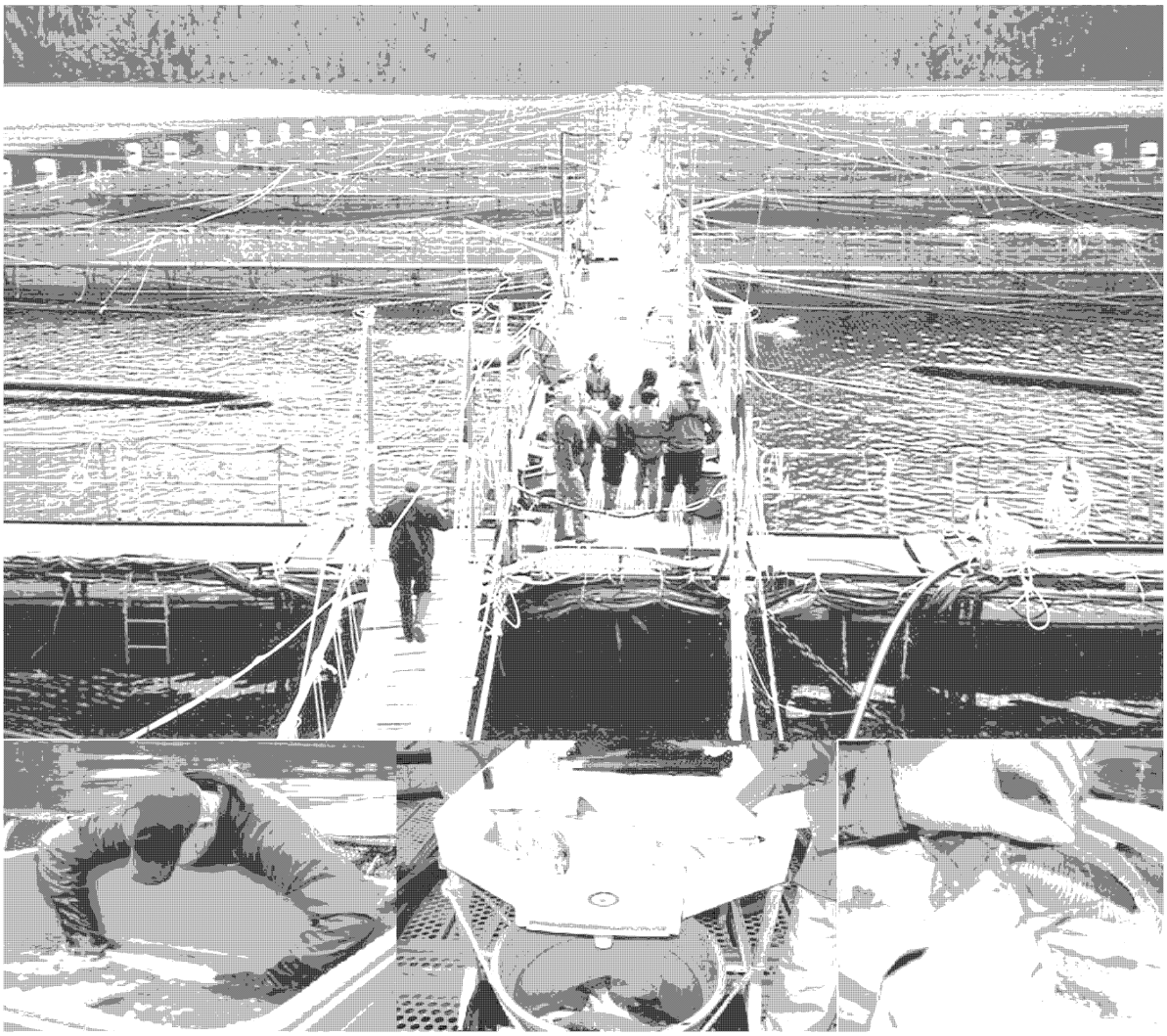
2009

Ministry of Agriculture and Lands

Animal Health Branch – Fish Health



BRITISH COLUMBIA
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ANNUAL REPORT
FISH HEALTH PROGRAM

Section 1: Overview 2009

1.1 Executive Summary

The Province of British Columbia (BC) initiated a comprehensive health management program for salmon aquaculture in 2001 and the Ministry of Agriculture and Lands (BCMAL) and has been verifying compliance and reporting the performance of that program since 2003. The Fish Health Program includes a requirement for on-farm health management plans, mandatory monitoring and reporting of disease events, and a BCMAL audit of industry-reported information, all of which now appears on the web quarterly.

Farmed salmon have the same diseases as wild salmon. In 2009, BCMAL completed 116 salmon farm health audits and collected diagnostic samples for disease analysis from 585 dead fish. All farms categorize their carcasses, giving probable explanation for the cause of death. During audits, about 25% of the routine fish mortality are categorised as "silvers". Silvers are fresh carcasses that still have silver skin. This group of dead fish are used as best indicators of active disease in the robust living population. Roughly 8 to 10% of those silver carcasses are sampled and tested by BCMAL for cause of death and specific infectious diseases.

For Atlantic salmon health audits: 80% of the case diagnoses were „no infectious disease" (at the farm-level). Of the infectious disease cases, the main diagnoses were mouth myxobacteriosis (11%) and VHS virus (North America strain, common to Pacific herring, 4%). For farmed Pacific salmon health audits: 59% of the case diagnoses were „no infectious disease" (at the farm-level, Fig. 4a), and the main disease diagnoses were bacterial kidney disease (35%) and vibriosis (6%). All of these diseases are endemic in wild fish populations of BC so it is rational that these same diseases would also occur in farmed fish.

The Fish Health Audit and Surveillance Program found the same diseases as those reported by industry. The Ministry surveillance program detected no pathogens in farmed salmon that would affect trade from BC or Canada.

Audits of sea lice abundance at Atlantic salmon farms confirm that the aquaculture industry is complying with the 2008/2009 sea lice management strategy. In 2009, BCMAL conducted lice counts at 74 farms and assessed over 4,400 live fish. Both the „salmon louse" and the „herring louse" can parasitize host salmon so a lice abundance trigger, established to guide the management of the salmon louse, was introduced and fully implemented in 2004. To date, use of a trigger level of three salmon lice per farmed fish (especially during the wild salmon out-migration period: March 1st to June 30th) continues to be precautionary for lice management in BC; the lice abundance in farmed and wild salmon has declined since 2004, although autumn 2009 did reflect a slight elevation in average lice abundance compared to historical abundance during this season. Recent research continues to support the current lice management strategy. Genetic studies offer a plausible explanation as to why Atlantic salmon raised in British Columbia show little or no outward signs of ill health from the Pacific Ocean strain of salmon lice.

The Ministry's Fish Health Program facilitates a comprehensive understanding of the health status of fish stocks on salmon farms. The program supports the monitoring, reporting, and governance of fish disease, and addresses health concerns that may arise in farmed fish. This annual Fish Health Report summarizes the information generated by the audit and surveillance portion of the provincial fish health program for one calendar year.

1.2 Mandate and Background

In response to the 1997 Environmental Assessment Review of Aquaculture, the government of BC developed a comprehensive policy to improve the monitoring of fish disease on salmon farms and to establish governance of health management in the aquaculture industry. The Fish Health Program was implemented in 2001, requiring salmon producers to document their health management plans, and to engage in mandatory standard reporting. BCMAL uses these reports and its own findings to monitor health aspects of fish cultured at private and public facilities.

1.3 Objectives

The overriding objectives of the provincial Fish Health Program are to monitor and minimise the risks of disease in farmed fish, and to facilitate public and agency confidence that aquaculture health management in BC occurs at a high standard. The cornerstone of this program is the salmon Health Management Plan (HMP). These corporate management plans encompass all aspects of salmon farming that can affect the health of the animals at the aquaculture facility. Since 2003, all private companies and public salmon culture facilities have developed and maintained a current HMP specific to their facility. For private companies and the provincially licenced public facilities, the HMP remains enforceable as a Term & Condition of an aquaculture licence.

Another objective of the program is to ensure access to accurate and verifiable data on the disease status of cultured salmon. For salmon aquaculture, all commercial facilities in freshwater and saltwater are required to report site-specific information to the BC Salmon Farmers Association"s (BCSFA) industry database on a monthly basis. Companies must report all mortality, causes of mortality and Fish Health Events (FHE) [1]. From that database, quarterly reports of industry"s fish health status are submitted to government and posted for public viewing on the Animal Health Branch – Fish Health website. On-site health monitoring and reporting of disease status are requirements under the HMP and compliance monitoring is built-in to the system.

[1] Fish Health Event (FHE), for the purpose of industry database reporting and this program, is defined as an active disease occurrence or a suspected infectious event on a farm that triggers: 1) veterinary involvement and 2) an action, such as: lab diagnosis, recommendation/report, husbandry change, prescription medication, further investigation, etc. where such action is intended to reduce or mitigate risk associated with that event.

Section 2: Salmon Health Management Plans

2.1 Salmon Health Management Plans

The salmon Health Management Plan (HMP) outlines the minimum standard of husbandry for cultured salmon in British Columbia.

2.1.1 Review of HMPs

Three documents are used to develop a corporate HMP: the Required Elements document provides the guiding principles for the HMP process; the Template for Writing a Facility Specific Fish Health Management Plan, details what is required of operators and lists required Standard Operating Procedures (SOP) for management of specific farm activities affecting fish health; and the Manual of Fish Health Practices is used by government regulators as a standards document against which the industry SOPs are assessed.

2.1.2 Monitoring and Compliance of HMPs

All salmon producers rearing privately owned fish in net pen or tank farms conduct their activities based on updated HMPs which have been reviewed by Ministry veterinarians of the Animal Health Branch.

With regard to public fish enhancement facilities, several key hatcheries of the Freshwater Fisheries Society of British Columbia operate under one general HMP. Each rearing site has its own SOP document. A similar arrangement exists for numerous large federal enhancement hatcheries of Fisheries and Oceans Canada (DFO) in BC; they continue to operate guided by one overarching HMP template document with facility-specific HMPs and SOPs. These public facilities record all husbandry and health events as per their HMPs.

The Ministry sends an annual reminder letter to all industry HMP coordinators to request that revisions, if any, be communicated. Any revisions to private aquaculture HMPs and/or SOPs are submitted to and reviewed by fish health veterinarians of the Animal Health Branch annually. BCMAL also conducts an annual review of its guiding Template and Manual documents. Any changes to the latter documents are posted on the Animal Health Branch – Fish Health website and reflect amendments to the fish health standards set by government against which industry practices are compared. No changes were made in 2009. In addition, the renewal of aquaculture licences, amendments to an existing licence, or the issuing of a new licence, will trigger an assessment of the company"s HMP status. If changes are required at the time of the review a letter of notification is sent to the company.

2.2 Industry Monitoring and Reporting

The HMP dictates that all major commercial salmon farming companies operating in British Columbia must monitor their fish and report to the BCSFA database monthly, addressing the status of fish health at their farms. These monitoring results are aggregated in terms of fish health sub-zones and reported to BCMAL on a quarterly basis. The reports are standardized and include: total mortality, and infectious and non-infectious causes of that mortality for all farms. The list of various causes of mortality is found in Appendix 7.1. In addition, and on a quarterly basis, industry veterinarians or technicians report FHEs to the BCSFA if veterinary intervention has occurred. FHEs account for the population-level diseases or incidents of husbandry that occur on farms.

2.2.1 Verification and Compliance of Industry Database Reports

Three types of reports are provided to BCMAL from the BCSFA database: quarterly Fish Health Events, Cause of Mortality reports, and monthly Sea Lice Monitoring reports. This reporting structure is a condition of licence under the HMP.

The BCSFA database is operated by a third party and verified by an independent private veterinarian. Monitoring the compliance of companies that report to the BCSFA database is built into the reporting protocol as follows: all industry fish health reports destined for the BCSFA database are due on the 10th of the month following each calendar quarter (example: Quarter 1, January to March, is due April 10th); all sea lice data are required on the 10th day of the month following the monitoring event (example: January data is due February 10th). If a farm does not comply with the reporting requirements, it is granted 10 days to communicate. If by the 20th of the month a company has not reported, the BCSFA database manager will provide the Ministry with details of the non-compliance and, depending on the nature and reason for non-compliance, the Ministry would reiterate the company‘s licence obligations. Continued non-compliance may result in enforcement action. On-farm reports can be generated by companies to verify that a farm has entered the required data for a particular calendar quarter.

On-farm audit and records review by Ministry staff further verifies industry-reported information. During farm visits, the producer cooperates and volunteers the delivery of carcasses to the surface. This allows samples from fish to be collected for testing for specific diseases and pathogens of concern. The producer also volunteers live fish to be monitored for sea lice abundance. These visits ensure that farm staff are collecting and compiling the information and classifying dead fish and their causes of mortality, as per established protocols.

Section 3: Fish Health Audit and Surveillance

3.1 Fish Health Audit and Surveillance Program

The Fish Health Audit and Surveillance (FHAS) component of the Ministry"s Fish Health Program consists of three main tasks:

1) Provincial fish health bio-technicians monitor activities and review health-related records at marine salmon farms, as outlined in HMPs;

2) Provincial fish health bio-technicians collect samples from recently dead or moribund fish to facilitate active surveillance for bacteria, viruses and parasites and to determine farm-level disease events. The provision of carcasses by the producer is voluntary; and,

3) The audit results are compared to reports generated through the BCSFA database.

The FHAS program audits industry"s activities, searches for and reports specific diseases and pathogens of concern (i.e. pathogens recognised federally and internationally that may affect fish movement and trade), and identifies diseases at farms that are common to BC fish - wild and farmed - including indigenous pathogens that may emerge in farmed salmon populations.

3.2 Methodology

3.2.1 Zonation

British Columbia coastal waters are divided into fish health zones and sub-zones by DFO loosely based on watersheds for salmonid transfers (Table 2; map in Appendix 7.2). The zones also follow natural geographical divisions of the aquaculture industry. Zone 2 represents Vancouver Island and Zone 3 is from the Fraser River north to the Alaska/BC border.

Atlantic salmon farm information is summarized by sub-zone whereas the Pacific salmon farms report by zone to minimise singling out these smaller individual farms or companies.

Table 1: Fish Health Zones and Sub-zones of British Columbia

Zone	Sub-zone	Geographical Description
Atlantic Salmon Reporting Sub-zones		
2	2.3	West Coast of Vancouver Island, Southern Area
2	2.4	West Coast of Vancouver Island, Northern Area
2 + 3	2.1 + 3.1	South East Coast Vancouver Island + Sunshine Coast
3	3.2	Campbell River Area (aka. „Discovery Islands")
3	3.3	Broughton Area
3	3.4	Port Hardy Area
3	3.5	Central Coast Area
Pacific Salmon Reporting Zones		
2		Vancouver Island
3		East of Vancouver Island

3.2.2 Sampling Methodology

BCMAL applies a multistage selection system within designated fish health zones. All farms within a zone are assigned a random number and a computer selection of the farms within a sub-zone is weighted (based on the fish species and the number of "active farms" [2] operating in that sub-zone as a percentage of the total number of active farms in the province). For example, if an area contains 30% of the total number of active BC farms then 30% of the farms selected for audit would be randomly chosen from that area. This ensures an equal probability of each farm being selected for sampling every calendar quarter. The farms are widely dispersed in remote areas of the coastline; for practical reasons and efficient resource allocation, the maximum audit number is 30 farms per quarter. The aim is to achieve 120 farm audits annually.

There are approximately 135 provincial land tenures for marine finfish aquaculture in British Columbia upon which 60 to 80 salmon farms operate at any given time. In 2009, the number of active farms available for health audit each quarter ranged from 63 to 70 (mean = 67, see Table 2 and Appendix 7.3). The audit of 30 farms means that approximately 50% of the farms were assessed for aspects of fish health alone. In addition, farm selection for sea lice audits is conducted independently, so a further 25 to 50% of active Atlantic salmon farms are visited each quarter (see Section 4.0, Sea Lice).

The definition of an active farm (within the auditing program) differs for a fish health audit and a sea lice audit. For health audits a farm is considered active once three pens of fish have been present for 30 days, following entry of the first pen of fish. For large fish, if a harvest is underway or is planned, three pens of fish must be present on the farm on the day of the scheduled audit.

However for sea lice evaluation, an audit can arise once the first pen of salmon has been present at the farm for 120 days and at least three pens are stocked. On occasion, due to scheduling conveniences and with the producer"s assurance that the smolt population is stable and acclimated, a lice audit of three pens of juvenile fish may be arranged sooner (i.e. after 30 days of sea water rearing). For pre-harvest fish there must be a minimum of three fully stocked net pens on-farm to enable a statistically significant sampling. In Table 2, the calculation of an average number of farms often results in a non-integer (i.e. 10.8) so the calculated numbers have been rounded up or down to whole integers accordingly.

[2] Active farms are those farms which are determined to have a minimum of 3 pens of fish on-site (for at least 30 days) during the quarter which sampling is to occur. This definition does not include broodstock.

3.2.3 Salmon Farm Selection

As each calendar quarter begins, a list of all licenced farms is reviewed by the fish health bio-technicians to determine which farms fit the active definition. From the list of active farms a computer-generated random group of farms becomes destined for audit. Although the total number of farms chosen for audit is normally 30 (see Table 3 and Figure 1), farm audits sometimes must be cancelled due to adverse weather, or overriding health issues such as plankton blooms, low marine oxygen, or other unforeseen circumstances. Whenever possible these cancelled farm audits are rescheduled in the same quarter.

3.2.4 Sampling and Sample Selection

Farm audits are conducted in conjunction with the farm"s regularly scheduled carcass removal, facilitating staff access to the dead fish. The approach of targeted disease sampling on recently dead fish increases the likelihood of finding disease (compared with random sampling of all live fish at the farm - most of which would be healthy). Dead fish are categorised in accordance with industry health standards (see Appendix 7.1 for definitions). A sub-set of the "fresh silvers" is selected for standard histopathology, bacteriology, and virology. These samples are used to establish the presence or absence of specific diseases-of-concern, as well as endemic diseases; this information is then compared with the industry-reported health information.

Carcasses to be sampled are those of fish that had grown well prior to death and generally still have red or pink gills – these are fish that died most recently and may or may not show signs of disease. This group provides the greatest diagnostic value, is most reflective of potential disease, and is most representative of the robust living population (without sampling the living fish). Typically, five to eight silvers per farm are collected, depending on availability. Sampling is aimed at achieving a 95% confidence of detection of 2% disease prevalence among farmed fish during a quarter. The total number of dead or moribund fish sampled varies at each farm because of variation in availability of fresh silvers. The number of carcasses tested in 2009 was 585 (Table 4).

Samples are collected for bacteriology, histopathology and molecular diagnostics/virology. For bacteriology, kidney tissue from each individual fish is aseptically transferred to trypticase soy agar and blood agar plates. If bacteria are isolated within 72 hours, the cultures are shipped to the provincial Animal Health Centre (AHC) for identification by means of biochemical analyses and/or gene sequencing.

Tissues sampled for histopathology from each carcass include: anterior kidney, posterior kidney, liver, spleen, heart, pyloric caeca, brain, and other gross lesions (e.g., gill or mouth). Tissues are preserved in 10% neutral buffered formalin and processed routinely into paraffin, sectioned, and stained with haematoxylin and eosin for light microscopy.

Tissues sampled for molecular diagnostics and virology from each carcass include: anterior kidney, posterior kidney, liver, spleen, gill, and pyloric caeca. Additional samples are selected when tissues show gross lesions. Tissues are kept on ice until returning to the laboratory, where they frozen at -80°C until further processing.

3.2.5 Diagnostic Testing

Fish samples are sent to the province"s Animal Health Centre (AHC) in Abbotsford for evaluation. The Animal Health Centre is accredited by the American Association of Veterinary Laboratory Diagnosticians (AAVLD). The use of an accredited laboratory provides confidence in the diagnostic results due to high standards of quality assurance and quality control.

Samples for molecular diagnostics and virology are pooled to a maximum of five fish per pool, frozen to -80C, and subsequently screened using Polymerase Chain Reaction (PCR) techniques for the following pathogens of concern:

- Infectious Salmon Anemia Virus (ISAV)
- Infectious Pancreatic Necrosis Virus (IPNV)
- Infectious Hematopoietic Necrosis Virus (IHNV)
- Viral Hemorrhagic Septicemia (VHSV, North American strain, type IVa)
- Piscirickettsia salmonis (P.salmonis)

If PCR findings are positive for a virus, the pooled sample is subsequently transferred to appropriate cell lines for confirmation. Standard cell lines include CHSE 214 and EPC.
IHNV, VHSV (NA strain type IVa) and P.salmonis are each indigenous pathogens to British Columbia"s coast. As such, these pathogens occur in farmed fish from time to time; either seasonally (in the case of VHSV and P.salmonis) or after a number of years (in the case of IHNV).

All tissue samples for histopathology are examined for signs of inflammation and other abnormalities to determine the cause of the mortality. Histopathology enables detailed review of the cause of mortality on an individual fish basis, it provides a mechanism for validating the significance of PCR and bacteriology results, and it can identify new diseases. All analyses are done by a fish pathologist certified in anatomic pathology by the American College of Veterinary Pathologists.

3.2.6 Other Components of Audits

3.2.6.1 Record Assessment

During farm audits Ministry fish health personnel assess farm records for mortality level, carcass categories, record of treatments (if any) and reasons for treatment.

3.2.6.2 Audit of Fish Health-Related Activities

The farm visits also allow assessment of: 1) the frequency of the carcass collections, and 2) biosecurity protocols during carcass handling. A biosecurity and HMP checklist is also part of the audit to standardise the assessment and better evaluate the compliance with the producer"s salmon Health Management Plan. Compliance was 100% at all commercial production farms.

3.3 Results

3.3.1 Number of Active Salmon Farms

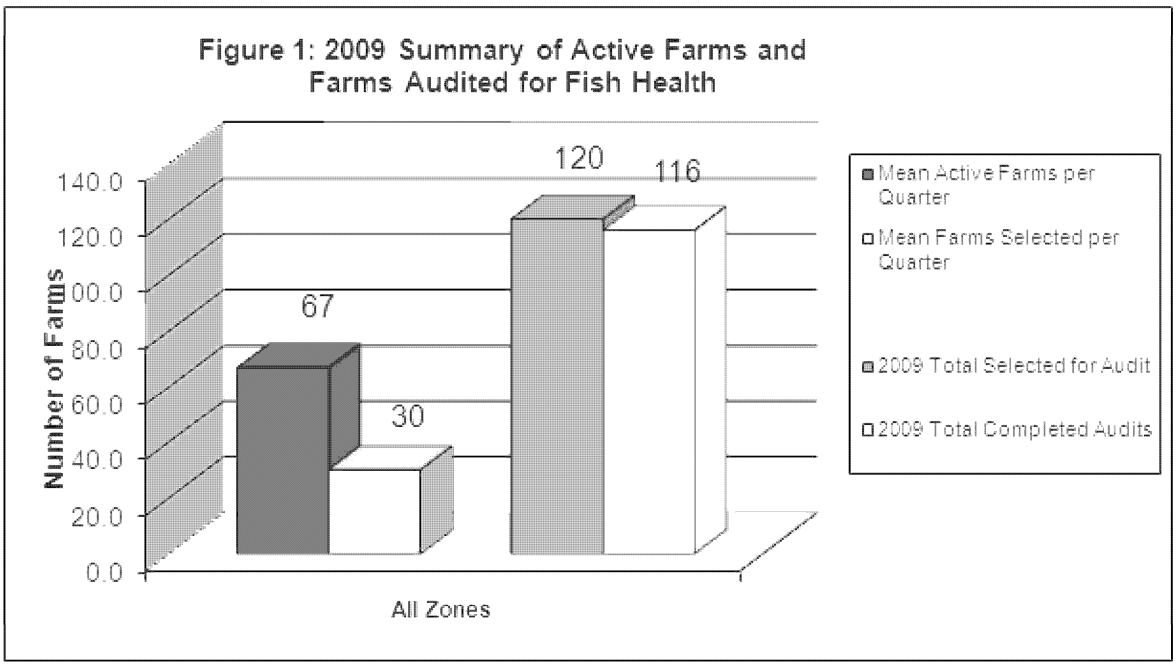
The number of active farms in 2009 is provided in Table 2, and by calendar quarter in Appendix 7.3

Table 2. Average Number of Active Salmon Farms in 2009	
Atlantic Salmon	**2009**
Zone 2.3 SW Vancouver Island	11
Zone 2.4 NW Vancouver Island	9
Zone 3.1 Sunshine Coast	2
Zone 3.2 Campbell River Area	13
Zone 3.3 Broughton Area	14
Zone 3.4 Port Hardy Area	6
Zone 3.5 Central Coast Area	4
Pacific Salmon	
Zone 2 Vancouver Island	3
Zone 3 East of Vancouver Island	5

NB: BCSFA considers member farms with any fish present to be an active production farm so BCSFA"s list of farms inevitably reflects a higher number of farms than BCMAL"s list of „active for audit" farms. In addition, a few independent marine corporations are not members of the BCSFA and do not report to the industry database because their activities are considered either a pilot project or the activity has a research focus. However, these „farms" have HMPs and are subject to provincial monitoring. Broodstock populations are not audited by BCMAL because the brood fish are raised under unique husbandry management. They are not sold for food. As such, they are not reflective of the food-animal, production population.

Table 3: Number of Salmon Farms Selected for Health Audit During Each Quarter of 2009					
Location	**Q1 Jan - Mar**	**Q2 Apr – Jun**	**Q3 Jul - Sep**	**Q4 Oct – Dec**	**2009 Totals**
Sub-zone 2.3 SW Vancouver Island	5	4	5	6	20
Sub-zone 2.4 NW Vancouver Island	2	4	5	5	16
Sub-zone 3.1 Sunshine Coast	1	1	1	1	4
Sub-zone 3.2 Campbell River Area	6	6	5	4	21
Sub-zone 3.3 Broughton Area	6	5	6	5	22
Sub-zone 3.4 Port Hardy Area	3	3	3	6	15
Sub-zone 3.5 Central Coast	2	2	1	1	6
Atlantic Sub-total	**25**	**25**	**26 (25)**	**28 (25)**	**104 (100)**
Zone 2 Vancouver Island	1	2	1	1	5
Zone 3 East of Vanc. Island	4	3	3	1	11
Pacific Sub-total	**5**	**5**	**4**	**2**	**16**
Grand Total	**30**	**30**	**30 (29*)**	**30 (27*)**	**120 (116)**

* In Q3, 29 farms instead of 30 were audited due to harmful plankton blooms. In Q4, 27 farms instead of 30 were audited due to inclement winter weather.



3.3.2 Number of Farmed Salmon Sampled

All dead fish retrieved from the farm during the audit were examined grossly by farm and MAL personnel but only those that were suitably fresh were chosen for detailed diagnostic evaluation. An average of five (to a maximum of 20) fish were selected across all pens for diagnostic tissue collection. The number actually sampled depended on the mortality level at the farm which, in turn, depended on the size, age of fish, time of year, and if there had been a recent fish health event.

No carcasses were available or suitable for collection from seven of the 116 audits (Tables 4 and 5); however, all other aspects of the audit were conducted, including an assessment of on-farm record keeping and carcass retrieval techniques.

Table 4 : Number of Carcasses Sampled Each Quarter of 2009					
Location	**Q1 Jan - Mar**	**Q2 Apr - Jun**	**Q3 Jul - Sep**	**Q4 Oct - Dec**	**2009 Totals**
Sub-zone 2.3 SW Vancouver Island	27	14	30	32	103
Sub-zone 2.4 NW Vancouver Island	9	17	18	19	63
Sub-zone 3.1 Sunshine Coast	8	3	0	5	16
Sub-zone 3.2 Campbell River Area	32	42	40	27	141
Sub-zone 3.3 Broughton Area	45	25	13	30	113
Sub-zone 3.4 Port Hardy Area	8	15	17	24	64
Sub-zone 3.5 Central Coast	5	6	2	0	13
Atlantic Sub-total	**134**	**122**	**120**	**137**	**513**
Zone 2 Vancouver Island	6	11	3	1	21
Zone 3 East of Vancouver Island	15	13	18	5	51
Pacific Sub-total	**21**	**24**	**21**	**6**	**72**
Grand Total	**155**	**146**	**141**	**143**	**585**

3.3.3 The Use of Bacteriology

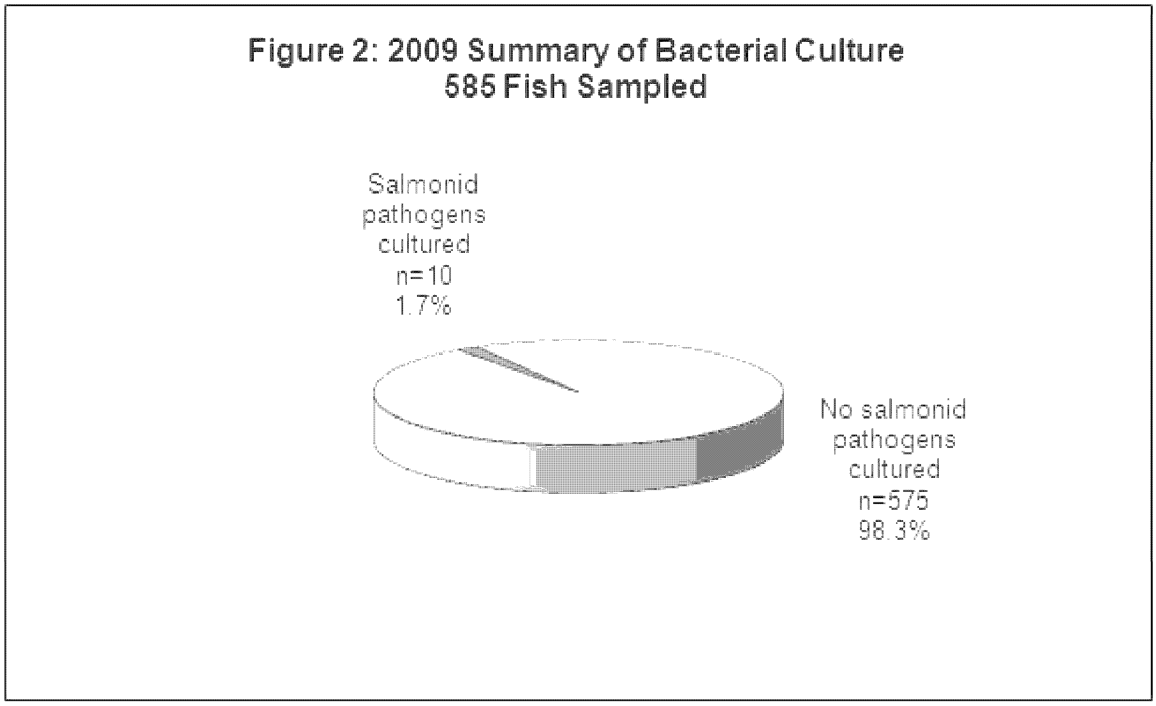
Table 5 and Figure 2 contain Gram-negative bacteriology results from the fish health audit program. The data represents the findings from fish examined within each coastal sub-zone. The data reflects only those micro-organisms that can readily cause disease in fish (i.e. pathogens). Some bacterial pathogens, such as Renibacterium, Tenacibaculum and P.salmonis, are not represented in the table because they are more effectively verified and diagnosed by other laboratory techniques.

In 98.3% of the 585 carcasses sampled no disease-causing bacteria (pathogens) were isolated. In other words, only ten fish (1.7%) collected during audits led to a laboratory culture of a bacterial pathogen. An additional 44 carcasses tested positive for opportunistic or spoilage species that are considered inconsequential to fish production or fish health events. Details of bacteriology results (by zone, sub-zone, quarter and annual summary) are provided in Appendix 7.4 which includes the names of the pathogenic and non-pathogenic bacteria identified by the laboratory (Table 7.4.10).

Table 5: 2009 Total farms with carcasses to sample, and number of fish with bacterial pathogens cultured (by quarter)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms sampled *	26	29	27	27	**109**
# fish sampled	155	146	141	143	**585**
# fish with a pathogen cultured	0	6	1	3	**10**

*116 health audits were conducted yet fish samples were available from only 109 of those farms; no fish carcasses were available or suitable for diagnostic testing at seven of the farms.



3.3.4 The Use of Molecular Diagnostics (PCR) / Virology

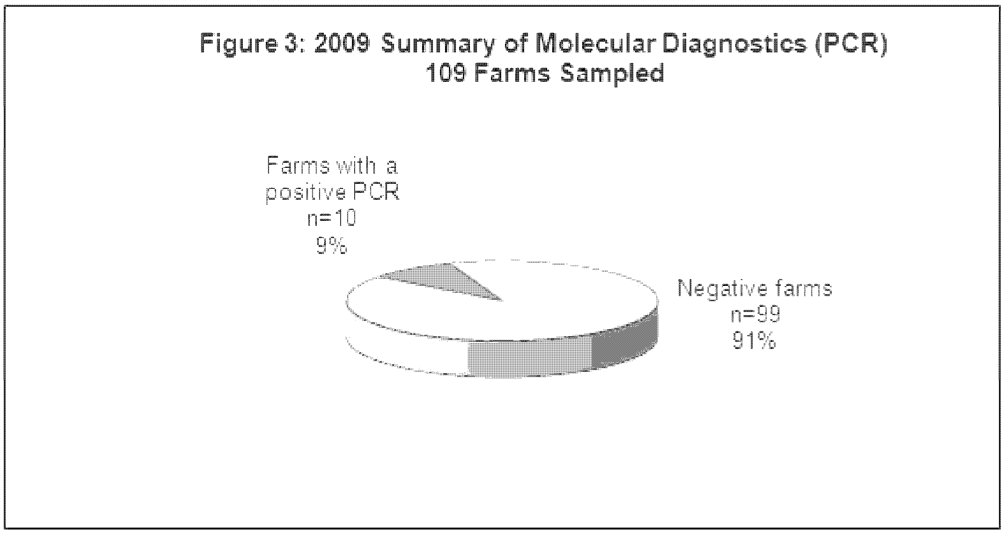
Molecular diagnostic analysis (polymerase chain reaction, PCR) is used to identify genetic material of known disease-causing micro-organisms from all tissue samples collected. Some of the pathogens BCMAL tests for are indigenous to British Columbia while others have yet to be found in BC so are considered exotic to the region.

The majority of the 109 pooled samples (91%) tested negative for the five pathogens of concern. Because fish samples were pooled, results are summarized at the farm-level rather than individual fish-level. A summary of the annual findings is provided in Table 6 and Figure 3. Detailed results of all testing from each zone/sub-zone (by quarter and annually) are provided in Appendix 7.5. Of the total 109 farms sampled*, ten pooled groups of carcasses from those ten farms had positive PCR results – all were common pathogens indigenous to BC marine waters (i.e. P.salmonis and VHSV IVa).

Table 6: 2009 Total farms with carcasses to sample, and number of farms with a positive PCR result (per quarter)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms sampled *	26	29	27	27	**109**
# fish sampled	155	146	141	143	**585**
# farms with a positive PCR test	4	2	0	4	**10**

*116 health audits were conducted yet fish samples were available from only 109 of those farms; no fish carcasses were available or suitable for diagnostic testing at seven of the farms.



3.3.5 The Importance of Histopathology

Over 4,000 tissue samples (585 fish x 7 organs) on approximately 1,200 histology slides are sectioned, stained and interpreted annually as part of the audit diagnoses. Histopathology is a complex and important aspect of the health audits. Individual fish results are combined with all other field and laboratory information to determine a farm-level diagnosis supported by an incidental cause of death within individual carcasses.

In 2007, brains and pyloric caeca were added to the list of tissues for collection and assessment using histology. This change in protocol led to a several fold enhancement of diagnostic ability and assignment of „probable cause of death". For example, two microscopic parasites have appeared sporadically in the brains of a limited number of Atlantic salmon carcasses since 2007, and these micro-parasites continue to be of scientific interest. These histological lab findings contribute to the information derived from surveillance efforts. One of the micro-parasites is associated with occasional, low-level, mortality in pen-reared Atlantic salmon in BC and may represent the emergence of an indigenous pathogen worthy of close monitoring or scientific investigation. This parasite was first reported in BC farmed salmon in 1995; the source is likely in the environment or wild fish. There is no evidence that these parasites are moving beyond the brain vault of their Atlantic salmon host. In 2009, BCMAL"s routine histological assessments revealed eighteen Atlantic salmon carcasses, over four coastal sub-zones, afflicted by the brain parasite. Although there is no obvious link between the fish from different sub-zones, the fresh water source of these salmon groups warrants further investigation.

3.3.6 The Final Step: Making Case Diagnoses from Audit information

Two provincial fish health veterinarians make a farm- or population-level diagnosis of disease by verifying and considering all the information collected and recorded during the individual audit. This information includes: the mortality level at the farm on the day of the audit; recent treatments that have occurred; bio-technicians" field observations; and results of the laboratory tests. The simple presence of a pathogen in an individual carcass does not always indicate a clinical disease event in a population. Cases often reflect micro-organisms that have been isolated or identified in the laboratory (e.g., VHSV and P.salmonis); however, these findings do not always correspond to a farm-level diagnosis of disease attributable to that particular microscopic agent. To ensure accurate interpretation of the information gathered, diagnoses must be made by veterinarians experienced in the management of fish health and disease. In addition, more than one diagnosis can be assigned per audit so the number of diagnoses does not always equal the number of audits.

3.3.7 Annual Summary of Disease Diagnoses by Species and Sub-zone

Disease agents detected in farmed fish are controlled through husbandry or farm management techniques, or by applying veterinary prescribed therapeutants. In some instances the diseases themselves are simply seasonal and self-limiting (e.g., VHS). Appropriate health management of stocks enables farms to minimise disease and when disease does occur to control it quickly. The overall mortality rate of salmon aquaculture populations is low – usually less than 2% mortality per quarter in each sub-zone (see Figure 14a and Appendix 7.7) and less than 1.0% when considering only the mortality due to infectious diseases (see Figure 14b, BCSFA reported).

The following series of tables and charts reflect the „snapshot" of the farm-level diagnoses derived from health audits in 2009. The audit information reflects the proportion of audit cases in which disease-causing organisms were detected from the 116 completed audits, including those where fish samples were not available. When assessing these data please note that 20% of the audits identified the presence of disease-causing organisms within the fresh Atlantic

salmon carcasses assessed, 80% did not; it does not mean that 20% of all fish farms were undergoing disease epidemics.

$$\text{Proportion of Audit Diagnoses} = \frac{\text{Number of Cases of Disease (diagnosed by audit)}}{\text{Total Number of Audits Conducted}}$$

Information on the total proportion of disease reported by industry is calculated from the BCSFA Fish Health Events reported on a quarterly basis to the BCMAL website. A comparison of findings between the provincial audit and the industry Fish Health Event reports is provided in Section 3.4 of this report.

The number of „cases of disease" is greater than the number of farms audited. This indicates that farm visits identified multiple diagnoses from a single audit. For example, both VHS and Mouth myxobacteriosis may be diagnosed from one Atlantic salmon farm as a result of one farm audit.

Table 7, and Figures 4 and 4a, summarize farm-level diagnoses based on 2009 audits. Further detail (by sub-zone, calendar quarter, and species) is in Figures 5 to 13 and accompanying Tables 8 to 16. Audit case definitions of the various diseases are provided in Appendix 7.6.

Table 7: 2009 Summary of 121 Diagnoses from 116 Health Audits

Atlantic Salmon	**Number of Diagnostic Cases = 104**
No Infectious Disease (NID)*	**83**
Mouth Myxobacteriosis	11
Bacterial Kidney Disease	1
VHS (NA strain)	4
Rickettsiosis	1
Furunculosis	1
Enteric Red Mouth	0
Skin Ulcers (filamentous myxobacteriosis)	3
Net Pen Liver Disease (NID)	(0)
Cardiomyopathy (no etiological agent found, NID)	(0)
No Significant Finding (NID)	(7)
Other- Parasitic meningitis (NID)	(18)
Peritonitis (NID)	(0)
Environmental (NID)	(0)
Pacific Salmon	**Number of Diagnostic Cases = 17**
No Infectious Disease (NID)*	**10**
Bacterial Kidney Disease	6
Loma	0
Rickettsiosis	0
Marine Anemia	0
Vibriosis	1
No Significant Finding (NID)	(4)
Enteritis (NID)	(0)
Environmental (NID)	(0)
Non-performer / non-smolt (coho, NID)	(0)
Jaundice syndrome (NID)	(2)

* No Infectious Disease (NID) includes:

the audits where no carcass samples were available (i.e. there were 116 completed audits of farms yet, at 7 of the farms, no dead fish or none suitable to sample were available = no active infectious disease underway); and „Open" diagnoses; and laboratory cases where no identifiable cause for mortality was diagnosed from the carcasses examined or sampled. These include „No Significant Finding" where neither gross nor microscopic lesions were found (11 audits). It also includes the diseases caused by: environment; Net Pen Liver Disease (an environmental toxin); enteritis and post-vaccination peritonitis. Each of these diseases exhibit gross or microscopic lesions but the cause of death is not considered transmissible to other fish. The number of these NID cases appears in parentheses ( ) and are included in the total NIDs noted at the top of each list.

Figure 4: 2009 Audit Case Summary - Atlantic Salmon

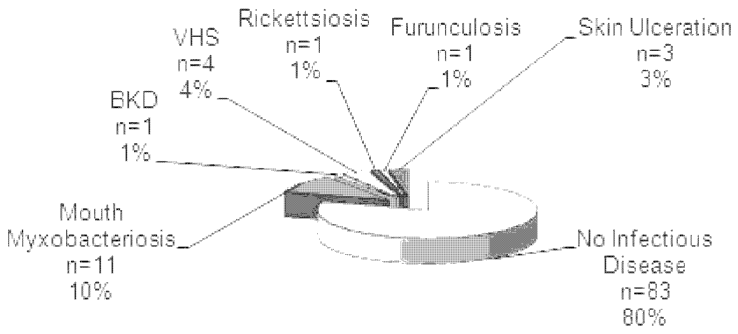
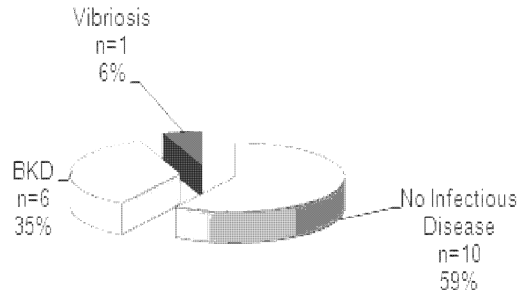


Figure 4a: 2009 Audit Case Summary - Pacific Salmon

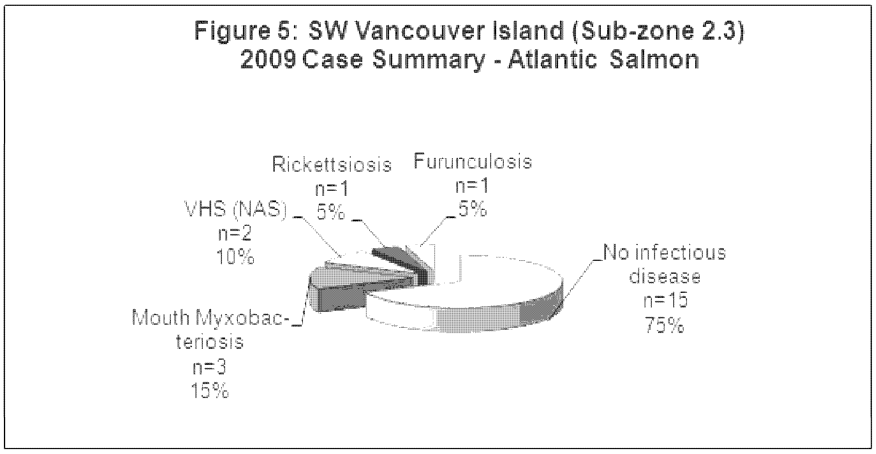


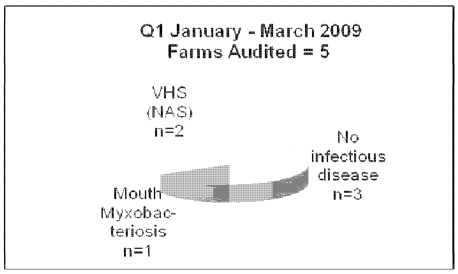
3.3.7.1 Atlantic Salmon

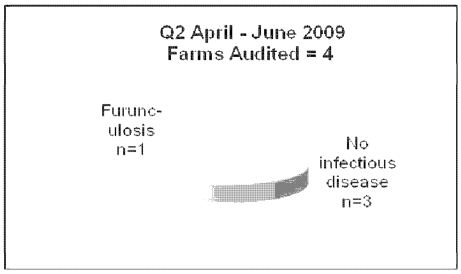
Sub-zone 2.3 South West Vancouver Island

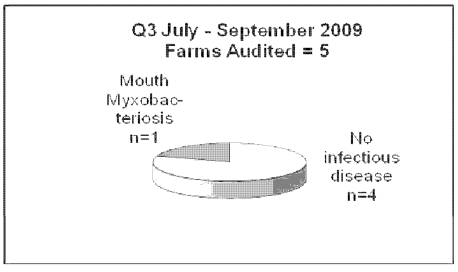
Table 8. 2009 Diagnoses for sub-zone 2.3 (South West Vancouver Island) Atlantic Salmon Farms		
Number of Farm Audits	**Number of Cases** [3]	**Farm- level Diagnoses**
20 (19)*	15	No Infectious Disease (NID**)
	3	Mouth Myxobacteriosis
	2	VHS (North American strain, genotype IVa)
	1	Rickettsiosis
	1	Furunculosis

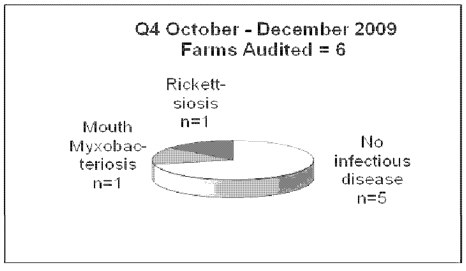
* The number in parentheses ( ) indicates the farms at which carcasses were available for sampling.
** See the footnote of „No Infectious Disease" (NID) in Table 7.







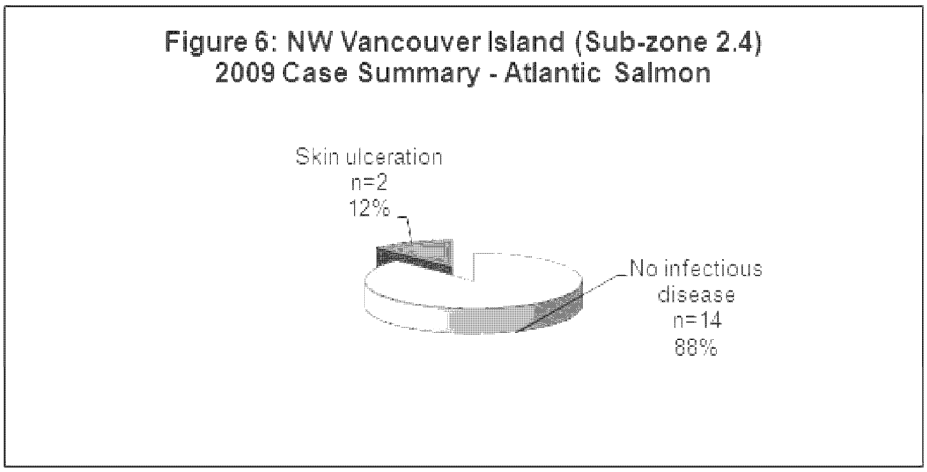


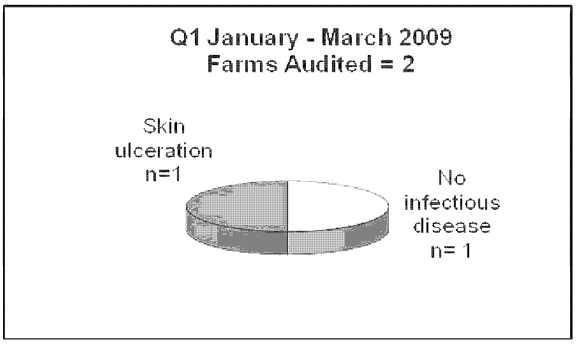


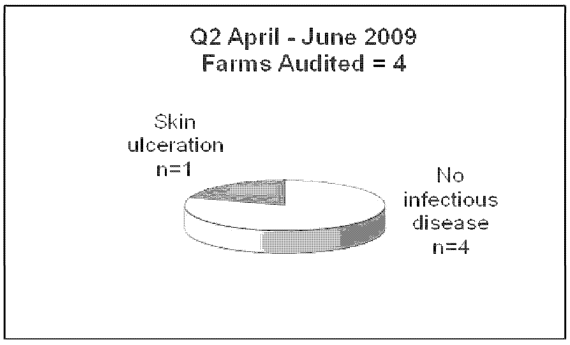
[3] Number of cases or diagnoses does not always equal the number of farm audits conducted because some audits do not result in fish samples. In addition, more than one farm-level diagnosis can be made per farm so the number of cases can exceed the number of farms audited (i.e. 2 diagnoses yet only 1 farm audit).

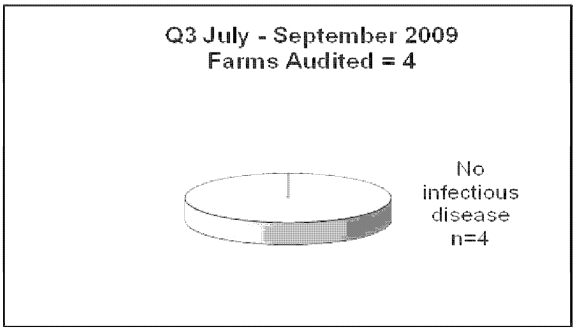
Sub-zone 2.4 North West Vancouver Island

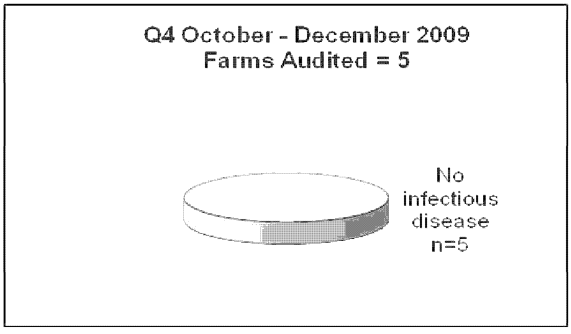
Table 9. 2009 Diagnoses for sub-zone 2.4 (North West Vancouver Island) Atlantic Salmon Farms		
Number of Farm Audits	**Number of Cases**	**Farm-level Diagnoses**
15 (13)	14	No Infectious Disease (NID)
	2	Skin Ulceration







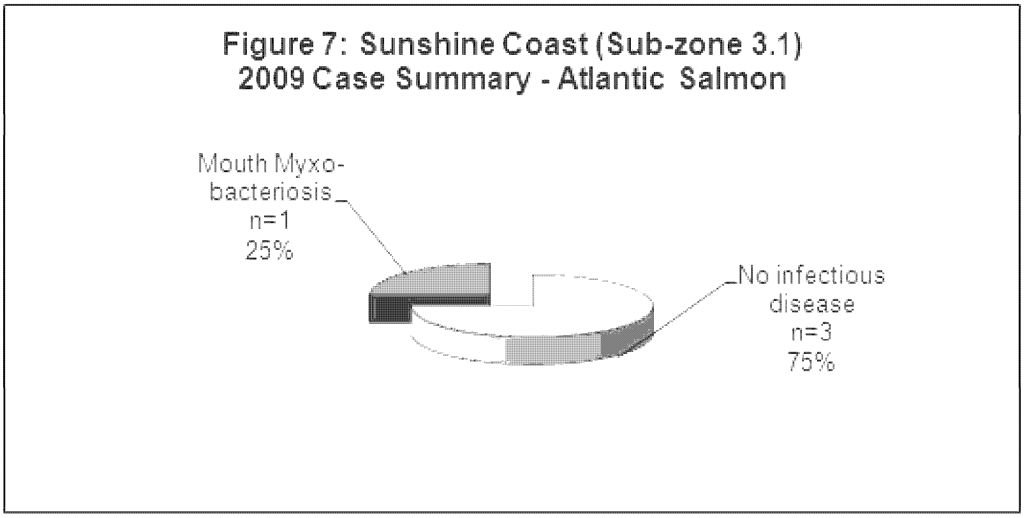


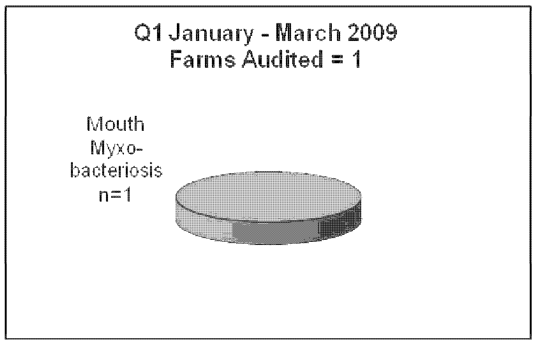


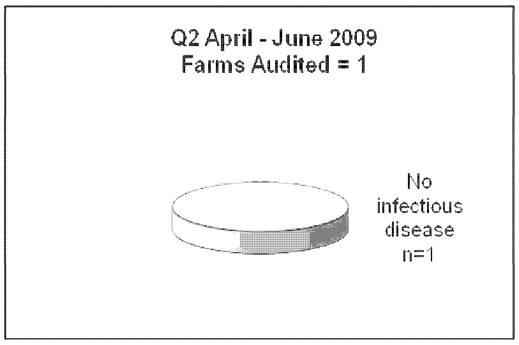
Sub-zone 3.1 Sunshine Coast

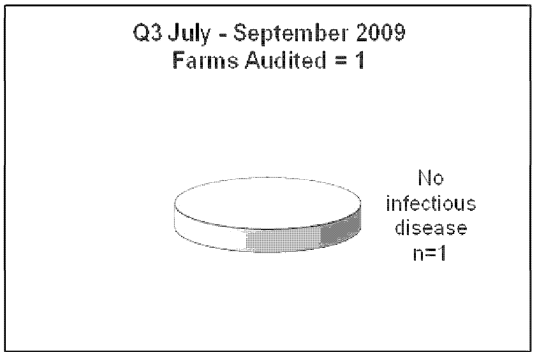
Table 10. 2009 Diagnoses for sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farms

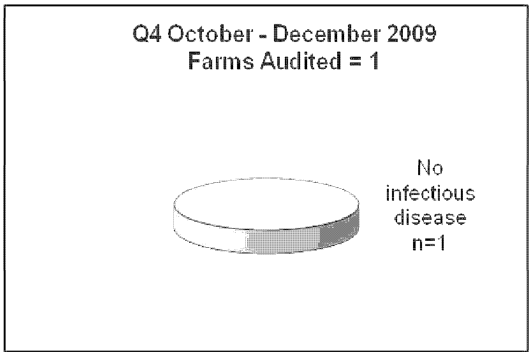
Number of Farm Audits	Number of Cases	Farm-level Diagnoses
4 (3)	3	No Infectious Disease (NID)
	1	Mouth Myxobacteriosis





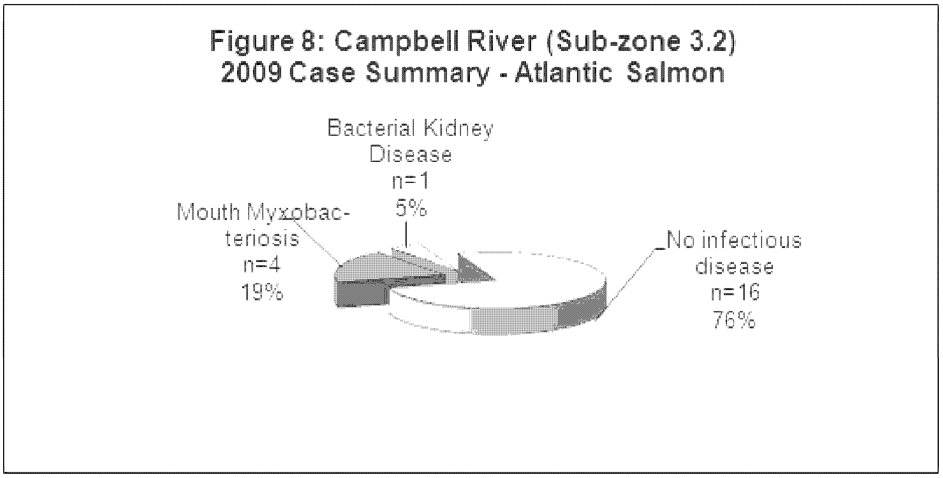


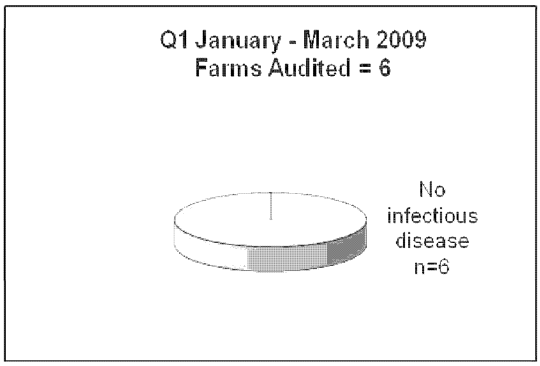


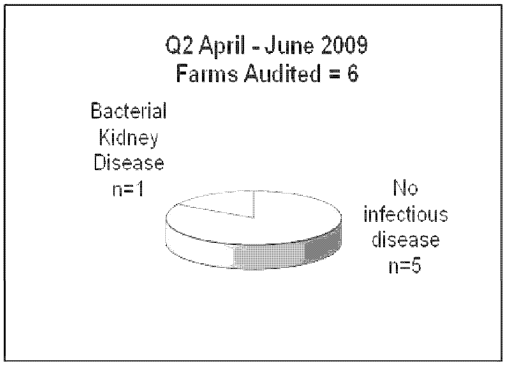


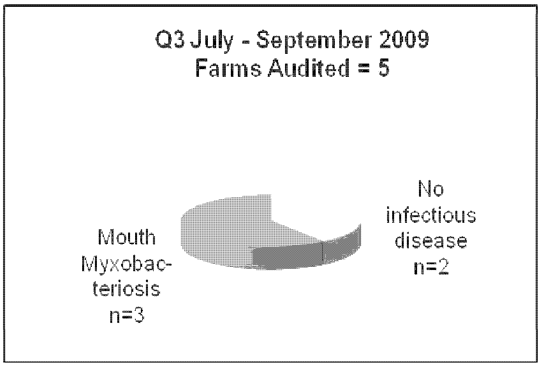
Sub-zone 3.2 Campbell River Area

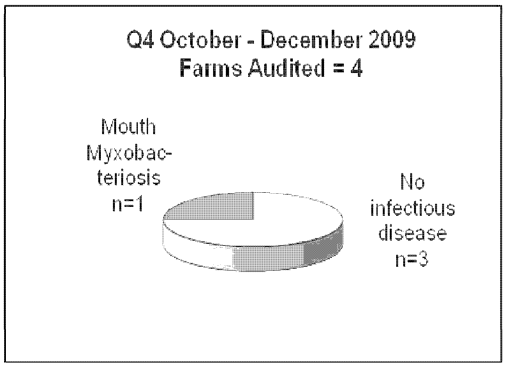
Table 11. 2009 Diagnoses for sub-zone 3.2 (Campbell River / 'Discovery Islands') Atlantic Salmon Farms		
Number of Farm Audits	**Number of Cases**	**Farm-level Diagnoses**
21	16	No Infectious Disease (NID)
	4	Mouth Myxobacteriosis
	1	Bacterial Kidney Disease







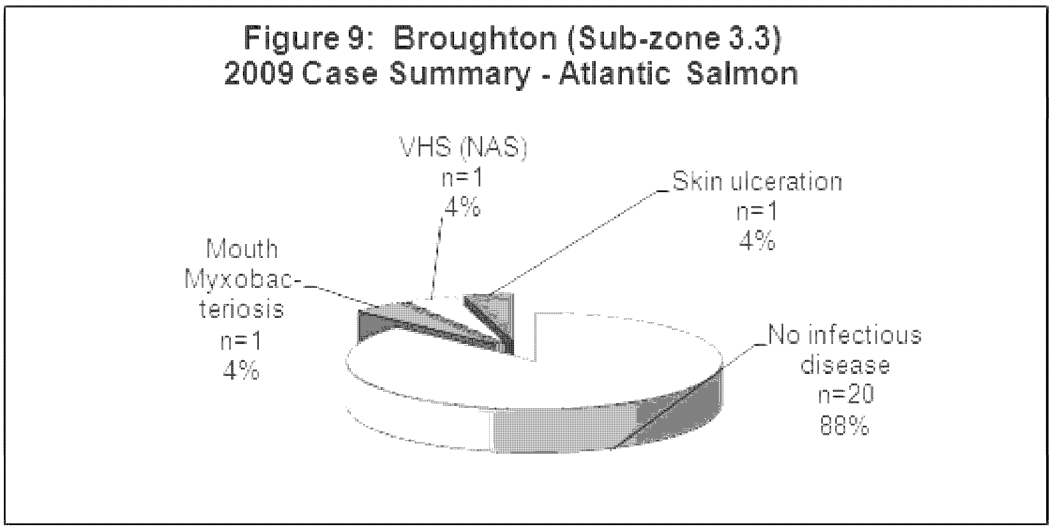


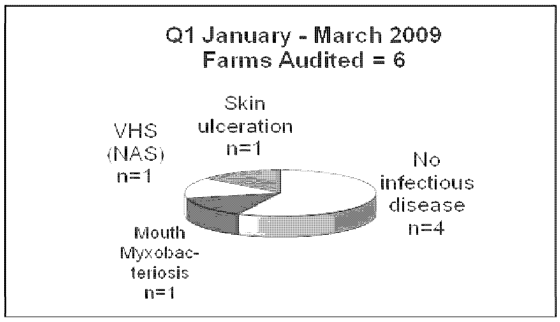


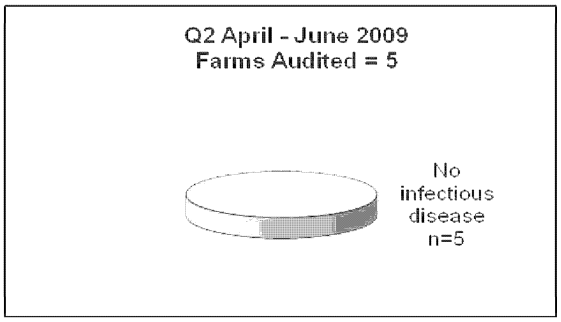
Sub-zone 3.3 Broughton Area

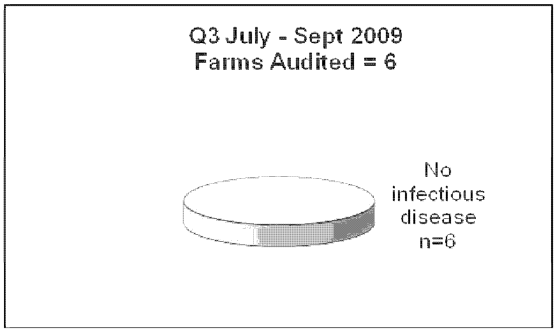
Table 12. 2009 Diagnoses for sub-zone 3.3 (Broughton) Atlantic Salmon Farms

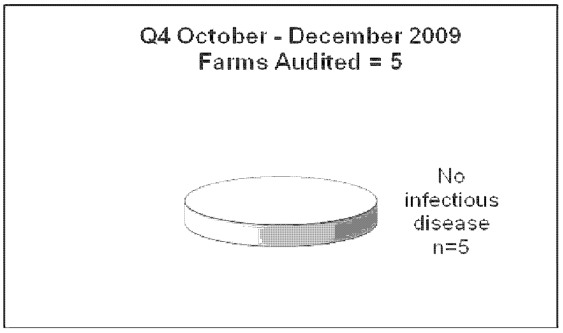
Number of Farm Audits	Number of Cases	Farm-level Diagnoses
22 (21)	20	No Infectious Disease (NID)
	1	VHS (North American strain, genotype IVa)
	1	Mouth Myxobacteriosis
	1	Skin Ulceration







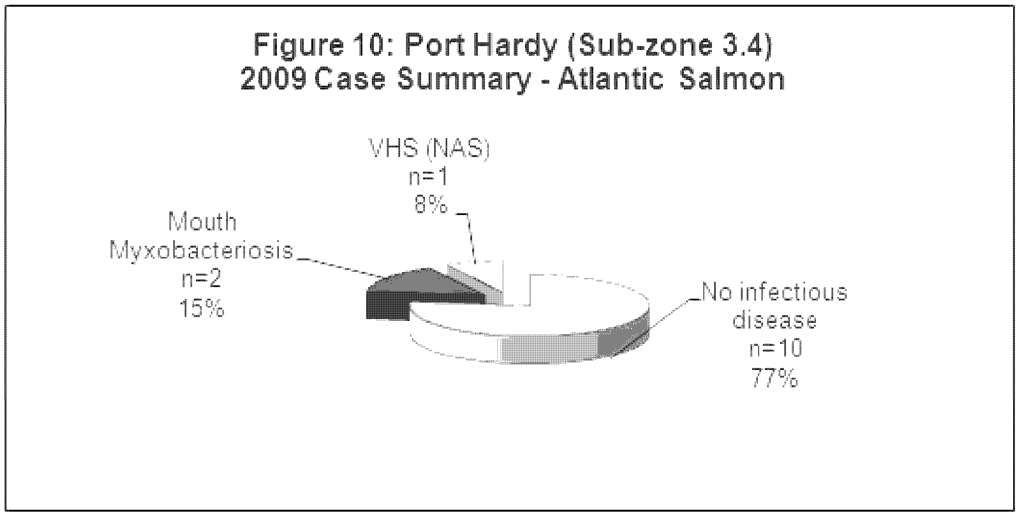


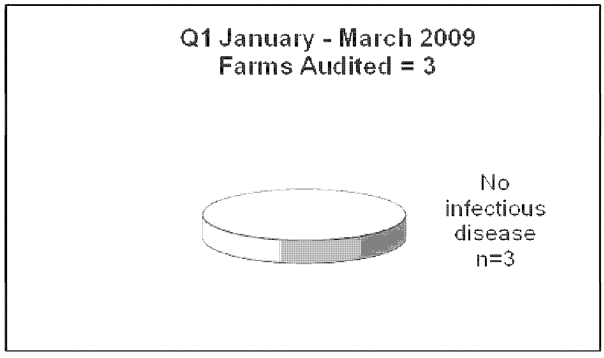


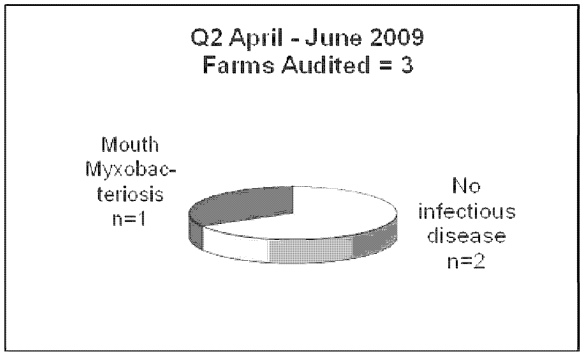
Sub-zone 3.4 Port Hardy Area

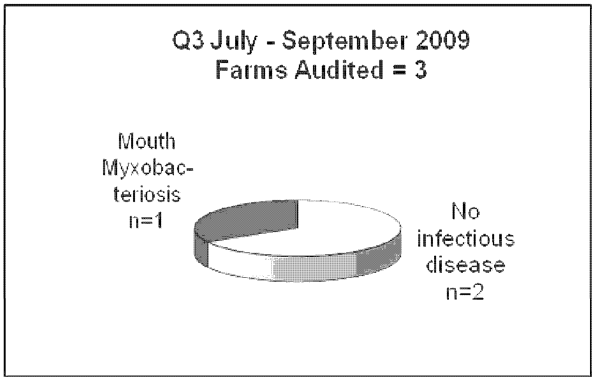
Table 13. 2009 Diagnoses for sub-zone 3.4 (Port Hardy) Atlantic Salmon Farms

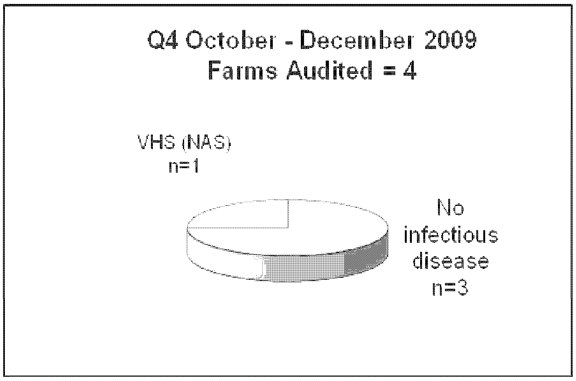
Number of Farm Audits	Number of Cases	Farm-level Diagnoses
13 (12)	10	No Infectious Disease (NID)
	2	Mouth Myxobacteriosis
	1	VHS (North American strain, genotype IVa)





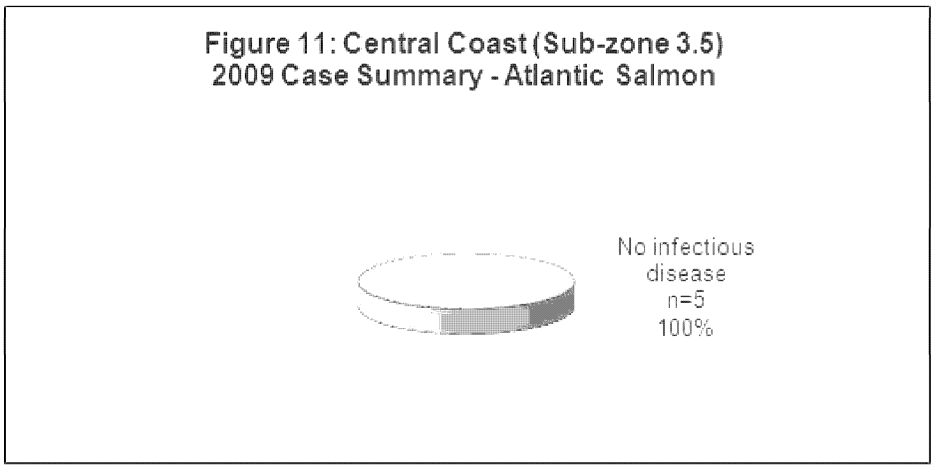


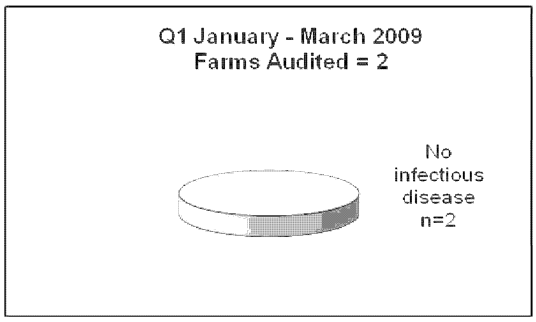


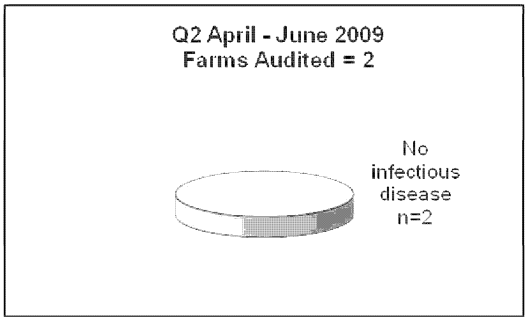


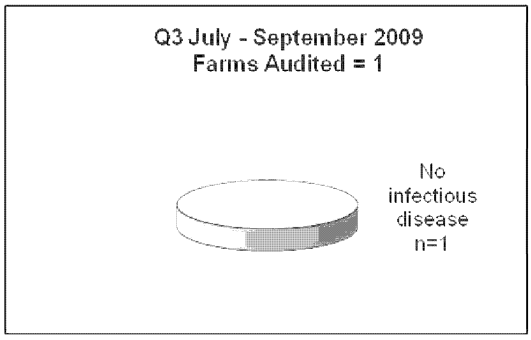
Sub-zone 3.5 Central Coast

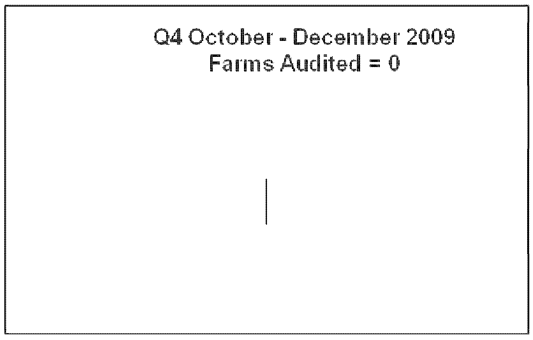
Table 14. 2009 Diagnoses for sub-zone 3.5 (Central Coast) Atlantic Salmon Farms		
Number of Farm Audits	**Number of Cases**	**Farm-level Diagnoses**
5 (4)	5	No Infectious Diseases (NID)







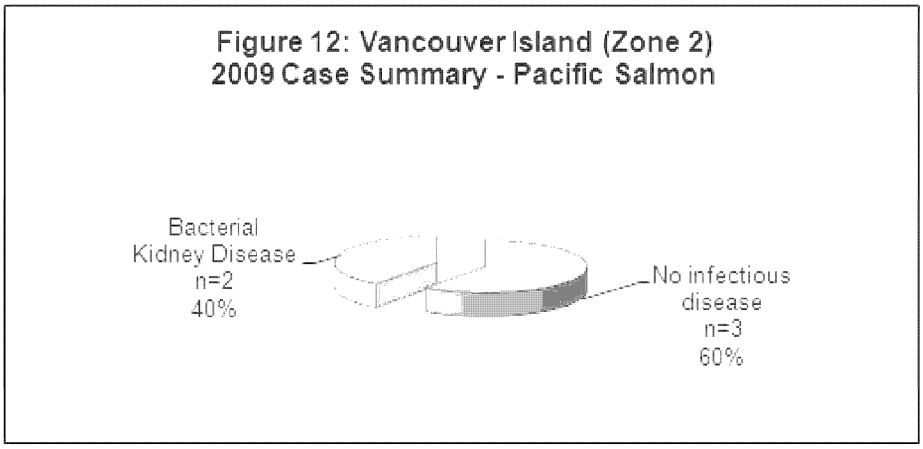


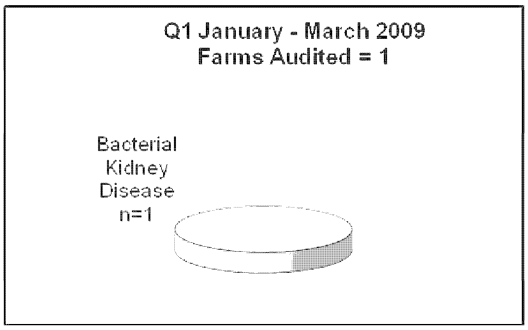


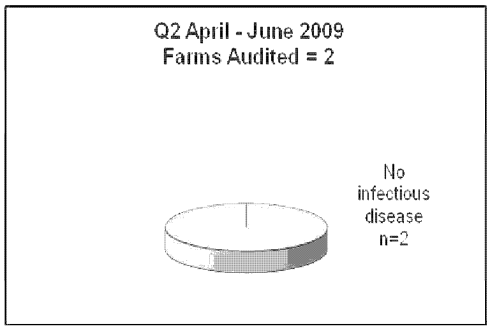
3.3.7.2 Pacific Salmon

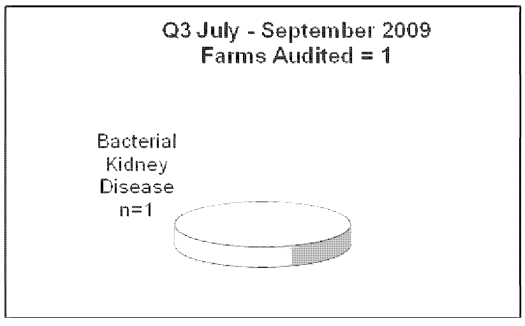
Zone 2 Vancouver Island

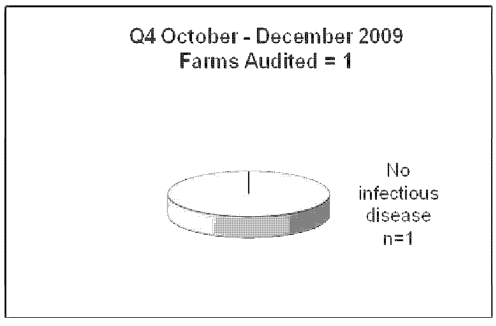
Table 15. 2009 Diagnoses for Zone 2 (Vancouver Island) Pacific Salmon Farms		
Number of Farm Audits	**Number of Cases**	**Farm-level Diagnoses**
5	3	No Infectious Disease (NID)
	2	Bacterial Kidney Disease







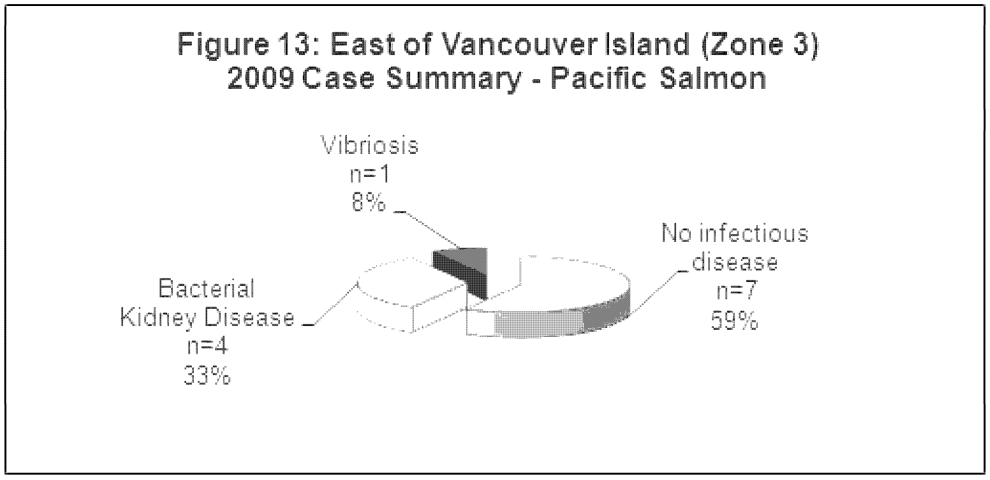


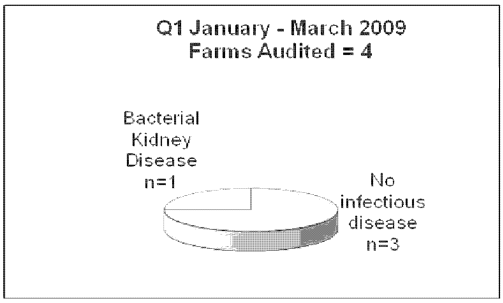


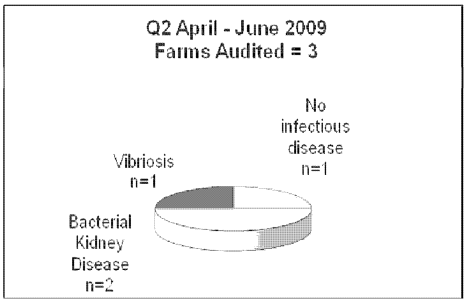
Zone 3 East of Vancouver Island

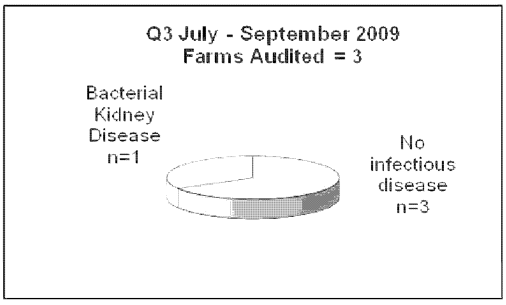
Table 16 2009 Diagnoses for Zone 3 (East of Vancouver Island) Pacific Salmon Farms *		
Number of Farm Audits	**Number of Cases**	**Farm-level Diagnoses**
11	7	No Infectious Disease (NID)
	4	Bacterial Kidney Disease
	1	Vibriosis

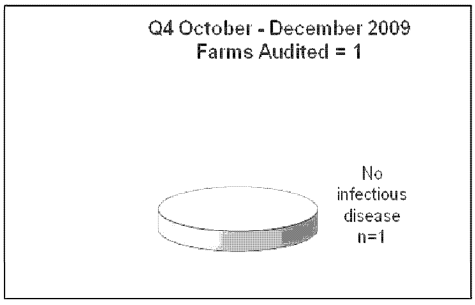
* These audit cases of Zone 3 include results from two fish-rearing facilities that are not considered conventional „production farms"; rather, the sites are best described as a pilot „solid wall pen" and a research-focused facility.











3.3 Comparison to Industry Reports

One major objective of the provincial Fish Health Program is to, as best as the data allow, verify the state of health on fish farms as reported by industry. Audits - a "snapshot" to which the more complete picture of industry"s reports can be compared - provide data for disease distribution to compare with industry"s Fish Health Events (FHEs). The audits are not expected to yield exactly the same results reported by the farms. To do so would require Ministry staff to be present on all farms, at all times. Individual farm-reported disease information is captured in the industry reports required as part of salmon Health Management Plans (HMPs) and it is available quarterly on the Ministry website: http://www.al.gov.bc.ca/ahc/fish_health/bcsfa_reports.htm. These on-line BCSFA reports are included as part of this annual report in Appendix 7.7 and 7.8.

Private veterinary medical records and the industry"s database and reports represent all production farms, excluding pilot or research facilities, and therefore offer a more detailed picture of the health status of farmed salmon compared to the aggregate audit information presented here. In addition, each individual farm maintains a record of the mortality and mitigative action (or disease diagnoses) to fulfil the record-keeping component of their HMP.

Three reports are provided to government by the industry on a quarterly basis and they summarise the overall losses and common causes of death at both private and DFO fish culture facilities:

1. Average mortality (by species) and by fish health zone for both fresh and salt water farms (see summary bar charts - Figures 14a and 14b)
2. Mortality Rates by Infectious and Non-infectious Cause
3. Fish Health Events (see summary Figures 15a and 15b)

FHEs are situations of husbandry or disease management where intervention by a veterinarian typically occurs. In other words, a diagnosis, recommendation or prescription medication occurs. Industry"s routine lice management activity also falls within FHEs. The BCMAL health audits enable a randomized validation of the industry-reported information, accentuated by targeted disease testing. Comparison of the disease diagnoses reported by farms to those diagnosed during audit enables independent assessment of which diseases are affecting fish and being reported by industry.

The overall mortality rate of BC"s Atlantic salmon population is low; in general, less than 2% mortality per quarter due to all causes of death (e.g., toxic algae blooms, environmental conditions, predation, death by maturation, disease, etc.) See Figure 14a and Appendix 7.7. The exception to this low rate occurred in Q4. In sub-zone 2.3 (Tofino area), the average mortality slightly exceeded 2%, and in sub-zones 3.1&3.2*, the average mortality reached 5% largely due to predation by sea lions and some autumn/spawning maturation mortality of Pacific salmon. When considering mortality events that are more likely due to infectious diseases (see Figure 14b, BCSFA data), the fresh silver carcasses are the best indicators of this. Less than 1.0% (and in many cases less than 0.5%) of the Atlantic salmon died of possible

* Data from sub-zones 3.1&3.2 are combined to respect the proprietary details of individual farms or companies (i.e. only one aquaculture producer raises salmon in sub-zone 3 1).

infectious disease each quarter. The exception to this is in Q4 where the mortality rates crept above 1% in some sub-zones due to groups of under-sized fish culled at harvest and some fry were culled from a fresh water hatchery. Fresh silvers from Pacific salmon farms also showed an infectious-related mortality rate of less than 0.5% per quarter.

Figure 14a BCSFA data: The Average Quarterly Mortality Rate of Atlantic salmon (from smolt to brood) in each coastal sub-zone.

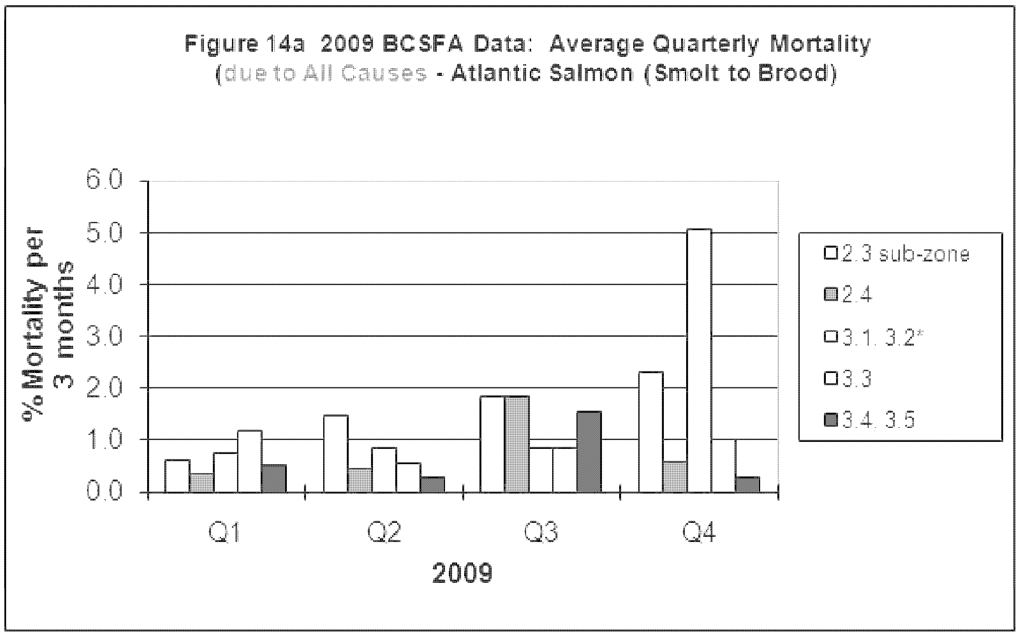
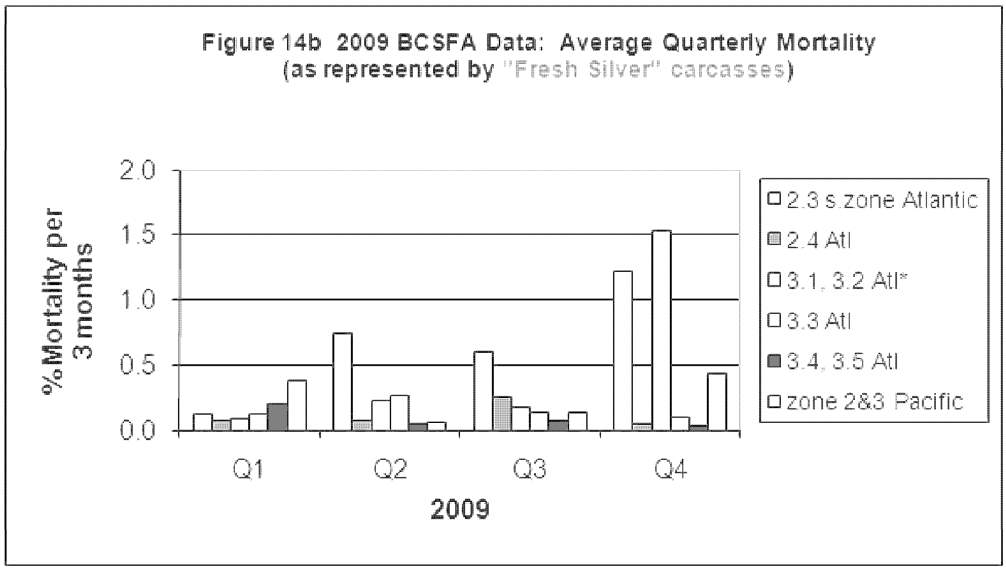


Figure 14b BCSFA data: The Average Quarterly Mortality Rate (represented by fresh carcasses, potentially reflecting active infections) in each coastal sub-zone.



The Ministry audit data is a smaller dataset of industry‟s database; however, MAL data has greater specificity (lower probability of false negatives) than does the industry data. The audit information in MAL Figures 4/4a on page 19 (and corresponding Figures 5 -13/Tables 8-16) is useful to verify the BCSFA‟s results graphed in Figures 15a/b below (and Figures 14a/b).

There is strong agreement between MAL audit results and BCSFA‟s FHE reports. Indigenous pathogens are found both during audit assessments and routine laboratory work arranged by industry. These infections do not necessarily trigger veterinary involvement or husbandry changes because the infection can be self-limiting or there may be no effective treatment. Examples of these infections and endemic diseases are: Viral Hemorrhagic Septicaemia (VHS, North American strain – genotype IVa), Loma branchitis and Marine Anaemia. Furunculosis and Rickettsiosis are, on occasion, detected during an audit yet, again, may not have triggered a farm-wide treatment since these infections are often managed concurrently with a medicated feed prescribed to address Bacterial Kidney Disease or Mouth Myxobacteriosis in the same group of fish.

Figure 15a BCSFA data: Annual Fish Health Events (FHEs) of groups of Atlantic salmon within farms that experience a FHE; reported quarterly by the BC Salmon Farmers Association in 2009 for all coastal sub-zones. Of the 144 FHEs reported as requiring husbandry or veterinary management in Atlantic salmon: almost 50% was sea lice monitoring activity.

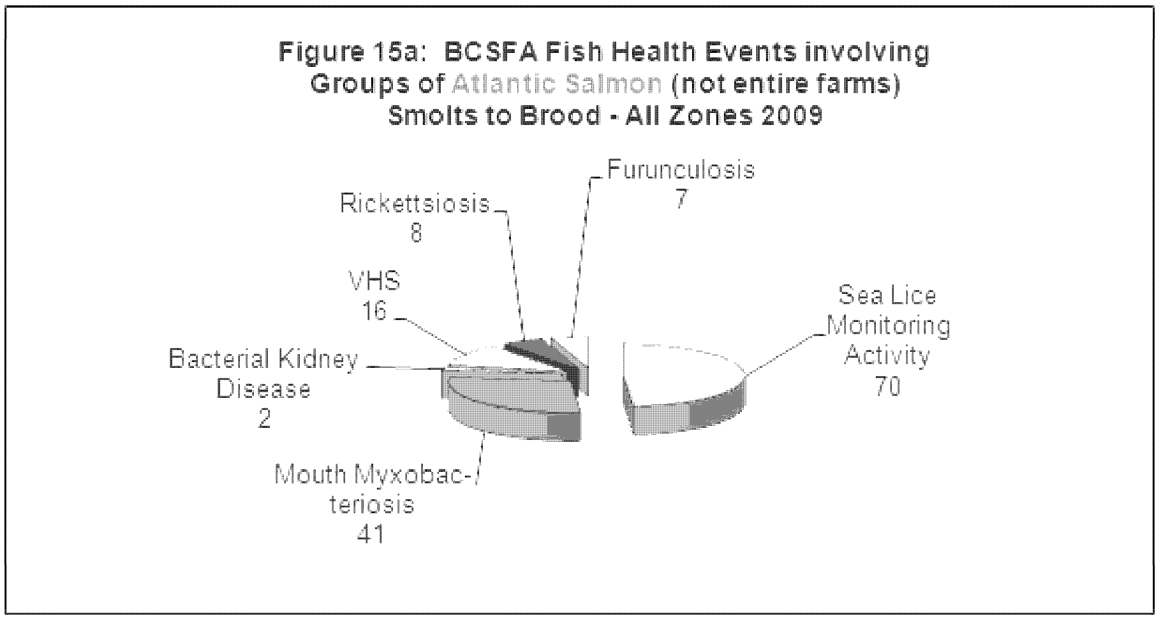
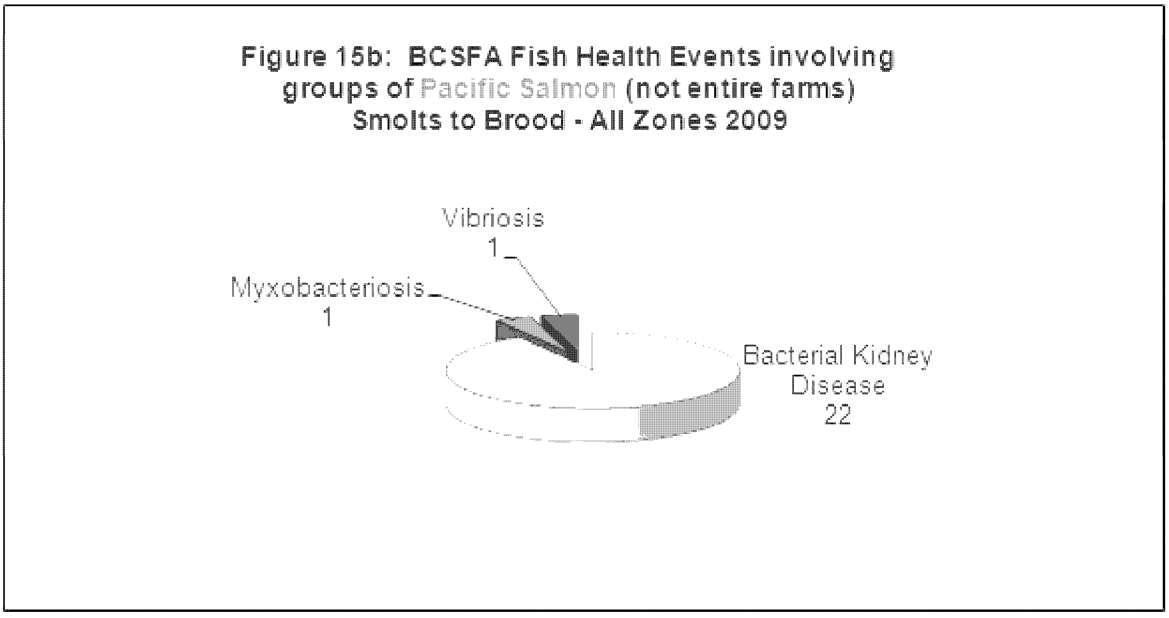


Figure 15b BCSFA data: Annual Fish Health Events (FHEs) of groups of Pacific salmon within production farms (not pilot or research facilities) reported by the BC Salmon Farmers Association each quarter in 2009 for all coastal zones. Of the 24 FHEs reported as requiring husbandry or veterinary management in farmed Pacific salmon: 22 were BKD-related, one was vibriosis, and one was myxobacterial disease.



Section 4: Sea Lice Management Program

4.1 Mandate

Community concern, the ecosystem and the ongoing protection of salmon, both wild and farmed, requires management of sea lice to ensure continued animal and ecosystem health and welfare. The provincial program generates information to assess trends in lice abundance, to verify on-farm lice data reported by industry, to validate the control of lice on farmed salmon if or when necessary, and to compare on-farm management of lice with data arising from seasonal wild stock measurements via researchers.

4.2 Overview

Sea lice are common parasitic copepods that have the potential to affect both farmed and wild fish stocks. The Ministry of Agriculture and Lands, with voluntary cooperation by farmers, has been actively monitoring the status of lice infections on BC salmon farms since 2003. A lice management strategy is integral to HMPs and the lice audits target active Atlantic salmon farms of BC. As part of the reporting requirement of the HMPs, industry information is provided to government monthly where it is posted to the BCMAL Fish Health website. In addition, the Ministry conducts audits of industry to verify the accuracy of the counts. In 2009, Ministry fish health staff conducted 74 random farm audits and assessed over 4,400 live Atlantic salmon for sea lice.

4.3 Provincial Sea Lice Monitoring

There are two components to the lice monitoring program:

1. Industry"s on-farm monitoring and reporting (to BCMAL and, by some companies, directly to their own corporate web sites), and
2. BCMAL"s audit of the on-farm monitoring and industry"s recording procedure.

BCMAL requires industry to conduct lice assessments at each active Atlantic salmon farm on a monthly basis and report that monthly data (in an aggregated form) from each sub-zone, with the exception of sub-zone 3.1[4]. A „Trigger level" of lice abundance has been established to minimise the potential accumulation and amplification of salmon lice on farms. The salmon lice trigger level is set at three motile lice year round. Corresponding management actions are species-specific and outlined below. The industry"s on-farm sampling program is based on internationally accepted standards for sea lice monitoring.

4.4 Industry Monitoring and Sampling Protocols

Industry veterinarians responsible for the health management of farmed fish oversee the information collected at farms and evaluate the need for intervention. These health professionals are responsible for the management and treatment of fish raised under their care.

[4] See Figure 20a and its accompanying footnote

The lice monitoring program assesses the abundance and life stages of two types of sea louse found on farmed fish: the „salmon louse", Lepeophtheirus salmonis, and the „herring louse", Caligus clemensi, with awareness of the differences in fish susceptibility to these lice types. More detail about the life stages and categories assigned to lice is in Appendix 7.9.

4.4.1 Atlantic Salmon Farms

Industry lice counts are conducted a minimum of once a month within most coastal sub-zones (unless an acceptable reason for not sampling was provided[5]). The frequency of monthly sampling is increased to twice monthly should the trigger level of three motile lice (salmon lice) per fish be reached anytime. During the out-migration of wild juvenile salmon (March 1st to June 30th), should a farm reach that same trigger level, the lice management strategy outlines additional action to be adopted to reduce the average abundance of lice on that farm (e.g., medication or harvest). Continuous review of the sea lice data from wild and farmed fish stocks may lead to refinement of the lice control strategies in various farming sub-zones.

4.4.2 Sampling Regimen

At each farm, monthly assessments are conducted using three pens; 20 live fish per pen are anaesthetised and examined (farm total = 60 fish). Pens chosen for assessment include one reference or index pen (i.e. first pen stocked at the farm, or the pen with the highest likelihood of having lice, based on historical counts). The reference pen is sampled each month. Two additional pens may be selected by farm staff either by rotation or convenience.

During the gathering procedure, hundreds of fish are typically captured using a seine net, box seine, or other methods that ensure an initial crowding of fish followed by representative and random sampling from that population. The method of capture is recorded by staff. Twenty fish (4 to 6 at a time) are dip-netted into an anaesthetic bath. Handling of the live fish is minimised to avoid dislodging lice. The fish are examined for the presence of lice regardless of the health status of the fish (i.e. robust or moribund).

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[5] Reasons for not reporting include:

i Farm is harvesting and < 3 pens left on the farm
ii Smolt entry and < 3 pens on farm, or <1 month since third smolt pen entered
iii Fish being treated for sea lice
iv Fish being treated/ managed for other fish health concerns.
v Fish could not be safely handled due to environmental concerns, e.g., low DO

Monitoring in sub-zone 3.1 (Sechelt) will be required only if there is a visible increase in lice levels on the farms detected through routine health monitoring programs.

4.4.3 Reporting

All farms report count numbers to the BCSFA database which in turn submits aggregate monthly reports to BCMAL by sub-zone. If the trigger level is reached between March 1st and June 30th either harvest or treatment is undertaken to reduce lice concentrations per fish. For the remainder of the year the trigger level may simply include more frequent counts (i.e. two per month), yet other husbandry considerations and lice management efforts are also considered.

4.5 Provincial Audit of Industry

The sea lice audit program is designed to verify the industry reported results and provide government with up-to-date knowledge of lice levels on BC farmed salmon. The audit program follows the model of the fish health audit program with a sub-set of active farms selected on a quarterly basis.

4.5.1 Zonation

The same fish health sub-zones as described in section 3.2.1 are used for the sea lice audit program. A map of the sub-zones is provided in Appendix 7.2.

4.5.2 Farm selection for audit

BCMAL uses the same multi-stage selection system for lice audits as is used for selecting fish health audits. All farms within a zone are assigned a random number and selection of the farms within a sub-zone (the unit of concern) is weighted based on the number of farms in that sub-zone as a percentage of the total number of farms in the province. For example, if an area contains 30% of the total number of active BC farms, then 30% of the farms selected for audit would be randomly chosen from that area. This ensures equal probability of each farm being selected for audit.

Twenty five percent of the active[6] Atlantic salmon farms is the target selection for lice audits each quarter. During the second quarter (April, May, June) the audit and monitoring frequency doubles to 50% of the active farms to correspond with the period of the wild smolt out-migration (see Table 17 and Figure 16).

4.5.3 Records evaluation

The Ministry fish health bio-technicians evaluate farm lice records as part of the standard audit protocol. The date of the most recent lice count is recorded, as is the latest treatment used (if any) in that quarter to minimise lice numbers. Ministry bio-technicians also record the marine environmental parameters for the day: water temperature, dissolved oxygen and salinity are recorded at 1, 5 and 10 metre depths.

[6] Active farms are those farms holding fish for at least 30 days (preferably 120 days) and have a minimum of 3 fully stocked pens on-site during the quarter which sampling is to occur. Broodstock are not sampled for sea lice by BCMAL.

4.5.4 Fish collection and counting procedures

Fish collection and lice identification/counting procedures are also evaluated during the farm audit. BCMAL bio-technicians are experienced in fish handling and follow standard operating procedures for fish handling, anaesthesia and lice counts.

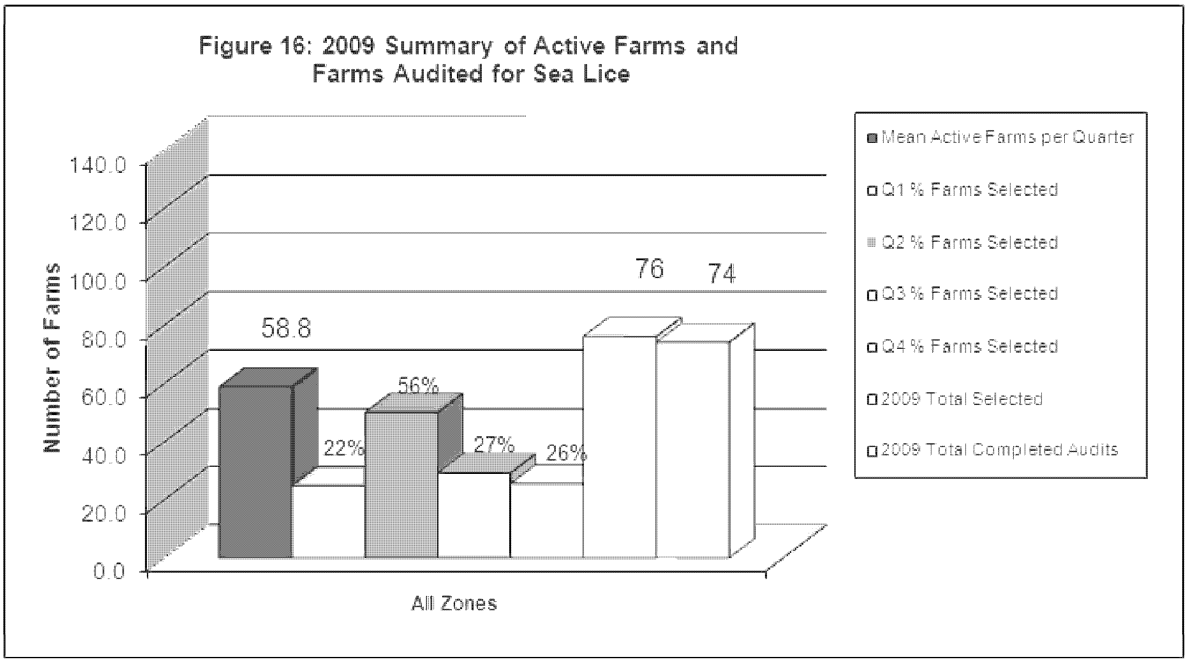
Whenever possible, BCMAL lice audit data are collected on days that the farm"s lice count is already scheduled. Audit data contributes to the monthly and twice-monthly data collected by industry. The BCMAL data is a sub-set of the farm-reported data and therefore is not an independent estimate of sea lice abundance. We must refer to these "snapshot" comparisons of farm and sub-zone data as "sub-sample validation" which is a useful tool to evaluate confidence in the data collected and submitted by industry. Ten fish from each of the selected pens are evaluated by the BCMAL bio-technician and ten fish by a farm staff member. Anaesthetised fish are systematically examined while in the anaesthetic bath or recovery tote and lice are identified, classified to life stage, and enumerated. On occasion, BCMAL staff may also collect lice from anaesthetised or euthanised fish for specific evaluation and confirmation of lice species and life-stage. All lice that become dislodged in the counting containers are counted for each pen and included in the summation for the farm count. All statistical analyses were performed using Microsoft Statistix 9, and the level of significance was set at 5% ($0.05 \geq P$).

4.5.5 Analysis of Sea Lice Audit Data: Atlantic Salmon Farms

Table 17 summarises the audit activity of 2009. In reality, one or two farm visits may be missed each quarter as a result of bad weather, environmental conditions such as low dissolved oxygen or plankton bloom, or due to equipment or staffing restrictions. The table below reflects two such audit cancellations, one in Q3 and one in Q4.

Table 17: 2009 Total farms selected, total farms audited for lice, and numbers of live fish assessed (per quarter)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms selected by computer	14	30	16	16	**76**
# farms audited	14	30	15	15	**74**
# live fish examined	840	1780	900	900	**4420**



The on-farm, split-sample, lice-counting procedure and the examination of records represent a compliance audit. The split-sample counts are combined and submitted as that farm"s monthly count (except in quarter 2). These assessments are included as part of the audit data for the sub-zone that quarter and are used for on-farm, and „within sub-zone" analyses and the sub-sample validation (see Figures 18 to 24). Tables 18a/b, and corresponding Figures 16a/b, show the results of the BCMAL lice audits. These represent the mean abundance of lice on Atlantic salmon for all sub-zones in 2009.

The statistical difference between mean lice counts obtained by BCMAL and those obtained by farm staff are evaluated quarterly, both at the sub-zone level (two-sample Student `t`test, using pooled average) and at the farm level (Kruskal-Wallis AOV, to account for between farm and within farm variation, followed by Tukey HSD pair-wise comparison). On two occasions in 2009, differences between BCMAL counts and farm staff counts occurred at the sub-zone level for the Leophtheirus motile stages. These two cases occurred in different quarters and different sub-zones; in both cases:

- BCMAL counts were significantly higher than farm counts (Student „t" test, p=0.024 and p=0.018),
- In one of these cases, BCMAL counts were also higher for female stages (p=0.0017),
- In the second case, farm staff counts of female stages were higher (p=0.005), but this occurred in the previous quarter.

Three other count differences occurred in other sub-zones where single farm audits occurred in the sub-zone. Differences between BCMAL counts and farm staff counts arise more often with these „one-farm comparisons" and BCMAL does not pursue these discrepancies unless there are successive quarters showing data disagreement.

At the sub-zone level, some significant differences were also identified between farm and BCMAL counts for Caligus motile stages; however, Caligus motile stages tend to detach from fish to swim freely in the tote during the handling so Caligus count comparisons do not lend themselves to validation objectives.

In summary, disagreement occurred in seven (7) of 50 testable (non-zero) comparisons of the counts of Lepeophtheirus motile or female stages. This is 86% agreement. This level of agreement between split-sample count results provides confidence in the technical competence of the farm personnel generating the abundance estimates that industry reports, and that the data they provide can be properly interpreted.

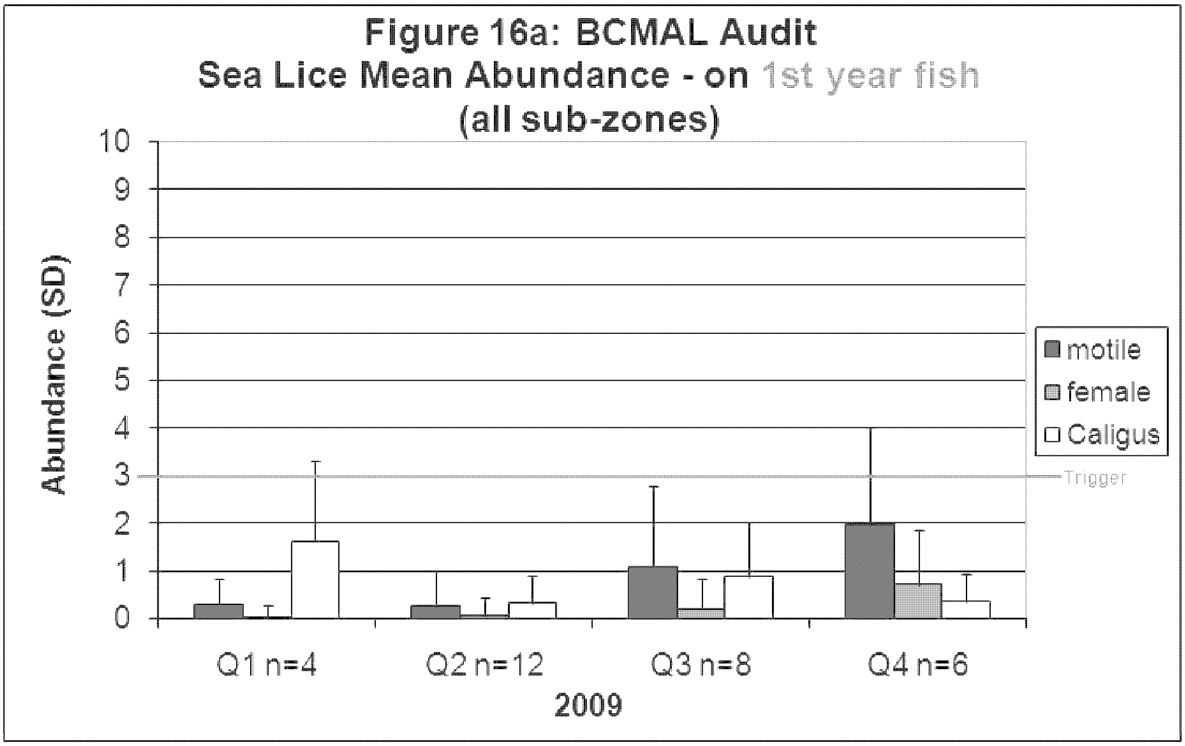
Table 18a. Mean abundance of: motile, female L. salmonis, chalimus sea lice and motile Caligus clemensi during Atlantic salmon farm audits in 2009 (per quarter) – 1st year class*

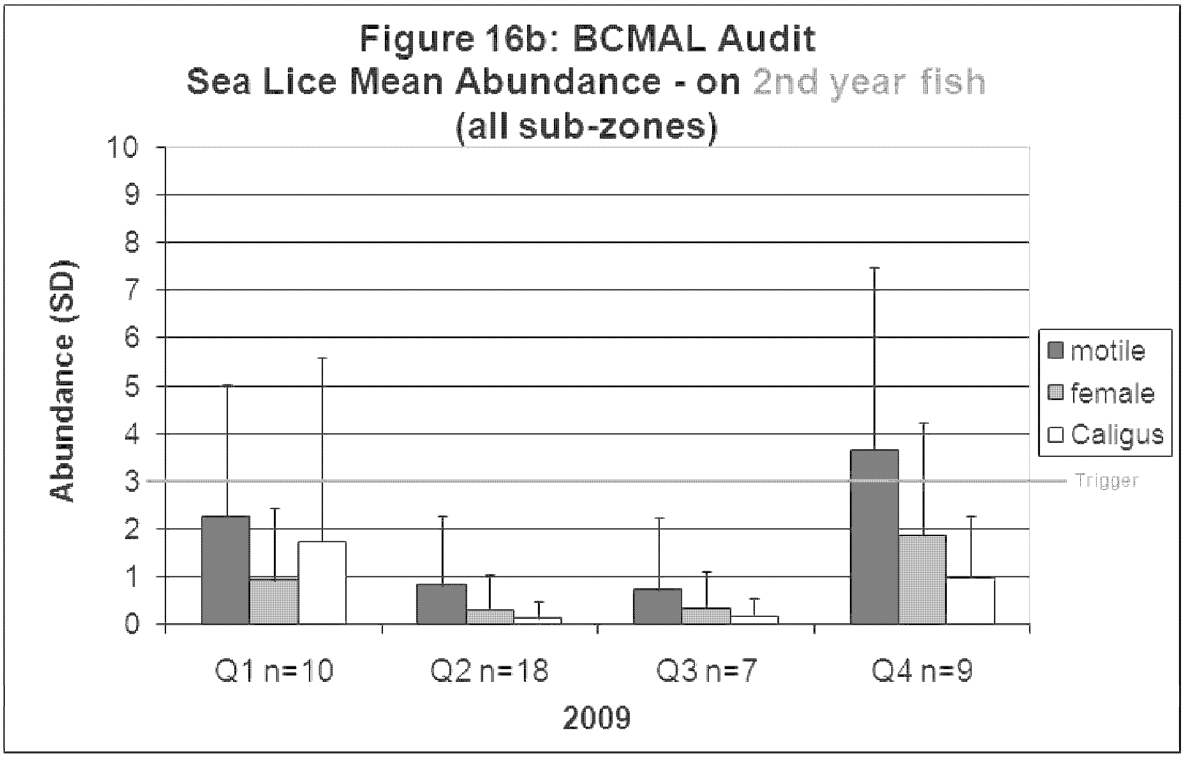
2009 Mean Abundance	Q1	Q2	Q3	Q4
Number of Farms Audited (n)	4	13	8	6
Motile	0.3	0.26	1.1	2.0
Standard Deviation (SD)	0.54	0.74	1.7	2.1
Female	0.046	0.073	0.20	0.71
SD	0.23	0.38	0.64	1.1
Chalimus	1.2	0.96	0.86	0.93
SD	1.9	2.5	1.4	2.1
Caligus Motile	1.6	0.33	0.88	0.36
SD	1.7	0.58	1.2	0.58

Table 18b. Mean abundance of: motile, female L. salmonis, chalimus sea lice and motile Caligus clemensi during Atlantic salmon farm audits in 2009 (per quarter) – 2nd year class*

2009 Mean Abundance	Q1	Q2	Q3	Q4
Number of Farms Audited (n)	10	17	7	9
Motile	2.3	0.83	0.73	3.7
Standard Deviation (SD)	2.8	1.5	1.5	3.8
Female	0.93	0.31	0.34	1.9
SD	1.5	0.74	0.76	2.4
Chalimus	1.9	0.44	0.49	2.4
SD	9.3	1.2	1.1	4.5
Caligus Motile	1.4	0.13	0.17	0.98
SD	3.3	0.35	0.39	1.3

* Tables of audit data (of medians and means) on separate year classes of Atlantic salmon including tote counts can be found in Appendix 7.10





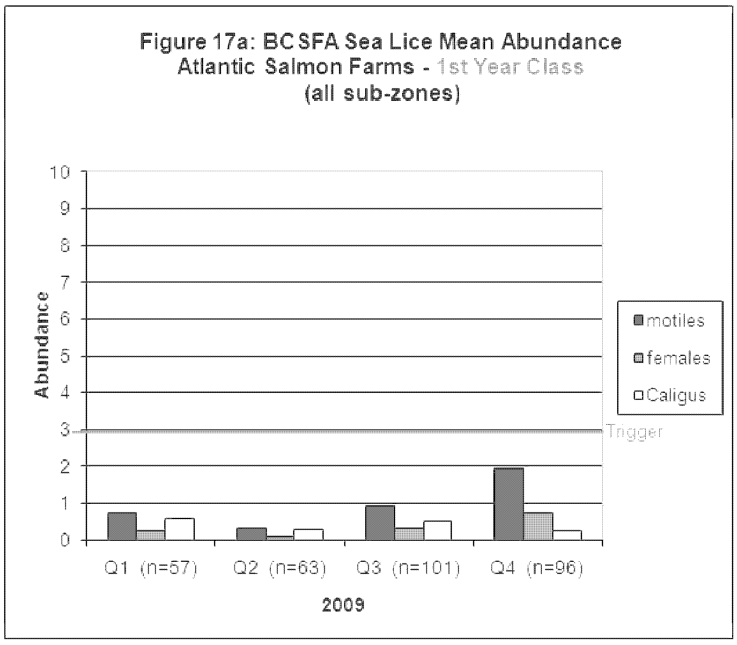
NB. Abundance in these graphs is: total lice counted (on the fish and in the anaesthetic bath) divided by total fish counted.

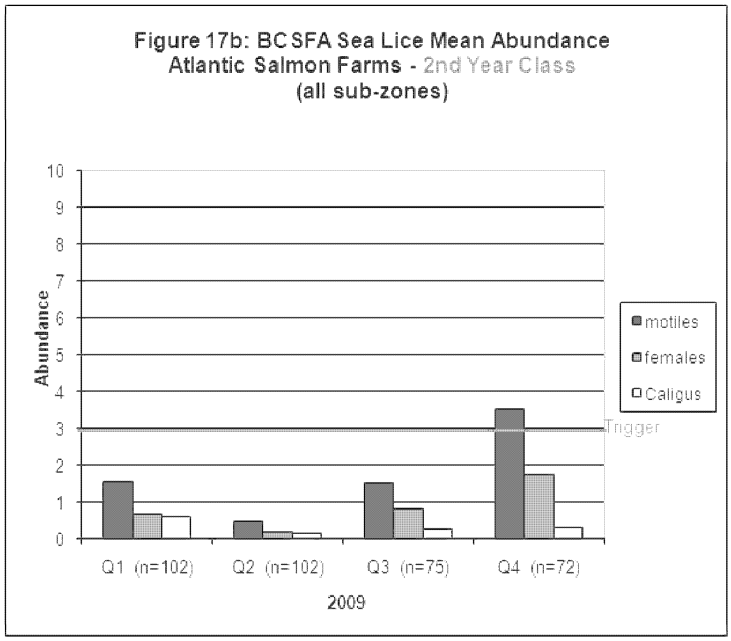
With regard to farmed Pacific salmon, initial monitoring assessments in 2004 corroborated scientific reports that farmed Pacific salmon harbour very few lice (see Fish Health Report 2003-2005). As a result, BCMAL no longer requires Pacific salmon producers to routinely count and report lice abundance; however, producers continue to visually monitor the Pacific salmon for sea lice at opportune times, such as: during routine carcass assessments, weight sampling events or at times when lice have historically been documented (i.e. at harvest or during brood sorts in the autumn). This information is made available for review by BCMAL fish health staff upon request.

4.5.6 Evaluation and Audit Comparison to Industry Lice Reports

The 2009 BCSFA average abundance of lice on Atlantic salmon farms (calculated from the monthly means reported for each sub-zone, by year class) is shown below in Figures 17a/b. The overall average remains well below three lice per fish in most calendar quarters; quarter 4 is the exception due to the recruitment of lice from returning wild salmon. The „n" values reflect the total number of counts conducted by industry (per quarter) which exceeds the total number of farms because many farms count their lice more than once per month. As a result, industry conducted 668 counts on approximately 40,000 live fish. The sub-zone tables and bar charts submitted monthly by BCSFA to BCMAL, for regular posting to the web, are found in Appendix 7.11.

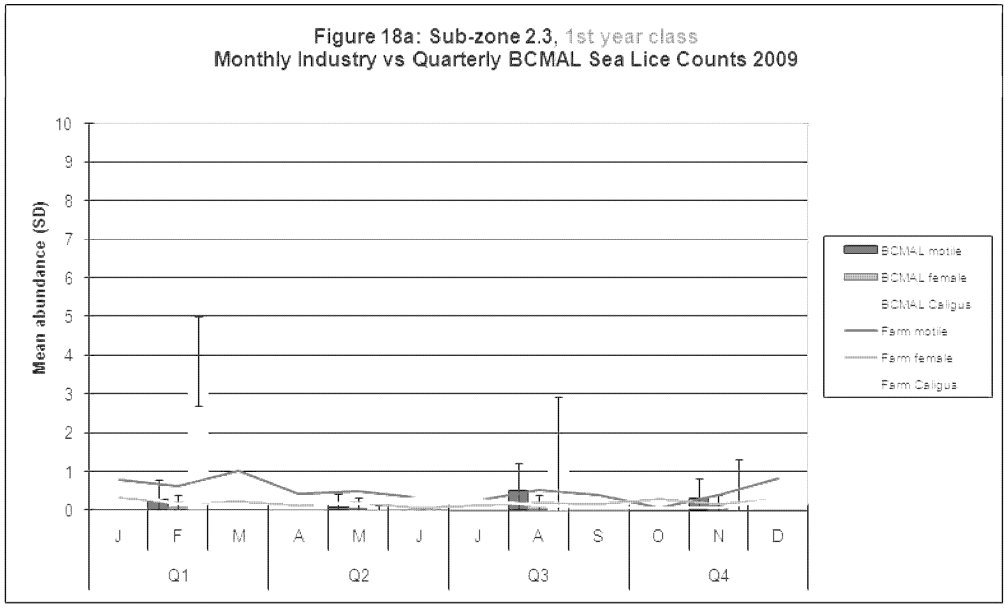
In Figures 18a -24b, the sub-zone abundance is given. This abundance, like the abundance reported by industry, includes lice found loose in the anaesthetic bath (i.e. motile lice that originated on the sampled fish but detached themselves). These lice, loose in the anaesthetic bath (the "tote count"), present a statistical challenge to calculating variation at the unit of concern, the fish. Since the tote count is recorded for each cage, the solution for including these fish-dissociated lice is to add tote count (then divided by 20 fish), to the count on each of the 20 fish from that cage. The variation for the sub-zone is then calculated from these adjusted "fish counts", and the mean for the sub-zone is the sum of the total lice counted divided by the total fish counted.

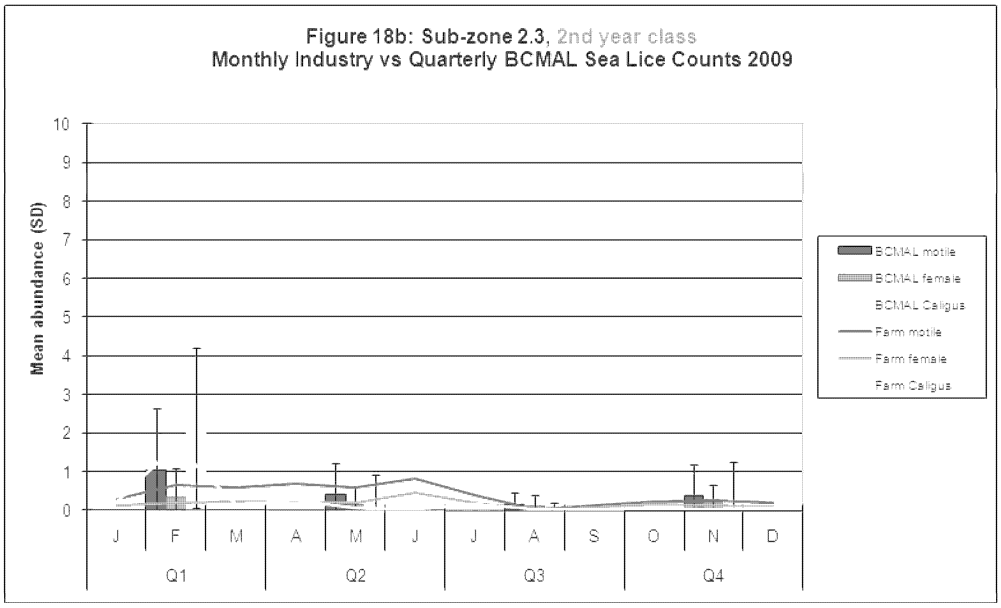




NB. Abundance in these graphs is a calculated mean from the industry-reported sub-zone means. Sub-zone means are calculated from farm-level mean abundance (which includes lice both on fish and lice found loose in anaesthetic baths).

Figures 18a to 24b are graphs of BCMAL counts (the bars) and the monthly average lice abundance submitted by industry (the lines). In the graphs, BCMAL audit data are placed mid-quarter; however, in reality, the sampling date may have occurred any time within that quarter. Despite this variation in date of data collection, the BCMAL sub-sampling validation shows acceptable agreement with the abundance reported by industry. Overall agreement in 2009, based on overlapping 95% confidence intervals (data not shown), has been consistent since 2005. Taken together, these tests from the audit data provide confidence that industry is complying with their lice monitoring obligations. For more detail by sub-zone, refer to tables in Appendix 7.10.





NB. Farm monitoring and audit activity identified an abundance of Caligus lice species in sub-zone 2.3 in quarters 1, 3 and 4. Caligus are common parasites of non-salmonid fishes. Their presence in 2009 is largely attributed to wild herring and pilchard populations near salmon farms. Caligus are considered opportunists and incidental on salmon, nevertheless monitoring their abundance is useful.

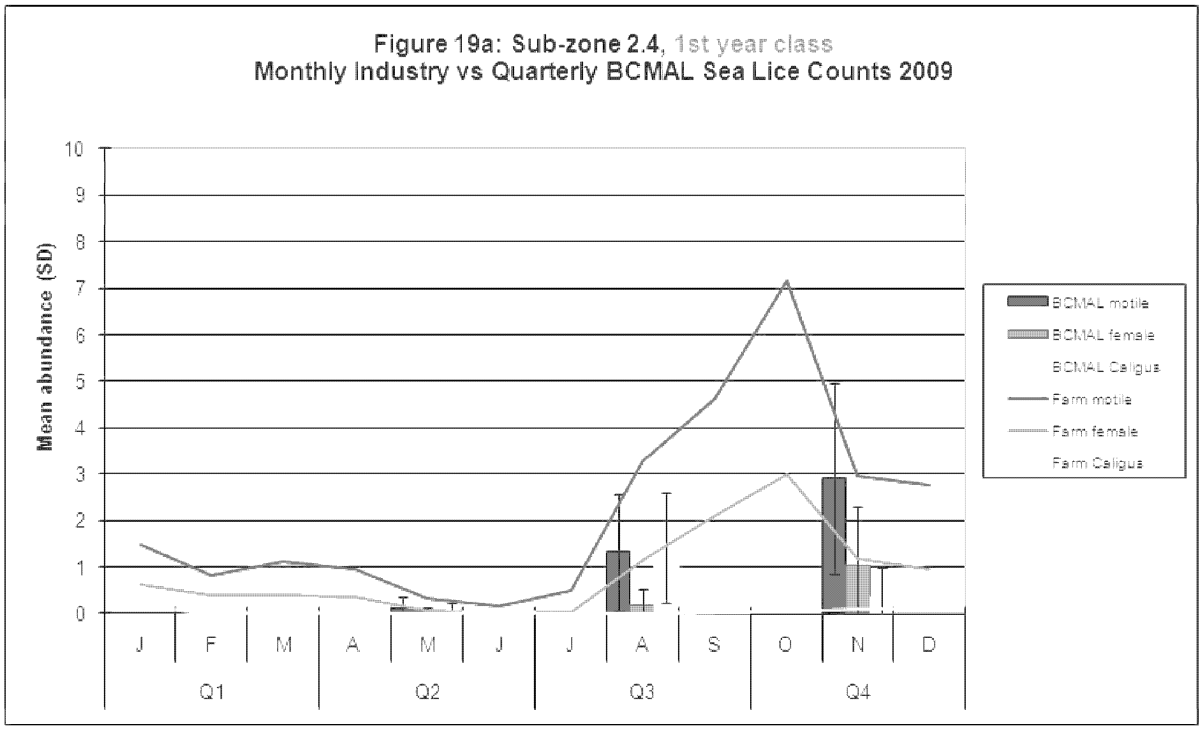


Figure 19a: Sub-zone 2.4, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009
Mean abundance (SD)
0
1
2
3
4
5
6
7
8
9
10
J
F
M
A
M
J
J
A
S
O
N
D
Q1
Q2
Q3
Q4
BCMAL motile
BCMAL female
BCMAL Caligus
Farm motile
Farm female
Farm Caligus

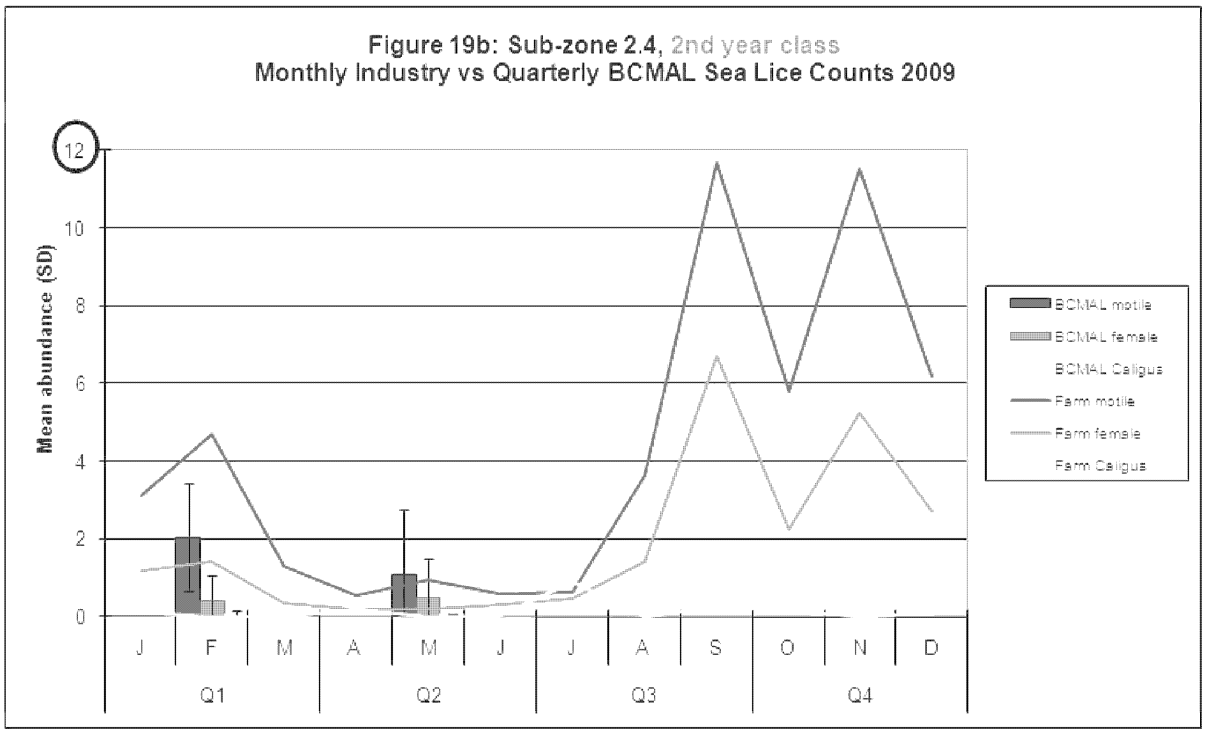
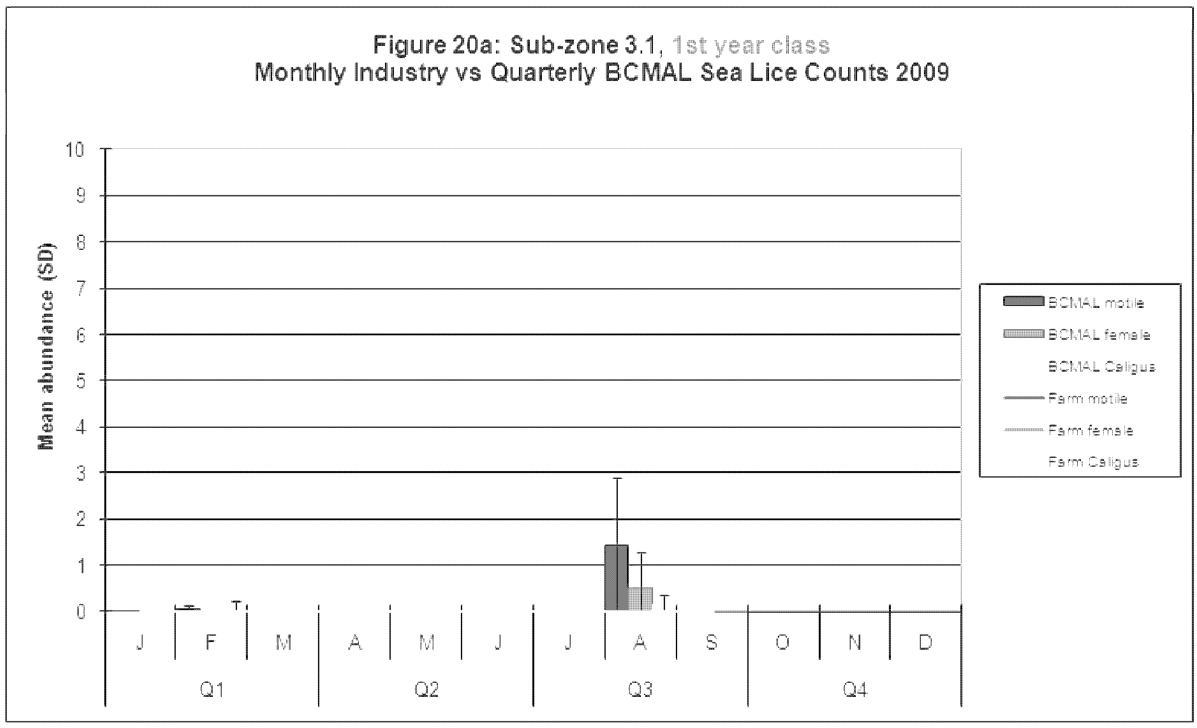
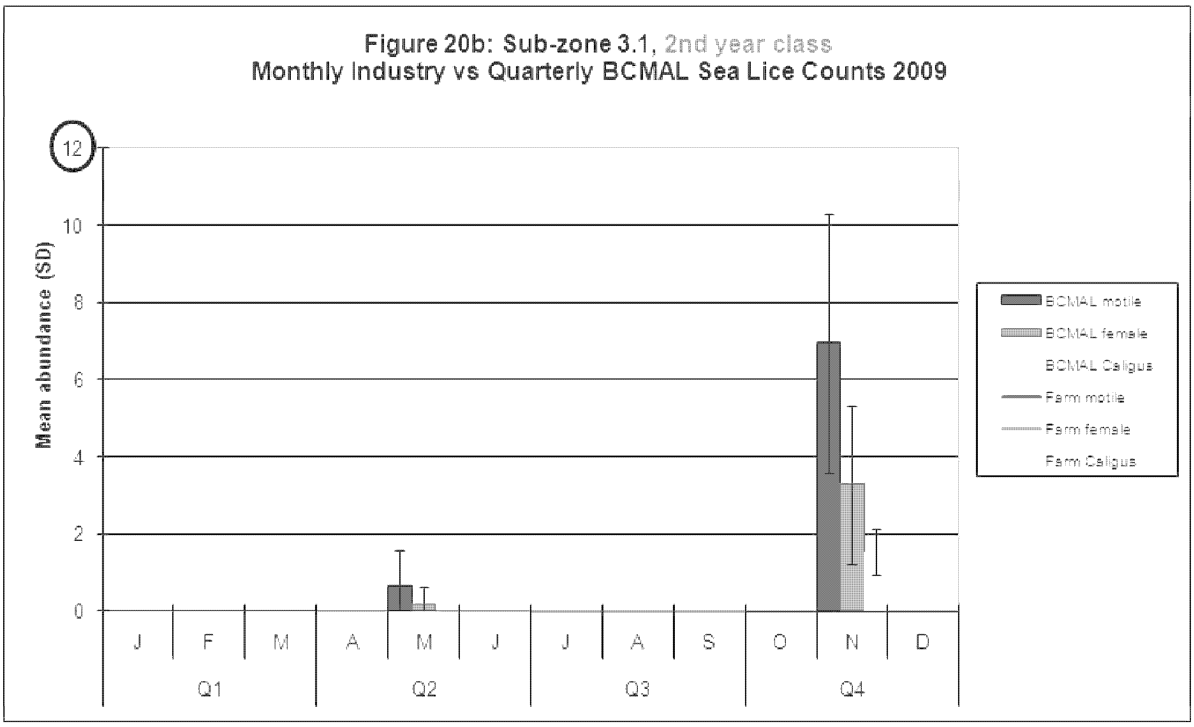


Figure 19b: Sub-zone 2.4, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009
Mean abundance (SD)
0
2
4
6
8
10
12
J
F
M
A
M
J
J
A
S
O
N
D
Q1
Q2
Q3
Q4
BCMAL motile
BCMAL female
BCMAL Caligus
Farm motile
Farm female
Farm Caligus





NB. Farms operating in sub-zone 3.1 were again exempt from routine monitoring and reporting sea lice abundance in 2009 due to the historically very low abundance on the Atlantic salmon. The stress & handling of fish monthly was deemed an excessive risk relative to the value of the data generated; however, BCMAL continued to assess the Atlantic salmon farms as per its audit selection procedure. An increase in average lice abundance in this region was detected toward the end of 2009 so the exemption has since been recanted – in 2010 the producer is required to re-initiate the monthly monitoring and reporting of lice abundance on its Atlantic salmon.

Figure 21a: Sub-zone 3.2, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009

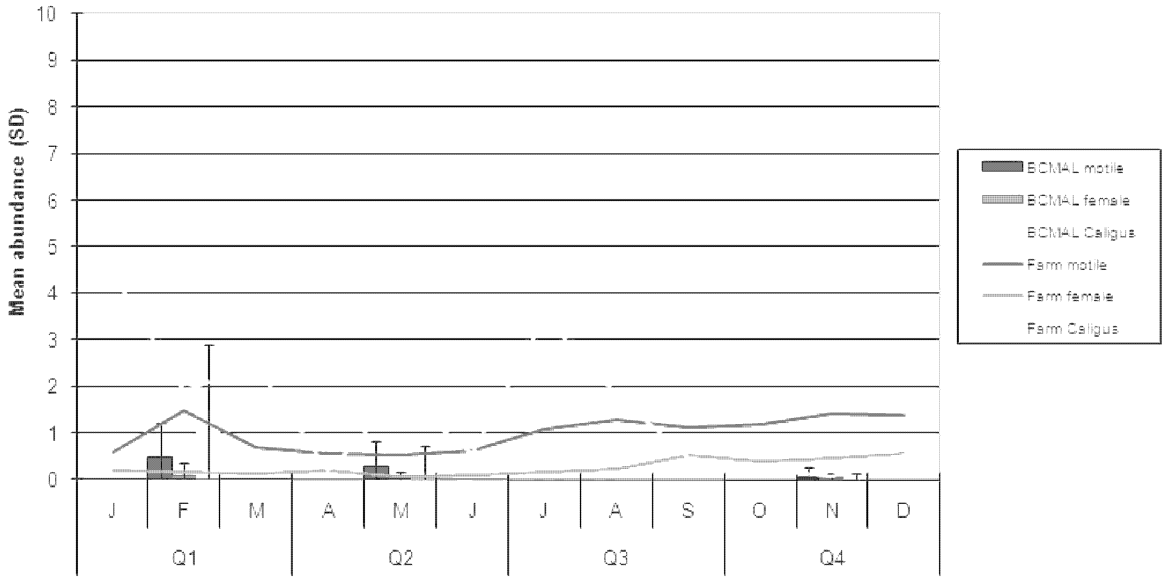


Figure 21b: Sub-zone 3.2, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009

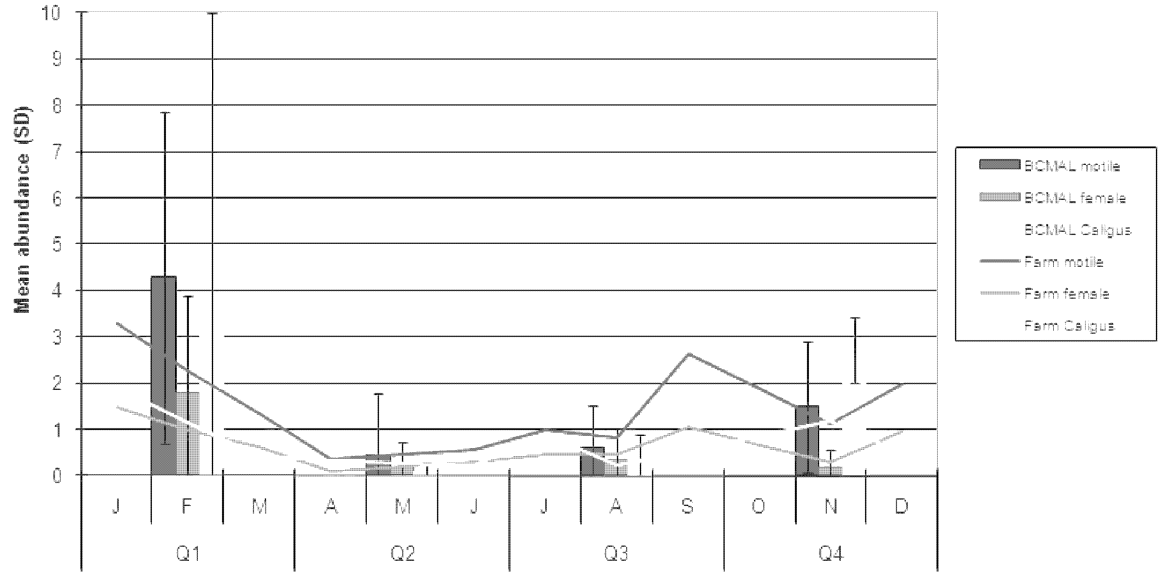


Figure 22a: Sub-zone 3.3, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009

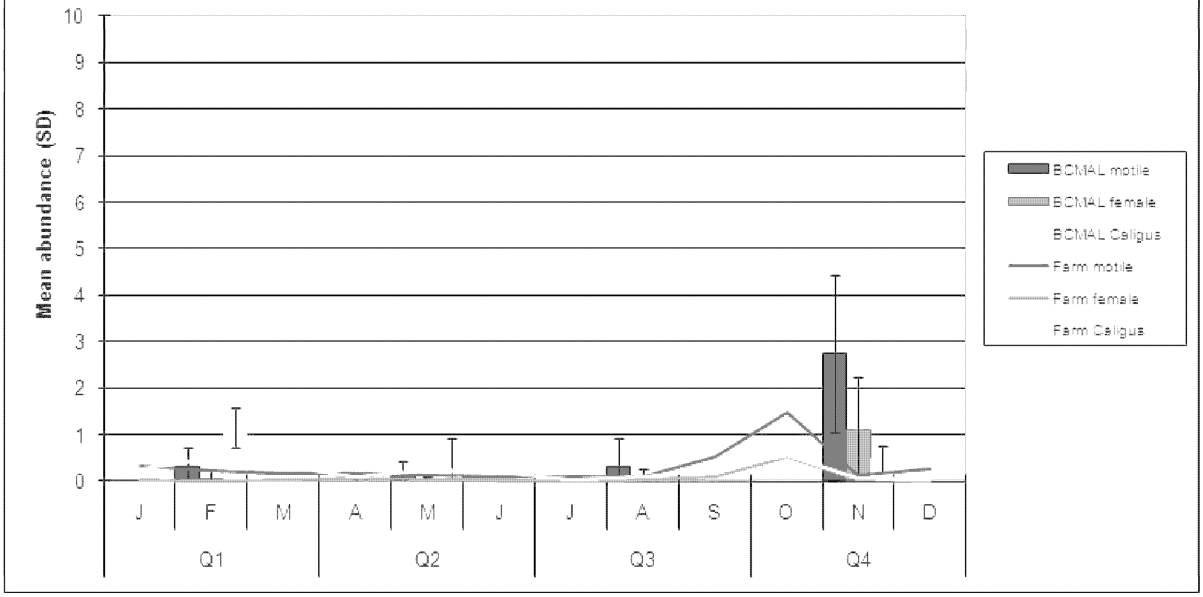


Figure 22b: Sub-zone 3.3, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009

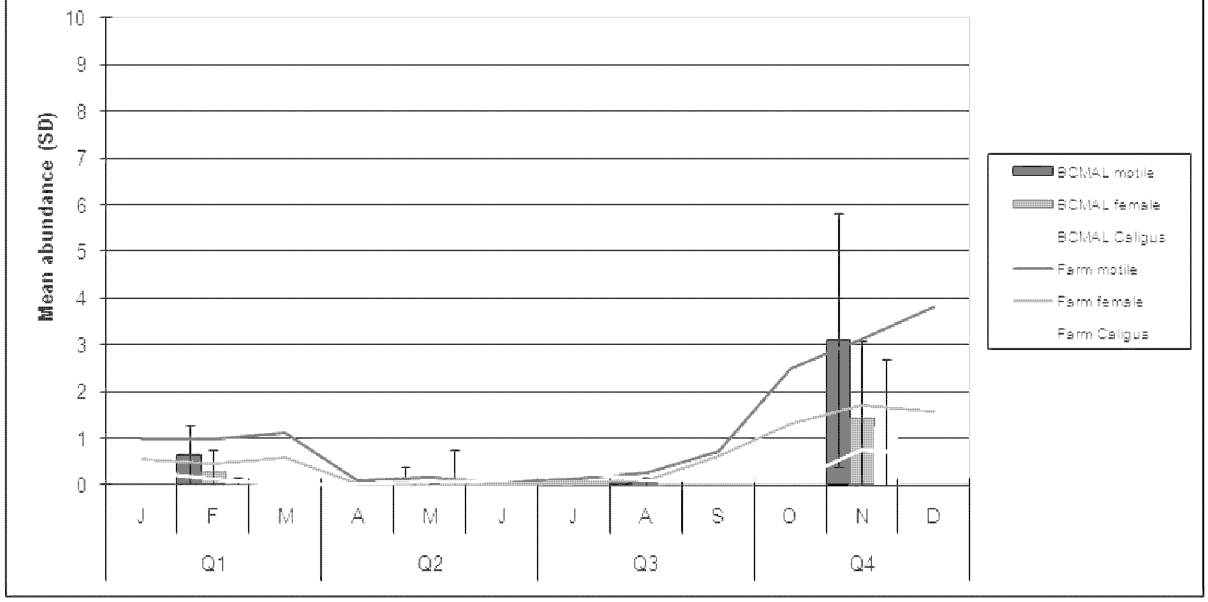


Figure 23a: Sub-zone 3.4, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009

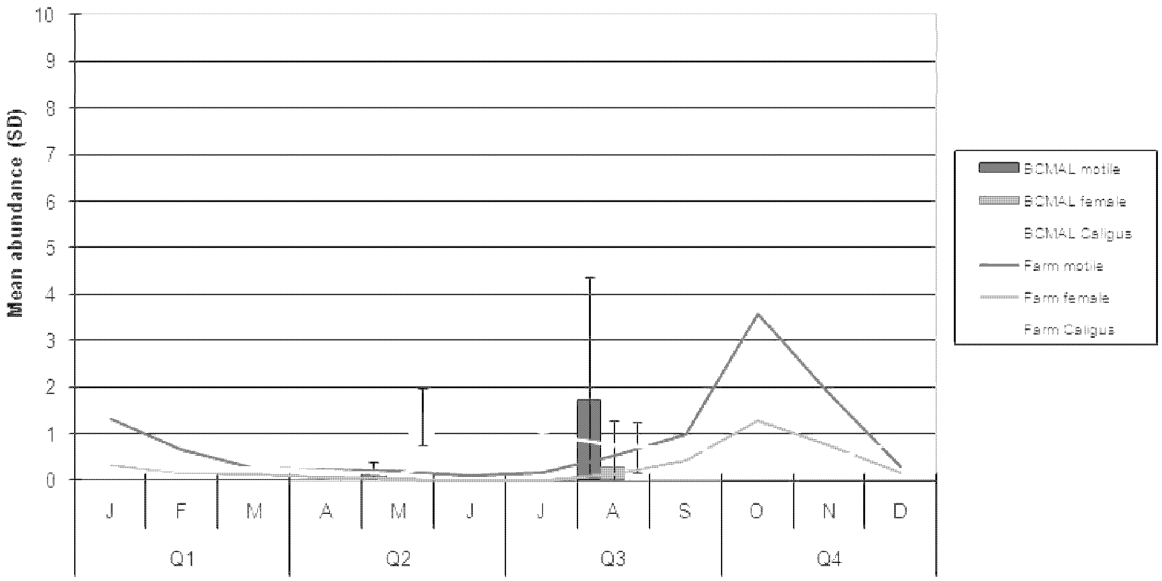
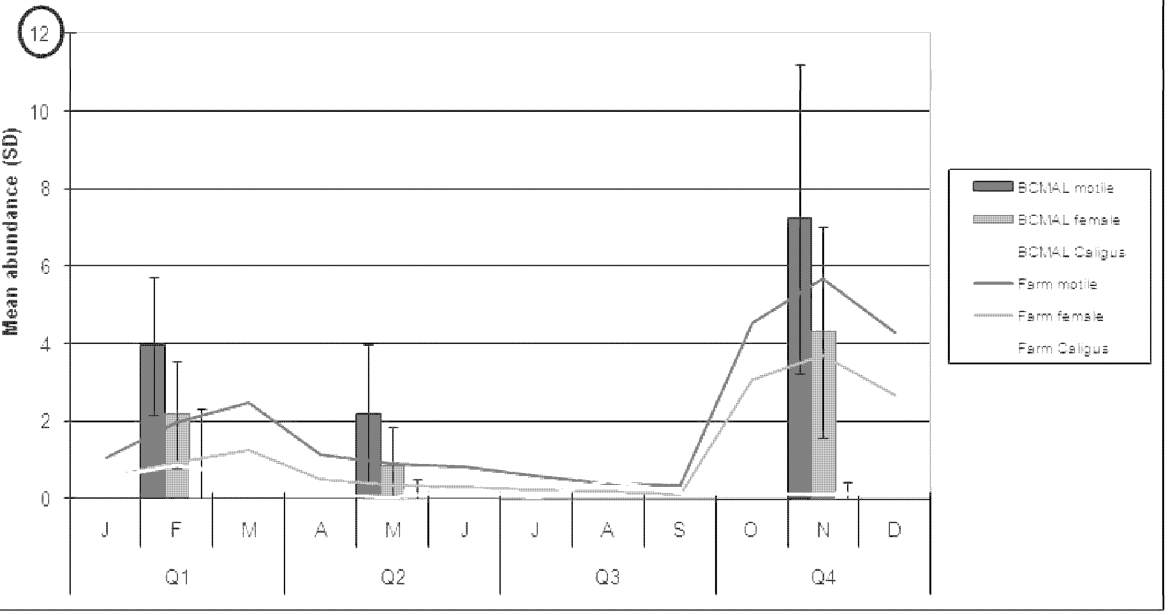


Figure 23b: Sub-zone 3.4, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009



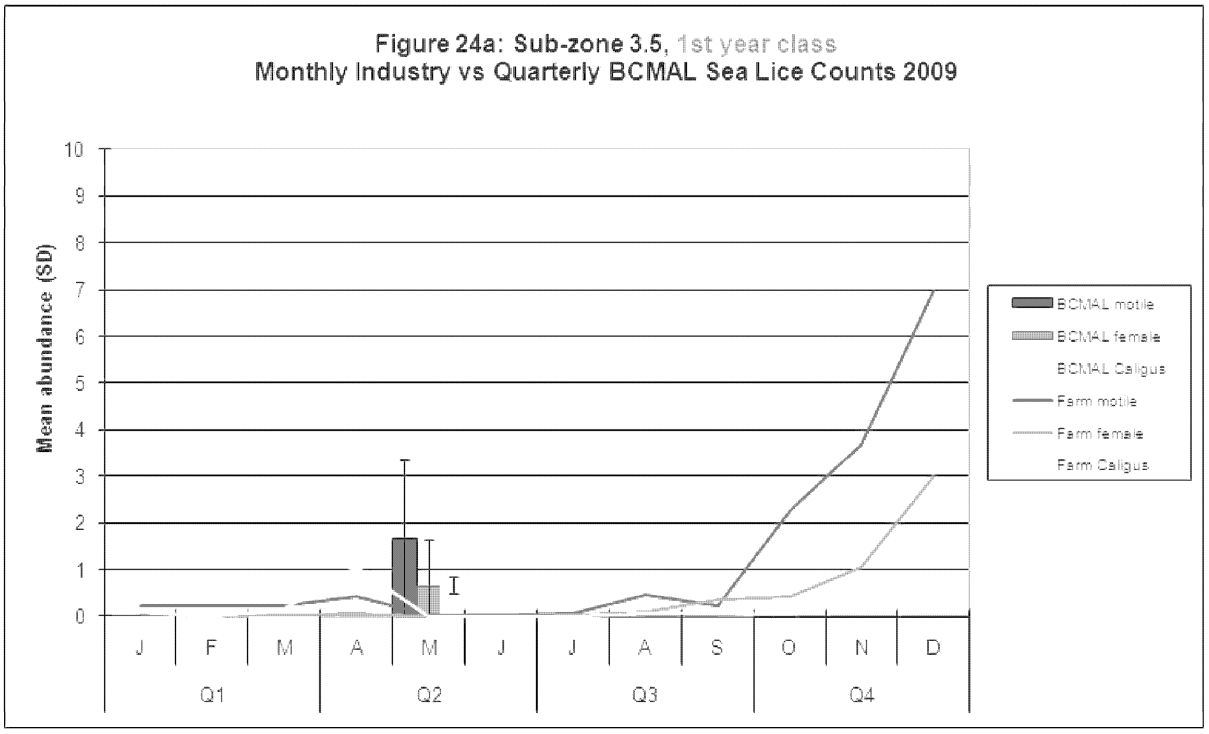


Figure 24a: Sub-zone 3.5, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009
Mean abundance (SD)
0
1
2
3
4
5
6
7
8
9
10
J
F
M
A
M
J
J
A
S
O
N
D
Q1
Q2
Q3
Q4
BCMAL motile
BCMAL female
BCMAL Caligus
Farm motile
Farm female
Farm Caligus

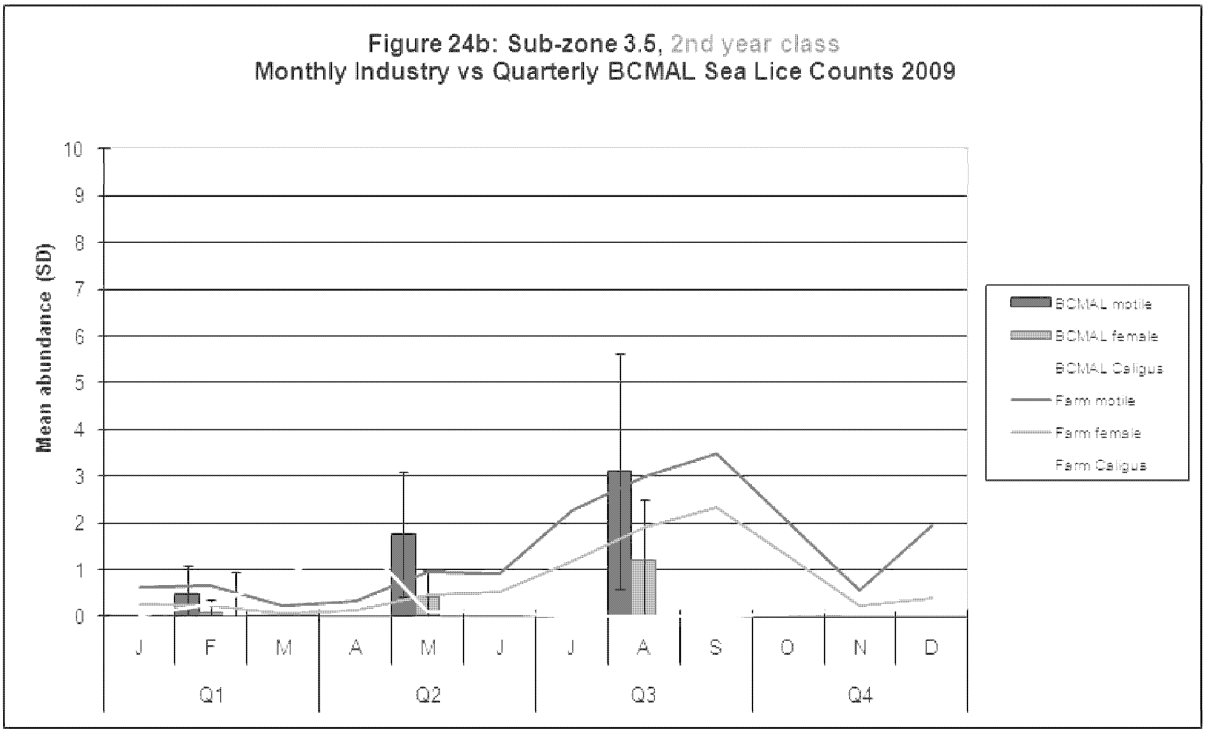


Figure 24b: Sub-zone 3.5, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2009
Mean abundance (SD)
0
1
2
3
4
5
6
7
8
9
10
J
F
M
A
M
J
J
A
S
O
N
D
Q1
Q2
Q3
Q4
BCMAL motile
BCMAL female
BCMAL Caligus
Farm motile
Farm female
Farm Caligus

4.6 Rationale for the Three Motile Lice Trigger

In 2003 the sea lice monitoring program was extended beyond the Broughton Archipelago to include other sub-zones of BC"s salmon farming industry. BCMAL implemented the monitoring program as a part of the obligations of salmon Health Management Plans (2003-2009) and also instituted the audit and verification program.

In 2004/05 all the data collected from industry and the BCMAL audit programs were evaluated. Based on this information, a conservative on-farm trigger level of three motile lice per fish was assigned throughout the year. During the late summer returning migration of adult wild Pacific salmon, the abundance of sea lice can be higher on wild fish than is found on farmed fish. Farm treatments, in the face of increased background levels of lice and recruitment of the parasites from wild sources, could reduce the efficacy of the anti-lice medication; hence, during the autumn, lice abundance on farms can exceed the trigger value of three. In this case, monitoring frequency must be increased by staff of affected farms.

The in-feed drug available to control sea lice, emamectin benzoate (trade name SLICE®), normally has an efficacy period of several months unless local parasite recruitment occurs. As part of an integrated management approach to pest control, if treatment is strategically timed in the autumn or winter (i.e. November to February, after the fresh water migration of wild brood fish) the result is minimal lice abundance on farms when the wild juvenile out-migration occurs. BCMAL and DFO continue to work with the aquaculture sector to ensure these necessary data are gathered and integrated to farm management programs.

4.7 Comparison to Other Countries

The trigger levels for control of lice in Norway recently tightened to 0.5 adult females or three motile lice per fish throughout the year. Scotland is thought to have target lice levels but has no assigned abundance values that trigger medical management of lice. A summary of the 2009 trigger levels in different jurisdictions is provided in Table 19.

Table 19: Comparison of Trigger Levels in Salmon Farming Jurisdictions

Country	Time of Year	Trigger Level	Action(s)
Norway	Year round	3 motile lice per fish; or 0.5 adult females	Various treatments are available
Scotland	Spring time	No official trigger but targets are: 0.5 adult females	Various treatments are available
	Remainder of year	1 adult female	
Ireland	Mar 1 – Apr 30	0.3 - 0.5 egg-producing (gravid) females per fish	Various treatments are available
	May 1 – Feb28	2 gravid females per fish	
Chile	Year round	6 motile lice per fish	Various treatments are available
BC Canada	Mar 1- Jun 30	3 motile lice per fish*	Harvest or treat (1 available drug)
	Jul 1 – Feb 28	3 motile per fish	Elevate monitoring, or apply treatment; or harvest

* An analysis of BCMAL data (of 2nd Quarters 2006 – 2009, the fry out-migration period) indicates that an average abundance of zero to three motile lice per fish includes fewer than 0.3 gravid females per fish in that same season, March to July. This low abundance of gravid females in BC remains lower than trigger values assigned in other countries.

While it is important to consider the experiences of other countries in regard to sea lice infestations, it is equally important to understand sea lice dynamics in the context of local conditions of British Columbia. Atlantic salmon in other countries and regions are challenged by disease and death due to sea lice. However, the clinical effects of Pacific sea lice on farmed Atlantic salmon in BC are minimal when compared to the physical damage caused by strains of Atlantic sea lice in the Atlantic Ocean regions. Genetic research by Yazawa et al. (Mar Biotechnol (NY) 2008 Nov-Dec; 10(6):741-9) and Koop et al.: (http://www.physorg.com/news157831652.html) shows that, although the Pacific and Atlantic forms of the salmon louse look identical, the Pacific L. salmonis louse is genetically distinct from the Atlantic Ocean louse (i.e. genome differences in the order of 10%) and has evolved independently for a number of million years. This is a pivotal discovery in that the independent evolutionary history and the significant genetic diversity between these lice may explain marked differences in louse virulence and pathology caused by Pacific sea lice on Atlantic salmon.

The policy of conservative triggers in British Columbia is precautionary; the principle followed when management is evidence-based and gaps in knowledge still exist. Justifications and debate of the conservative triggers will continue while research advances our understanding.

Synopsis of Industry Sea Lice Results - 2009

The following information is a brief review of the temporal and spatial occurrence of lice on farms by way of BCMAL audits and the examination of industry sea lice reports submitted to the Ministry in 2009.

Summary:

- **Sea lice are naturally occurring parasites of fish**. Data collected from wild fish stocks shows that returning adult salmon carry high numbers of salmon lice. Undoubtedly this host-parasite relationship is a natural phenomenon of salmon and herring. The herring louse and the salmon louse both appear on farmed Atlantics and neither parasite is known to lead to sickness in BC farmed fish.
- **Abundance of lice on farmed fish in 2009 during the out-migration period of wild fry (March to July) was below the trigger level of 3 motile salmon lice per fish in all sub-zones.** By early March 2009, the lice abundance on the salmon farms had declined or been managed such that fewer than 3 motile salmon lice per fish were present (March-July). That low abundance of motile lice persisted for at least five months through the spring and summer and for ten months of 2009 in the Broughton area. In other words, no within-farm recruitment and expansion of lice populations was evident between February and July.
- **Seasonal increases in lice abundance were evident in 2009.** Annually, in most sub-zones, motile lice arrive at farms in July/August when wild salmon populations return to the BC coastline in greatest numbers. In autumn 2009, there was a moderate elevation in lice abundance on farmed fish in most areas associated with substantial returns of wild salmon to many coastal watersheds.
- **Abundance of lice varies naturally from year to year**. Sea lice data have been collected and reported consistently for more than six years in BC (2004 -2009 inclusive) using a standardised protocol and reporting structure. Annual comparisons interest some individuals and groups but direct comparisons are difficult because the location of „active" and reporting farms change from year-to-year. An annual fluctuation in average lice abundance in all sub-zones is to be expected.
- **Lice abundance can vary substantially between areas.** Data collected by industry on a farm-by-farm basis and submitted to government clearly shows that there are areas where lice abundance has consistently been very low for years. For example, sub-zones 3.1 (Sechelt) and 3.3 (Broughton) have low abundance whereas other areas (sub-zone 2.4, west coast) experienced increases in lice abundance for various reasons in 2009. With the exception of the fourth quarter in 2009, most areas showed a louse abundance that averaged lower than 2 motile lice per fish.
- **The trigger level of three motile lice per fish continues to be a conservative monitoring and management objective**. Sea lice are natural marine parasites of fish in all regions. There is no indication in the sentinel Atlantic salmon population of BC farms of ill health even when afflicted by higher numbers of lice observed each autumn.

- **Lice abundance varies between year classes.** The overall abundance of lice on juvenile Atlantic salmon is generally lower in their first year of sea water compared to 2nd year fish (adults). One exception can be seen in sub-zone 3.2 (Campbell River area) where herring lice appear to show a preference to juvenile farmed salmon over adult fish.
- **Marine conditions and returning wild salmon can affect the occurrence and abundance of lice on farms.** Information on environmental conditions and the impact on salmon and lice survival and reproduction is well documented. The following publications speak to the environmental factors and biology/behaviour of wild salmon and Lepeophtheirus salmonis: Heuch et al., 2000; Revie et al., 2002; Tucker et al., 2000; Jones et al., 2006, 2007, 2008, 2009; Webster et al., 2007; Krkosek, 2007; Brooks and Jones, 2007; Yazawa et al., 2008; State of the Salmon proceedings, 2009.

4.8 Sea Lice Abundance on Farmed Atlantic Salmon in the Broughton Archipelago

The analysis of spatial and temporal variations in sea lice abundance on farmed salmon and out-migrating wild juvenile salmon in the Broughton Archipelago (as conducted in parallel by DFO, BCMAL, industry and environmental non-government organisations, ENGOs) has provided critical information to further our knowledge of the region and of lice-host interactions. Determining the degree of association will be a key step to assessing whether there is a causal link between sea lice found on farmed salmon and those found on wild salmon fry in the Broughton Archipelago. The Pacific Salmon Forum Final Report is a useful resource explaining related projects and results to date.

The average abundance of motile sea lice on both 1st and 2nd year class Atlantic salmon reared in the Broughton area were 1.0 or fewer motile lice per fish for nine consecutive months in 2009, including the period of wild salmon out-migration. The average abundance remained well below 3 motile lice per fish throughout 2009 with the exception of the autumn. Figures 22a/b (sub-zone 3.3, above) and corresponding appendix Tables 7.10.5 and 7.11.5 reflect lice data specific to the Broughton region.

In 2009, sub-zone 3.3 (Broughton):

- Juvenile Atlantic salmon (1st year class fish) had an average lice abundance less than 0.5 motile lice per fish from January through August 2009.

- Larger 2nd year class fish had an average lice abundance of 1.0 or less from January to September 2009.

- Two types of lice were present on farmed salmon: the „salmon louse" Lepeophtheirus salmonis, (L.salmonis), and the „herring louse" Caligus clemensi (C. clemensi).

- The typical seasonal pattern of increasing louse abundance on farmed fish began in September when the abundance increased to approximately 1.0 lice per adult fish and subsequently reached 3 lice by November 2009. A similar pattern was evident in juvenile farmed salmon. These increases have been attributed to large returns of wild Pacific salmon to the Broughton area.

Section 5: Therapeutant Use and Monitoring

5.1 Therapeutant Use and Monitoring

The Ministry of Agriculture and Lands monitors finfish aquaculture"s use of therapeutants in food fish on an annual basis. BCMAL receives a report from all licensed feed mills that reflects all medicated orders milled for fish each year. In-feed medication is the only practical method of delivering therapeutants to large fish populations (i.e. production food fish). Immersion bath treatments, for example to control external parasites like sea lice, do occur in other regions or countries under special permit but this technique has yet to be considered a viable practice in marine net pens of British Columbia.

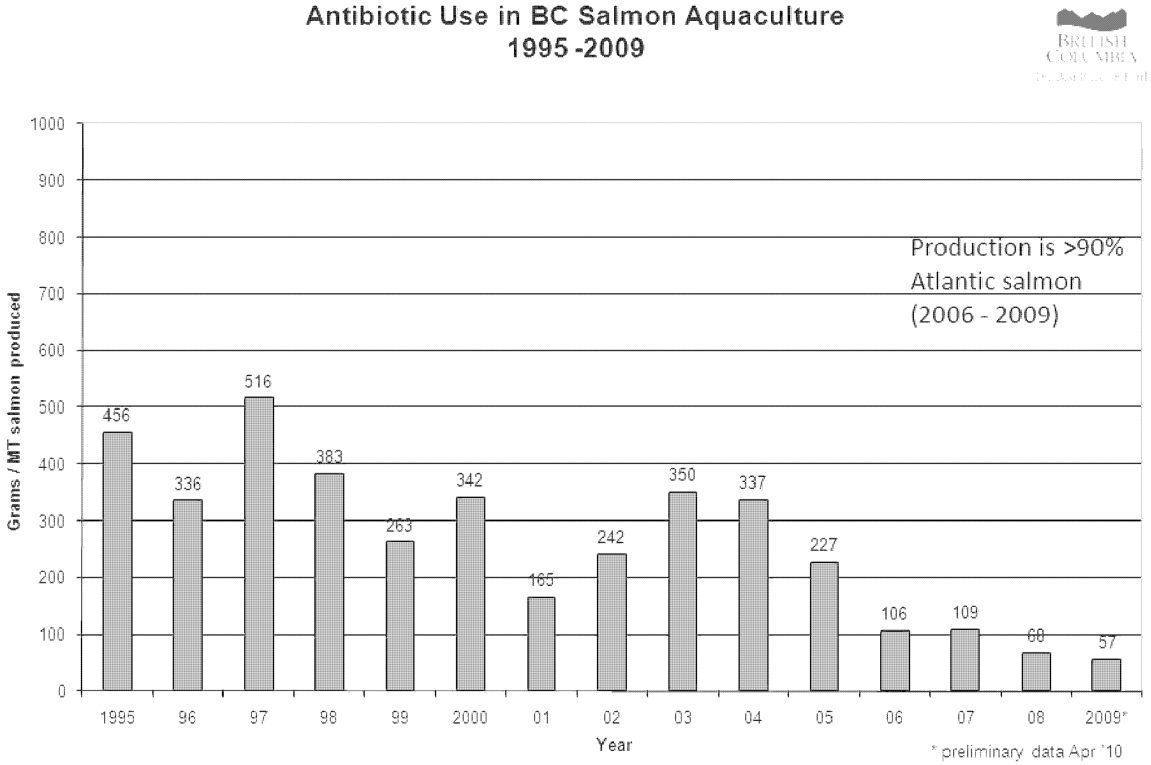
5.1.1 Antibiotics:

Few drugs are available for use in food fish and all, if used, are applied by veterinary prescription in BC. Four (4) antibacterial products are licenced for finfish in Canada include: Terramycin Aqua® (oxytetracycline hydrochloride); Aquaflor® (florfenicol); Tribrissen® (trimethoprim and sulphadiazine); and Romet 30® (ormetoprim and sulphadimethoxine). Additional drug products are available at the discretion of attending veterinarians but their use is uncommon. If necessary, broodstock are medicated using appropriate antibiotics through in-feed delivery or by injection. Brood fish are not raised for human consumption. BC feed mills abide by provincial pharmacy regulations, whereas the veterinary use of injectable products in the brood is recorded and tracked by the prescribing veterinarian and by the farming companies.

As shown in Figure 25, the antibiotic use has fluctuated from the 1997 peak of 516 grams (g) of active drug per tonne of fish to an all-time low of 57 grams used in 2009. It is noteworthy that these annual uses (i.e. grams per tonne of fish produced) include the volume of antibiotics fed to broodstock (i.e. non-food fish); meaning that, the main production fish, or „food fish", in reality are exposed to less antibiotic than the bar graph indicates.

BC"s fish populations are not managed with antibiotics in the absence of infection yet medications are occasionally used to minimise, and to some extent mitigate, disease events that may arise seasonally or following a stressor. Attending prescribing veterinarians manage this aspect of fish health.

Figure 25: Summary of Antibiotic Use in Salmon Aquaculture 1995 – 2009 (including broodstock populations).



5.1.2 Sea Lice Medical Management:

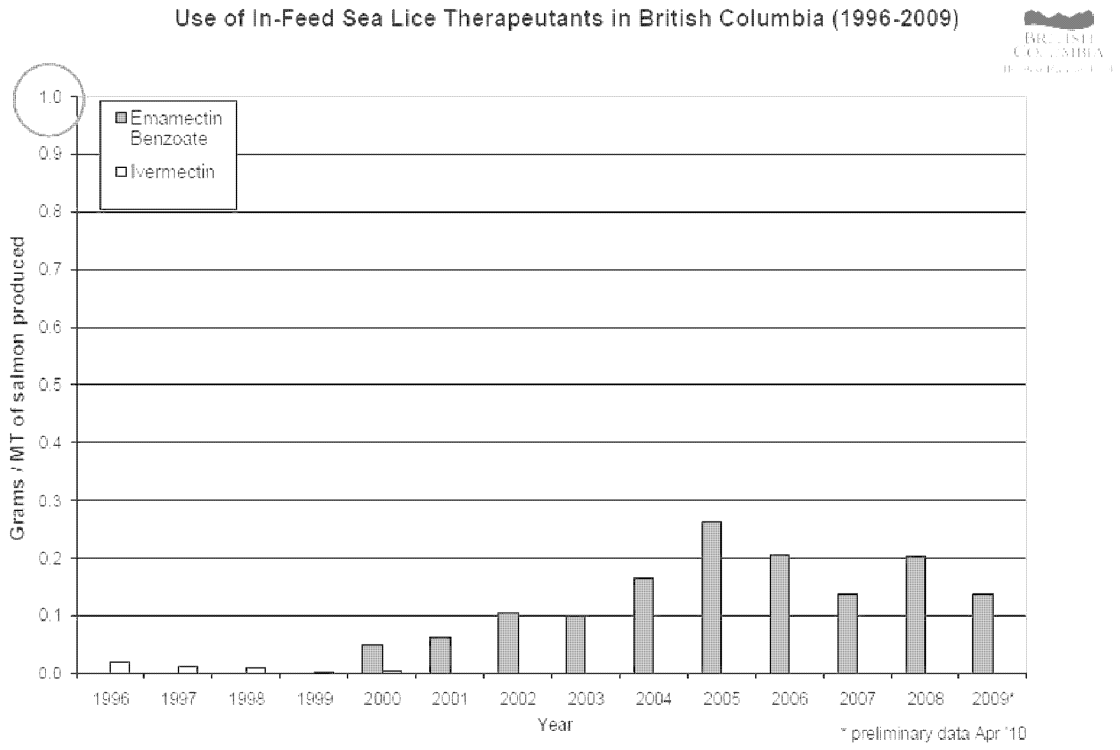
Currently, only one product is available for controlling sea lice in British Columbia: emamectin benzoate, commercially known under the trade name SLICE®. The in-feed therapeutant reached the formal status of a licenced and labelled drug in 2009 following a thorough federal review and approval process under the authority of Health Canada. Emamectin benzoate continues to be an efficacious drug for lice management, such that post-treatment lice abundance on farms (in BC) typically remains low for five or six months.

As illustrated in Figure 26, the use of anti-lice medication is below 0.15 grams per tonne of fish produced in BC. Initially, from 2000 to 2003, harvest-sized Atlantic salmon would generally not have been medicated with emamectin benzoate because that treatment could have interfered with harvest dates (i.e. the historical permitted withdrawal period varied from 30 to 68 days). Between 2003 and 2005, and upon the implementation of the provincial Sea Lice Management Strategy, the prescription use of emamectin benzoate increased primarily because the larger fish were medicated in late winter to minimise any potential effect their lice may have on wild fish fry during the spring out-migration. In 2006 and 2007, the reduced lice abundance on wild fry and farmed fish, as well as efforts to harvest farmed salmon in the early spring, all helped to reduce the use of the anti-lice medication – particularly in large fish. The variation in use of emamectin benzoate from 2005 to 2009 does not reflect a veterinary

response to lice abundance (which, for example, declined to 2008 but increased slightly in 2009); rather, it illustrates the influence of environmental and marine conditions, as well as societal expectations and the precautionary focus of managing sea lice in BC. In other words, to further minimise the potential risk of lice transfer to wild out-migrating salmon fry.

In recent years, aquaculture regions outside of BC have been investigating alternate treatments to control lice over concerns of decreasing efficacy when using in-feed emamectin benzoate. Non-responsive treatments, as seen in other regions, have not been evident in BC. This is likely due to two key reasons. First, the use of emamectin is infrequent (i.e. on average one treatment per fish group annually). Second, BC"s coastal ecosystem experiences an annual influx of chemically-naive lice accompanying the return of wild salmon, more so than a recruitment of chemically-exposed lice from fish farms. In 2009, a single, alleged, non-responsive lice treatment was reported in the media; it was readily explained once unique environmental influences, harvest delays, and feeding activity of the affected Atlantic salmon group were considered. In short, and as always, in-feed medications are only effective if the host animal is consuming the feed.

Figure 26: Summary of Use of Sea Lice Products in BC Aquaculture 1996 – 2009 (including broodstock populations).



NB. The trigger level of 3 motile lice per fish was assigned by 2004 and consequently influenced the volume and frequency of therapeutic management of lice on farmed Atlantic salmon, particularly during the winter months (i.e. prior to the out-migration period of wild salmon fry, March – June).

Section 6: Summary and Conclusions

Since 2003, the BCMAL fish health program has published an overview of the health of salmon on fish farms in British Columbia and the program provides regulators an avenue to enforce disease management on the farms. The cornerstone of the program is the Health management Plan (HMP), which is a Term and Condition of a salmon aquaculture licence issued by the provincial government. The HMP requires marine salmon farmers to record and report fish health events, mortality rates and causes (and sea lice abundance if Atlantic salmon are reared).

The 2009 audit and surveillance data indicate that diseases, when detected on salmon farms in British Columbia, are natural to the marine region and have been previously identified in free-ranging wild Pacific salmon.

One objective of the audit program is to ensure accurate and verifiable data on the health and disease status of cultured fish stocks. This is accomplished by requiring farms to report to their industry database monthly (then to BCMAL quarterly) on mortality and fish health events that occur in fish farm populations. The findings of the audit program show agreement with BCSFA"s Fish Health Events reported in 2009.

Compliance with HMPs is monitored by on-farm inspection, log review and an extensive checklist during the routine audit procedures. Industry compliance is high. All HMPs are reviewed annually and updated accordingly. HMPs are designed to ensure that the highest standards for fish health are achieved, thus minimising any risk of effect on wild stocks and minimising any risk of transfer of pathogens to other populations.

All salmon begin their life cycle in fresh water where they are free of sea lice. After farmed fry are transported to marine net cages, lice may transfer from wild salmon (and other marine fishes) to farmed fish. Atlantic salmon are known to be one of the most susceptible fishes to lice infestation in other parts of the world; thus, farmed Atlantic salmon serve as the appropriate sentinel population in British Columbia to monitor lice abundance. The Province continues to work with Fisheries and Oceans Canada (DFO), industry, and other researchers to monitor sea lice and integrate new information into annual lice control strategies.

The objective of the provincial lice audit is to ensure that on-farm counting protocols are followed and to verify the degree of lice infestation on BC Atlantic salmon farms. The industry has embraced the lice management strategy and full compliance occurs with the Ministry"s requirements for monitoring. Overall, lice abundance on Atlantic salmon farms in 2009 remained low with spring-time averages in all regions being well below the trigger of three motile lice per fish.

Section 7: Supplement – Appendices to Fish Health Report

2009

Ministry of Agriculture and Lands

Animal Health Branch – Fish Health

BRITISH COLUMBIA
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ANNUAL REPORT
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