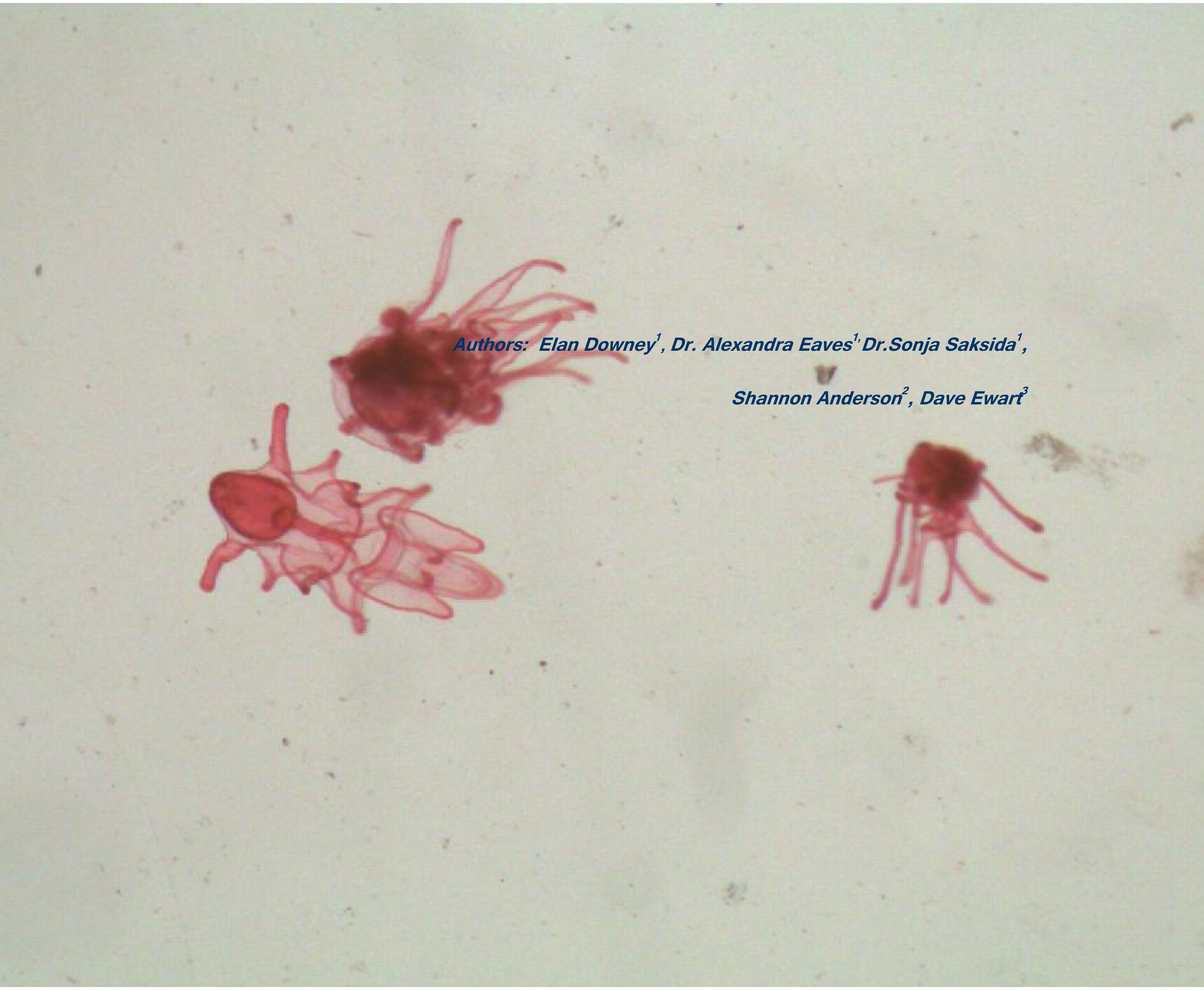
Discovery Passage Plankton Monitoring and

Juvenile Salmon Assessment 2009



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Introduction:

Coho salmon (*Oncorhynchus kisutch*) are an important sport fish and provide limited commercial fishing opportunities on the Pacific Coast. The Quinsam River Salmon Hatchery, along with other Fisheries and Oceans Canada (DFO) facilities, time the release enhanced of coho smolts according to guidelines established in the early 1980's. These procedures are based on observations that survival rates for area coho were best when released near the third week of May at a size of 20-25g (Bilton et al 1984). At the Quinsam Hatchery, (Campbell River, BC), and other salmon hatcheries that border the Strait of Georgia, recent smolt to adult survival for coho have been approximately 1% (Beamish et al 2008), down from the 8-10% in the 1980's (Beamish et. al. 2000,2004), when the smolt release guidelines were first established. Furthermore, the diet of coho during their early marine development changes both monthly and interannually depending on the availability of their preferred prey items (larval and juvenile fish, crab larvae, euphausids, and amphipods (Daly et al 2009), and juvenile salmon are highly selective for these preferred prey items regardless of the abundance and composition of available zooplankton (Schabetsberger et al 2003). Since the development of the original plankton monitoring protocol nearly three decades ago, several factors have likely influenced the availability of juvenile salmon food resources including oceanographic changes, declines in groundfish stocks (source of larval fish prey) and changes to the plankton communities (Emmett and Brodeaur 2000, Daly et al 2009). Changes in the magnitude and timing of ocean productivity in the Strait of Georgia (Beamish et al 2004) have likely resulted in a mismatch between the timing of smolt release and the occurrence of spring plankton blooms they rely on as a primary food source (Dave Ewart, personal communication). However, there is a lack of data monitoring the abundance of juvenile salmon prey in plankton communities (Daly et al 2009).

Furthermore, Dr. R. Beamish of Fisheries and Oceans Canada (personal communications) suggests there is a strong correlation between the abundance of coho juveniles found in the Strait of Georgia in early summer and the corresponding return of this population as adults. His research suggests that survival of the juvenile coho salmon is tied to the fish reaching a critical size (nose-fork length), by the summer solstice. Dr. Ron Tanasichuk of DFO, in his studies on the west coast of Vancouver Island (2002) suggests that feed type, particularly zooplankton, and its abundance during Spring plays a primary role in ensuring this early growth in the marine environment.

Hatchery release programs in Alaska have historically used plankton abundance as a guide for timing releases of hatchery reared pink and chum salmon. The Discovery Passage Plankton Monitoring project has focused on developing a program to monitor plankton productivity, and examine the diets of coho captured in the near-shore marine environment. The objective of this program is to develop and a monitoring program that could best predict the timing of smolt releases to coincide with favourable marine food availability to increase juvenile coho survival. This project has completed its third year of phytoplankton and zooplankton surveys in the nearshore marine environment near the Campbell River Estuary. The program sampled salmon to collect early growth and diet information for juvenile coho salmon during the spring. Fish-specific information was related back to the plankton data to establish what the juveniles are eating when they exited the estuary and enter the near-shore marine environment.

The information collected in this program has been used by the staff at DFO's Quinsam River Salmon Hatchery allowing them the opportunity to adjust release schedules for coho smolts if ocean conditions indicate a shift in plankton production. The success of this program will be measured by the survival of returning adult coho salmon to the hatchery, assessed through the retrieval of coded wire tag (CWT) data.

Results

Plankton and Fish Sampling

Between February 24, 2009 and June 29, 2009, 31 plankton sampling trips were completed in Discovery Passage near Campbell River. Sampling was done weekly until mid-March and then biweekly thereafter. Beach seining to sample juvenile salmonids in the nearshore marine habitat, as well as the Campbell River estuary, was done 8 times between Apr 27 and June 29, 2009. Table 1 provides a summary of the sampling dates. Although we weekly throughout May, coho were not caught in the seine until late in the month.

Figure 1 Sampling dates for plankton and beach seining for juvenile salmon, in 2009

Date	February	March	April	May	June
Plankton sampling	24	2, 10, 20,26,30	3,7,9,14,17, 23,27	1,6,8,14,19, 22,25,28	1,4,8,12,15, 18,23,25,30
Beach seine			30	7, 14,21,29	5, 12,19

All of the plankton sampling occurred in the late morning of each day. All tide phases were covered over the sampling period.

Environment

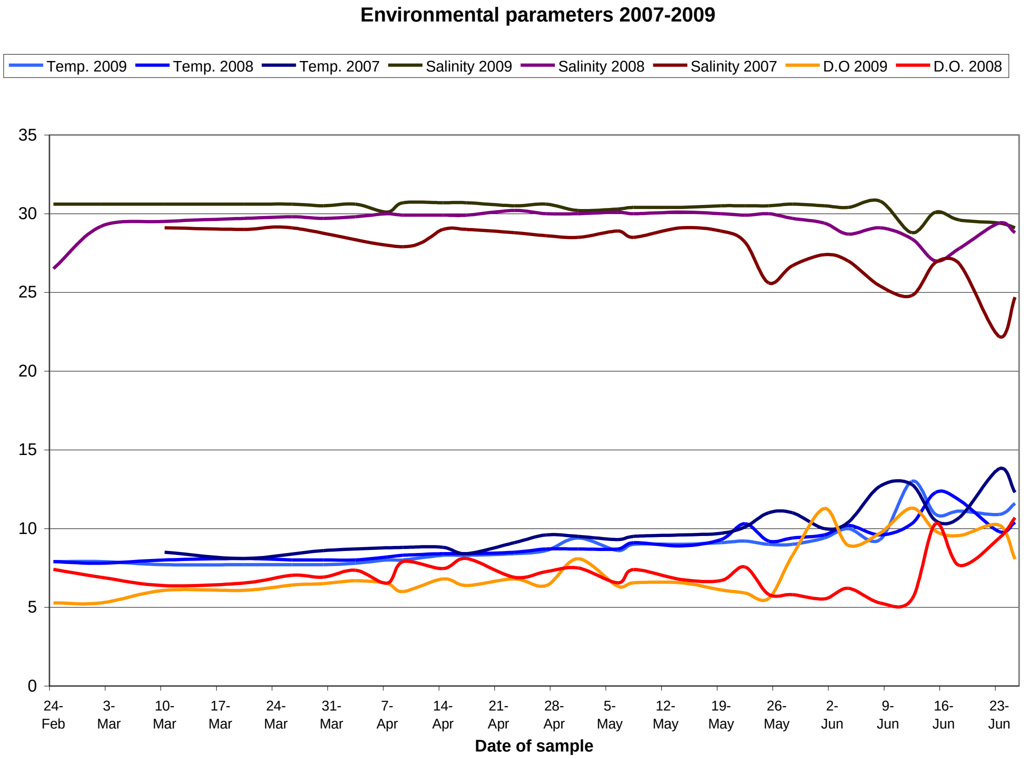


Figure 1. Salinity (S), dissolved oxygen (DO) and temperature (oC) at 5m.

Environmental data collected is summarized in Figure 1. There was a trend towards increasing water temperatures. Salinity over the sampling period was steady around 30ppt. The higher salinity values in 2009 are likely a result of low freshwater input over the winter season. The salinities in 2007 were much lower (25-27ppt) indicating more freshwater influence. The dissolved oxygen levels did not change during the sampling period and stayed below 10 mg/L. The temperatures for all three years track fairly consistently.

Plankton

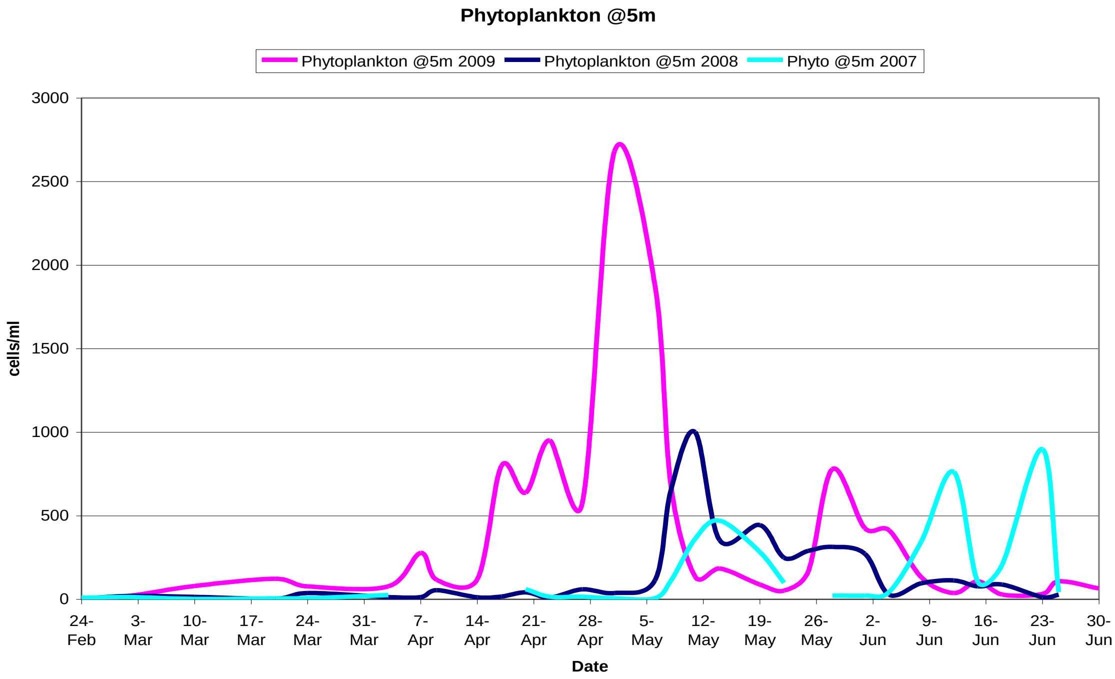


Figure 2 Discrete phytoplankton levels measured at 5m

The first main phytoplankton bloom observed occurred in late April and it was a substantial bloom (see Figure 2) with cell counts remaining high until mid-May. Comparison of the phytoplankton blooms of 2007 and 2008 shows a later bloom in 2008 and 2007 with numbers not as high as 2009. In 2007 there were two more phytoplankton blooms but 2009 saw one major bloom with a small bloom in late May/early June.

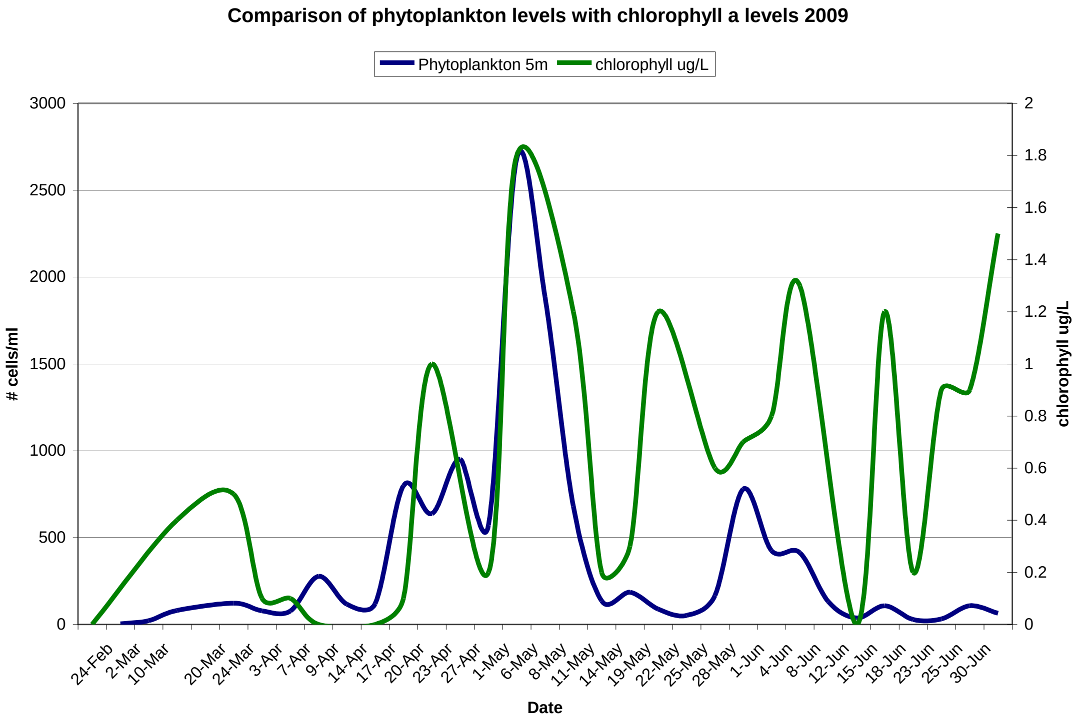


Figure 3 Comparison of discrete plankton sample counts (cells/ml) with chlorophyll a (µ/l) from the same sample.

Phytoplankton densities (measured at 5m) were compared with results from chlorophyll a (Figure 3). Chlorophyll a analysis indicates that both levels track very closely. The correlation between phytoplankton concentration and chlorophyll a is good (r=0.501 p=0.023).

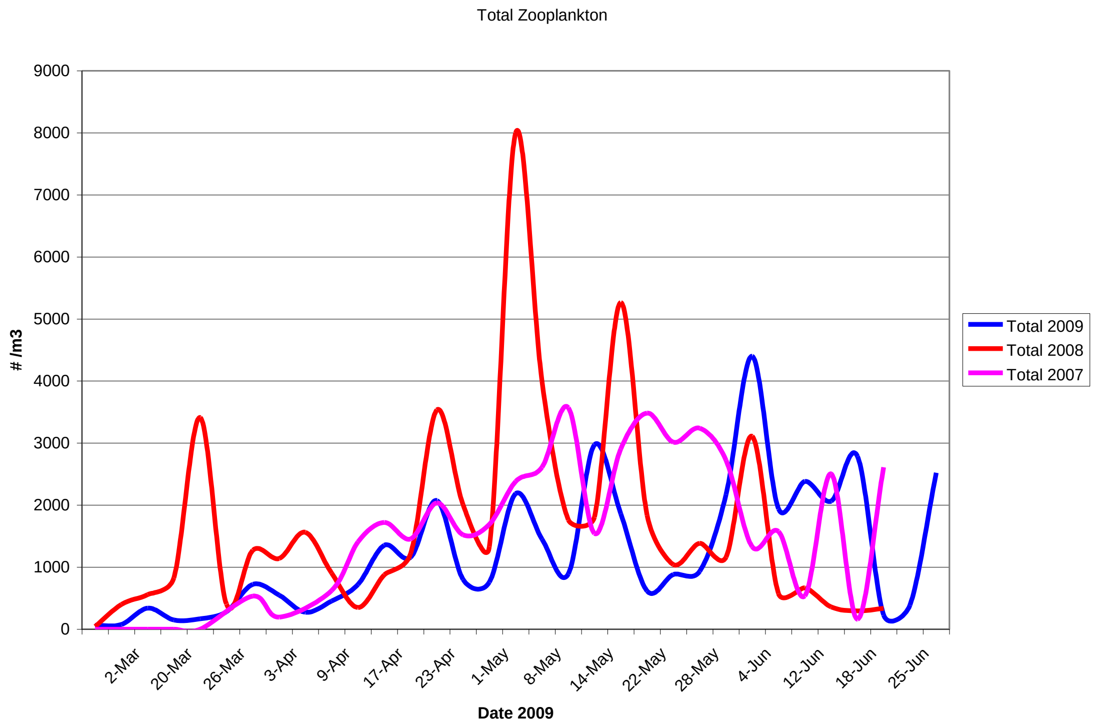


Figure 4 Zooplankton blooms from 2007-2009

For the past three years, zooplankton blooms (Fig.4) have been fairly strong in the early spring and densities have maintained high levels through to early summer. 2008 appears to a particularly strong year for densities.

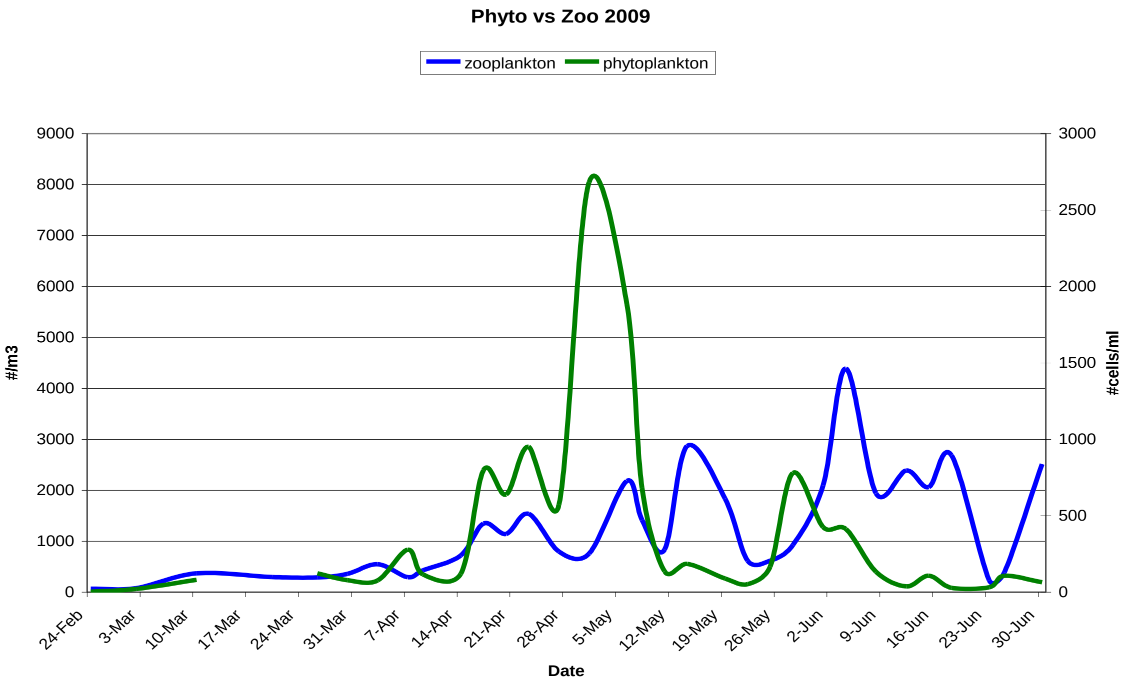


Figure 5 Phytoplankton vs zooplankton trends.

Figure 5 illustrates the relationship between phytoplankton blooms and zooplankton blooms in 2009. The zooplankton densities appeared to increase in association with phytoplankton levels as measured by counts at 5m.

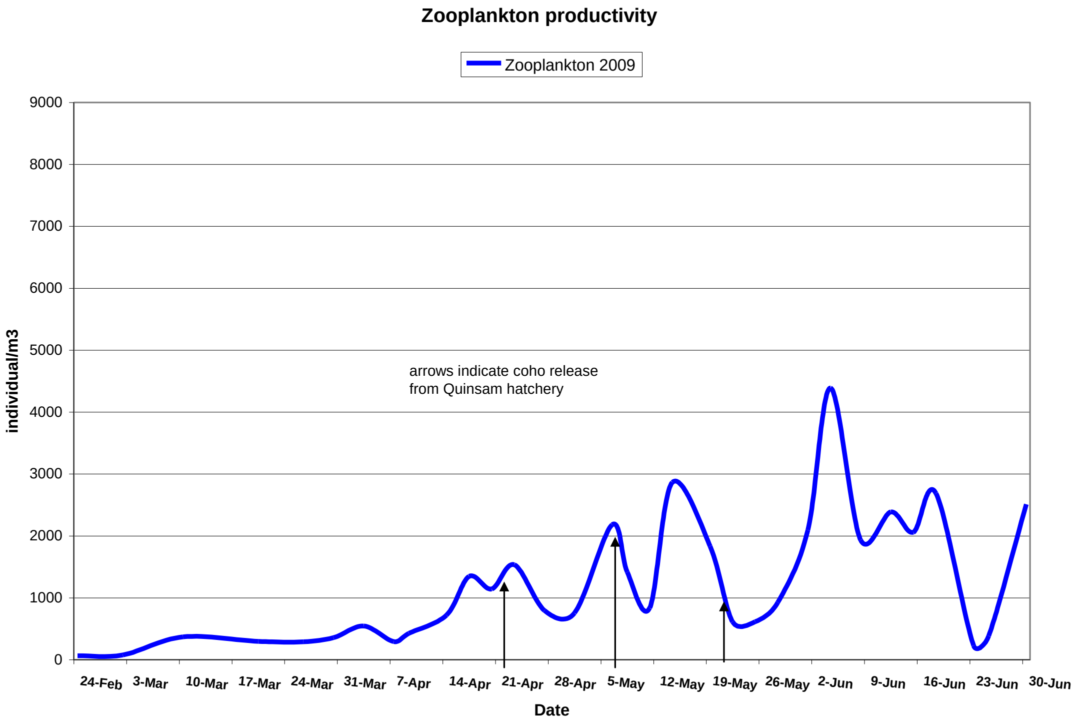


Figure 6 Zooplankton densities at during spring 2009. Black arrows indicate hatchery coho release dates from hatchery.

Figure 6 shows the relationship zooplankton density when the hatchery coho were released into the river. It would appear that the zooplankton numbers in the seawater were high or were increasing at each release date.

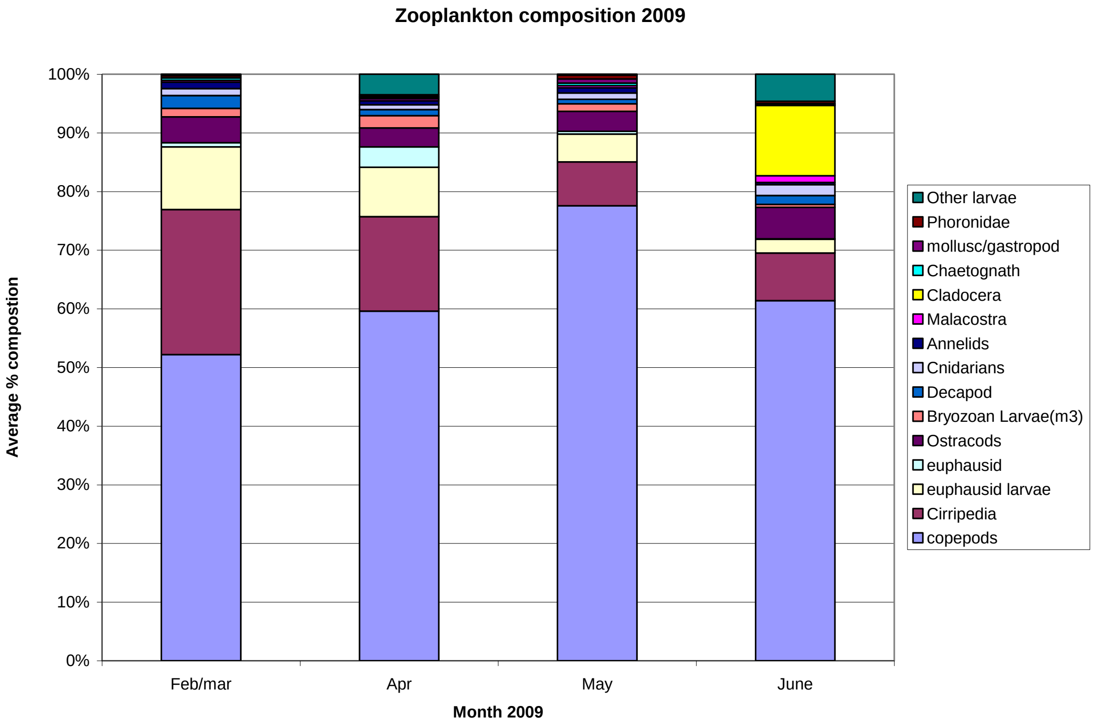


Figure 7 Zooplankton composition 2009

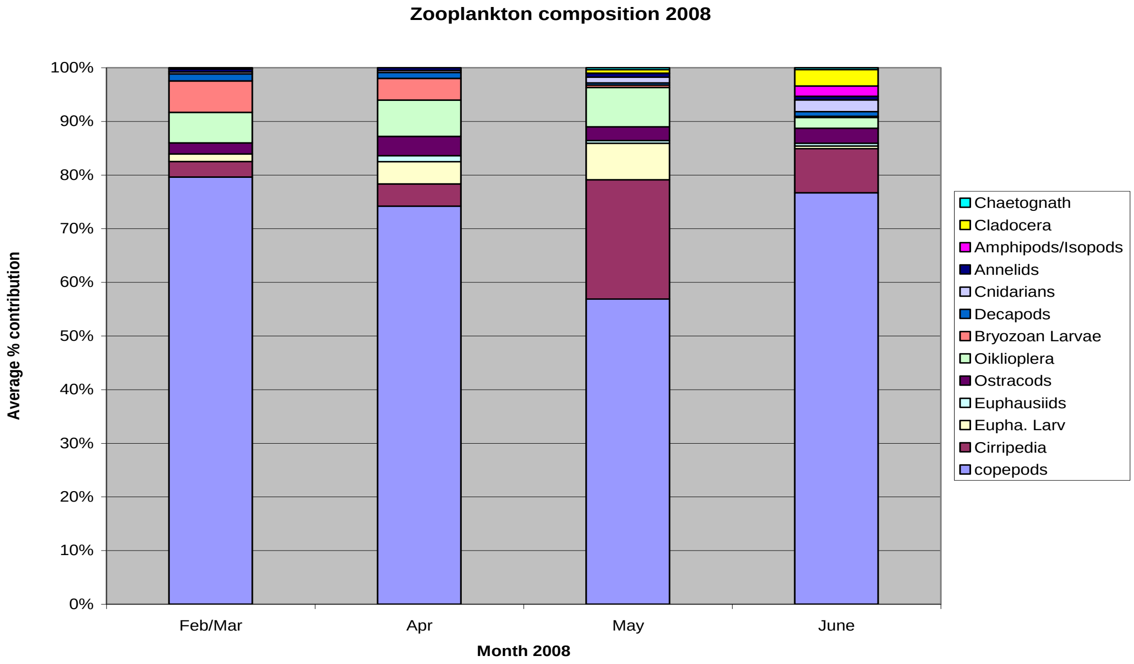


Figure 8 Zooplankton composition 2008

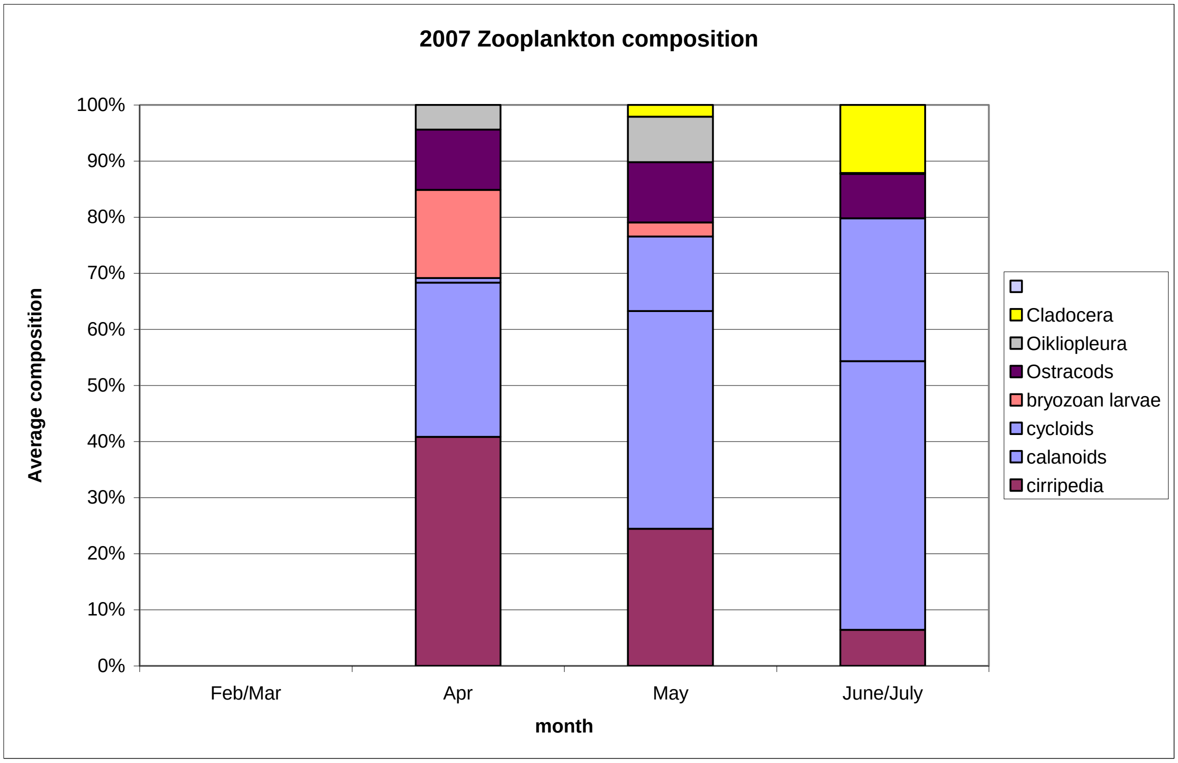


Figure 9 Zooplankton composition 2007.

Figure 7 through 9 illustrate the composition of the zooplankton population during the spring of 2007 through 2009. They show a breakdown of zooplankton groups found at each sampling date. The graph covers the time period shortly before coho releases from Quinsam Hatchery until the end of the sampling period. Copepods and cirripedians represent the majority of the zooplankters in the water during the sampling period. 2008 and 2009 showed a high number of euphausid larvae as well with the larvae appearing in larger numbers earlier in the spring in 2009. These were present throughout the sampling period dominant zooplankton in the tows throughout the sampling period. Euphausid larvae appear to be absent in the 2007 sampling (the technician doing the counting combined the euphasid larvae and cirrepidia larvae together).

During the initial and final beach seines on in early May, no wild or hatchery coho salmon were captured in the near shore salt water. Observations from seines done inside the estuary at the same time (data not shown) showed that the coho were still in the estuary. Although both wild and hatchery coho were caught in the beach seines up unitl the end of June, observations of seines done in the estuary showed that coho were still seen in seines from the estuary. Figure 10 and 11show the average weight and length of the sampled hatchery and wild coho. We found that there was no difference between the length and the weight of the enhanced and wild coho. There was consistently more body fat in the hatchery coho which may be explained by the fact that unlike wild fish, hatchery reared fish are fed on a regular basis allowing them to build up fat reserves.

Fish Data

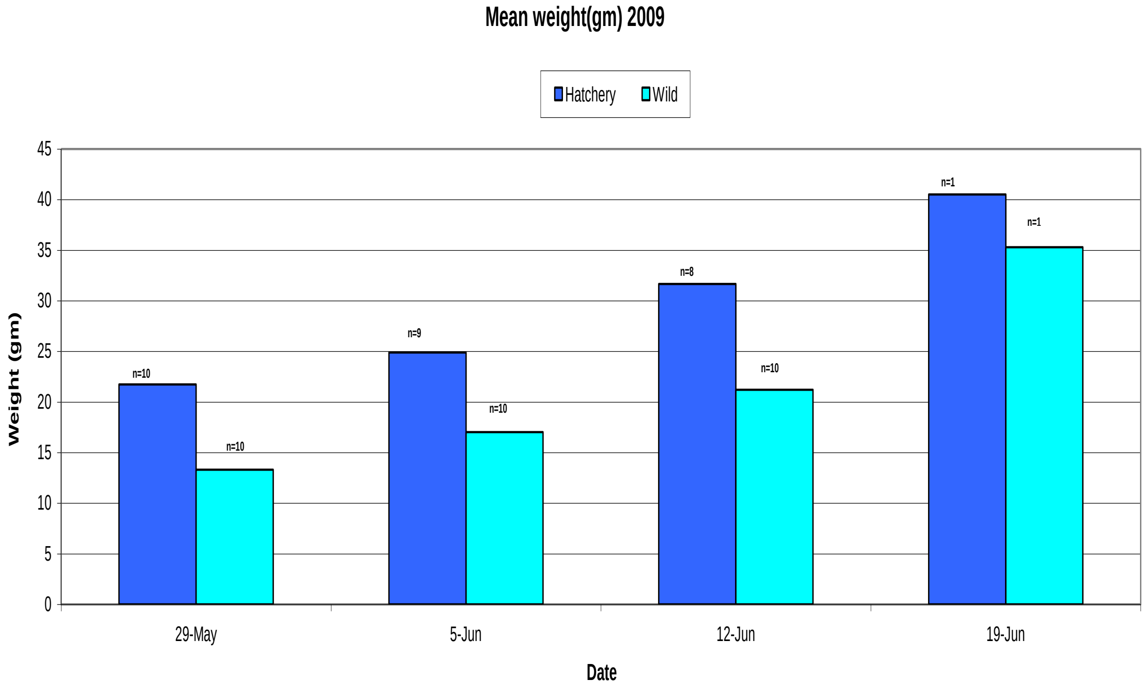


Figure 10 Average weight of sampled hatchery and wild coho.

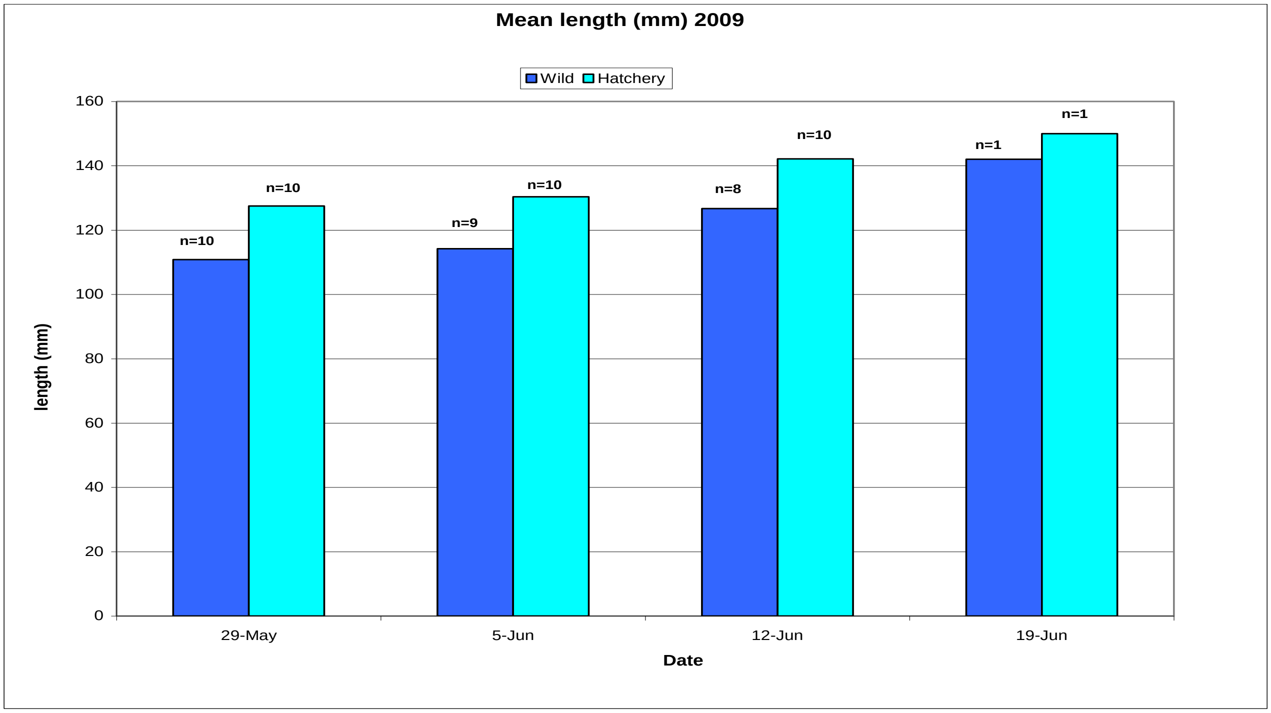


Figure 11 Average length of sampled hatchery and wild coho.

Figure 12 summarizes the stomach contents of the wild and hatchery coho caught during each seine. The dominant zooplankton seen in the stomach samples represent the larger prey items in the zooplankton sample. There is the possibility that any smaller prey would be digested quickly leaving the remains of larger animals in the stomach contents. As with the results of 2007 and 2008, the hatchery coho appear to have more variety in their diet than the wild coho.

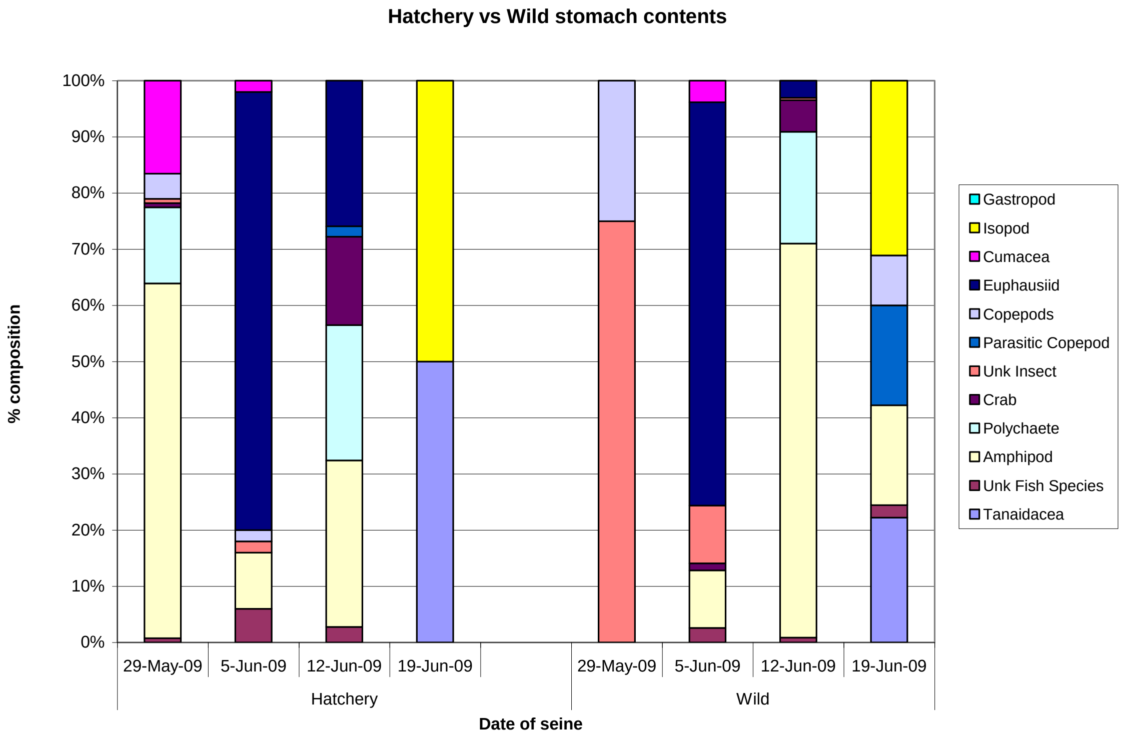


Figure 12. Hatchery and wild coho stomach compositions. % composition based on total numbers of organisms in stomach.

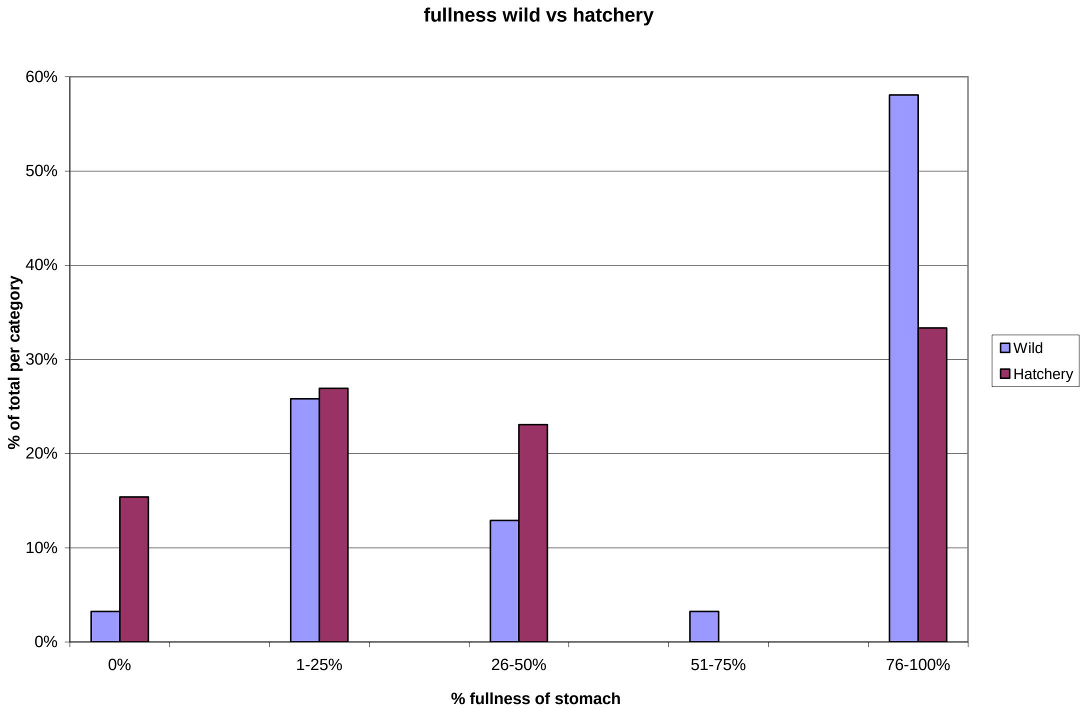
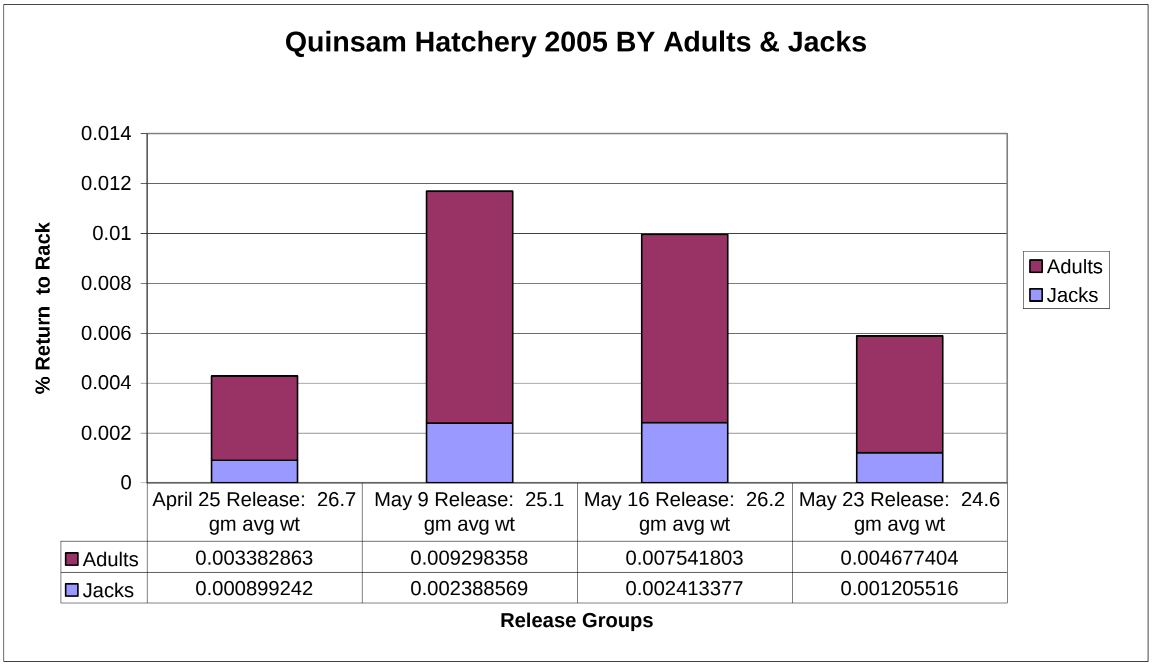


Figure 13 Degree of stomach fullness

Figure 13 demonstrates the degree of stomach fullness of hatchery and wild coho. Most of the fish were eating when they were caught in the seine.



	April 25 Release: 26.7 gm avg wt	May 9 Release: 25.1 gm avg wt	May 16 Release: 26.2 gm avg wt	May 23 Release: 24.6 gm avg wt
■ Adults	0.003382863	0.009298358	0.007541803	0.004677404
■ Jacks	0.000899242	0.002388569	0.002413377	0.001205516

Figure 14

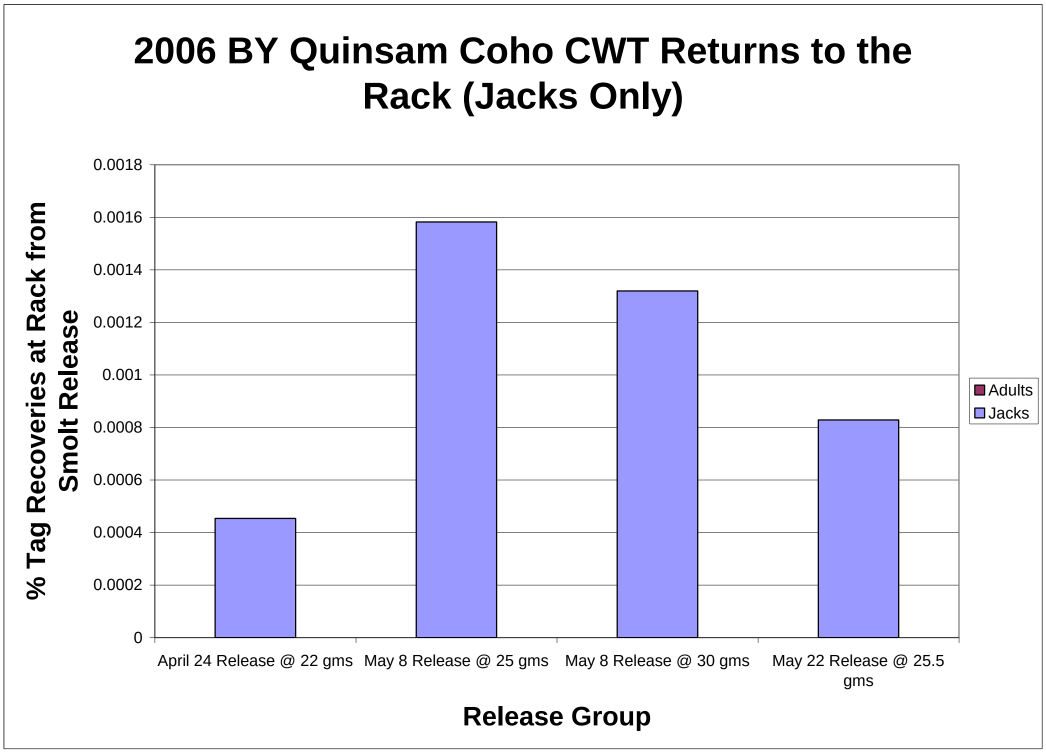


Figure 15

Figures 14 and 15 describe the number of coded wire tagged coho (adults and jacks) that returned to the Quinsam River rack. These numbers represent river escapement and do not include any catch statistics. This data is raw data and has had no statistical extrapolation done to it. Figure 14 represents the brood year 2005 and subsequent coho release in spring 2007 (the first year of the project). The best jack returns were for the Early and Mid May releases, and the best adult returns were in the Early May releases.

Fish Health

Figure 15 represents the 2006 brood year (BY) and subsequent coho release in spring 2008. The jack returns in fall 2008 showed that Early may releases saw the better survival. Adult data is presently being collected.

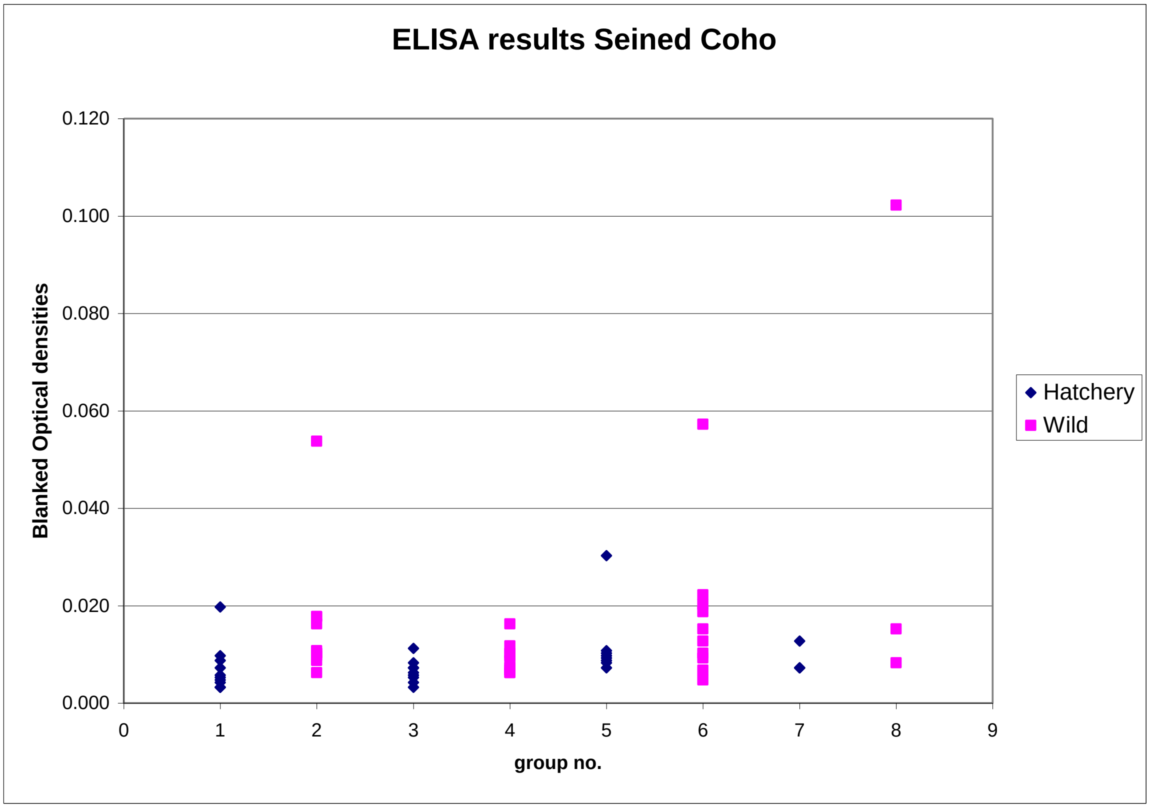


Figure 16 ELISA results for Bacterial Kidney Disease

Sixty-four (63) kidney samples were analyzed using ELISA (Figure 16). Based on DFO cut-off levels (0.14 OD), 100% were BKD negative. All fish tested were below levels set by DFO for release (less than 0.14 optical densities).

Discussion

This project is a cooperative pilot initiative between the BC Centre for Aquatic Health Sciences (BC CAHS) and Fisheries and Oceans Canada (DFO) to establish a plankton monitoring program for the local area, **specifically Discovery Passage and** the near shore ocean habitats encountered by out-migrating juveniles from Quinsam River Salmon Hatchery. Discovery Passage lies at the northern tip of the Strait of Georgia and southern end of Johnstone Strait. This area is a major migration route of many of the lower eastern Vancouver Island and BC interior salmonid stocks. Data on ocean conditions from February to June 2009, including phytoplankton and zooplankton densities, environmental conditions, juvenile salmon diet, timing and distribution have been summarized.

This is the third year of a five year project that is involved in developing a routine sampling program to gather data, summarize it and identify trends in bloom cycles. The phytoplankton data showed a strong phytoplankton bloom in begin in mid- April 2009 and continued until early May. This is earlier than in 2007 or 2008. Water temperatures in 2009 followed similar trends as 2007 and 2008. Phytoplankton densities were compared with the chlorophyll *a* levels and were found to correlate with one another. The data also showed that an increase in phytoplankton levels was followed by an increase in zooplankton density indicating a possible relationship between phytoplankton and zooplankton density. Zooplankton densities increased in early April and the primary constituents of the samples were small copepods and euphasid larvae. The zooplankton levels were increasing in late April into early May at the time the first coho were released from Quinsam Hatchery. There was a good variety of food available to the juvenile coho. During all three releases of coho, the fish encountered high levels of prey although the coho did not appear to leave the estuary until late May which coincided with the best zooplankton densities in the nearshore environment. In comparison, in 2007, there were a 2 additional phytoplankton and zooplankton blooms throughout the spring. Both 2007 and 2008 data showed that zooplankton levels increased in conjunction with increasing phytoplankton density.

Chlorophyll and phytoplankton abundance

Chlorophyll a levels were positively correlated with phytoplankton density (r=0.501 p=0.023) for the third year in a row and would therefore be a good indicator of phytoplankton titres. Our evidence suggests that discrete sampling at specific depths may not be the most appropriate method to assess phytoplankton due to boat and crew availability. Laboratory analysis of phytoplankton samples is also time consuming, making quick turnaround of results difficult, especially if multiple samples are being submitted from various areas. The vertical net tow proved useful in identifying what the make up of the phytoplankton was but the time commitment for analysis was extreme, especially during periods of blooms. In all three years, chlorophyll a levels indicate increasing phytoplankton activity not shown in discrete samples. This is likely due to the fact that the quantifying of phytoplankton is limited to species larger than the 20 -50 um range. chlorophyll a sampling would allow early detection of small phytoplankton that precedes the bloom of the larger diatoms in the spring. Identifying when the major phytoplankton bloom occurs may give more flexibility in adapting the monitoring schedule for zooplankton. The hatchery would then have more lead time to adjust any changes in the release schedule of the coho smolts. In the summer of 2009 (after sampling had ceased),BC CAHS received by donation from Turner Designs,a bench top Trilogy Laboratory Fluorometer. In 2010, we will eliminate the phytoplankton sampling portion of the sampling portion. This will allow us to establish chlorophyll a levels quicker and allow other facilities and users to have samples analyzed. We would work closely with Valerie Forsland (Ocean Chemistry Division, IOS, Victoria, BC) and instigate a standard sampling regime including 10% duplicates to maintain data quality and integrity.

Zooplankton versus gut content abundance

According to coho smolt gut content analysis, amphipods and polycheates were a dominant species observed in the stomach analysis but not a significant component of zooplankton samples. This finding could be a result of sampling for zooplankton during daylight hours, as many zooplankton species are known to have vertical migration patterns (moving up the water column at night). Amphipods, polycheates, and isopods tend to be benthic forms of zooplankton and sampling the entire depth of the water column near shore may not result in capture of these animals.

For the third year in a row, the hatchery coho appear to have a more varied diet than the wild coho perhaps indicating a learning curve as to the best prey type when the hatchery juveniles get to the marine near shore environment. The coho were maintaining themselves in the estuary for much longer than anticipated even though there seemed to be a good food supply in the nearshore environment. (Data collected by Fisheries and Oceans at time of each seine). This may indicate that there was also a sufficient food supply inside the estuary.

Results from this spring sampling would indicate that this year's release dates for the coho was optimal.

Coded Wire Tag Returns to Quinsam Hatchery

Jack returns in fall of 2007 indicated that the juveniles that were released into a zooplankton bloom, (early May, a period of high productivity), had better returns than the fish released earlier, (late April), and later, (end of May). The adult return data indicates that the early May release coho also had the better return numbers.

The jack returns in the fall of 2008 (spring 2008 release) indicate that early May releases did better and this is also indicated in the adult returns in fall of 2009. Our zooplankton sampling indicated that there were high densities of zooplankton in the water for both these release dates.

Juvenile coho released in spring of 2009 had jacks return this fall)(2009) and again the early May release indicate a better survival. We saw the highest zooplankton densities occur at this time.

These results indicate that the timing of juvenile releases to time with best zooplankton availability is an important tool. The fact that we may not be able to find many coho in the beach seines may indicate that the fish do not spend much time in the nearshore when zooplankton densities are high. Our estuary sampling this year indicated many juvenile coho staying in the estuary longer and this may indicate that food densities in that environment were also high. The juveniles may have found this a more favourable environment to remain in for longer.

Fish Health

The ELISA results for Bacterial Kidney Disease indicate that the hatchery coho had low levels of BKD but were well below the DFO cutoff for release. There would appear to be low to negative levels of BKD in these stocks would indicate that returning brood also have low levels of BKD. This disease is endemic in our wild fish but Quinsam Hatchery would appear to have healthy returning stocks. This could be further evaluated through broodstock screening at the hatchery during spawning.

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