Fish Health Program / 2007

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Section 1: Overview

1.1 Executive Summary

The Province of British Columbia maintains a comprehensive health management program for salmon aquaculture. The program includes a requirement for on-farm health management plans, mandatory monitoring and reporting of disease events and a British Columbia Ministry of Agriculture and Lands (BCMAL) audit of industry reported information.

In 2007 the BCMAL completed 118 salmon farm audits and collected diagnostic samples for disease analysis from 763 fish mortalities. By way of explanation, all farms categorize their dead fish, giving probable explanation for the losses. A small portion of the routine fish mortality is termed "silvers". Silvers are fresh carcasses that still have silver skin/scales and died most recently for no apparent reason, or they may show signs of disease. These mortalities are used as indicators of active disease and reflect the robust production population. They generally represent 25% of the total dead group gathered during an audit. Approximately 10% of this group of silvers is tested by BCMAL for cause of death and specific infectious diseases.

With respect to Atlantic salmon, 78% of the audit cases found few silvers and no infectious disease (at the farm-level). Of the remaining cases, the main disease diagnoses were mouth myxobacteriosis (10%) and bacterial kidney disease (7%). For farmed Pacific salmon, 29% of the audits cases found few silvers and no infectious disease (at the farm-level), and the main disease diagnoses were bacterial kidney disease (47%) and Loma (19%). These diseases are endemic in free-ranging salmon in British Columbia and it is expected that they would be found.

The audit found the same endemic diseases as those reported by industry. The Ministry surveillance program detected no pathogens in farmed salmon that would affect BC or Canadian trade and export.

Audits of sea lice abundance at Atlantic farms confirm that the aquaculture industry is complying with the provincial sea lice management strategy. In 2007, BCMAL conducted lice counts at 57 farms and assessed 3,380 live fish. Lice abundance triggers, established to guide the management of sea lice, were introduced and fully implemented in 2004 after examining the data available in the published literature and from governments of other provinces and countries. To date, trigger levels of three (3) motile lice per fish continue to be viewed as rational and precautionary for lice management. The latest genetic research (by Yazawa et al., 2008) has the potential to influence management strategies in that his findings appear to offer a plausible explanation as to why Atlantic salmon in British Columbia show little or no outward signs of ill health from Pacific sea lice (see Section 4.7).

The Ministry's Fish Health Program provides regulators with a comprehensive understanding of the health status of fish stocks on salmon farms. The program supports the monitoring, reporting, and regulation of fish disease, and addresses health concerns that may arise in farmed fish. The annual Fish Health Report summarizes the information generated by the program for the calendar year.

1.2 Mandate and Background

In response to the 1997 Environmental Assessment Review of Aquaculture, the government of British Columbia developed a comprehensive policy designed to improve monitoring and regulation of fish disease in the aquaculture industry. The intent of the fish health program is to ensure a standardized approach to the management of disease of fish cultured at private and public facilities in British Columbia.

In 1999, BCMAL accepted the recommendations, developed a new Salmon Aquaculture Policy and committed to addressing concerns through the staged implementation of a new regulatory and management framework with the major objective to improve fish health. The program was implemented in 2001 and has served to better regulate the finfish aquaculture sector.

1.3 Objectives

A key objective of the provincial Fish Health Program is to ensure a comprehensive approach to aquaculture health management. The cornerstone of this program is the Fish Health Management Plan (FHMP). These individual management plans encompass all aspects of farming that can affect the health of the animals at the aquaculture site. Since 2003, all private companies and public fish culture facilities must develop and maintain a current FHMP specific to their rearing unit. For private companies and the provincially licensed public facilities, the FHMP is enforceable as a Term & Condition of an aquaculture licence.

Another objective of the Fish Health Program is to ensure access to accurate and verifiable data on the disease status of cultured fish stocks. For salmon aquaculture, all facilities in freshwater and saltwater are required to report site-specific information to an industry database monthly; companies must report all mortality, causes of mortality and Fish Health Events[1]. In addition, quarterly reports of the health status are submitted to government and posted for public viewing on the Animal Health Branch – Fish Health website. Health monitoring and reporting of disease status is a requirement under the FHMP and compliance monitoring is built-in to the system.

[1] Fish Health Event (FHE) is defined as a disease occurrence on a farm in which a veterinarian intervened in some manner (i.e. by diagnosis, recommendation/report, prescription medication, etc.).

Section 2: Fish Health Management Plans

2.1 Fish Health Management Plans

The Fish Health Management Plan (FHMP) outlines the best possible health conditions for cultured fish in British Columbia.

2.1.1 Review and Approval of FHMP

Three documents are used to develop a 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 (SOPs) for management of 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 FHMP

A number of corporate mergers transpired in 2006/2007 and corresponding FHMPs have been updated accordingly. During this process all salmon producers with fish on private marine farms continued activities based on pre-existing FHMPs that met Ministry requirements.

With respect to 'public' enhancement facilities, in 2007 five key rearing facilities of the Freshwater Fisheries Society of British Columbia were operating under one general draft FHMP. In 2007, 15 key federal enhancement hatcheries of Fisheries and Oceans Canada continued to report their Fish Health Events to the BC Salmon Farmers' database, and the majority of those 15 fish-rearing units have FHMPs in final draft stages considered to be stable and operational.

Reminder letters are sent to all industry FHMP coordinators each year to request that revisions, if any, be communicated. Any revisions to private aquaculture FHMPs 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 2007. In addition, the renewal of aquaculture licenses, amendments or the issuing of a new licence, triggers 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 Fish Health Management Plan dictates that all major 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 within fish health 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, private sector veterinarians report Fish Health Events to the BCSFA when veterinary intervention has occurred. Fish Health Events account for the population-level diseases that occur on farms. To enhance public confidence and to validate industry information, BCMAL audits the Fish Health Events reported and selects a sub-set of fresh silvers specifically to test for diseases and pathogens of concern (i.e. pathogens recognised federally and internationally that may affect fish movement and trade). The identification of other endemic diseases is also documented.

2.2.1 Verification and Compliance of Industry Database Reports

Two types of reports are provided to BCMAL from the British Columbia salmon farmers' database (BCSFA database): quarterly Fish Health and Mortality reports, and monthly Sea Lice Monitoring reports. These reports are a condition of license under the Fish Health Management Plan.

The BCSFA database is operated by a third party computer company and verified by an independent private veterinarian. Monitoring the compliance of companies who 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, they are granted 10 days to communicate. If by the 20th of the month a company has not complied, the BCSFA database manager will provide details of the non-compliance in a report to the Ministry. Depending on the nature and reason for non-compliance, actions may consist of a letter reminding companies of their legal obligations and outlining the specific actions that must be taken or may entail enforcement action, if required.

On-farm audit and records review by Ministry staff further verifies industry-reported information. During farm visits, samples from fish are collected for testing for specific diseases and monitored for sea lice abundance. These visits ensure that farm staff are collecting and compiling the information and classifying dead fish and causes of mortality as per established protocols. On-farm reports can be generated by companies to verify that the farm has entered the required data for a particular quarter.

Section 3: Fish Health Auditing and Surveillance

3.1 Fish Health Auditing and Surveillance Program

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

1) Fish health bio-technicians monitor activities and review health-related records at marine salmon net pens, as outlined in Fish Health Management Plans;

2) Fish health bio-technicians collect samples from fresh silvers to allow for 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 Fish Health Auditing and Surveillance Program audits industry's activities; reports and searches for specific diseases and pathogens of concern and identifies endemic diseases common to BC fish - wild and farmed - as well as other diseases that may emerge in salmon populations.

3.2 Methodology

3.2.1 Zonation

British Columbia coastal waters are divided into fish health zones and sub-zones based on Fisheries and Oceans (DFO) watersheds for salmonid transfers. 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 are reported by zone to avoid singling out an individual farm or company. 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
	2.1 + 3.1	South East Coast Vancouver Island + Sunshine Coast
3	3.2	Inside Passage - Campbell River Area
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 multi-stage 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 sub-zones is weighted (based on the fish species and the number of active farms 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 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 so 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, which ensures that each active farm has equal likelihood to be sampled within a year.

There are approximately 135 tenures and between 60 and 80 operating farms annually; however, for audit purposes, the total number of "active farms"[2] varies. In 2007, the number of active farms available for audit each quarter ranged from 56 to 65 (mean = 62, see Table 2 and Appendix 7.3 for detail). The audit of 30 farms means that approximately 50% of the farms were assessed for aspects of fish health alone. For the sea lice audit farm selection is conducted separately so an additional 25 to 50% of active Atlantic salmon farms are audited each quarter (see Section 4.0).

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 are considered active. From the list of active farms a computer-generated random selection of farms is selected for audit. Farm audits are conducted in conjunction with the weekly dive schedule to enable staff access to the dead fish; this approach of targeted disease sampling increases the likelihood of finding disease when present. The total number of farms chosen for audit is always 30 (see Table 3 and Figure 1).

Occasionally, farm audits are cancelled due to weather conditions, over-riding health issues such as plankton blooms or other unforeseen events. Whenever possible these farm audits are rescheduled; however, there are periods when it is not possible to complete all 30 farm audits during a calendar quarter.

3.2.4 Sampling and Sample Selection

Fish sampling for audit purposes occurs during routine diving for carcasses conducted by industry. 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 routine histopathology, bacteriology, and virology. A key objective is to establish the presence or absence of specific diseases-of-concern, as well as endemic diseases; this information can then be compared with the industry-reported health information.

[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.

Carcasses to be sampled are those that had grown well prior to death and have red or pink gills – these are fish that have died most recently and may or may not show signs of disease. This group provides the greatest diagnostic value, is most reflective of active disease, and is representative of the robust living population. Their selection increases the likelihood of detecting acute and emerging disease. Typically, six 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 fish sampled varies at each farm because the availability of fresh silvers is often limited. The number of carcasses tested in 2007 was 763 (see details: 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 an American Association of Veterinary Laboratory Diagnosticians (AAVLD) accredited diagnostic laboratory. 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, virology, histopathology and molecular diagnostics. For bacteriology, kidney tissue from each individual fish is transferred to trypticase soy agar and blood agar plates. Biochemical analyses and/or gene sequencing are used to identify bacteria.

Tissues for virology from each individual 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 and screened using Polymerase Chain Reaction (PCR) techniques for the following pathogens of concern:

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

If PCR findings are positive, individual samples are subsequently transferred to appropriate cell lines for confirmation. Standard cell lines include CHSE 214 and EPC.

All tissue samples for histology are examined for signs of inflammation and abnormality and, if possible, to determine the cause of the mortality. The fish pathologist is an American College of Veterinary Pathologists (ACVP) board-certified veterinary pathologist. Histopathology enables detailed review of the cause of mortality on an individual fish basis, and it provides a mechanism for validating the significance of PCR and bacteriology results.

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, records 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. In 2007, a biosecurity checklist was added to standardise the assessment to better evaluate compliance with the Fish Health Management Plan.

3.3 Results

3.3.1 Number of Active Farms

The number of active farms in 2007 is provided in Table 2 (see details by calendar quarter in Appendix 7.3). The definition of an active farm for the auditing program varies between a fish health audit and a sea lice audit.

To sample for fish health a farm is considered active if stock is present for more than 30 days following entry of the first pen of fish on the farm. Due to the dynamic nature of farming, for the farm to be considered active when a harvest is either underway or planned, three pens of fish must be present on the day of the scheduled audit during that quarter.

For sea lice evaluation, an audit is arranged if the fish have been present at the farm for more than 120 days following entry of the first pen of fish. For harvest fish there must be a minimum of three full net pens on farm to enable a statistically significant sampling. In Table 2, the calculation of an average often results in a non-integer (i.e. 12.7) so the calculated numbers have been rounded up or down accordingly.

Table 2. Average Number of Active Salmon Farms in 2007

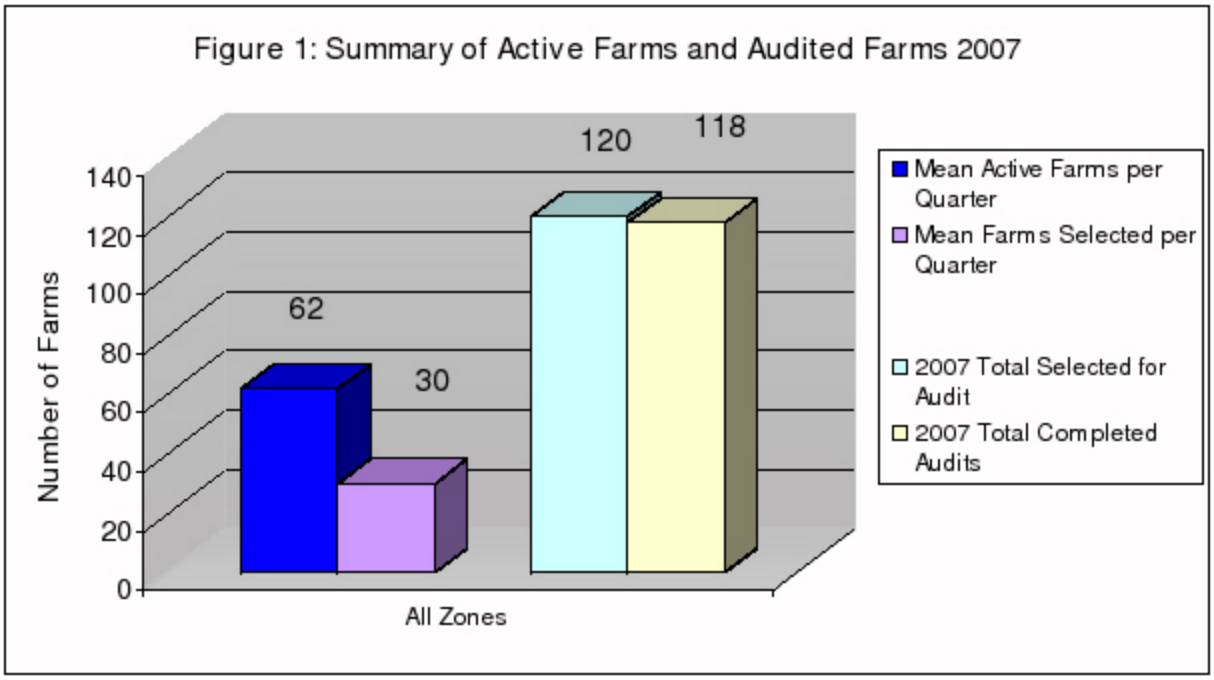
Atlantic Salmon	2007
Zone 2.3 SW Vancouver Island	9.7 = 10
Zone 2.4 NW Vancouver Island	9
Zone 3.1 Sunshine Coast	3
Zone 3.2 Campbell River Area	11
Zone 3.3 Broughton Area	12.7 = 13
Zone 3.4 Port Hardy Area	5.7 = 6
Zone 3.5 Central Coast Area	2.2 = 2
Pacific Salmon	
Zone 2 Vancouver Island	3
Zone 3 East of Vancouver Island	5.5 = 6

NB: BCSFA considers 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. Broodstock populations are not audited by BCMAL because the brood fish are a distinct and separate population under unique husbandry management. As such, they are not reflective of the food-animal, production population.

Table 3: Number of Salmon Farms Selected for Audit (and Completed) During Each Quarter of 2007

Location	Jan – March	April - June	July - Sept	Oct – Dec	2007 Totals
Sub-zone 2.3 SW Vancouver Island	4	5	5	5	19
Sub-zone 2.4 NW Vancouver Island	4	5	4 (3)	4	17 (16)
Sub-zone 3.1 Sunshine Coast	1	1	1	1	4
Sub-zone 3.2 Campbell River	5	5	6	6	22
Sub-zone 3.3 Broughton	6	6	6	6	24
Sub-zone 3.4 Port Hardy	4	3	3	2	12
Sub-zone 3.5 Central Coast	1	2	2 (1)	1	5
Atlantic Sub Total	25	27	27 (25)	25	104 (102)
Zone 2 Vancouver Island	1	1	1	1	4
Zone 3 East of Vancouver Island	4	2	2	4	12
Pacific Sub Total	5	3	3	5	16
Grand Total	30	30	30 (28)	30	120 (118)

NB: When only one number is present in the cell it indicates that the number of farms selected for audit and number of farms actually visited is the same. Where a 2nd smaller number appears in parentheses ( ) it reflects the actual number of farms visited (i.e. an audit may have been cancelled due to adverse weather or the farm had since been harvested, etc.). On rare occasions a grand total of >30 farms per quarter is selected particularly if one farm contain two species of fish on site, so it may be selected twice by the MAL computer to audit both the Atlantic salmon and the Pacific salmon raised on that farm. Such farms are rare.



3.3.2 Number of Fish Sampled

Dozens of fish may be examined grossly during a farm audit but only those that are suitably fresh are chosen for detailed diagnostic evaluation. A maximum of 20 fish are selected across all pens for diagnostic tissue collection. The number actually sampled will depend on the mortality level at the farm which, in turn, depends on the size and age of fish, time of year and if there had been a recent health event.

During some audits no fish are available or suitable for collection; however, when this occurs all other aspects of the audit are still conducted including assessment of mortality records and dive procedures. In 2007, 118 farm audits were conducted and fish samples were collected at 115 of those farm audits (see Table 4).

Table 4 : Number of Fish Sampled During Each Quarter of 2007					
Location	Jan - March	April - June	July - Sept	Oct - Dec	2007 Totals
Sub-zone 2.3 SW Vancouver Island	26	34	37	33	130
Sub-zone 2.4 NW Vancouver Island	27	44	21	29	121
Sub-zone 3.1 Sunshine Coast	2	0	4	3	9
Sub-zone 3.2 Campbell River	45	42	42	41	170
Sub-zone 3.3 Broughton	31	32	33	23	119
Sub-zone 3.4 Port Hardy	32	15	12	12	71
Sub-zone 3.5 Central Coast	5	5	8	5	23
Atlantic Sub Total	168	172	157	146	643
Zone 2 Vancouver Island	1	7	12	8	28
Zone 3 East of Vancouver Island	40	23	12	17	92
Pacific Sub Total	41	30	24	25	120
Grand Total	209	202	181	171	763

3.3.3 Bacteriology

Table 5 and Figure 2 contain Gram-negative bacteriology results from the BCMAL 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 diagnosed by other techniques.

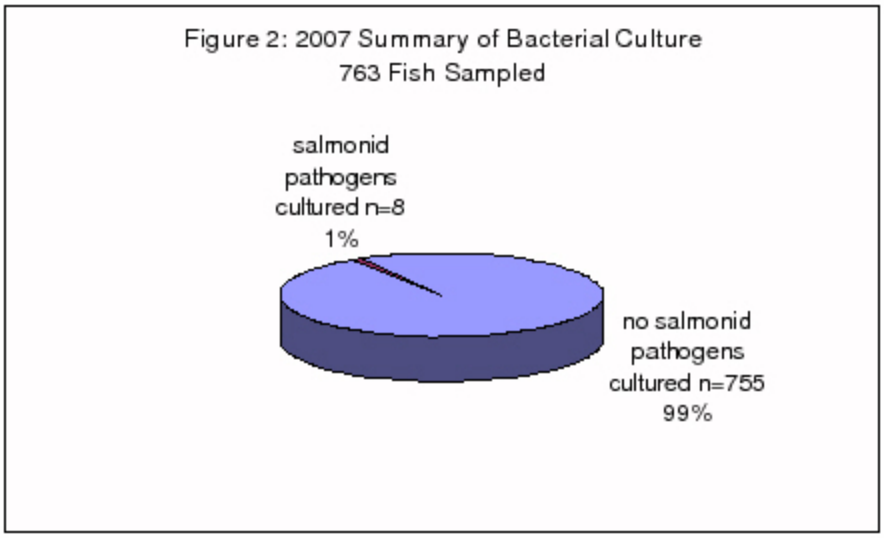
In 99% of the dead fish sampled, no disease-causing bacteria (pathogens) were isolated. In 2007 a total of 763 carcasses were sampled for the presence of bacterial agents yet only eight fish (1.0%) revealed a salmonid pathogen. Bacteria were also isolated and cultured from thirty three (33) additional carcasses; however, these bacteria are considered opportunistic and 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: 2007 Total farms and numbers of fish carcasses sampled, and number of fish with positive cultures (by quarter)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms sampled *	30	28	28	29	115
# fish sampled	209	202	181	171	763
# fish with a pathogen cultured	2	3	0	3	8

* During some farm audits no fish carcasses were available or suitable for diagnostic testing. Although 118 farm audits were conducted, fish samples were collected from only 115 of those farms.



3.3.4 Virology / Molecular Diagnostics

Molecular diagnostic analysis of samples for genetic material of known pathogens is completed on all tissue samples collected for a specific list of known fish disease-causing agents. Some are indigenous to British Columbia while others remain exotic to BC.

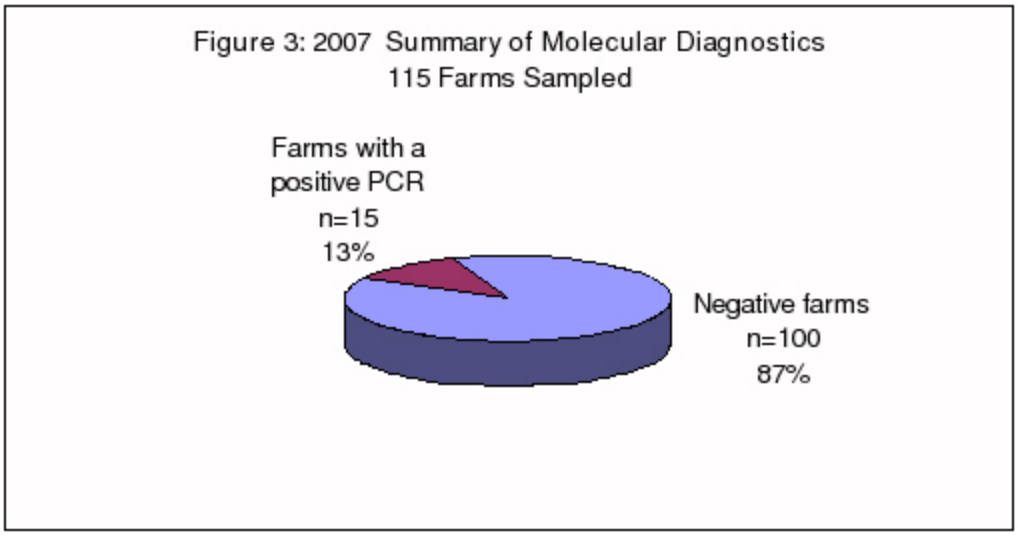
Seven hundred and sixty three dead fish provided tissue samples for examination using molecular diagnostic techniques (polymerase chain reaction, PCR). The majority of fish were negative for the five pathogens tested. Tissue samples were collected and frozen from individual fish but sub-samples of each group were pooled for testing. Any molecular "test positive" for virus leads to further evaluation by means of tissue culture to determine if viable virus is present. Because fish samples are 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*, 15 farms had positive PCR results

from pooled groups of carcasses, and 87% of farms sampled showed no detectable viral agents and no *Piscirickettsia*.

Table 6: 2007 Total farms and numbers of fish carcasses sampled, and number of farms with a positive PCR result (per quarter).

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms sampled *	30	28	28	29	115
# fish sampled	209	202	181	171	763
# farms with a positive PCR	5	3	2	5	15

* During some farm audit visits no fish carcasses were available or suitable for diagnostic testing. Although 118 farm audits were conducted, fish samples were collected from only 115 of those farms.



3.3.5 Histopathology

Tissue samples (anterior and posterior kidney, liver, spleen, heart, pyloric caeca, brain and occasionally gill) from each selected fresh silver are collected for microscopic examination by an ACVP board-certified veterinary pathologist of the Ministry's Animal Health Centre. Tissue samples in addition to those listed may also be collected during an audit if lesions are visible or if disease-causing organisms are suspected. Histopathology results are used in combination with all other information collected to distinguish between a farm-level diagnosis and incidental cause of death within individual carcasses.

3.3.6 Disease Diagnosis from Audit information

Farm-level diagnosis of disease is made on the basis of a review by fish health veterinarians of 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, treatments that have occurred and results of diagnostic tests. It is important to understand that the presence of a pathogen in an individual carcass does not indicate a clinical disease event in a population. To ensure accurate interpretation of the information gathered, diagnoses must be made by veterinarians experienced in the management of fish health and disease. Thus, the reported results represent the final audit diagnosis of disease at the farm population level which is based on the information collected and results of testing from an audit. Cases arise where micro-organisms have been isolated or identified in the laboratory; however, this does not necessarily correspond to a farm-level diagnosis of disease attributable to that particular microscopic agent. 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 2007 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: 2007 Summary of 128 Diagnoses from 115 Audit Samples	
Atlantic Salmon	Number of Diagnostic Cases = 107
No Infectious Disease (NID)*	83
Mouth Myxobacteriosis	11
Bacterial Kidney Disease	8
VHS (NA strain)	2
Rickettsiosis	2
Furunculosis	0
Enteric Red Mouth	1
Net Pen Liver Disease (NID)	(1)
Peritonitis (NID)	(0)
Environmental (NID)	(1)
Pacific Salmon	Number of Diagnostic Cases = 21
No Infectious Disease (NID)*	6
Bacterial Kidney Disease	10
Loma	4
Rickettsiosis	1
Marine Anaemia	0
Enteritis (NID)	(0)
Environmental (NID)	(0)

* No Infectious Disease (NID) includes: the audits where no carcass samples were available (NSF); '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; 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 cases appears in parentheses ( ).

Figure 4: 2007 Audit Case Summary - Atlantic Salmon

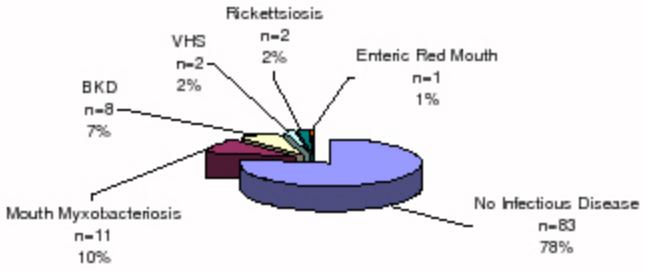
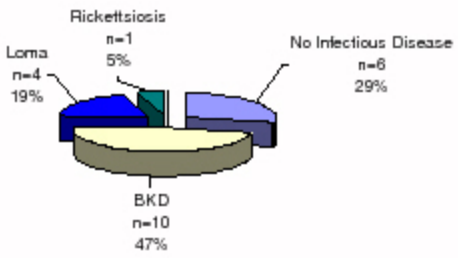
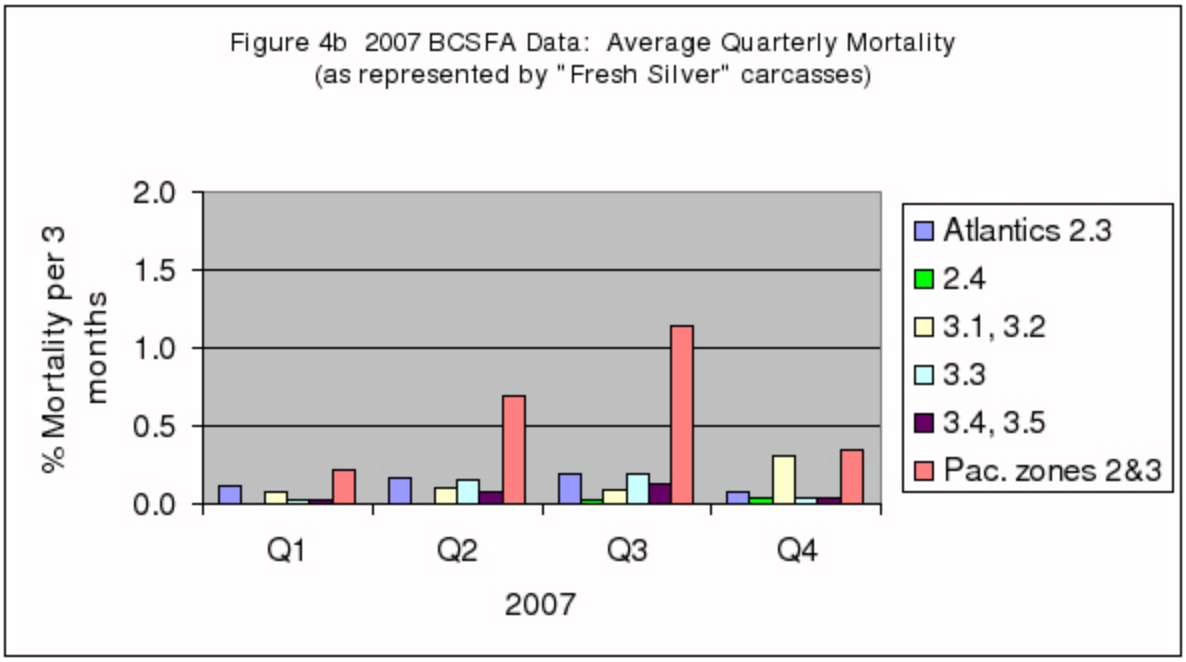


Figure 4a: 2007 Audit Case Summary - Pacific Salmon



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 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; when disease does occur it can be controlled relatively quickly. The overall mortality in the aquaculture sector is low. When considering fresh silvers (i.e the group we use as indicators of active disease), among all the Atlantic salmon being farmed during the quarter, less than 1% will die of infectious disease (see Figure 4b; BCSFA data). Fresh silvers from Pacific salmon farms also reflect low mortality with the exception of a 1.14% loss overall in quarter three.



The following pages reflect the 'snapshot' of the farm-level diseases diagnosed from farm audits in 2007. When examining the data, please bear in mind that the audit information does not represent the total number of cases of disease amongst industry farms, rather it represents the proportion of the audit cases where disease was found. Hence:

$$\text{Proportion of Audit Diagnosis} = \frac{\text{Number of Cases of Diseases Diagnosed on Audit}}{\text{Total Number of Audits Conducted}}$$

Information on the total proportion of disease reported from industry farms is calculated from the BCSFA database and reported on a quarterly basis as Fish Health Event documents on the MAL website. A comparison of the findings between the audit and 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 provided in Appendix 7.7.

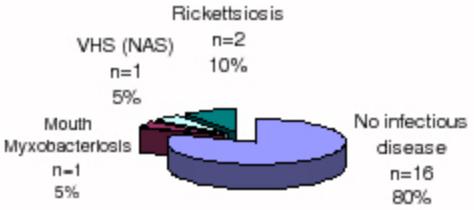
3.3.7.1 Atlantic Salmon

3.3.7.1.1 Sub-zone 2.3 South West Vancouver Island

Table 8. 2007 Diagnoses for sub-zone 2.3 (South West Vancouver Island) Atlantic Salmon Farms

Number of Farm Audits	Number of Cases[3]	Farm Level Diagnoses
19	16	No Infectious Disease
	1	Mouth Myxobacteriosis
	1	VHS (North American strain genotype IVa)
	2	Rickettsiosis

Figure 5: SW Vancouver Island (Zone 2.3)
2007 Case Summary - Atlantic Salmon



3.3.7.1.2 Sub-zone 2.4 North West Vancouver Island

Table 9. 2007 Diagnoses for sub-zone 2.4 (North West Vancouver Island) Atlantic Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
16	14	No Infectious Disease
	1	Mouth Myxobacteriosis
	2	Bacterial Kidney Disease

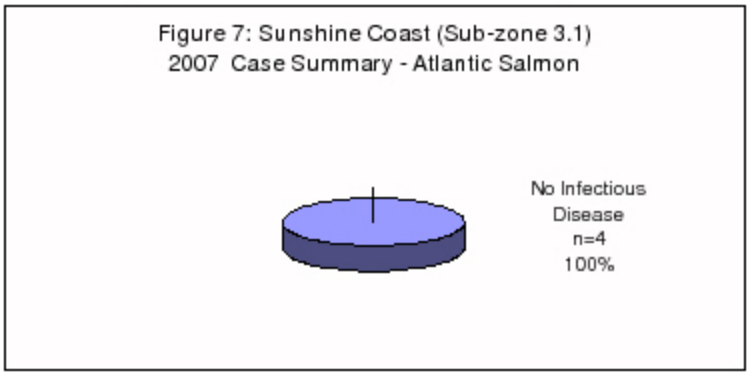
Figure 6: NW Vancouver Island (Sub-zone 2.4)
2007 Case Summary - Atlantic Salmon

[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).

3.3.7.1.3 Sub-zone 3.1 Sunshine Coast

Table 10. 2007 Diagnoses for sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farms

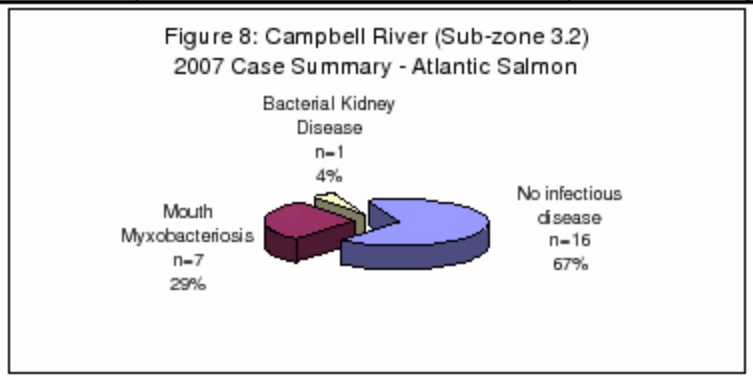
Number of Farm Audits	Number of Cases	Farm Level Diagnoses
4	4	No Infectious Disease



3.3.7.1.4 Sub-zone 3.2 Campbell River

Table 11. 2007 Diagnoses for sub-zone 3.2 (Campbell River) Atlantic Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
22	16	No Infectious Disease
	7	Mouth Myxobacteriosis
	1	Bacterial Kidney Disease

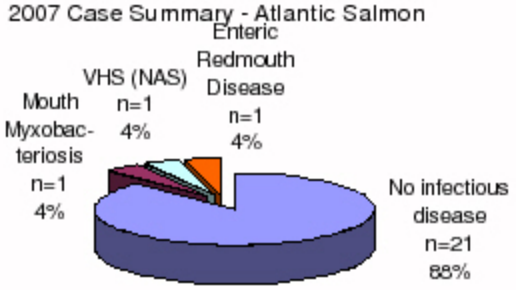


3.3.7.1.5 Sub-zone 3.3 Broughton Area

Table 12. 2007 Diagnoses for sub-zone 3.3 (Broughton) Atlantic Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
24	21	No Infectious Disease
	1	VHS (North American strain genotype IVa)
	1	Mouth Myxobacteriosis
	1	Enteric Red Mouth

Figure 9: Broughton (Sub-zone 3.3)
2007 Case Summary - Atlantic Salmon

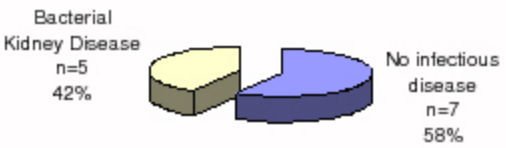


3.3.7.1.6 Sub-zone 3.4 Port Hardy Area

Table 13. 2007 Diagnoses for sub-zone 3.4 (Port Hardy) Atlantic Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
12	7	No Infectious Disease
	5	Bacterial Kidney Disease

Figure 10: Port Hardy (Sub-zone 3.4)
2007 Case Summary - Atlantic Salmon

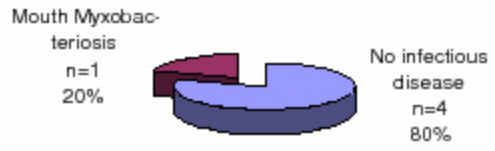


3.3.7.1.7 Sub-zone 3.5 Central Coast

Table 14. 2007 Diagnoses for sub-zone 3.5 (Central Coast) Atlantic Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
5	4	No Infectious Diseases
	1	Mouth Myxobacteriosis

Figure 11: Central Coast (Sub-zone 3.5) 2007 Case Summary - Atlantic Salmon



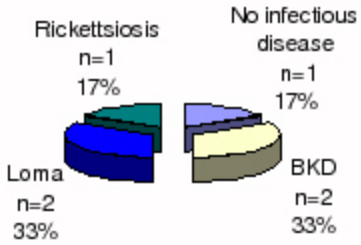
3.3.7.2 Pacific Salmon

3.3.7.2.1 Zone 2 Vancouver Island

Table 15. 2007 Diagnoses for Zone 2 (Vancouver Island) Pacific Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
4	1	No Infectious Disease
	2	BKD
	2	Loma
	1	Rickettsiosis

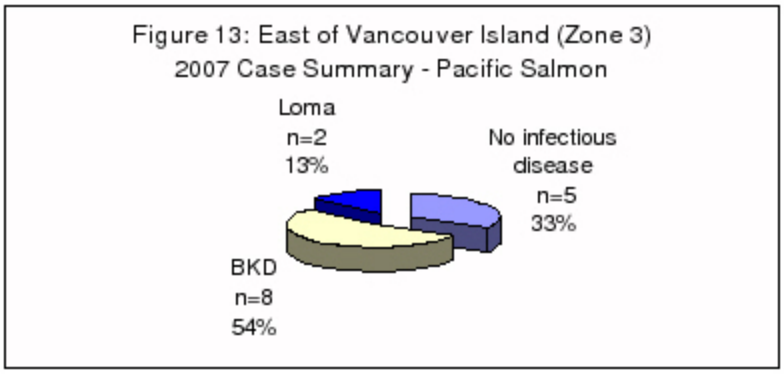
Figure 12: Vancouver Island (Zone 2) 2007 Case Summary - Pacific Salmon



3.3.7.2.2 Zone 3 East of Vancouver Island

Table 16 2007 Diagnoses for Zone 3 (East of Vancouver Island) Pacific Salmon Farms

Number of Farm Audits	Number of Cases	Farm Level Diagnoses
12	5	No Infectious Disease
	8	BKD
	2	Loma



3.4 Comparison to Industry

One major objective of the Fish Health Program is to verify the disease status of fish farms as reported regularly by industry. This presents some challenges for two reasons: first, the audit provides only a "snapshot" to which the more complete picture of industry's reports can be compared; and second, the sub-set of fresh silvers collected during an audit may not always reflect the Fish Health Events reported by industry. The presence of BCMAL fish health technicians on farms, reviewing records and testing for disease in parallel with industry fish health staff provides valuable information on how things are recorded and reported.

The audit information does not represent the 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, this disease information is captured in the industry reports required as part of Fish Health Management Plans and it is available on the Ministry website: http://www.al.gov.bc.ca/ahc/fish_health/index.htm. The audit enables a randomized validation of the reported information with targeted disease testing. The industry reports represent all farms and therefore provide a more complete picture of the health status of farmed salmon.

Three reports are provided to government by the industry on a quarterly basis:

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

These reports summarise the overall losses and common causes of death at both private and public fish culture facilities.

Fish Health Events are situations of husbandry or disease management where intervention by a veterinarian 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 data reports are incorporated in this report as Appendix 7.8 and 7.9. An annual summary of those Fish Health Event diagnoses is displayed in Figures 15a and 15b. The common Fish Health Events such as: Bacterial Kidney Disease (*Renibacterium*), Rickettsiosis (*Piscirickettsia*) and Mouth Myxobacteriosis were verified through the audit process. The BC Salmon Farmers' database contains a complete dataset from individual farms as opposed to the aggregate information presented here. In addition, each individual farm maintains a record of the mortality and disease diagnoses to fulfil the record-keeping component of their Fish Health Management Plan.

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.

There is strong agreement between audit results and Fish Health Event 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 do not trigger a farm-wide treatment since these infections can be managed at the same time with a medication arranged 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 2007 was less than 2%. Data from sub-zones 3.1 and 3.2

has been combined to respect the proprietary details of individual farms or companies (i.e. only one aquaculture producer raises salmon in sub-zone 3.1).

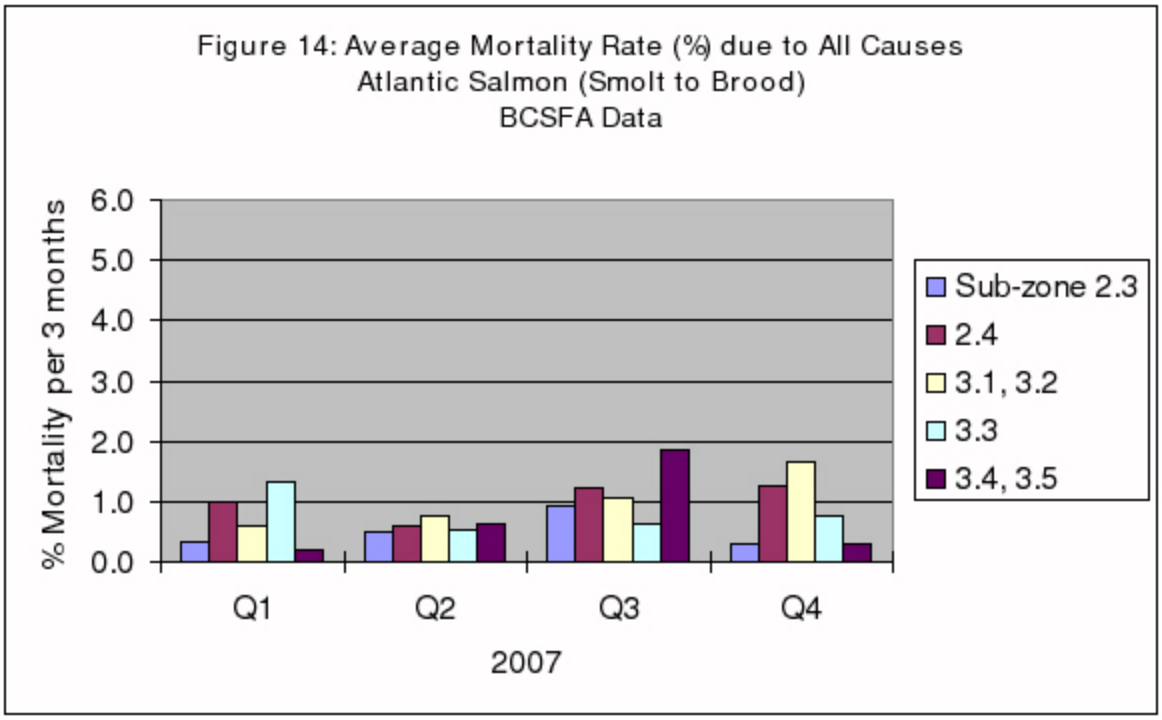


Figure 15a. BCSFA data: Annual Fish Health Events of groups of Atlantic salmon within farm sites that do experience an FHE; reported quarterly by the BC Salmon Farmers Association in 2007 for all zones.

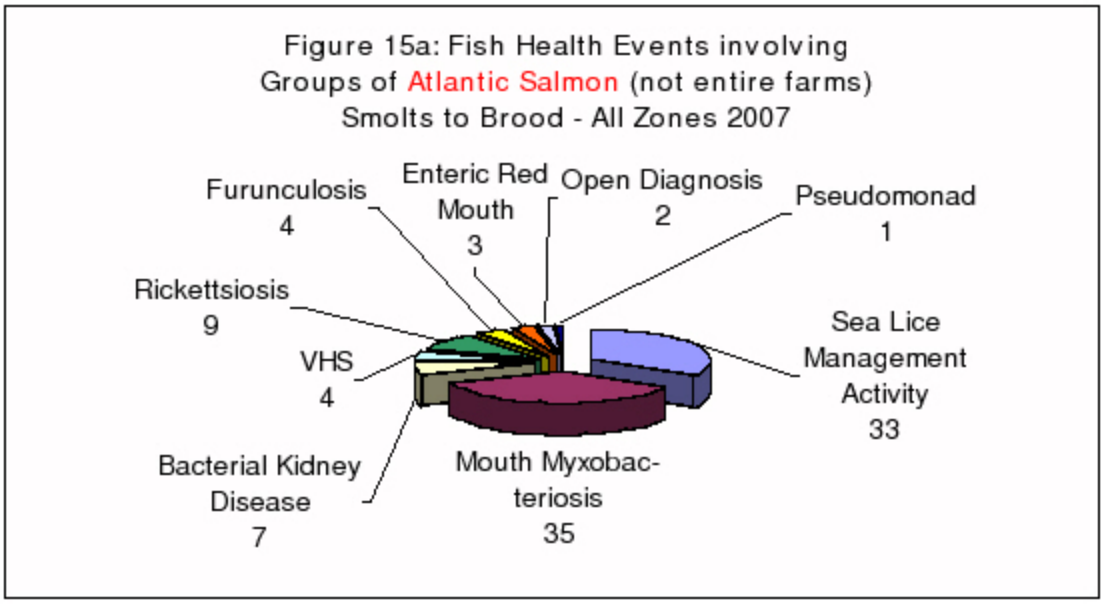
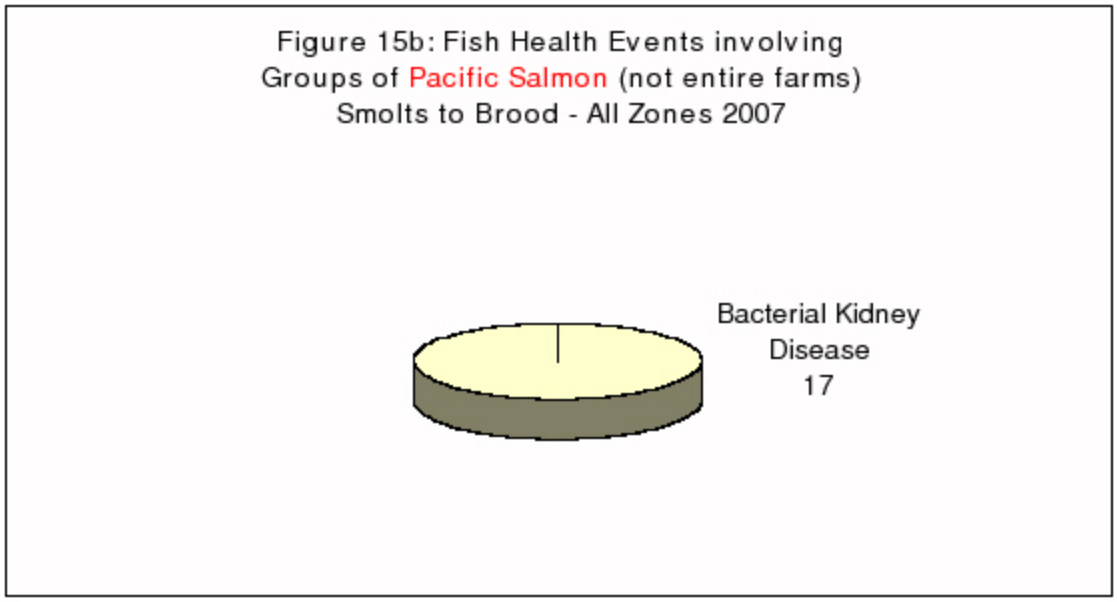


Figure 15b. BCSFA data: Annual Fish Health Events of groups of Pacific salmon within farm sites reported by the BC Salmon Farmers Association each quarter in 2007 for all zones. Seventeen cases of BKD were the only Fish Health Events reported as requiring husbandry or veterinary management in Pacific salmon.



Section 4: Sea Lice Management Program

4.1 Mandate

Sea lice are common parasitic copepods that have the potential to affect both farmed and wild fish stocks. Lice monitoring conducted on Atlantic salmon farms provides information for effective management and treatment decisions at the farm level. The program generates information to determine trends in lice abundance, the management of sea lice on farmed salmon, and to integrate with data on wild stock migration when possible.

4.2 Overview

The Ministry of Agriculture and Lands has been actively monitoring the status of sea lice infections on BC salmon farms since 2003. By 2004 the sea lice management strategy was integrated into the provincial Fish Health Management Plans (FHMPs) and the associated lice auditing aspect was extended to include the entire British Columbia aquaculture industry. As part of the reporting requirements of the FHMPs, industry information is provided to government monthly and posted to the BCMAL Fish Health website. In addition, the Ministry audits industry to verify the accuracy of the reporting. In 2007, Ministry fish health staff audited 57 farms and 3,380 live production fish for sea lice. The objective of the FHMPs and the audit program is to validate the status of lice infestations within BC's Atlantic salmon farms.

4.3 Provincial Sea Lice Monitoring

There are two components to the lice monitoring initiative:

1. Industry's on-farm monitoring and reporting, and
2. BCMAL's audit of these procedures.

BCMAL requires monthly sea lice sampling and reporting of aggregate, monthly data by fish health zone. In 2004, 'trigger levels' of lice abundance were established to minimise the potential accumulation of sea lice. Lice trigger levels were initially set at three motile lice per fish between March 1 to July 1, then six for the remainder of the year; however, in 2005, those triggers were reduced to 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

A working group of fish health experts responsible for management of farmed fish assist with integrating the information collected and evaluating the effectiveness of the program. These health professionals, including veterinarians, are responsible for the management and treatment of farmed fish raised under their care.

The monitoring program is divided into categories according to the species of sea lice found on farms and differences in susceptibility to lice amongst farmed fish species. For detailed definitions of lice stages see Appendix 7.10

4.4.1 Atlantic Salmon Farms

Industry lice counts are conducted once a month within each coastal sub-zone (unless an acceptable reason for not sampling was provided [4]). The intensity of monthly sampling is increased to twice monthly should the trigger level of three motile lice per fish is reached anytime. During the out-migration of wild juvenile salmon (March to July) should a farm reach the trigger of three motile lice per fish, regulations require that action, such as treatment or harvest, must be taken to reduce the lice concentration. 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 sampled (farm total = 60 fish). Pens chosen for sampling include one "reference" or index pen (i.e. first pen entered in the system or the pen with the highest probability of having lice (based on historical counts)). This pen is sampled each month. Two additional pens may be selected by the farm either haphazardly, or by rotation, or as convenient.

Hundreds of fish are captured using a seine or another method that ensures representative sampling of the population. 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 method of handling is recorded. The fish are examined for the presence of lice regardless of the health status of the fish. After lice abundance has been assessed and recorded, some fish may be culled from the population.

---

[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 problem
v Fish could not be handled due to environmental problem, e.g. low DO
vi 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.

levels on the farms were 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 (25) percent of the active[5] Atlantic salmon farms are selected for lice audit each quarter. During the second quarter (April – June) the audit and monitoring frequency doubles to 50 percent of the active farms to correspond with the period of the wild smolt out-migration.

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 any treatment that may have occurred during that quarter. Ministry bio-technicians also record the marine environmental parameters for the day; water temperature and salinity are recorded at 0, 1, 5 and 10 meters depth.

4.5.4 Fish collection and counting procedures

Fish collection and counting procedures are evaluated during the farm visit. Fish health technicians are experienced in fish handling and follow standard operating procedures for fish handling, anaesthesia and lice counts.

[5] Active farms are those farms which have held fish for 120 days and have a minimum of 3 pens of fish on site during the quarter which sampling is to occur. Broodstock are not sampled for sea lice.

Twenty fish from each of three net pens are sampled, as is required for a standard industry sea lice count. Ten fish from each pen are evaluated by the BCMAL bio-technician and 10 by an industry staff member. The anaesthetized fish are systematically examined while in the anaesthetic bath and lice are enumerated and classified accordingly. On occasion, BCMAL staff may also collect lice from anaesthetized or euthanized 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.

4.5.5 Analysis of Sea Lice Audit Data: Atlantic Salmon Farms

Active farms that satisfy the criteria for sea lice audit were identified and randomly selected for audit. Table 17 summarizes the audit activity of 2007. It is common that one or two farm visits are 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 four audit cancellations.

Table 17: 2007 Total farms selected, total farms audited and numbers of live fish assessed (per quarter)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
# farms selected	11	26	11	13	61
# farms visited	11	25	9	12	57
# fish counted	640	1,480	540	720	3,380

Analysis of the 57 lice-counting comparisons made in 2007 found no significant difference between counts performed by BCMAL personnel and designated farm staff at the farm-level for the *Lepeophtheirus* motile or female stages, or the *Caligus* motiles ($p>0.05$). This agreement between paired count results (of the mean abundance of lice counted, on different fish, from the same pen) provides confidence in the technical proficiency of the farm personnel generating the count data as reported by the farms.

This on-farm, split-sample, lice-counting procedure and the examination of records represents a compliance audit. The results of the joint count serve as that farm's monthly count and the results 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 'within sub-zone' analysis and the sub-sample validation test (see Figures 18 to 24 below).

Tables 18a/b and Figures 16a/b show the aggregated results of the BCMAL average abundance of sea lice on Atlantic salmon farms for all sub-zones in 2007. In general, the lice abundance on farmed Atlantic salmon was the lowest level seen since the inception of BC's monitoring and audit programs. In quarter four (Q4), elevations of motile and female lice occurred without corresponding increases of the chalimus (i.e. early) life stage. This is evident in both first and second year class fish (see Tables 18a/b). This observation supports the premise that wild fish

returning in the late summer are the most likely source of motile lice rather than mature lice being generated from younger lice stages on farms. For more detail by sub-zone, refer to Appendix 7.11.

To further increase the confidence in the data reported by industry, data from the audited farms within each sub-zone were examined for 'within farm' (farm-level) and 'within sub-zone' variation together. This is an important test for the auditing function because it best models the industry situation: collection of information from different farms, with different personnel, occurring on different days, with different ages of fish exposed to lice, etc. All statistical analyses were completed using Microsoft Statistix 8.

Our analyses found no significant difference between counts performed by government personnel and farm personnel at the sub-zone level, for all but a few cases. Farm staff did have higher counts for two cases of *Caligus* and BCMAL staff had higher counts in one case. Related to that, the *Caligus* motile stages tend to detach from fish during the handling and anaesthetic bath, more so than *Lepeophtheirus*. In each case where counts differed, *Caligus* were recovered from the anaesthetic totes and counts were added to the audit total.

In conclusion, lice detection and identification by industry in 2007 was found to tolerate statistical scrutiny, both at the farm- and the sub-zone levels, which provides confidence in the industry-reported lice abundance.

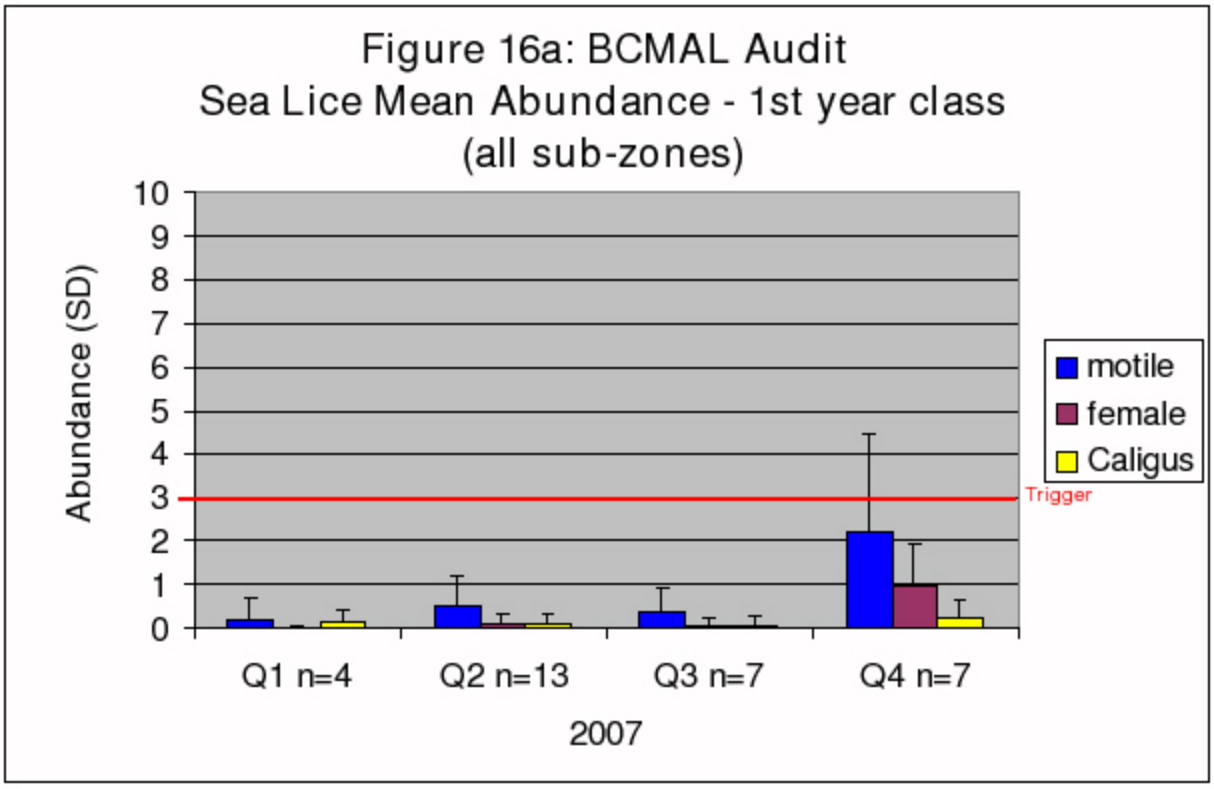
Table 18a. Mean abundance of motile, female *L. salmonis*, chalimus sea lice and motile *Caligus clemensi* during Atlantic salmon farm audits in 2007 (per quarter) – 1st year class*

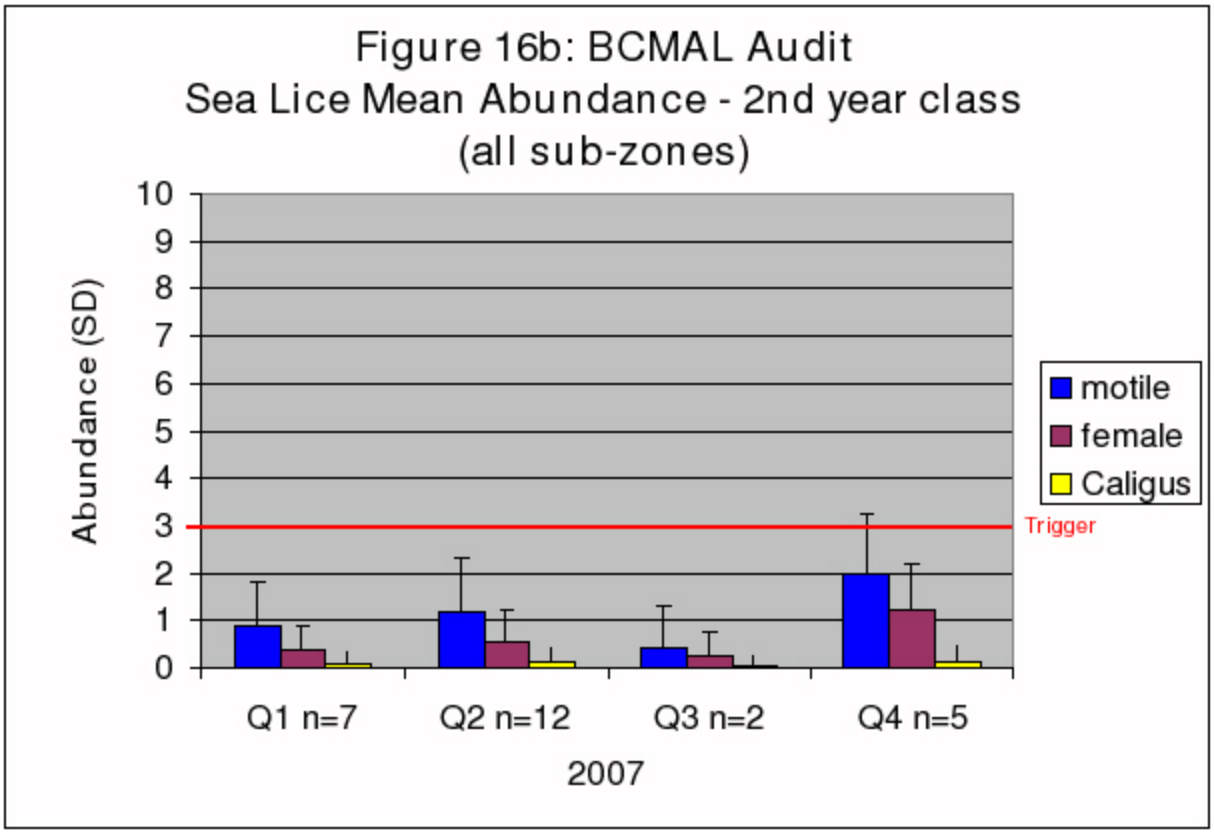
2007 Mean Abundance	Q1	Q2	Q3	Q4
Number of Farms Audited (n)	4	13	7	7
Motile	0.19	0.51	0.39	2.21
Standard Deviation (SD)	0.505	0.684	0.533	2.235
Female	0.01	0.07	0.05	0.96
SD	0.046	0.224	0.183	0.994
Chalimus	1.60	0.37	0.72	0.44
SD	1.824	0.861	1.543	1.346
Caligus Motile	0.16	0.10	0.05	0.23
SD	0.251	0.216	0.223	0.429

* Tables of comparable audit data reflecting separate year classes of Atlantic salmon can be found in Appendix 7.11.

Table 18b. Mean abundance of motile, female *L. salmonis*, chalimus sea lice and motile *Caligus clemensi* during Atlantic salmon farm audits in 2007 (per quarter) – 2nd year class

2007 Mean Abundance	Q1	Q2	Q3	Q4
Number of Farms Audited (n)	7	12	2	5
Motile	0.90	1.15	0.43	1.98
Standard Deviation (SD)	0.894	1.185	0.904	1.273
Female	0.36	0.51	0.22	1.21
SD	0.530	0.716	0.535	0.976
Chalimus	0.54	0.72	0.13	0.09
SD	1.394	2.847	0.365	0.482
Caligus Motile	0.07	0.10	0.03	0.13
SD	0.270	0.303	0.220	0.327





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 time 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 2007 BCSFA average abundance of sea lice on Atlantic salmon (in all zones combined, by year class) is shown below in Figures 17a and b. The overall average remains well below three lice per fish with the exception of autumn. The 'n' value in each quarter reflects the number of lice assessments conducted by industry; over 600 counts and approximately 38,000 fish in total. The monthly sub-zone tables and bar charts submitted by BCSFA to BCMAL are found in Appendix 7.12.

Figure 17a: BCSFA Sea Lice Averages on Atlantic salmon - 1st Year Class (all sub-zones)

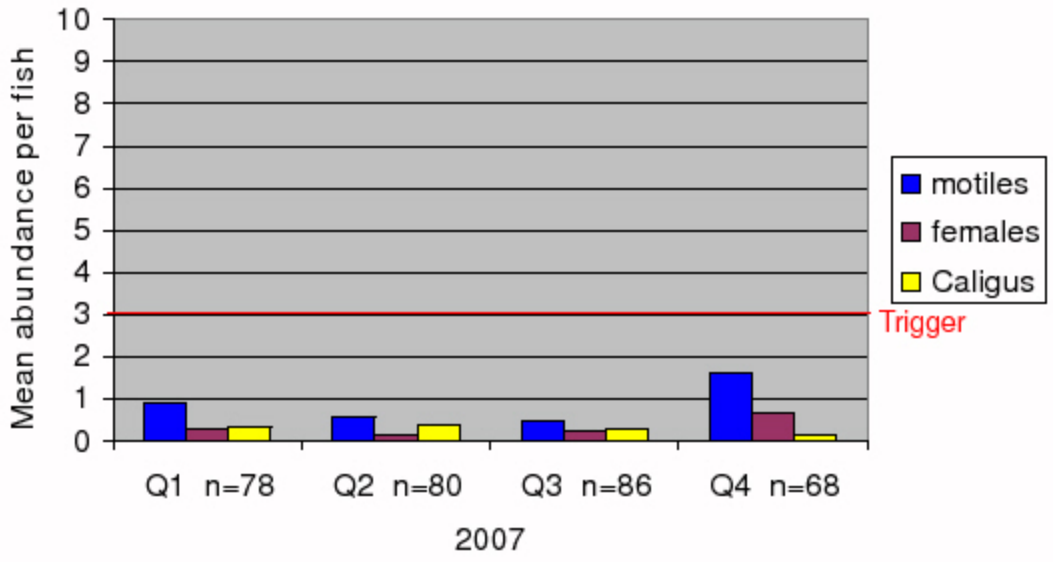
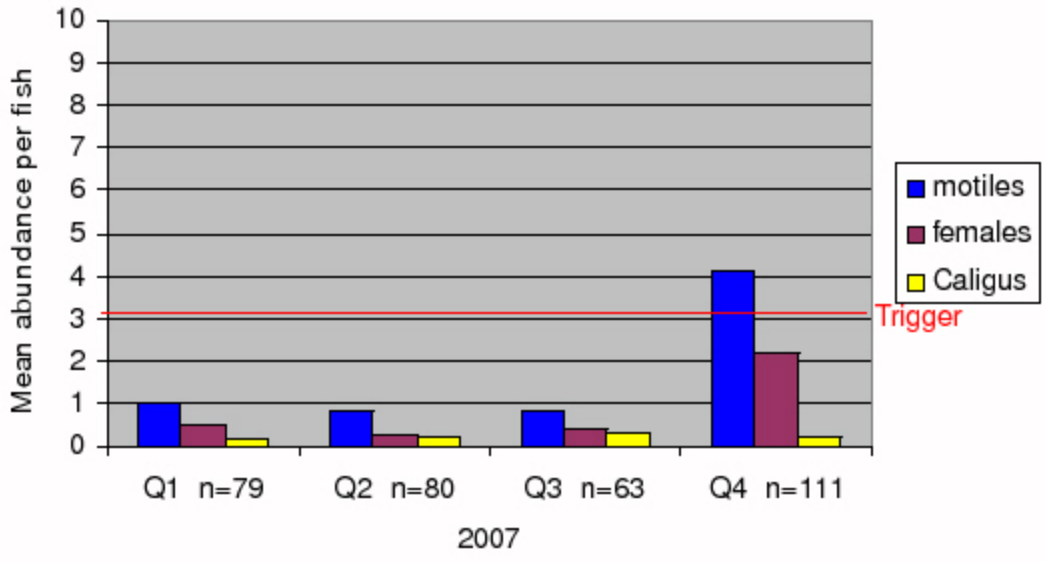
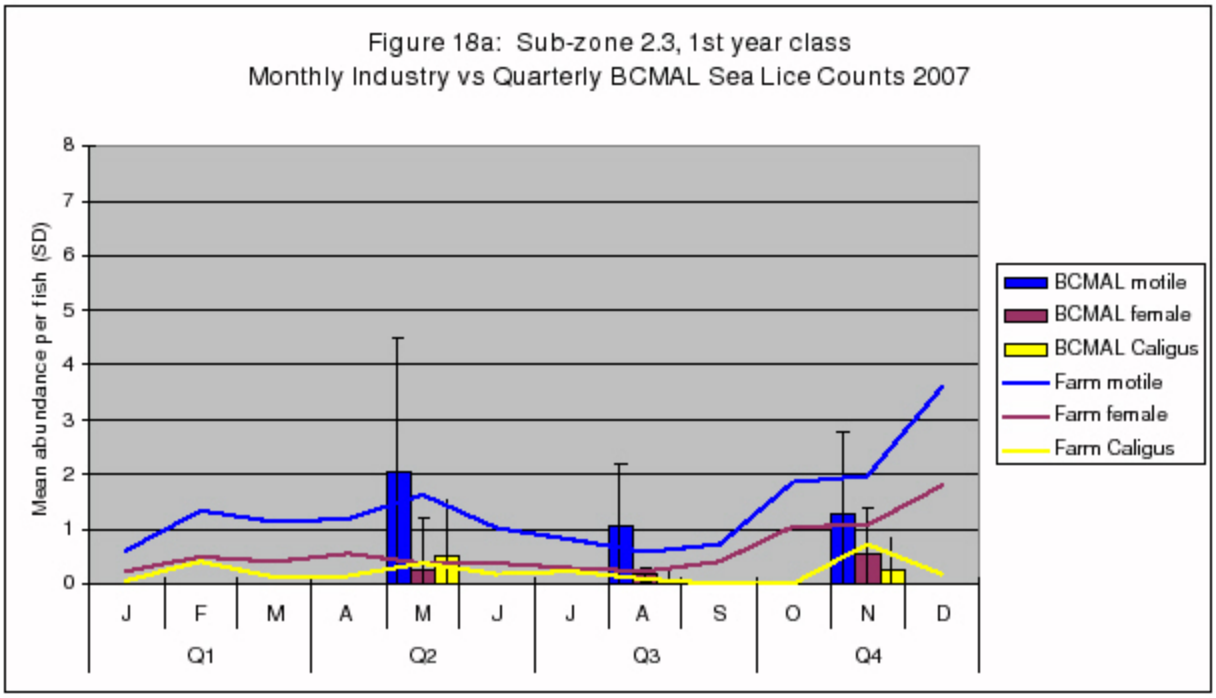


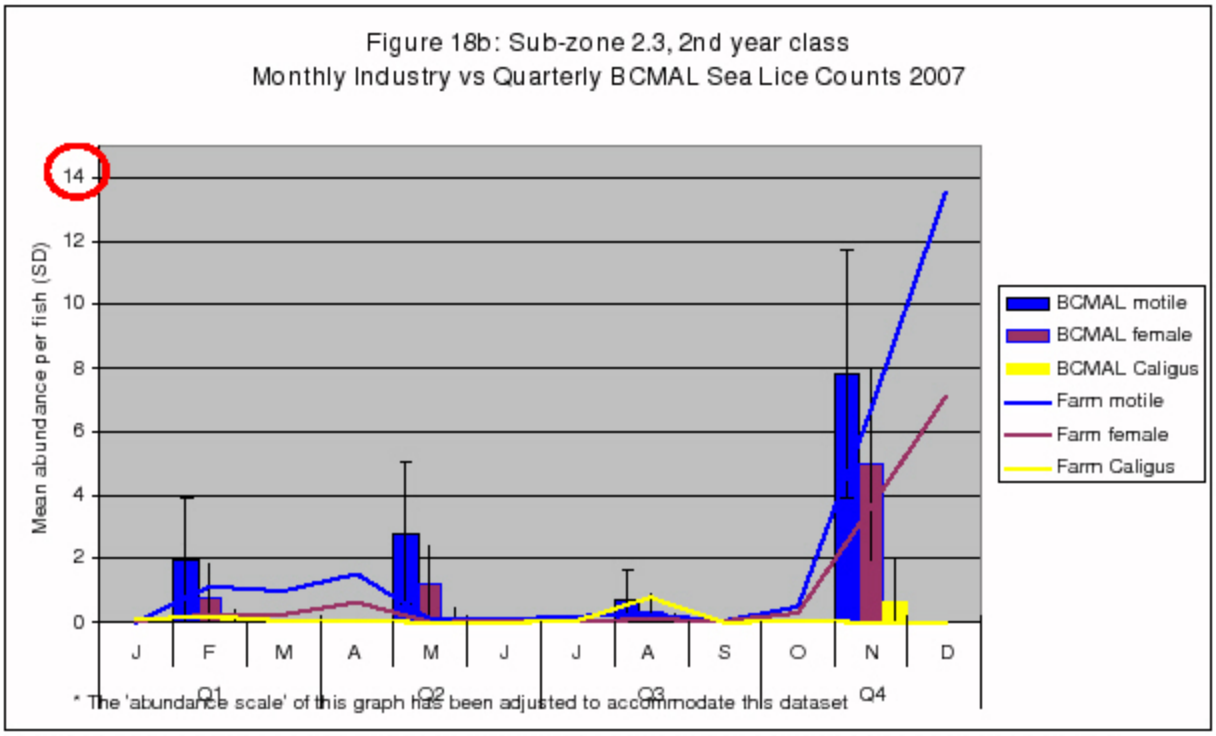
Figure 17b: BCSFA Sea Lice Averages on Atlantic salmon - 2nd Year Class (all sub-zones)



BCMAL sea lice audit data is collected each quarter on days that the farm has already scheduled for lice counts. 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.

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' (and the difficulty in generating a good estimate of lice abundance due to the 'within pen', 'between pen', and 'between farms within a sub-zone' variance), the BCMAL sub-sampling validation shows acceptable agreement with the abundance reported by industry. In the few cases where the audit data does not fall in agreement with the more frequent and representative industry counts (i.e. the best estimate of lice abundance on farmed fish), in each case the industry reported higher sea lice abundance.





NB. Quarter 4 lice abundance in sub-zone 2.3, although exceeding the trigger level of three (3) motile lice per fish, was monitored and managed accordingly. The abundance was reduced effectively by January 2008.

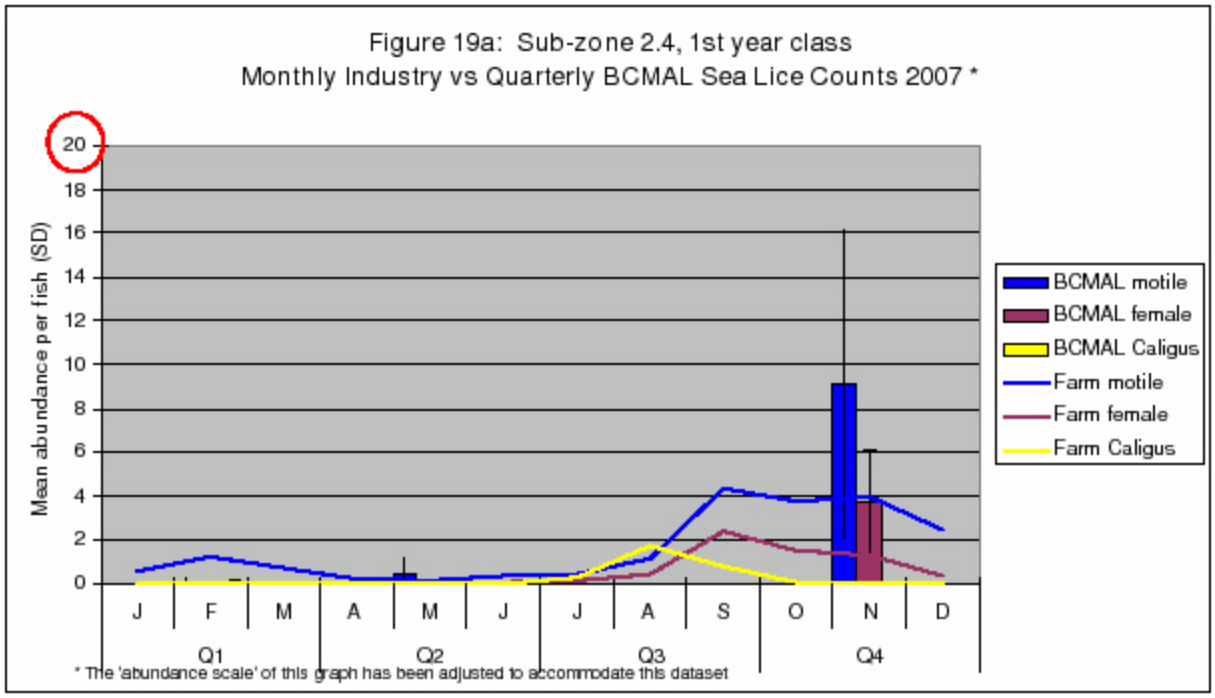


Figure 19a: Sub-zone 2.4, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2007 *
Mean abundance per fish (SD)
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D
Q1 Q2 Q3 Q4
BCMAL motile
BCMAL female
BCMAL Caligus
Farm motile
Farm female
Farm Caligus
* The 'abundance scale' of this graph has been adjusted to accommodate this dataset

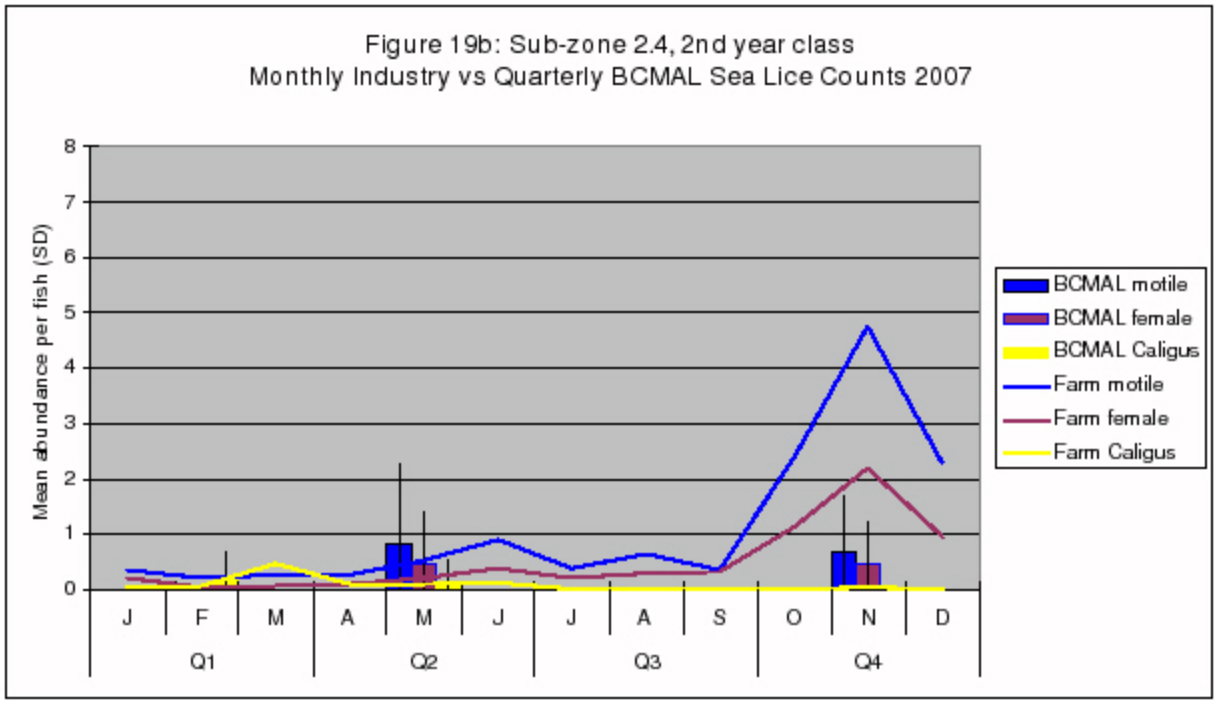
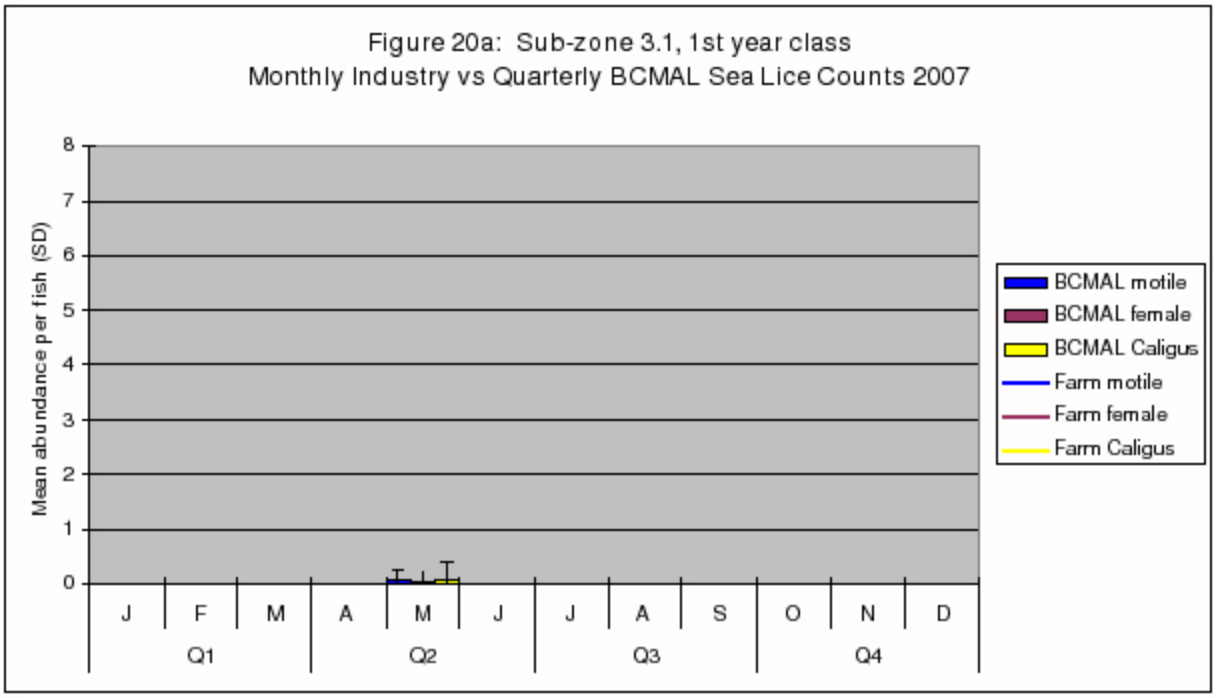
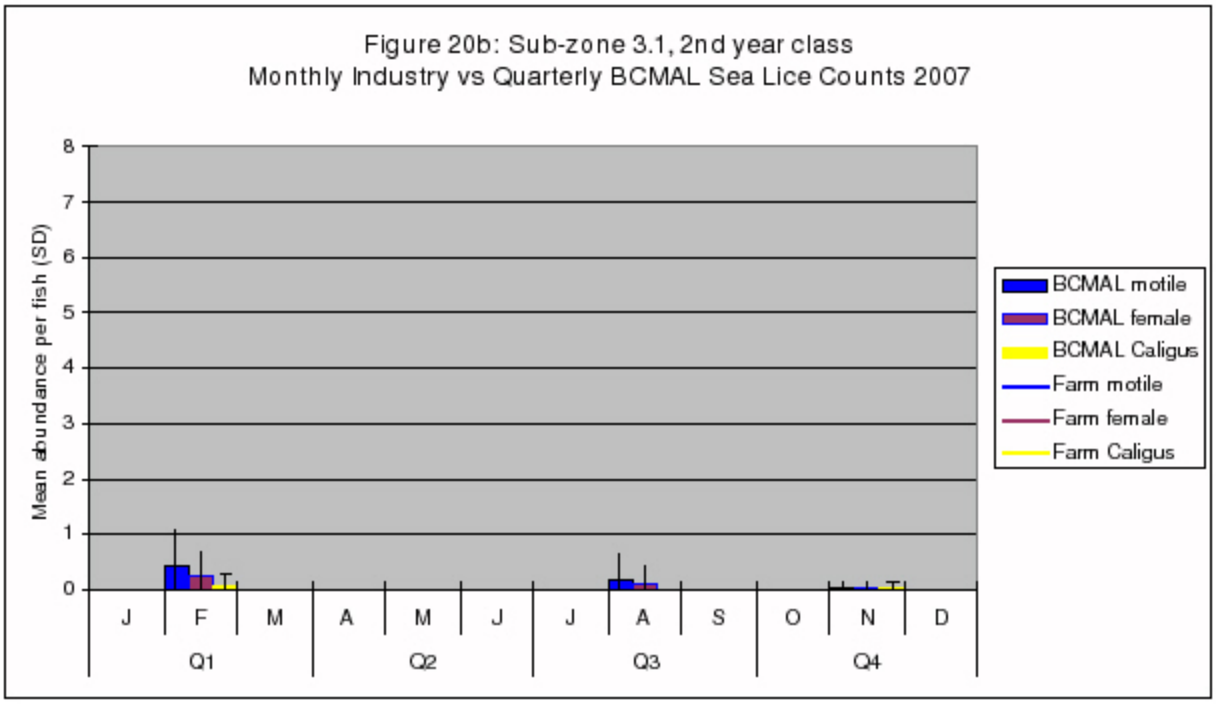
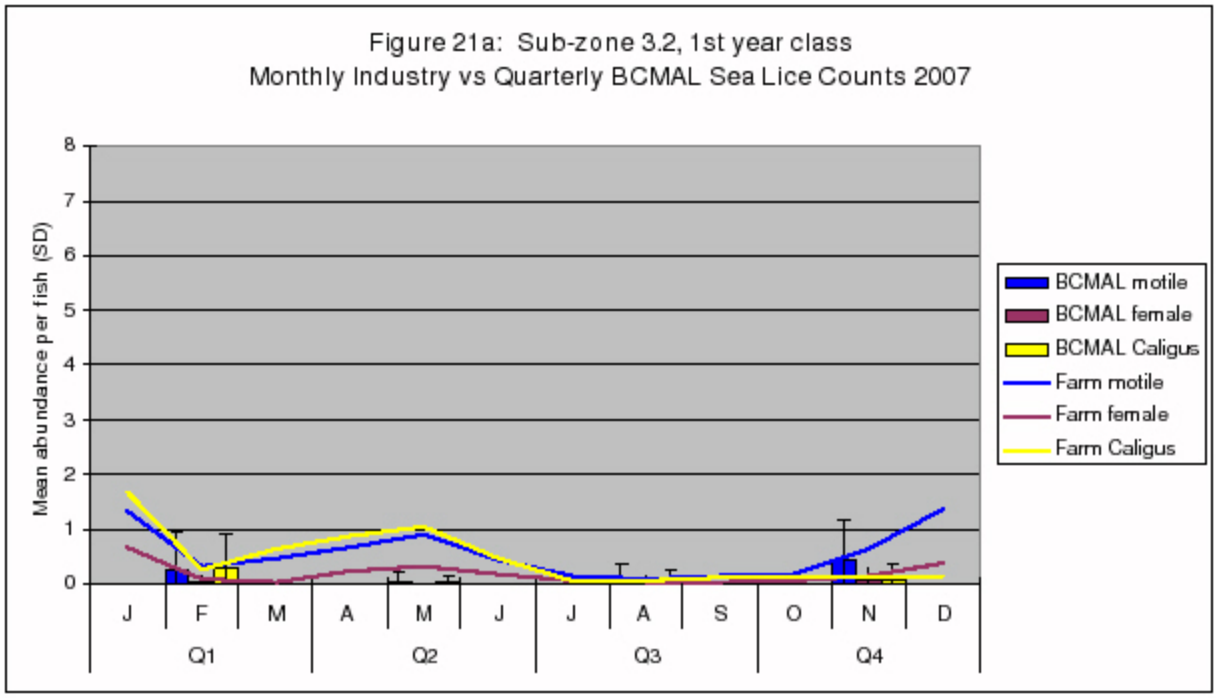


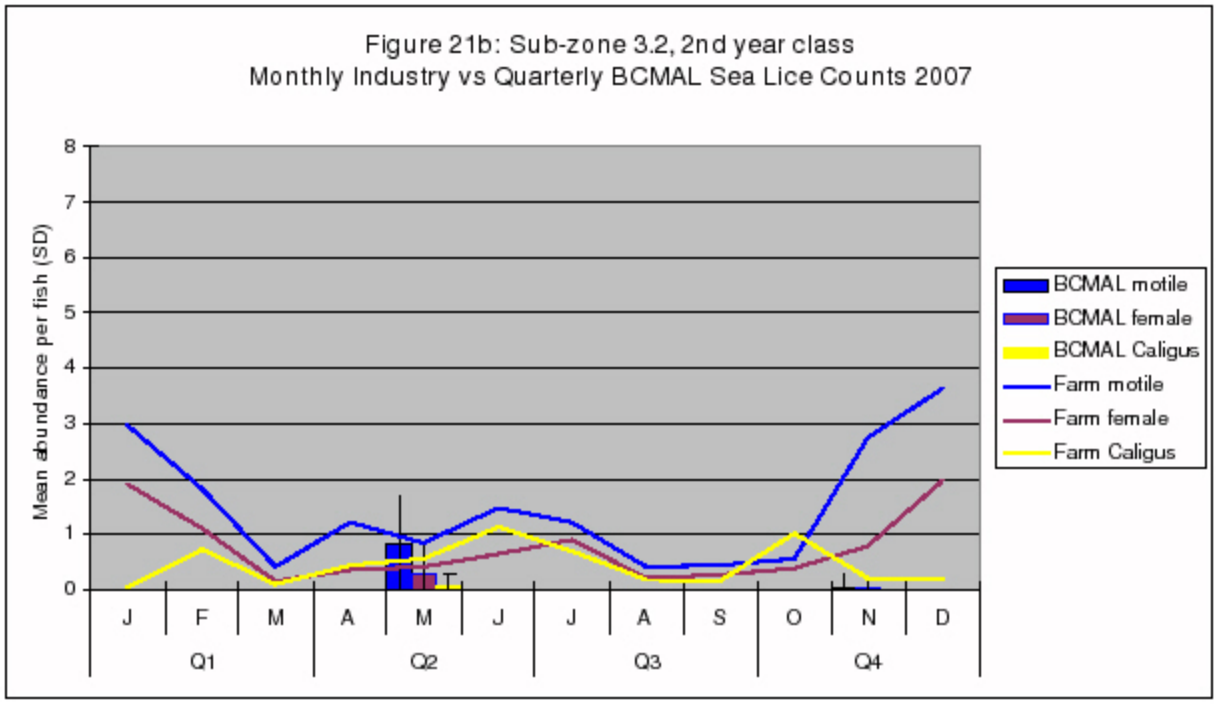
Figure 19b: Sub-zone 2.4, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2007
Mean abundance per fish (SD)
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
Q1 Q2 Q3 Q4
BCMAL motile
BCMAL female
BCMAL Caligus
Farm motile
Farm female
Farm Caligus





NB. Farms operating in sub-zone 3.1 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.





NB. Farm monitoring and audit procedures continue to identify a presence of *Caligus* lice species in sub-zone 3.2. *Caligus* species are common on non-salmonid fishes. Their presence in 2007 is attributable to wild herring and pilchard populations near salmon farms. *Caligus* lice are ubiquitous and recording their abundance on farmed fish will enable trend analysis.

Figure 22a: Sub-zone 3.3, 1st year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2007

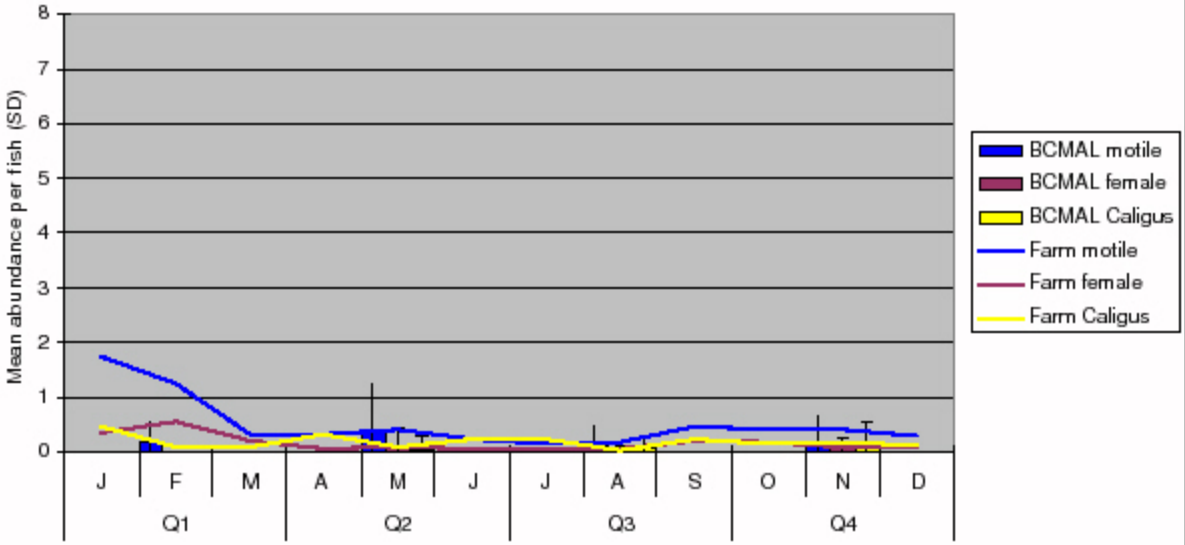
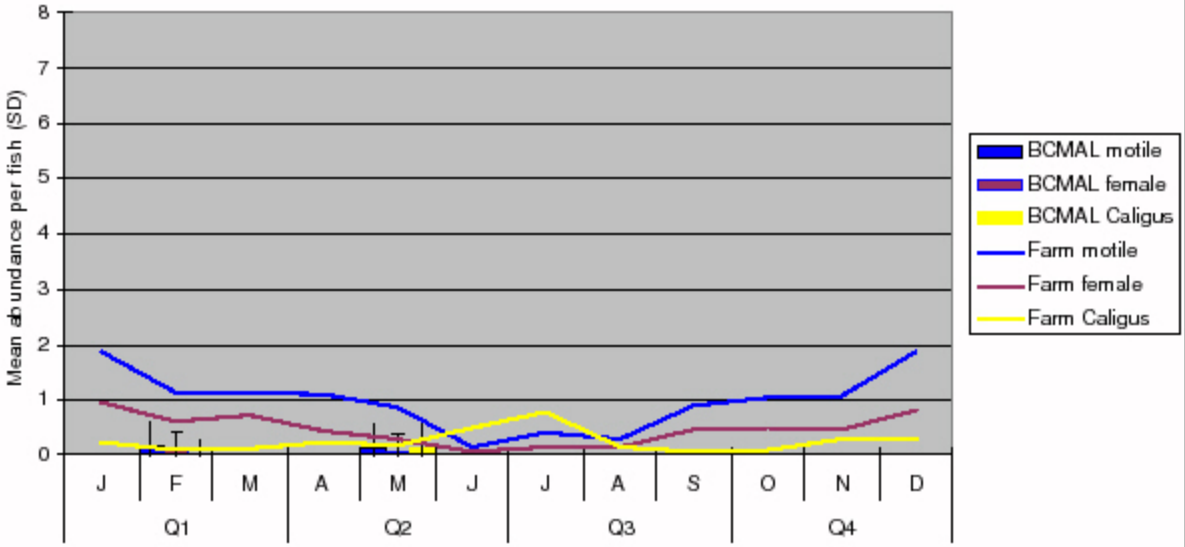
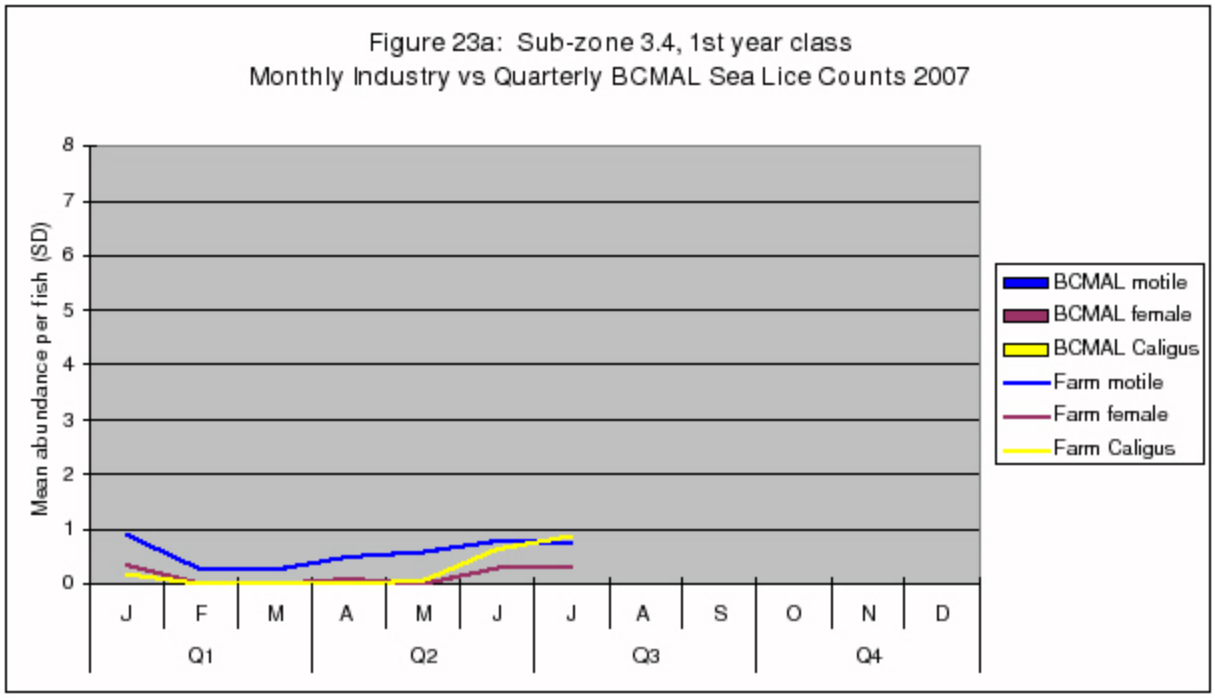
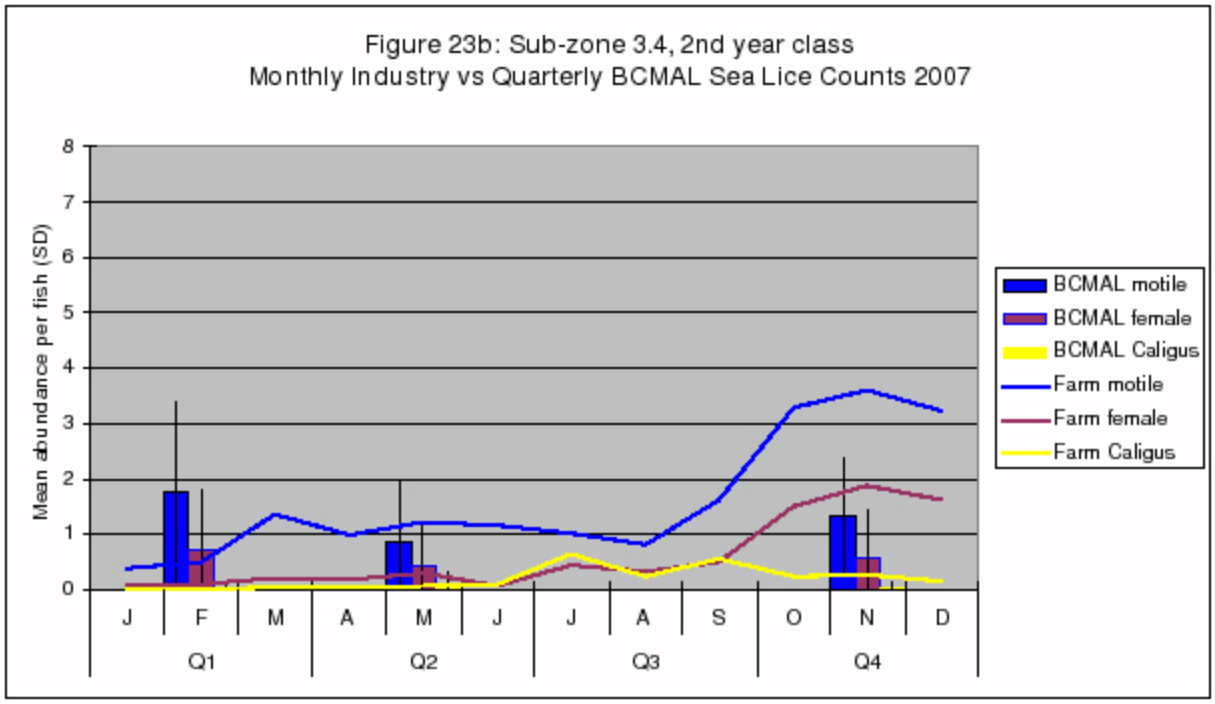


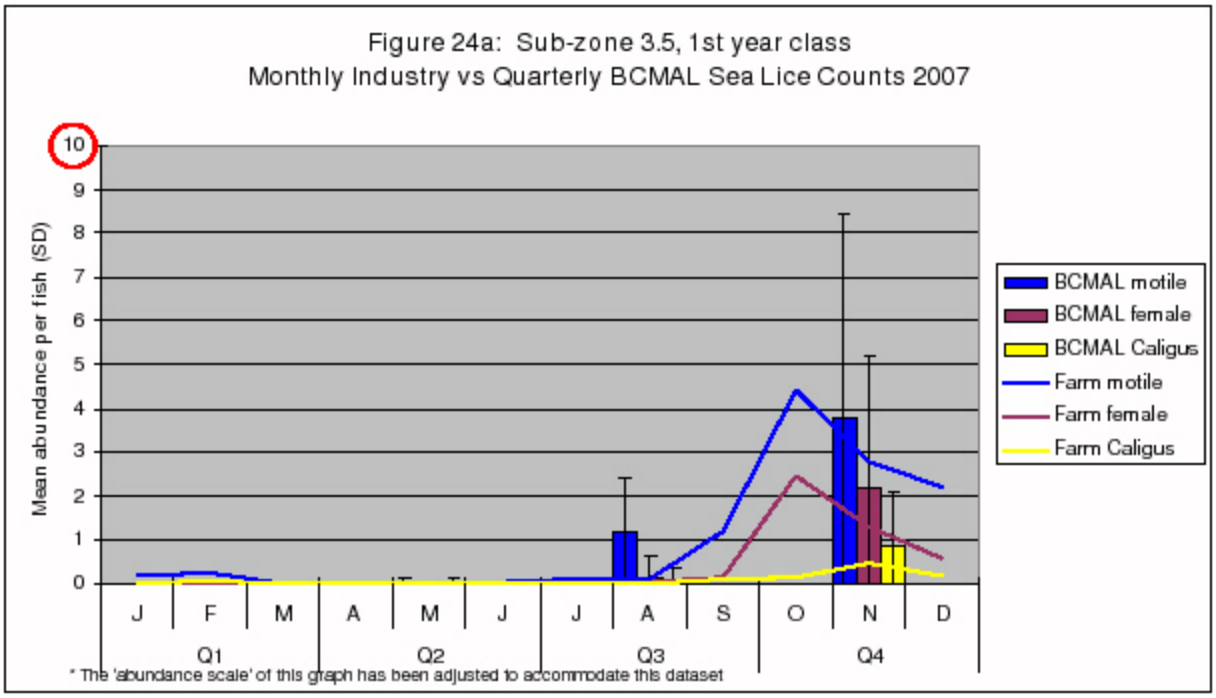
Figure 22b: Sub-zone 3.3, 2nd year class
Monthly Industry vs Quarterly BCMAL Sea Lice Counts 2007

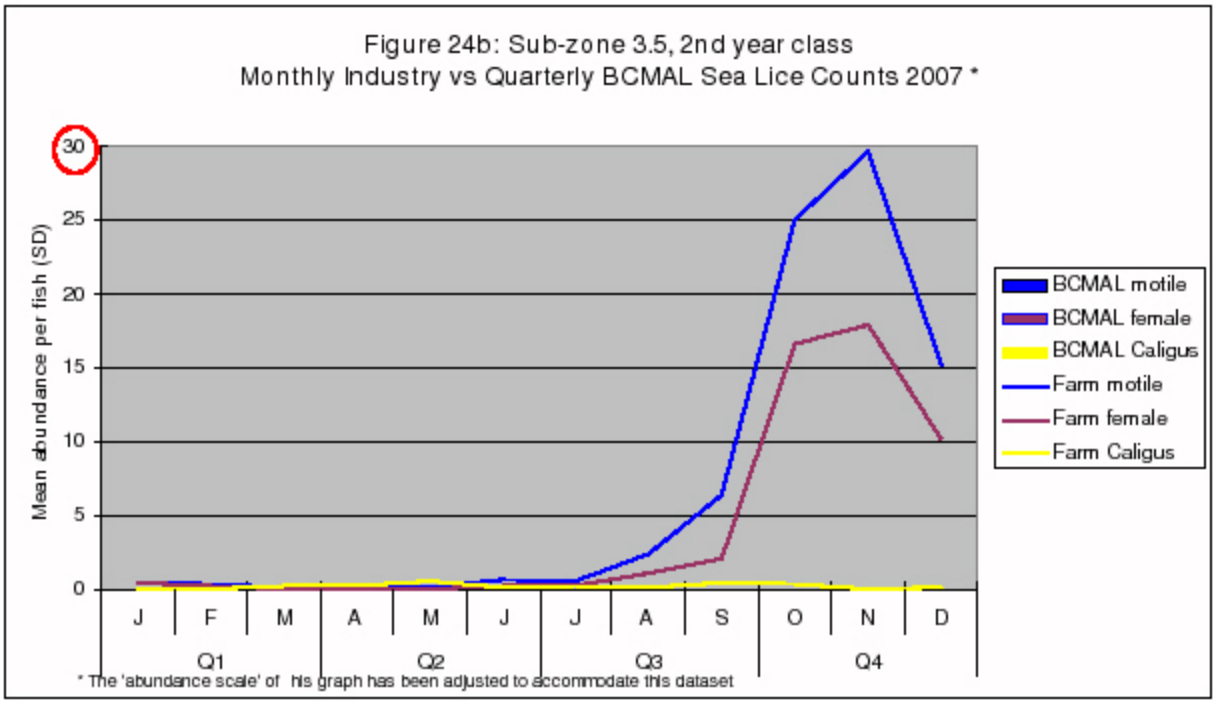






NB. In Figure 23a the populations of 1st year class fish in sub-zone 3.4 were moved or re-classified as 2nd year class fish in July 2007, marking the end of monitoring and reporting from aquaculturists in sub-zone 3.4 for the remainder of the year.





NB. Audit counts were performed in quarter 1; the mean abundance was 0.017 motile per fish at that time (see Appendix 7.11, Table 7.11.7). The marked rise in abundance of sea lice in sub-zone 3.5 in quarter 3 is an annual seasonal phenomenon. Environmental factors and producers manage the abundance accordingly each autumn and winter.

4.6 Rationale for the Three Motile Lice Trigger

In 2002 an on-farm lice monitoring pilot project was initiated in the Broughton Archipelago. A plan was devised to establish trigger levels based on international data and information. After examining the data available in the published literature and from government sources in other jurisdictions, trigger levels of three (3) motile sea lice during out migration and six (6) motile lice for remainder of the year, were viewed as rational and precautionary based on the existing science at that time. In 2003 the sea lice monitoring program was extended beyond the Broughton to include the entire BC salmon farming industry. BCMAL has since implemented the monitoring program as a part of the Fish Health Management Plans and has 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 levels on farms tend to be greater than the trigger value of three. In this case it is required that monitoring frequency be increased by farm staff at the affected location.

The drug product available to control sea lice, emamectin benzoate (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 winter (i.e. December, January or 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 Fisheries and Oceans Canada (DFO) continue to work with the aquaculture sector to ensure the necessary data is gathered to integrate findings with the farm management programs.

4.7 Comparison to Other Countries

The trigger levels for treatment of lice in Norway are 0.5 gravid females and/or 5 motile lice per fish during the juvenile migration period, increasing to 2 gravid females and 10 motile lice for the remainder of the year. To our knowledge, neither Scotland nor Chile have assigned abundance values to trigger lice management. A summary of the triggers in different jurisdictions is provided in Table 19 below.

Table 19: Comparison of Trigger Levels in Salmon Farming Jurisdictions

Country	Time of Year	Trigger Level	Action
Norway	Dec 1 – Jul 1	0.5 gravid females; 5 motile lice	Treatment required
	Jul 1 – Dec 1	2 gravid females; 10 motile lice	
Scotland		No trigger level known	Area Management
Ireland	Mar 1 – May 1	0.3 - 0.5 egg-producing (gravid) adult females per fish	Treatment required
	May 1 – Mar 1	2 egg-producing (gravid) adult female lice per fish	
Chile		No trigger level known	
BC Canada	Mar 1- Jul 1	3 motile lice per fish	Treatment / Harvest
	Jul 1 – Mar 1		Increased monitoring, treatment or harvest

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 regions. Recent genetic research by Yazawa et al. (in press, 2008) shows that the Pacific *L. salmonis* louse is genetically distinct from the Atlantic Ocean louse and has evolved independently for a number of million years. The data is suggestive (though not conclusive) of an Atlantic Ocean origin of Pacific sea lice. This is a pivotal discovery in that the independent evolutionary history may explain marked differences in louse virulence and pathology caused by Pacific sea lice on Atlantic salmon.

The policy of more conservative triggers in British Columbia has been precautionary; the principle followed when management is evidence-based and there are gaps in knowledge. Justification of the conservative triggers will continue to be debated while research advances understanding.

4.8 Synopsis of Industry Sea Lice Results - 2007

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 2007.

Summary:

- Abundance of lice in 2007 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 2006 had declined or been managed to fewer than 2 motile lice per fish by February 2007 and abundance of motile lice remained low for at least six months. In other words, no obvious recruitment of lice populations arose from within the farms between February and August 2007.
- 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 ill health even when afflicted by relatively high numbers of lice observed each autumn.
- Lice levels vary between year classes. The overall abundance of lice on juvenile Atlantic salmon is lower in their first year of sea water compared to 2nd year fish (adults).
- Lice levels can vary significantly 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 point since monitoring began whereas other areas experience increases in lice levels each autumn. With the exception of the autumn months, in 2007 most sub-zones had lice counts that averaged fewer than 1.5 motile lice per fish.
- Abundance of lice varies naturally from year to year. Sea lice data have been collected consistently over a four year period (2004 -2007 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 changes from year-to-year. Annual fluctuation in average lice abundance in all sub-zones is to be expected.
- Sea lice are naturally occurring parasites of wild fish. Data collected from wild stocks shows that returning adult salmon can carry high numbers of sea lice. Undoubtedly this is a natural life cycle of this parasite on its native fish hosts.

- Marine conditions can affect the occurrence and abundance of lice on farms. Information on environmental conditions and the impact on lice survival and reproduction is well documented. Two key factors are temperature and salinity. In general, elevated water temperature and greater salinity tends to favour the survival and reproduction rate of sea lice. The following authors have published relevant works speaking to the environmental factors and biology/behaviour of *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.

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

The ongoing 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)) will provide critical information required to further our knowledge of the region and of sea lice behaviour. 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 juvenile salmon in the Broughton Archipelago. The Pacific Salmon Forum Final Report is a useful resource explaining current projects and results to date.

The average abundance of motile sea lice on both 1st and 2nd year class Atlantic salmon raised in the Broughton area were well below trigger levels throughout the year including the period of wild salmon out-migration season. Figures 22a/b and corresponding Tables 7.11.5 and 7.12.5 in the appendices reflect lice counts pertaining to sub-zone 3.3.

In 2007:

- Juvenile Atlantic salmon (1st year class fish) had an average abundance of less than 0.5 motile lice per fish from March 2007 through December 2007.
- Larger 2nd year class fish had an abundance of less than 1.2 from February 2007 to November.
- Two species of lice were most common on farmed salmon: *Lepeophtheirus salmonis, (L. salmonis)* and *Caligus clemensi* (*C. clemensi*).
- The predictable seasonal pattern of increased abundance of motile lice in the autumn began in September; the abundance increased to 1 louse per adult fish and subsequently to 1.9 lice in November 2007. This pattern was not evident in juvenile farmed salmon.

Section 5: Therapeutant Use and Monitoring

5.1 Therapeutant Use and Monitoring

The Ministry of Agriculture and Lands monitors the use of therapeutants in food fish production 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 do not occur in marine net pens and have yet to be considered a viable practice in British Columbia.

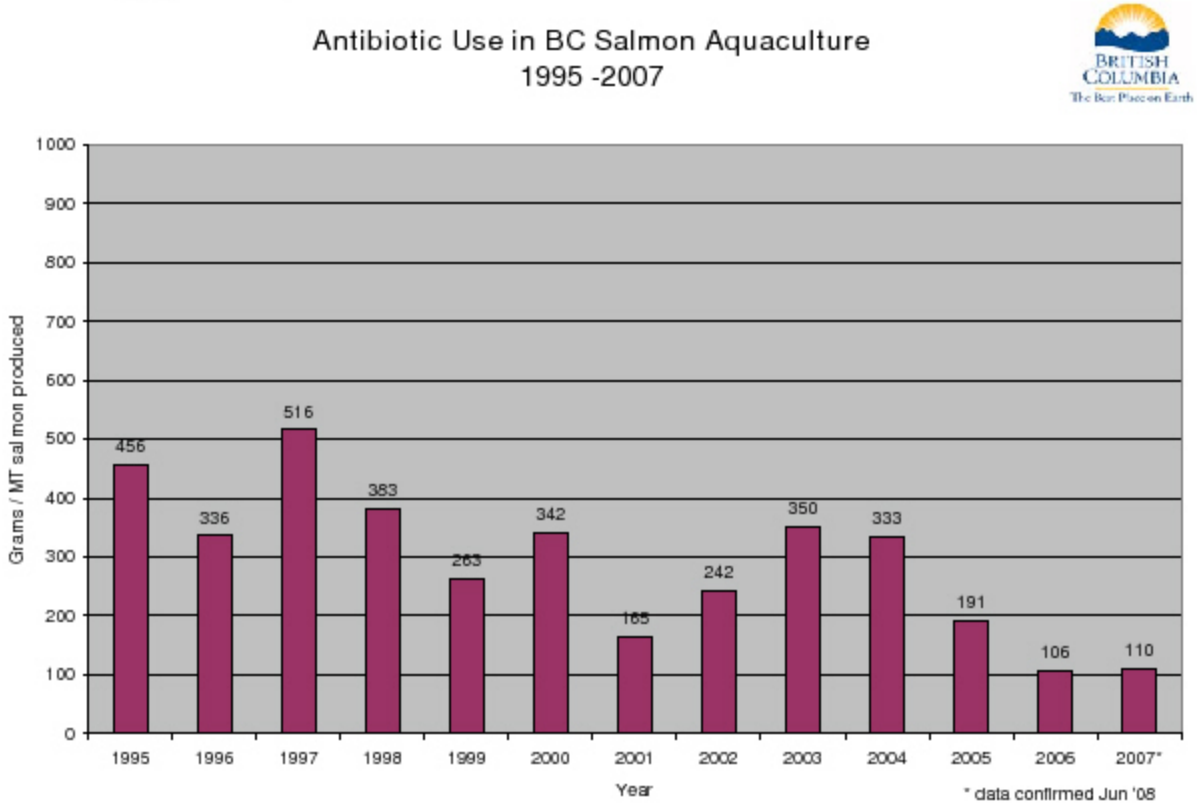
5.1.1 Antibiotics:

Few drugs are available for use in food fish. Four (4) antibiotic products are licensed for fish 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 rare. Broodstock are sometimes medicated with other drugs if necessary and the brood may also receive injectable antibiotics, however these fish are not destined for human consumption. Feed mills report the use of antibiotics in broodstock diets but the use of injectable products in the brood is tracked by the prescribing veterinarian and companies.

As shown in Figure 25, in the past decade antibiotic use has ranged from a peak of 516 grams (g) of active drug per metric tonne (MT) of fish (1997) to a low of 106 grams (2006). In 2007 a comparable 110 g / MT was used. It is noteworthy that these annual "grams per metric tonne of fish produced" values include the volume of antibiotics fed to broodstock, meaning that the marketed production fish are, in reality, exposed to lower amounts of antibiotic than shown in the bar graph.

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

Figure 25: Summary of Antibiotic Use in Aquaculture 1995 – 2007 (includes use in broodstock populations).

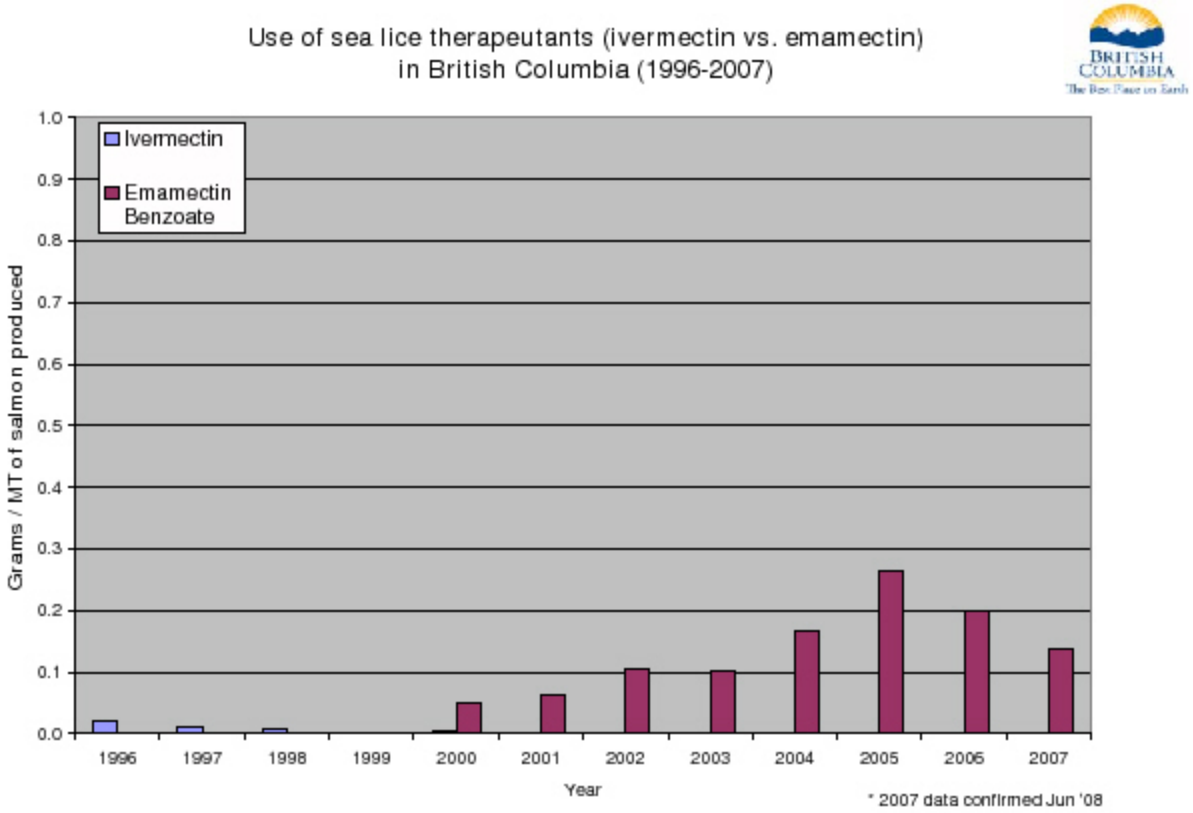


5.1.2 Sea Lice Medical Management:

Currently only one product is available for controlling sea lice in British Columbia: emamectin benzoate, otherwise known as SLICE®. The therapeutant remains in its final stages of the federal review and approval process under the authority of Health Canada. As such, it has yet to receive a license and label. The product is available by the Emergency Drug Release (EDR) program. Emamectin benzoate is an efficacious product for sea lice management and, following treatment in BC, lice abundance on farms typically remains low for 5 months.

As illustrated in Figure 26, the anti-lice treatments have declined in the past few years. This coincides with a general decline in sea lice abundance on farmed fish over the same corresponding period. Initially, from 2000 to 2003, harvest-sized Atlantic salmon would generally not have been medicated with SLICE® because the presence of sea lice on these fish does not result in ill health, and the medication would interfere with harvest flexibility. Between 2003 and 2005, and upon the implementation of the provincial Sea Lice Management Strategy, the prescription use of SLICE® 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 loads and pre-spring harvests help to explain the reduced use of the anti-lice medication.

Figure 26: Summary of Use of Sea Lice Products in BC Aquaculture 1996 – 2007, including use in broodstock populations.



(The arrow indicates when the trigger level of 3 motile lice per fish was assigned and subsequently influenced the volume and frequency of therapeutic management)

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 basis of the program is the Fish Health Management Plan which is a Term and Condition of an aquaculture license. The Fish Health Management Plan requires marine salmon farmers to report fish health events, mortality rates and causes, and sea lice abundance.

The 2007 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. Brains and pyloric caeca from silver carcasses were recently added to the tissues submitted for histological assessment and this change allowed an improvement in diagnosis of cause of death. Two marine parasites found in the brains of a limited number of Atlantic salmon carcasses in 2007 are of scientific interest and contribute to the information derived from surveillance efforts. These parasites may represent the emergence of an indigenous pathogen worthy of close monitoring and further

investigation however there is no evidence that they are exotic to British Columbia (see Appendix 7.6).

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 monthly on mortality and fish health events that occur amongst farm populations. The findings of the audit program show agreement with BCSFA's Fish Health Event reports in 2007.

Compliance with FHMPs is monitored by on-farm inspection and log review during the routine audit procedure. There is full compliance with FHMPs on marine salmon farms and a number of the plans are under review following recent corporate mergers. Fish Health Management Plans 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 transfer of pathogens to other populations.

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 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 2007 was the lowest on record with averages in most regions being well below the three motile lice per fish. Detailed data is available for viewing on the Ministry's website and Appendices 7.11 and 7.12.

Salmon begin their life cycle in fresh water where they are free of sea lice. After being transported to marine farms, lice infestations arise as a result of exposure to sea lice from wild salmon and other marine fishes. Atlantic salmon are known to be one of the most susceptible fishes to sea lice infestation; thus, farmed salmon serve as the appropriate sentinel population in British Columbia to monitor abundance. The Province continues to work with Fisheries and Oceans Canada, other researchers and the Pacific Salmon Forum to monitor sea lice and to integrate new information into lice control strategies.

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: APPENDICES

APPENDIX 7.1 List of Mortality Classifications

Mortality Rate and Mortality Categories Recorded and Reported by BC Salmon Farmers Association Fish Health Database.

Average Mortality Rate

The average mortality rate is calculated as the total number of mortalities out of the total number of fish cultured in that zone or sub-zone. This is reported for each species in the zone or sub-zone for each category of water type on a quarterly basis. For example, "all zones" Pacific freshwater data indicates the average mortality rate for all Pacific salmon cultured in all zones in fresh water.

Mortality Rate by Cause (previously: Proportional Mortality by Cause)

The mortality rate by cause is intended to provide a more detailed breakdown of the average mortality rate into the various causes of mortality. This breakdown helps to indicate what proportion of the average mortality is due to each of the causes provided. As these reasons vary in fresh and saltwater and by species, reports provided reflect these differential causes.

Mortality Causes – Fresh water

Data entry starts at the EYED EGG stage and is reported in monthly intervals to the Database.

- Culls/quality control: includes all culls for inventory management (e.g., precocious males and non-smolts.)
- Systems related: rolled up category that includes all losses due to acute incidents, including:
    - systems/physical plant problems (e.g. power outage),
    - transport incidents, accidents
    - any acute disruption of "life support" for the fish.
    - vandalism and acute human induced toxicological events
- Background mortality: Rolled up category that includes all causes that are not culls, systems-related or fresh carcasses, including:
    - Poor performers (smalls, deformities, non-smolts (died, not culled), pin heads etc.)
    - Water chemistry problems
    - Eye pick
    - Jumpers
    - Feed/ feeding problems
    - Handling
    - Old (not of histological (diagnostic) quality)
    - Fungus
    - Parasites
    - Bacterial Gill Disease
    - Predators

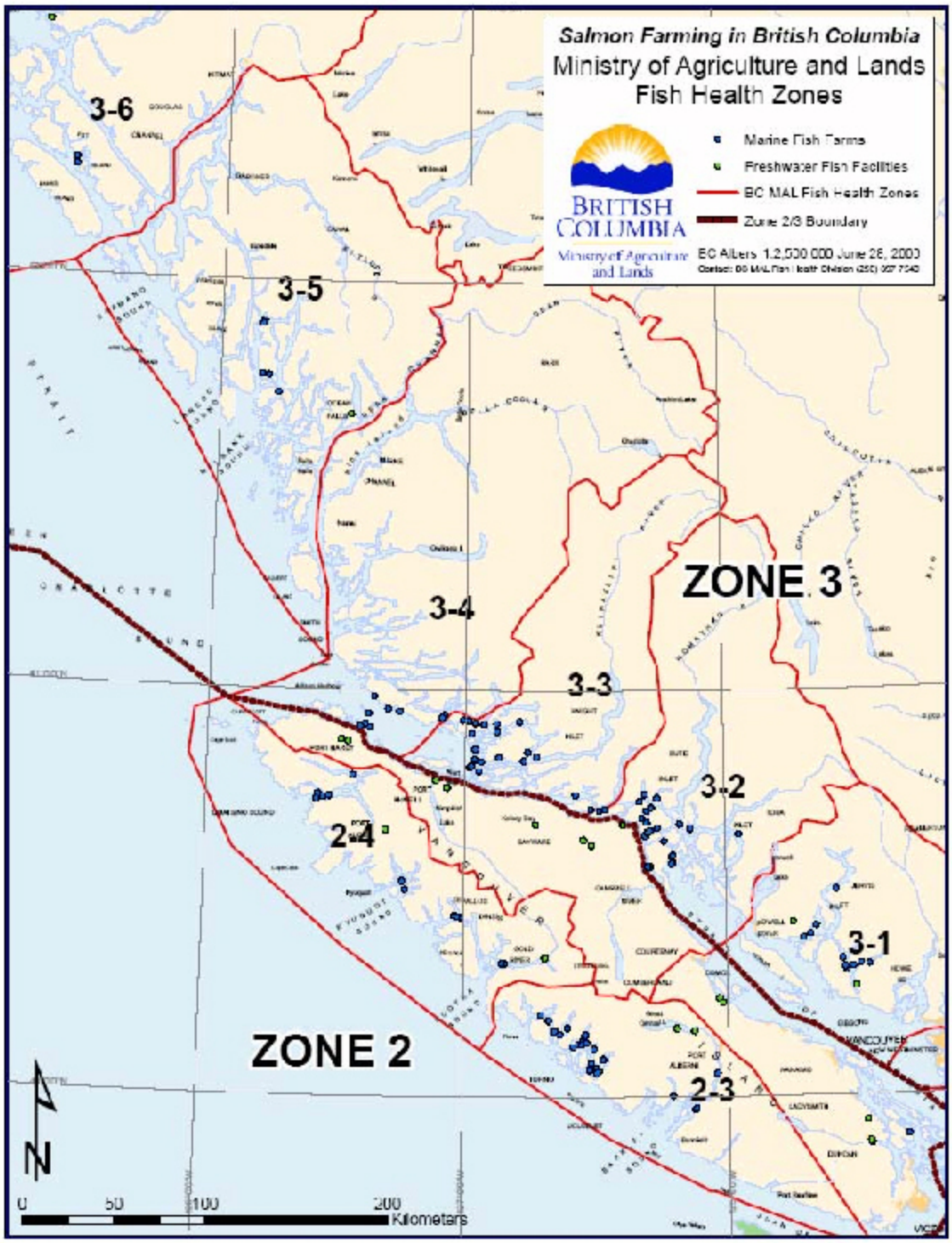
- Fisheries and Oceans Canada (DFO) divides the background mortality category into:
  - Husbandry-related including feed/feeding problems, handling, treatment errors
  - Routine / daily: mortalities—fungus, predators etc…
- Fresh: rolled up category that includes total number of "fresh" carcasses
  - Mortalities due to suspected disease
  - Unexplained mortality
  - Mortalities "of concern"
- DFO puts all fresh carcasses with unexpectedly high mortality levels and all suspect mortalities, including BGD, parasites, and other disease, into this category.

Mortality Causes – Salt water

This applies to all seawater farms, captive brood stock (DFO) and preliminary rearing of select stocks prior to saltwater release (DFO). These categories are intended for smolt and post-smolt life stages, including "smolt", "immature/grow-out/harvest" and "brood stock".

- Predators: total number of carcasses due to predators
- Environmental: Total number of carcasses due to environment (e.g. algae, low D.O)
- Poor Performers: Total number of carcasses due to poor performers (includes precocious and maturing males and poor performers)
- Handling/Transport: Total number of carcasses due to handling, transport or mechanical damage
- Old" Total number of carcasses not of diagnostic quality (no reliable histological diagnosis)
- "Silvers": Total number of fresh carcasses that still have silver skin/scales and have died most recently, due to: no apparent reason, or they may show signs of disease. These carcasses are most reflective of the robust production population and they generally represent 20 to 30% of the dead group.
- Matures: Jacks – Pacific salmon species only.

APPENDIX 7.2 Map of Fish Health Zones in British Columbia.



APPENDIX 7.3 Active Farms 2007

Table 7.3.1 Active Salmon Farms 2007

Atlantic Salmon	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Average
Sub-zone 2.3 SW Vanc. Island	8	11	9	11	9.7 = 10
Sub-zone 2.4 NW Vanc. Island	8	12	8	8	9
Sub-zone 3.1 Sunshine Coast	3	2	3	4	3
Sub-zone 3.2 Campbell River	10	10	11	13	11
Sub-zone 3.3 Broughton	11	13	13	14	12.7= 13
Sub-zone 3.4 Port Hardy	5	7	7	4	5.7 = 6
Sub-zone 3.5 Central Coast	2	2	3	2	2.2 = 2
Pacific Salmon					
Zone 2 Vancouver Island	3	3	3	3	3
Zone 3 East of Vanc. Island	6	6	4	6	5.5 = 6
Totals	56	66	61	65	62

APPENDIX 7.4 Bacteriology Findings 2007

Table 7.4.1: Bacterial Findings for Sub-zone 2.3 (SW Vancouver Island) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled *	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria ^	Bacterial species cultured
1 Jan - Mar	4	26	0	0	No bacteria cultured
2 Apr – Jun	5	34	1	4	*Pseudomonas lundensis*
3 July – Sept	5	37	2	4	*Psychrobacter* sp.
				1	*Pseudoalteromonas* sp.
				1	*Vibrio splendidus*
4 Oct – Dec	5	33	1	1	*Vibrio* sp.
Totals	19	130	4	11	

* Occasionally there are no fish available or suitable for sampling on a farm. When a site audit is conducted but no samples were taken, the number of farms where samples were collected is indicated in brackets (e.g. 5(4) indicates that 5 farms were visited but fish samples were only available from 4 of the 5 farms).

^ Not all bacteria cultured are the cause of disease (i.e. pathogenic); many are opportunists. For a complete list of the bacteria cultured and their classification as either pathogen or opportunist, see Table 7.4.10 within this Appendix.

Figure 7.4.1: Summary of Bacterial Findings from Sub-zone 2.3 Atlantic Salmon Farm Audits 2007

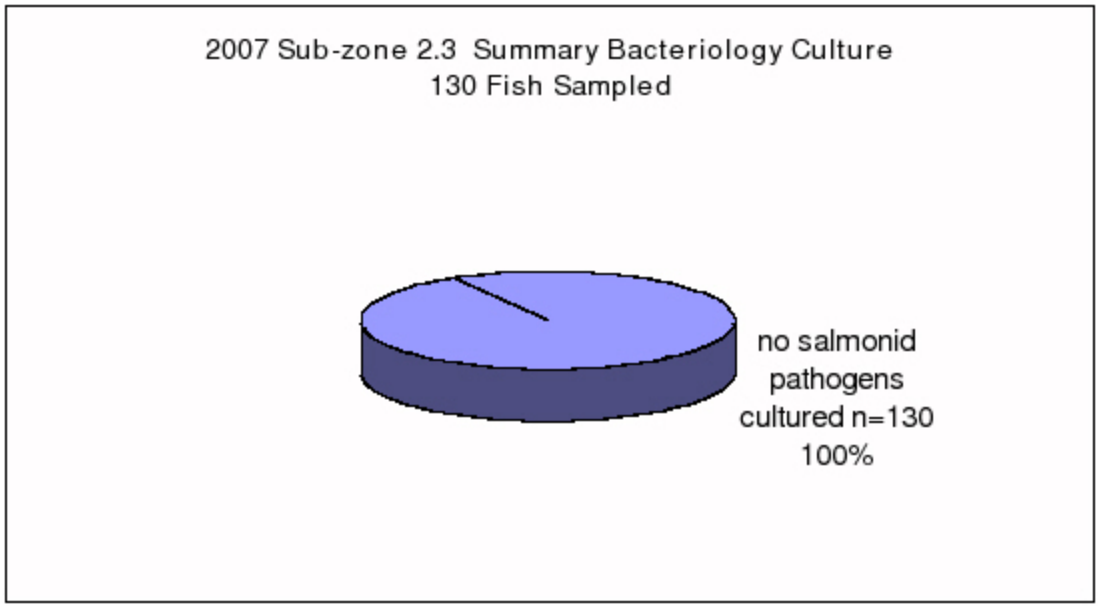


Table 7.4.2 : Bacterial Findings for Sub-zone 2.4 (NW Vancouver Island) Atlantic Salmon Farm Audits 2007					
Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan - Mar	4	27	1	1	*Photobacterium phosphoreum*
				1	*Carnobacterium maltaromaticum*
2 Apr - Jun	5	44	1	1	*Vibrio aestuarianus*
				1	*Vibrio tubiashii*
				1	*Vibrio logei*
3 July - Sept	4 (3)	21	1	1	*Vibrio splendidus*
4 Oct - Dec	4	29	1	1	*Aeromonas salmonicida*
				1	*Vibrio splendidus*
Totals	16	121	4	8	

Figure 7.4.2: Summary of Bacterial Findings from Sub-zone 2.4 Atlantic Salmon Farm Audits 2007

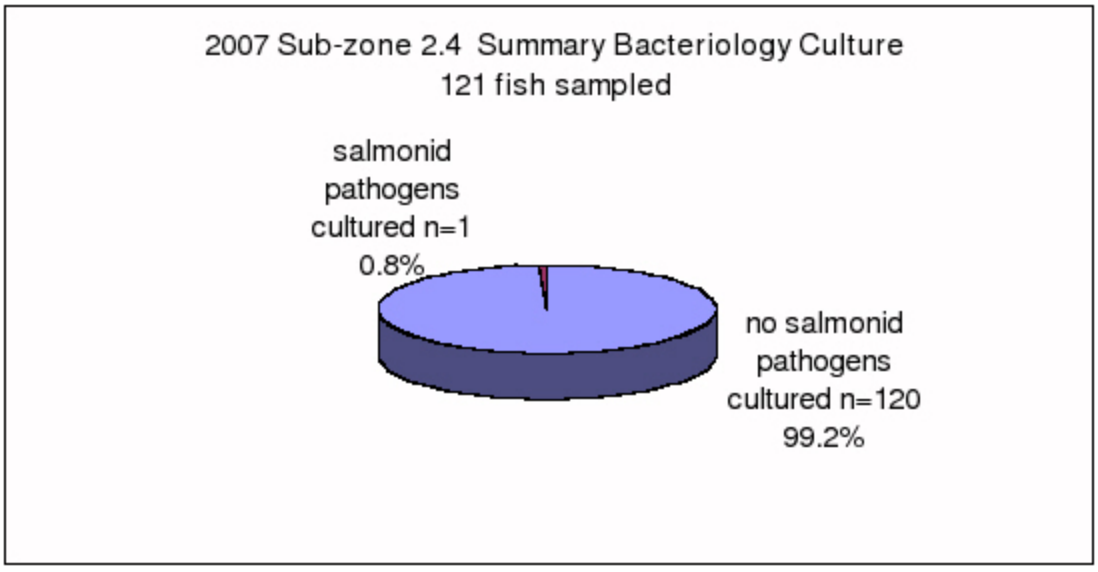


Table 7.4.3: Bacterial Findings for Sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	1	2	1	1	*Photobacterium phosphoreum*
2 Apr – Jun	1 (0)	0	0	0	No bacteria cultured
3 July – Sept	1	4	0	0	No bacteria cultured
4 Oct – Dec	1	3	0	0	No bacteria cultured
Totals	3	9	1	1	

Figure 7.4.3: Summary of Bacterial Findings from Sub-zone 3.1 Atlantic Salmon Farm Audits 2007

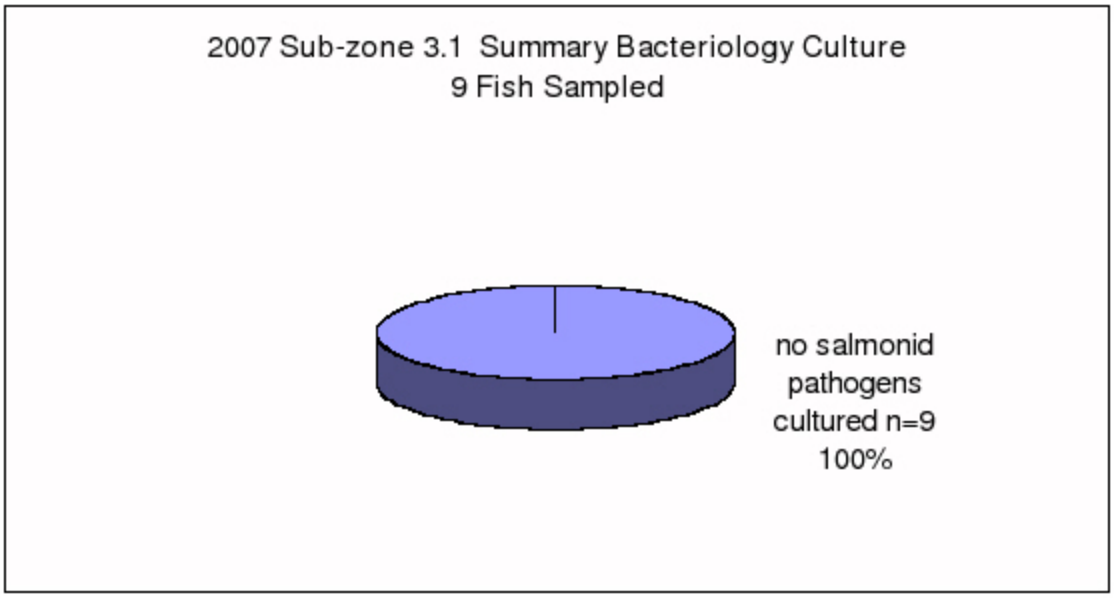


Table 7.4.4: Bacterial Findings for Sub-zone 3.2 (Campbell River) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	5	45	1	1	*Yersinia ruckeri*
2 Apr – Jun	5	42	1	1	*Vibrio* sp.
3 July – Sept	6	42	0	0	No bacteria cultured
4 Oct – Dec	6	41	0	0	No bacteria cultured
Totals	22	170	2	2	

Figure 7.4.4: Summary of Bacterial Findings from Sub-zone 3.2 Atlantic Salmon Farm Audits 2007

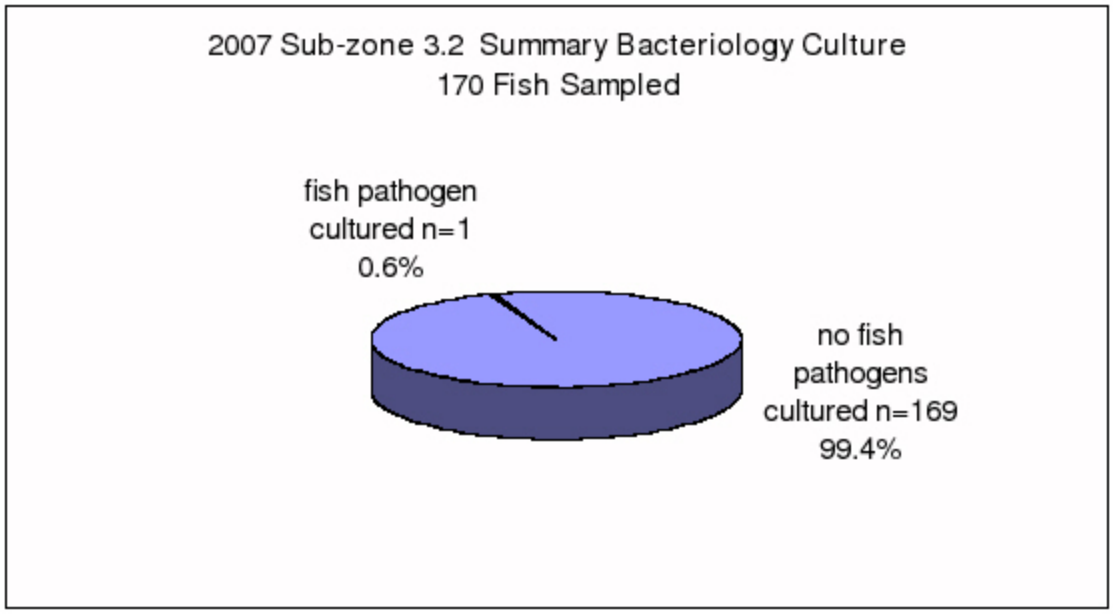


Table 7.4.5: Bacterial Findings for Sub-zone 3.3 (Broughton) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	6	31	0	0	No bacteria cultured
2 Apr – Jun	6 (5)	32	1	3	*Yersinia ruckeri*
				1	*Vibrio logei*
3 July – Sept	6	33	1	1	*Photobacterium phosphoreum*
4 Oct – Dec	6 (5)	23	1	2	*Aeromonas salmonicida*
Totals	22	119	3	7	

Figure 7.4.5: Summary of Bacterial Findings from Sub-zone 3.3 Atlantic Salmon Farm Audits 2007

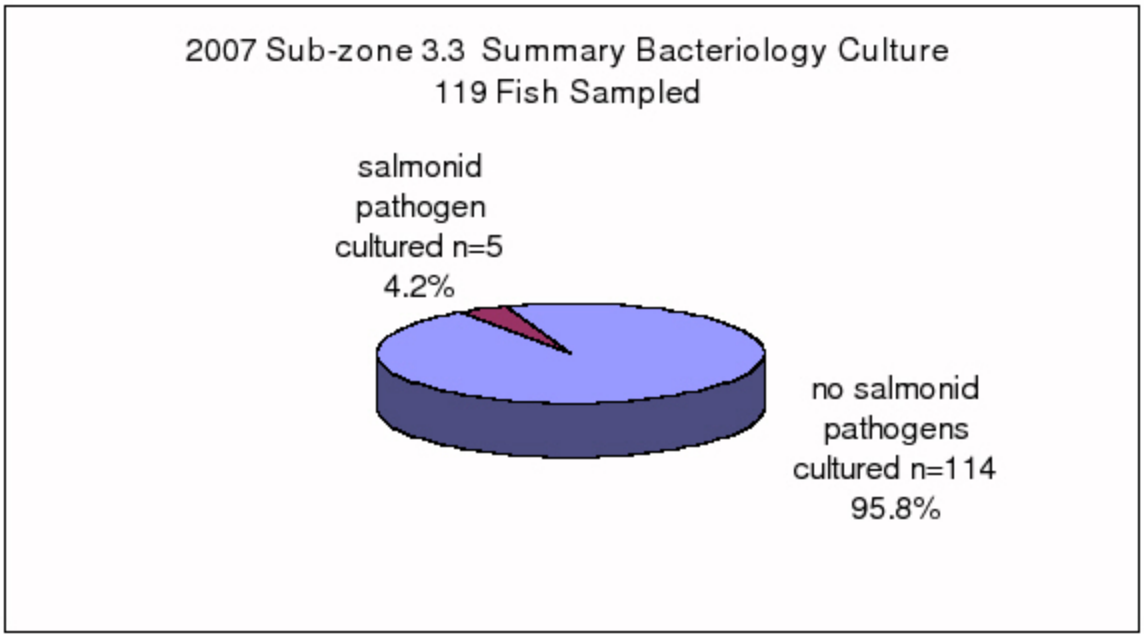


Table 7.4.6: Bacterial Findings for Sub-zone 3.4 (Port Hardy)
Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	4	32	1	1	*Yersinia ruckeri*
2 Apr – Jun	3	15	0	0	No bacteria cultured
3 July – Sept	3	12	0	0	No bacteria cultured
4 Oct – Dec	2	12	0	0	No bacteria cultured
Totals	12	71	1	1	

Figure 7.4.6: Summary of Bacterial Findings from Sub-zone 3.4
Atlantic Salmon Farm Audits 2007

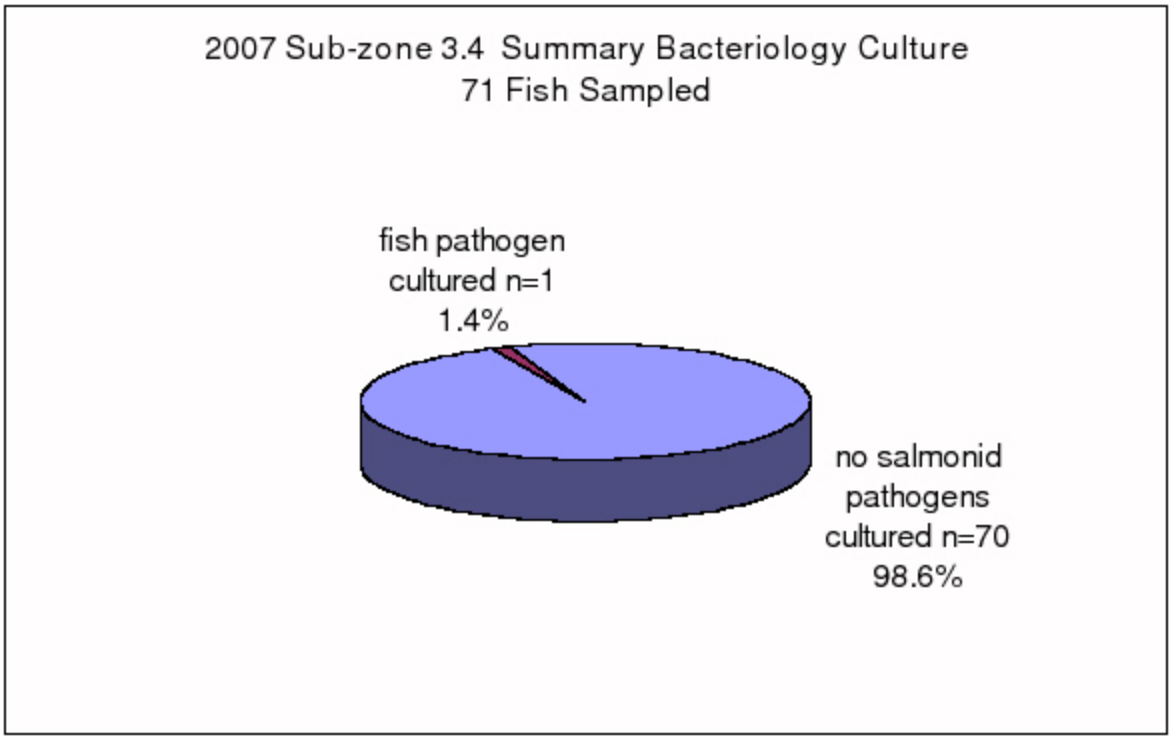


Table 7.4.7: Bacterial Findings for Sub-zone 3.5 (Central Coast) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	1	5	0	0	No bacteria cultured
2 Apr – Jun	2	5	0	0	No bacteria cultured
3 July – Sept	2 (1)	8	0	0	No bacteria cultured
4 Oct – Dec	1	5	0	0	No bacteria cultured
Totals	5	23	0	0	

Figure 7.4.7: Summary of Bacterial Findings from Sub-zone 3.5 Atlantic Salmon Farm Audits 2007

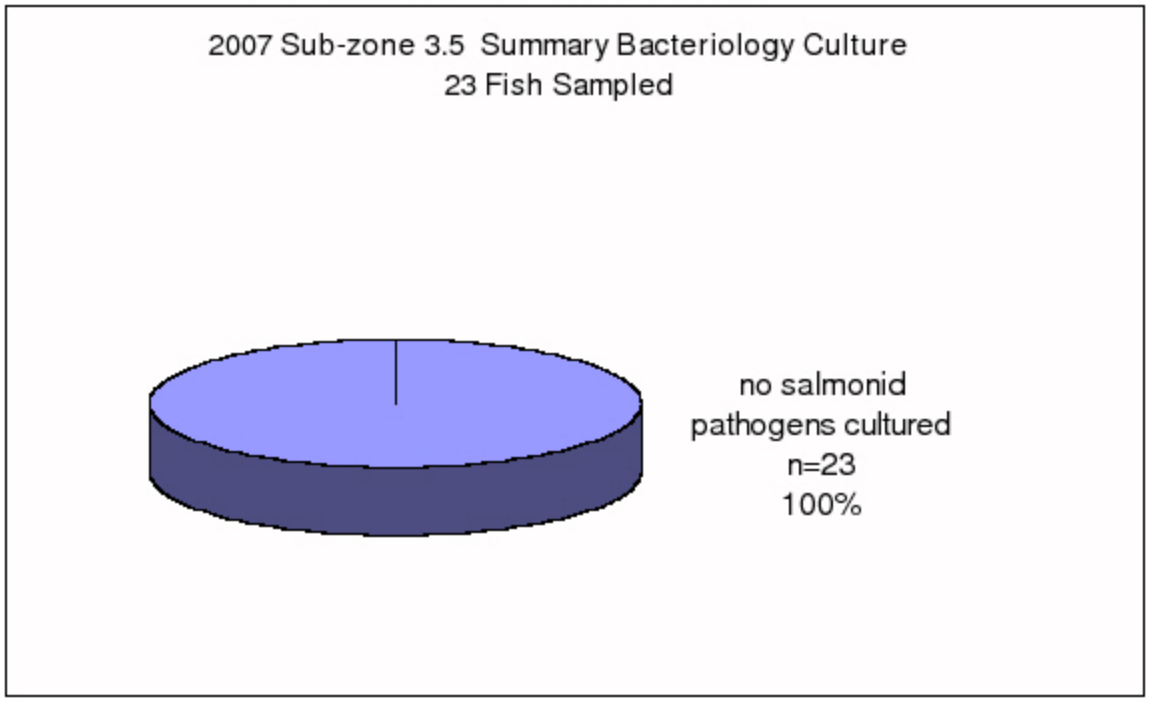


Table 7.4.8: Bacterial Findings for Zone 2 (Vancouver Island) Pacific Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	1	1	0	0	No bacteria cultured
2 Apr – Jun	1	7	0	0	No bacteria cultured
3 July –Sept	1	12	0	0	No bacteria cultured
4 Oct – Dec	1	8	0	0	No bacteria cultured
Totals	4	28	0	0	

Figure 7.4.8: Summary of Bacterial Findings from Zone 2 Pacific Salmon Farm Audits 2007

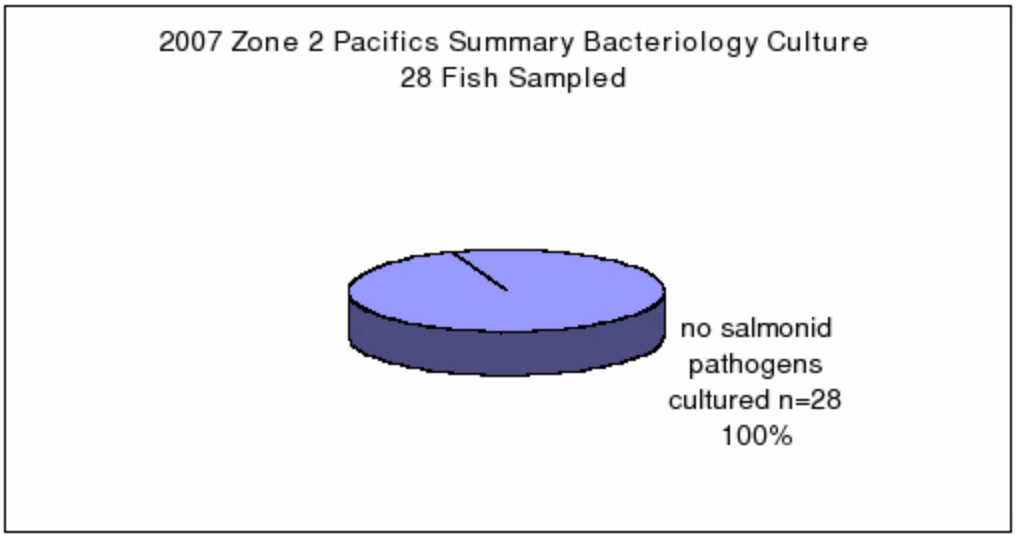


Table 7.4.9: Bacterial Findings for Zone 3 (East of Vancouver Island) Pacific Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	# of farms with bacteria cultured	Number of positive fish per bacteria	Bacterial species cultured
1 Jan – Mar	4	40	1	1	*Vibrio splendidus*
2 Apr - Jun	2	23	0	0	No bacteria cultured
3 July – Sept	2	12	1	2	*Vibrio* sp.
				1	*Vibrio parahaemolyticus*
4 Oct – Dec	4	17	1	1	*Vibrio wodanis*
Totals	12	92	3	5	

Figure 7.4.9: Summary of Bacterial Findings from Zone 3 Pacific Salmon Farm Audits 2007

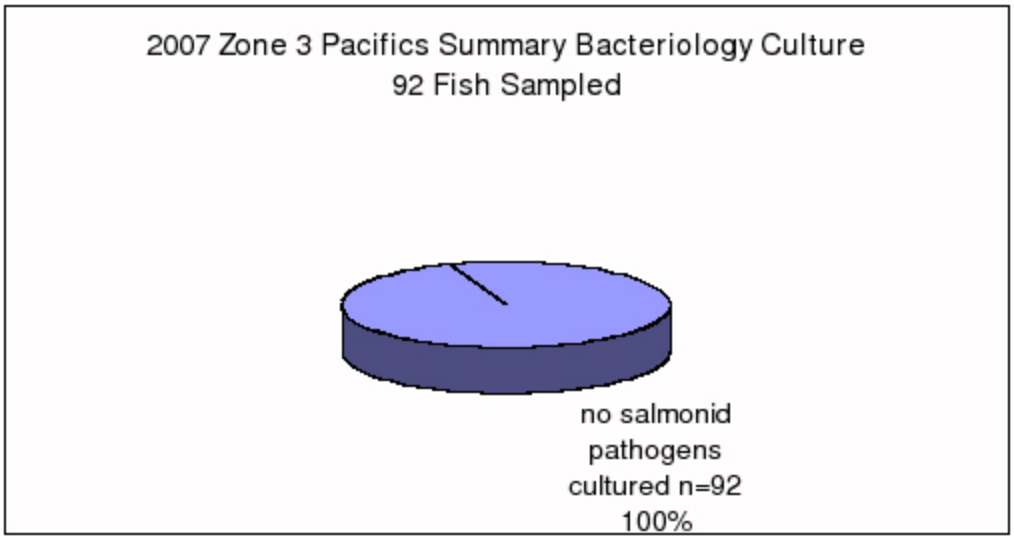


Table 7.4.10: Summary of Bacterial Organisms Cultured 2007	
Salmon Pathogens	Opportunists / Environmental
	Carnobacterium maltaromaticum
Aeromonas salmonicida	*Psychrobacter sp.*
	Vibrio logei *Vibrio tubiashii* *Vibrio aestuarianus* *Vibrio parahaemolyticus* *Vibrio splendidus* *Vibrio wodanis* *Vibrio sp.* *Photobacterium phosphoreum* *Pseudomonas lundensis* *Pseudoalteromonas sp*
Yersinia ruckeri	

APPENDIX 7.5 Molecular Diagnostics Findings 2007

Table 7.5.1: Molecular Testing Results for Sub-zone 2.3 (SW Vancouver Island) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	4	26	7	7	7	7	7	2	VHSv NAS
2 Apr-Jun	5	34	10	10	10	10	10	1	VHSv NAS
3 Jul-Sep	5	37	11	11	11	11	11	1	*Piscirickettsia salmonis*
4 Oct-Dec	5	33	8	8	8	8	8	3	*Piscirickettsia salmonis*
Totals	19	130	36	36	36	36	36	7	

Figure 7.5.1: Summary of Molecular Diagnostics Findings from Sub-zone 2.3 Atlantic Salmon Farm Audits 2007

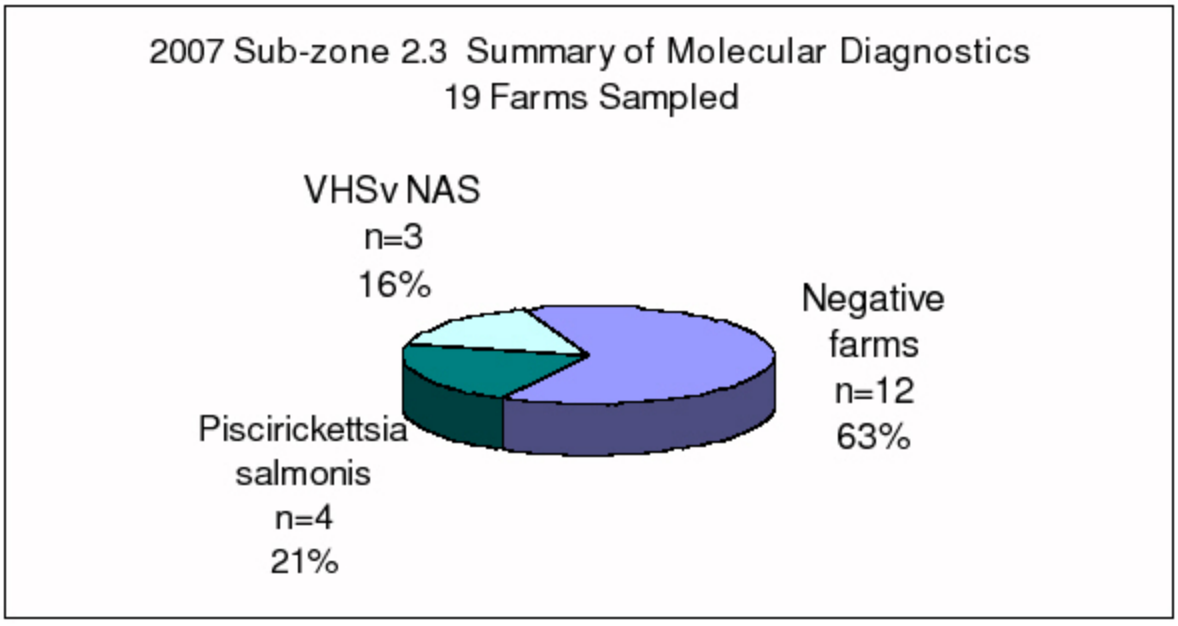


Table 7.5.2: Molecular Testing Results for Sub-zone 2.4 (NW Vancouver Island) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	4	27	7	7	7	7	7	1	VHSv NAS
2 Apr-Jun	5	44	10	10	10	10	10	1	VHSv NAS
3 Jul-Sep	3	21	5	5	5	5	5	0	None
4 Oct-Dec	4	29	7	7	7	7	7	1	*Piscirickettsia salmonis*
Totals	16	121	29	29	29	29	29	3	

Figure 7.5.2: Summary of Molecular Diagnostics Findings from Sub-zone 2.4 Atlantic Salmon Farm Audits 2007

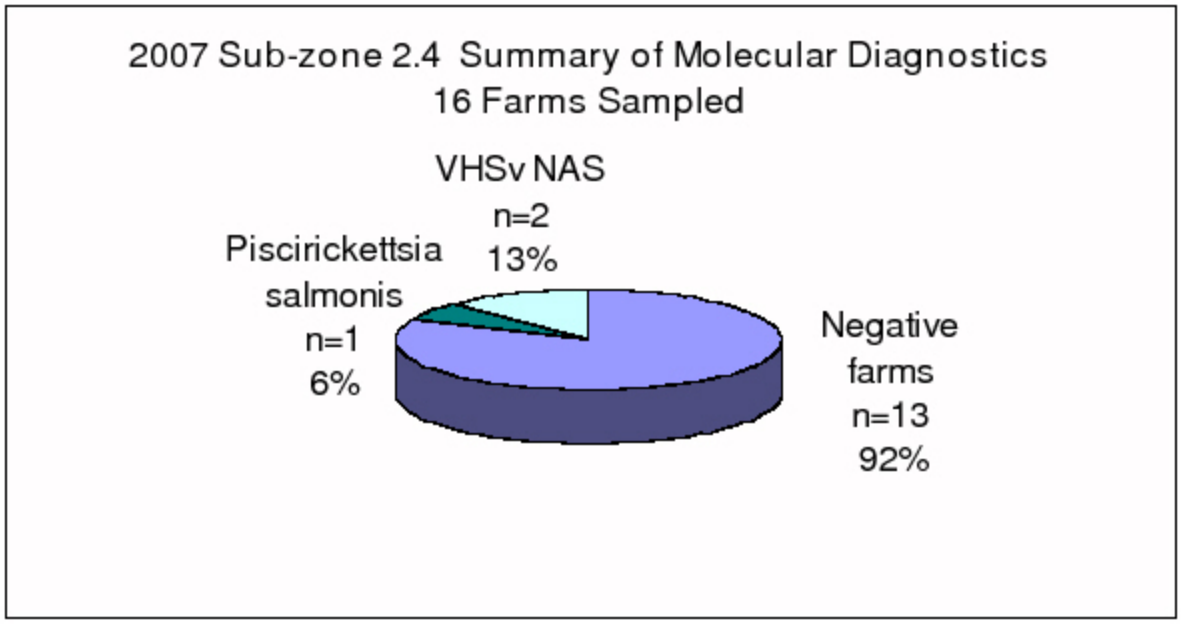


Table 7.5.3: Molecular Testing Results for Sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	1	2	1	1	1	1	1	0	None
2 Apr-Jun	0	0	0	0	0	0	0	0	None
3 Jul-Sep	1	4	1	1	1	1	1	0	None
4 Oct-Dec	1	3	1	1	1	1	1	0	None
Totals	3	9	3	3	3	3	3	0	

Figure 7.5.3: Summary of Molecular Diagnostics Findings from Sub-zone 3.1 Atlantic Salmon Farm Audits 2007

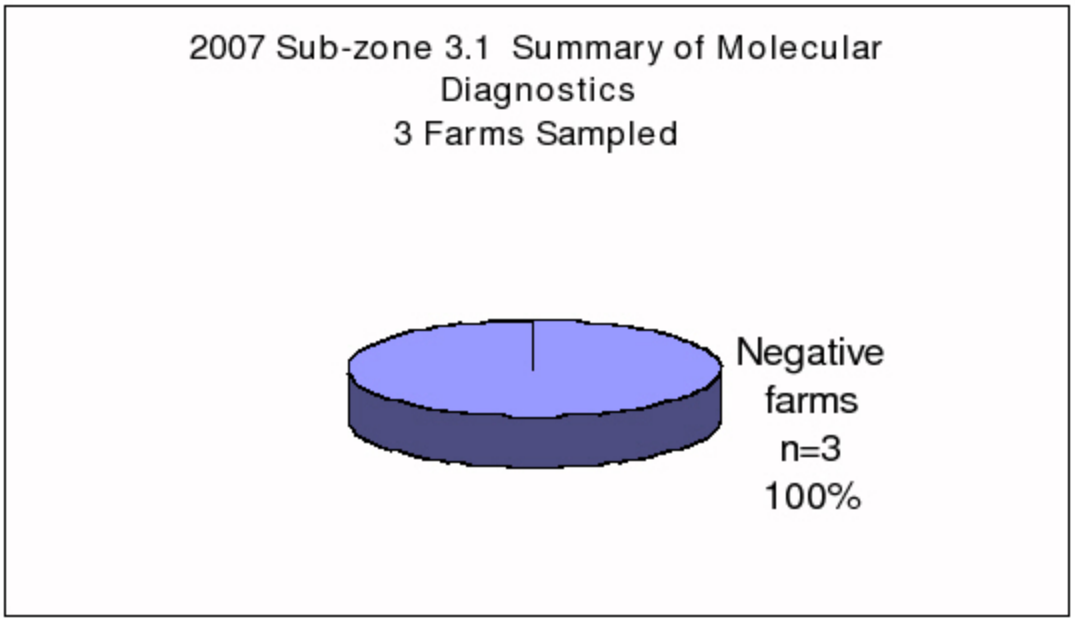


Table 7.5.4: Molecular Testing Results for Sub-zone 3.2 (Campbell River) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	5	45	12	12	12	12	12	0	None
2 Apr-Jun	5	42	11	11	11	11	11	0	None
3 Jul-Sep	6	42	12	12	12	12	12	0	None
4 Oct–Dec	6	41	11	11	11	11	11	0	None
Totals	22	170	46	46	46	46	46	0	

Figure 7.5.4: Summary of Molecular Diagnostics Findings from Sub-zone 3.2 Atlantic Salmon Farm Audits 2007

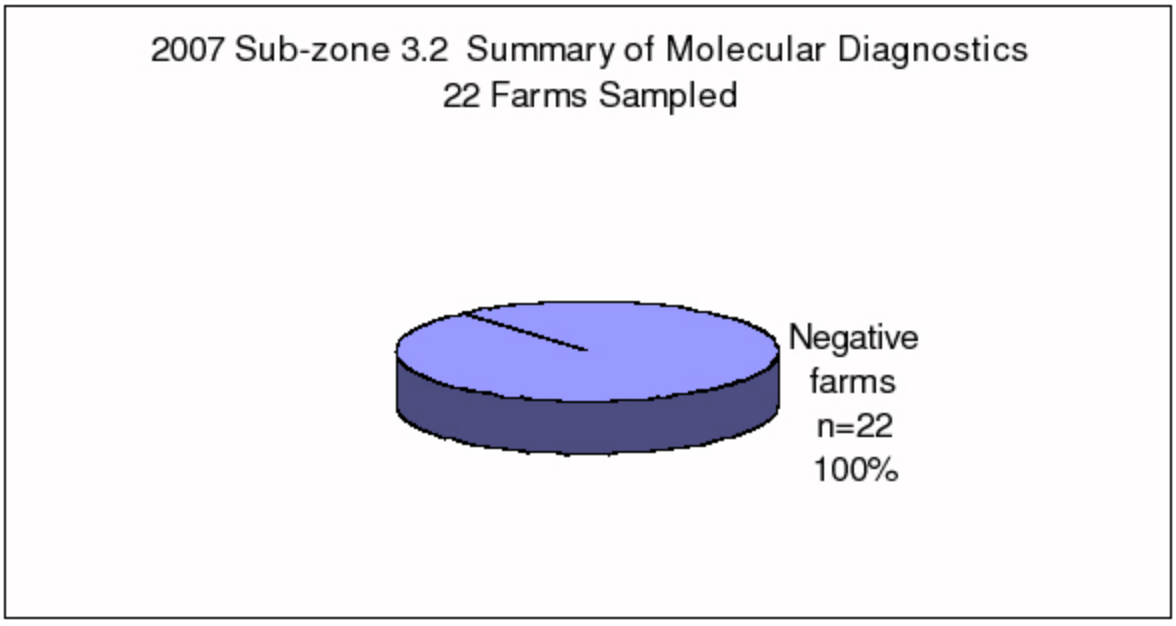


Table 7.5.5: Molecular Testing Results for Sub-zone 3.3 (Broughton) Atlantic Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	6	31	9	9	9	9	9	2	VHSv NAS
2 Apr-Jun	5	32	8	8	8	8	8	1	VHSv NAS
3 Jul-Sep	6	33	9	9	9	9	9	0	None
4 Oct-Dec	5	23	7	7	7	7	7	0	None
Totals	22	119	33	33	33	33	33	3	

Figure 7.5.5: Summary of Molecular Diagnostics Findings from Sub-zone 3.3 Atlantic Salmon Farm Audits 2007

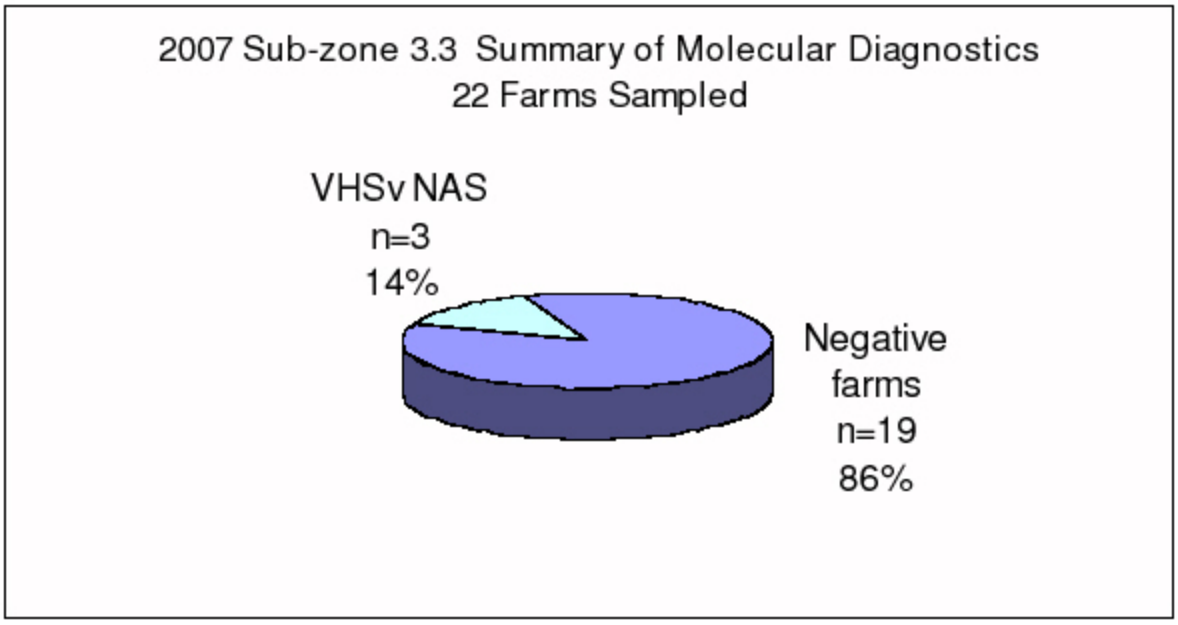


Table 7.5.6: Molecular Testing Results for Sub-zone 3.4 (Port Hardy) Atlantic Salmon Farm Audits 2007									
Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv NAS		
1 Jan-Mar	4	32	8	8	8	8	8	0	None
2 Apr-Jun	3	15	4	4	4	4	4	0	None
3 Jul-Sep	3	12	3	3	3	3	3	0	None
4 Oct-Dec	2	12	3	3	3	3	3	0	None
Totals	12	71	18	18	18	18	18	0	

Figure 7.5.6: Summary of Molecular Diagnostics Findings from Sub-zone 3.4 Atlantic Salmon Farm Audits 2007

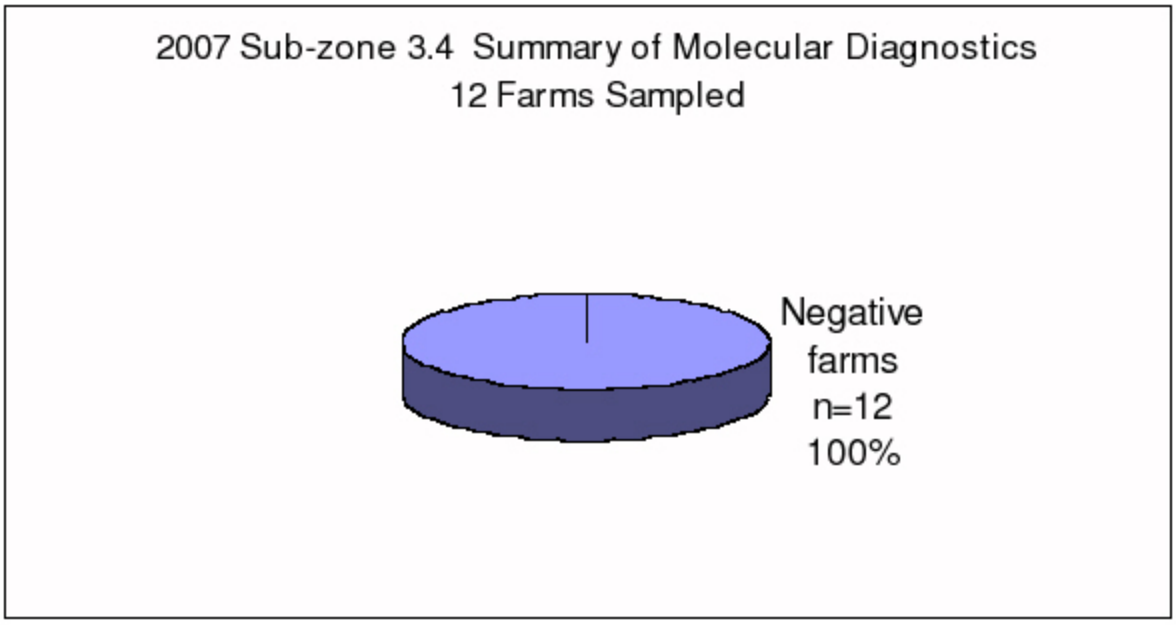


Table 7.5.7: Molecular Testing Results for Sub-zone 3.5 (Central Coast) Atlantic Salmon Farm Audits 2007									
Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv NAS		
1 Jan-Mar	1	5	1	1	1	1	1	0	None
2 Apr-Jun	2	5	2	2	2	2	2	0	None
3 Jul-Sep	1	8	2	2	2	2	2	0	None
4 Oct-Dec	1	5	1	1	1	1	1	0	None
Totals	5	23	6	6	6	6	6	0	

Figure 7.5.7: Summary of Molecular Diagnostics Findings from Sub-zone 3.5 Atlantic Salmon Farm Audits 2007

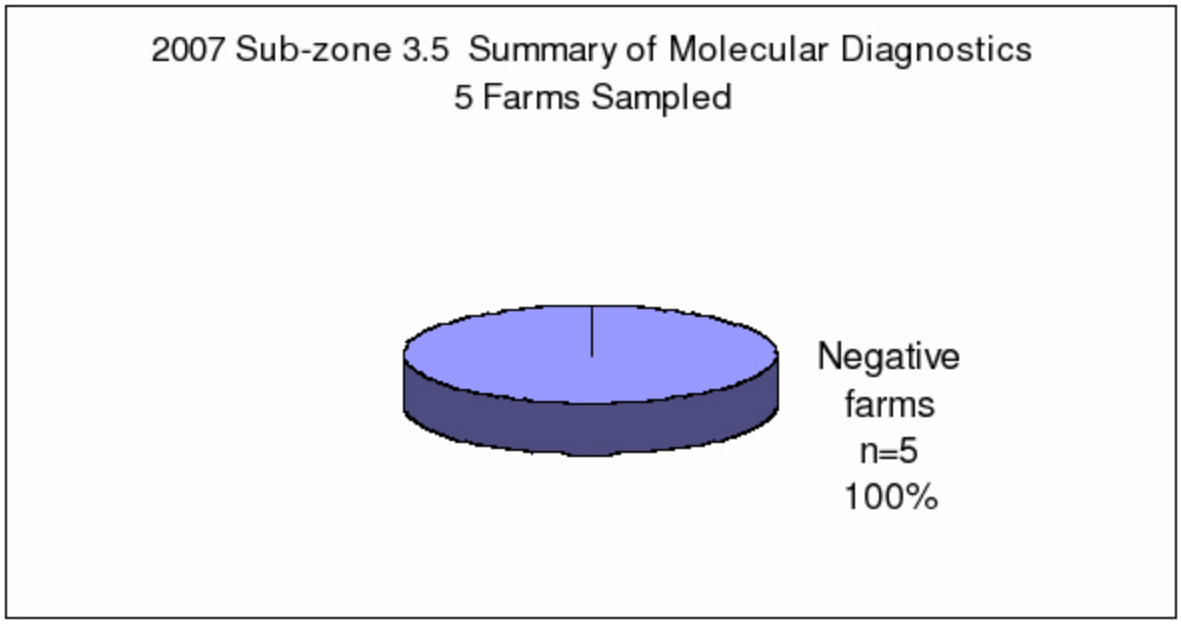


Table 7.5.8: Molecular Testing Results for Zone 2 (Vancouver Island) Pacific Salmon Farm Audits 2007

Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	1	1	1	1	1	1	1	0	None
2 Apr-Jun	1	7	2	2	2	2	2	0	None
3 Jul-Sep	1	12	3	3	3	3	3	1	VHSv NAS
4 Oct-Dec	1	8	2	2	2	2	2	1	*Piscirickettsia salmonis*
Totals	4	28	8	8	8	8	8	2	

Figure 7.5.8: Summary of Molecular Diagnostics Findings from Zone 2 Pacific Salmon Farm Audits 2007

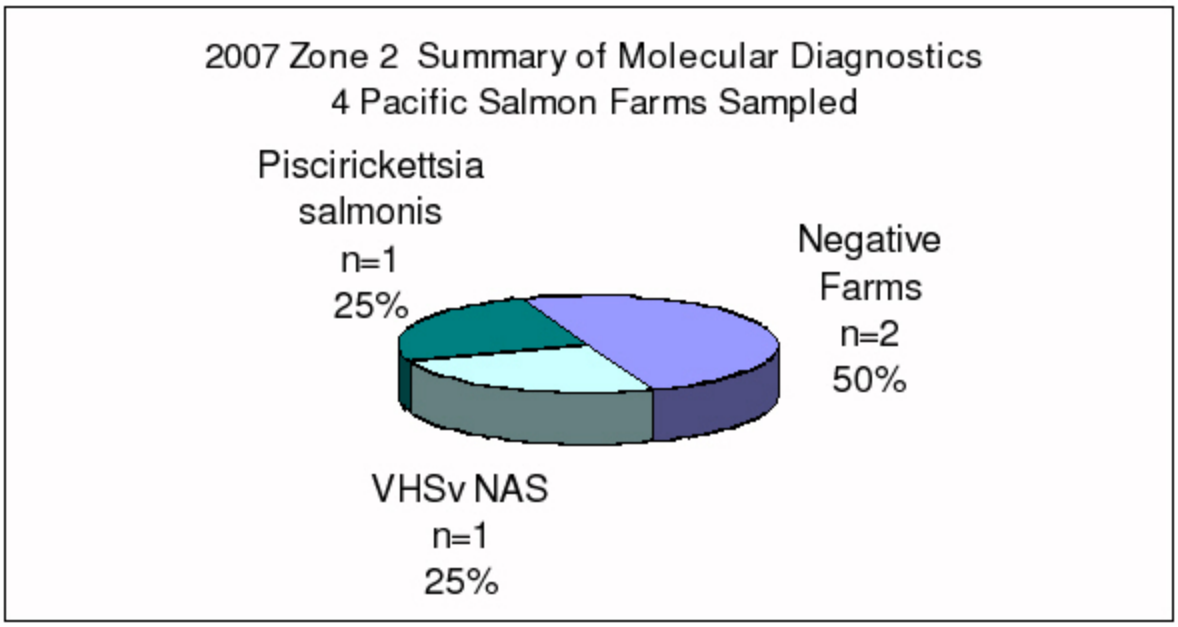
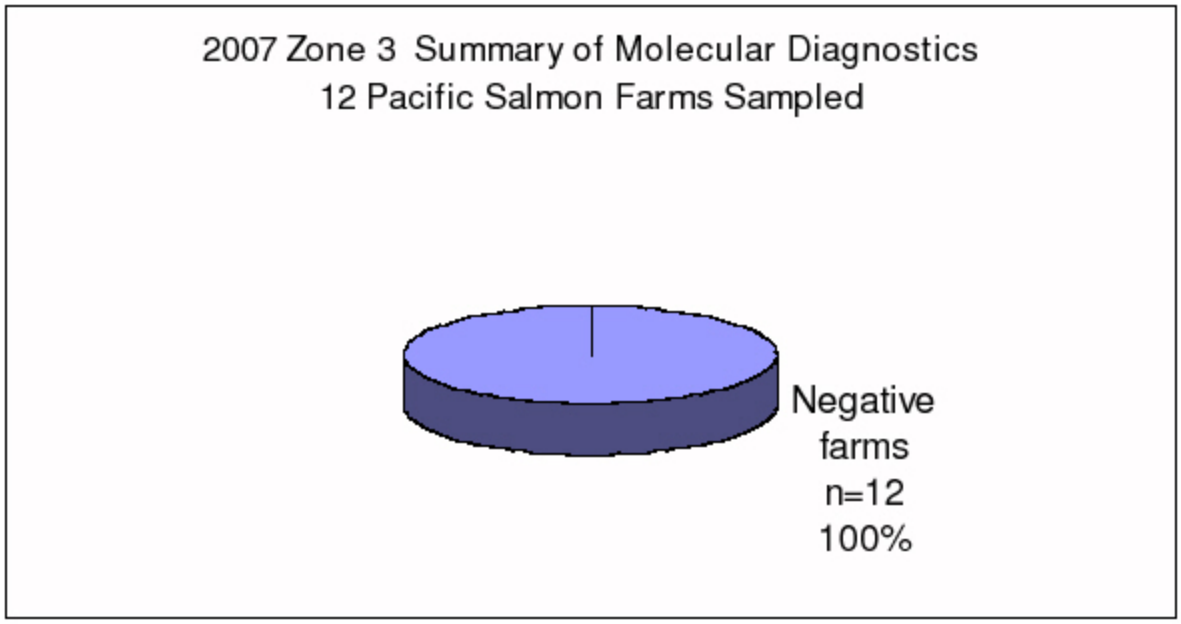


Table 7.5.9: Molecular Testing Results for Zone 3 (East of Vancouver Island) Pacific Salmon Farm Audits 2007									
Quarter	# farms sampled	# fish sampled	Number of Molecular Tests					Positive Farms	Organism Identified
			IHNV	IPNV	ISAV	Rickettsia	VHSv-NAS		
1 Jan-Mar	4	40	11	11	11	11	11	0	None
2 Apr-Jun	2	23	5	5	5	5	5	0	None
3 Jul-Sep	2	12	3	3	3	3	3	0	None
4 Oct-Dec	4	17	5	5	5	5	5	0	None
Totals	12	92	24	24	24	24	24	0	

Figure 7.5.9: Summary of Molecular Diagnostics Findings from Zone 3 Pacific Salmon Farm Audits 2007



APPENDIX 7.6 Audit Case Definitions

Bacterial Kidney Disease: A chronic granulomatous disease; the causative agent is *Renibacterium salmoninarum*. BKD is diagnosed in farmed salmon populations when the population is undergoing treatment for the disease and/or if numerous dead silvers show: gross clinical signs of the disease with histopathologic confirmation of BKD, and the farm is experiencing population-level losses to the disease.

Furunculosis: A septicaemic disease caused by Gram negative *Aeromonas salmonicida*. Furunculosis is diagnosed in an Atlantic salmon population when the farm is undergoing treatment for the disease and/or when sampled carcasses exhibit septicaemia, the bacteria is isolated on agar, and the farm is experiencing population-level losses to the disease.

Furunculosis rarely occurs in farmed Pacific salmon populations however the definition matches that of Atlantic salmon with the disease.

Infectious Haematopoietic Necrosis (IHN): A viral 'septicaemia' caused by a marine rhabdovirus. Atlantic salmon do not appear to have a natural and effective immunity to IHN virus. The disease is diagnosed on a farm by means of a positive Polymerase Chain Reaction (PCR) test for the virus and confirmation by cell culture. Experiments reveal that high morbidity and elevated mortality rates are often evident within 7 to 10 days of the initial infection. Farmed Chinook and Coho salmon are refractory to disease.

Loma: An endemic disease of Pacific salmonids characterized by grossly visible xenomas in the gill and pseudobranch, and in some internal organs by histology. *Loma salmonae* is a microsporidian parasite that has been reported in fresh and saltwater populations of wild fish yet has been most evident in marine farmed Chinook salmon. Farmed Chinook populations may exhibit elevated and significant weekly mortality rates over several months due to this parasite, especially when water temperatures are between 12 -17C.

Marine Anaemia (MA): An endemic disease of farmed Pacific salmon characterized by: marked gill pallor, enlarged kidney, spleen and liver, ascites and exophthalmia. The cause of this disease may include a retroviral infection and/or an intranuclear microsporidian, *Nucleospora salmonis*. Marked haemoblast proliferation in specific organs is the histopathological hallmark of the disease. Grossly MA can appear similar and concurrent to BKD. A diagnosis of MA is a considered in Pacific salmon populations if: the fish sampled have gross clinical signs of MA, histopathological lesions of MA (with no evidence of granulomata), and the farm is experiencing population-level losses. Atlantic salmon are not afflicted by MA.

Mouth Myxobacteriosis: A production disease of Atlantic salmon smolts during initial months of entry to sea water; the disease tends to be problematic in spring-entered smolts more so than in fall-entered smolts. The bacterium *Tenacibaculum maritimum* is consistently found with the mouth lesions and is generally accepted as the etiologic agent. This diagnosis is assigned to an Atlantic smolt population when the group is being medicated for the disease, or if the fish sampled show gross clinical signs, histological evidence of the disease and the farm is experiencing population-level losses to the disease.

Net Pen Liver Disease (NPLD): Some farmed Atlantic smolts experience a debilitating liver condition thought to be associated with the natural algal toxin microcystin LR. The disease is environmental, not infectious, and is diagnosed as NPLD in Atlantic smolt populations when it's characterized by runted fish, hepatic necrosis, hepatocellular megalocytosis and the farm is experiencing population-level losses to the disease.

No Significant Findings: Occasionally audit visits are scheduled yet result in either a lack of fresh silver carcasses available for collection, or an interruption of travel or assessment due to weather, dive problems or natural harmful algae blooms. On these occasions insufficient data is available to assign a diagnosis of the fish.

Open diagnosis: The information collected and observations made during an audit are often inconsistent with the results of laboratory tests, or the test results of the samples submitted reflect a mixed etiolology, or 'no pathogen observed'. Often insufficient evidence exists to suggest 'population involvement' of a specific disease (i.e. low mortality rate and few silvers available). In these cases, one must conclude that either the cause of death remains unknown or the mortality observed is incidental and not sufficient to assign a "farm-wide diagnosis".

Parasitic Meningitis and/or Encephalitis: Microsporidian and Myxosporean parasites are indigenous to waters of BC. Their presence in the brains of individual Atlantic salmon can result in abnormal swimming behaviour. Other hosts of these parasites and the routes of transmission are unknown. Its relevance to aquaculture requires further investigation. To date there is no evidence to suggest fish-to-fish transmission therefore its likelihood as a production disease is low.

Post-vaccination Peritonitis (PVP): The presence of adhesions and peritonitis is observed grossly and histologically in farmed Atlantic and Pacific salmon that have received intra-peritoneal oil-based vaccines. Severe PVP can decrease fish productivity and perhaps contribute to mortality as well as downgrades at harvest due to adhesions and blackness in the flesh.

Rickettsiosis: A chronic granulomatous and systemic disease caused by the intracellular pathogen *Piscirickettsia salmonis*. Piscirickettsia is diagnosed on an audit if the farm is undergoing an oral medication to control the disease mortality or has: silvers with gross clinical signs of septicaemic disease, a positive PCR test for

the pathogen, histopathological lesions of rickettsiosis and the farm is experiencing population-level losses to the disease.

Viral Haemorrhagic Septicaemia, North American strain, genotype IVa (VHS): A viral 'septicaemia' caused a rhabdovirus. VHS is endemic in the herring populations in the Pacific Ocean and its presence in BC farms coincides with the herring migration. VHS is diagnosed on an audit if there is: evidence of clinical signs; a positive PCR for VHS virus and/or positive culture on appropriate cell line; population-level losses (that may reach 2% per month) and histopathological lesions consistent with VHSV infection.

APPENDIX 7.7 Audit Diagnoses 2007

Table 7.7.1: 2007 Diagnoses from Sub-zone 2.3 (South West Vancouver Island) Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases^	Farm-level Diagnosis
1 Jan - Mar	4	3	No Infectious Disease *
		1	VHS (North American Strain, genotype IVa)
2 Apr – June	5	4	No Infectious Disease
		1	Mouth Myxobacteriosis
3 July – Sept	5	5	No Infectious Disease
		1	Rickettsiosis
4 Oct - Dec	5	4	No Infectious Disease
		1	Rickettsiosis

^ The number of farm-level diagnoses (or audit cases) can be greater than the number of farms audited because, on occasion, the carcasses from one farm may represent more than one disease affecting that farm, such as: ERM and Mouth Myxo, which would result in two farm-level diagnoses assigned to one farm.

* 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.

Figure 7.7.1: Diagnoses from Sub-zone 2.3 (SW Vancouver Island) Atlantic Salmon Farm Audits 2007

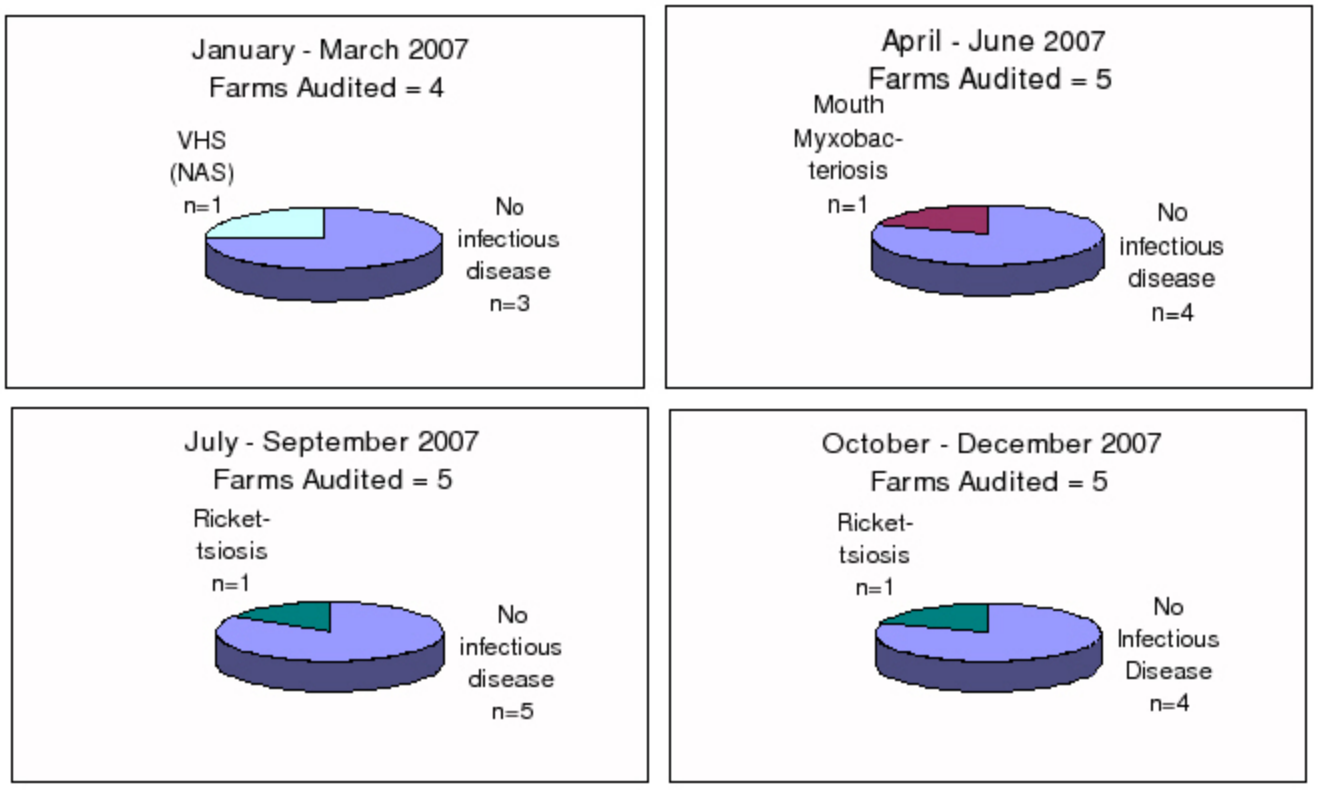


Table 7.7.2: 2007 Diagnoses from Sub-zone 2.4 (North West Vancouver Island) Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	4	3	No Infectious Disease
		1	Bacterial Kidney Disease
2 Apr – June	5	4	No Infectious Disease
		1	Mouth Myxobacteriosis
3 July – Sept	3	3	No Infectious Disease
		1	Bacterial Kidney Disease
4 Oct - Dec	4	4	No Infectious Disease

Figure 7.7.2: Diagnoses from Sub-zone 2.4 (NW Vancouver Island) Atlantic Salmon Farms Audits 2007

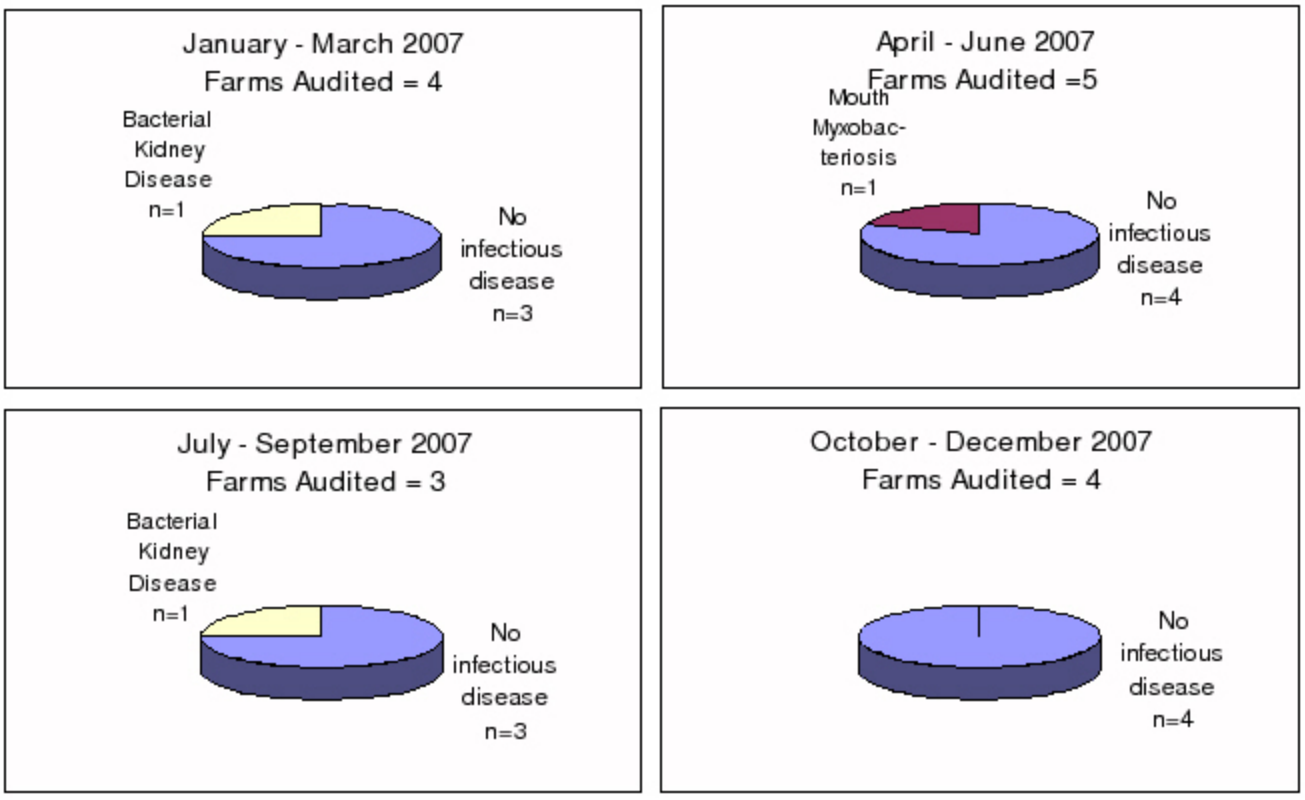


Table 7.7.3: 2007 Diagnoses from Sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	1	1	No Infectious Disease
2 Apr – June	1	1	No Infectious Disease
3 July – Sept	1	1	No Infectious Disease
4 Oct - Dec	1	1	No Infectious Disease

Figure 7.7.3: Diagnoses from Sub-zone 3.1 (Sunshine Coast) Atlantic Salmon Farm Audits 2007

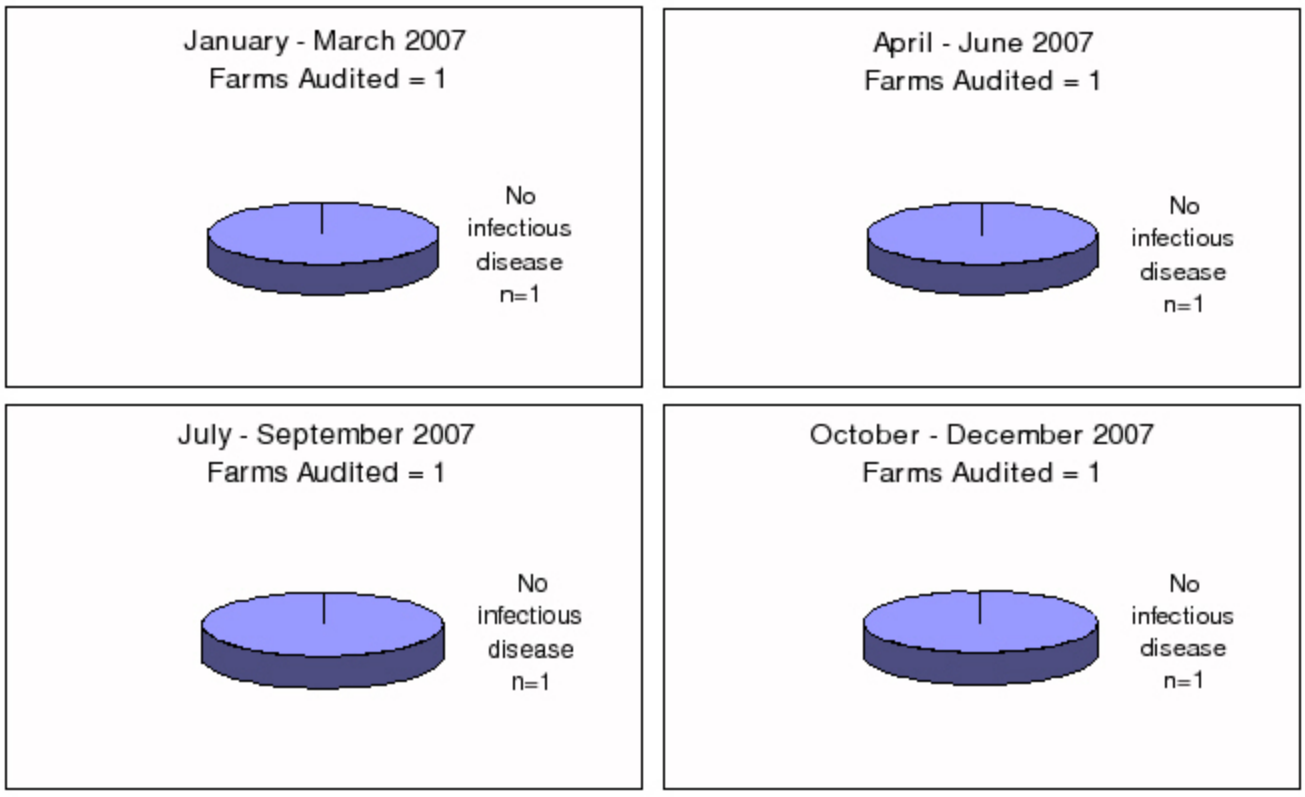


Table 7.7.4: 2007 Diagnoses from Sub-zone 3.2 (Campbell River) Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	5	3	No Infectious Disease
		2	Mouth Myxobacteriosis
		1	Bacterial Kidney Disease
2 Apr – June	5	3	No Infectious Disease
		2	Mouth Myxobacteriosis
3 July – Sept	6	5	No Infectious Disease
		1	Mouth Myxobacteriosis
		1	Net Pen Liver Disease
4 Oct - Dec	6	6	No Infectious Disease
		1	Mouth Myxobacteriosis

Figure 7.7.4: Diagnoses from Sub-zone 3.2 (Campbell River) Atlantic Salmon Farm Audits 2007

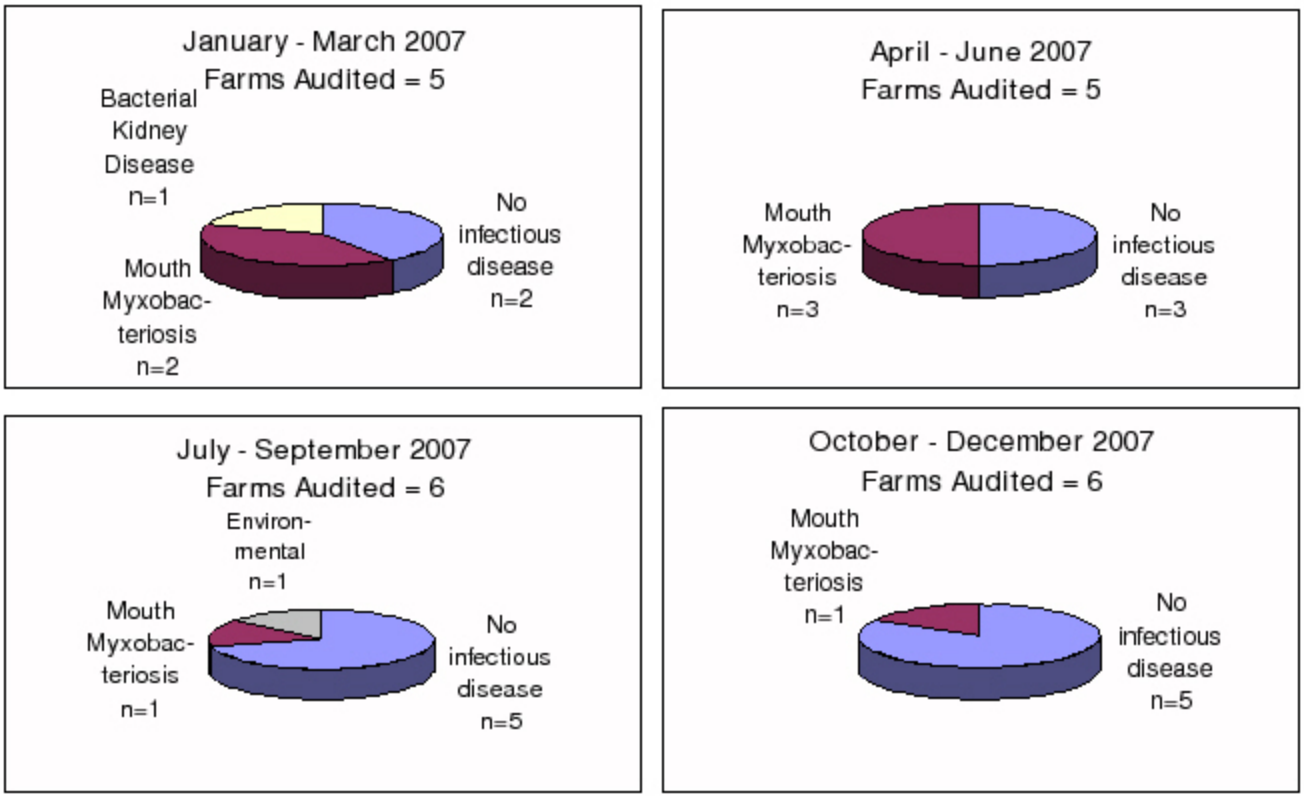


Table 7.7.5: 2007 Diagnoses from Sub-zone 3.3 (Broughton)
Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	6	5	No Infectious Disease
		1	VHS (North American Strain, genotype IVa)
2 Apr – June	6	5	No Infectious Disease
		1	Enteric Redmouth Disease
3 July – Sept	6	5	No Infectious Disease
		1	Mouth Myxobacteriosis
4 Oct - Dec	6	6	No Infectious Disease

Figure 7.7.5: Diagnoses from Sub-zone 3.3 (Broughton) Atlantic Salmon Farm Audits 2007

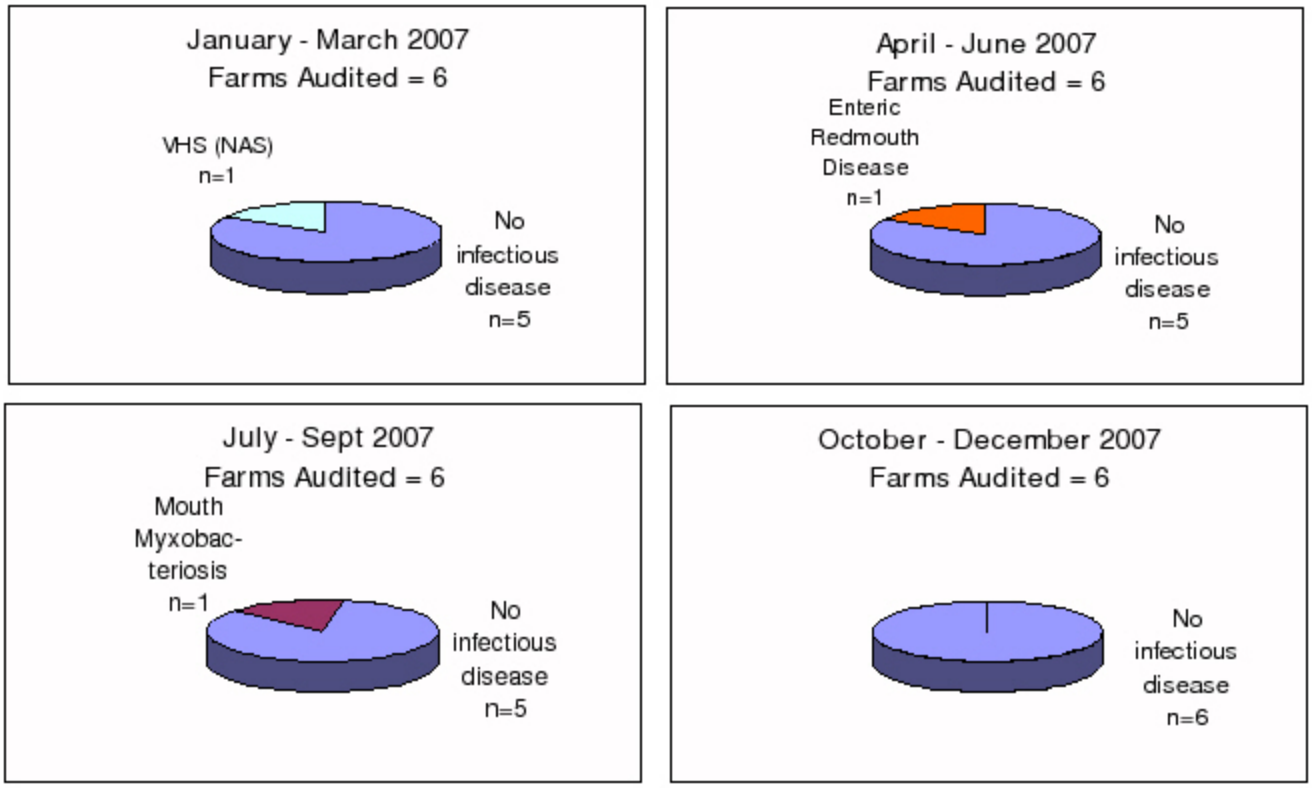


Table 7.7.6: 2007 Diagnoses from Sub-zone 3.4 (Port Hardy)
Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	4	2	No Infectious Disease
		2	Bacterial Kidney Disease
2 Apr – June	3	2	No Infectious Disease
		1	Bacterial Kidney Disease
3 July – Sept	3	3	No Infectious Disease
		1	Bacterial Kidney Disease
4 Oct - Dec	2	2	No Infectious Disease

Figure 7.7.6: Diagnoses from Sub-zone 3.4 (Port Hardy)
Atlantic Salmon Farm Audits 2007

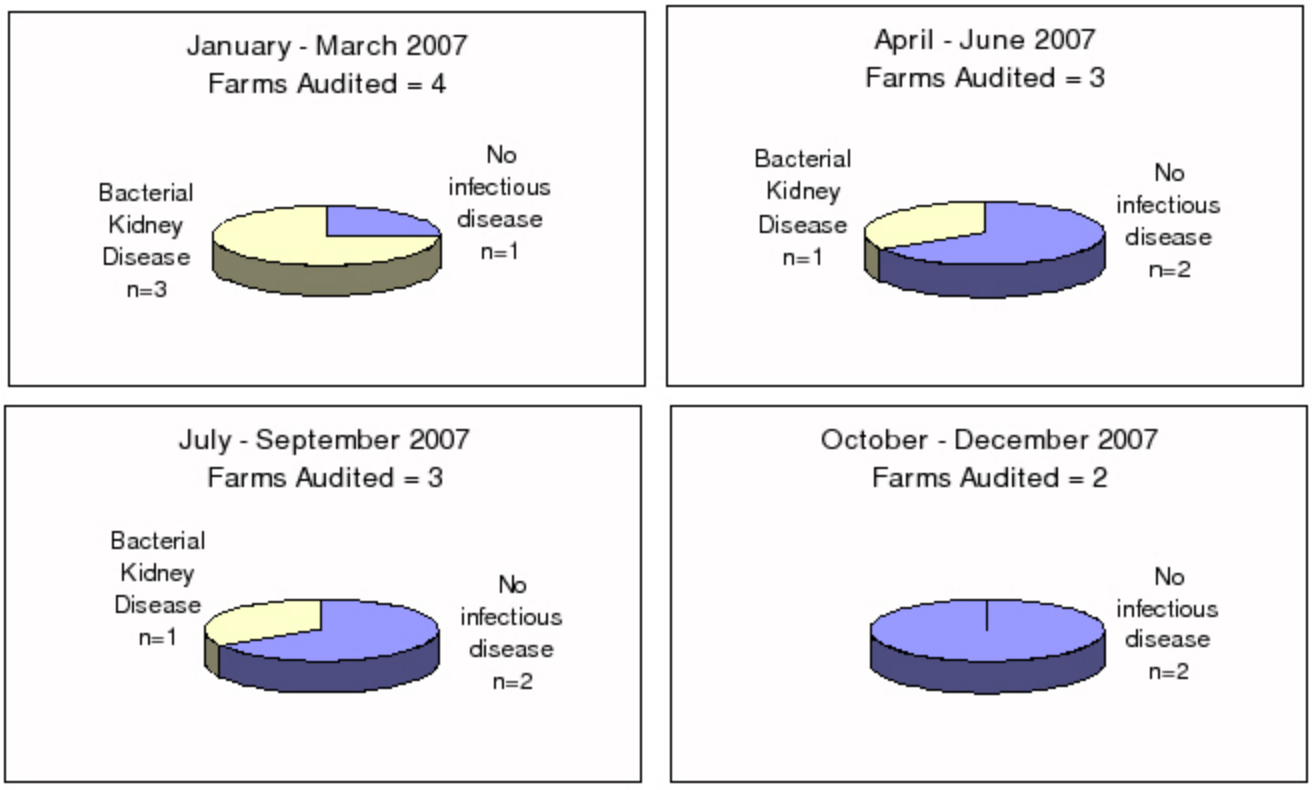


Table 7.7.7: 2007 Diagnoses from Sub-zone 3.5 (Central Coast) Atlantic Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	1	1	No Infectious Disease
2 Apr – June	2	2	No Infectious Disease
3 July – Sept	1	1	No Infectious Disease
4 Oct - Dec	1	1	No Infectious Disease

Figure 7.7.7: Diagnoses from Sub-zone 3.5 (Central Coast) Atlantic Salmon Farm Audits 2007

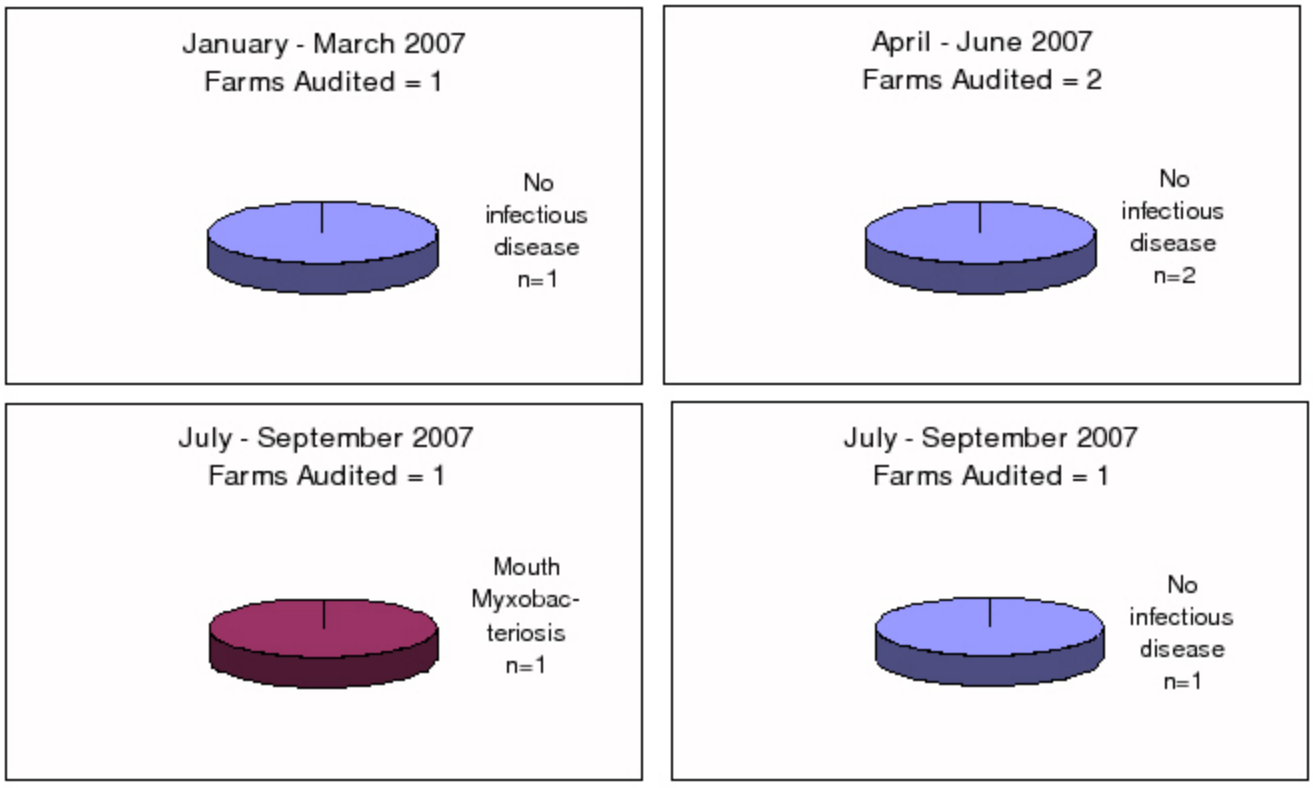


Table 7.7.8: 2007 Diagnoses from Zone 2 (Vancouver Island) Pacific Salmon Farm Audits

Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	1	1	No Infectious Disease
2 Apr – June	1	1	No Infectious Disease
3 July – Sept	1	1	Bacterial Kidney Disease
		1	Loma
4 Oct - Dec	1	1	Rickettsiosis
		1	Loma

Figure 7.7.8: Diagnoses from Zone 2 (Vancouver Island) Pacific Salmon Farm Audits 2007

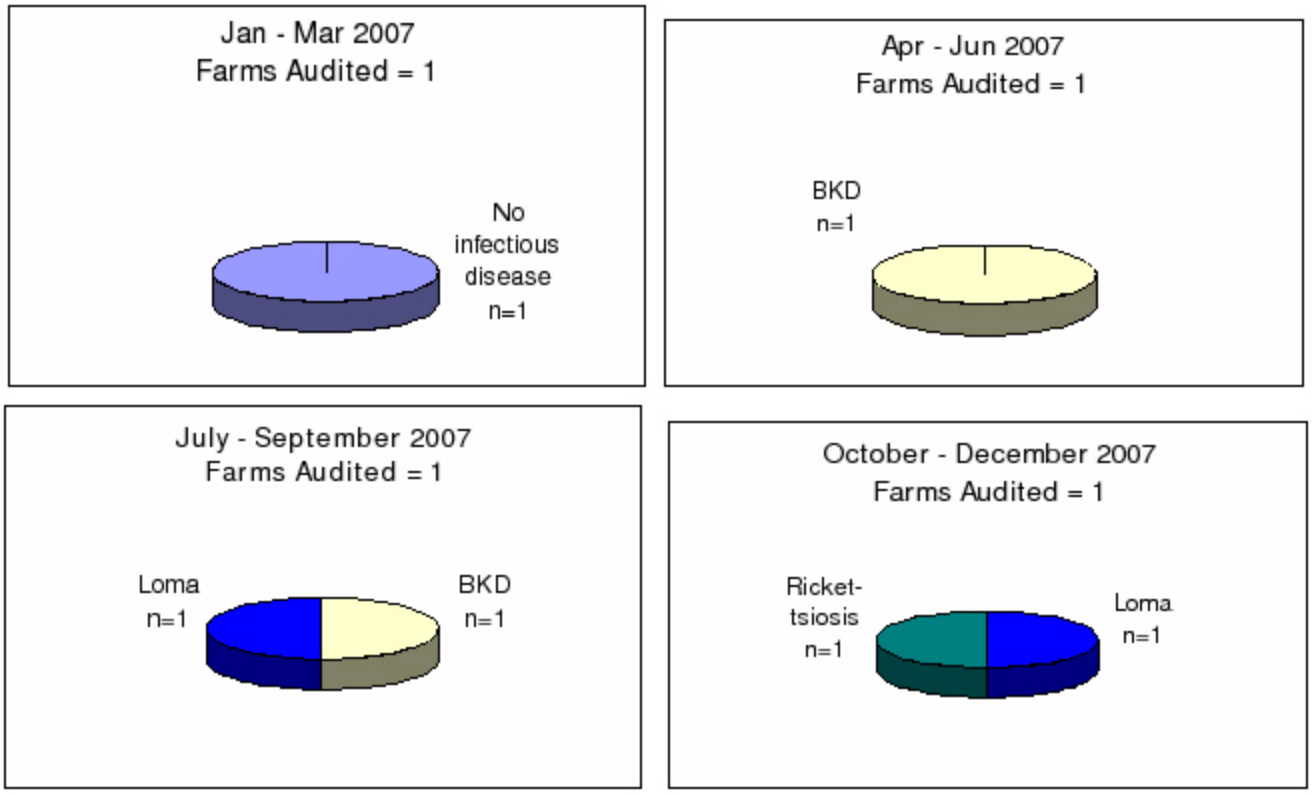
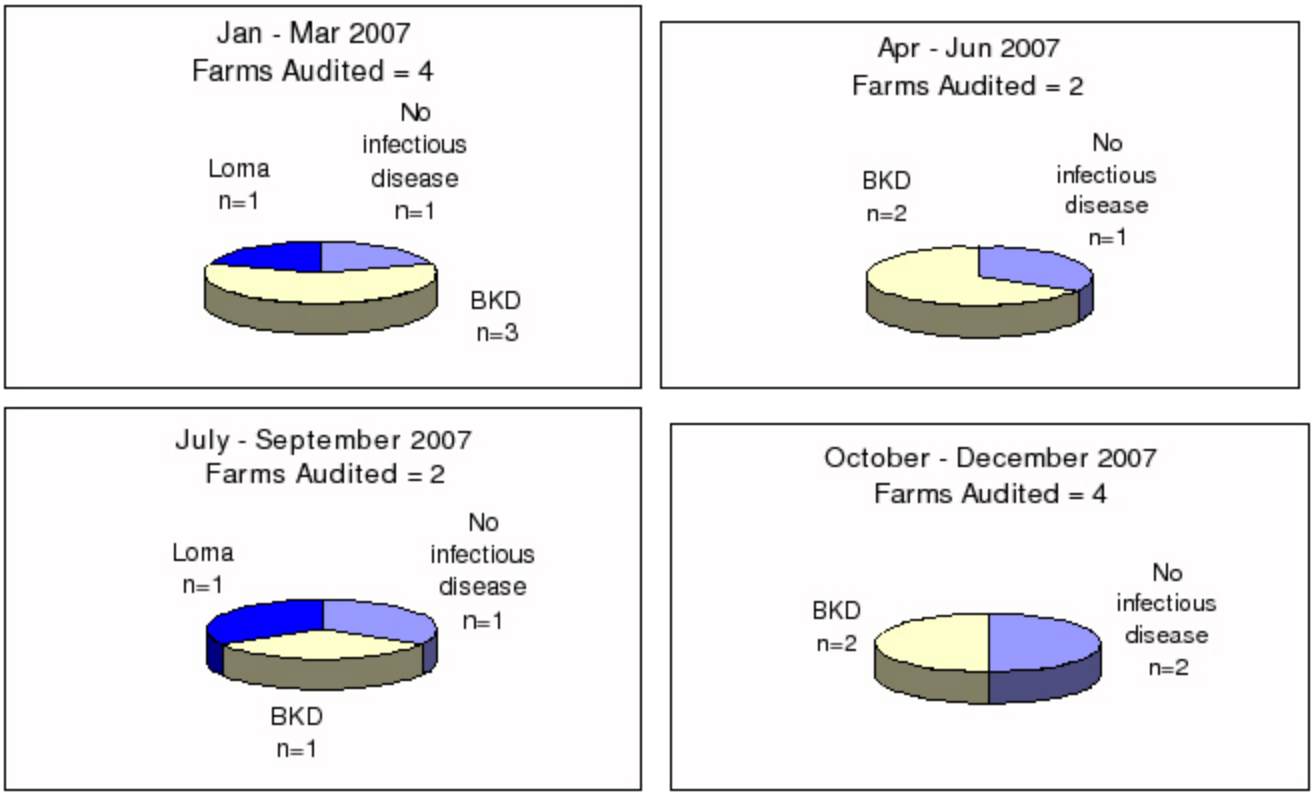


Table 7.7.9: 2007 Diagnoses from Zone 3 (East of Vancouver Island) Pacific Salmon Farm Audits			
Quarter	Number of Farms Audited	Number of Cases	Farm Level Diagnosis
1 Jan - Mar	4	1	No Infectious Disease
		3	Bacterial Kidney Disease
		1	Loma
2 Apr – June	3	1	No Infectious Disease
		2	Bacterial Kidney Disease
3 July – Sept	2	1	No Infectious Disease
		1	Bacterial Kidney Disease
4 Oct - Dec	4	2	No Infectious Disease
		2	Bacterial Kidney Disease

Figure 7.7.9: Diagnoses from Zone 3 (East of Vancouver Island) Pacific Salmon Farm Audits 2007



APPENDIX 7.8 BCSFA Mortality Reports 2007

BCSFA Mortality Reports: Quarter 1, 2007

Average Mortality Rate (First Quarter - 2007)					
Fish Health SubZone	Species	Life stages	# Fish Group	# Site	Rate
All Zones	Atlantic salmon	"Early"	21	14	5.02%
2-3	Atlantic salmon	"Later"	11	10	0.33%
2-4	Atlantic salmon	"Later"	12	11	1.00%
3-1 + 3-2	Atlantic salmon	"Later"	16	15	0.61%
3-3	Atlantic salmon	"Later"	28	20	1.33%
3-4 + 3-5	Atlantic salmon	"Later"	12	12	0.20%
All Zones [4]	Atlantic salmon	"Later"	83	2	1.54%
All Zones	Pacific salmon	"Early"	90	14	0.97%
All Zones	Pacific salmon	"Later"	38	14	1.34%

Notes

1 Rate figures are aggregate weighted averages (agreed to with BC MAFF April 25, 2003)

2 Defintions for lifestages:

"Early"	Eyed Egg -->	Alevin / Larvae / Fry -->		Pre-smolt (= parr)
"Later"	Smolt -->	Grow-out / Harvest (= immature adult) -->	Broodstock -->	Spent/Post-Spawn (public facilities)

3

The following participants' data are in the system for this quarter	Companies/ participants not yet on the system	Data in the system for this quarter but may be incomplete
Creative Salmon Grieg Seafoods Heritage Salmon Marine Harvest Canada/ Stolt Seafarms Mainstream (Pacific National Aquaculture) Panfish Canada (Omega Salmon Group) Target Marine Products West Coast Fish Culture	AgriMarine Industries Omega Pacific Saltstream Engineering Totem Oysters Yellow Island Aquaculture Freshwater Fisheries Society of BC (some data in the system)	Fisheries and Oceans Canada

4 This field has been added to encompass a small number of later lifestage Atlantic salmon (e.g., broodstock) raised in areas other than the subzones shown above.

Mortality Rates by Cause (First Quarter - 2007) [1,2]						
Early Life stages						
Fish Health SubZone	Species	# Fish Groups	Background Mortality	Systems Related	Fresh	Culls / Quality Control
All Zones	Atlantic salmon	21	1.39%	0.14%	0.23%	3.26%
All Zones	Pacific salmon	90	0.83%	0.11%	0.00%	4.00%

Mortality Rates by Cause (First Quarter - 2007)									
Later Life stages									
Fish Healtjh SubZone	Species	# Fish Groups	Environmental	Fresh "Silvers"	Handling / Transport	Matures	Old	Poor Performers	Predators
All Zones	Atlantic salmon	83	0.00%	0.00%	0.10%	0.52%	0.17%	0.07%	0.07%
2-3	Atlantic salmon	11	0.00%	0.11%	0.00%	0.04%	0.10%	0.05%	0.06%
2-4	Atlantic salmon	12	0.00%	0.00%	0.05%	0.00%	0.08%	0.02%	0.14%
3-1 + 3-2	Atlantic salmon	16	0.00%	0.03%	0.26%	0.00%	0.11%	0.04%	0.12%
3-3	Atlantic salmon	28	0.01%	0.02%	0.12%	0.48%	0.33%	0.14%	0.02%
3-4 + 3-5	Atlantic salmon	12	0.00%	0.02%	0.01%	0.00%	0.10%	0.01%	0.05%
All Zones	Pacific salmon	38	0.00%	0.22%	0.04%	0.14%	0.24%	0.03%	0.68%

Notes

1 See notes for Average Mortality Rate report

2 Sum of individual Proportional Mortality Rates reconciles to Average Mortality Rate to 0.005% (rounding errors)

BCSFA Mortality Reports: Quarter 2, 2007

Average Mortality Rate (Second Quarter - 2007)					
Fish Health SubZone	Species	Life stages	# Fish Group	# Site	Rate
All Zones	Atlantic salmon	"Early"	10	5	2.92%
2-3	Atlantic salmon	"Later"	28	16	0.50%
2-4	Atlantic salmon	"Later"	21	11	0.60%
3-1 + 3-2	Atlantic salmon	"Later"	25	18	0.76%
3-3	Atlantic salmon	"Later"	38	23	0.52%
3-4 + 3-5	Atlantic salmon	"Later"	19	13	0.63%
All Zones [4]	Atlantic salmon	"Later"	139	5	0.78%
All Zones	Pacific salmon	"Early"	21	7	0.99%
All Zones	Pacific salmon	"Later"	20	15	1.72%

Notes

1 Rate figures are aggregate weighted averages (agreed to with BC MAFF April 25, 2003)

2 Defintions for lifestages:

"Early"	Eyed Egg -->	Alevin / Larvae / Fry -->		Pre-smolt (= parr)
"Later"	Smolt -->	Grow-out / Harvest (= immature adult) -->	Broodstock -->	Spent/Post-Spawn (public facilities)

3

The following participants' data are in the system for this quarter	Companies/ participants not yet on the system	Data in the system for this quarter but may be incomplete
Creative Salmon	AgriMarine Industries	Fisheries and Oceans Canada
Grieg Seafoods	Omega Pacific	
Heritage Salmon	Saltstream Engineering	
Marine Harvest Canada/ Stolt Seafarms	Totem Oysters	
Mainstream (Pacific National Aquaculture)	Yellow Island Aquaculture	
Panfish Canada (Omega Salmon Group)	Freshwater Fisheries Society of BC (some data in the system)	
Target Marine Products		
West Coast Fish Culture		

4 This field has been added to encompass a small number of later lifestage Atlantic salmon (e.g., broodstock) raised in areas other than the subzones shown above.

Mortality Rates by Cause (Second Quarter - 2007) [1,2]						
Early Life stages						
Fish Health SubZone	Species	# Fish Groups	Background Mortality	Systems Related	Fresh	Culls / Quality Control
All Zones	Atlantic salmon	10	2.51%	0.03%	0.03%	0.24%
All Zones	Pacific salmon	20	0.70%	0.70%	0.00%	0.28%

Mortality Rates by Cause (Second Quarter - 2007)									
Later Life stages									
Fish Healtjh SubZone	Species	# Fish Groups	Environmental	Fresh "Silvers"	Handling / Transport	Matures	Old	Poor Performers	Predators
All Zones	Atlantic salmon	139	5.30%	0.01%	0.97%	0.41%	0.48%	0.88%	0.25%
2-3	Atlantic salmon	28	0.02%	0.17%	0.01%	0.01%	0.11%	0.11%	0.07%
2-4	Atlantic salmon	21	0.22%	0.00%	0.05%	0.00%	0.08%	0.05%	0.02%
3-1 + 3-2	Atlantic salmon	25	0.00%	0.10%	0.36%	0.00%	0.17%	0.07%	0.07%
3-3	Atlantic salmon	38	0.05%	0.15%	0.02%	0.03%	0.17%	0.06%	0.03%
3-4 + 3-5	Atlantic salmon	19	0.01%	0.08%	0.15%	0.00%	0.26%	0.03%	0.03%
All Zones	Pacific salmon	20	0.04%	0.69%	0.11%	0.06%	0.34%	0.15%	0.27%

Notes

1 See notes for Average Mortality Rate report

2 Sum of individual Proportional Mortality Rates reconciles to Average Mortality Rate to 0.005% (rounding errors)

BCSFA Mortality Reports: Quarter 3, 2007

Average Mortality Rate (Third Quarter - 2007)					
Fish Health SubZone	Species	Life stages	# Fish Group	# Site	Rate
All Zones	Atlantic salmon	"Early"	10	5	3.55%
2-3	Atlantic salmon	"Later"	16	14	0.94%
2-4	Atlantic salmon	"Later"	11	11	1.23%
3-1 + 3-2	Atlantic salmon	"Later"	15	15	1.06%
3-3	Atlantic salmon	"Later"	22	21	0.62%
3-4 + 3-5	Atlantic salmon	"Later"	13	13	1.87%
All Zones [4]	Atlantic salmon	"Later"	93	89	1.11%
All Zones	Pacific salmon	"Early"	23	8	1.75%
All Zones	Pacific salmon	"Later"	26	18	2.93%

Notes

1 Rate figures are aggregate weighted averages (agreed to with BC MAFF April 25, 2003) 1

2 Defintions for lifestages:

"Early"	Eyed Egg -->	Alevin / Larvae / Fry -->		Pre-smolt (= parr)
"Later"	Smolt -->	Grow-out / Harvest (= immature adult) -->	Broodstock -->	Spent/Post-Spawn (public facilities)

3

The following participants' data are in the system for this quarter	Companies/ participants not yet on the system	Data in the system for this quarter but may be incomplete
Creative Salmon	AgriMarine Industries	Fisheries and Oceans Canada
Grieg Seafoods	Omega Pacific	
Heritage Salmon	Saltstream Engineering	
Marine Harvest Canada/ Stolt Seafarms	Totem Oysters	
Mainstream (Pacific National Aquaculture)	Yellow Island Aquaculture	
Panfish Canada (Omega Salmon Group)		
Target Marine Products	Freshwater Fisheries Society of BC (some data in the system)	
West Coast Fish Culture		

4 This field has been added to encompass a small number of later lifestage Atlantic salmon (e.g., broodstock) raised in areas other than the subzones shown above.

Mortality Rates by Cause (Quarter 3 2007) [1,2]						
Early Life stages						
Fish Health SubZone	Species	# Fish Groups	Background Mortality	Systems Related	Fresh	Culls / Quality Control
All Zones	Atlantic salmon	10	1.38%	0.00%	0.03%	2.15%
All Zones	Pacific salmon	23	0.56%	1.18%	0.00%	0.01%

Mortality Rates by Cause (Quarter 3 2007)									
Later Life stages									
Fish Healtjh SubZone	Species	# Fish Groups	Environmental	Fresh "Silvers"	Handling / Transport	Matures	Old	Poor Performers	Predators
All Zones	Atlantic salmon	93	0.36%	0.25%	0.09%	0.01%	0.22%	0.16%	0.01%
2-3	Atlantic salmon	16	0.15%	0.19%	0.00%	0.01%	0.15%	0.41%	0.03%
2-4	Atlantic salmon	11	0.99%	0.03%	0.01%	0.00%	0.15%	0.05%	0.00%
3-1 + 3-2	Atlantic salmon	15	0.24%	0.09%	0.21%	0.00%	0.26%	0.25%	0.01%
3-3	Atlantic salmon	22	0.03%	0.19%	0.04%	0.04%	0.25%	0.08%	0.01%
3-4 + 3-5	Atlantic salmon	13	1.17%	0.13%	0.20%	0.00%	0.30%	0.06%	0.01%
All Zones	Pacific salmon	26	0.77%	1.14%	0.11%	0.22%	0.29%	0.09%	0.05%

Notes

1 See notes for Average Mortality Rate report

2 Sum of individual Proportional Mortality Rates reconciles to Average Mortality Rate to 0.005% (rounding errors)

BCSFA Mortality Reports: Quarter 4, 2007

Average Mortality Rate (Fourth Quarter - 2007)					
Fish Health SubZone	Species	Life stages	# Fish Group	# Site	Rate
All Zones	Atlantic salmon	"Early"	10	5	6.29%
2-3	Atlantic salmon	"Later"	19	15	0.31%
2-4	Atlantic salmon	"Later"	16	11	1.25%
3-1 + 3-2	Atlantic salmon	"Later"	22	17	1.67%
3-3	Atlantic salmon	"Later"	37	20	0.76%
3-4 + 3-5	Atlantic salmon	"Later"	20	13	0.30%
All Zones [4]	Atlantic salmon	"Later"	130	86	1.21%
All Zones	Pacific salmon	"Early"	22	8	0.73%
All Zones	Pacific salmon	"Later"	40	23	1.50%

Notes

1 Rate figures are aggregate weighted averages (agreed to with BC MAFF April 25, 2003) 1

2 Defintions for lifestages:

"Early"	Eyed Egg -->	Alevin / Larvae / Fry -->		Pre-smolt (= parr)
"Later"	Smolt -->	Grow-out / Harvest (= immature adult) -->	Broodstock -->	Spent/Post-Spawn (public facilities)

3

The following participants' data are in the system for this quarter	Companies/ participants not yet on the system	Data in the system for this quarter but may be incomplete
Creative Salmon	AgriMarine Industries	Fisheries and Oceans Canada
Grieg Seafoods	Omega Pacific	
Heritage Salmon	Saltstream Engineering	
Marine Harvest Canada/ Stolt Seafarms	Totem Oysters	
Mainstream (Pacific National Aquaculture)	Yellow Island Aquaculture	
Panfish Canada (Omega Salmon Group)		
Target Marine Products	Freshwater Fisheries Society of BC (some data in the system)	
West Coast Fish Culture		

4 This field has been added to encompass a small number of later lifestage Atlantic salmon (e.g., broodstock) raised in areas other than the subzones shown above.

Mortality Rates by Cause (Quarter 4 2007) [1,2]						
Early Life stages						
Fish Health SubZone	Species	# Fish Groups	Background Mortality	Systems Related	Fresh	Culls / Quality Control
All Zones	Atlantic salmon	10	0.73%	0.01%	0.07%	5.47%
All Zones	Pacific salmon	22	0.84%	0.06%	0.00%	0.03%

Mortality Rates by Cause (Quarter 4 2007)									
Later Life stages									
Fish Healtjh SubZone	Species	# Fish Groups	Environmental	Fresh "Silvers"	Handling / Transport	Matures	Old	Poor Performers	Predators
All Zones	Atlantic salmon	130	0.10%	0.40%	0.08%	0.34%	0.22%	0.05%	0.04%
2-3	Atlantic salmon	19	0.00%	0.08%	0.00%	0.03%	0.11%	0.05%	0.04%
2-4	Atlantic salmon	16	0.74%	0.04%	0.05%	0.00%	0.32%	2.39%	0.03%
3-1 + 3-2	Atlantic salmon	22	0.01%	0.31%	0.10%	1.16%	0.09%	0.04%	0.04%
3-3	Atlantic salmon	37	0.01%	0.04%	0.15%	0.13%	0.35%	0.06%	0.01%
3-4 + 3-5	Atlantic salmon	20	0.03%	0.04%	0.01%	0.01%	0.18%	0.04%	0.02%
All Zones	Pacific salmon	40	0.00%	0.35%	0.14%	0.59%	0.21%	0.02%	0.23%

Notes

1 See notes for Average Mortality Rate report

2 Sum of individual Proportional Mortality Rates reconciles to Average Mortality Rate to 0.05% (rounding errors)

APPENDIX 7.9 BCSFA Fish Health Events 2007

Fish Health Events (First Quarter - 2007)

Fish Health SubZone	Species	Life Stage	Veterinary Diagnosis	Count of Fish Health Events [1,2,3]		
				New	Ongoing/ Recurring	Relapsing
All	Atlantic Salmon	"Early"		0	0	0
All zones [5]	Atlantic Salmon	"Later"		0	0	0
2-3	Atlantic Salmon	"Later"	Lepeophtheirus Infection	1	0	0
			Piscirickettsia salmonis Infection	0	2	0
			Yersinia ruckeri Infection	0	1	0
2-4	Atlantic Salmon	"Later"	Case worked up but no diagnosis	0	1	0
			Aeromonas salmonicida Infection	1	0	0
			Myxobacterial Infection	3	0	0
			Renibacterium salmoninarum Infection	2	1	0
3-1 + 3-2	Atlantic Salmon	"Later"	Lepeophtheirus Infection	2	1	0
			Myxobacterial Infection	2	1	0
3-3	Atlantic Salmon	"Later"	Lepeophtheirus Infection	11	0	0
			Myxobacterial Infection	2	0	0
			Viral Haemorrhagic Septicemia Virus Infection	1	0	0
3-4 + 3-5	Atlantic Salmon	"Later"	Case worked up but no diagnosis	0	1	0
			Lepeophtheirus Infection	1	0	0
All zones	Pacific Salmonids	"Early"	Myxobacterial Infection	2	0	0
All zones	Pacific Salmonids	"Later"	Renibacterium salmoninarum Infection	4	0	0

Fish Health Events (Second Quarter - 2007)

Fish Health SubZone	Species	Life Stage	Veterinary Diagnosis	Count of Fish Health Events [1,2,3]		
				New	Ongoing/ Recurring	Relapsing
All	Atlantic Salmon	"Early"		0	0	0
All zones [5]	Atlantic Salmon	"Later"	Lepeophtheirus Infection	0	2	0
			Infection	0	1	0
2-3	Atlantic Salmon	"Later"	Aeromonas salmonicida Infection	0	1	0
			Lepeophtheirus Infection	2	0	0
			Myxobacterial Infection	2	0	0
			Piscirickettsia salmonis Infection	0	2	0
			Yersinia ruckeri Infection	0	1	0
2-4	Atlantic Salmon	"Later"	Myxobacterial Infection	1	0	0
			Infection	1	0	0
3-1 + 3-2	Atlantic Salmon	"Later"	Lepeophtheirus Infection	2	0	0
			Myxobacterial Infection	3	1	0
3-3	Atlantic Salmon	"Later"	Myxobacterial Infection	1	2	0
			Viral Haemorrhagic Septicemia Virus Infection	0	1	0
3-4 + 3-5	Atlantic Salmon	"Later"		0	0	0
All zones	Pacific Salmonids	"Early"	Case worked up but no diagnosis [4]	1	0	0
			Myxobacterial Infection	5	0	0
All zones	Pacific Salmonids	"Later"	Renibacterium salmoninarum Infection	8	0	0

Notes

1. Reporting reflects life stage rather than water type. See notes 1 - 2 of Average Mortality Rate report.
2. Counts of veterinary diagnosis are based on FISH GROUP (not site); more than one fish group may exist at a site.
3. Fish Health Events reflect the following categories:
   - New: First time occurrence; new event
   - Ongoing/Recurring: Repeat or ongoing occurrence from previous calendar quarter
   - Relapsing: Repeat occurrence from calendar quarter at least two quarters preceding the current one
4. "Case worked up but no diagnosis" category requires workup and management steps taken, e.g., further investigation, husbandry change etc.
5. This field has been added to encompass a small number of later lifestage Atlantic salmon (e.g., broodstock) raised in areas other than the subzones shown above.

Fish Health Events (Third Quarter 2007)						
Fish Health SubZone	Species	Life Stage	Veterinary Diagnosis	Count of Fish Health Events [1,2,3]		
				New	Ongoing/ Recurring	Relapsing
All	Atlantic Salmon	"Early"		0	0	0
All zones [6]	Atlantic Salmon	"Later"		0	0	0
2-3	Atlantic Salmon	"Later"	Myxobacterial Infection	0	2	0
			Net Pen Liver Disease	1	0	0
			Piscirickettsia salmonis Infection	0	2	0
			Yersinia ruckeri Infection	0	1	0
2-4	Atlantic Salmon	"Later"		0	0	0
3-1 + 3-2	Atlantic Salmon	"Later"	Aeromonas salmonicida Infection	1	0	0
			Myxobacterial Infection	3	3	0
3-3	Atlantic Salmon	"Later"	Aeromonas salmonicida Infection	1	0	0
			Pseudomonas Infection	1	0	
			Viral Haemorrhagic Septicaemia Virus Infection	0	1	0
			Renibacterium salmoninarum Infection	1	0	0
3-4 + 3-5	Atlantic Salmon	"Later"	Myxobacterial Infection	1	0	0
All zones	Pacific Salmonids	"Early"	Myxobacterial Infection	3	0	0
All zones	Pacific Salmonids	"Later"	Renibacterium salmoninarum Infection	3	1	0

Fish Health Events (Fourth 2007)						
Fish Health SubZone	Species	Life Stage	Veterinary Diagnosis	Count of Fish Health Events [1,2,3]		
				New	Ongoing/ Recurring	Relapsing
All	Atlantic Salmon	"Early"		0	0	0
All zones [6]	Atlantic Salmon	"Later"		0	0	0
2-3	Atlantic Salmon	"Later"	Lepeophtheirus Infection	2	1	0
			Piscirickettsia salmonis Infection	1	2	0
2-4	Atlantic Salmon	"Later"	Lepeophtheirus Infection	0	1	0
			Renibacterium salmoninarum Infection	0	1	0
			Myxobacterial Infection	0	2	0
3-1 + 3-2	Atlantic Salmon	"Later"	Myxobacterial Infection	4	2	0
			Lepeophtheirus Infection	4	0	0
3-3	Atlantic Salmon	"Later"	Viral Haemorrhagic Septicaemia Virus Infection	0	1	0
3-4 + 3-5	Atlantic Salmon	"Later"	Lepeophtheirus Infection	3	0	0
All zones	Pacific Salmonids	"Early"		0	0	0
All zones	Pacific Salmonids	"Later"	Renibacterium salmoninarum Infection	1	0	0

Notes

1 Reporting reflects lifestage rather than water type. See notes 1 - 2 of Average Mortality Rate report.

2 Counts of veterinary diagnosis are based on FISH CROP (net site); more than one fish group may exist at a site.

3 Fish Health Events reflect the following categories:

New First time occurrence; new event.

Ongoing/ recurring Repeat or ongoing occurrence from previous calendar quarter.

Relapsing Repeat occurrence from calendar quarter at least two quarters preceding the current one.

4 "Case worked up but no diagnosis" category requires workup and management steps taken, e.g., further investigation, husbandry change etc.

5 This field has been added to encompass a small number of later lifestage Atlantic salmon (e.g., broodstock) raised in areas other than the subzones shown above.

APPENDIX 7.10 Definitions of Sea Lice Stages for Industry Monitoring and Audit Purposes

Lepeophtheirus salmonis:

Adult female – includes adult female lice with egg strings (i.e. gravid) or without egg strings.

Motile Lice – includes all 'not permanently attached' motile stages: adult females (as above) plus adult male and pre-adults male/female lice.

Caligus – total numbers of motile *Caligus clemensi* or other species if detectable grossly.

Chalimus - attached immature stages of both *Caligus* and *Lepeophtheirus* species. Both species are categorised as chalimus since louse identification at those very early stages is not practically possible.

Year class – age of fish in saltwater.

- "Year class 1" represents fish groups that share a similar date of salt water entry with the first fish on farm (i.e. within 6 months), plus the subsequent 12 months.
- "Year class 2" is defined as the remaining time in saltwater after that initial 12 months.
- Broodstock held in saltwater would be included in the Year class 2 group, up to March 1st of the year in which eggs will be collected. See Broodstock section for more detail. For broodstock relocated to freshwater facilities, information on health will be included in freshwater section of the database reports.

APPENDIX 7.11 Sea Lice Audit Tables 2007

Table 7.11.1 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 2.3 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	0		2		1		1	
Motile	ø	ø	2.067	1	1.067	1	1.28	1
Standard Deviation (SD)			2.43		1.13		1.51	
Female	ø	ø	0.267	0	0.167	0	0.55	0
SD			0.923		0.129		0.852	
Chalimus	ø	ø	0.292	0	0.083	0	0.1	0
SD			0.627		0.279		0.354	
Caligus Motile	ø	ø	0.05	0	0.033	0	0.267	0
SD			1.045		0.181		0.578	
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	2		3		1		1	
Motile	1.97	2	2.83	2.5	0.683	0	7.85	7
SD	1.97		2.24		0.930		3.89	
Female	0.717	0	1.19	1	0.350	0	4.98	4
SD	1.101		1.24		0.547		3.0056	
Chalimus	0.483	0	0.089	0	0.267	0	0.367	0
SD	0.916		0.3705		0.483		0.991	
Caligus Motile	0.083	0	0.094	0	0.05	0	0.617	0
SD	0.3063		0.346		0.220		1.38	

Table 7.11.2 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 2.4 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		3		0		1	
Motile	0.05	0	0.400	0	ø	ø	9.15	8
Standard Deviation (SD)	0.220		0.744				7.025	
Female	0	0	0.033	0	ø	ø	3.72	3
SD			0.18				2.39	
Chalimus	0.183	0	0.094	0	ø	ø	1.53	0
SD	0.431		0.329				2.81	
Caligus Motile	0.017	0	0	0	ø	ø	0	0
SD	0.130							
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		2		0		1	
Motile	0.017	0	0.817	0	ø	ø	0.667	0
SD	0.129		1.43				1.020	
Female	0	0	0.458	0	ø	ø	0.45	0
SD			0.961				0.769	
Chalimus	2.18	1.5	0.192	0	ø	ø	0	0
SD	2.72		0.584					
Caligus Motile	0.167	0	0.133	0	ø	ø	0	0
SD	0.493		0.387					

Table 7.11.3 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 3.1 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	0		1		0		0	
Motile	ø	ø	0.05	0	ø	ø	ø	ø
Standard Deviation (SD)			0.220					
Female	ø	ø	0.033	0	ø	ø	ø	ø
SD			0.181					
Chalimus	ø	ø	0.600	0	ø	ø	ø	ø
SD			1.012					
Caligus Motile	ø	ø	0.100	0	ø	ø	ø	ø
SD			0.3025					
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		0		1		1	
Motile	0.400	0	ø	ø	0.167	0	0.017	0
SD	0.669				0.457		0.129	
Female	0.217	0	ø	ø	0.083	0	0.017	0
SD	0.454				0.334		0.129	
Chalimus	0.033	0	ø	ø	0	0	0.017	0
SD	0.181						0.129	
Caligus Motile	0.05	0	ø	ø	0	0	0.017	0
SD	0.220						0.129	

Table 7.11.4 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 3.2 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	2		3		2		2	
Motile	0.258	0	0.028	0	0.075	0	0.442	0
Standard Deviation (SD)	0.7041		0.196		0.295		0.731	
Female	0.017	0	0	0	0.012	0	0.058	0
SD	0.129				0.129		0.235	
Chalimus	2.52	2	0.706	0	0.842	0	0.183	0
SD	1.93		1.28		1.44		0.534	
Caligus Motile	0.292	0	0.017	0	0.05	0	0.067	0
SD	0.600		0.128		0.219		0.282	
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	0		1		0		1	
Motile	ø	ø	0.800	1	ø	ø	0.033	0
SD			0.879				0.258	
Female	ø	ø	0.283	0	ø	ø	0.017	0
SD			0.524				0.129	
Chalimus	ø	ø	0	0	ø	ø	0	0
SD								
Caligus Motile	ø	ø	0.05	0	ø	ø	0	0
SD			0.220					

Table 7.11.5 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 3.3 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		3		3		2	
Motile	0.175	0	0.367	0	0.111	0	0.175	0
Standard Deviation (SD)	0.385		0.89		0.364		0.496	
Female	0	0	0.0778	0	0.011	0	0.05	0
SD			0.358		0.1051		0.219	
Chalimus	0.95	1	0.322	0	0.072	0	0.192	0
SD	0.986		0.774		0.2803		0.4902	
Caligus Motile	0	0	0.039	0	0.044	0	0.15	0
SD			0.254		0.232		0.4027	
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		3		0		0	
Motile	0.183	0	0.111	0	ø	ø	ø	ø
SD	0.431		0.434					
Female	0.117	0	0.061	0	ø	ø	ø	ø
SD	0.324		0.302					
Chalimus	0.217	0	2.506	0	ø	ø	ø	ø
SD	0.865		5.18					
Caligus Motile	0.033	0	0.133	0	ø	ø	ø	ø
SD	0.258		0.4409					

Table 7.11.6 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 3.4 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	0		0		0		0	
Motile	ø	ø	ø	ø	ø	ø	ø	ø
Standard Deviation (SD)								
Female	ø	ø	ø	ø	ø	ø	ø	ø
SD								
Chalimus	ø	ø	ø	ø	ø	ø	ø	ø
SD								
Caligus Motile	ø	ø	ø	ø	ø	ø	ø	ø
SD								
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		3		0		1	
Motile	1.75	1	0.831	0	ø	ø	1.33	1
SD	1.61		1.16				1.068	
Female	0.733	0	0.394	0	ø	ø	0.583	0
SD	1.055		0.736				0.850	
Chalimus	0.167	0	0.069	0	ø	ø	0.083	0
SD	0.376		0.3905				0.279	
Caligus Motile	0.017	0	0.069	0	ø	ø	0.017	0
SD	0.129		0.254				0.129	

Table 7.11.7 Quarterly Mean and Median Abundance of Motile and Female *Lepeophtheirus salmonis*, Chalimus (*L. salmonis* and *Caligus clemensi*) and Motile *C. clemensi* on Atlantic Salmon. Sub-zone 3.5 (BCMAL Audits 2007)

Year Class 1 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	0		1		1		1	
Motile	ø	ø	0.017	0	1.15	1	3.78	2
Standard Deviation (SD)			0.129		1.26		4.68	
Female	ø	ø	0	0	0.133	0	2.2	1
SD					0.468		2.99	
Chalimus	ø	ø	0.267	0	3.033	2	0.683	0
SD			0.446		2.29		1.47	
Caligus Motile	ø	ø	0.017	0	0.067	0	0.883	0
SD			0.129		0.312		1.21	
Year Class 2 - 2007	Q1		Q2		Q3		Q4	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of Farms Audited (n)	1		0		0		0	
Motile	0.017	0	ø	ø	ø	ø	ø	ø
SD	0.129							
Female	0	0	ø	ø	ø	ø	ø	ø
SD								
Chalimus	0.233	0	ø	ø	ø	ø	ø	ø
SD	0.647							
Caligus Motile	0.033	0	ø	ø	ø	ø	ø	ø
SD	0.181							

APPENDIX 7.12 Sea Lice BCSFA Tables and Graphs 2007

KEY
Motile ~ *Lepeophtheirus* sp (pre adult and adult stages)
Female ~ Adult female *Lepeophtheirus* sp (adult female)
Caligus ~ sp. (pre adult and adult)
Yearclass 1~ For salmon 1 year or less in seawater.
Yearclass 2 ~ For salmon 2 years or more in seawater.

Notes:
( ) ~ total number of farms counts for months where two counts have been requested.

* Reasons for missing farm lice counts
~Site is fallow
~Site is harvesting and < 3 pens left on site
~Smolt entry and < 3 pens on site, or <1 month since third smolt pen entered
~Fish being treated for sea lice
~Fish being treated/ managed for other fish health problem
~Fish could not be handled due to environmental concerns, e.g. low DO

Atlantic Salmon Sea Lice Abundance

Yearclass 1						Yearclass 2					
ZONE/SUBZONE 2.3		Motile	Female	Caligus	n	ZONE/SUBZONE 2.3		Motile	Female	Caligus	n
Jan-07		0.62	0.23	0.07	4	Jan-07		0.02	0.07	0.09	2
	std error	0.30	0.09	0.06			std error	0.01	0.02	0.09	
Feb-07		1.32	0.48	0.42	5	Feb-07		1.12	0.27	0.21	3
	std error	0.48	0.21	0.15			std error	0.514	0.052	0.21	
Mar-07		1.13	0.41	0.11	5	Mar-07		0.98	0.27	0.07	1
	std error	0.47	0.18	0.05			std error				
Apr-07		1.18	0.55	0.15	4	Apr-07		1.54	0.64	0.06	5
	std error	0.29	0.13	0.15			std error	0.51	0.22	0.02	
May-07		1.62	0.37	0.39	5	May-07		0.08	0.02	0.00	3
	std error	0.42	0.08	0.31			std error	0.04	0.01	0.00	
Jun-07		1.01	0.37	0.17	5	Jun-07		0.11	0.07	0.01	3
	std error	0.16	0.11	0.10			std error	0.03	0.00	0.01	
Jul-07		0.81	0.28	0.23	4	Jul-07		0.21	0.06	0.06	3
	std error	0.29	0.20	0.20			std error	0.20	0.05	0.05	
Aug-07		0.58	0.23	0.10	5	Aug-07		0.23	0.10	0.77	1
	std error	0.20	0.08	0.05			std error				
Sep-07		0.72	0.41	0.00	5(6)	Sep-07		0.06	0.05	0.01	2
	std error	0.27	0.17	0.00			std error	0.03	0.02	0.01	
Oct-07		1.86	1.05	0.01	5(6)	Oct-07		0.50	0.32	0.03	2
	std error	0.50	0.32	0.01			std error	0.03	0.05	0.03	
Nov-07		1.96	1.08	0.72	4(5)	Nov-07		6.78	3.66	0.02	2(4)
	std error	0.92	0.54	0.06			std error	2.92	1.65	0.01	
Dec-07		3.58	1.80	0.17	4(7)	Dec-07		13.50	7.10	0.02	1
	std error	2.21	1.05	0.12			std error				

ZONE/SUBZONE 2.4		Motile	Female	Caligus	n
Jan-07		0.60	0.03	0.01	4
	std error	0.24	0.02	0.01	
Feb-07		1.26	0.07	0.06	4
	std error	0.56	0.03	0.06	
Mar-07		0.69	0.09	0.02	5
	std error	0.42	0.06	0.02	
Apr-07		0.22	0.02	0.00	5
	std error	0.15	0.02	0.00	
May-07		0.18	0.03	0.00	5
	std error	0.09	0.02	0.00	
Jun-07		0.37	0.04	0.00	3
	std error	0.18	0.01	0.00	
Jul-07		0.46	0.13	0.29	6
	std error	0.22	0.08	0.20	
Aug-07		1.13	0.40	1.74	5
	std error	0.38	0.14	1.07	
Sep-07		4.32	2.39	0.83	2
	std error	0.96	0.64	0.24	
Oct-07		3.76	1.49	0.06	4(5)
	std error	1.90	0.78	0.06	
Nov-07		3.97	1.30	0.00	2
	std error	3.40	0.97	0.00	
Dec-07		2.43	0.33	0.00	2
	std error	1.20	0.33	0.00	

ZONE/SUBZONE 2.4		Motile	Female	Caligus	n
Jan-07		0.35	0.19	0.02	5
	std error	0.20	0.11	0.02	
Feb-07		0.20	0.03	0.07	4
	std error	0.11	0.01	0.07	
Mar-07		0.26	0.06	0.47	5(6)
	std error	0.17	0.03	0.36	
Apr-07		0.25	0.10	0.08	4
	std error	0.06	0.04	0.08	
May-07		0.51	0.20	0.09	3
	std error	0.20	0.11	0.09	
Jun-07		0.90	0.37	0.11	5
	std error	0.34	0.13	0.10	
Jul-07		0.37	0.21	0.00	2
	std error	0.37	0.21	0.00	
Aug-07		0.63	0.28	0.01	3
	std error	0.47	0.20	0.01	
Sep-07		0.35	0.32	0.00	1
	std error				
Oct-07		2.38	1.11	0.00	4
	std error	1.16	0.53	0.00	
Nov-07		4.74	2.19	0.02	6(9)
	std error	2.13	1.07	0.02	
Dec-07		2.26	0.95	0.00	7(8)
	std error	0.87	0.38	0.00	

Yearclass 1

ZONE/SUBZONE 3.1		Motile	Female	Caligus	n
Jan-07					
	std error				
Feb-07					
	std error				
Mar-07					
	std error				
Apr-07					
	std error				
May-07					
	std error				
Jun-07					
	std error				
Jul-07					
	std error				
Aug-07					
	std error				
Sep-07					
	std error				
Oct-07					
	std error				
Nov-07					
	std error				
Dec-07					
	std error				

Yearclass 2

ZONE/SUBZONE 3.1		Motile	Female	Caligus	n
Jan-07					
	std error				
Feb-07					
	std error				
Mar-07					
	std error				
Apr-07					
	std error				
May-07					
	std error				
Jun-07					
	std error				
Jul-07					
	std error				
Aug-07					
	std error				
Sep-07					
	std error				
Oct-07					
	std error				
Nov-07					
	std error				
Dec-07					
	std error				

ZONE/SUBZONE 3.2		Motile	Female	Caligus	n
Jan-07		1.34	0.66	1.68	6
	std error	0.72	0.45	0.62	
Feb-07		0.31	0.11	0.26	5
	std error	0.18	0.07	0.23	
Mar-07		0.46	0.02	0.65	4
	std error	0.27	0.02	0.37	
Apr-07		0.66	0.22	0.88	5(6)
	std error	0.49	0.17	0.66	
May-07		0.90	0.31	1.03	7(8)
	std error	0.64	0.28	0.81	
Jun-07		0.43	0.16	0.45	7(8)
	std error	0.23	0.12	0.25	
Jul-07		0.14	0.05	0.06	8
	std error	0.09	0.05	0.03	
Aug-07		0.10	0.03	0.07	8
	std error	0.04	0.01	0.03	
Sep-07		0.14	0.03	0.12	8
	std error	0.04	0.01	0.08	
Oct-07		0.17	0.05	0.11	7(8)
	std error	0.02	0.22	0.04	
Nov-07		0.65	0.14	0.13	6
	std error	0.13	0.05	0.06	
Dec-07		1.36	0.38	0.14	6(7)
	std error	0.38	0.13	0.03	

Yearclass 1

ZONE/SUBZONE 3.3		Motile	Female	Caligus	n
Jan-07		1.73	0.35	0.46	6(7)
	std error	0.56	0.22	0.29	
Feb-07		1.26	0.54	0.09	6(8)
	std error				
Mar-07		0.33	0.19	0.09	7
	std error	0.10	0.12	0.06	
Apr-07		0.31	0.06	0.33	9
	std error	0.14	0.04	0.12	
May-07		0.41	0.09	0.10	7(8)
	std error	0.12	0.04	0.05	
Jun-07		0.24	0.07	0.22	9
	std error	0.08	0.04	0.08	
Jul-07		0.15	0.05	0.24	11
	std error	0.09	0.04	0.15	
Aug-07		0.18	0.07	0.04	9
	std error	0.11	0.06	0.02	
Sep-07		0.47	0.20	0.23	10
	std error	0.25	0.11	0.15	
Oct-07		0.40	0.17	0.14	8
	std error	0.23	0.11	0.08	
Nov-07		0.40	0.08	0.18	5
	std error	0.25	0.06	0.08	
Dec-07		0.28	0.09	0.11	3
	std error	0.00	0.01	0.06	

ZONE/SUBZONE 3.2		Motile	Female	Caligus	n
Jan-07		2.97	1.89	0.02	5
	std error	1.42	0.95	0.02	
Feb-07		1.82	1.10	0.73	5
	std error	0.91	0.57	0.41	
Mar-07		0.39	0.13	0.09	5
	std error	0.18	0.04	0.05	
Apr-07		1.20	0.34	0.44	5
	std error	0.59	0.10	0.42	
May-07		0.84	0.39	0.54	5(6)
	std error	0.28	0.16	0.48	
Jun-07		1.46	0.64	1.13	3
	std error	0.73	0.34	0.82	
Jul-07		1.22	0.89	0.68	3
	std error	0.79	0.65	0.38	
Aug-07		0.41	0.20	0.18	3
	std error	0.36	0.18	0.18	
Sep-07		0.44	0.27	0.14	3
	std error	0.37	0.25	0.14	
Oct-07		0.54	0.36	1.00	4
	std error	0.23	0.17	0.08	
Nov-07		2.74	0.77	0.19	5
	std error	1.08	0.26	0.09	
Dec-07		3.62	1.96	0.20	6(11)
	std error	1.30	0.87	0.06	

Yearclass 2

ZONE/SUBZONE 3.3		Motile	Female	Caligus	n
Jan-07		1.87	0.94	0.24	8(9)
	std error	0.88	0.41	0.20	
Feb-07		1.13	0.59	0.10	8
	std error	0.29	0.18	0.04	
Mar-07		1.13	0.72	0.12	8
	std error	0.54	0.43	0.05	
Apr-07		1.08	0.42	0.22	6
	std error	0.65	0.27	0.18	
May-07		0.85	0.29	0.18	6(7)
	std error	0.45	0.16	0.15	
Jun-07		0.15	0.05	0.50	5(6)
	std error	0.05	0.03	0.34	
Jul-07		0.40	0.15	0.79	5
	std error	0.14	0.05	0.39	
Aug-07		0.28	0.13	0.14	6
	std error	0.11	0.06	0.10	
Sep-07		0.90	0.45	0.06	7
	std error	0.43	0.21	0.05	
Oct-07		1.04	0.50	0.09	9
	std error	0.35	0.18	0.06	
Nov-07		1.06	0.46	0.28	11
	std error	0.29	0.16	0.14	
Dec-07		1.87	0.81	0.29	13(14)
	std error	0.52	0.27	0.13	

ZONE/SUBZONE 3.4		Motile	Female	Caligus	n
Jan-07		0.91	0.35	0.17	5(6)
	std error	0.61	0.22	0.17	
Feb-07		0.25	0.00	0.00	3
	std error	0.19	0.00	0.00	
Mar-07		0.26	0.00	0.00	3
	std error	0.15	0.00	0.00	
Apr-07		0.50	0.10	0.00	1
	std error				
May-07		0.59	0.01	0.05	2
	std error	0.29	0.01	0.05	
Jun-07		0.79	0.29	0.63	1
	std error				
Jul-07		0.75	0.33	0.87	1
	std error				
Aug-07		*	*	*	
	std error				
Sep-07		*	*	*	
	std error				
Oct-07		*	*	*	
	std error				
Nov-07		*	*	*	
	std error				
Dec-07					
	std error				

ZONE/SUBZONE 3.4		Motile	Female	Caligus	n
Jan-07		0.38	0.09	0.00	2(3)
	std error	0.25	0.04	0.00	
Feb-07		0.49	0.09	0.00	3
	std error	0.32	0.09	0.00	
Mar-07		1.34	0.19	0.04	4
	std error	0.48	0.19	0.05	
Apr-07		0.97	0.17	0.03	6
	std error	0.27	0.13	0.03	
May-07		1.21	0.28	0.06	6
	std error	0.31	0.12	0.06	
Jun-07		1.14	0.05	0.09	6
	std error	0.37	0.02	0.05	
Jul-07		1.02	0.43	0.62	6
	std error	0.25	0.09	0.17	
Aug-07		0.80	0.32	0.23	7
	std error	0.08	0.04	0.13	
Sep-07		1.61	0.49	0.56	4
	std error	0.52	0.06	0.09	
Oct-07		3.29	1.49	0.23	5(7)
	std error	1.20	0.57	0.13	
Nov-07		3.60	1.86	0.25	4(8)
	std error	1.40	0.72	0.14	
Dec-07		3.22	1.61	0.13	5(6)
	std error	1.24	0.61	0.05	

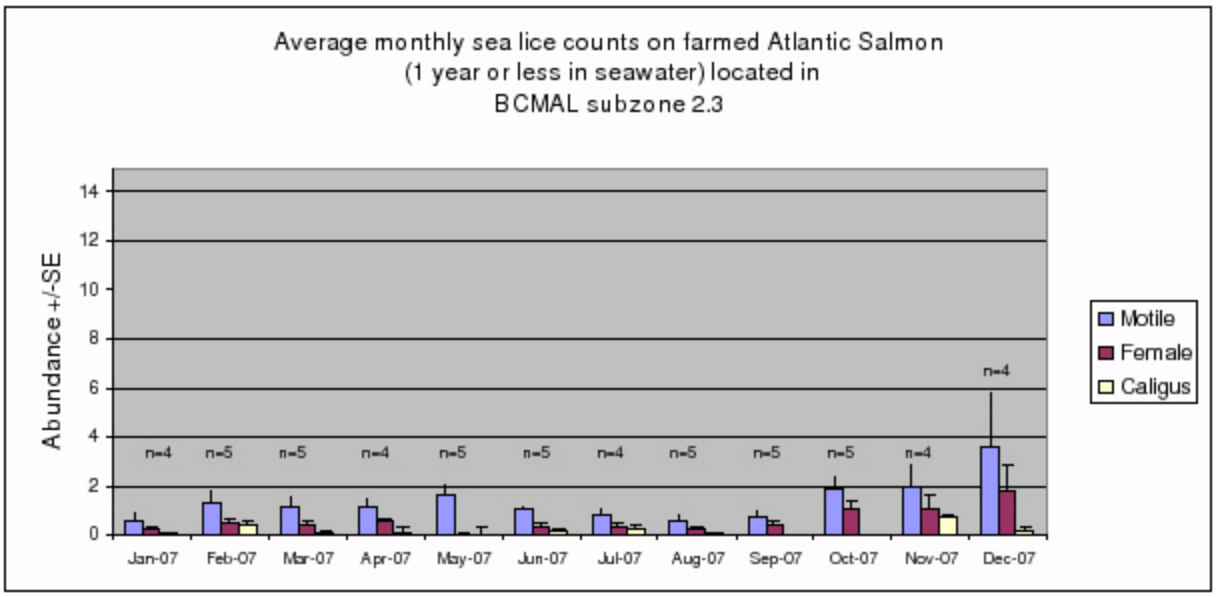
Yearclass 1

ZONE/SUBZONE 3.5		Motile	Female	Caligus	n
Jan-07		0.17	0.00	0.00	1
	std error				
Feb-07		0.27	0.00	0.08	1
	std error				
Mar-07					
	std error				
Apr-07					
	std error				
May-07					
	std error				
Jun-07		0.03	0.00	0.05	1
	std error				
Jul-07		0.12	0.02	0.00	1
	std error				
Aug-07		0.12	0.03	0.00	1
	std error				
Sep-07		1.20	0.15	0.12	1
	std error				
Oct-07		4.43	2.45	0.13	1
	std error				
Nov-07		2.80	1.29	0.48	1(2)
	std error				
Dec-07		2.22	0.57	0.18	1
	std error				

Yearclass 2

ZONE/SUBZONE 3.5		Motile	Female	Caligus	n
Jan-07		0.48	0.42	0.03	3
	std error	0.30	0.30	0.03	
Feb-07		0.28	0.20	0.00	2
	std error	0.13	0.13	0.00	
Mar-07		0.11	0.03	0.18	3
	std error	0.02	0.01	0.08	
Apr-07		0.15	0.00	0.25	2
	std error	0.05	0.00	0.15	
May-07		0.16	0.04	0.54	2
	std error	0.01	0.02	0.49	
Jun-07		0.65	0.24	0.12	2
	std error	0.12	0.06	0.12	
Jul-07		0.50	0.18	0.18	2
	std error	0.38	0.13	0.11	
Aug-07		2.42	1.09	0.16	2(3)
	std error	0.90	0.47	0.07	
Sep-07		6.32	2.02	0.43	2
	std error	0.71	0.45	0.35	
Oct-07		25.06	16.67	0.32	2
	std error	0.48	0.60	0.32	
Nov-07		29.70	17.92	0.00	2
	std error	10.37	8.50	0.00	
Dec-07		15.21	10.16	0.15	2(4)
	std error	5.18	3.66	0.02	

Figure 7.12.1 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on farmed Atlantic Salmon in sub-zone 2.3 as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.



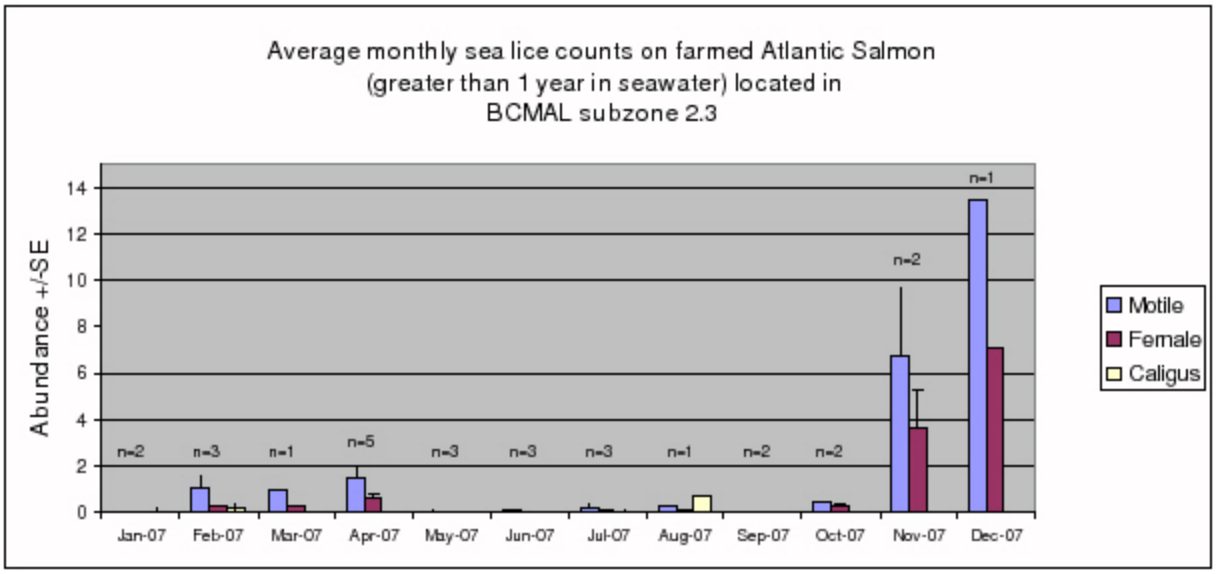
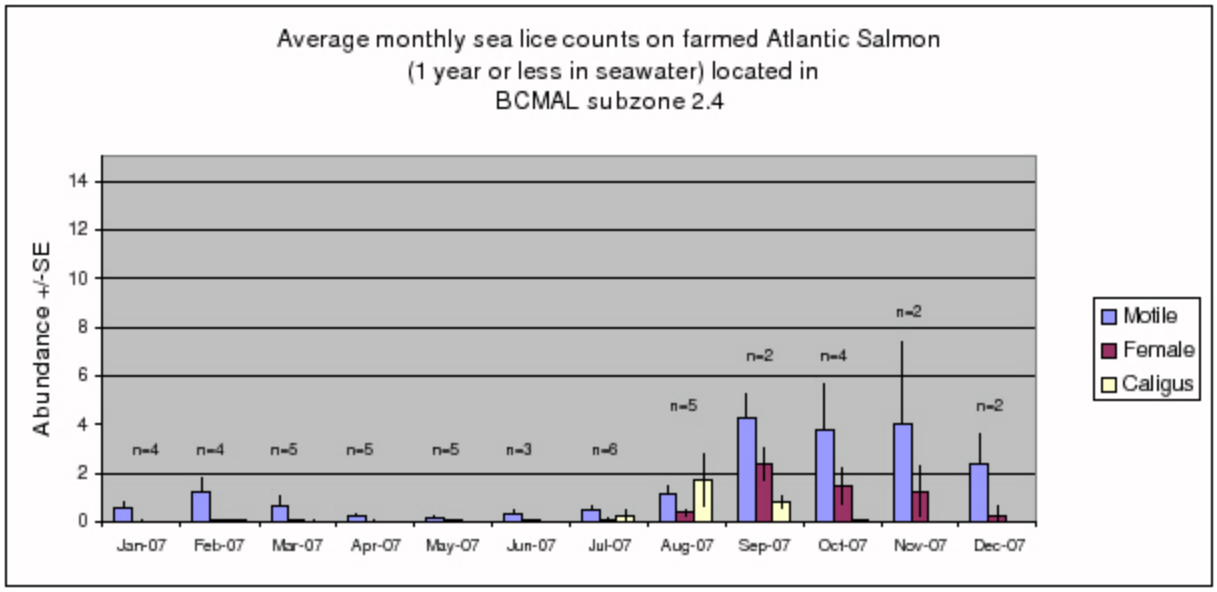


Figure 7.12.2 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on farmed Atlantic Salmon in sub-zone 2.4 as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.



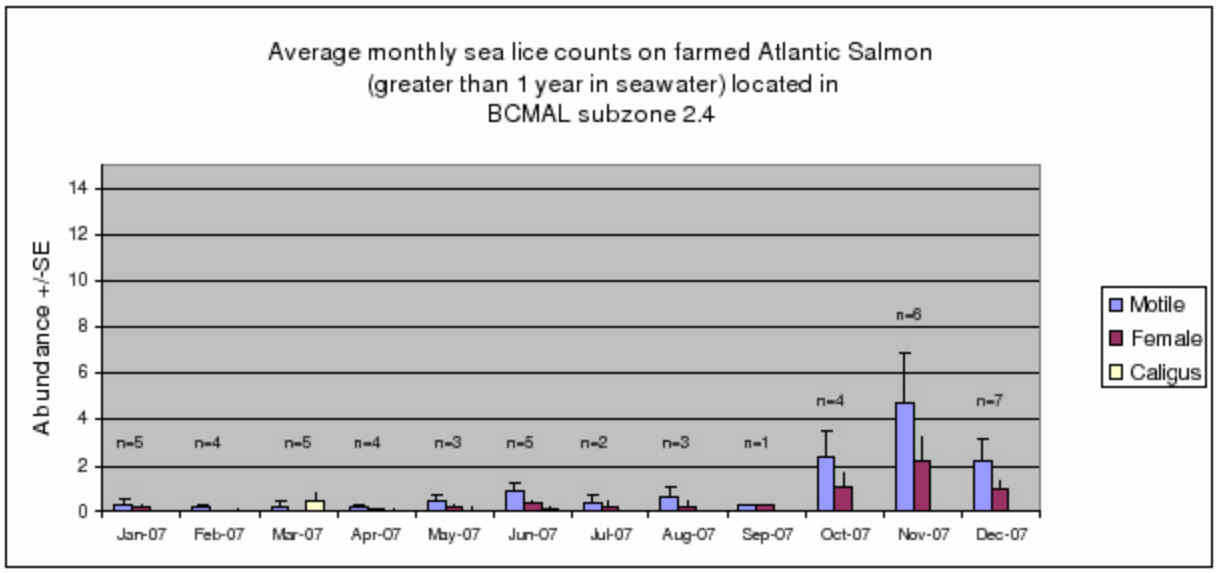
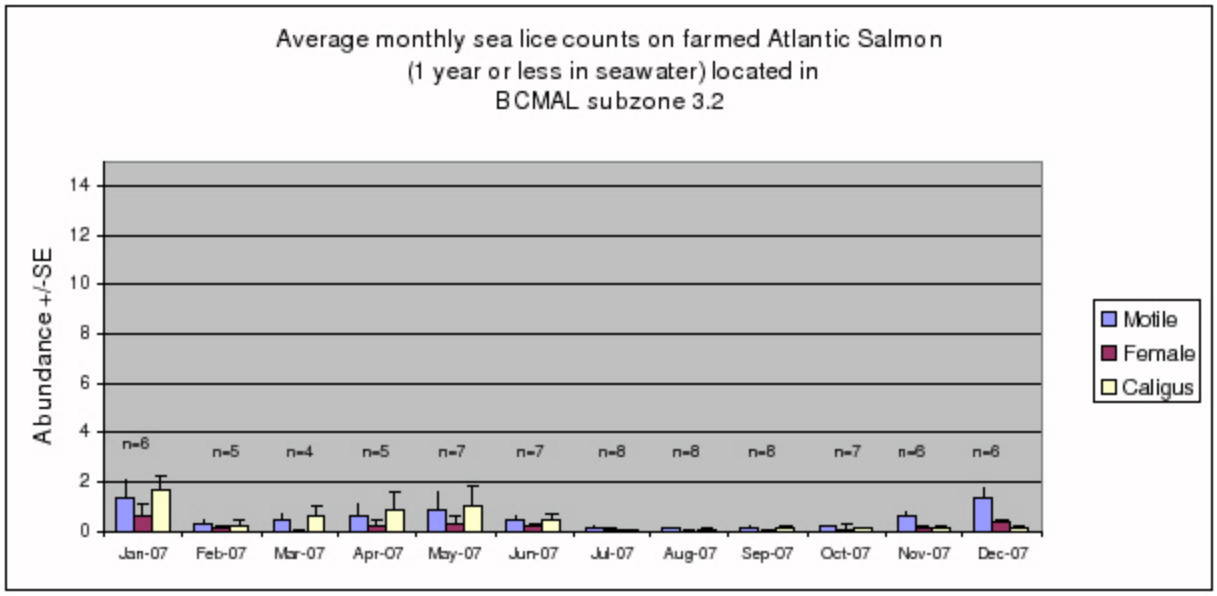
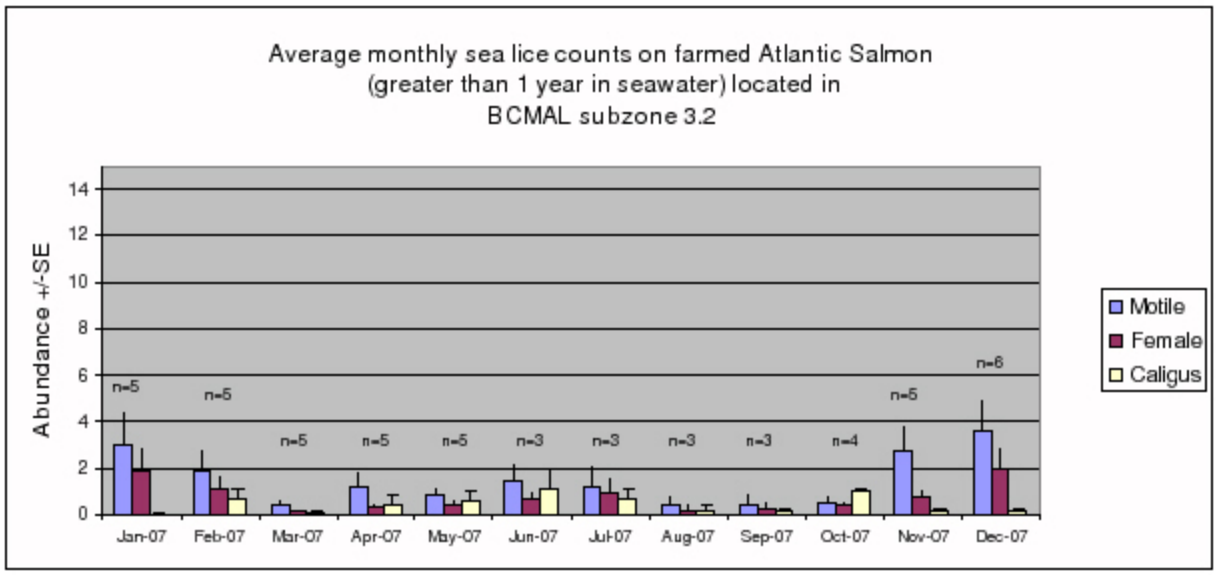


Figure 7.12.3 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on Farmed Atlantic Salmon in sub-zone 3.1 [6] as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.

[6] Sea lice abundance on salmon raised within sub-zone 3.1 has been so low since monitoring began (2003) that the handling of fish alone was deemed to be more harmful than useful. Consequently, this area was granted a 'reprieve until further notice' from routine sea lice counts yet opportune counts are conducted by farm staff whenever possible. Audit counts by BCMAL continue (see Figures 20a and 20b).

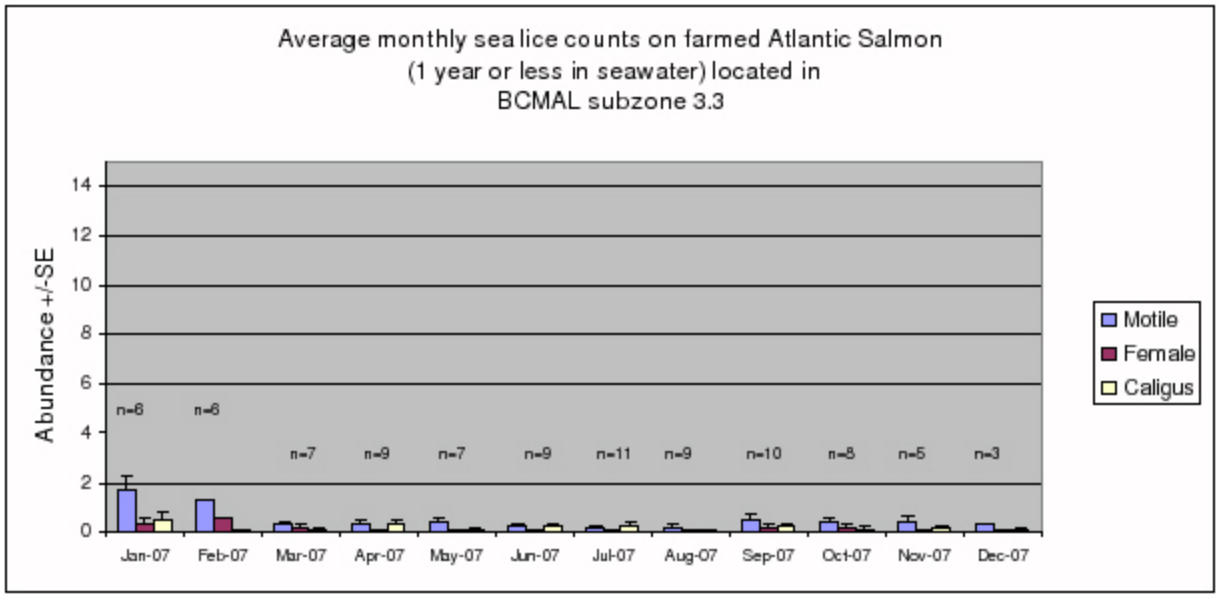
Figure 7.12.4 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on Farmed Atlantic Salmon in sub-zone 3.2 as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.





NB. Farm monitoring and audit procedures continue to identify a presence of *Caligus* lice species in sub-zone 3.2. *Caligus* species are common on non-salmonid fishes. Their presence in 2007 is attributable to wild herring and pilchard populations near salmon farms. *Caligus* lice are ubiquitous and recording their abundance on farmed fish will enable trend analysis.

Figure 7.12.5 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on Farmed Atlantic Salmon in sub-zone 3.3 as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.



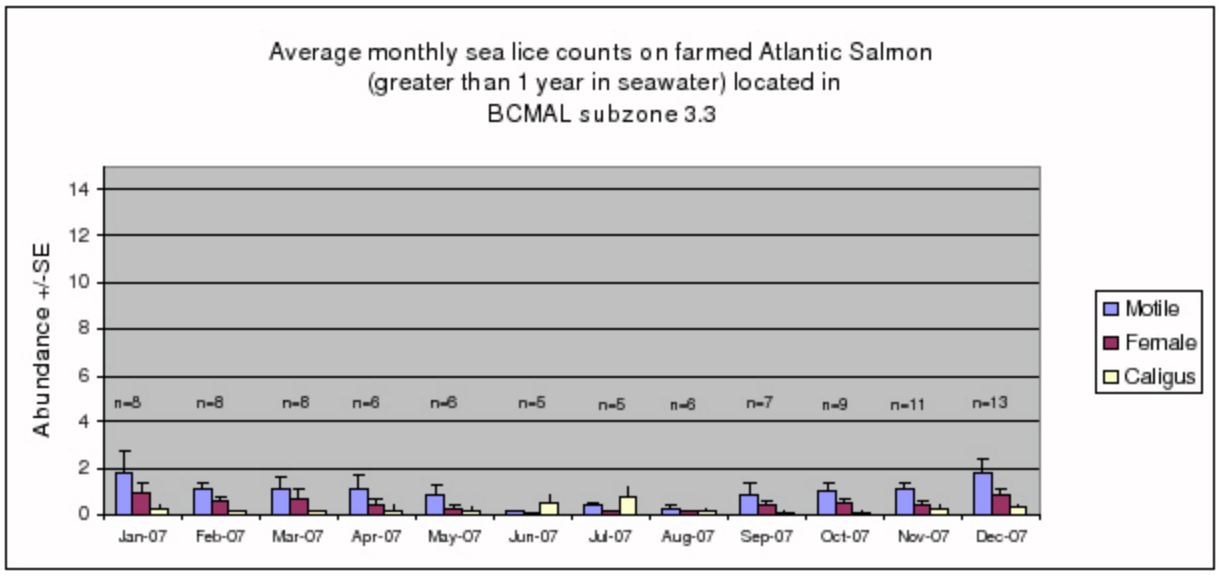
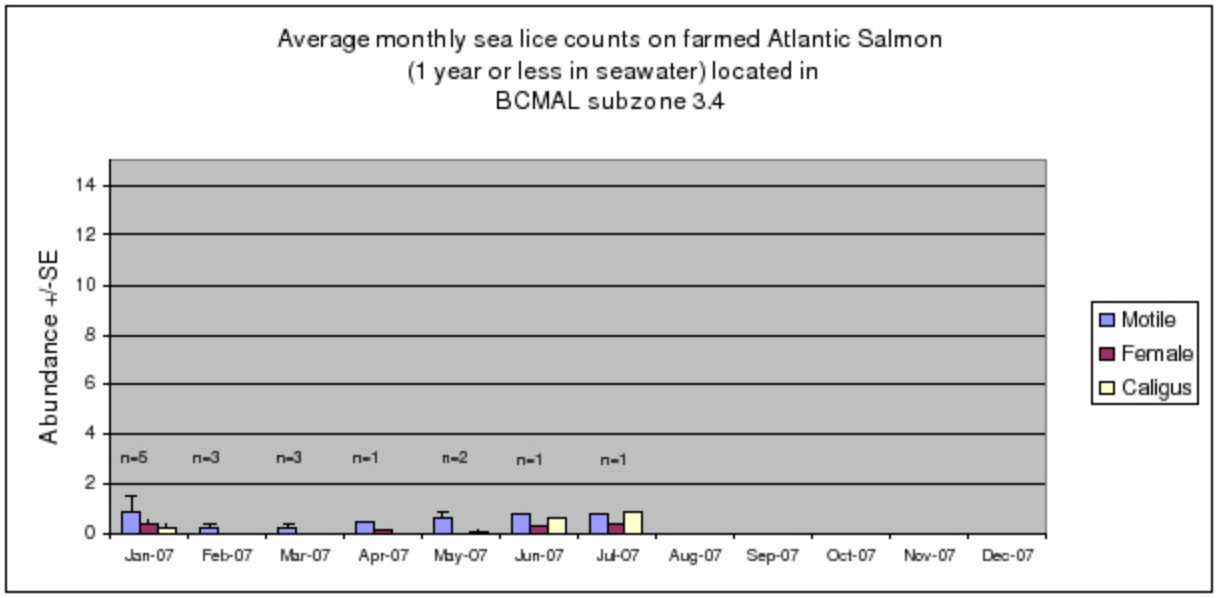
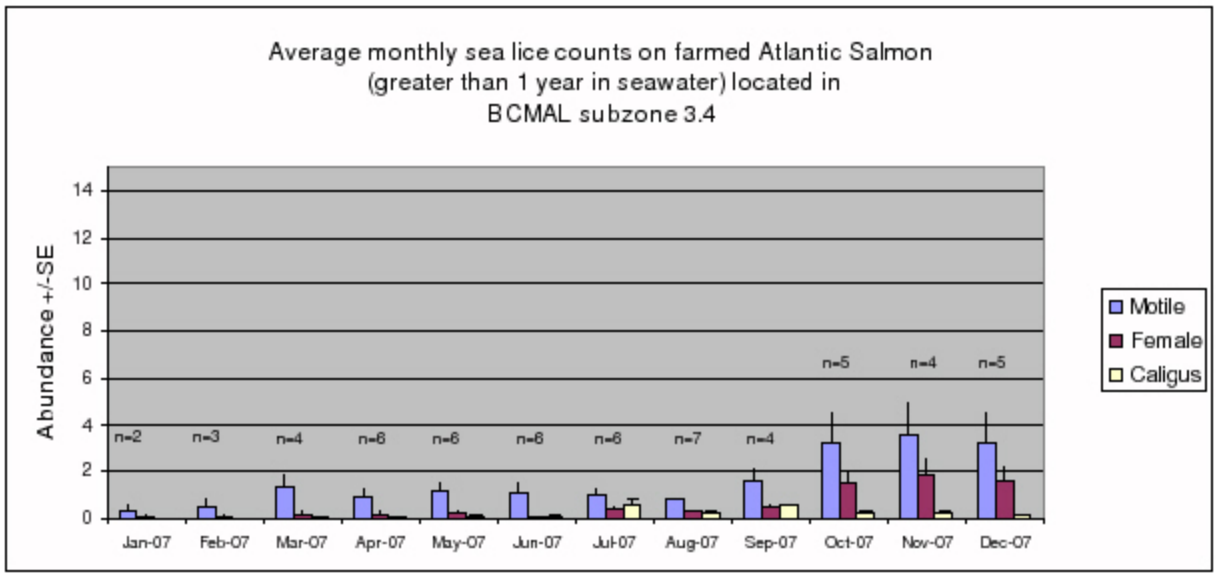


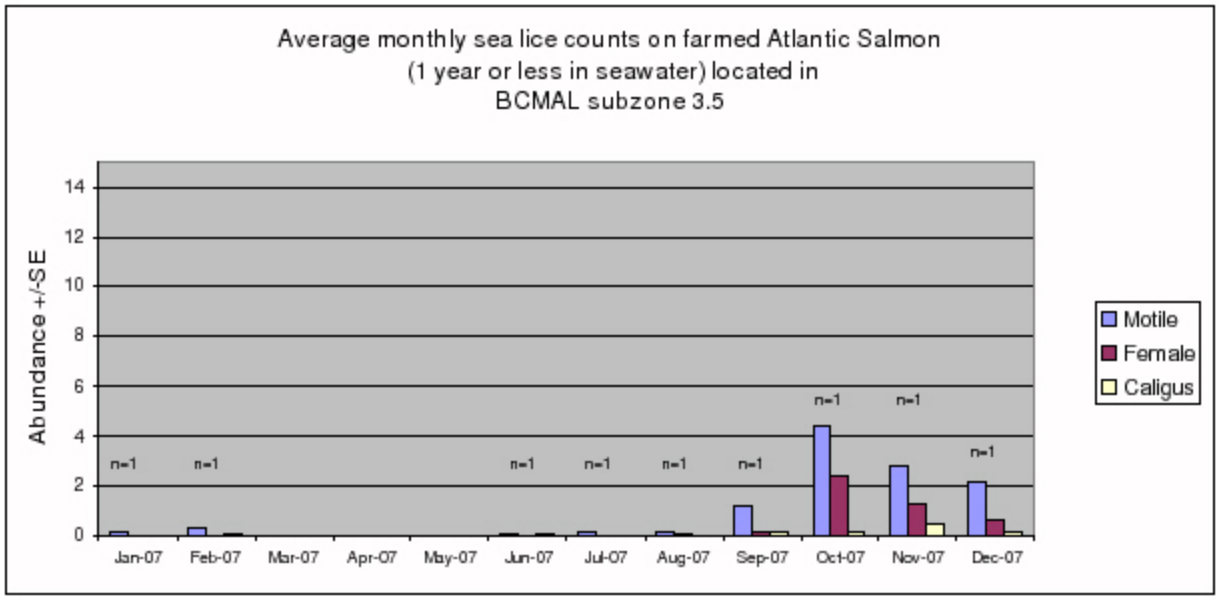
Figure 7.12.6 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on Farmed Atlantic Salmon in sub-zone 3.4[7] as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.

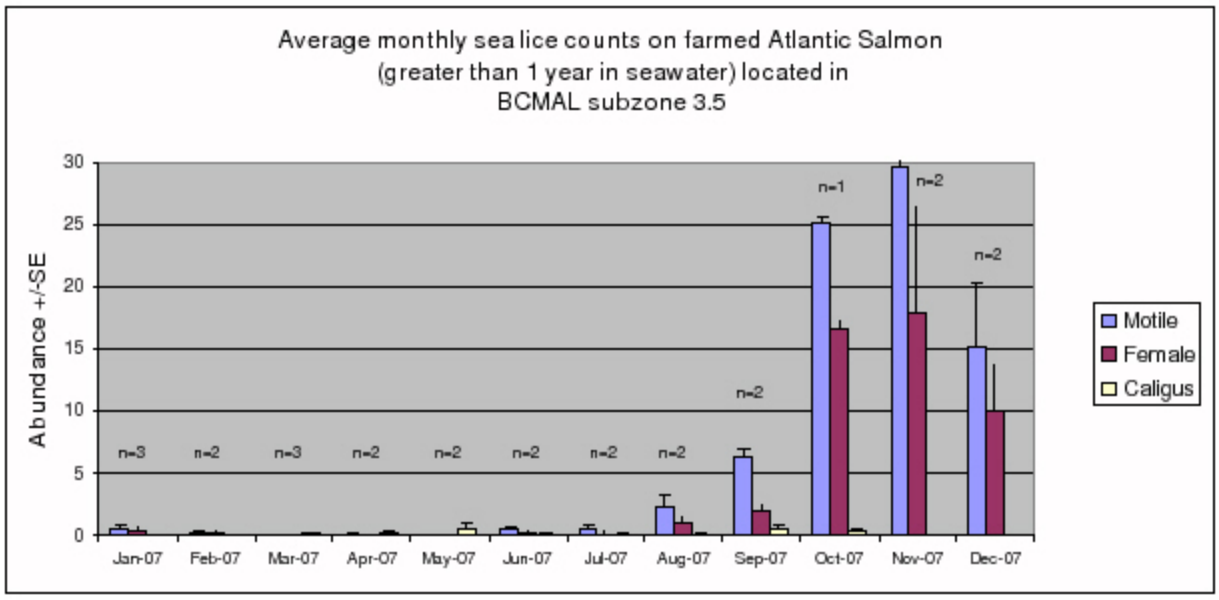




[7] The populations of 1st year class fish in sub-zone 3.4 were moved or re-classified as 2nd year class fish in July 2007, marking the end of monitoring and reporting from aquaculturists in sub-zone 3.4 for the remainder of the year.

Figure 7.12.7 Monthly mean abundance of motile and female *Lepeophtheirus salmonis*, and motile *C. clemensi* on Farmed Atlantic Salmon in sub-zone 3.5 as submitted to BCMAL by the BC Salmon Farmers Association (BCSFA) in 2007.



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