Pilot Project Technology Initiative

Technology Test:
Alternative Feed Ingredients

Saltspring Island
Marine Harvest Canada

Year 1 Monitoring Report
Draft
First Production Cycle

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TABLE OF CONTENTS

PAGE

LIST OF TABLES iii

LIST OF FIGURES iv

LIST OF APPENDICES v

1.0 INTRODUCTION 1

2.0 APPROACH AND METHODS 2

2.1 GENERAL APPROACH 2

2.2 FISH PERFORMANCE MONITORING 4

2.2.1 DATA SETS USED FOR EVALUATION 4

2.2.2 STARTING FISH GROUPS 4

2.2.3 FISH WEIGHT MEASUREMENT 5

2.2.4 MORTALITY REMOVAL 5

2.2.5 TIMEFRAME FOR TECHNOLOGY TRIALS 5

2.2.6 DATA ANALYSIS 6

2.3 FEED AND FEEDING 6

2.4 OPERATION/MAINTENANCE OF CAGES 6

2.5 HEALTH MANAGEMENT 7

2.6 SEA BED OBSERVATIONS 7

2.6.1 FIELD SURVEYS 7

2.6.2 DATA ANALYSIS AND PRESENTATION 7

3.0 ENVIRONMENTAL CONDITIONS 8

4.0 TECHNOLOGY EVALUATION: STOCK PERFORMANCE 9

4.1 FISH GROWTH 9

4.2 FISH SURVIVAL 12

4.3 FEED CONVERSION 12

5.0 WASTE PRODUCTION 14

5.1 DIRECT OBSERVATION 14

5.1.1.1 October 2001 14
5.1.1.2 May 2002 16
5.1.1.3 September 2002 16
5.2 WASTE ESTIMATES BASED ON FEED CONSUMPTION 17

6.0 HEALTH PROBLEMS 18

7.0 SUMMARY OF RESULTS 19

LIST OF TABLES

Page

Table 2.1 Fish stocking information for alternate feed technology trials 4

Table 3.1 Summary of surface water temperatures for the three trial periods 8

Table 4.1 Summary of fish weight and biomass for the three growth periods 9

Table 4.2 Summary of fish mortalities in each fish containment unit 12

Table 4.3 Feed conversion ratios (FCR) for fish in feed trial cages 13

LIST OF FIGURES

Page

Figure 2.1 Layout of fish containment units during technology trials 3

Figure 4.1 Fish Growth During Alternate Feed Trials 10

Figure 4.2 Specific Growth Rates for Fish on Control and Alternate Diets 11

Figure 4.3 Thermal growth Coefficient for Fish on Control and Alternate Diets 11

Figure 4.4 Economic Food Conversion Ratios for Control and Alternate Feeds 13

Figure 5.1 Location of Remote Operated Vehicle Transects for Benthic Environment Evaluation 15

LIST OF APPENDICES

Appendix 1 Feed Allocation From First Stocking in Steel Cages - Alternate Feed Trials

1.0 INTRODUCTION

This document presents an evaluation of environmental performance of feeds containing alternative oils/protein at the Marine Harvest Salt Spring Island site. Environmental performance of fish production using the alternative feeds is being compared to fish production using conventional feeds. This technology test is being undertaken as part of the provincial Pilot Project Technology Initiative (PPTI) program.

Alternative oil and protein feeds have potential to remove feed manufacturing from reliance on traditional oil and meal sources, such as anchovy and, at the same time, to yield the same or reduced quantities of nutrients entering the receiving environment. Research has been undertaken in recent years to develop feeds containing protein from non-fish meal sources, particularly from vegetable sources. This has involved developing feeds that have palatability, digestibility and conversion characteristics that are at least as good as conventional feed. The environmental objective for the alternative protein feed being used at the site is to determine whether solid waste matter production is equal to or lower than conventional feed. If feed trials are successful, the alternative feeds will have offsite benefits related to reduced use of pelagic fish stocks.

Data collected during the technology test were assessed to determine environmental performance of fish that were produced under full-scale commercial operating conditions over the technology-test period.

This document presents results generated from data collected during the first production cycle of the technology trials. The data collection period started with fish stocking in mid-June 2001 and ended when fish were harvested in 2002 (fish harvesting commenced in March 2002 and continued until mid-July 2002). A second round of trials to test the efficacy of alternative feed is planned for the second production cycle, 2002-2003.

2.0 APPROACH AND METHODS

2.1 GENERAL APPROACH

The first year of the alternate feed evaluation trials was carried out under commercial grow-out conditions at the Marine Harvest Saltspring Island site using standard practices for feeding and monitoring of fish and environmental conditions. The methods used in the trials can be summarized as follows:

- Six 100 ft by 100 ft steel grow-out cages were used in the technology evaluation (see Figure 2.1).
- Three of the cages contained fish that were fed the alternate feed and three held fish given the conventional feed.
- Each of the six cage units contained between 40,000 to 70,000 smolts at the start of the trial on June 21, 2001.
- Standard feeding practices were used throughout the trial, including the application of medicated feed when required. Detailed information on the types and quantities of the various feeds provided to the fish in the six grow-out units was recorded.
- Fish growth was monitored regularly throughout the trials using a video image capturing and sizing system (VICASS) and periodic sample weight measurements.
- Water temperature was monitored on a regular basis in the cage system to assist in evaluating growth data. Dissolved oxygen levels were also monitored in the cages to ensure that growth conditions were optimal. In general, dissolved oxygen is not a problem in the conventional grow-out cages at the Saltspring Island site due to the good water exchange patterns in the area.
- Data were recorded digitally and used for a range of analyses, including the generation of growth curves and calculation of feed conversion ratios.

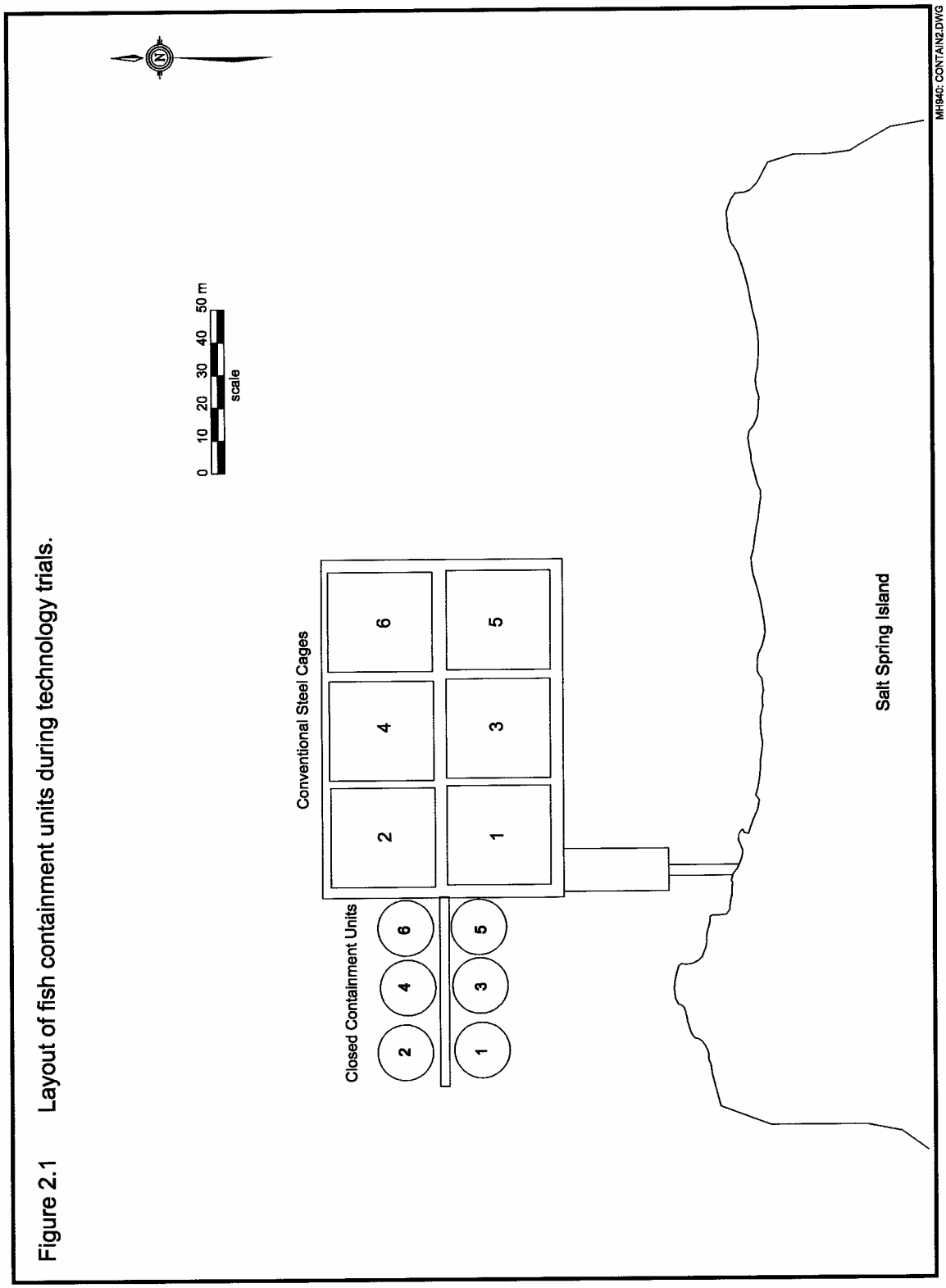


Figure 2.1 Layout of fish containment units during technology trials.

2.2 FISH PERFORMANCE MONITORING

2.2.1 Data Sets Used for Evaluation

Several datasets were reviewed for preparation of this monitoring report. These were detailed site inventory and performance data collected by farm site personnel and recorded in Excel workbooks. Marine Harvest staff provided these data on two occasions: in November 2001 and October 2002. In addition, Marine Harvest Canada Campbell River head office staff supplied weekly production data for the period from November 2001 to June 2002. These data were summary outputs from data management software (Superior) being used by Marine Harvest to collate data from all farm sites.

2.2.2 Starting Fish Groups

Fish numbers and size in each rearing unit prior to startup of the feed trials are summarized below in Table 2.1. Final VICASS estimates prior to initiating the trials are shown, as well as the last actual weights before starting the trials and the first VICASS estimates carried out during the trials. Average fish weight just prior to trial startup was approximately 450 to 750 g. The latest direct fish measurement prior to preparation of this report was undertaken on March 22, 2002. Average fish weight at that time was approximately 3,900 g in the control cages and 3,600 g in the alterative cages.

Table 2.1 Fish stocking information for alternate feed technology trials.

Cage No.	VICASS Estimate Prior to Start of Trials					Actual Weight Measurements			
						Before Start of Trial[2]		After Start of Trial[3]	
	Date	Number[1]	Avg. Weight (kg)	Biomass (kg)	Density (kg/m^3)	Date	Avg. Weight (kg)	Date	Avg. Weight (kg)
Alternative Feed									
3	11/06/01	57,480	0.470[4]	31,614	2.2	30/4/01	0.445	16/07/01	0.770
5	11/06/01	56,288	0.640	36,024	2.5	29/4/01	0.502	16/07/01	0.860
6	11/06/01	57,596	0.700	40,317	2.8	29/4/01	0.493	16/07/01	0.796
Conventional Feed - Controls									
1	11/06/01	117,860	0.480	56,573	3.9	29/4/01	0.372	16/07/01	0.700
2	11/06/01	121,003	0.440	53,255	3.7	29/4/01	0.303	16/07/01	0.620
4	11/06/01	40,391	0.740	28,889	2.1	29/4/01	0.575	16/07/01	1.050

1 Number of fish in cages at time of weight measurement – fish transfers and mortalities occurred in cages prior to start of trials.
2 Actual hand weights.
3 VICASS weights.
4 Extrapolated weight of 0.550 kg used in trial as poor VICASS measurement suspected.

2.2.3 Fish Weight Measurement

Fish weight data used in this monitoring report are from two sources: a single hand measurement carried out prior to startup of the trials and periodic sample weight measurements collected at intervals over the trial period. Periodic sample weights were obtained using the non-intrusive VICASS remote camera sampling system. The VICASS system is operated by individuals who specialize in use of this system. During sampling a camera is placed in the sample cage and the camera is linked to a portable computer. The operator captures images of fish at different depths. A computer program then calculates weight of individual fish based on fork length and girth measurements. Approximately 250 images are used to calculate the average weight for the pen being sampled. Fish images are also examined for fish disease signs. Marine Harvest staff indicated that the VICASS provide approximate size data and more accurate data are generally not available until completion of harvest. VICASS data were collected from start of the trial in June 2001 until harvesting started in March-April 2002.

2.2.4 Mortality Removal

Fish mortalities, moribund fish and non-performing fish were regularly removed from rearing units when observed on the surface and during a routine diving program. Crews noted the reason for removal and/or probable cause of mortality for each fish and recorded these data.

2.2.5 Timeframe for Technology Trials

Fish were first stocked in the six grow-out units over a ten-day period between March 20 and 29, 2001. Over the period from later March to mid-June the number of fish in each cage changed due to mortalities and transfers to other units at the site. Final fish densities were established around the middle of June and the trials were started on June 21, 2001. The trials were conducted between June 21, 2001 and March 20, 2002, when the first harvest was carried out. Growth and feeding data were collected until the middle of July 2002 when all fish were harvested, however, these data were excluded from the analysis. This was done to avoid potential analytical problems resulting from numerous partial harvests carried out over the March to July 2002 period.

Three time periods were used to analyze the data collected from the trials corresponding to different fish growth phases. The periods are as follows:

- Period 1: June 21, 2001 to August 30, 2001;
- Period 2: August 31, 2001 to December 14, 2001; and
- Period 3: December 15, 2001 to March 22, 2002 (a two day extrapolation was used for Cage 4 to accommodate a partial harvest that occurred on March 20).

2.2.6 Data Analysis

Site weight data were used to calculate average weight data, specific growth rate and together with temperature data, thermal growth coefficients. Weight data were used with feed usage data to calculate feed conversion ratios. Both economic and biological feed conversions were calculated (biological feed conversion accounts for fish biomass removed from pens in the form of dead fish), however mortality was so low that often the same value was produced. Mortality data were used to calculate survival rates. Site data were also reviewed to identify potential differences in fish health, predator interaction and escapes.

2.3 FEED AND FEEDING

Feed handling and application practices used during the trials were similar for all cages. A number of feed types and sizes were used from the time of stocking until harvest. The type of feed used was dependent on fish growth stage, the need for medication and the application of tissue pigments (see Appendix 1). During the actual trial period the majority of feed used was either a control diet (conventional feed) or an alternate diet. The major difference between the control and alternate diets was that in the alternate diet approximately 25%-60% of the fish oil in the feed was replaced by canola oil.

Feeding frequency varied somewhat between cages over the trial period although feeding rates were comparable between cages. As an example, the feeding regime in Cage 1 (a control cage) was as follows:

Date	Feeding Regime
June 21 – August 14, 2001	Feed provided daily
August 15, 2001	Fish starved prior to the application of medicated feed
August 16 – August 20, 2001	Medicated feed provided daily
August 21 – August 26, 2001	Feed provided daily
August 27 – August 28, 2001	Medicated feed provided daily
August 29 – October 18, 2001	Feed provided daily
October 19, 2001	Fish starved due to sea lion inside the predator net
October 20, 2001 – January 20, 2002	Feed provided daily
January 21 – March 18, 2002	Feed provided every other day
March 19 – March 22, 2002	Feed provided daily

2.4 OPERATION/MAINTENANCE OF CAGES

Standard operating and maintenance procedures were used on the steel cage units included in the alternate feed trials. In particular, the cages nets were regularly inspected for damage and periodically replaced.

2.5 HEALTH MANAGEMENT

Fish were routinely examined for signs of disease. This included examination of dead fish and live fish observed using underwater cameras. Disease and parasite occurrence was low in the cage units throughout the trial period. Cage units were affected by mouthrot in August of 2001, and accordingly were treated with medicated feed.

2.6 SEA BED OBSERVATIONS

2.6.1 Field Surveys

Surveys of the sea bottom under the Saltspring Island cage system were undertaken on three occasions (October 2001, May 2002, and September, 2002) by personnel form Aquametrix Research Ltd. The sublittoral epibenthic surveys were conducted using a VideoRay Pro Remote Operated Vehicle (ROV). The VideoRay Pro, capable of dives to 100 metres, is equipped with approximately 120 metres of neutrally-buoyant tether and supports a high-resolution colour camera (vertical movement) and halogen lamps to view and photograph the sea floor. Onboard support includes the ROV controller, a colour monitor, VHS video recorder, and an 8mm digital video recorder.

Controlled from the survey vessel the ROV is maneuvered using vertical and horizontal thrusters. Heading, depth, time, and date are displayed on the video screen and are recorded in digital format with the video. The start point of each transect is plotted using differential GPS and the desired direction of travel is noted. Recording of the transect is started when the ROV has attained the required depth. The desired heading is kept as the ROV is driven along the bottom in a continuous transect line extending the distance determined appropriate for the survey. Recording of the transect is terminated when the surface is reached.

2.6.2 Data Analysis and Presentation

The video data are collected in digital format and later analyzed. Bottom composition, epibenthic species presence and comments on relative abundance were performed for the entire transect and summarized in a written format within this report. The presence of fish feed and fecal material was of particular interest, as these parameters were directly related to operational performance issues, and were thus the focus of the digital image review. Other related observations, including the presence of *Beggiatoa sp*., were also presented as an indication of cumulative impact effects associated with the production cycle.

3.0 ENVIRONMENTAL CONDITIONS

Surface (1 m) water temperature was monitored daily in each cage unit throughout the feed trials. Average water temperature in the cages for the trial period was very similar ranging from 9.6°C to 10.0°C. Temperature at depth (15 m) ranged from a maximum of 14.87°C on August 14, 2001 to a minimum of 6.66°C on January 28, 2002. Surface water temperature ranges for the three growth periods are summarized below in Table 3.1.

Table 3.1 Summary of surface water temperatures for the three trial periods.

Period	Dates	Average Temperature (°C)	Maximum Temperature (°C)	Minimum Temperature (°C)
1	June 21 – August 30, 2001	12.9	14.9 (July 16/01)	10.5 (June 24/01)
2	August 31 – December 14, 2001	10.4	13.6 (Sept. 14/01)	8.0 (Dec. 12/01)
3	December 15, 2001 – March 22, 2002	7.2	8.2 (Jan. 5/02)	6.3 (Jan. 29/02)

Dissolved oxygen levels in the cages were in excess of 6 mg/L throughout the trial period. Salinity was not recorded during the trial period, as this water quality parameter remains relatively constant at the Saltspring site.

4.0 TECHNOLOGY EVALUATION: STOCK PERFORMANCE

4.1 FISH GROWTH

Average fish weight and biomass in each rearing unit over the three growth periods in the trial, are presented below in Table 4.1.

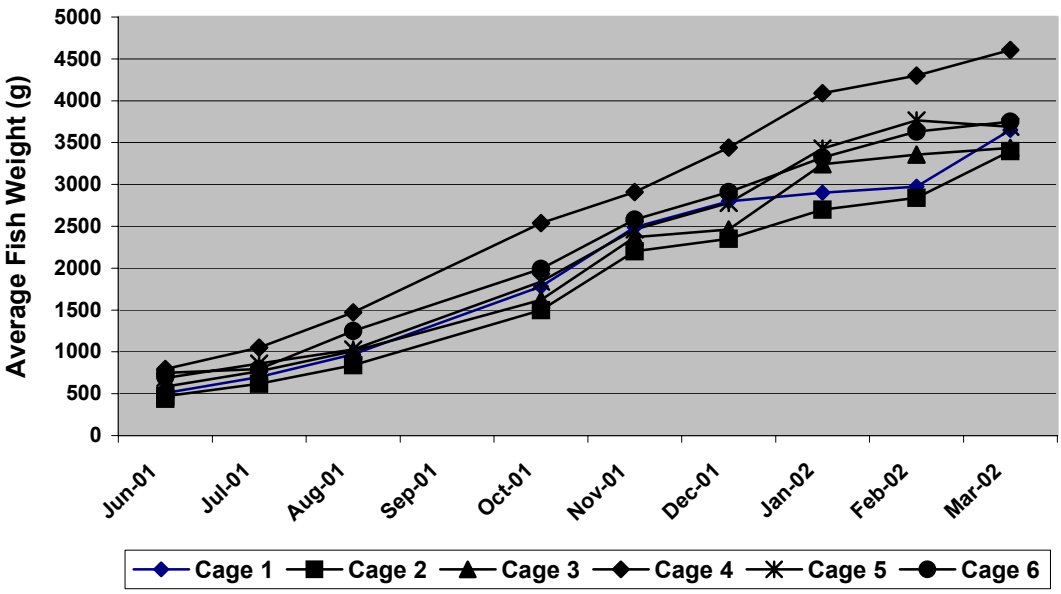
Table 4.1 Summary of fish weight and biomass for the three growth periods.

Cage No.	Unit Parameter	Sample Date			
		Trial Start Date June 21, 2001	End of Period 1 Aug. 30, 2001	End of Period 2 Dec. 14, 2001	End of Period 3 Mar. 22, 2002
Alternative Feeds					
3	**Avg. Fish Weight (kg)**	**0.586**	**1.010**	**2.460**	**3.435**
	Fish Number	57,403	56,963	56,488	56,288
	Biomass (kg)	**33,638**	**57,533**	**138,960**	**193,349**
	Density (kg/m^3)	2.3	4.0	9.7	13.4
5	**Avg. Fish Weight (kg)**	**0.688**	**1.030**	**2.780**	**3.689**
	Fish Number	56,239	55,991	55,588	55,424
	Biomass (kg)	**38,692**	**57,671**	**154,535**	**204,459**
	Density (kg/m^3)	2.7	4.0	10.7	14.2
6	**Avg. Fish Weight (kg)**	**0.750**	**1.250**	**2.910**	**3.750**
	Fish Number	57,550	57,215	56,758	56,622
	Biomass (kg)	**43,163**	**71,519**	**165,166**	**212,333**
	Density (kg/m^3)	3.0	5.0	11.5	14.7
Conventional Feed – Control					
1	**Avg. Fish Weight (kg)**	**0.508**	**0.970**	**2.800**	**3.650**
	Fish Number	67,823	67,046	66,520	66,293
	Biomass (kg)	**34,454**	**65,035**	**186,256**	**241,969**
	Density (kg/m^3)	2.4	4.5	12.9	16.8
2	**Avg. Fish Weight (kg)**	**0.470**	**0.840**	**2.350**	**3.400**
	Fish Number	70,049	69,151	68,604	68,148
	Biomass (kg)	**32,923**	**58,087**	**161,219**	**231,703**
	Density (kg/m^3)	2.3	4.0	11.2	16.1
4	**Avg. Fish Weight (kg)**	**0.796**	**1.470**	**3.440**	**4.608**
	Fish Number	40,361	40,132	39,901	39,423
	Biomass (kg)	**32,127**	**58,994**	**137,259**	**181,661**
	Density (kg/m^3)	2.2	4.1	9.5	12.6

Initial stocking rates ranged from about 40,000 to 70,000 fish per cage. Based on the average fish size this resulted in loading rates or densities in the order of 2.5 to 3 kg/m^3 for each cage. Fish stocked in Cage 4 (a control unit) had the highest average size at the start and finish of the trials, 796 g and 4,608 g, respectively.

Growth curves for fish in the six cage units are presented below in Figure 4.1.

Figure 4.1
Fish Growth During Alternate Feed Trials.



In general, fish growth was good on both the control and alternate diets. Although there was some variability in average fish size at the start of the trials, growth rates were generally comparable between fish fed the control and alternate diets (Figure 4.2 and 4.3). Data in Figures 4.2 and 4.3 suggest that growth rate of fish in control cages may have been slightly better than that of test fish in the early months of the production period. There appeared to be a minor slowing of the growth rates in Cages 1 and 2 during January 2001 and early February of 2002, but rates increased in both of these units by March 2002, prior to the termination of the trials. There is no apparent explanation for this rate reduction but it does not appear to be significant.

Specific growth rate for fish grown on the control and alternate diets averaged over the three growth periods are presented below in Figure 4.3. Rates are generally higher for fish produced on the control feed but differences are not considered significant. Similar results were also determined when the thermal growth coefficients were calculated for fish grown on the control verses the alternate diet (see Figure 4.4).

Figure 4.2
Specific Growth Rates for Fish on Control and Alternate Diets.

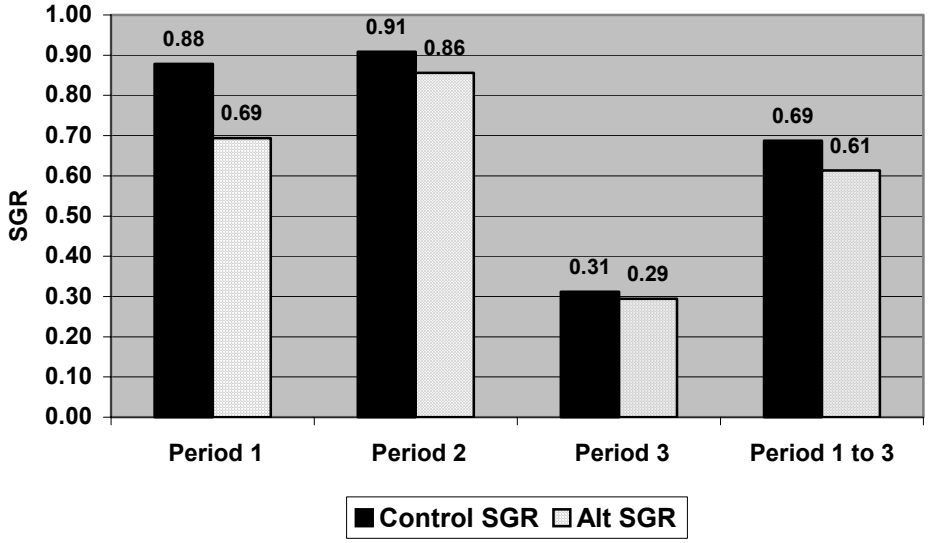
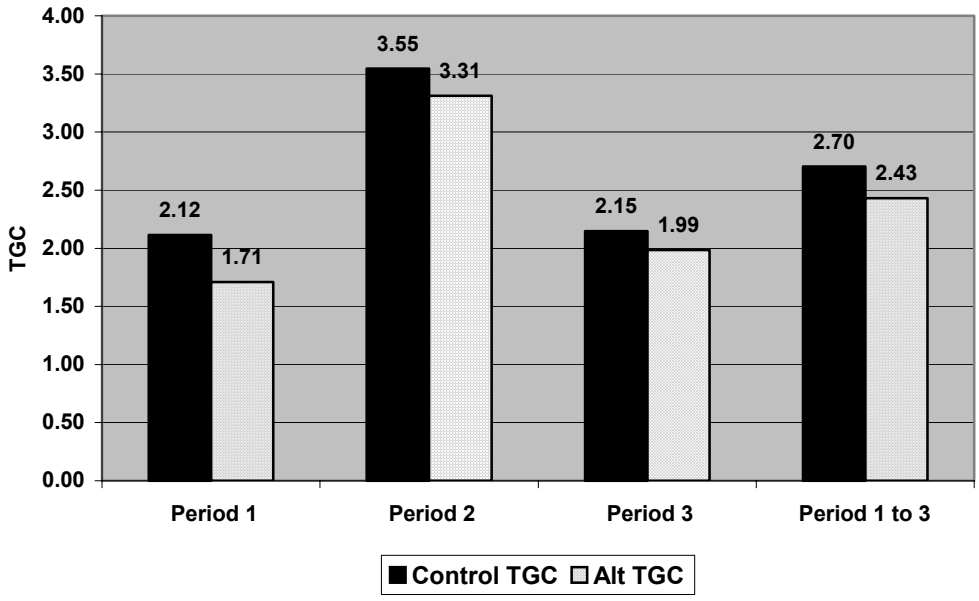


Figure 4.3
Thermal Growth Coefficient for Fish on Control and Alternate Diets.



Although the nature of the data collected and the experimental conditions under which the trials were conducted do not allow for rigorous statistical analysis of the growth data, it seems apparent that there was not a significant difference in growth rate between fish fed the control diet and those given the alternate diet.

4.2 FISH SURVIVAL

Fish mortality in each containment unit is summarized in Table 4.2. In general, mortalities were low throughout the entire trial period. Mortalities were attributable to several factors, including mouthrot, as well as non-performing fish and silvers. Percentage total fish mortalities for the study period did not differ significantly between alternate feed units and control feed units.

Table 4.2 Summary of fish mortalities in each fish containment unit.

Trial Period from June 21, 2001 to March 22, 2002		
Cage No.	**Number of Mortalities**	**Percent Mortality Over Trial Period**
1	1,530	2.26%
2	1,901	2.71%
3	1,115	1.94%
4	714	1.77%
5	815	1.45%
6	928	1.61%

4.3 FEED CONVERSION

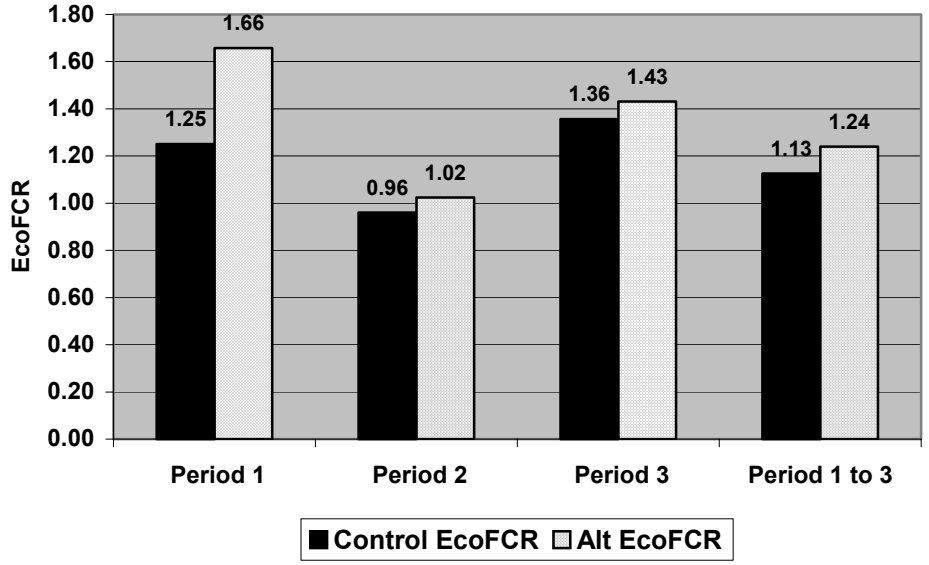
Feed conversion in each containment unit for the entire trial period (June 21, 2001 to harvest) is summarized below in Table 4.3. It is evident from the data presented that there was very little variability in feed conversion ratios between cages units. Biological FCR values ranged from a low of 1.23 in Cages 1 and 5 to a high of 1.32 in Cage 2. Variation among economic FCR values was similar. There was no significant difference between the average alternate and control FCR values measured over the entire trial period.

Table 4.3 Feed conversion ratios (FCR) for fish in feed trial cages.

Cage No.	Initial Biomass (kg)	Final Biomass (kg)	Biomass Gained (kg)	Biomass of Mortalities (kg)	Biological FCR	Economic FCR
1	34,454	280,121	245,667	4,225	1.23	1.26
2	32,923	300,574	267,651	5,412	1.32	1.34
3	33,638	232,325	198,687	3,964	1.28	1.31
4	32,127	187,864	155,737	2,342	1.28	1.30
5	38,692	236,818	198,126	1,966	1.23	1.24
6	43,163	241,927	198,765	1,799	1.28	1.30
Avg. Control	35,132	258,519	223,387	7,033	1.26	1.30
Avg. Alternate	38,499	237,023	198,524	4,885	1.25	1.28

A summary of economic FCRs for all control and alternate feed cages over the three growth periods prior to the start of fish harvesting is provided below in Figure 4.4. The most significant difference in FCR between the two feed types occurred in period 1 (June 21, 2001 to August 30, 2001), where values for the alternate and control feed groups were 1.66 and 1.25, respectively. However, FCRs averaged over the three periods showed little variability.

Figure 4.4
Economic Food Conversion Ratios for Control and Alternate Feeds.



5.0 WASTE PRODUCTION

5.1 DIRECT OBSERVATION

Environmental observations of the benthic environment beneath the closed-containment and the traditional growout cages used at the Saltspring farm site were made on three occasions at all, or a subset, of four survey transects identified in Figure 5.1 below. The transects were established from the centre walkway (between the two systems) with the ROV pathways extending in four directions, two under each of two traditional (steel) cages and two under the bag system.

The following table indicates when and where the ROV transects were completed for this epibenthic evaluation.

Date	*Station ROV-1*	*Station ROV-2*	*Station ROV-3*	*Station ROV-4*
October/2001	x		x	
May/2002	X		x	
September/2002	X	x	x	X

NOTE: *Comparison of epibenthic observations of impact between the two cage system designs has limited value given the fact that fish were entered to the steel cages in December 2000, retained for six months and grown from 145 to 475 grams, and then graded and entered into the closed- containment system for ongrowing and operational evaluation. The following comments should consider this limitation.*

5.1.1.1 October 2001

Conducted approximately four months after the start of the production cycle of this Pilot Project (fish entry to the bag system), this initial survey examined the conditions under a single bag and a single steel netcage (stations ROV-1 and ROV-03 shown in Figure 5.1).

The transects were conducted across comparable bathymetric contours (28 to 31 metres) with substrate comprised of fine sand, shell and some silt/clay. Station ROV-03, under the steel cage system, revealed scattered evidence of fish fecal material and incidental feed pellets. However, under the bag system the fecal and feed material was concentrated near the centre of the system and was quite dense; excess feed was clearly evident and a potential issue with feeding was relayed to farm staff. Changes in camera operational procedures, orientation within the bag, etc., was apparently adopted following this bottom survey.

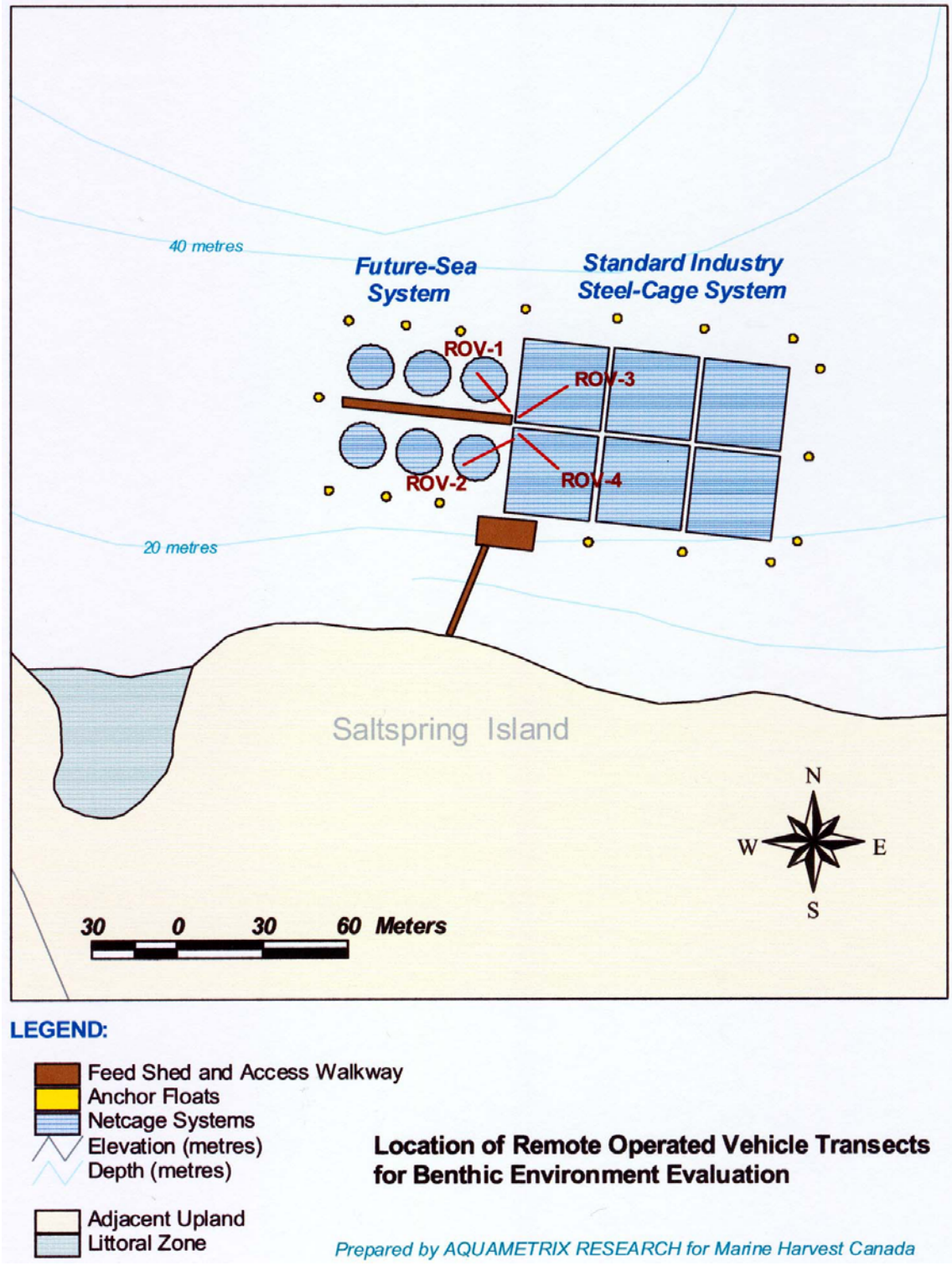

40 metres
Future-Sea System
Standard Industry Steel-Cage System
ROV-1
ROV-3
ROV-2
ROV-4
20 metres
Saltspring Island
N
W
E
S
30 0 30 60 Meters
LEGEND:
Feed Shed and Access Walkway
Anchor Floats
Netcage Systems
Elevation (metres)
Depth (metres)
Adjacent Upland
Littoral Zone
Location of Remote Operated Vehicle Transects for Benthic Environment Evaluation
Prepared by AQUAMETRIX RESEARCH for Marine Harvest Canada

Figure 5.1

Biological attributes of the benthic environment under both cages appeared to be minimally affected by the farm operation. Under both systems there were numerous flatfish, rockfish, sculpins, and sedentary macroinvertebrates such as *Metridium senile*. Other observations included the presence of Dungeness crab (*Cancer magister*) and incidental seastars such as *Pycnopodia helianthoides*.

There was no evidence of *Beggiatoa sp*. or any discoloration in bottom sediments that may be related to chemical changes in the sediments.

5.1.1.2 May 2002

The second survey was conducted 11 months following entry of fish into the closed containment system (18 months after entry to the cage system). Survey transects were the same as those completed in October 2001.

The primary observation of note from this survey was the lack of "piled" feed and fecal material beneath the closed-containment bag system. It is likely that changes to the feeding practices, as applied to the bag system following the October surveys, were successful in reducing wastage and in limiting the localized benthic affects of these inputs. The apparent visual effect of waste distribution across the seafloor was comparable between the two systems (along each of the surveyed transects).

Biological attributes were comparable with the previous survey, with notable numbers of flatfish, sculpins and rockfish. Although there was no obvious discoloration of sediments, despite disruption with the ROV thrusters, there was some *Beggiatoa sp*. noted along edges of rocks, branches, or other material, which provided some protection from tidal current flows across the sediment-water interface. Nevertheless, the perceived impacts from the visual record were minimal.

5.1.1.3 September 2002

This survey was conducted immediately following harvest of all cages at this site. It was assumed that this survey would represent a worse-case period in the production cycle, with impacts associated within the cumulative organic input across the farm over the entire production cycle (cages: 21 months; bags: 15 months). Two additional transects were completed as a part of this survey.

Again, the distribution of excess feed and/or fecal material appeared comparable between the areas beneath the cage and bag production systems. Macroinvertebrate and fish species present in the area remained unchanged from previous surveys, with numerous flatfish, rockfish, sculpins, seastars, *Metridium*, etc.

Disruption of the surface sediment using the ROV thrusters did not reveal any black subsurface sediments which might have suggested a shift from aerobic to anaerobic assimilation of organic material at the site. However, a dramatic increase in the presence of *Beggiatoa sp*. was noted in all areas observed directly beneath the cages and bags, a condition directly related to the

distribution pattern and assimilative process of the organic wastes originating from the farm operation.

Given the strong bottom currents at this site, it is anticipated that the organic material will be quickly assimilated and that the biological condition of the epibenthic environment will not be jeopardized further from the farm activities. Ongoing monitoring is recommended.

5.2 WASTE ESTIMATES BASED ON FEED CONSUMPTION

Feed conversion data suggest that feed conversion ratios using the control diet were comparable to that for fish fed the alternate diet, although there was some variability in feed conversion ratio at times among the individual rearing units. Maximum waste loading occurs during the final months of production when fish biomass and food administration is greatest. If clear differences in food conversion had been evident, waste production could be calculated by use of factors to estimate amounts of eaten feed and digestibility of eaten feed. However, this has not been done because there is no clear difference in feed conversion between the control and alternate diets used in the trial.

6.0 HEALTH PROBLEMS

Fish health conditions were generally good in all the steel cage units. The most common disease-related mortality that was reported during the alternate feed trials was mouthrot. Mouthrot is usually caused by myxobacteria, which are a group of microorganisms that are widespread in the natural environment and tend to invade fish tissue that has been damaged or is protected by a weakened immune system. Disease problems that may have placed wild fish species at risk were not evident in any of the containment units.

7.0 SUMMARY OF RESULTS

Growth and waste production of Atlantic salmon grown on a control diet and an alternate diet (a portion of the fish oil in the feed was replaced with canola oil) was compared over a period between June 22, 2001 and March 22, 2002. Fish were grown in large 100 ft by 100 ft steel cages under commercial conditions that included standard feeding regimes and the use of medicated feeds to control disease problems in the system. Results of the trials can be summarized as follows:

1. In general, fish growth was good on both the control and alternate diets. Data collected during the first production cycle suggests that growth of fish fed with alternate ingredients over the production test period was comparable to control fish growth rate. Although control fish appeared to do slightly better during the early months (first summer) of the trial period. Although there was some variability in average fish size at the start of the trials, final growth rates were generally similar between fish fed the control and alternate diets. Average specific growth rates for the trial period for the control and alternate diets were 0.69 and 0.61, respectively.

2. Similarly, data suggest that feed conversion was similar between the two fish groups, with better conversion among control fish during the early months of the trail period. Feed conversion ratio (FCR) was very good for fish grown on both the control and alternate diets. Economic FCRs averaged over the three growth periods that made up the trial duration were close for the two diet types. The average control and alternate diet economic FCRs were 1.13 and 1.24, respectively. Although the nature of the data collected and the experimental conditions under which the trials were conducted do not allow for rigorous statistical analysis of the growth and feed conversion data, it seems apparent that there was not a significant difference in these parameters between fish fed the control diet and those given the alternate diet.

3. Differences in waste production were neither observed during sea bed surveys nor expected based on similar fish growth and feed conversion. Given the low FCRs and the comparable values determined for the control verses the alternate diet it was decided that a calculation of waste production for this first set of trials was unnecessary. If significant differences are evident during follow-up trials, appropriate waste production rates can be calculated at that time.

Fish survival and health appeared to be similar among control fish and test fish. Mortalities of fish in the six cage units were low throughout the trial period, ranging from 1.5% to 2.3%. In general, fish health in all the cage units was good throughout the trial period.

Appendices

Appendix 1

Feed Allocation From First Stocking in Steel Cages - Alternate Feed Trials

APPENDIX 1

Feed Allocation From First Stocking in Steel Cages - Alternate Feed Trials

Feed Type	Cage 1		Cage 2		Cage 3		Cage 4		Cage 5	
	kg Fed	% of Total	kg Fed	% of Total	kg Fed	% of Total	kg Fed	% of Total	kg Fed	% of Total
Smolt HP 3.5mm	7039	2%	8,595	3%	2,245	1%	1,325	1%	1,760	1%
RX 053 3.5mm	2,040	1%	1,720	0.5%	600	0.2%	580	0.3%	700	0.3%
Atlantic 6.5 mm 70					25,271	9%	715	0.3%	25,990	10%
5mm 076 med Seq	490	0.1%	510	0.2%						
Nep Atl 8.5mm 70	25,234	8%	23,559	7%			31,481	15%		
RX 103 6.5mm	2,706	1%	2,481	1%	2,191	1%	1,875	1%	2,476	1%
Atlantic 8.5 mm 70					28,052	10%	1,085	1%	27,236	10%
Atlantic 11 mm 40					36,281	13%			44,796	17%
Neptune 11mm 40	62,262	19%	34,669	10%			32,285	15%		
11 mm Apollo 40 (Alternate Diet)	10,670	3%	1,945	1%	**91,581**	**33%**	9,294	4%	**100,914**	**38%**
AAS 3000	-	-	4,000	1%	8,283	3%			8,073	3%
NSH 3000	3,680	1%	21,155	6%						
Orion 5mm	1,040	0.3%	580	0.2%	780	0.3%	400	0.2%	420	0.2%
Atlantic 5mm 70	8,780	3%	6,565	2%	17,081	6%	6,782	3%	19,185	7%
RX 064 5mm					560	0.2%	560	0.3%	640	0.2%
RX 076 5mm	2,064	1%	1,936	1%	974	0.4%	878	0.4%	1,069	0.4%
Nep Atl 5mm 70	20,243	6%	18,540	6%	223	0.1%	3,286	2%	287	0.1%
Atlantic 8.5mm 40					20,222	7%			13,559	5%
Atlantic 11mm 70					809	0.3%			7,001	3%
Nep Atl 6.5mm 70	25,789	8%	22,868	7%			23,241	11%		
Nep Atl 8.5mm 40	25,239	8%	50,025	15%			19,050	9%		
11 mm Orion 40 (Control Diet)	**112,747**	**34%**	**112,847**	**34%**			**82,234**	**38%**		
11 mm Nep Orion Proactive 40 ppm Cantha (Nep)	17,266	5%	15,260	5%			380	0.2%		
11 mm Apollo Proactive 40 ppm Cantha (Atl)	7,836	2%	2,989	1%	19,772	7%			8,229	3%
AAS Harv 3000					20,402	7%				
Total Feed Since Stocking	335,125		330,244		275,327		215,451		262,335	
Total Feed Used in Feed Trials	308,455		306,431		260102		202000		246566	

Notes:

Control Diet - Cages 1,2 and 4

Alternate Diet - Cages 3, 5 and 6