3398054	4073507	4263877	3911813
114	Nitinat River	Hatchery	SW Vancouver Island	4349763	2393859	3693049	3478890
102	Little Qualicum River	Combination hatchery/channel	Geo St Van Is	2356623	2621390	2862170	2613394
117	Conuma River	Hatchery	NW Vancouver Island	2751181	2411702	2325746	2496210
105	Puntledge River	Hatchery	Geo St Van Is	1886653	2194346	2633358	2238119
107	Chilliwack River	Hatchery	Lower Fraser River	1628862	1724397	1622398	1658552
146	Kitimat River	Hatchery	Central coast	1429140	1727621	1647816	1601526
153	Tenderfoot Creek	Hatchery	Geo St Main N	579987	686819	1470359	912388
154	Chehalis River	Hatchery	Lower Fraser River	995965	764089	498844	752966
160	Spius Creek	Hatchery	Thom Mainstem	494918	443278	571823	503340
	Capilano Hatchery						500000
150	Inch Creek	Hatchery	Lower Fraser River	97426	321123	287645	235398
142	Fulton River	Spawning channel	Skeena River				
1661	Nadina Spawning Channel	Spawning channel	Upper Fraser River				
143	Pinkut Creek	Spawning channel	Skeena River				
	Rosewall Creek	Hatchery					
235	Weaver Spawning Channel	Spawning channel	Lower Fraser River				

7.4.8. Chum salmon production from DFO salmonid enhancement facilities

				Production/year			
ID	**Project Name**	**Type**	**Production Area**	**chum 09**	**chum 08**	**chum 07**	**Average**
114	Nitinat River	Hatchery	SW Vancouver Island	7631058	13004139	28909371	16514856
100	Big Qualicum	Hatchery/channel		0	14845685	30821275	15222320
154	Chehalis River	Hatchery	Lower Fraser River	5866344	6087316	7406243	6453301
235	Weaver Spawning Channel	Spawning channel	Lower Fraser River	3808013	3435397	3392490	3545300
146	Kitimat River	Hatchery	Central coast	1457826	2899393	4622504	2993241
105	Puntledge River	Hatchery	Geo St Van Is	1745365	2842105	3934536	2840669
107	Chilliwack River	Hatchery	Lower Fraser River	3461574	1493816	2045707	2333699
117	Conuma River	Hatchery	NW Vancouver Island	1977552	445289	2909211	1777351
150	Inch Creek	Hatchery	Lower Fraser River	1216110	1105850	1096694	1139551
153	Tenderfoot Creek	Hatchery	Geo St Main N	421037	120111	54838	198662
106	Quinsam River	Hatchery	Johnstone St	0	69711	0	23237
104	Robertson Creek	Hatchery	SW Vancouver Island				
102	Little Qualicum River	Combination hatchery/channel	Geo St Van Is				
160	Spius Creek	Hatchery	Thom Mainstem				
	Capilano Hatchery						
142	Fulton River	Spawning channel	Skeena River				
1661	Nadina Spawning Channel	Spawning channel	Upper Fraser River				
143	Pinkut Creek	Spawning channel	Skeena River				
	Rosewall Creek	Hatchery					

7.4.9. Coho salmon production from DFO salmonid enhancement facilities

				Production/year			
ID	**Project Name**	**Type**	**Production Area**	**coho 09**	**coho 08**	**coho 07**	**Average**
107	Chilliwack River	Hatchery	Lower Fraser River	1182421	1257895	1047226	1162514
106	Quinsam River	Hatchery	Johnstone St	1176333	1200809	842408	1073183
154	Chehalis River	Hatchery	Lower Fraser River	926270	898789	748454	857838
100	Big Qualicum	Hatchery/channel		704078	884773	660598	749816
105	Puntledge River	Hatchery	Geo St Van Is	819231	699143	634318	717564
104	Robertson Creek	Hatchery	SW Vancouver Island	0	624258	1347749	657336
150	Inch Creek	Hatchery	Lower Fraser River	456518	538891	592449	529286
	Capilano Hatchery						525000
146	Kitimat River	Hatchery	Central coast	410730	458238	412023	426997
153	Tenderfoot Creek	Hatchery	Geo St Main N	380915	422018	223753	342229
160	Spius Creek	Hatchery	Thom Mainstem	306372	242417	230172	259654
114	Nitinat River	Hatchery	SW Vancouver Island	242949	91058	285455	206487
117	Conuma River	Hatchery	NW Vancouver Island	144144	46646	55797	82196
235	Weaver Spawning Channel	Spawning channel	Lower Fraser River				
102	Little Qualicum River	Combination hatchery/channel	Geo St Van Is				
142	Fulton River	Spawning channel	Skeena River				
1661	Nadina Spawning Channel	Spawning channel	Upper Fraser River				
143	Pinkut Creek	Spawning channel	Skeena River				
	Rosewall Creek	Hatchery					

7.4.10. Pink salmon production from DFO salmonid enhancement facilities

				Production/year			
ID	**Project Name**	**Type**	**Production Area**	**pink 09**	**pink 08**	**pink 07**	**Average**
106	Quinsam River	Hatchery	Johnstone St	6290910	6751073	6343946	6461976
105	Puntledge River	Hatchery	Geo St Van Is	2101761	2340177	1209659	1883866
235	Weaver Spawning Channel	Spawning channel	Lower Fraser River	0	1741808	0	580603
154	Chehalis River	Hatchery	Lower Fraser River	0	706452	0	235484
153	Tenderfoot Creek	Hatchery	Geo St Main N		257195	3136	130166
107	Chilliwack River	Hatchery	Lower Fraser River	0	8588	0	2863
100	Big Qualicum	Hatchery/channel					
104	Robertson Creek	Hatchery	SW Vancouver Island				
150	Inch Creek	Hatchery	Lower Fraser River				
	Capilano Hatchery						
146	Kitimat River	Hatchery	Central coast				
160	Spius Creek	Hatchery	Thom Mainstem				
114	Nitinat River	Hatchery	SW Vancouver Island				
117	Conuma River	Hatchery	NW Vancouver Island				
102	Little Qualicum River	Combination hatchery/channel	Geo St Van Is				
142	Fulton River	Spawning channel	Skeena River				
1661	Nadina Spawning Channel	Spawning channel	Upper Fraser River				
143	Pinkut Creek	Spawning channel	Skeena River				
	Rosewall Creek	Hatchery					

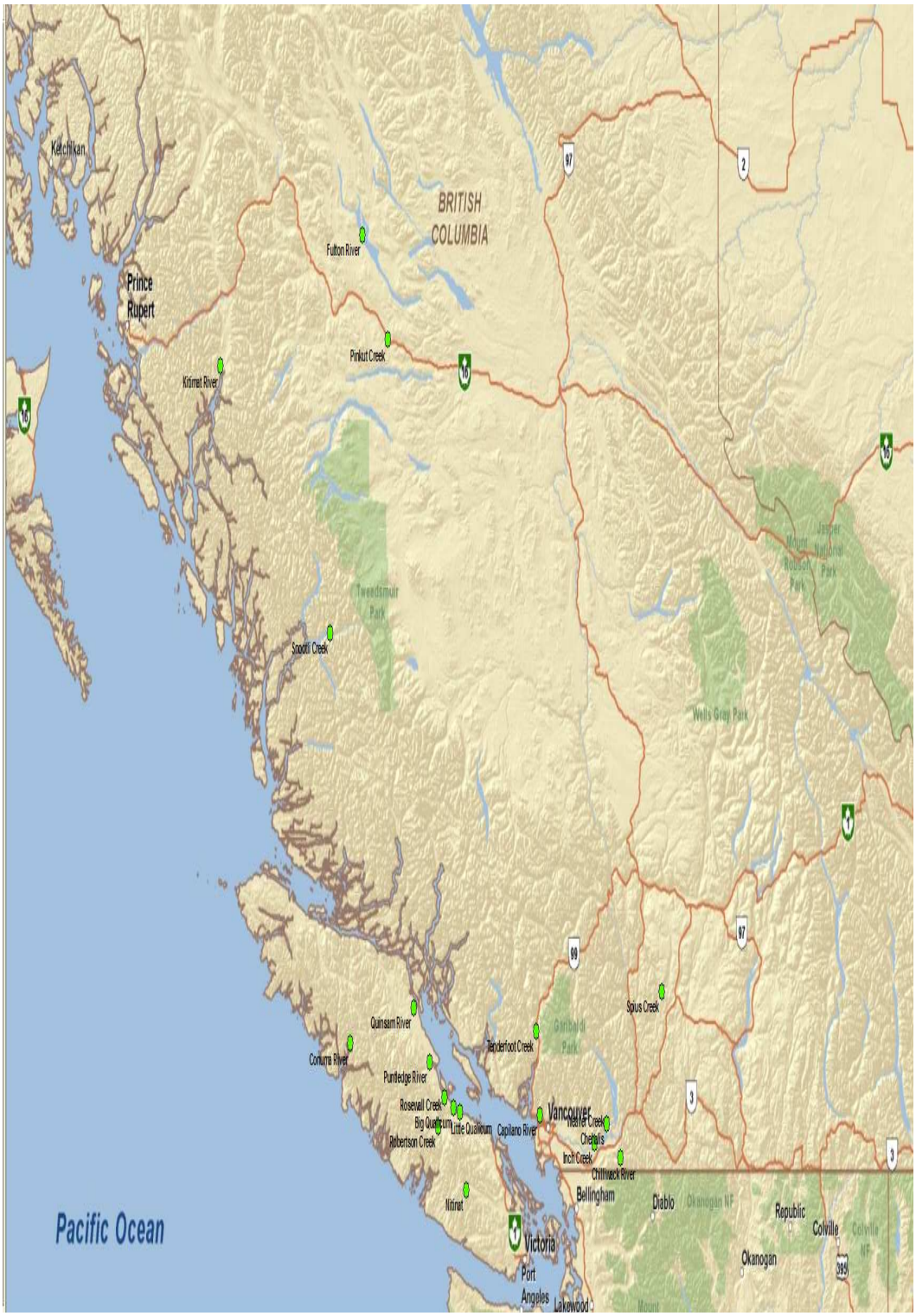
7.4.11. Sockeye salmon production from DFO salmonid enhancement facilities

				Production/year		
ID	**Project Name**	**Type**	**Production Area**	**sockeye 09**	**sockeye 08**	**sockeye 07**
142	Fulton River	Spawning channel	Skeena River	70800000	109344347	105200000
143	Pinkut Creek	Spawning channel	Skeena River	43836017	74954299	48536610
235	Weaver Spawning Channel	Spawning channel	Lower Fraser River	1396451	28493605	46285610
1661	Nadina Spawning Channel	Spawning channel	Upper Fraser River	5100000	1090000	5450000
106	Quinsam River	Hatchery	Johnstone St			
105	Puntledge River	Hatchery	Geo St Van Is			
154	Chehalis River	Hatchery	Lower Fraser River			
153	Tenderfoot Creek	Hatchery	Geo St Main N			
107	Chilliwack River	Hatchery	Lower Fraser River			
100	Big Qualicum	Hatchery/channel				
104	Robertson Creek	Hatchery	SW Vancouver Island			
150	Inch Creek	Hatchery	Lower Fraser River			
	Capilano Hatchery					
146	Kitimat River	Hatchery	Central coast			
160	Spius Creek	Hatchery	Thom Mainstem			
114	Nitinat River	Hatchery	SW Vancouver Island			
117	Conuma River	Hatchery	NW Vancouver Island			
102	Little Qualicum River	Combination hatchery/channel	Geo St Van Is			
	Rosewall Creek	Hatchery				

7.4.12. Steelhead production from DFO salmonid enhancement facilities

				Production/year			
ID	**Project Name**	**Type**	**Production Area**	**steelhead 09**	**steelhead 08**	**steelhead 07**	**Average**
104	Robertson Creek	Hatchery	SW Vancouver Island	94996	112418	127383	111599
107	Chilliwack River	Hatchery	Lower Fraser River	124862	102916	95259	107679
154	Chehalis River	Hatchery	Lower Fraser River	52842	56382	52468	53897
146	Kitimat River	Hatchery	Central coast	57808	48227	39684	48573
150	Inch Creek	Hatchery	Lower Fraser River	20121	20132	20306	20186
	Capilano Hatchery						15000
153	Tenderfoot Creek	Hatchery	Geo St Main N	0	8731	10801	6511
100	Big Qualicum	Hatchery/channel		0	0	2333	778
106	Quinsam River	Hatchery	Johnstone St				
142	Fulton River	Spawning channel	Skeena River				
143	Pinkut Creek	Spawning channel	Skeena River				
235	Weaver Spawning Channel	Spawning channel	Lower Fraser River				
1661	Nadina Spawning Channel	Spawning channel	Upper Fraser River				
105	Puntledge River	Hatchery	Geo St Van Is				
160	Spius Creek	Hatchery	Thom Mainstem				
114	Nitinat River	Hatchery	SW Vancouver Island				
117	Conuma River	Hatchery	NW Vancouver Island				
102	Little Qualicum River	Combination hatchery/channel	Geo St Van Is				
	Rosewall Creek	Hatchery					

7.4.13. Map of Commercial salmon harvesting areas (from BC Salmon Marketing Council)



7.4.14. Map of DFO Fish Enhancement Hatcheries

7.5. References

Amend, DF. 1972. Transmission of IHN virus. In: Progress in Sport Fishery Research, Bureau of Sport Fisheries and Wildlife. Resource Publication 106. pgs. 108-111.

Amend DF. 1975. Detection and transmission of infectious hematopoietic necrosis virus in rainbow trout. Journal of Wildlife Diseases 11: 471-478.

Amend DF, Wood JW. 1972. Survey for infectious hematopoietic necrosis (IHN) virus in Washington salmon. The Progressive Fish-Culturist 34: 143–147.

Amend DF, Yasutake WT, Fryer JL, Pilcher KS, Wingfield WH. 1973. Infectious hematopoietic necrosis. Symposium on the Major Communicable Fish Diseases in Europe and their Control. Technical Paper 17 (Supplement 2). EIFAC, FAO. pgs. 80-98.

Armstrong R, Robinson J, Rymes C, Needham T. 1993. Infectious haematopoietic necrosis virus in Atlantic salmon in British Columbia. Canadian Veterinary Journal 34: 312-313.

Barja JL, Toranzo AE, Lemos ML, Hetrick FM. 1983. Influence of water temperature and salinity on the survival of IPN and IHN viruses. Bulletin of the European Association of Fish Pathologists 3: 47-50.

Batts WN. 1987. Factors affecting the binding of IHN virus to salmonid sperm cells. Fish Health Section/American Fisheries Society Newsletter 15(2): 3.

Baudin Laurencin F. 1987. IHN in France. Bulletin of the European Association of Fish Pathologists 7: 104.

Biacchesi S, Le Berre M, Le Guillou S, Benmansour A, Brémont M, Quillet E, Boudinot P. 2007. Fish genotype significantly influences susceptibility of juvenile rainbow trout, *Oncorhynchus mykiss* (Walbaum), to waterborne infection with infectious salmon anaemia virus. Journal of Fish Diseases 30: 631-636.

Biering E, Nilsen F, Rødseth OM, Glette J. 1994. Susceptibility of Atlantic halibut *Hippoglossus hippoglossus* to infectious pancreatic necrosis virus. Diseases of Aquatic Organisms 20: 183-190.

Bootland LM, Lorz HV, Rohovec JS, Leong JC. 1994. Experimental infection of brook trout with infectious hematopoietic necrosis virus types 1 and 2. Journal of Aquatic Animal Health 6: 144-148.

Bootland LM, Dobos P, Stevenson RMW. 1991. The IPNV carrier state and demonstration of vertical transmission in experimentally infected brook trout. Diseases of Aquatic Organisms 10: 13-21.

Bovo G, Giorgetti G, Jørgensen PEV, Olesen NJ. 1987. Infectious haematopoietic necrosis: first detection in Italy. Bulletin of the European Association of Fish Pathologists 7: 124.

Burke J, Grischkowsky R. 1984. An epizootic caused by infectious haematopoietic necrosis virus in an enhanced population of sockeye salmon, *Oncorhynchus nerka* (Walbaum), smolts at Hidden Creek, Alaska. Journal of Fish Diseases 7: 421–429.

Busch RA. 1983. Viral disease considerations in the commercial trout industry in Idaho. In: Leong JC, Braila TY (eds) Workshop on viral diseases of salmonid fishes in the Columbia River basin. Special Publication of the Bonneville Power Administration, Portland, OR, pgs. 84–100.

Carlisle JC, Schat KA, Elston R. 1979. Infectious hematopoietic necrosis in rainbow trout *Salmo guirdneri* Richardson in a semi-closed system. Journal of Fish Diseases 2: 511-517.

Castric J, Jeffroy J. 1991. Experimentally induced diseases in marine fish with IHNV and a rhabdovirus of eel. Aquaculture Europe '91, Dublin (Eire), June 10-12, 1991. Special Publication of the European Aquaculture Society. 14, 54-55.

Eaton WD, Hulett J, Brunson R, True K. 1991. The first isolation in North America of infectious hematopoietic necrosis virus (IHNV) and viral hemorrhagic septicemia virus (VHSV) in Coho salmon from the same watershed. Journal of Aquatic Animal Health 3: 114–117.

Emmenegger EJ, Kurath G. 2002. Genetic characterization of infectious hematopoietic necrosis virus of coastal salmonid stocks in Washington State. Journal of Aquatic Animal Health 14: 25–34.

Emmenegger EJ, Meyers TR, Burton TO, Kurath G. 2000. Genetic diversity and epidemiology of infectious hematopoietic necrosis virus in Alaska. Diseases of Aquatic Organisms 40: 163-176.

Engelking HM, Kaufman J. 1994. Infectious hematopoietic necrosis virus (IHNV) found in four geographically distinct feral populations of salmonids in Oregon. Fish Health Section/American Fisheries Society Newsletter 22(1): 10-12.

Engelking HM, Kaufman J. 1994. Brown trout (*Salmo trutta*) loss to infectious hematopoietic necrosis virus (IHNV). Fish Health Section/American Fisheries Society Newsletter 22(3): 20–22.

Engelking HM, Kaufman J, Bootland L. 1992. Infectious hematopoietic necrosis virus (IHNV) in steelhead trout at spawning and during two epizootic outbreaks at Leaburg Fish Hatchery: detection and transmission. Fish Health Section/American Fisheries Society Newsletter 20(2): 3-6.

Enzmann P-J, Dangschat H, Feneis B, Schmitt D, Wizigmann G, Schlotfeldt HJ. 1992. Demonstration of IHN virus in Germany. Bulletin of the European Association of Fish Pathologists 12(6): 185.

Enzmann P-J, Kurath G, Fichtner D, Bergmann SM. 2005. Infectious hematopoietic necrosis virus: monophyletic origin of European isolates from North American Genogroup M. Diseases of Aquatic Organisms 66: 187-195.

Follett JE, Thomas JB, Hauck AK. 1987. Infectious hematopoietic necrosis virus in moribund and dead "juvenile" chum, *Oncorhynchus keta*, (Walbaum) salmon, and spawning chinook, *O. tshawytscha* (Walbaum), and adult chum salmon at an Alaskan hatchery. Journal of Fish Diseases 10: 309–313.

Follett JE, Meyers TR, Burton TO, Geesin JL. 1997. Comparative susceptibilities of several salmonid species in Alaska to infectious hematopoietic necrosis virus (IHNV) and North American viral hemorrhagic septicemia virus (VHSV). Journal of Aquatic Animal Health. 9: 34-40.

Garver KA, Troyer RM, Kurath G. 2003. Two distinct phylogenetic clades of infectious hematopoietic necrosis virus overlap within the Columbia River basin. Diseases of Aquatic Organisms 55: 187-203.

Garver KA, Batts WN, Kurath G. 2006. Virulence comparisons of infectious hematopoietic necrosis virus U and M genogroups in sockeye salmon and rainbow trout. Journal of Aquatic Animal Health 18: 232-243.

Godoy MG, Aedo A, Kibenge MJT, Groman DB, Yason CV, Grothusen H, Lisperguer A, Calbucura M, Avendaño F, Imilán M, Jarpa M, Kibenge FSB. 2008. First detection, isolation and molecular characterization of infectious salmon anaemia virus associated with clinical disease in farmed Atlantic salmon (Salmo salar) in Chile. BMC Veterinary Research 4:28.

Goldes SA, Mead SL. 1992. Susceptibility of brook trout *Salvelinus fontinalis* to infectious hematopoietic necrosis virus. Fish Health Section/American Fisheries Society Newsletter 20(1): 4.

Goldes SA, Traxler G, Seaton G. 1986. Isolation of IHNV from native British Columbia rainbow trout broodstock. Fish Health Section/American Fisheries Society Newsletter 14(4): 5.

Grischkowsky RS, Amend DF. 1976. Infectious hematopoietic necrosis virus: prevalence in certain Alaskan sockeye salmon, *Oncorhynchus nerka*. Journal of the Fisheries Research Board of Canada 33: 186-188.

Grove S, Hjortaas MJ, Reitan LJ, Dannevig BH. 2007. Infectious salmon anaemia virus (ISAV) in experimentally challenged Atlantic cod (*Gadus morhua*). Archives of Virology 152: 1829-1837.

Gustafson LL, Ellis SK, Bartlett CA. 2005. Using expert opinion to identify risk factors important to infectious salmon-anemia (ISA) outbreaks on salmon farms in Maine, USA and New Brunswick, Canada. Preventive Veterinary Medicine 70: 17-28.

Hammell KL, Dohoo IR. 2005. Risk factors associated with mortalities attributed to infectious salmon anaemia virus in New Brunswick, Canada. Journal of Fish Diseases 28: 651-661.

Hattenberger-Baudouy AM, Danton M, Merle G. (1988). La nécrose hématopoïétique infectieuse (NHI) des salmonides. II. Données épidémiologiques en France. Pisciculture Français. 91: 10-13.

Helmick CM, Bailey FJ, LaPatra S, Ristow S. 1995. The esophagus/cardiac stomach region: site of attachment and internalization of infectious hematopoietic necrosis virus in challenged juvenile rainbow trout *Oncorhynchus mykiss* and coho salmon *O. kisutch*. Diseases of Aquatic Organisms 23(3):189–199.

Hetrick, FM, Fryer JL, Knittel MD.1979. Effect of water temperature on the infection of rainbow trout *Salmo gairdneri* Richardson with infectious haematopoietic necrosis virus. Journal of Fish Diseases. 2: 253-257.

Holway JE, Smith CE. 1973. Infectious hematopoietic necrosis of rainbow trout in Montana: a case report. Journal of Wildlife Diseases 9: 287-290.

Hopper K. 1987. IHN virus in Washington chum salmon. Fish Health Section/American Fisheries Society Newsletter 15(3): 4.

Janeke P. 1984. IHN outbreak in Colorado. Fish Health Section/American Fisheries Society Newsletter 12(1): 6.

Jenčič V, Hostnik P, Maganja DB, Grom J. 2002. The spread of salmonid viral diseases in Slovenia. Slovenian Veterinary Research. 39: 197-205.

Kamei Y, Yoshimizu M, Ezura Y, Kimura T. 1988. Effects of environmental water on the infectivities of infectious hematopoietic necrosis virus (IHNV) and infectious pancreatic necrosis virus (IPNV). Journal of Applied Ichthyology 4: 37-41.

Kent ML, Traxler GS, Kieser D, Richard J, Dawe SC, Shaw RW, Prosperi-Porta G, Ketcheson J, and Evelyn TPT. 1998. Survey of salmonid pathogens in ocean-caught fishes in British Columbia, Canada. Journal of Aquatic Animal Health 10: 211–219.

Kibenge FSB, Gárate ON, Johnson G, Arriagada R, Kibenge MJT, Wadowska D. 2001. Isolation and identification of infectious salmon anaemia virus (ISAV) from Coho salmon in Chile. Diseases of Aquatic Organisms 45: 9–18.

Kim W-S, Oh M-J, Nishizawa T, Park J-W, Kurath G, Yoshimizu M. 2007. Genotyping of Korean isolates of infectious hematopoietic necrosis virus (IHNV) based on the glycoprotein gene. Archives of Virology 152: 2119-2124.

Kimura T, Yoshimizu M. 1991. Viral diseases of fish in Japan. Annual Review of Fish Diseases 1: 67-82.

Knuesel R, Segner H and Wahli T. 2003. A survey of viral diseases in farmed and feral salmonids in Switzerland. Journal of Fish Diseases 26: 167–182.

Kurath G, Garver KA, Troyer RM, Emmenegger EJ, Einer-Jensen K, Anderson ED. 2003. Phylogeography of infectious haematopoietic necrosis virus in North America. Journal of General Virology 84: 803-814.

LaPatra SE. 1990. Infectious hematopoietic necrosis virus (IHNV) transmission studies in Oregon. Fish Health Section/American Fisheries Society Newsletter 18(1): 4-5.

LaPatra S, Fliszar K. 1990. Examination of mucus and coelomic fluid throughout the spawning of adult Chinook salmon for infectious hematopoietic necrosis virus. Fish Health Section/American Fisheries Society Newsletter 18(4): 2-3.

LaPatra SE, Fryer JL, Wingfield WH, Hedrick RP. 1989. Infectious hematopoietic necrosis (IHNV) in coho salmon. Journal of Aquatic Animal Health. 1: 227-280.

LaPatra SE, Lannan CN, Kreps TD. 1990. An epizootic of infectious hematopoietic necrosis in yearling Chinook salmon. Fish Health Section/American Fisheries Society Newsletter 18(2): 4-5.

LaPatra SE, Lauda KA, Woolley MJ, Armstrong R. 1993. Detection of a naturally occurring coinfection of IHNV and IPNV. Fish Health Section/American Fisheries Society Newsletter 21(1): 9-10.

LaPatra SE, Williams SR, Parson JE, Jones GR, McRoberts WO. 1994. Susceptibility of cutthroat trout, rainbow trout, and hybrids to infectious hematopoietic necrosis. Fish and Health Section/American Fisheries Society Newsletter 22(2): 1-4.

LaPatra SE, Jones GR, Lauda KA, McDowell TS, Schneider R, Hedrick RP. 1995. White sturgeon as a potential vector of infectious hematopoietic necrosis virus. Journal of Aquatic Animal Health 7: 225-230.

Luqi N, Zhizhuang Z. 1988. The epidemiology of IHN and IPN of rainbow trout in northeast China. Shui Chan Xue Bao (Journal of Fisheries China) 12: 327-332.

MacLean SA, Bouchard DA, Ellis SK. 2003. Survey of nonsalmonid marine fishes for detection of infectious salmon anaemia virus and other salmonid pathogens. In: International Response to
Infectious Salmon Anemia: Prevention, Control, and Eradication: Proceedings of a Symposium, 3–4 September 2002, New Orleans, LA. Technical coordinators: Miller O, Cipriano RC. US Department of Agriculture, Animal and Plant Health Inspection Service, US Department of the Interior, US Geological Survey, US Department of Commerce, National Marine Fisheries Service. Technical Bulletin No. 1902, Washington, DC. pp. 135–143.

McAllister PE, Bebak J, Wagner BA. 2000. Susceptibility of Arctic char to experimental challenge with infectious hematopoietic necrosis virus (IHNV) and infectious pancreatic necrosis virus (IPNV). Journal of Aquatic Animal Health 12: 35-43.

McClure CA, Hammell KL, Dohoo IR. 2005. Risk factors for outbreaks of infectious salmon anemia in farmed Atlantic salmon, *Salmo salar*. Preventive Veterinary Medicine 72: 263-280.

Millard PJ, Bickerstaff LE, LaPatra SE, Kim CH. 2006. Detection of infectious haematopoietic necrosis virus and infectious salmon anaemia virus by molecular padlock amplification. Journal of Fish Diseases 29: 201-213.

Mortensen SH, Evensen Ø, Rødseth OM, Hjeltnes BK. 1993. The relevance of infectious pancreatic necrosis virus (IPNV) in farmed Norwegian turbot (*Scophthalmus maximus*). Aquaculture 115: 243-252.

Mortensen SH. 1993. Passage of infectious pancreatic necrosis virus (IPNV) through invertebrates in an aquatic food chain. Diseases of Aquatic Organisms 16: 41-45.

Morzunov S P, Winton J R, Nichol ST. 1995. The complete genome structure and phylogenetic relationship of infectious hematopoietic necrosis virus. Virus Research 38: 175–192.

Mulcahy, D. 1981. IHN virus found in all populations of Pacific Coast sockeye salmon, potentially in most kokanee populations regardless of location, and in chinook salmon from the Sacramento River drainage. U.S. Fish and Wildlife Service Research Bulletin. No. 81-10.

Mulcahy DM, Tebbit GL, Groberg WJ, McMichael JS, Winton JR, Hendrick RP, Phillippon-Fried M, Pilcher KS, and Fryer JL. (1980) The occurrence and distribution of salmonid viruses in Oregon. Oregon State University Sea Grant College Program, ORESU-T- 80–004. Oregon Agricultural Experiment Station, Corvallis, OR. Technical paper No. 5504 [accessed Aug10, 2010 at:http://nsgl.gso.uri.edu/oresu/oresut80004.pdf].

Mulcahy D, Pascho RJ. 1984. Adsorption to fish sperm of vertically transmitted fish viruses. Science 225: 333-335.

Mulcahy D, Klaybor D, Batts WN. 1990. Isolation of infectious hematopoietic necrosis virus from a leech (*Piscicola salmositica*) and a copepod (*Salmincola sp*.), ectoparasites of sockeye salmon *Oncorhynchus nerka*. Diseases of Aquatic Organisms. 8: 29-34.

Nishizawa T, Kinoshita S, Kim W-S, Higashi M, Yoshimizu M. 2006. Nucleotide diversity of Japanese isolates of infectious hematopoietic necrosis virus (IHNV) based on the glycoprotein gene. Diseases of Aquatic Organisms 71: 267-272.

Nylund A, Alexandersen S, Løvik P, Jakobsen P. 1994. The response of brown trout (*Salmo trutta* L.) to repeated challenge with infectious salmon anaemia (ISA). Bulletin of the European Association of Fish Pathologists 14: 167-170.

Okamoto, N., Kanon, T. 1991. Effects of water temperature on mortality of rainbow trout infected with IPNV. (Abstract) 14th Annual American Fisheries Society/Fish Health Section Meeting, 32nd Western Fish Disease Conference, (31 July-3 August, 1991).

Olson C, Thomas J. 1994. An outbreak of infectious hematopoietic necrosis in the Baker River system affecting two year classes of sockeye. Fish Health Section/American Fisheries Society Newsletter 22(3): 1-3.

Oshima KH, Arakawa CK, Higman KH, Landolt ML, Nichol ST, Winton JR. 1995. The genetic diversity and epizootiology of infectious hematopoietic necrosis virus. Virus Research. 35, 123–141.

Park MA, Sohn SG, Lee SD, Chun SK, Park JW, Fryer JL, Hah YC. 1993. Infectious haematopoietic necrosis virus from salmonids cultured in Korea. Journal of Fish Diseases 16: 471-478.

Pietsch, J.P.; Amend, D.F.; Miller, C.M., 1977: Survival of infectious hematopoietic necrosis virus held under various environmental conditions. Journal of the Fisheries Research Board of Canada 34: 1360-1364.

Plarre H, Devold M, Snow M, Nylund A. 2005. Prevalence of infectious salmon anaemia virus (ISAV) in wild salmonids in western Norway. Diseases of Aquatic Organisms 66: 71-79.

Plumb, J.W. 1972. A virus-caused epizootic of rainbow trout (*Salmo gairdneri*) in Minnesota. Transactions of the American Fisheries Society; 1: 121-123

Polinski MP, Fehringer TR, Johnson KA, Snekvik KR, LaPatra SE, LaFrentz BR, Ireland SC, Cain KD. 2010. Characterization of susceptibility and carrier status of burbot, *Lota lota* (L.), to IHNV, IPNV, *Flavobacterium psychrophilum*, *Aeromonas salmonicida* and *Renibacterium salmoninarum*. Journal of Fish Diseases. 33:559–570.

Raissy M, Momtaz H, Ansari M, Moumeni M. 2010. Diagnosis of infectious hematopoietic necrosis in rainbow trout hatcheries, Iran. African Journal of Microbiology Research 4: 1868-1871.

Reschova S, Pokorova D, Hulova J, Kulich P, Vesely T. 2008. Surveillance of viral fish diseases in the Czech Republic over the period January 1999 - December 2006. Veterinarni Medicina 53: 86-92.

Roberts S. 1986. IHN strikes rainbow trout at two Washington Department of Game hatcheries. Fish Health Section/American Fisheries Society Newsletter 14(1): 7.

Roberts SD. 1993. IHN at Lyons Ferry Hatchery: a case study of vertical transmission. Fish Health Section/American Fisheries Society Newsletter 21(1): 13-14.

Rodger HD, Frerichs GN. 1997. Clinical infectious pancreatic necrosis virus infection in farmed halibut in the United Kingdom. Veterinary Record 140: 401-402.

Rudakova SL, Kurath G, Bochkova EV. 2007. Occurrence and genetic typing of infectious hematopoietic necrosis virus in Kamchatka, Russia. Diseases of Aquatic Organisms 75: 1-11.

Sadasiv EC. 1995. Immunological and pathological responded of salmonids to infectious pancreatic necrosis virus (IPNS). Annual Review of Fish Diseases 5: 209-223.

Saft RR, Follett JE, Thomas JB. November, 1987. Infectious hematopoietic necrosis in Alaskan Chum salmon. Alaska Department of Fish and Game, FRED Technical Report No. 79, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska.

Saksida SM. 2006. Infectious haematopoietic necrosis epidemic (2001 to 2003) in farmed Atlantic salmon *Salmo salar* in British Columbia. Diseases of Aquatic Organisms 72: 213-223.

Sano T, Nishimura T, Okamoto N, Yamazaki T, Hanada H, Watanabe Y. 1977. Studies on viral diseases of Japanese fish. VI. Infectious hematopoietic necrosis (IHN) of salmonids in the mainland of Japan. Journal of the Tokyo University of Fisheries 63: 81–85.

Shors ST, Winston V. 1989b. Detection of infectious hematopoietic necrosis virus in an invertebrate *(Callibaetis sp)*. American Journal of Veterinary Research 50: 1307-1309.

Smail DA, Bruno DW, Dear G, McFarlane LA, Ross K. 1992. Infectious pancreatic necrosis (IPN) virus Sp serotype in farmed Atlantic salmon, *Salmo salar* L., post-smolts associated with mortality and clinical disease. Journal of Fish Diseases 15: 77–83.

Smail DA, Huntly PJ, Munro ALS. 1993. Fate of four fish pathogens after exposure to fish silage containing fish farm mortalities and conditions for the inactivation of infectious pancreatic necrosis virus. Aquaculture 113: 173-181.

Smail DA, Munro ES. 2008. Isolation and quantification of infectious pancreatic necrosis virus from ovarian and seminal fluids of Atlantic salmon, *Salmo salar* L. Journal of Fish Diseases 31: 49-58.

Sohn SG, Park MA, and Lee SD. 1992. A histological study on masu salmon, *Oncorhynchus masou* fry infected with infectious hematopoietic necrosis virus. Bulletin of the National Fisheries Research and Development Agency of Korea. 46, 145-150.

St-Hilaire 2000. Epidemiology of infectious hematopoietic necrosis disease in net-pen reared Atlantic salmon in British Columbia, Canada. PhD thesis, University of Guelph, Guelph, Ontario.

St-Hilaire S, Ribble CS, Stephen C, Anderson E, Kurath G, Kent ML (2002). Epidemiological investigation of infectious hematopoietic necrosis virus in salt water net-pen reared Atlantic salmon in British Columbia, Canada. Aquaculture 212, 49–67.

Tafalla C, Saint-Jean SR, Pérez-Prieto S. 2006. Immunological consequences of the coinfection of brown trout (*Salmo trutta*) with infectious hematopoietic necrosis virus (IHNV) and infectious pancreatic necrosis virus (IPNV). Aquaculture 256: 15-22.

Toranzo AE, Hetrick FM. 1982. Comparative stability of two salmonid viruses and poliovirus in fresh, estuarine and marine waters. Journal of Fish Diseases 5: 223-231.

Totland GK, Hjeltnes BK, Flood PR. 1996. Transmission of infectious salmon anaemia (ISA) through natural secretions and excretions from infected smolts of Atlantic salmon *Salmo salar* during their presymptomatic phase. Diseases of Aquatic Organisms 26: 25-31.

Traxler GS. 1983. A survey for infectious hematopoietic necrosis virus in adult sockeye salmon (*Oncorhynchus nerka*) in Great Central Lake, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1205. 11 p.

Traxler G. 1985. IHN outbreak in Lake Cowichan, British Columbia. Fish Health Section/American Fisheries Society Newsletter 13(3): 4.

Traxler GS. 1986. An epizootic of infectious haematopoietic necrosis virus in 2-year-old kokanee, *Oncorhynchus nerka* (Walbaum) at Lake Cowichan, British Columbia. Journal of Fish Diseases 9: 545–549.

Traxler GS. 1988. IHN mortality of kokanee in Cameron Lake, British Columbia. Fish Health Section/American Fisheries Society Newsletter 16(1): 4.

Traxler GS, Rankin JB. 1989. An infectious hematopoietic necrosis epizootic in sockeye salmon *Oncorhynchus nerka* in Weaver Creek spawning channel, Fraser River system, B.C., Canada. Diseases of Aquatic Organisms 6:221-226.

Troyer RM, Kurath G. 2003. Molecular epidemiology of infectious hematopoietic necrosis virus reveals complex virus traffic and evolution within southern Idaho aquaculture. Diseases of Aquatic Organisms 55: 175-185.

Troyer RM, LaPatra SE, Kurath G. 2000. Genetic analyses reveal unusually high diversity of infectious haematopoietic necrosis virus in rainbow trout aquaculture. Journal of General Virology 81: 2823–2832.

Vardić I, Kapetanović D, Teskeredžić Z, Teskeredžić E.2007. First record of infectious haematopoietic necrosis virus in rainbow trout fry in Croatia. Acta Veterinaria Brno 76: 65-70.

Vilas MP, Rodriguez S, Perez S. 1994. A case of coinfection of IPN and IHN virus in farmed rainbow trout in Spain. Bulletin of the European Association of Fish Pathologists 14: 47-50.

Wang W-S, Lee J-S, Shieh M-T, Wi Y-L, Huang C-J, Chien M-S . 1996. Detection of infectious hematopoietic necrosis virus in rainbow trout *Oncorhynchus mykiss* from an outbreak in Taiwan by serological and polymerase chain reaction assays. Diseases of Aquatic Organisms 26: 237-239.

Wedemeyer GA, Nelson NC, Smith CA. 1978. Survival of the salmonid viruses infectious hematopoietic necrosis (IHNV) and infectious pancreatic necrosis (IPNV) in ozonated, chlorinated, and untreated waters. Journal of the Fisheries Research Board of Canada 35: 875-879.

Williams IV, Amend DF. 1976. A natural epizootic of infectious hematopoietic necrosis in fry of sockeye salmon *Oncorhynchus nerka*, at Chilko Lake, British Columbia. Journal of the Fisheries Research Board of Canada 33: 1564-1567

Wolf K, Quimby MC, Pettijohn LL, Landolt ML. 1973. Fish viruses: isolation and identification of infectious hematopoietic necrosis in eastern North America. Journal of the Fisheries Research Board of Canada. 30: 1625-1627.