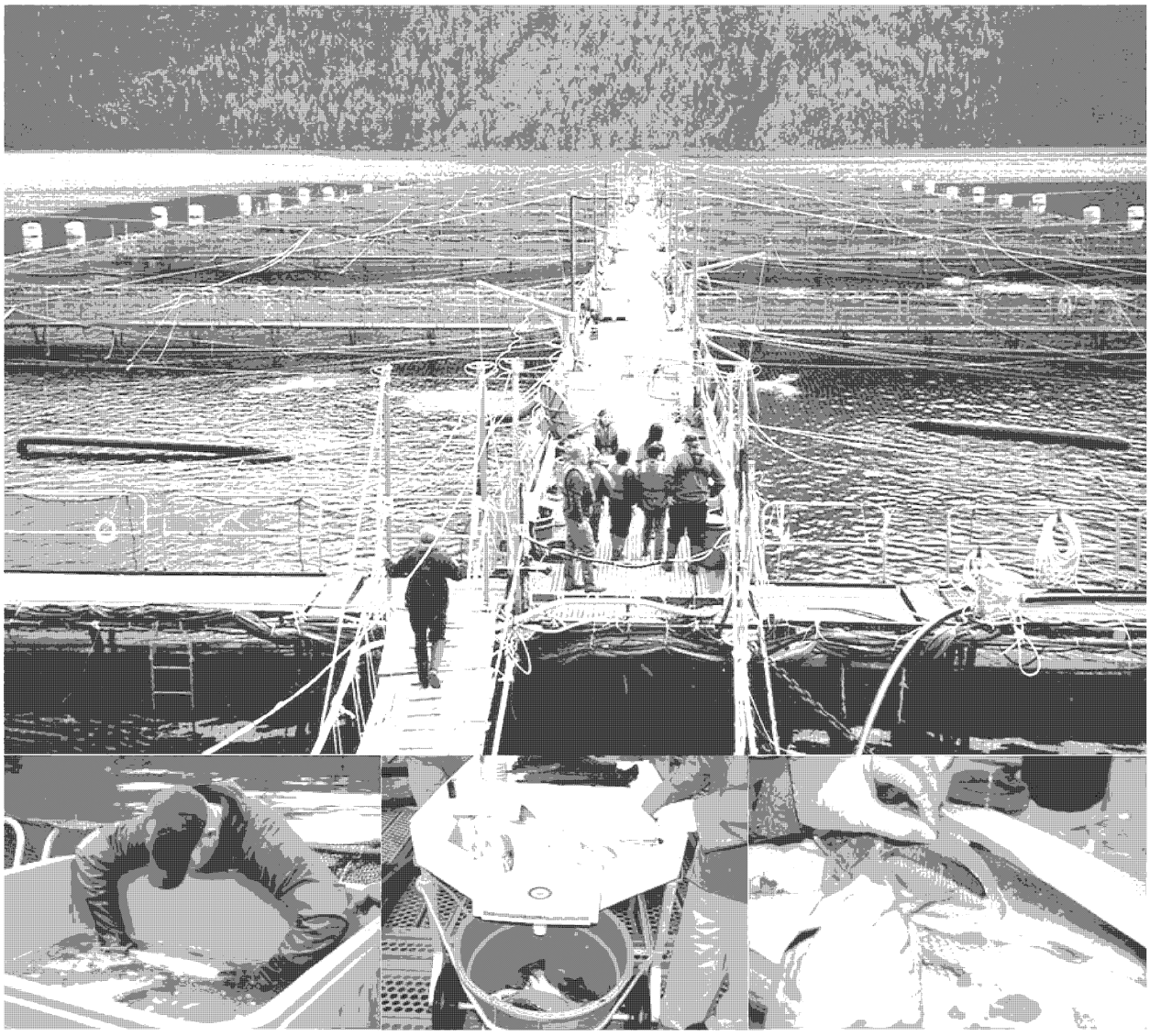
2008

Ministry of Agriculture and Lands

Animal Health Branch – Fish Health



BRITISH COLUMBIA
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FISH HEALTH PROGRAM ANNUAL REPORT

Section 1: Overview

1.1 Executive Summary

The Province of British Columbia (BC) established a comprehensive health management program for salmon aquaculture and the Ministry of Agriculture and Lands (BCMAL) has been verifying compliance and assessing performance of the 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.

In 2008 the BCMAL completed 119 salmon farm audits and collected diagnostic samples for disease analysis from 588 fish that had recently died. All farms categorize their dead fish, giving probable explanation for the cause of death. About 25 % of the routine fish mortality are "silvers". Silvers are fresh carcasses that still have silver skin/scales and died most recently. These carcasses are used as indicators of active disease in the robust living population. Roughly 10% of the silver group is selected and tested by BCMAL for cause of death and specific infectious diseases.

For Atlantic salmon, 80% of the audit cases found 'no infectious disease' (at the farm-level). Of the infectious disease cases, the main diagnoses were mouth myxobacteriosis (11%) and bacterial kidney disease (4%). For farmed Pacific salmon, 50% of the audits cases found 'no infectious disease' (at the farm-level), and the main disease diagnoses were bacterial kidney disease (45%) and vibriosis (5%). All of these diseases are endemic in wild salmon in British Columbia and it is expected that these diseases would also occur in farmed fish.

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

Audits of sea lice abundance at Atlantic salmon farms confirm that the aquaculture industry is complying with the sea lice management strategy. In 2008, BCMAL conducted lice counts at 71 farms and assessed over 4,200 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 continues to be precautionary for lice management in BC; the lice abundance in farmed and wild salmon has declined since 2004. Further, recent genetic research supports the current lice management strategy. This research offers a plausible explanation as to why Atlantic salmon raised in British Columbia show little or no outward signs of ill health from salmon lice of the Pacific Ocean strain (see Section 4.7).

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 Fish Health Management Plan (FHMP). These corporate management plans encompass all aspects of 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 FHMP specific to their rearing units. For private companies and the provincially licensed public facilities, the FHMP remains enforceable as a Term & Condition of an aquaculture licence (2008).

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' 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 FHMP 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: 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: Fish Health Management Plans

2.1 Fish Health Management Plans

The Fish Health Management Plan (FHMP) outlines the ideal husbandry conditions for cultured fish in British Columbia.

2.1.1 Review of FHMPs

Three documents are used to develop a corporate FHMP: the *Required Elements* document provides the guiding principles for the FHMP 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 FHMPs

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

With regard to public enhancement facilities, five key rearing facilities of the Freshwater Fisheries Society of British Columbia operated under one general FHMP. Each rearing site has its own SOP document. A similar arrangement exists for fifteen large federal enhancement hatcheries of the Department of Fisheries and Oceans Canada (DFO) in BC; they continue to operate under one over-arching FHMP with facility-specific SOPs. These public facilities report their FHEs to the BC Salmon Farmers' database quarterly.

The Ministry sends an annual reminder letter to all industry FHMP coordinators to request that revisions, if any, be communicated. Any revisions to private aquaculture FHMPs and/or SOPs are submitted to and reviewed by the Animal Health Branch of BCMAL 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 2008. In addition, the renewal of aquaculture licenses, amendments or the issuing of a new licence, will trigger an assessment of the company's FHMP 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 FHMP dictates that all major commercial salmon farming companies operating in British Columbia must monitor their fish and report to the BC Salmon Farmers Association's (BCSFA) database monthly, addressing the status of fish health at their farms. These monitoring results are aggregated by 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 when veterinary intervention has occurred. FHEs account for the population-level diseases or demands 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 and Mortality reports, and monthly Sea Lice Monitoring reports. This reporting structure is a condition of license under the FHMP.

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 license 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, samples from fish carcasses are collected for testing for specific diseases and pathogens of concern, and live fish are 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 FHMPs;

2) Provincial fish health bio-technicians collect samples from recently dead or moribund silvers to facilitate active surveillance for bacteria, viruses and parasites and to determine farm-level disease events; 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. 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 North Coast. These two major zones are divided into several sub-zones.

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 summarizes the fish health zones and a map of the fish health zones is found in Appendix 7.2.

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 / '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 to be 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 land tenures in British Columbia upon which 60 to 80 salmon farms operate at any given time. In 2008, the number of active farms available for audit each quarter ranged from 57 to 69 (mean = 64, 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.

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. 12.7) so the calculated numbers have been rounded up or down to integers accordingly.

3.2.3 Salmon Farm Selection

As each calendar quarter begins, a list of all licensed 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, or other unforeseen circumstances. Whenever possible these cancelled farm audits are rescheduled.

[2] Active farms are those farms which are determined to have a minimum of 3 pens of fish on site during the quarter which sampling is to occur. This does not include broodstock.

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 experts (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 active disease, and is most representative of the robust living population (without sampling the living fish). The selection of these carcasses increases the likelihood of detecting acute and emerging disease. Typically, five to eight silvers per farm are collected to a maximum of 20. 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 the availability of fresh silvers is often limited. The number of carcasses tested in 2008 was 588 (Table 4).

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 are assessed by 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 for molecular diagnostics and virology from each carcass include: anterior kidney, posterior kidney, liver, spleen, gill and pyloric caeca. Additional samples of tissues with lesions are selected as required. Samples are pooled to a maximum of five fish per pool, frozen and 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)
- *Piscirickettsia 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 *Piscirickettsia* are each indigenous pathogens to British Columbia's coast. As such, these pathogens are found in farmed fish from time to time; either seasonally (in the case of VHSV and *Piscirickettsia*) or after a number of years (in the case of IHNV).

All tissue samples for histopathology are examined for signs of inflammation and abnormality 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. The anterior and posterior kidney, liver, spleen, heart, pyloric caeca, brain (and occasionally gill if a lesion is evident) are collected from each selected fresh silver carcass for microscopic examination by a Fish Pathologist certified in anatomic pathology by the American College of Veterinary Pathologists (ACVP). Additional tissue samples may also be collected during an audit if lesions are visible or if disease-causing organisms are suspected.

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 FHMP checklist is also part of the audit to standardise the assessment and better evaluate the compliance with the producer's Fish Health Management Plan.

3.3 Results

3.3.1 Number of Active Farms

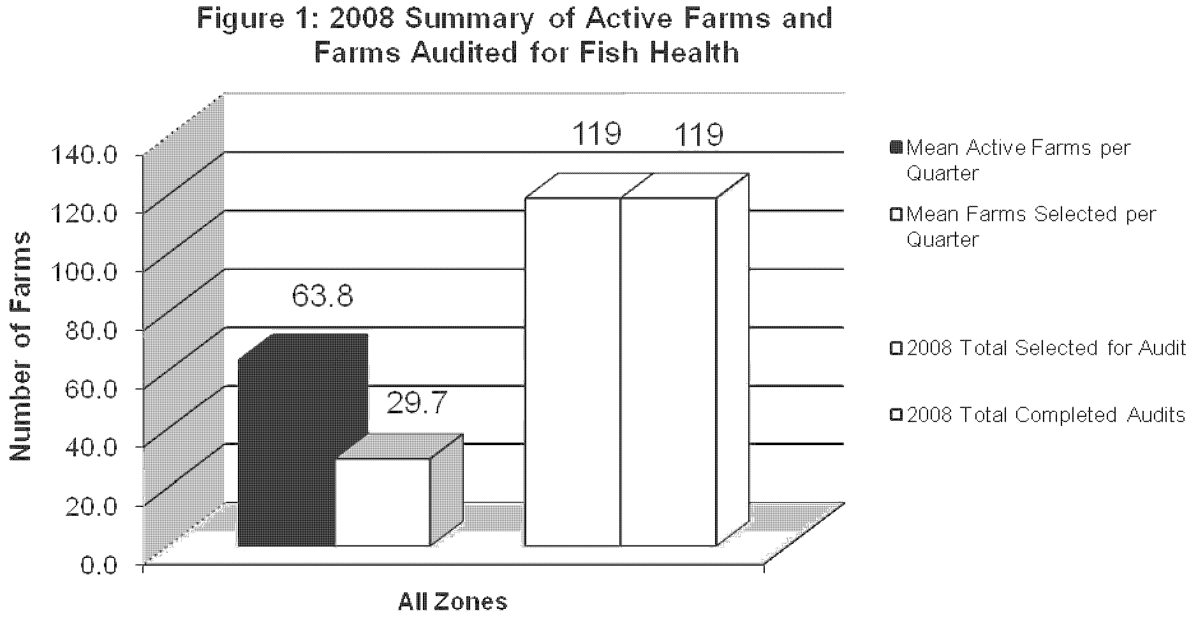
The number of active farms in 2008 is provided in Table 2, and by calendar quarter in Appendix 7.3.

Table 2. Average Number of Active Salmon Farms in 2008	
Atlantic Salmon	2008
Zone 2.3 SW Vancouver Island	10
Zone 2.4 NW Vancouver Island	7
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	5
Zone 3.5 Central Coast Area	4
Pacific Salmon	
Zone 2 Vancouver Island	3
Zone 3 East of Vancouver Island	6

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, two small marine aquaculturists are not members of the BCSFA and do not report to the industry database because their activity is considered either a pilot project or the activity has a research focus. However, these two 'farms' are included in provincial audits. 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 2008					
Location	Q1 Jan - Mar	Q2 Apr – Jun	Q3 Jul - Sep	Q4 Oct – Dec	2008 Totals
Sub-zone 2.3 SW Vancouver Island	4	3	3	5	15
Sub-zone 2.4 NW Vancouver Island	3	4	4	1	12
Sub-zone 3.1 Sunshine Coast	1	1	0	1	3
Sub-zone 3.2 Campbell River Area	6	7	7	8	28
Sub-zone 3.3 Broughton Area	7	5	6	6	24
Sub-zone 3.4 Port Hardy Area	2	2	2	2	8
Sub-zone 3.5 Central Coast	2	2	2	2	8
Atlantic Sub-total	25	24	24	25	98
Zone 2 Vancouver Island	1	3	2	3	9
Zone 3 East of Vanc. Island	3	3	4	2	12
Pacific Sub-total	4	6	6	5	21
Grand Total	29*	30	30	30	119

* Upon implementing a new database in 2008, in Q1 29 farms instead of 30 were inadvertently selected - in subsequent quarters the selection algorithm was corrected accordingly.



3.3.2 Number of Fish 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.

During four of the 119 audits no fish were available or suitable for collection (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 During Each Quarter of 2008					
Location	Q1 Jan - Mar	Q2 Apr - Jun	Q3 Jul - Sep	Q4 Oct - Dec	2008 Totals
Sub-zone 2.3 SW Vancouver Island	27	23	17	33	100
Sub-zone 2.4 NW Vancouver Island	16	26	15	8	65
Sub-zone 3.1 Sunshine Coast	2	7	0	2	11
Sub-zone 3.2 Campbell River Area	26	24	33	40	123
Sub-zone 3.3 Broughton Area	30	28	20	27	105
Sub-zone 3.4 Port Hardy Area	4	11	16	12	43
Sub-zone 3.5 Central Coast	2	3	12	6	23
Atlantic Sub-total	107	122	113	128	470
Zone 2 Vancouver Island	10	14	7	17	48
Zone 3 East of Vancouver Island	15	19	23	13	70
Pacific Sub-total	25	33	30	30	118
Grand Total	132	155	143	158	588

3.3.3 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 *Piscirickettsia*, are not represented here because they are more efficiently verified and diagnosed by other laboratory techniques.

In 98% of the carcasses sampled no disease-causing bacteria (pathogens) were isolated. In other words, only 11 fish (2%) collected during audits led to a laboratory culture of a bacterial pathogen. An additional 34 carcasses tested positive for opportunistic or spoilage species that are considered inconsequential to fish production or fish health events.

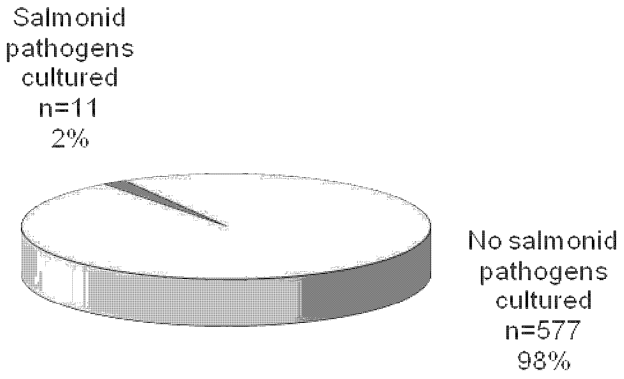
Details of bacteriology results (by zone, sub-zone, quarter and annual summary) are provided in Appendix 7.4 which includes the names of the pathogenic and non-pathogenic bacteria identified by the laboratory.

Table 5: 2008 Total farms and numbers of carcasses sampled, and number of fish with positive cultures (by quarter)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms sampled *	27	30	29	29	115
# fish sampled	132	155	143	158	588
# fish with a pathogen cultured	7	0	1	3	11

* 119 farm audits were conducted yet fish samples were available from 115 of those farms; no fish carcasses were available or suitable for diagnostic testing at four of the farms.

Figure 2: 2008 Summary of Bacterial Culture
588 Fish Sampled



3.3.4 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 are indigenous to British Columbia while others have yet to be found in BC so are considered exotic.

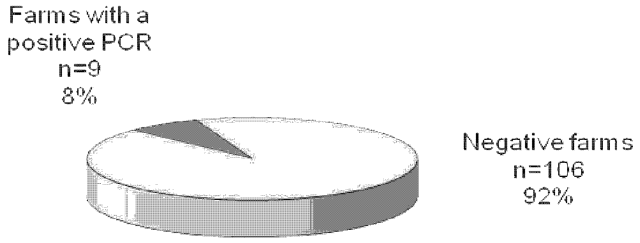
The majority of pooled samples (106 of 115) tested negative for the five pathogens of concern. Because fish samples were pooled, results are summarized at the farm-level rather than individual fish-level. A summary of the annual findings is provided in Table 6 and Figure 3. Complete results of all testing from each zone/sub-zone (by quarter and annually) are provided in Appendix 7.5. Of the total 115 farms sampled*, nine farms had positive PCR results from pooled groups of carcasses whereas 92% of farms sampled were negative for all tested pathogens.

Table 6: 2008 Total farms and numbers of carcasses sampled, and number of farms with a positive PCR result (per quarter).

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms sampled *	27	30	29	29	115
# fish sampled	132	155	143	158	588
# farms with a positive PCR	5	1	1	2	9

* 119 farm audits were conducted yet fish samples were available from 115 of those farms; no fish carcasses were available or suitable for diagnostic testing at four of the farms.

Figure 3: 2008 Summary of Molecular Diagnostics
115 Farms Sampled



3.3.5 Histopathology

Over 4,000 organs and 1,100 histology slides were sectioned, stained and interpreted as part of the audit diagnoses in 2008. Histopathology is a complex and important aspect of the health audits. Results are combined with all other field and laboratory information to distinguish between a farm-level diagnosis and an incidental cause of death within individual carcasses.

3.3.6 Disease Diagnosis 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 (egs. VHSV and *Piscirickettsia*); 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.

Table 7 and Figures 4 and 4a summarize farm-level diagnoses based on 2008 audits. Further detail (by sub-zone and species) appears in Figures 5 to 13. Audit case definitions of the various diseases are provided in Appendix 7.6.

Table 7: 2008 Summary of 125 Diagnoses from 119 Health Audits	
Atlantic Salmon	Number of Diagnostic Cases = 103
No Infectious Disease (NID)*	83
Mouth Myxobacteriosis	11
Bacterial Kidney Disease	4
VHS (NA strain)	2
Rickettsiosis	1
Furunculosis	0
Enteric Red Mouth	1
Skin Myxobacteriosis	1
Net Pen Liver Disease (NID)	(0)
Cardiomyopathy (no etiological agent found,NID)	(1)
No Significant Finding (NID)	(3)
Peritonitis (NID)	(0)
Environmental (NID)	(3)
Pacific Salmon	Number of Diagnostic Cases = 22
No Infectious Disease (NID)*	11
Bacterial Kidney Disease	10
Loma	0
Rickettsiosis	0
Marine Anemia	0
Vibriosis	1
No Significant Finding (NID)	(1)
Enteritis (NID)	(0)
Environmental (NID)	(0)
Non-performer / non-smolt (coho, NID)	(1)

* No Infectious Disease (NID) includes: the audits where no carcass samples were available; and 'Open' diagnoses; and laboratory cases where no identifiable cause for mortality was diagnosed from the carcasses collected. It also includes the diseases caused by: environment; Net Pen Liver Disease (toxin); enteritis and post-vaccination peritonitis. Each of the latter 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: 2008 Audit Case Summary - Atlantic Salmon

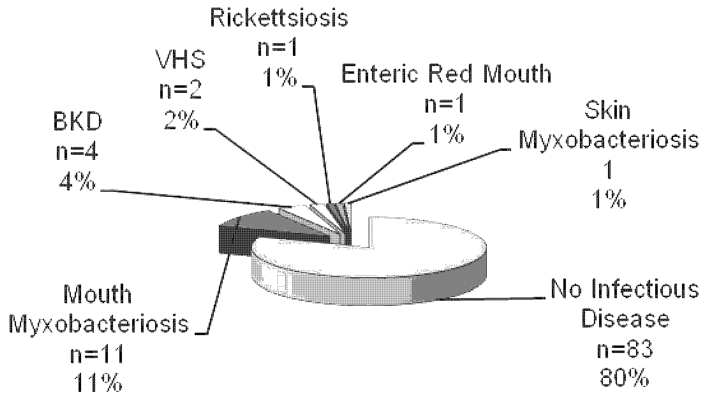
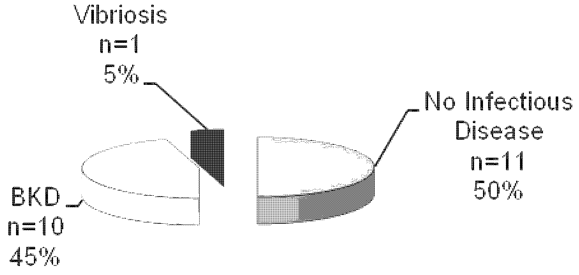


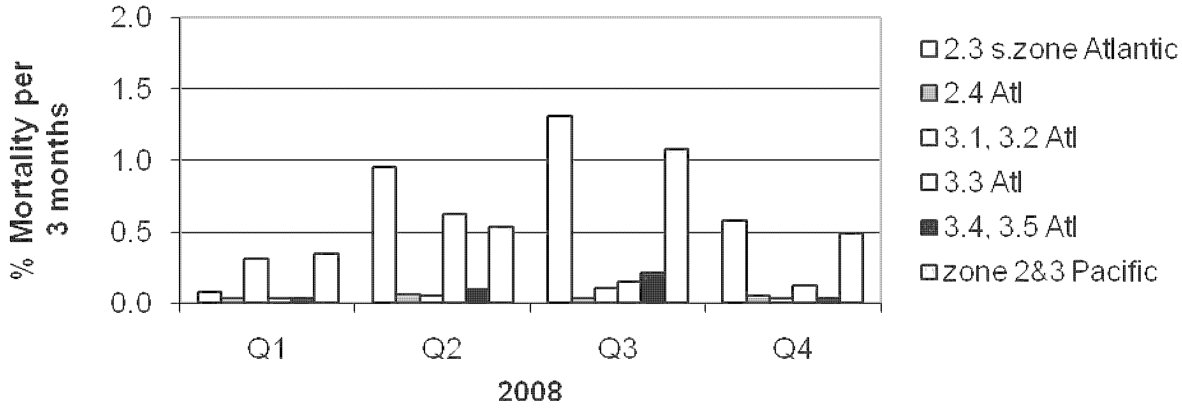
Figure 4a: 2008 Audit Case Summary - Pacific Salmon



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

The naturally occurring disease agents detected in farmed fish are controlled through husbandry or farm management techniques, or by applying veterinary therapeutants approved for fish. In some instances the diseases themselves are simply seasonal and self-limiting. Appropriate health management of stocks enables farms to minimise disease and when disease does occur it can be controlled relatively quickly. The overall mortality in salmon aquaculture is low – in general less than 2% mortality per quarter (see Figure 14 and Appendix 7.7; Quarterly mortality due to all causes). When considering fresh silvers, less than 1% of the Atlantic salmon died of infectious disease each quarter, with one exception noted in Q3 where the mortality crept above 1% due to a group of smolts that acclimated poorly and became susceptible to marine pathogens in sub-zone 2.3 (see Figure 4b and Appendix 7.7; BCSFA data). Fresh silvers from Pacific salmon farms showed low mortality rates with the exception of a 1.14% loss overall in quarter three, generally due to combinations of BKD, Loma and marine conditions low in oxygen.

Figure 4b 2008 BCSFA Data: Average Quarterly Mortality
(as represented by "Fresh Silver" carcasses)



The following pages reflect the 'snapshot' of the farm-level diseases diagnosed from health audits in 2008. When examining these data please note that, as depicted in Figure 4, approximately 80% of the audits showed no infectious disease at the farm-level. In other words, the audit information does not represent the total number of cases of disease amongst industry farms. Instead, the data reflects the proportion of audit cases where disease was found.

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

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.

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. Details by year and zone/sub-zone are provided in Tables 8 to 16 and corresponding Figures 5 to 13. Further detail, by calendar quarter, is also charted.

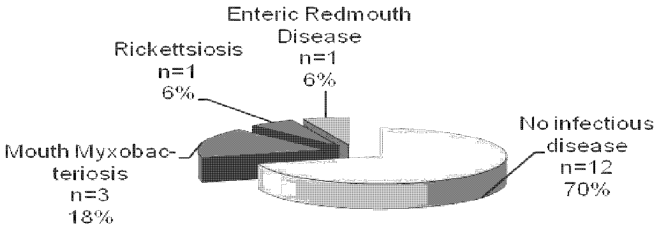
3.3.7.1 Atlantic Salmon

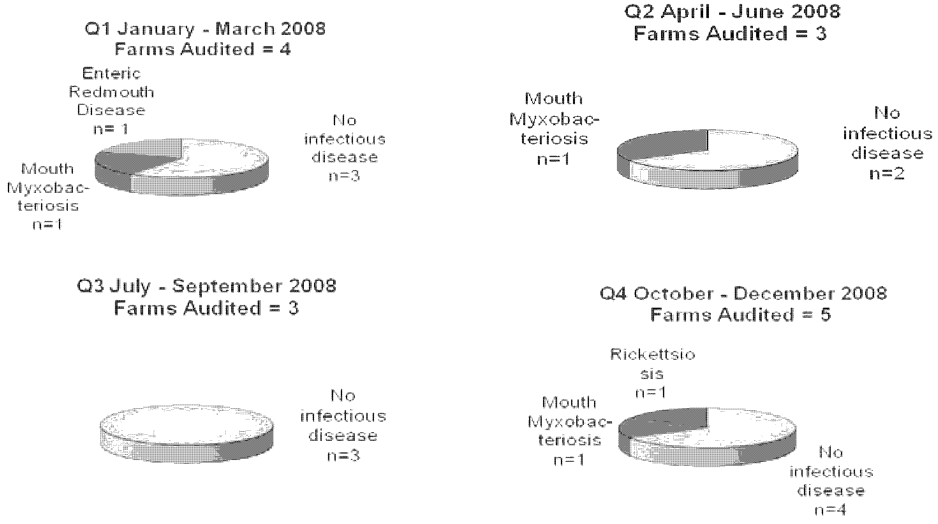
3.3.7.1.1 Sub-zone 2.3 South West Vancouver Island

Table 8. 2008 Diagnoses for sub-zone 2.3 (South West Vancouver Island) Atlantic Salmon Farms		
Number of Farm Audits	Number of Cases [3]	Farm Level Diagnoses
15	12	No Infectious Disease (NID)
	3	Mouth Myxobacteriosis
	1	Enteric Redmouth Disease
	1	Rickettsiosis

* No Infectious Disease (NID) includes: the cases where no identifiable cause for mortality was diagnosed from the carcasses collected, as well as the diseases: environmental, NPLD, enteritis and post-vaccination peritonitis; each of the latter diseases do exhibit lesions but the cause of death is not considered transmissible to other fish.

Figure 5: SW Vancouver Island (Sub-zone 2.3) 2008 Case Summary - Atlantic Salmon



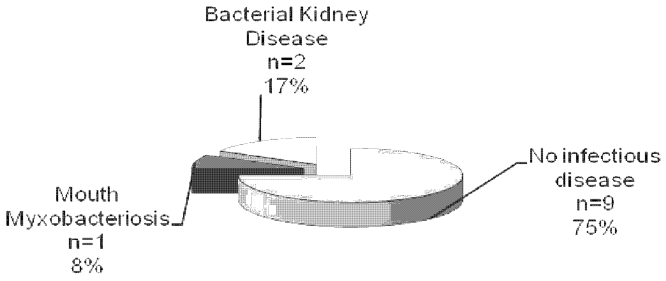


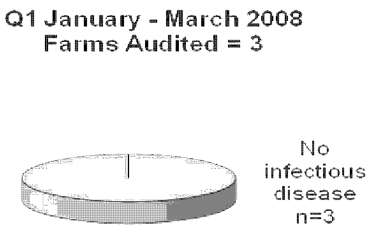
[3] Number of cases does not always equal the number of farm audits because some audits do not result in fish samples. In addition, more than one farm-level diagnosis can be made per farm so the number of cases can exceed the number of farms audited (i.e. 2 diagnoses yet only 1 farm audit).

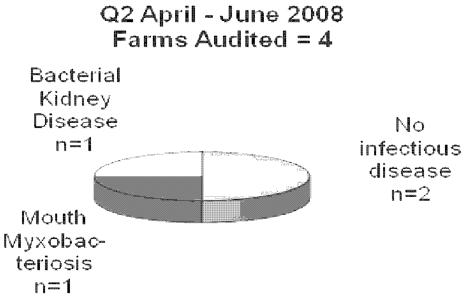
3.3.7.1.2 Sub-zone 2.4 North West Vancouver Island

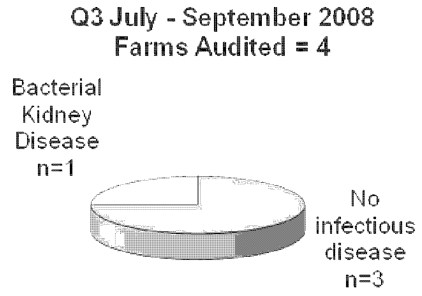
Table 9. 2008 Diagnoses for sub-zone 2.4 (North West Vancouver Island) Atlantic Salmon Farms		
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
12	9	No Infectious Disease
	1	Mouth Myxobacteriosis
	2	Bacterial Kidney Disease

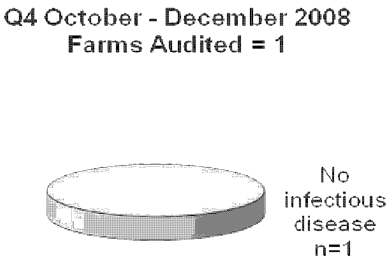
Figure 6: NW Vancouver Island (Sub-zone 2.4)
2008 Case Summary - Atlantic Salmon









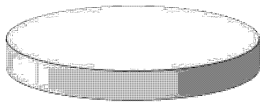


3.3.7.1.3 Sub-zone 3.1 Sunshine Coast

Table 10. 2008 Diagnoses for sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farms

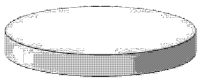
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
3	3	No Infectious Disease

Figure 7: Sunshine Coast (Sub-zone 3.1) 2008 Case Summary - Atlantic Salmon



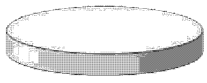
No Infectious Disease n=3 100%

Q1 January - March 2008
Farms Audited = 1



No infectious disease n=1

Q2 April - June 2008
Farms Audited = 1



No infectious disease n=1

Q3 July - September 2008
Farms Audited = 0

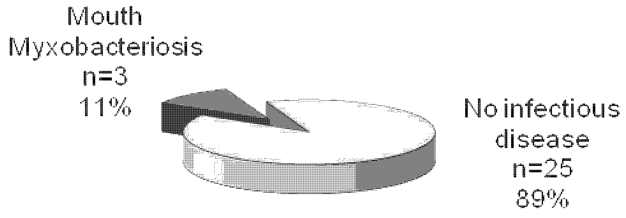
Q4 October - December 2008
Farms Audited = 1

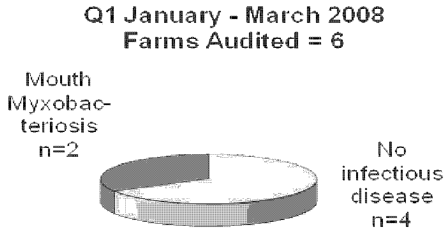
No infectious disease n=1

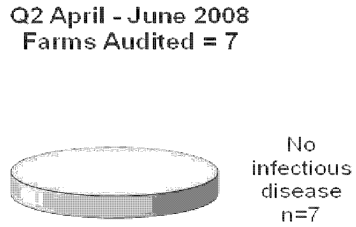
3.3.7.1.4 Sub-zone 3.2 Campbell River Area

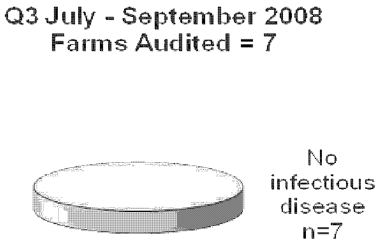
Table 11. 2008 Diagnoses for sub-zone 3.2 (Campbell River / Discovery Islands) Atlantic Salmon Farms		
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
28	25	No Infectious Disease
	3	Mouth Myxobacteriosis

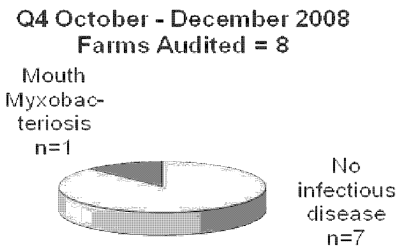
Figure 8: Campbell River (Sub-zone 3.2)
2008 Case Summary - Atlantic Salmon









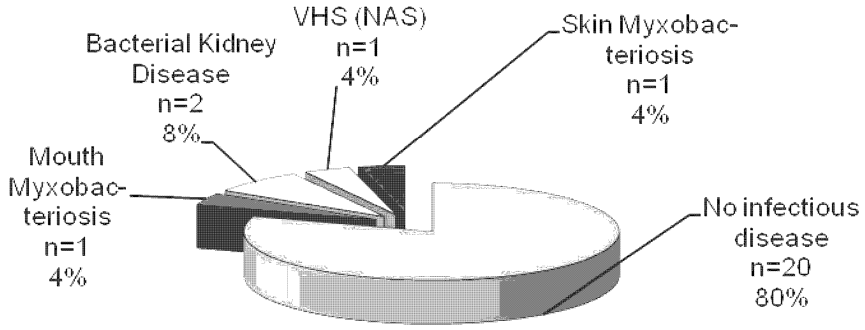


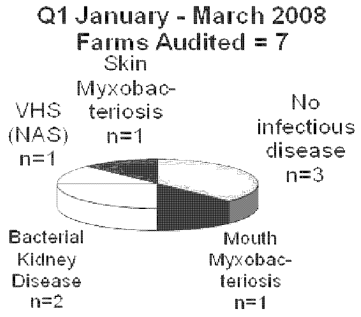
3.3.7.1.5 Sub-zone 3.3 Broughton Area

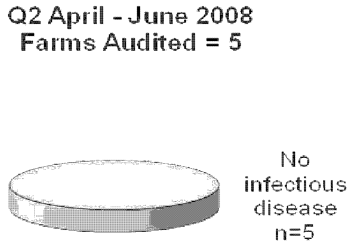
Table 12. 2008 Diagnoses for sub-zone 3.3 (Broughton) Atlantic Salmon Farms

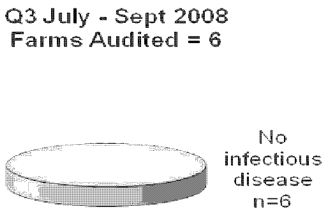
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
24	20	No Infectious Disease
	1	VHS (North American strain genotype IVa)
	1	Mouth Myxobacteriosis
	2	Bacterial Kidney Disease
	1	Skin Myxobacteriosis

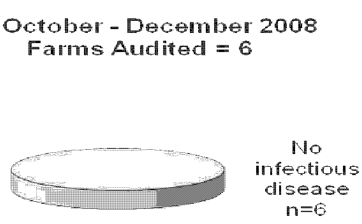
Figure 9: Broughton (Sub-zone 3.3)
2008 Case Summary - Atlantic Salmon







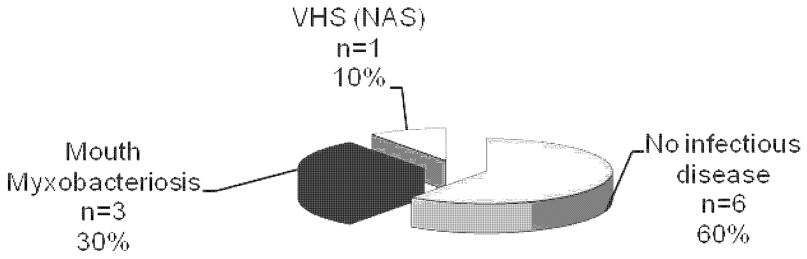


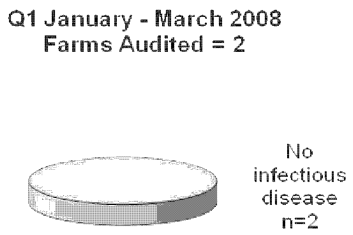


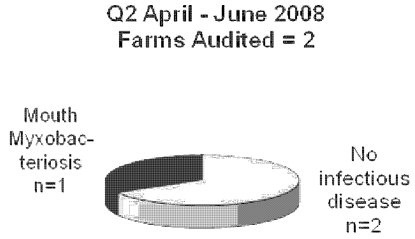
3.3.7.1.6 Sub-zone 3.4 Port Hardy Area

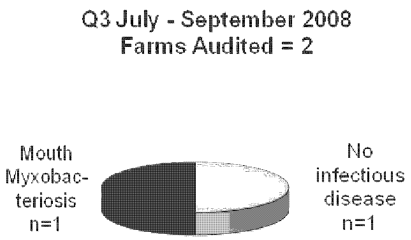
Table 13. 2008 Diagnoses for sub-zone 3.4 (Port Hardy) Atlantic Salmon Farms		
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
8	6	No Infectious Disease
	3	Mouth Myxobacteriosis
	1	VHS (North American strain genotype IVa)

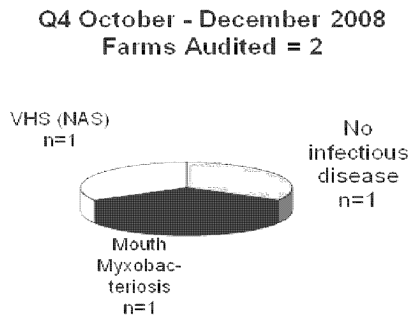
Figure 10: Port Hardy (Sub-zone 3.4)
2008 Case Summary - Atlantic Salmon









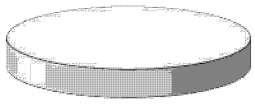


3.3.7.1.7 Sub-zone 3.5 Central Coast

Table 14. 2008 Diagnoses for sub-zone 3.5 (Central Coast) Atlantic Salmon Farms

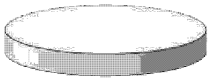
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
8	8	No Infectious Diseases

Figure 11: Central Coast (Sub-zone 3.5)
2008 Case Summary - Atlantic Salmon



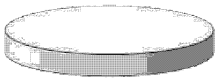
No infectious disease n=8 100%

Q1 January - March 2008
Farms Audited = 2



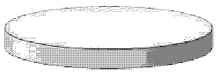
No infectious disease n=2

Q2 April - June 2008
Farms Audited = 2



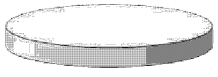
No infectious disease n=2

Q3 July - September 2008
Farms Audited = 2



No infectious disease n=2

Q4 October - December 2008
Farms Audited = 2



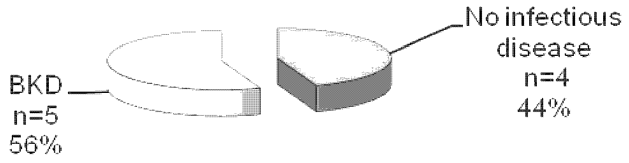
No infectious disease n=2

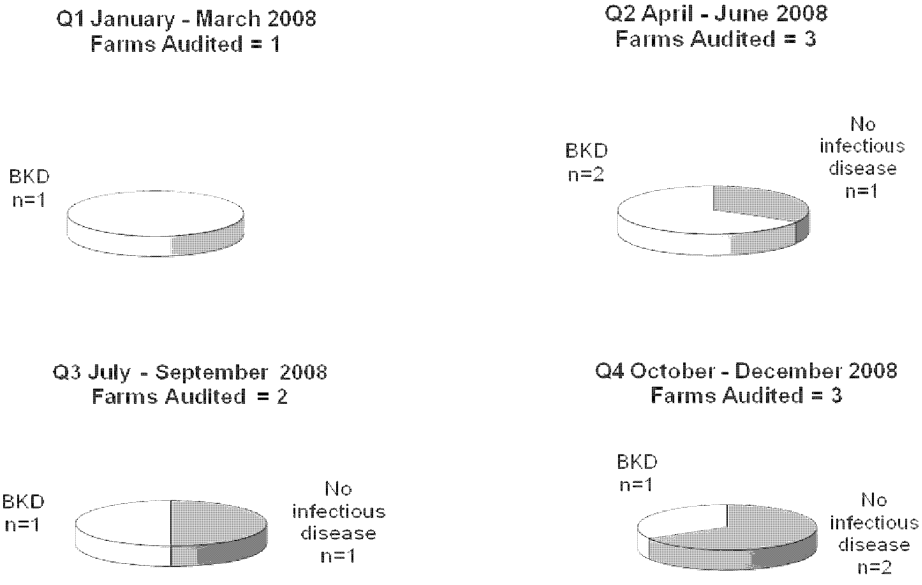
3.3.7.2 Pacific Salmon

3.3.7.2.1 Zone 2 Vancouver Island

Table 15. 2008 Diagnoses for Zone 2 (Vancouver Island) Pacific Salmon Farms		
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
9	4	No Infectious Disease
	5	BKD

Figure 12: Vancouver Island (Zone 2)
2008 Case Summary - Pacific Salmon





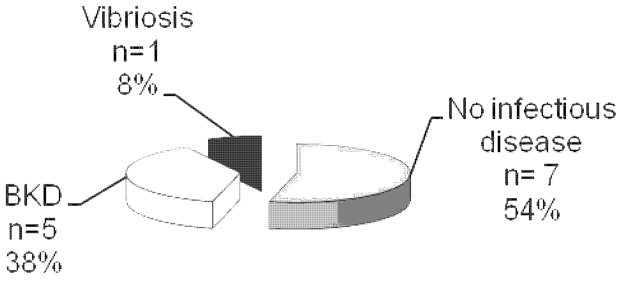
3.3.7.2.2 Zone 3 East of Vancouver Island

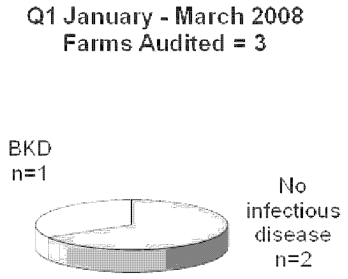
Table 16 2008 Diagnoses for Zone 3 (East of Vancouver Island) Pacific Salmon Farms *

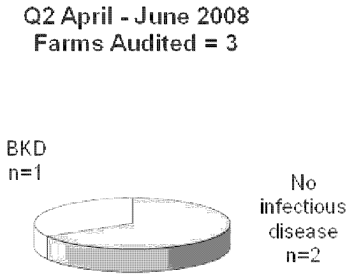
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
12	7	No Infectious Disease
	5	BKD
	1	Vibriosis

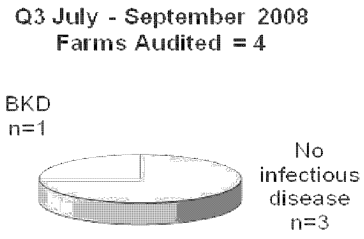
* These audit cases of Zone 3 include results from two fish rearing facilities that are not considered conventional 'production farms'; rather, they are best described as a pilot farm and a research-focused facility.

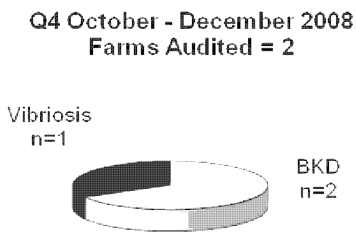
Figure 13: East of Vancouver Island (Zone 3) 2008 Case Summary - Pacific Salmon











3.4 Comparison to Industry

One major objective of the Fish Health Program is to, as best as the quantitative data allows, 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. The audits are not expected to estimate total proportion of disease diagnosed amongst industry farms. To do so would require Ministry staff to be present on all farms, at all times. Rather, that disease information is captured in the industry reports required as part of Fish Health Management Plans and it is available quarterly on the Ministry website: http://www.al.gov.bc.ca/ahc/fish_health/index.htm. The industry reports represent all production farms, not pilot or research facilities, and therefore provide a more complete picture of the health status of farmed salmon. The health audits enable a randomized validation of the industry-reported information, with additional targeted disease testing.

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

1. Average mortality (by species) and by fish health zone for both fresh and salt water sites (see Figure 14 – Atlantic salmon)
2. Mortality Rates by Infectious and Non-infectious Cause
3. Fish Health Events (see Figures 15a and 15b)

Fish Health Events are situations of husbandry or disease management where intervention by a veterinarian typically occurs. In other words, a diagnosis, recommendation/report or prescription medication arises. Routine lice management activities also fall within this definition. 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 BCSFA reports are incorporated in this report as Appendix 7.7 and 7.8. An annual summary of those Fish Health Event diagnoses is displayed in Figures 15a and 15b. The BCSFA database contains a complete dataset from individual production farms as opposed to the aggregate 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 FHMP.

The Ministry audit data is a smaller data set; however, it has greater specificity (lower probability of false negatives) than does the industry data. The audit information in Figures 4, 4a and Figures 5 through 13 is useful to verify the BCSFA's results graphed in Figures 14, 15a and 15b below, with the possible exception of audit Figure 13 which includes two non-conventional Pacific salmon operations that do not report to the industry database.

There is strong agreement between audit results and FHE reports from the BCSFA. Indigenous pathogens are found 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. Enteric Red Mouth and Rickettsiosis are, on occasion, detected during an audit yet may not have triggered a farm-wide treatment since these infections can be managed concurrently with a medication prescribed to address Bacterial Kidney Disease or Mouth Myxobacteriosis in the same group of fish.

Figure 14. BCSFA data: The average quarterly mortality rate of Atlantic salmon (from smolt to brood) reported by the BCSFA in 2008 was generally less than 2% with the exception of the outer coast of Vancouver Island that experienced losses of 3 to 5% due to environmental phenomena and predation. Data from sub-zones 3.1 and 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).

Figure 14 2008 BCSFA Data: Average Quarterly Mortality (due to All Causes) - Atlantic Salmon (Smolt to Brood)

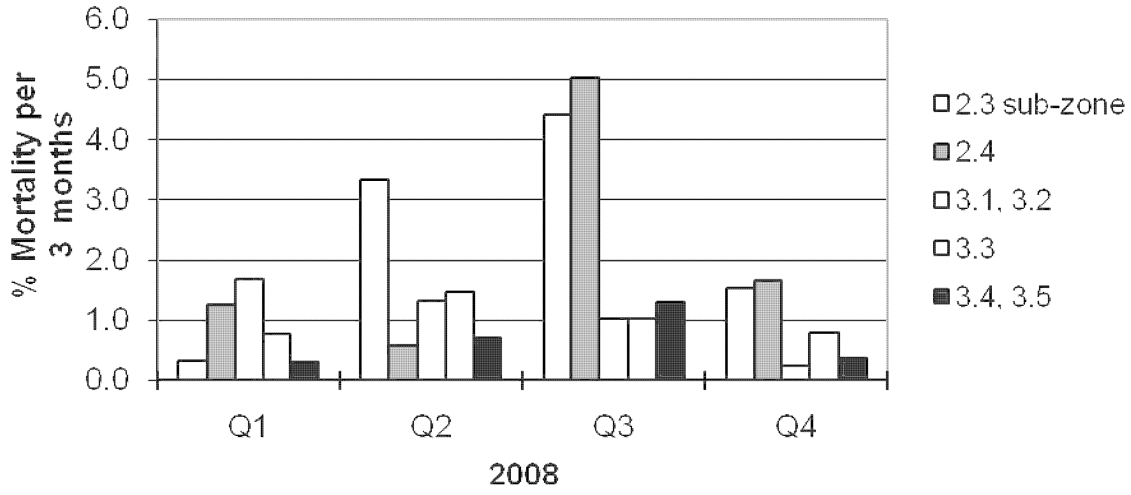


Figure 15a BCSFA data: Annual Fish Health Events of groups of Atlantic salmon within farms that do experience an FHE; reported quarterly by the BCSFA in 2008 for all zones.

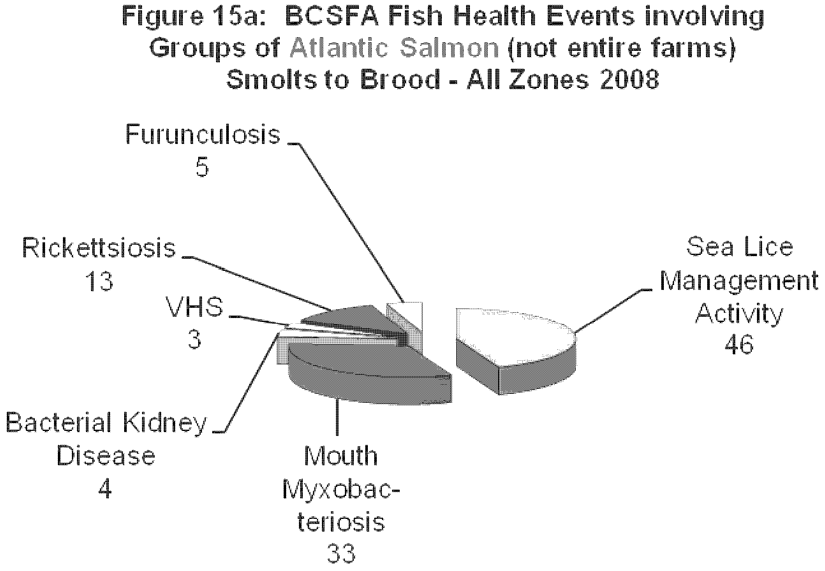
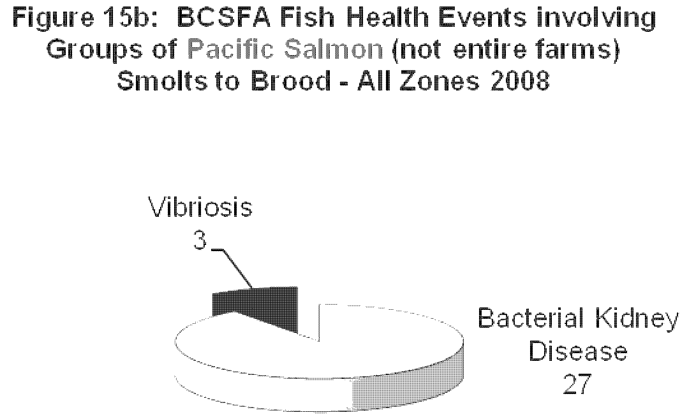


Figure 15b BCSFA data: Annual FHEs of groups of Pacific salmon within production farms (not pilot or research facilities) reported by the BC Salmon Farmers Association each quarter in 2008 for all zones. Twenty seven cases of BKD and three cases of vibriosis were the only Fish Health Events reported as requiring husbandry or veterinary management in cultured Pacific salmon.



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 both 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 available from wild stock measurements as data become available via DFO and 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 has been actively monitoring the status of lice infections on BC salmon farms since 2003. A lice management strategy is integral to FHMPs and the lice audits target active Atlantic salmon farms of BC. As part of the reporting requirement of the FHMPs, 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 2008, Ministry fish health staff conducted 71 random farm audits and assessed over 4,200 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, and
2. BCMAL's audit of these procedures.

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. 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 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.

The lice monitoring program assesses the abundance and life stages of two types of sea louse found on farmed fish: the 'salmon louse', *Lepeophtheirus,* and the 'herring louse', *Caligus*, 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 once a month within most coastal sub-zones (unless an acceptable reason for not sampling was provided [4]). 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 to July), should a farm reach that same trigger level, the lice management strategy outlines additional action, such as treatment or harvest, be adopted to reduce the average abundance of lice on that farm. 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 ensures representative sampling of the population. The method of capture is recorded by staff. Twenty fish are dip-netted into an anaesthetic bath although, on occasion when other tests are underway, farms choose to humanely euthanize the fish before examination. 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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[4] 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 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 from March to July either harvest or treatment is undertaken to reduce lice concentrations per fish. For the remainder of the year management action includes more frequent counts (i.e. two per month) in addition to other husbandry considerations and management efforts.

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. The unit of concern is the fish health sub-zone. To reiterate, all farms within a zone are assigned a random number and selection of the farms within a sub-zone for sampling 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 has 30% of the farms then only 30% of the farms in the area would be randomly selected. This ensures equal probability of each farm being selected for audit.

Twenty five percent of the active[5] 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 well as the latest treatment to reduce lice that may have occurred in that quarter. 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.

[5] 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 counting procedures are evaluated during the farm visit. BCMAL bio-technicians are experienced in fish handling and follow standard operating procedures for fish handling, anaesthesia and lice counts.

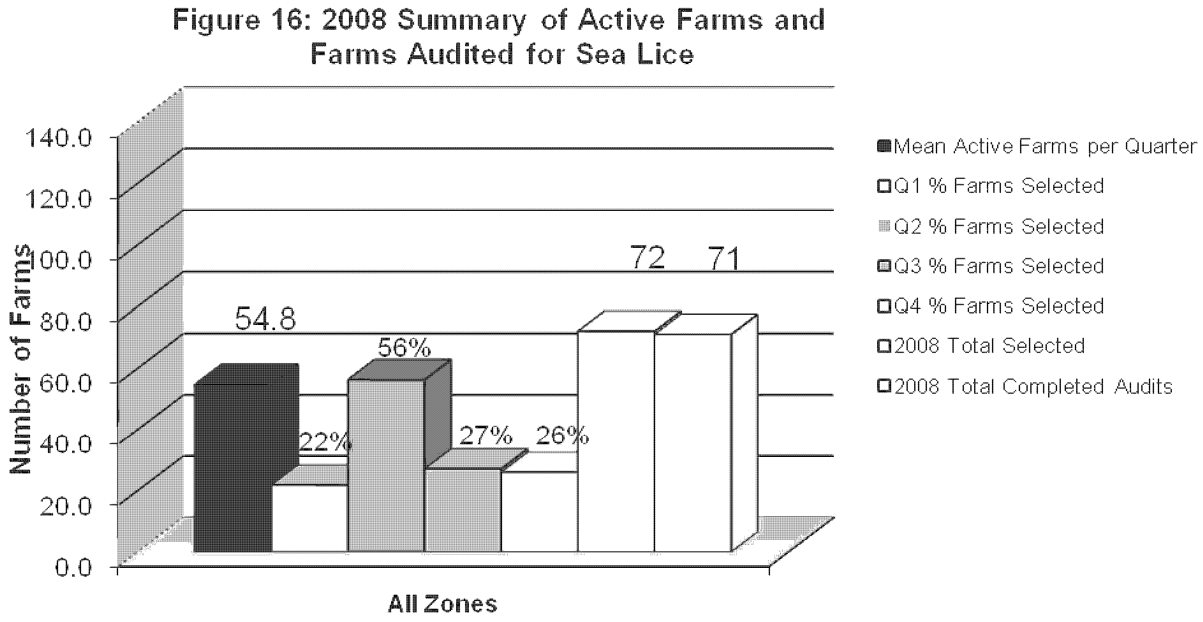
BCMAL lice audit data are collected on days that the farm's lice count is already scheduled. Audit data contributes to the monthly and twice-monthly data collected by industry. As such, the BCMAL data is a sub-set of the farm-reported data and therefore is not an independent estimate of sea lice abundance. 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 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 anaesthetic bath are 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 2008. It is common for one or two farm visits to be cancelled 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 one audit cancellation.

Table 17: 2008 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	12	31	16	13	72
# farms audited	12	30	16	13	71
# fish examined	700	1,800	960	780	4,240



The on-farm, split-sample, lice-counting procedure and the examination of records represents a compliance audit. The split-sample counts are combined and submitted as that farm's monthly count (except in quarter 2 when the farm must submit its own second independent count as well) and these data are recorded as the audit 'snapshot' of the farm. 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 Figures 16a/b show the results of the BCMAL lice audits. These represent the mean abundance of sea lice on Atlantic salmon for all sub-zones in 2008.

The difference between mean lice counts obtained by BCMAL and those obtained by farm staff were evaluated 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 pairwise comparison). In one quarter, BCMAL counts were significantly higher than farm counts for the *Lepeophtheirus* motile stages (at the sub-zone level, Student 't' test, p=0.012). In that same quarter, farm counts were significantly higher than BCMAL counts for the *Lepeophtheirus* female stages (at the sub-zone level, p=0.0037). There was second case of higher female lice counts by farm staff (p=0.048); however, this was the sole farm audited for the sub-zone and the difference in counts was considered a farm level difference.

At the sub-zone level, some significant differences were identified between farm and BCMAL counts for *Caligus* motile stages. However, *Caligus* motile stages tend to detach from fish during the handling so *Caligus* count comparisons are not considered worthy.

In summary, disagreement occurred in three of 52 testable (non-zero) comparisons of the counts of *Lepeophtheirus* motile or female stages. This 94.3% agreement is the same as that found from 2004 to 2007, i.e. since the inception of the auditing program. This level of agreement between split-sample count results provides confidence in the technical proficiency of the farm personnel generating the abundance estimates that industry reports.

In the sub-zone where BCMAL staff counted more motile lice, BCMAL conducted a follow-up workshop to address the disagreement.

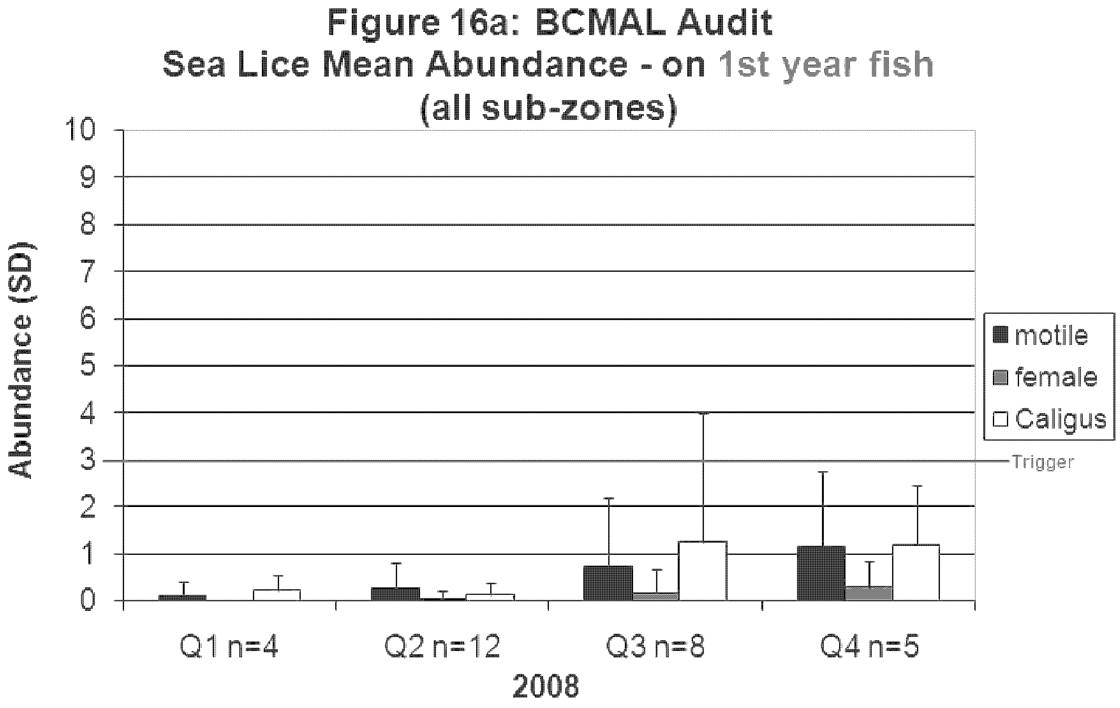
Table 18a. Mean abundance of motile, female *L. salmonis*, chalimus sea lice and motile *Caligus clemensi* during Atlantic salmon farm audits in 2008 (per quarter) – 1st year class*

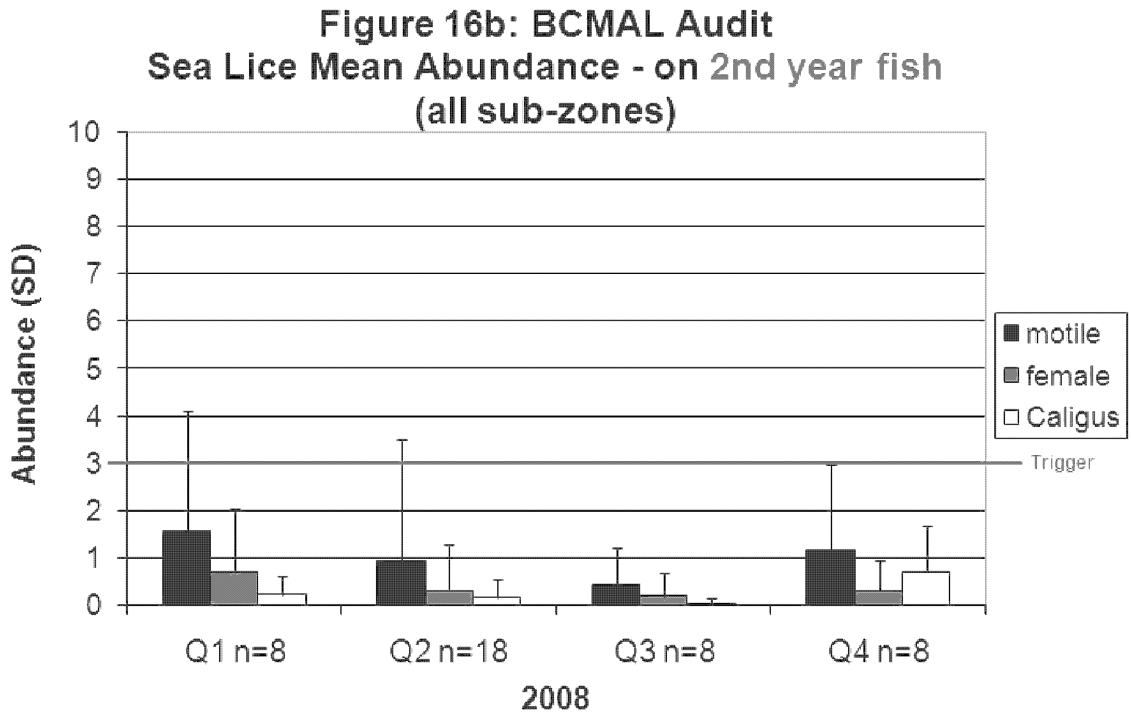
2008 Mean Abundance	Q1	Q2	Q3	Q4
Number of Farms Audited (n)	4	12	8	5
Motile	0.11	0.25	0.74	1.15
Standard Deviation (SD)	0.32	0.56	1.45	1.59
Female	0	0.036	0.17	0.29
SD	0	0.17	0.52	0.56
Chalimus	0.38	0.32	1.40	1.54
SD	0.73	0.81	3.17	2.91
Caligus Motile	0.23	0.12	1.24	1.19
SD	0.32	0.25	2.76	1.26

Table 18b. Mean abundance of motile, female *L. salmonis*, chalimus sea lice and motile *Caligus clemensi* during Atlantic salmon farm audits in 2008 (per quarter) – 2nd year class

2008 Mean Abundance	Q1	Q2	Q3	Q4
Number of Farms Audited (n)	8	18	8	8
Motile	1.57	0.92	0.42	1.15
Standard Deviation (SD)	2.52	2.58	0.80	1.82
Female	0.71	0.30	0.19	0.30
SD	1.34	0.97	0.50	0.64
Chalimus	0.56	0.38	0.21	1.88
SD	1.13	1.47	0.79	4.15
Caligus Motile	0.22	0.16	0.03	0.70
SD	0.38	0.38	0.10	0.97

* Tables of audit data (of medians and means) on separate year classes of Atlantic salmon not including tote counts (i.e. fish only data) 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 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 must be available for audit review to BCMAL fish health staff upon request.

4.5.6 Evaluation and Audit Comparison to Industry Lice Reports

The 2008 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 and b. The overall average remains well below three lice per fish in each calendar quarter. 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 597 counts on approximately 36,000 live fish. The sub-zone tables and bar charts submitted by BCSFA to BCMAL monthly are found in Appendix 7.11.

In Figures 17 a/b, and 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 (tote count), present a 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 divided by 20, 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.

Figure 17a: BCSFA Sea Lice Mean Abundance
Atlantic Salmon Farms - 1st Year Class
(all sub-zones)

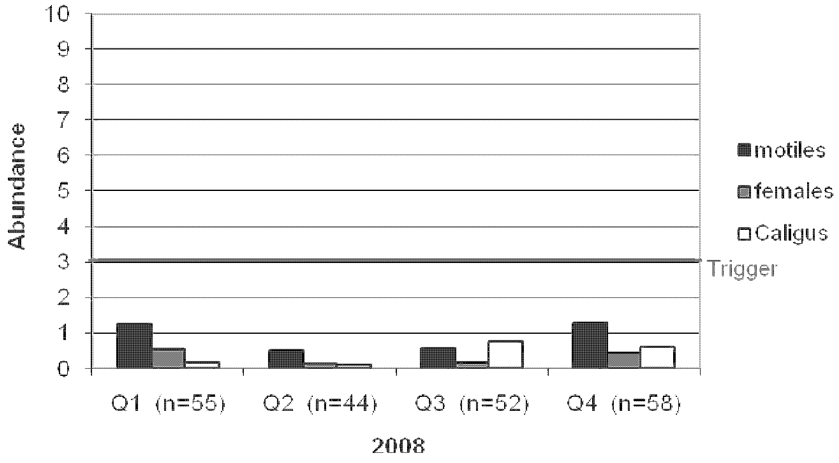
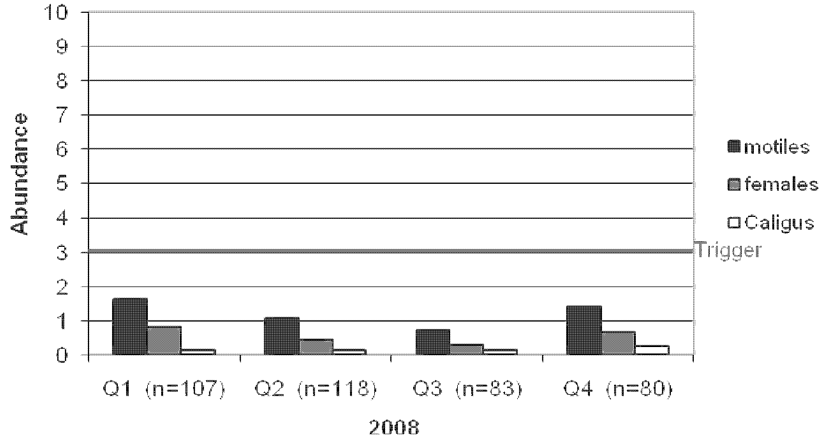


Figure 17b: BCSFA Sea Lice Mean Abundance
Atlantic Salmon Farms - 2nd Year Class
(all sub-zones)



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 estimates (bars) overlying monthly average lice abundance (lines) submitted by industry. 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 'time of data collection' the BCMAL sub-sampling validation shows acceptable agreement with the abundance reported by industry. In general, the lice abundance on farmed Atlantic salmon was the lowest level seen since the inception of BC's monitoring and audit programs. For more detail by sub-zone, refer to Appendix 7.10.

Figure 18a: Sub-zone 2.3, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

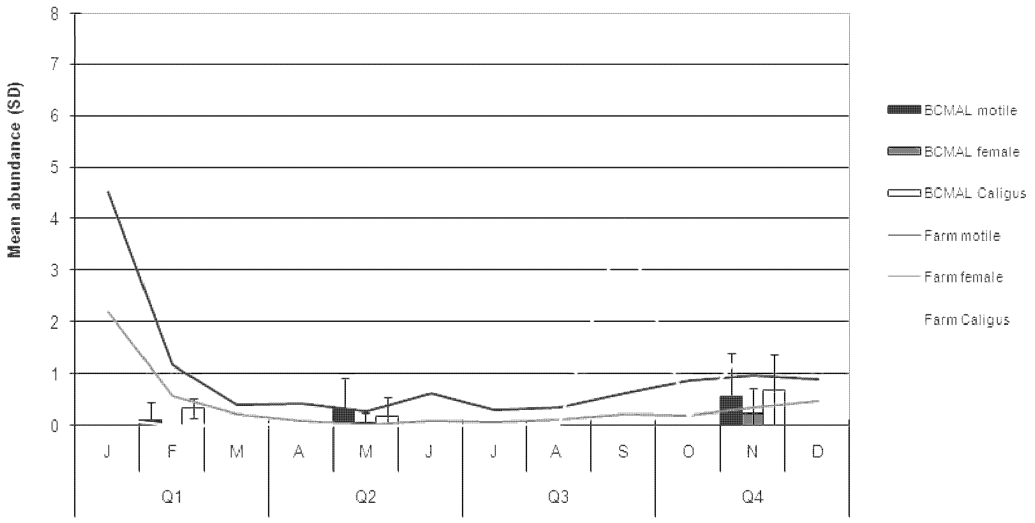
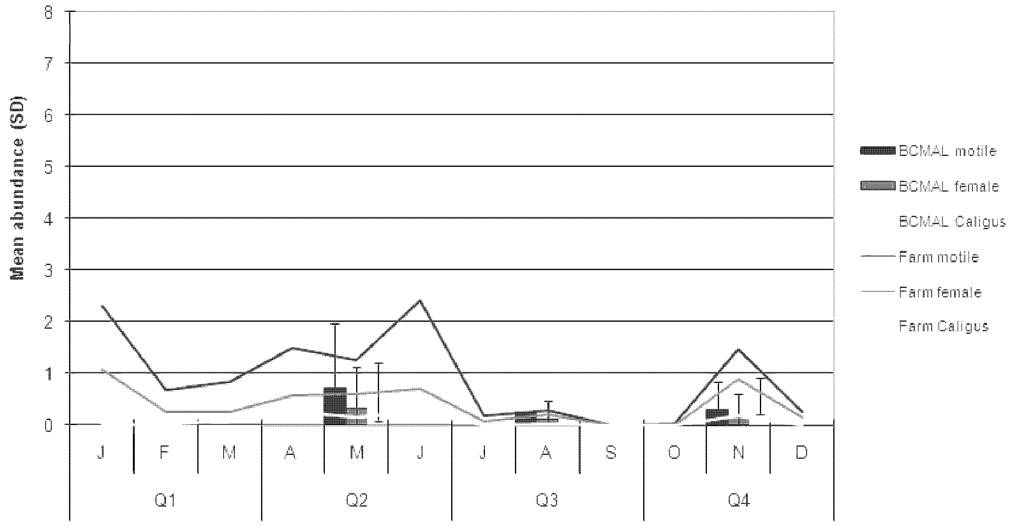


Figure 18b: Sub-zone 2.3, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008



NB. Farm monitoring and audit activity identified an abundance of *Caligus* lice species in sub-zone 2.3 in quarters 3 and 4. *Caligus* species are common on non-salmonid fishes. Their presence in 2008 is attributable to wild herring and pilchard populations near salmon farms. *Caligus* lice are considered opportunists and incidental on salmon, nevertheless monitoring is useful.

Figure 19a: Sub-zone 2.4, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

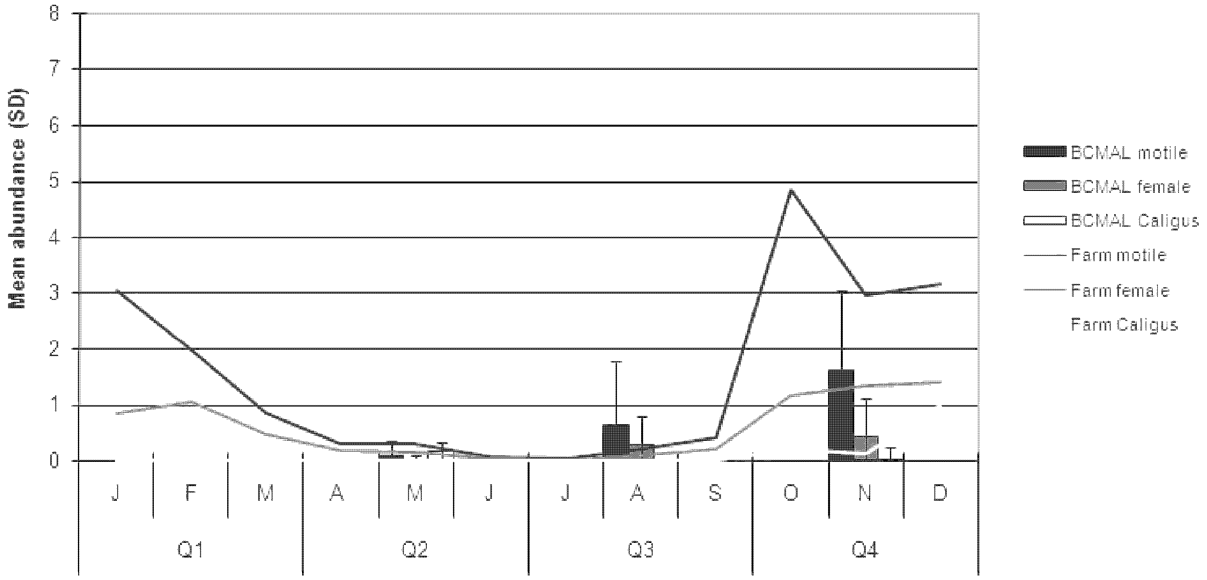


Figure 19b: Sub-zone 2.4, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

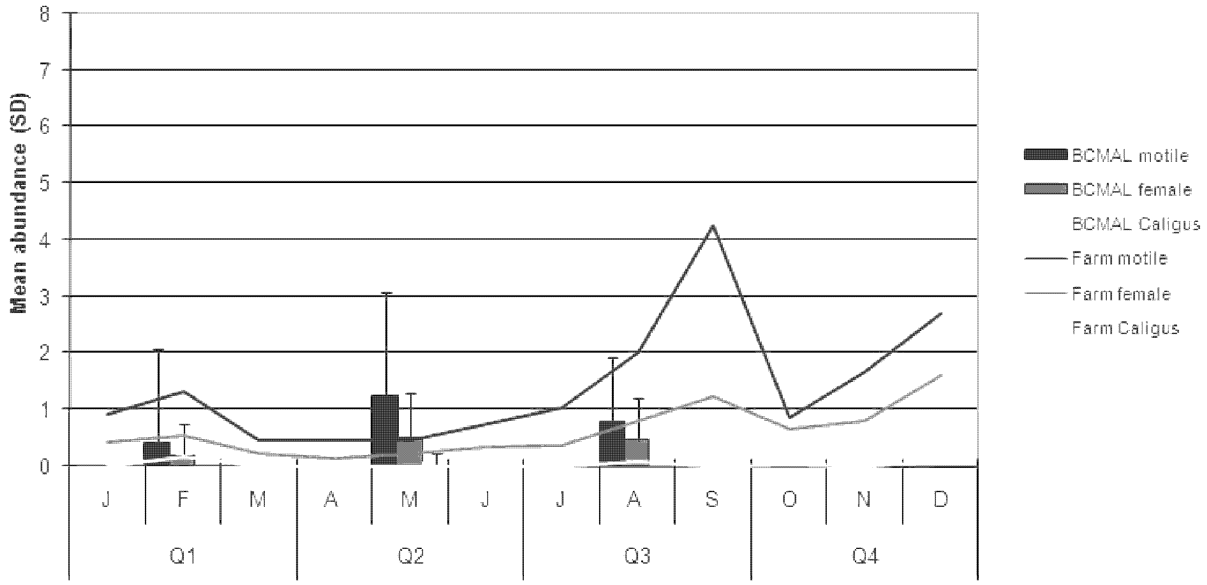


Figure 20a: Sub-zone 3.1, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

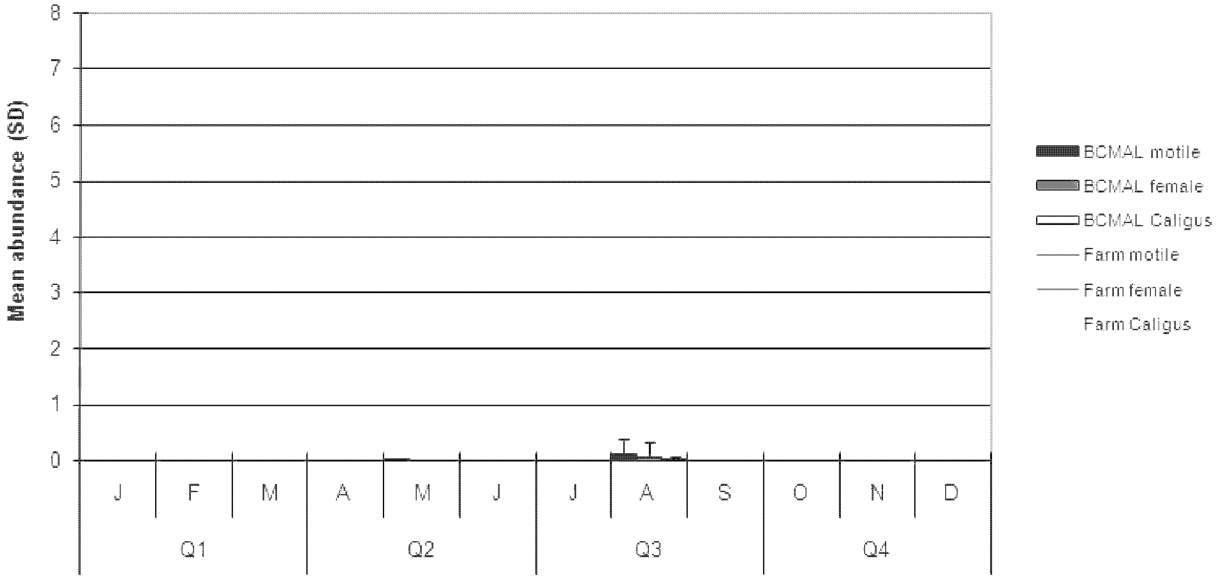
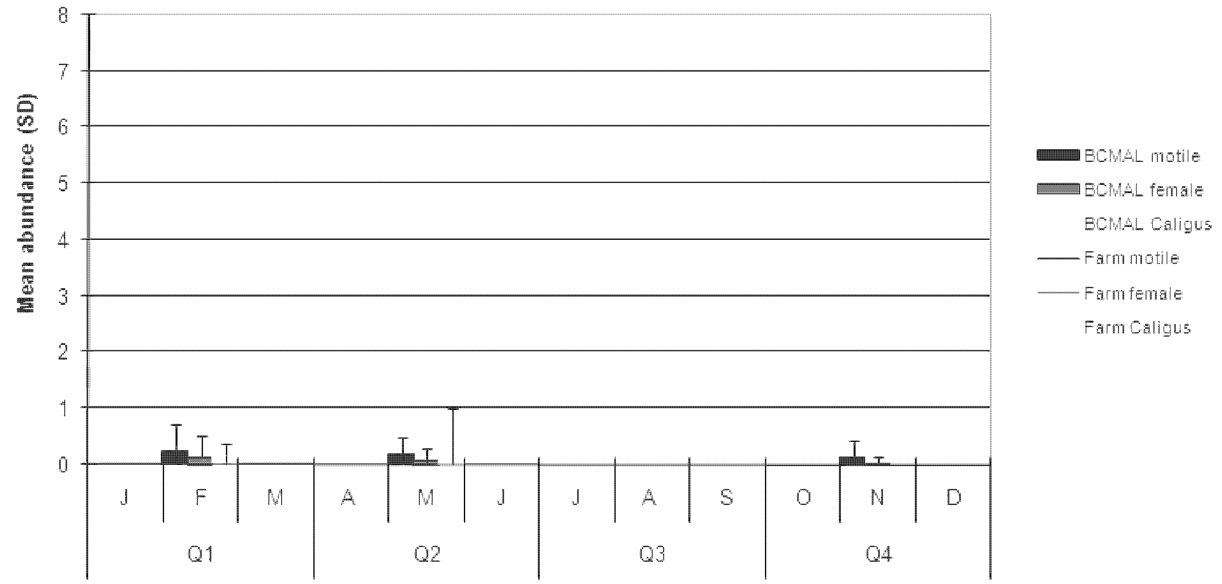


Figure 20b: Sub-zone 3.1, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008



NB. Farms operating in sub-zone 3.1 are currently exempt from routine monitoring and reporting sea lice abundance due to the historically very low abundance on the Atlantic salmon. The stress & handling of fish was deemed an excessive risk relative to the value of the data generated. BCMAL however continues to assess the Atlantic salmon as per its audit selection procedure.

Figure 21a: Sub-zone 3.2, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

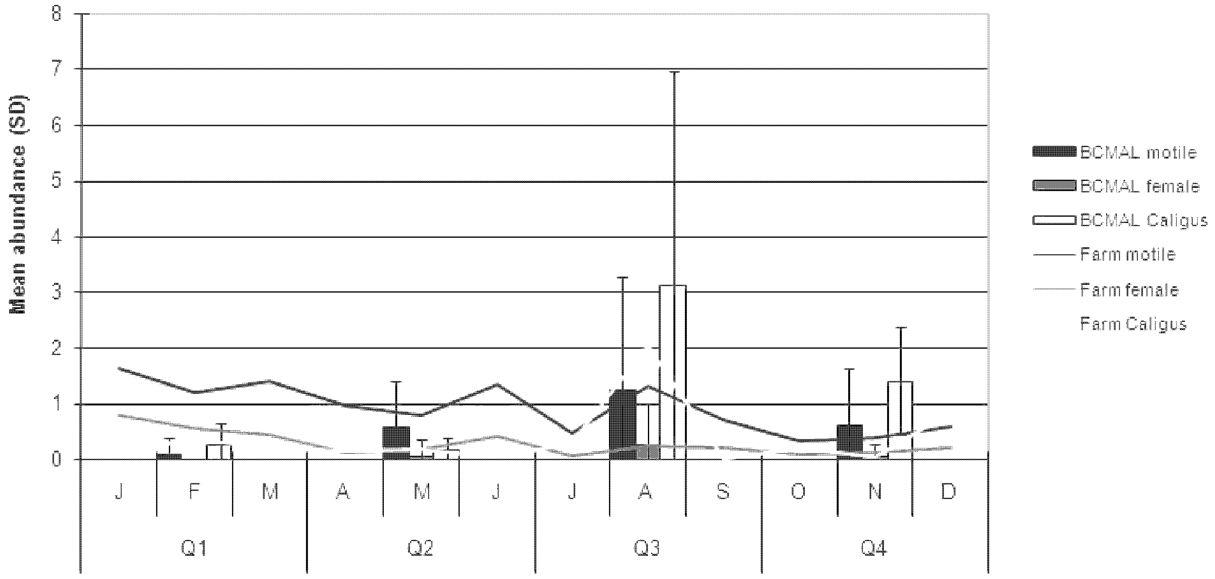
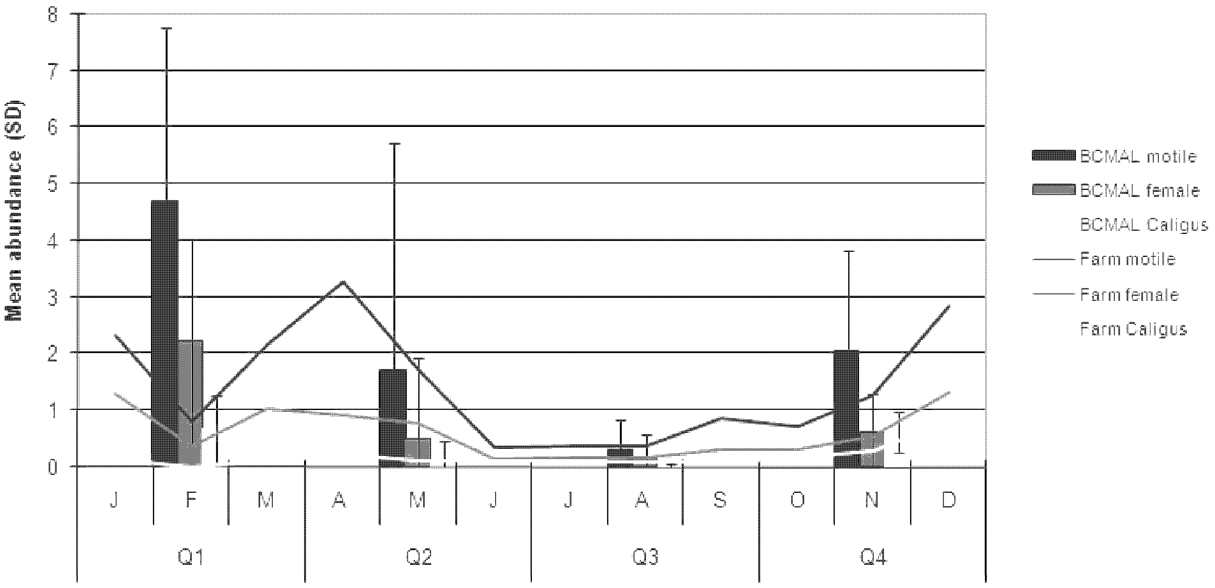


Figure 21b: Sub-zone 3.2, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008



NB. An unanticipated rise in motile sea lice abundance in February-March 2008 was identified and reported by producers within sub-zone 3.2. At some farms the abundance surpassed the 3 motile per fish trigger level in quarter 2 and the affected farms were managed accordingly. The lice levels declined promptly.

Figure 22a: Sub-zone 3.3, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

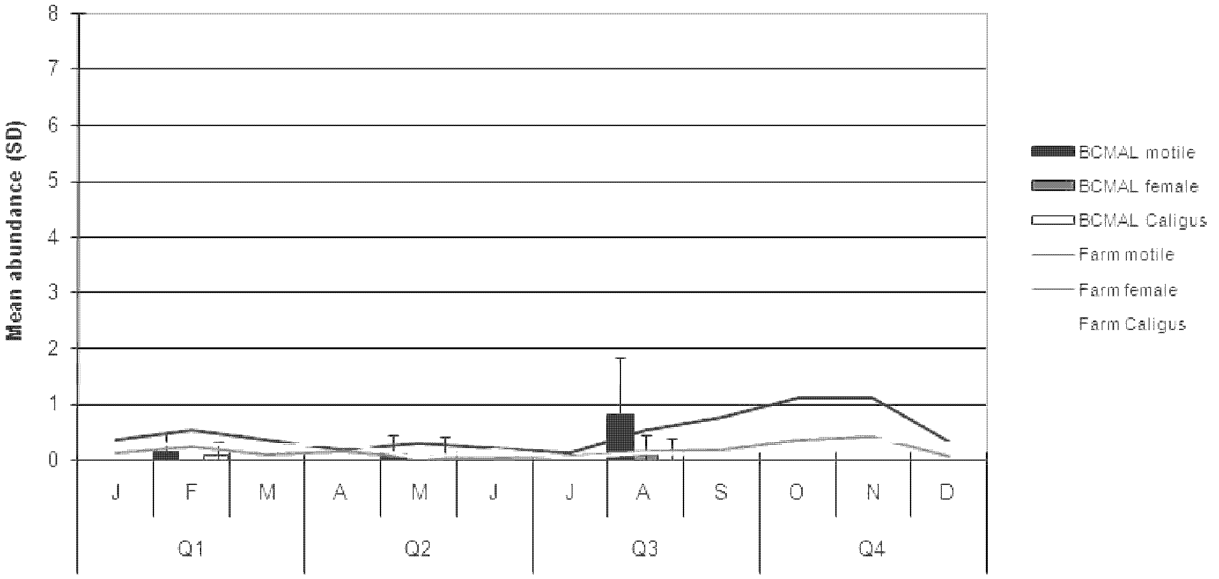


Figure 22b: Sub-zone 3.3, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

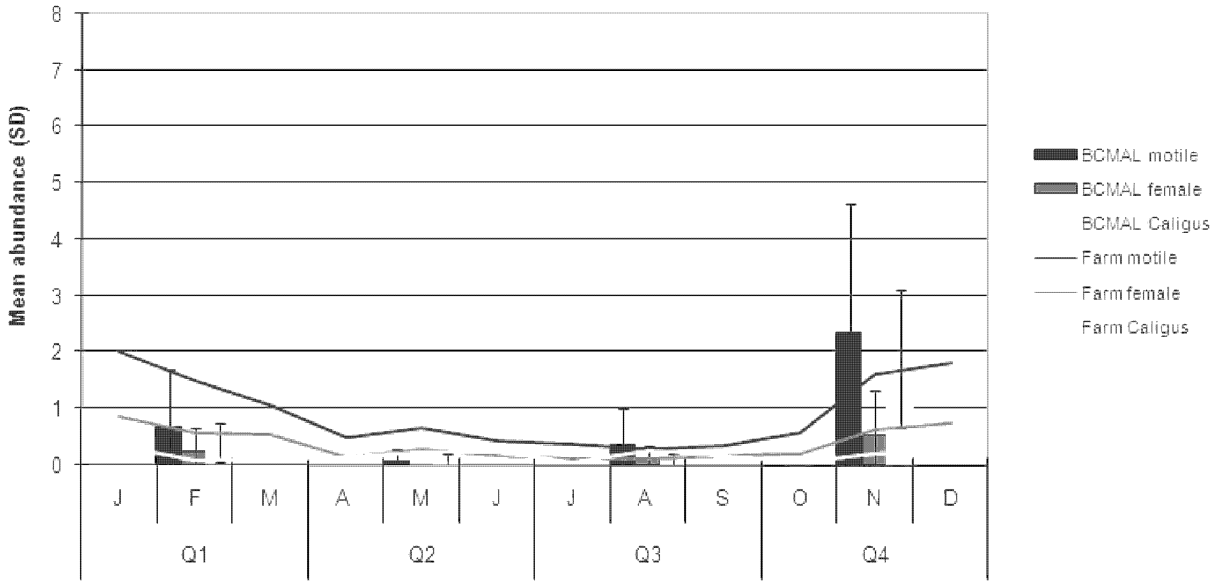


Figure 23a: Sub-zone 3.4, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

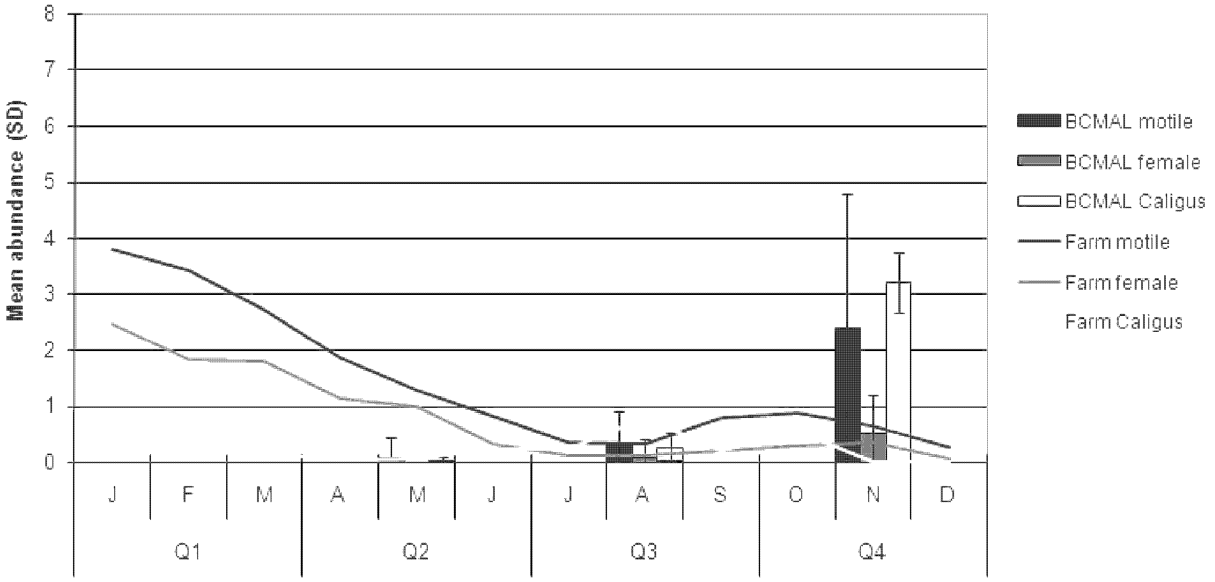


Figure 23b: Sub-zone 3.4, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

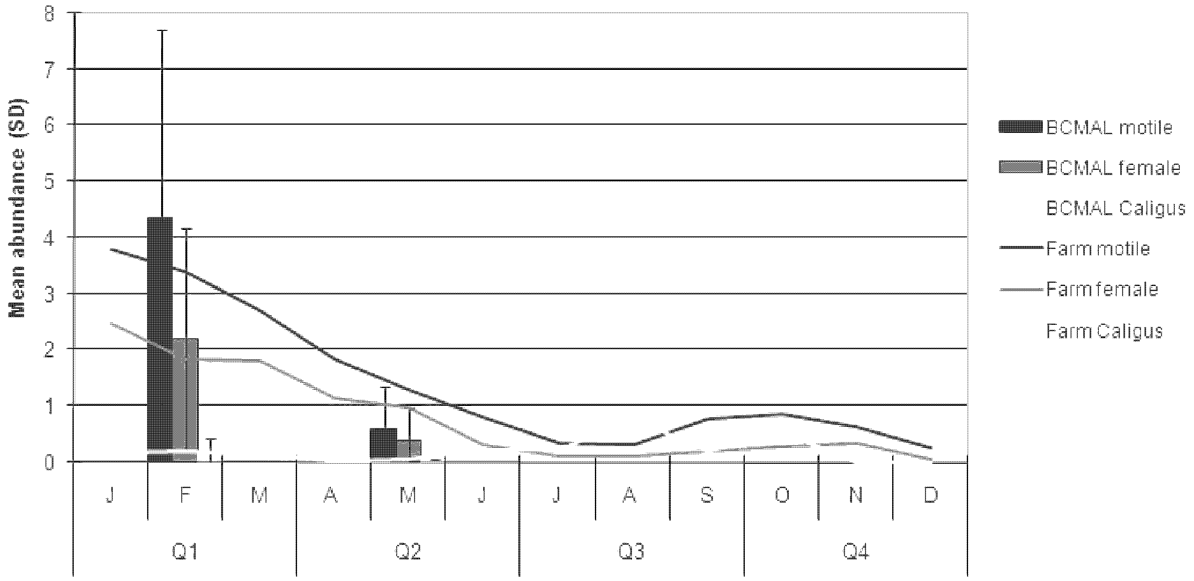


Figure 24a: Sub-zone 3.5, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008

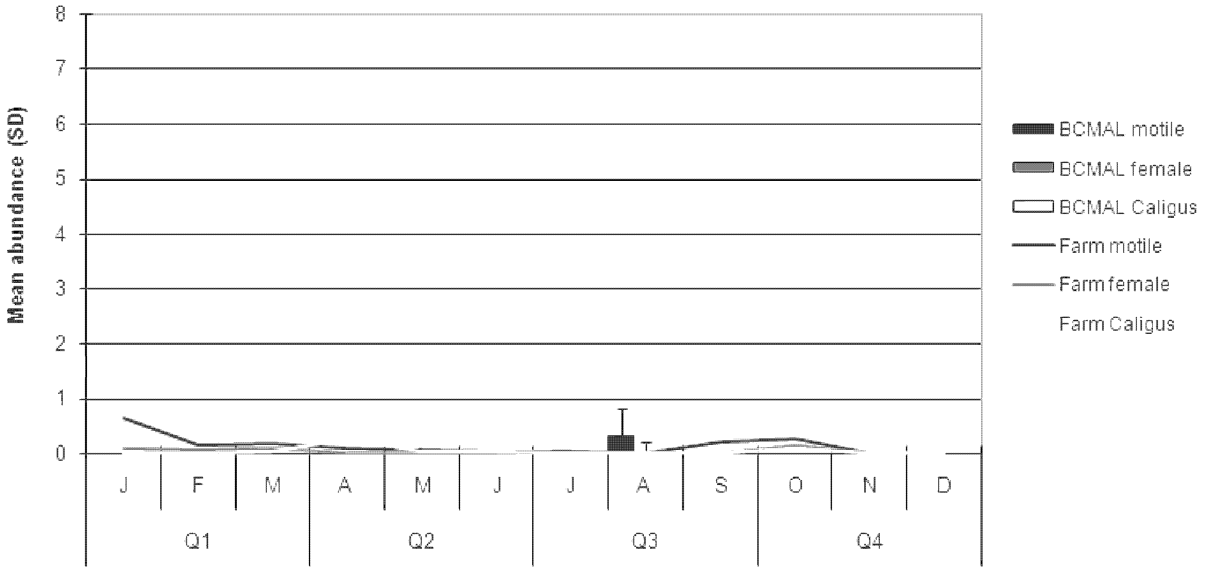
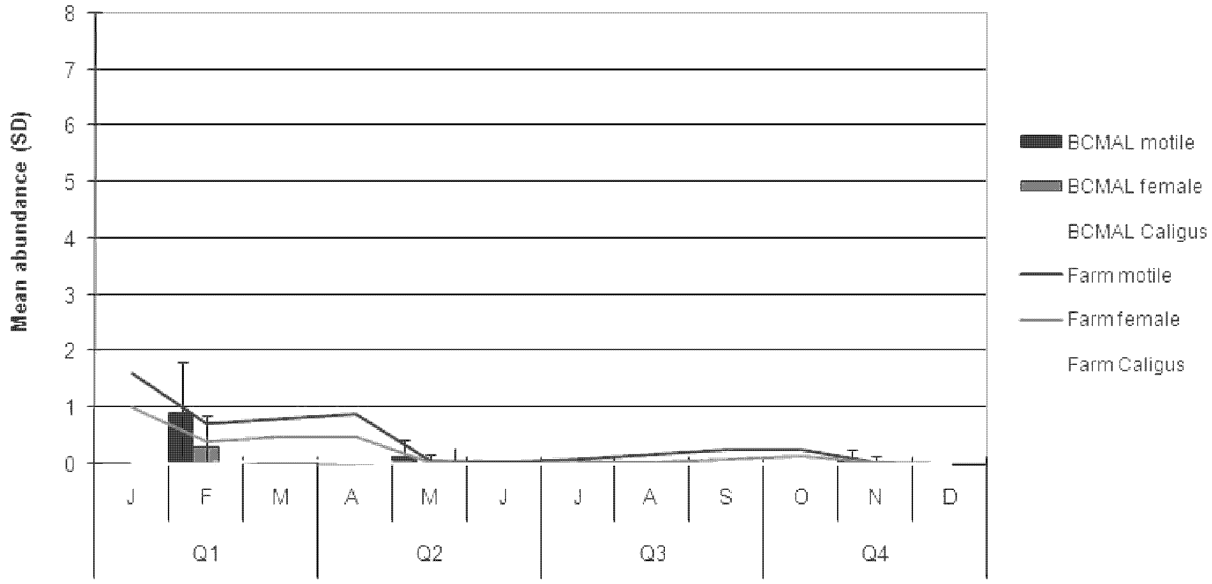


Figure 24b: Sub-zone 3.5, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2008



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 FHMPs (2003-2009) and also instituted the audit and verification program.

In 2004/05 all the data collected from farm and the government 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 autumn inward migration of adult wild salmon, the abundance of sea lice can be higher on wild fish than is found on farmed fish. Treatment, in the face of increased background levels of sea lice and recruitment of the parasites from wild sources, would reduce the efficacy of treatment hence, during the autumn; lice abundance on farms sometimes exceeds the trigger value of three. In this case, monitoring frequency must be increased by farm staff at the affected location.

The in-feed drug available to control sea lice, emamectin benzoate (trade name SLICE®), 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 return of adult wild salmon) the result is low lice abundance on farms during the wild juvenile out-migration period. BCMAL and DFO continue to work with the aquaculture sector to ensure these necessary data are gathered to integrate findings with the farm management programs.

4.7 Comparison to Other Countries

The trigger levels for treatment of lice in Norway recently tightened to 0.5 adult females or three motile lice per fish throughout the year. To our knowledge, Scotland has target levels but has no assigned abundance values that trigger medical management of lice. A summary of the 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 (2009)	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 (Quarter 2 of 2006, 2007, 2008) indicates that an abundance of zero to three motile lice per fish includes (on average) 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 set 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 Atlantic sea lice in Atlantic Ocean regions. Recent 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 sea louse look identical, the Pacific *L. salmonis* louse is genetically distinct from the Atlantic Ocean louse (i.e. 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 - 2008

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 2008.

Summary:

- Abundance of lice on farmed fish in 2008 during the out-migration period of wild fry (March to July) was well below the trigger level of 3 motile lice per fish in all sub-zones. In most cases the lice abundance on the salmon farms in late 2007 and early 2008 had declined or been managed such that fewer than 2 motile lice per fish were present by April 2008. That abundance of motile lice remained low, typically for five or six months. In other words, no within-farm recruitment of lice populations was evident between March and August 2008.
- 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).
- 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. Sub-zone 3.1 (Sechelt) has not had its lice abundance approach the trigger level since monitoring began whereas other areas experience increases in lice abundance each autumn. With the exception of the autumn and winter months in 2008, most sub-zones showed a louse abundance that averaged less than 1.0 motile louse per fish.
- Abundance of lice varies naturally from year to year. Sea lice data have been collected and reported consistently for more than five years in BC (2004 -2008 inclusive) using a standardised protocol and reporting structure. Annual comparisons interest some people 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.
- Sea lice are naturally occurring parasites of fish. Data collected from wild stocks shows that returning adult salmon carry high numbers of sea lice. Undoubtedly this host-parasite relationship is a natural phenomenon of salmon.
- Marine conditions 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; 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 below 1.0 motile lice per fish for seven to nine consecutive months in 2008, including the period of wild salmon out-migration; average abundance remain well below 3 motile lice per fish throughout 2008 . 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 2008:

- Juvenile Atlantic salmon (1st year class fish) had an average lice abundance less than 0.5 motiles per fish from January through September 2008.

- Larger 2nd year class fish had an average lice abundance less than 1.0 from March to October 2008.

- 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 motile lice began in September; the abundance increased to 0.5 lice per adult fish and subsequently to 1.5 lice in October 2008. A similar pattern was evident in juvenile farmed salmon where the average abundance rose to 1.1 motile lice per fish in October.

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 by requiring feed mills to report all prescription orders on an annual basis. In-feed medication is the only practical method of delivering therapeutants to production fish; bath treatments have yet to be considered a viable practice in marine net pens of British Columbia.

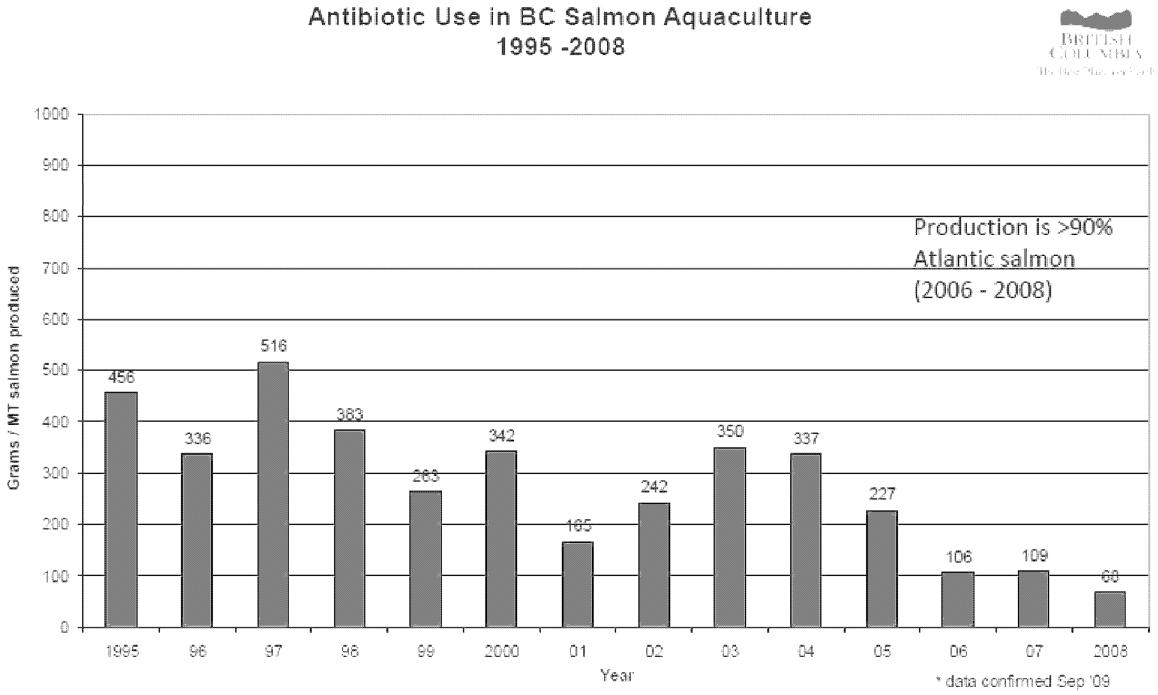
5.1.1 Antibiotics:

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 licensed 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. Broodstock are occasionally medicated with other drugs if necessary and the brood may also receive injectable antibiotics; however, these fish are not destined for human consumption. BC feed mills abide by provincial regulations and report the use of antibiotics used in manufactured feeds but the use of injectable products in the brood is tracked by the prescribing veterinarian and by the farming companies.

As shown in Figure 25, the antibiotic use has ranged from a peak of 516 grams (g) of active drug per metric tonne (MT) of fish (1997) to an all-time low of 68 grams in 2008. It is noteworthy that these annual values (i.e. grams per metric 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', are in reality exposed to lower amounts of antibiotic than the bar graph indicates.

Fish populations do not receive antibiotics in the absence of disease but medications are used to minimise, and to some extent mitigate, disease events that veterinarians recognise seasonally or arise following a stressor.

Figure 25: Summary of Antibiotic Use in Salmon Aquaculture 1995 – 2008 (including broodstock populations).

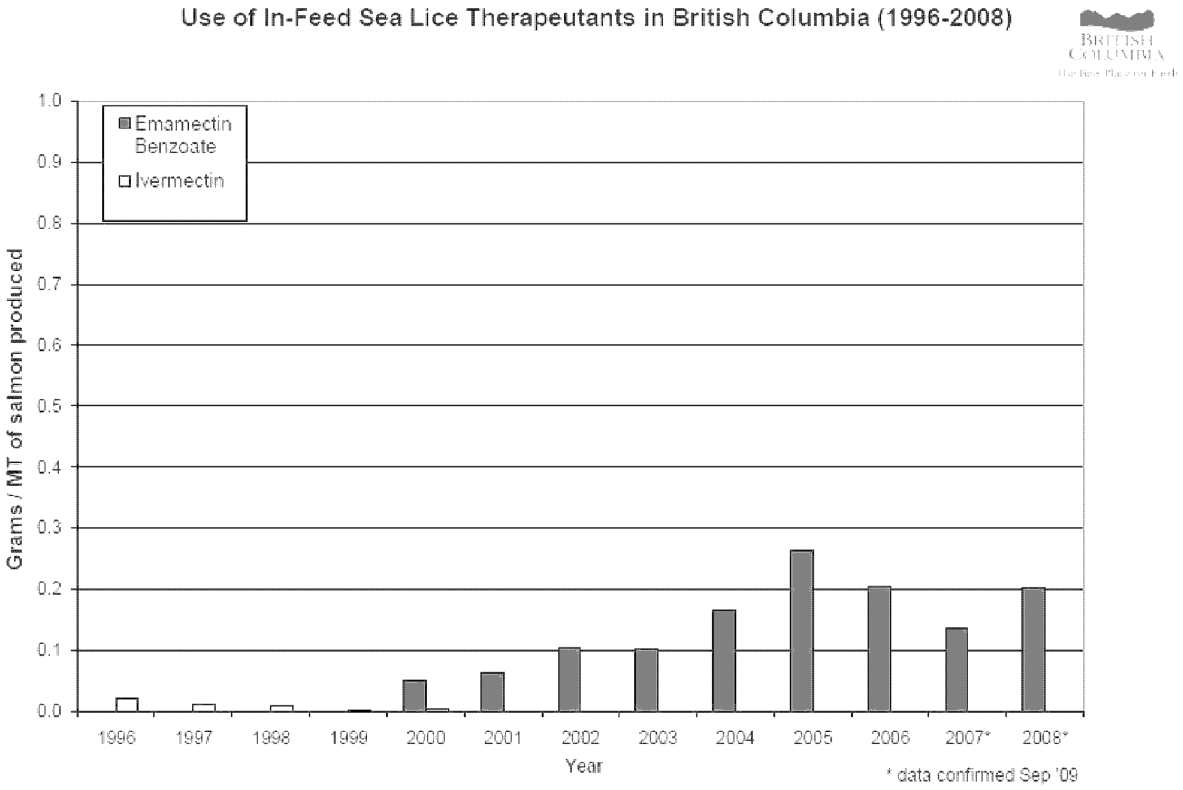


5.1.2 Sea Lice Medical Management:

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 licensed and labelled drug following a thorough federal review and approval process under the authority of Health Canada. Emamectin benzoate is an efficacious drug for lice management, such that lice abundance on farms (in BC) typically remains low for five or six months following the medication.

As illustrated in Figure 26, the use of anti-lice treatment remains below 0.25 grams per metric tonne of fish produced in BC. Initially, from 2000 to 2003, harvest-sized Atlantic salmon would generally not have been medicated with emamectin benzoate and the medication could have interfered with harvest dates (i.e. the historical withdrawal period ranged 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, reduced lice abundance on wild fry and farmed fish and pre-spring harvest of farmed salmon helped to reduce the use of the anti-lice medication. The slight increase in use of emamectin benzoate in 2008 does not reflect a response to lice abundance (which continued to decline in 2008); rather, it illustrates the influence of societal expectations and the precautionary focus of managing sea lice in BC, i.e. to further minimise the risk of lice transfer to wild out-migrating salmon fry.

Figure 26: Summary of Use of Sea Lice Products in BC Aquaculture 1996 – 2008 (including broodstock populations).



NB. The trigger level of 3 motile lice per fish was assigned in late 2003 and subsequently influenced the volume and frequency of therapeutic management of lice on farmed Atlantic salmon.

Section 6: Summary and Conclusions

Since 2003 the BCMAL fish health program has provided an overview of the health of salmon on fish farms in British Columbia and provides regulators an avenue to enforce disease management on the farms. The cornerstone of the program is the FHMP, which is a Term and Condition of an aquaculture license issued by the provincial government. The FHMP 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 2008 audit and surveillance data indicate that disease, when detected on salmon farms in British Columbia, is of a type that is natural to the marine region and has generally been previously identified in free-ranging wild Pacific salmon. Since 2007, brains and pyloric caeca from silver carcasses have been included as tissues submitted for histological assessment; this change led to an enhancement of diagnosis and assigning cause of death. Two marine parasites found in the brains of a limited number of Atlantic salmon carcasses in 2007 and 2008 continue to be of scientific interest. These histological lab findings contribute to the information derived from surveillance efforts. One of the microscopic parasites is associated with sporadic mortality in pen-reared Atlantic salmon in BC and may represent the emergence of an indigenous pathogen worthy of close monitoring and further scientific investigation. There is no evidence that these parasites are new-comers or exotic to British Columbia.

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 2008.

Compliance with FHMPs is monitored by on-farm inspection, log review and checklist during the routine audit procedure and industry compliance continues. All plans are reviewed annually and updated accordingly, some following corporate mergers in 2007. FHMPs are designed to ensure that the highest standards for fish health are achieved, thus minimising the risk of impact on wild stocks and minimising any risk of transfer of pathogens to other populations.

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

The objective of the sea lice audit is to ensure that on-farm counting protocols are followed and to verify the state of lice infestations on BC Atlantic salmon farms. The industry has embraced the sea lice management strategy and full compliance with the Ministry's requirements for monitoring occurs. Overall, lice abundance on Atlantic salmon farms in 2008 was the lowest on record, and springtime averages in all regions were well below the trigger of three motile lice per fish.

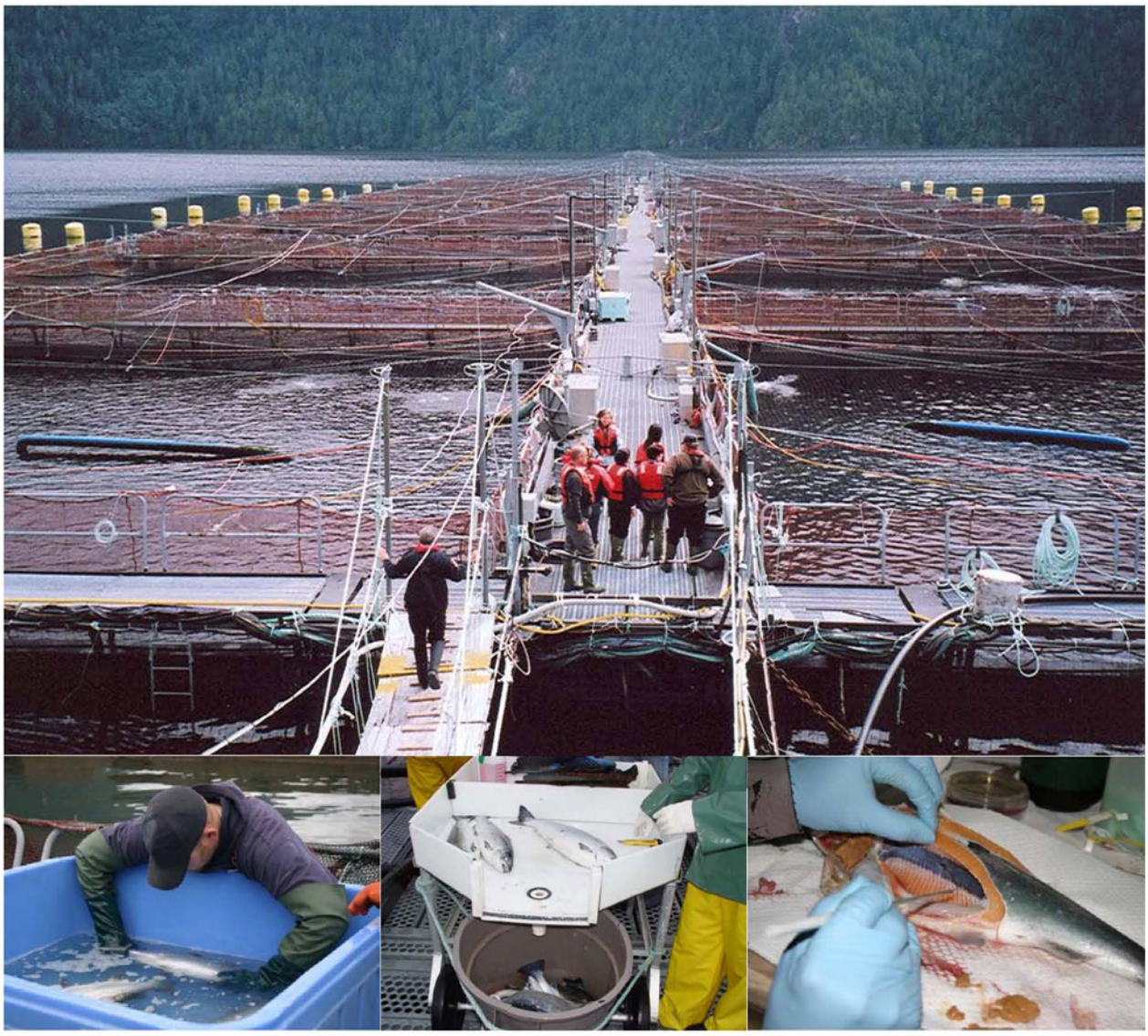
The Province is committed to continued improvement to the Fish Health program through integration of sound scientific information. This will ensure that the aquaculture sector of British Columbia remains productive and environmentally sustainable, while continuing to achieve the highest standards of sea food quality and wholesomeness through fish health management.

Section 7: Supplement – Appendices to Fish Health Report

2008

Ministry of Agriculture and Lands

Animal Health Branch – Fish Health



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