acffa Atlantic Canada Fish Farmers Association

Evaluation of Well Boat Technology for the Treatment of Sea Lice

A Cooperative Project by the Atlantic Canada Fish Farmers Association (Formerly the New Brunswick Salmon Growers Association)

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EXECUTIVE SUMMARY

New Brunswick has seen an increase in the prevalence of sea lice in the Bay of Fundy since 2009. This is the result of growing resistance to the only fully licensed sea lice treatment (SLICE), higher than average water temperatures which accelerates the life cycle of sea lice and the lack of access to a variety of alternative chemotherapeutants. It became evident to salmon farm operators in that new sea lice treatment products needed to be tested along with new approaches to sea lice management, including exploring new technologies to reduce the quantities of product required for treatments.

In February 2009 the Atlantic Canada Fish Farmers Association (formerly the New Brunswick Salmon Growers Association) received support for their business plan to support the *"Evaluation of Well Boat Technology in Treating Sea Lice: A Cooperative Project for the New Brunswick Salmon Farming Industry*". While the Atlantic Canada Fish Farmers Association (ACFFA) was the lead on this project, they acted on behalf of all salmon farming companies in southwest New Brunswick. This project had three primary objectives:

1. To evaluate the effectiveness of the use of a well boat in the application of bath treatments for the management of sea lice on salmon farms in the Bay of Fundy
2. Provide a platform for training, technology transfer and development of New Brunswick farm personnel in the operation of well boats and in the use of well boats for sea lice treatments
3. Determine potential for commercialization of well boat technology and/or provision of business services to be located in New Brunswick

A charter agreement was reached with Norwegian company Solvtrans for the *Ronja Carrier* for the period June 18 to December 18, 2010. Following early trials when vessel operations or when new products were tested, the *Ronja Carrier* treated a total of 190 net pens of salmon for sea lice. Of these, 77 were treated using Salmosan, eight with Alpha Max, and three with a combination of Interox, Salmosan and Alpha Max. Approximately 3.2 million fish were treated using the *Ronja Carrier*.

Interox Paramove 50, an environmentally benign hydrogen peroxide product, introduced for use with the well boat was effective in removal of the pre adult / adult male (PA/AM) and adult female (AF) sea lice. Over the entire growing season, Interox was successful in reducing lice counts 91 per cent of the time for PA/AM and 84 per cent of the time for AF. It was less effective for chalimus stage lice. Salmosan was shown to be effective in removal of pre adult /adult male, and adult female life stages. Over the entire growing season, Salmosan was successful in reducing lice counts 88 per cent of the time for PA/AM and 91 per cent of the time for AF. Like Interox it was less successful on chalimus with removal only 33 per cent of the time. Analysis of the Alpha Max product's efficacy is inconclusive as there were so few treatments.

This study showed a significant reduction in the amount of chemotherapeutant required for each treatment product when used in the well boat versus a tarped or skirted net pen. The cost for each treatment product is similar and for a treatment in a tarped net pen the cost is approximately $2,400. However, in a well boat treatment is reduced to $800. Future cost savings are projected through a reduction in the total number of treatments required overall.

This pilot project provided all farm crews and fish health personnel with New Brunswick salmon farming companies to learn and understand well boat technology for sea lice treatments. It also provided government personnel an opportunity to view and assess well boat operations.

As a result of this project, two salmon farming companies have purchased their own well boats; a third is engaged in the development of an alternative 'eco bath' technology.

BACKGROUND AND PROJECT OVERVIEW

The salmon aquaculture industry began in New Brunswick in 1979 and by the early 1980's had reached annual sales of $1 million. The industry grew quickly in the ensuing ten years and reached annual sales of $90 million in the early 1990's. Salmon farmed in New Brunswick now represents the province's largest cash crop. The industry generates approximately $273 million in revenue annually in Charlotte County alone where approximately 100 salmon aquaculture related businesses are located.

The industry grow-out value for 2007 was estimated at just over $116 million and includes hatchery and grow-out value at harvest but does not include the estimated sales outside of New Brunswick of one of the remaining independent hatcheries. This figure represents 24,575 tonnes or an estimated 6 million fish at an average of 9 lbs. per fish. Industry processing value for 2007 was just over $242 million and represents the processed value of the New Brunswick harvested fish and fish harvested outside of New Brunswick.

The New Brunswick salmon farming industry has faced significant challenges in the past, but has always risen above them to become stronger. Such challenges include threats from the Infectious Salmon Anemia (ISA) virus – which led to industry reorganization into a three-Bay Management Area structure, low prices, restrictions on new sites, attacks by special interest groups that have affected market volume, and decreased production as the industry adopted the Bay Management Area production cycle. As a result of these challenges, New Brunswick's 41 salmon companies consolidated to eight locally-owned companies.

The current challenge for the New Brunswick industry is to develop an effective sea lice management strategy. Sea lice are an external parasite and are considered a major vector for the transmission of the Infectious Salmon Anemia (ISA) virus. From 2000 to 2008 the salmon aquaculture industry in Canada was limited to the use of SLICE (emamectin benzoate), an in-feed anti-louse treatment. However, in July of 2008 tolerance to SLICE was linked to several cases of failed treatments. Canada is severely hampered by the lack of alternative sea lice control products which is an important element in a well structured integrated pest management strategy (IPM). In the summer of 2008 representatives from the Atlantic Provinces, DFO and Health Canada met to discuss the need for a full suite of tools for an IPM approach to sea lice management and identified this as the number one priority. This led to the September 2008 creation of the National Fish Health Working Group composed of representatives from both levels of government and industry.

In June 2009, NB gained limited access to a bath treatment Alpha Max. In October, Salmosan was also made available. However, access to these products was limited and combined with warmer than normal water temperature (a factor that contributes to growth and proliferation of sea lice) the abundance of this parasite increased and good clearance before winter was not achieved.

Sea lice bath treatments involve the application of a topical agent to the fish that will kill and remove the sea louse. Fish are treated by releasing the chemotherapeutant into a net pen that has been enclosed by a skirt or a tarp. These products can be very expensive and there is concern regarding the environmental fate following the release of the skirt or tarp. Based on data from other international jurisdictions using well boats for bath treatments, versus skirts and tarps, increased the efficacy for chemotherapeutants used for sea lice while also substantially reducing the quantity of chemotherapeutant required for a single treatment. In New Brunswick, it was expected that this will result in a one-third reduction of chemotherapeutant per treatment.

Using a well boat in treating sea lice would provide assurance to traditional fishers and others, that the salmon farming industry is committed to and investing in the protection of our shared marine resource. The well boat would also enable farms to use a hydrogen peroxide product for lice removal. The addition of a hydrogen peroxide product within an IPM, and the ability to rotate this product with others, will delay the development of resistance to other chemotherapeutants. Hydrogen peroxide is viewed as a green treatment option and is not seen as a risk to the marine environment or to non-target species.

Working together in the fall and early winter of 2009, the New Brunswick salmon farming industry developed a strategy that would support improved treatment efficacy and the introduction of new sea lice treatment products in 2010. This included a coordinated sea lice treatment plan, the introduction of well boat technology, the introduction of the hydrogen peroxide product Interox Paramove 50 and the implementation of the collaborative research program to support the use of sea lice bath treatments, enhance fish health, support improved environmental management and explore alternative green treatment options.

PROJECT OVERVIEW

There was no salmon farming company in New Brunswick that owned or had access to a well boat. Well boats can sell for $8 million to $35 million. After much discussion among the industry, a decision was made to charter a vessel on a cooperative basis through the New Brunswick Salmon Growers Association (later renamed the Atlantic Canada Fish Farmers Association) to enable the industry to fully evaluate the technology before investment was made in either the purchase, the construction or the re-fit of vessel(s) for use on a permanent basis.

The New Brunswick Salmon Growers Association (NBSGA) has been representing the salmon aquaculture sector since 1987. For this project the NBSGA represented 100 per cent of the salmon growing companies in New Brunswick.

The cooperative pilot project ran from June 18 to December 18, 2010.

PROJECT OBJECTIVES

This project had three primary objectives:

1. To evaluate the effectiveness of the use of a well boat in the application of bath treatments for the management of sea lice on salmon farms in the Bay of Fundy. Effectiveness will be measured in four ways:
    a. Reduce the potential impact on the marine environment from chemotherapeutants used in bath treatments for sea lice management
    b. To reduce costs of treatment for the salmon farming companies
    c. To increase effectiveness in reducing lice abundance on farmed salmon populations
    d. To measure the effectiveness of hydrogen peroxide as an effective treatment in reducing sea lice population on salmon farms in the Bay of Fundy
2. To provide a platform for training, technology transfer and development of New Brunswick farm personnel in the operation of well boats and in the use of well boats for sea lice treatments
3. To determine the potential for commercialization of well boat technology and/or provision of business services to be located in New Brunswick

Improved On-Farm Sea Lice Management Using Well Boats

Well boats are being used in administering sea lice bath treatments in salmon farming jurisdictions throughout the world. Its use has four primary benefits:

Increased efficacy of sea lice treatment options using a reduced amount of product required for a sea lice treatment

Based on data from other international jurisdictions using well boats increased the efficacy for chemotherapeutants used for bath treatments for sea lice while at the same time substantially reducing the quantity of chemotherapeutant required for a single treatment. In New Brunswick, it is expected that this will result in a reduction of one-third.

This increased efficacy occurs because when salmon are exposed to a bath treatment within a well boat, they are treated in a space that contains approximately 300-400 cubic metres of water. This is approximately one third of the water that would be in a net pen that has been enclosed using a skirt or tarp.

See page 8 for the scientific methodology for details on how this research and monitoring was conducted.

Improved access to products for sea lice treatments

Integrated pest management requires access to a broad range of treatment options – non-chemotherapeutants and chemotherapeutants. Because in Canada release of deleterious substances is regulated through the Fisheries Act, it is often difficult to access products for use in treating sea lice using bath products. By decreasing the quantity needed for effective treatment we expect that risk assessments will provide regulators with the assurances they require to support access to a broad range of chemotherapeutants for use throughout New Brunswick and Atlantic Canada.

This project also provided a platform to test the efficacy of hydrogen peroxide as a viable treatment option for sea lice. No resistance is believed to be developed by the lice to this product; therefore, its use in lieu of another chemotherapeutant, and as part of a rotational plan, will delay the development of resistance to the other chemotherapeutants. Hydrogen peroxide is also viewed as a green treatment option and is not seen as a risk to the marine environment or to non-target species.

Increased economic and environmental efficiency in treating sea lice

Using skirts or tarps is a labour intensive method for administering sea lice bath treatments to individual net pens on farms versus the use of a well boat.

The cost for crew, barge and equipment is approximately $7,200 per day for a treatment using a skirt with only approximately 4-6 net pens being possible to treat in a single day depending on tides. The number of net pens possible to treat will decrease if a full tarp is used.

The cost of a well boat was anticipated to be approximately $12,000 per day with the capacity to treat 5 net pens daily. While somewhat higher than using skirts or tarps the increased costs is off-set by:

- decreased costs of chemotherapeutant per treatment

- increased efficacy of each treatment; which should result in fewer treatments and extension of efficacy period of each class of product

Use of a well boat in treating sea lice will enable the salmon farming industry to provide assurance to traditional fishers and others who share the working waterfront, that the salmon farming industry is committed to and investing in the protection of our shared marine resource.

The industry did not expect that it would see significant cost savings in 2010 because the benefits will increase over time. Factors impacting 2010 included:

- In 2010 the industry needed to administer more sea lice treatments because it began the season with higher than normal lice abundance. This is a result of high lice counts at the end of 2009 due to limited access to effective treatment options.
- Mild winter saw water temperatures two degrees above normal so typical winter lice die-off did not occur at the normal level. This resulted in the need for sea lice treatments to begin in March 2010, which is well before the June/July start of previous years.
- The well boat vessel was not in New Brunswick for use before May, which meant treatment options available to farmers were limited (i.e. no hydrogen peroxide and no access to Alpha Max).
- Because of varied geographic and site conditions, one vessel was not sufficient to treat all salmon farms in the province; therefore, access was limited largely to AMBA 1. Additional traditional skirt and tarp treatments were required through 2010.

However, we anticipated the cost of therapeutants would be reduced by at least $2 million dollars in 2010.

Security to support increased stocking of salmon farms in fall 2010

This project has the potential to improve New Brunswick salmon farming production by almost one million fish if sea lice can be managed well. This would result in over $35 million in additional sales of New Brunswick farmed salmon.

Access to a well boat will provide farm companies with access to a suite of effective treatment options and the ability to gain control over sea lice by early summer. Based on information provided by salmon farming companies, it was estimated that as many as 1.5 million fewer smolts would be put in the water in the spring of 2010 if this assurance were not achieved. This not only would have significant impact on the financial viability of the farm companies, their employees and their communities, but it would also impact the provincial economy as a whole.

Improved On-Farm Environmental Management

While the New Brunswick salmon farming industry currently operates in an environmentally sustainable manner, the well boat pilot project would provide the industry with the opportunity to improve its economic sustainability by addressing fish health management for sea lice. It would also provide the ability to further demonstrate the environmental and social sustainability of the sector.

Because efficacy will be improved for all sea lice treatments by the use of a well boat, we expect that there will ultimately be fewer chemotherapeutant treatments required. This coupled with the fact that farms will be using smaller dosages of bath products will result in a significant reduction in the amount of product that will be discharged into the marine environment following treatments on New Brunswick salmon farms. In addition, a well boat would enable farmers to use hydrogen peroxide for treating their

fish. This product is considered to be environmentally friendly and because resistance to this product is unlikely, hydrogen peroxide could be a viable long-term, 'green' solution to sea lice management.

Using chemical bath products to treat sea lice is not considered to be an acceptable management practice by the local traditional fishing sector or by the broader environmental NGO community. By moving toward management options that are considered to be more environmentally sustainable, the New Brunswick salmon farming sector will achieve broader acceptance by our partners on the working waterfront, and by the local, national and international ENGO community. This kind of endorsement will provide salmon farmers with greater ability to meet international certification standards and greater market access.

WELL BOAT OPERATIONS

Well boats contain holds, or wells, which fish are loaded into for sea lice bath treatments. The wells are filled with water and then by creating a vacuum the salmon are brought on board. A counter records the number of fish and biomass for each well on the vessel. Once the fish have had a resting period, the prescribed amount of chemotherapeutant is added to each well through either a dosing system or mixing tank, and a pipe system that distributes the product. Each well is treated as an individual unit. Following the prescribed treatment time, the wells are flushed with clean sea water to reduce and eventually eliminate the concentration of product. After a second resting period, the fish are returned to the sea cage.

If a cage biomass is larger than the well boat's capacity, the net pen is seined so that only the appropriate portion of the population is brought on board for treatment then returned to the empty side of the seine, before the next group is brought on board.

Depending on size, well boats can have between 2 to 4 holds so their volume capacity for treatments can vary. The Ronja Carrier, the well boat chartered by the NBSGA in 2010, had two wells, each with a capacity of approximately 300 cubic metres.

Appendix 1 contains a pictorial sequence of various parts of this process.

SCIENTIFIC METHODOLOGY FOR RESEARCH ON TREATMENT PRODUCTS

This project was managed by the NBSGA Research and Development Coordinator with the assistance of a well boat Logistics Manager and in consultation with an industry steering committee. Weekly conference call meetings were conducted throughout the project in addition to face-to-face meetings as required. The weekly conference calls were also open to representatives from the project funders. Most of the scientific research, monitoring and surveillance were to be conducted through DFO and NBDAAF; however, the ACFFA (NBSGA) also engaged a data analyst to process the treatment data.

Based on the 2010 sea lice treatment plan, *Ronja Carrier* was scheduled to treat sites within ABMA 1 starting with those in the inner Passamaquoddy Bay area and moving down the Bay towards the sites at the end of Deer Island and into Campobello (see map in Appendix 2). This was the area most affected by the lack of treatment options in 2009 and held pre-market fish. There was also an option to prioritize site treatments based on need / sea lice numbers in the event that the initial plan had to be revised for any reason. Well boat treatments would also be conducted in ABMA 3a if warranted. The treatment schedule based on the order of sites to be visited and the number of pens/ treatments required was coordinated through this project by the well boat Logistic Manager in consultation with the RDC and industry project steering committee.

As part of normal operating procedures, the well boat crew were provided with forms that required completion for each treatment. The data recorded on the *Ronja Carrier* included water temperature; product type, concentration and treatment duration; oxygen levels, etc. These items are part of the conditions of the Emergency Registration from PMRA and will also be submitted as part of any new application process. Sea lice data was collected as often as possible on the farms pre and post treatment in order to evaluate the efficacy of the product used.

When completed, these forms provided the details of treatment. Treatments are defined as a single well. Forms were collected and provided to the data analyst. The data analyst used various statistical methods to identify potentially important treatment parameters.

Approval for the use of Interox Paramove 50 was received on June 11, 2010. To address the conditions of the ER for Interox, the farm operators planned to work with the New Brunswick Department of Agriculture Aquaculture and Fisheries, DFO's St. Andrews Biological Station and Atlantic Veterinary College to collect the following data:

1- EFFICACY:

a. Sea lice counts:

i. Pre-lice counts on six (6) sites no more than 24 hours prior to treatment day (counts should be conducted on net pens that will be treated that day)

ii. Post lice counts on six (6) sites within 48 hours of treatment (only pens that were treated). A second lice count should be completed 48 hours after the initial post count on pens that were treated.

b. Determination of sea lice survivability:

i. Using plankton tows, lice will be collected from two (2) wells on six (6) sites after treatment is completed and before flushing occurs. Lice will be held in plankton jars and transported to SABS immediately after collection.

ii. Using plankton tows, lice will be collected from the effluent of two (2) wells on six (6) sites. Lice will be held in plankton jars and transported to SABS immediately after collection.

iii. The following will be conducted at SABS by Jennifer Martin:

- Categorize lice from inside wells and effluent into dead; moribund and live lice (determine percentages of each based on total number of lice collected).
- 50 per cent of the lice will be held for approximately 48 hours and survivors will be introduced to naïve salmon at Huntsman to determine reattachment.
- The other 50 per cent of the lice will be held for a longer period of time to determine the fecundity of gravid females and viability of eggs strings after treatment.

2- DETERMINATION OF H_2O_2 CONCENTRATIONS:

a. Concentrations of H_2O_2 in the wells of boat during treatment:

- Two (2) wells on six (6) sites
- Data can be collected from titrations completed by attending veterinarian during treatments.

b. Concentrations of H_2O_2 in effluent water during flushing:

- Two (2) wells on six (6) sites.
- Water samples to be collected within a 10mX10m square around the effluent steam using Niskin bottles.
- Samples will be taken approximately every two (2) minutes from the start of flushing until flushing is completed.
- Samples will be analyzed directly on the boat using approved titration method to determine concentration of H_2O_2.

3. OTHER:

All information collected on the boat with regard to method used for treatment, temperature, concentration used, duration of treatment, number of fish, oxygen readings, and any noticeable effects on the fish or additional comments, etc. will be collected for the six (6) sites and submitted in order to help PMRA refine the use pattern for this product.

Similar methodology was also used on the well boat to evaluate Salmosan and Alpha Max. Approval for Salmosan in the well boat was received in August; approval for Alpha Max was not received until October, so data available for these products is limited.

ANALYSIS AND DISCUSSION OF RESULTS

Product Use

The use of Interox Paramove 50, a hydrogen peroxide compound, was introduced as an environmentally friendly treatment option in 2010. New Brunswick Department of Agriculture Aquaculture and Fisheries submitted an Emergency Registration application to Health Canada's Pest Management Regulatory Agency (PMRA) on April 19th 2010 and approval was received on June 11th 2010.

Approval from PMRA to use Salmosan in the well boat was received on August 3rd. Several trials had to be completed before full scale treatments could commence on August 31st on the *Ronja Carrier*. As a result of the positive trials, and high water temperatures, Salmosan was used through September until the Emergency Registration for the product expired on October 15th. The new ER was received November 4th and was used until water temperatures enabled a return to Interox Paramove.

Alpha Max was approved for use by PMRA for the period of October to December 31st. During this period, five treatments were conducted in the well boat.

During November, several combination treatments using either Interox with Alpha Max or Salmosan with Alpha Max were performed to determine if additional efficacy could be obtained. All the treatments on the *Ronja Carrier* conducted in December were with Interox.

Product Efficacy

Perhaps the largest factor influencing the integrity of the overall dataset is the sea lice count data. Irregularities in pre and post count dates are suspected as the cause for many of the outliers and seemingly "erroneous" data observed. This greatly influences statistical outcomes for this study. The delay between pre and post counts were often the result of weather – the vessel may not have been able to access the farm or the water temperatures increased, preventing a planned treatment of Interox.

INTEROX PARAMOVE 50

The first treatment with Interox Paramove 50 was on June 20th, 2010 but due to failures in the operating system, the vessel was returned to dock. Over the course of the next several weeks these systems were reviewed and corrections were made. During this period, testing of the Interox Paramove 50 in New Brunswick waters was also conducted. Trials were then conducted with small numbers of fish during the period July 7 to July 16. These trials provided assurance that the mechanical deficiencies had been corrected and that the product could be used safely and effectively in treating sea lice. Full scale treatments began in ABMA 1 with Interox Paramove 50 on July 17th.

Water temperatures were approximately 2°C higher than normal in the Bay of Fundy during 2010 so the Interox Paramove treatments being performed in the well boat were at temperatures higher than operations in Norway and Scotland would consider (14°C). Water temperatures recorded at sites in upper Passamaquoddy Bay reached 21°C so sites in this area had to be omitted from the treatment schedule in July. From this point forward, the sites to be treated using the well boat were determined by: water temperature / ability to use Interox safely and farm sea lice counts. The water temperature at sites located in lower Passamaquoddy Bay began spiking to 16°C at the end of July and this resulted in the well boat moving to BMA 3a where the water would be cooler.

The following is the guideline on the safe use of hydrogen peroxide in treating salmon with lice infestations taken from the product label:

Water Temperature	Hydrogen Peroxide Concentration (ppm or mg/L)	Amount of Interox Paramove 50 in Sea Water (g / L)
Below 8°C	1700 - 1800	3.4-3.6
8 - 10 °C	1550 - 1700	3.1-3.4
10 -14°C	1400 - 1550	2.8-3.1
Greater than 14°C	1200 – 1400	2.4-2.8

The treatment dose of 1200ppm is the lowest concentration permitted under the product label(above)and due to water temperatures, the highest concentration that veterinarians had been able to prescribe to date had been 1300ppm. The initial data from July and August showed that a 20 minute exposure time resulted in the removal of approximately 60 per cent of the sea lice; a concentration of 1250ppm Interox Paramove 50 or higher works better than 1200ppm. The continued settlement of chalimus on the salmon continued to make any conclusions regarding product efficacy on this life stage very difficult. Treatments to this date had resulted in an 80-92 per cent removal of the mobile and gravid stages.

Another strategy attempted to increase efficacy was to reduce the number of nozzles in the well that deliver the Interox product. This would increase the dose time (or the time it takes for the product to be completely injected into the well). After a number of nozzles in the well were closed off, the dose time increased from approximately three-four minutes to get the entire amount of product into the well to approximately seven-eight minutes for this process. This longer dose time appeared to relate to a higher treatment efficacy, but only for the PA/AM life stages.

By the end of November, the water temperatures had decreased to about 9°C. Interox Paramove was used for all treatments and veterinarians were able to increase the concentration and / or treatment duration. Treatment concentrations during this time increased to 1400ppm to 1500ppm and treatment duration was as long as 30 minutes.

The ACFFA conducted multiple statistical tests to evaluate the data at the conclusion of the treatments on the *Ronja Carrier*. Almost all variables with treatments of Interox Paramove 50 were significantly associated with the farm site. This means that there were site specific differences in temperature, oxygen levels, pre-treatment counts of pre-adult/adult male and adult female lice, average weight, stocking density, total weight, average number of fish and/or biomass and other growth measures of fish. There were no site associations with post-lice counts or percentage change in lice counts which suggests that other non-environmental factors (Interox concentration, dose time, treatment duration) affected the percentage change in lice counts at each site. However, environmental factors still play a role in efficacy of the treatment. All site data was analysed using ANOVA followed by a Tukey's test for multiple hypothesis testing.

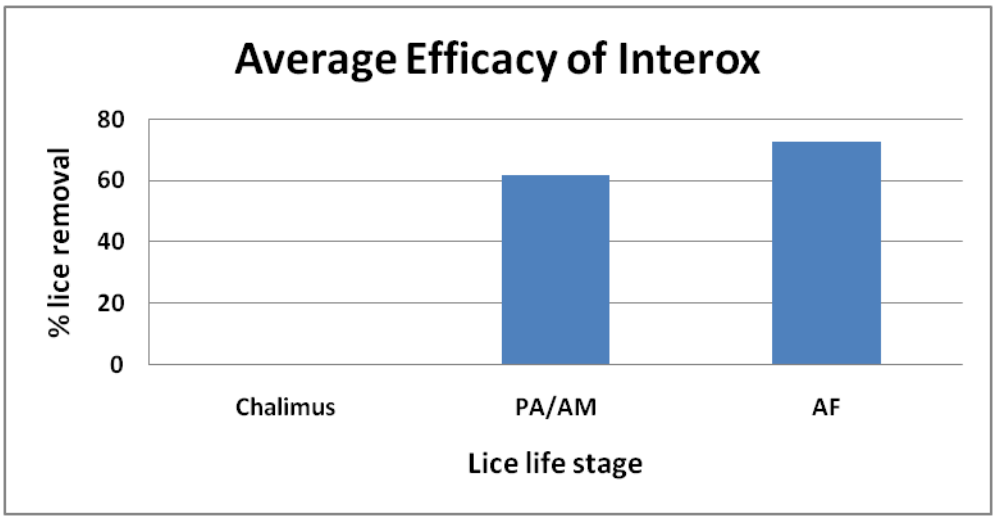
When grouping Interox treatments into four categories based on product concentration (A) less than 1250ppm (B) 1250ppm (C) 1300ppm and (D) greater than 1300ppm, only pre-adult / adult male life

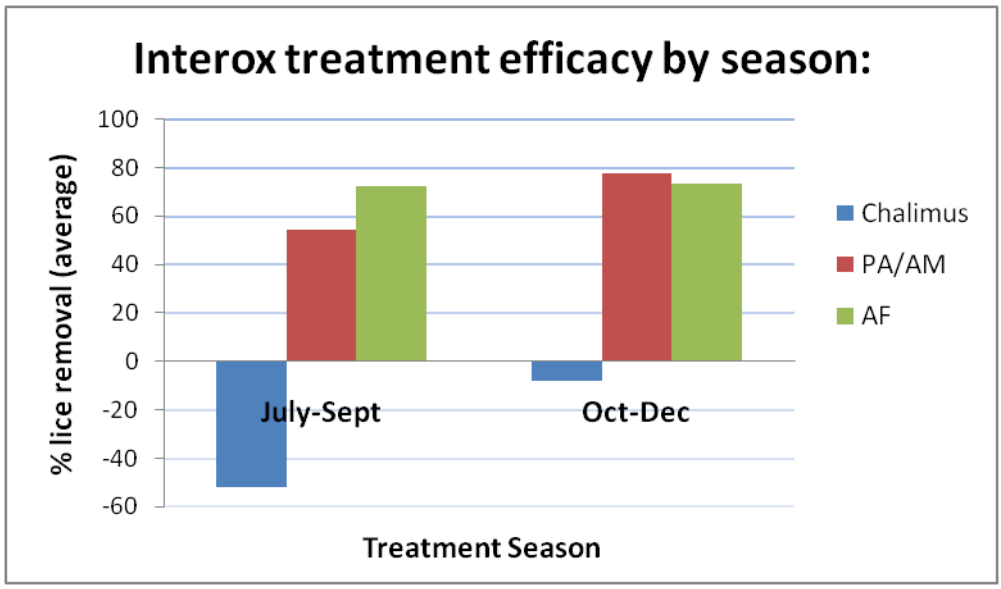
stages (PA/AM) showed that lower concentrations of Interox were less effective at 1250ppm compared to the other three groups. When grouping into two categories of (A) below 1300ppm and (B) above 1300ppm Interox, higher concentrations result in higher treatment efficacy. The higher concentrations of Interox (above 1300ppm) resulted in more effective treatments / larger decreases in PA/AM lice numbers. All concentrations were equally effective at reducing adult female (AF) counts. Therefore, it appears even low doses of the product are relatively effective in treating adult females. For example, a low dose of 1200ppm Interox is capable of decreasing lice counts between 60-100 per cent and at 1400ppm Interox decreased lice counts by 80-100 per cent.

Norway and Scotland use Interox Paramove 50 during spring and fall treatments when water temperatures permit product concentrations between 1500ppm and 1800ppm for over 30 minutes. At these dosages it appears that the Interox Paramove 50 product not only reduces the number of all life stages of sea lice on the salmon post treatment , but there is also evidence that the sea lice that survive are damaged resulting in reduced long term viability. Treatments with Interox on the *Ronja Carrier* did not reach these dosages and though it is assumed that similar results would be obtained, there is currently no data to support this conclusion. However, the New Brunswick pilot project did provide critical data in how Interox Paramove 50 can be used in higher water temperatures getting significant lice clearance while ensuring the safety of the fish being treated.

Interox was effective in removal of the pre adult / adult male (PA/AM), and adult female (AF) life stages. Over the entire growing season, Interox was successful in reducing lice counts 39 per cent of the time for chalimus, 91 per cent of the time for PA/AM and 84 per cent of the time for AF. High pre-treatment PA/AM lice counts tended to result in less efficacy of Interox on post PA/AM counts, after all other variables were accounted for. The statistics showed that Interox was much less effective on chalimus removal overall, although larger chalimus reductions were observed in November and December versus the summer months. There were significantly heavier pre-treatment chalimus loads in the summer, indicating the probable influence of settlement rates of chalimus on the salmon. The only treatment parameters that seemed to influence treatment efficacy for chalimus were related to the number / weight of fish at the time of treatment. The lower the number of fish and the lower the total weight, the more effective the treatment appeared to be at reducing chalimus numbers.

Given the environmental conditions, the amount of work required by the Emergency Registration permits for all products, time restrictions, and limited resources, not all of the detailed work originally planned was able to be completed during the 2010 treatment season. The work that was not completed will be rescheduled for April – May 2011 for submission to PMRA.





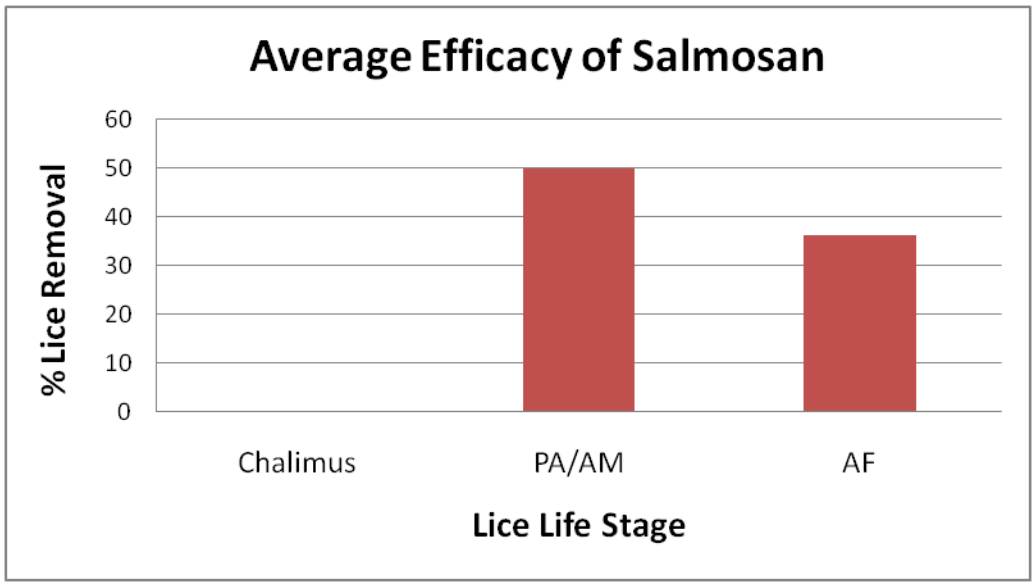
SALMOSAN

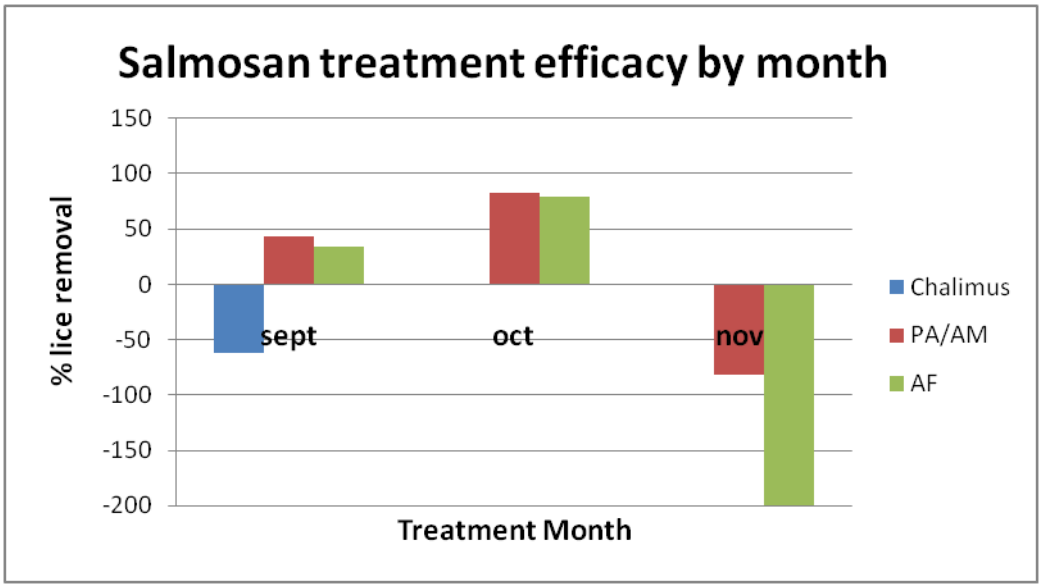
The same statistical analyses were performed on Salmosan treatment data. There were many site specific differences i.e.: sea water temperature, O2 levels, pre-lice counts, and there were differences in average weight, total weight and average number of fish used in the well boat treatment. These combined differences may have been responsible for the high lice removal rate seen at some sites versus others, and suggests that environmental factors at each site or other unmeasured variables affected the efficacy of Salmosan treatments on pre adult / adult male, and adult female life stages. For chalimus, site specific factors did not significantly influence the reductions in this life stage. All site data was analysed using ANOVA followed by a Tukey's test for multiple hypothesis testing.

Every continuous variable was tested in a linear regression to evaluate significant changes in lice counts for PA/AM and AF. The variable that showed a significant relationship with percentage change in PA/AM lice was the number of fish. The larger the average number of fish used in a treatment, the larger the change in PA/AM counts. For AF, temperature and average biomass were significantly associated with percentage change in AF counts. These data were also supported by a correlation analysis.

Salmosan was effective in the removal of pre adult /adult male, and adult female life stages but was not equally effective in reducing PA/AM lice numbers across sites. Variation in efficacy ranged from 16 to 92 per cent lice removal. The pattern of AF reduction following Salmosan treatment closely resembled that seen for PA/AM. The statistics indicate it was less effective for chalimus, and highly variable. Sometimes there were increases in chalimus after treatment, and other times chalimus numbers were reduced by up to 90 per cent. This is not the case in the PA/AM and AF life stages. Less than 10 per cent and 5 per cent of the data points respectively showed an increase after Salmosan treatment. Over the entire growing season, Salmosan was successful in reducing lice counts 33 per cent of the time for chalimus, 88 of the time for PA/AM and 91 per cent of the time for AF. Treatment time did not significantly influence the efficacy of the Salmosan in either PA/ AM or AF. There was some variation in this measure but it was not as variable as the data from the Interox.

There were only three months during which salmon were treated for sea lice with Salmosan (September, October, and November). For unknown reasons, October was the most successful month in reducing PA/AM and AF counts.





ALPHAMAX

Due to some concern by Environment Canada regarding the risk management of Alpha Max for use within the marine environment, access to Alpha Max as a sea lice treatment option was restricted to use in the well boat only. This was due to the fact that a lower level of the active ingredient deltamethrin was required for each treatment. Scientific monitoring and surveillance accompanied its use, in addition to two non-target sentinel species experiments using lobster. While the final data from this work is still to be analyzed, lobsters used in the research are still alive and going through normal life cycles.

Analysis of the product efficacy is inconclusive. There were so few treatments with the Alpha Max product alone, or even in combination, that there is not enough data to perform a statistical analysis or draw any conclusions about product efficacy.

Reduction in Pesticide Use

One clear benefit realized by the use of the well boat over the term of this project was the reduction in the amount of product required to complete a sea lice treatment. This applied to each of the various products used. This not only reduces the potent for environmental impact but also reduces the cost associated with topical treatments. These benefits are a result of having a consistent, known volume to calculate the product dosage. When a skirt or tarp is used for sea lice treatments, even though the main net is hauled up to crowd the fish and reduce the amount of water, the volume is still greater than in a well boat. The wells on the *Ronja Carrier* are approximately 300m^3 each for a total treatment volume of 600m^3(1000l of water per m^3). The estimated volume of a tarped 100m pen with the net drawn up to 4m is over 3000m^3.

The treatment dose for Salmosan is 0.2g/m^3 for well boat and tarp, and 0.3g/m^3 for skirt treatments. For a 100m net pen, a skirt treatment would require approximately 1000g of Salmosan, while a tarp treatment would require less than 650g. A well boat treatment with Salmosan for the same pen, assuming four wells @300m^3 per well, will require only 240g. Since Salmosan is a 50 per cent product, the amount of active ingredient (azamethiphos) is reduced from approximately 500g to 120g with the use of a well boat.

Given the treatment dosage of 0.2ml/m^3 for Alpha Max the approximate amount of product required for a treatment of a 100m net pen is 640ml. To treat the same 100m pen of fish with Alpha Max when brought on board the well boat would be 240ml (60 ml per well, assuming for four wells) of product. In this situation, the use of a well boat reduces the amount of the active ingredient (deltamethrin) from 6.4g to 2.4g.

As mentioned previously, vessels with larger well capacity would be able to treat the same 100m net pen using fewer wells and therefore further reduce the amount of product used to complete one treatment.

Cost Benefit Analysis

This project incurred costs beyond the normal scope of well boat operations. These costs included: crew training, research and scientific monitoring, regulatory costs associated with the use of a foreign vessel, standard operating procedure development, stakeholder communications and project management. These factors have been considered in calculating the cost benefits of well boat operations.

The cost of operating a well boat for sea lice treatments will always be higher than using a barge to deliver treatments using skirts or tarps. However, cost savings through the use of well boats can be realized through reductions in the cost of the treatment product and cost of labour.

Using skirts or tarps on individual net pens is a labour intensive method for administering sea lice bath treatments with an operational cost of approximately $7,200 per day. This covers the costs of crew, barge and equipment. Current ER conditions for products like Salmosan limit the quantity of product that can be used per day resulting in fewer treatments that can be performed using tarps or skirts. Without these restrictions when using skirts, four to six net pens can potentially be treated per day depending on tides, fewer if full tarps are used.

Based on a similar comparison, the cost of operating the *Ronja Carrier* is $11,557 per day. Some of the increased cost will be off-set by:

- lower cost for chemotherapeutant per treatment
- increased treatment efficacy; which should result in fewer treatments and extension of efficacy period of each class of product
- increased number of cages treated per day when ER conditions restrict product use
- the ability to use the well boat to grade or transport fish in the off season

This project did demonstrate that the cost for each treatment would be significantly reduced. A typical treatment in a tarped net pen will cost $2,400 for the chemotherapeutant. The cost for a well boat treatment is reduced to $800. We anticipate this cost saving will be further enhanced through a reduction in the number of treatments required overall. This assumption could not be tested in 2010 due to higher than normal lice loads and limited product availability.

This cooperative pilot project allowed the industry to identify errors in the original assumptions for cost benefit analysis while also providing information on farm management and site design to better support well boat operations.

The original project assumptions were based on the anticipation that the well boat could be operational almost 24 hours per day, seven days per week. However, due to the conditions of the charter agreement with Solvtrans and Karlsen Shipping in Nova Scotia who provided crew for the *Ronja Carrier* and Transport Canada regulations, the vessel operated only in daylight hours. Travel time to and from the host wharf also had to be factored in. The crew was not previously trained on the use of a well boat for sea lice treatments, so training time was required. There were two four person crews that rotated duty (three weeks on, one week off) on this vessel so training was required for both crews. Transport Canada has regulations on the number of hours that a crew can work without time off (14 hours). This means that for any vessel to operate on a 24/7 basis, additional crew members are required.

The initial estimate of five pens per day that could be treated was based on the well boat working 24/7, assuming the crews would be fully trained to complete treatments prior to arrival and that a pen could be treated using two wells. However, the actual time required for the vessel crew and farm crews to complete a two-well treatment when the project first began was approximately five hours. However, by the time full scale treatments began, the time had been reduced to approximately 3.5 hours.

Treatment time can be influenced by a variety of factors including: site preparation, water temperature, tides, weather events, fish stress or other environmental factors such as jelly fish or algae blooms. Because the project started later than anticipated, farm fish had grown and this resulted in most pens requiring four wells (two treatments) to complete. This along with the time required for travel to/from wharf for product loading, time required for cleaning and disinfection between farm sites and BMAs and regular maintenance resulted in fewer treatments than originally anticipated. Cleaning and disinfection of the *Ronja Carrier* between sites required approximately two hours; biosecurity between bay management areas required approximately six hours.

As part of a business case, the number of treatments that can be completed per day may be of greater importance for products such as Alpha Max and Salmosan than Interox Paramove.

Evaluation of the well boat technology identified limiting factors in site design and oceanographic conditions during 2010. The water depth and / or large tides prevented the use of the well boat at some locations. In New Brunswick, a typical farm layout is four-five rows of multiple pens which presented access problems for the well boat. Often the grid system did not permit the well boat to treat the inside rows of pens. The *Ronja Carrier* is considered a small vessel when compared to those being used in the

Norwegian and Scottish aquaculture industries. If similarly sized or larger well boats are going to be considered by the New Brunswick companies, current sites may have to be redesigned to two rows to permit access by well boat. There will be an initial cost associated with this change, as well as the time required to request these site amendments and potential boundaries changes with the various regulatory agencies.

Workplace Training and Technology Transfer

This pilot project provided all the salmon farming companies in New Brunswick with the opportunity to have their farm crews and fish health personnel learn and understand well boat technology for sea lice treatments. In addition, personnel and researchers from various organizations including DFO, Atlantic Veterinary College, New Brunswick Department of Agriculture Aquaculture and Fisheries, Department of Environment, PMRA and regulatory agencies had the opportunity to be on board the *Ronja Carrier* to learn about the vessel operation and treatment procedures.

In advance of the well boat schedule, farm mangers were brought on the *Ronja Carrier* to observe several treatments and discuss the preparation required with the farm manager of the site being serviced. Training sessions were also arranged with the various fish health management teams and the biologist from Aqua Pharma to learn the manual titration method used to test Interox Paramove 50 concentrations during the treatment process.

During the charter period, the *Ronja Carrier* completed treatments on 30 net pens belonging to Admiral Fish Farms, 47 net pens belonging to Northern Harvest Sea Farms, and 113 net pens owned by Kelly Cove Salmon. Though multiple opportunities were presented to Ocean Legacy, high water temperatures at their site in upper Passamaquoddy Bay prevented the scheduled use of the vessel by this company.

SUMMARY OF CONCLUSIONS

The *Ronja Carrier* arrived in New Brunswick on June 12, 2009. While the industry did not expect that it would see significant cost savings in 2010 because the benefits would only be realized over time, we did anticipate that the project would enable us to determine if we could increase treatment efficacy at the same time we further improved our on-farm environmental management.

This project also enabled us to bring people together to learn about this technology. This included personnel from the various farm management teams to learn about the treatment process in addition to personnel from the various federal and provincial regulatory agencies. Collaborations were enhanced with the various pharmaceutical companies and researchers. This project also provided a platform to build and enhance relationships with community stakeholders through information meetings, consultations, etc.

During the charter period the *Ronja Carrier* treated a total of 190 net pens of salmon for sea lice; 19 of those net pens were located in ABMA 3a and the remainder within ABMA 1. This does not include net pens, or parts thereof used in trials with various products. Of the 190 pens treated, 77 were treated with Salmosan, eight with Alpha Max, and three with a combination of two of these products. A total of approximately 3.2 million fish were treated with the *Ronja Carrier*.

While the aquaculture industry in New Brunswick considers this project a success, due to a range of circumstances, the extensive evaluation of the well boat technology and the various sea lice treatment products, such as AlphaMax, was not as detailed as initially intended. However, we do know that product quantity was reduced and efficacy increased.

What we have learned includes:

TREATMENT EFFICACY:

Interox Paramove 50:

- There were no site associations with post-lice counts or percentage change in lice counts which suggests that while environmental factors can play a role in efficacy, other non-environmental factors (Interox concentration, dose time, treatment duration) affected the percentage change in lice counts at each site.
- Various product concentrations were tested; all concentrations were equally effective at reducing adult female counts
- Interox Paramove was effective in removal of the pre adult / adult male (PA/AM) and adult female (AF) life stages. Over the entire growing season, Interox was successful in reducing lice counts 39 per cent of the time for chalimus, 91 per cent of the time for PA/AM and 84 per cent of the time for AF
- High pre-treatment PA/AM lice counts tended to result in less efficacy of Interox and Interox was much less effective on chalimus removal overall, although larger chalimus reductions were observed in November and December versus the summer months.
- The only treatment parameters that seemed to influence treatment efficacy for chalimus were related to the number / weight of fish placed in the well at the time of treatment. The lower the number of fish and the lower the total weight, the more effective the treatment appeared to be at reducing chalimus numbers.

Salmosan:

- There was a significant influence of site specific factors on percentage decrease of the pre adult /adult male (PA/ AM) and adult female (AF) life stages
- Because Salmosan dose was consistent, this suggests environmental factors or technical / unmeasured factors affected the efficacy of Salmosan treatments on PA/AM, and AF life stages.
- For chalimus, site factors did not significantly influence declines
- Salmosan was effective in removal of pre adult /adult male, and adult female life stages. Statistics indicate it was less effective for chalimus, and highly variable. Over the entire growing season, Salmosan was successful in reducing lice counts 33 per cent of the time for chalimus, 88 per cent of the time for PA/AM and 91 per cent of the time for AF.
- There were only three months during which salmon were treated for sea lice with Salmosan (September, October, and November). For unknown reasons, October was the most successful month in reducing PA/AM and AF counts.
- Treatment time did not significantly influence the efficacy of the Salmosan in either PA/ AM or AF. There was some variation in this measure but it was not as variable as the data from the Interox.

Alpha Max

- Analysis of the product efficacy is inconclusive. There were so few treatments with the Alpha Max product alone, or even in combination, that there is not enough data to perform a statistical analysis or draw any conclusions about product efficacy.

REDUCTION IN CHEMICAL USE/CHEMICAL COST

The quantity of active ingredient in Salmosan (azamethiphos) is reduced from approximately 500g to 120g with use in a well boat of an assumed volume versus a skirt used on a net pen of the same size and an assumed volume.

Given the same assumptions, the active ingredient in Alpha Max (deltamethrin) was reduced from 6.4g to 2.4g when used in a well boat versus a net pen treatment with a tarp.

Larger well boat capacity would also support a reduction in chemical use.

The costs of products are very similar. The chemotherapeutant required to treat a tarped net pen will cost $2,400. The cost for a well boat treatment is reduced to $800. Further cost savings are projected through a reduction in the total number of treatments required overall. This assumption could not be tested in 2010 due to a variety of circumstances including higher than normal lice loads and limited product availability.

TECHNOLOGY TRANSFER

This pilot project provided all the salmon farming companies in New Brunswick with the opportunity to have their farm crews and fish health personnel learn and understand well boat technology for sea lice treatments. In addition personnel and researchers from various organizations including Department of Fisheries and Oceans, Atlantic Veterinary College, New Brunswick Department of Agriculture Aquaculture and Fisheries, Department of Environment, Pest Management Regulatory Agency and other regulatory agencies had the opportunity to be on board the *Ronja Carrier* to learn about the vessel operation and treatment procedures.

This pilot project also provided critical data on how Interox Paramove 50 can be used in higher water temperatures getting significant lice clearance while ensuring the safety of the fish being treated. Parameters tested in New Brunswick had never been tested in either Norway or Scotland where this product has been used only when water temperatures permit product concentrations between 1500ppm and 1800ppm for over 30 minutes.

MOVING FORWARD

No one is more committed to finding sustainable solutions to challenges than the province's farm operators themselves. Over its 30 year history, New Brunswick's salmon farming industry has proven time and time again that by working together and in partnerships with national and international colleagues, researchers, and federal and provincial departments, there is no issue where sustainable solutions cannot be found.

Through the research conducted in preparation for this project and based on early results, salmon farming companies recognized early the benefit of adopting well boat treatment technology. Two salmon farming companies opted to purchase their own well boats; a third is engaged in the development of an alternative 'Eco Bath' technology.

Northern Harvest Sea Farms signed a charter with purchase agreement with Solvtrans and acquired the vessel, *Ronja*. The *Ronja* arrived in mid-July and was in operation in early August, 2010. All technical information learned from the operations on the *Ronja Carrier* was shared with Northern Harvest and the crew of the *Ronja*. This was very important when it came to identifying system and operational deficiencies when the *Ronja* arrived in New Brunswick. Corrections were made before the vessel was used to treat fish. It should also be noted that Northern Harvest retained the services of the *Ronja Carrier*'s crew following the conclusion of the *Ronja Carrier* charter. Northern Harvest may potentially use this vessel in sea lice treatments at its Newfoundland sites and use the vessel to transport and grade fish.

Cooke Aquaculture also purchased a well boat. The *Colby Perse* arrived on September 10thfrom Chile and began full operation shortly after arrival. Company personnel made several trips to Chile prior to the purchase to address issues of concern based on the experience with the *Ronja Carrier* and *Ronja*. Cooke is also pursuing the purchase of two other, larger vessels in order to meet the demands of their site operations in New Brunswick, Maine and Newfoundland.

The reality of well boats becoming part of routine operations for multiple companies in multiple Atlantic jurisdictions provides the strongest indication that this pilot project was a success. The results of this project also benefit smaller companies and they are using the information to support the development of alternative closed technology for use on those sites for which a well boat is not an option.

APPENDIX 1
Treatment Process on Well Boat *Ronja Carrier*

The *Ronja Carrier* –

Main dimension:	
Length o.	40,00 m
Breadth	10,00 m
Depth	5,00 m

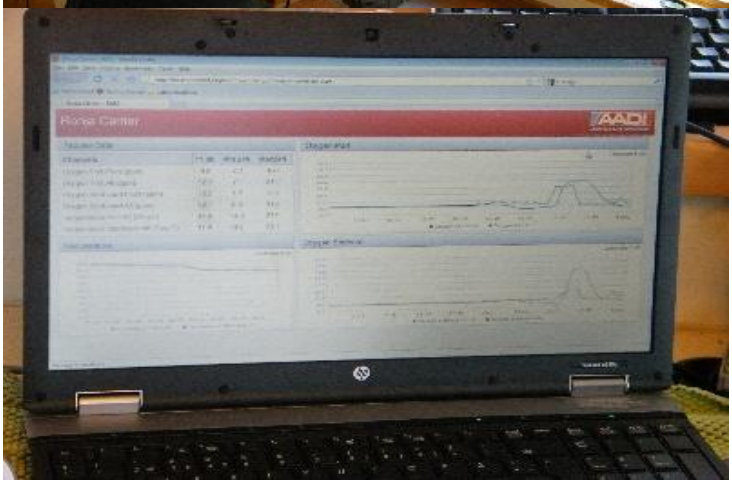
The deck of the *Ronja Carrier* showing the ISO storage tank for the Interox Paramove 50 product, the covers for the two wells (300m^3 each), and the hoses / pumps for bring the fish on board and returning them to the cage.

Boom placing hose into seined group of fish to bring on board *Ronja Carrier*

Salmon in a well on the *Ronja Carrier.* Recovery period

Salmon being monitored as they are being brought on board the well boat for treatment.

The well boat captain and farm management / veterinarians monitor the fish during treatment. The vet (and prescription) indicate product, concentration, and treatment time and control the process.



Oxygen and temperature within each well are monitored during each treatment.

Fish health personnel perform manual titrations during Interox Paramove 50 treatment to monitor concentration of product

Salmon being returned to sea cage post treatment, flushing and second recovery period

APPENDIX 2
Bay Management Areas in Southwest New Brunswick