

GREAT LAKES FISHERY COMMISSION

2001 Project Completion Report<sup>1</sup>

Compensatory Mechanisms in Great Lakes Sea Lamprey  
Populations: An Integrated Program of Research and Assessment

by:

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November 2001

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November 30, 2001

Final report of research for the Great Lakes Fishery Commission,  
Ann Arbor, MI.

## **Completion Report for the Sea Lamprey Compensatory Mechanisms Project**

### **The Streams**

Grafton Creek (also called Barnum House Creek), approximately 12 km east of Cobourg, Ontario, had a Sea Lamprey Control Centre (SLCC) low-head barrier installed in 1987 and was last treated with 3-trifluoromethyl-4-nitrophenol (TFM) above the barrier in May, 1988. Since this time, there have been no recorded incidents of sea lamprey passage over the barrier. Grafton Creek is divided into two sections: a lower section of approximately 4.5 km from the SLCC barrier to a small (low-head type) barrier in the Conservation Area and an upper section of approximately 4.2 km. The historical distribution of sea lampreys in the upper section was separated from a previously un-colonized portion of the stream by an old milldam. This structure was destroyed by a flood event in the early 1990's. Consequently, we installed a (temporary) low head barrier to prevent introduced adults from reaching new habitat and to reduce the requirements of the post study treatment program.

The second stream, Port Britain Creek, is located approximately 8 km west of Port Hope, Ontario. A SLCC low-head barrier was built in 1989, and the entire stream (9.6 km) was treated with TFM in May of 1991. There have been no recorded breaches of the barrier by sea lampreys since this treatment. On Port Britain Creek, we reduced the amount of stream available to the sea lampreys to 3.2 km by the construction of a (temporary) low head barrier at the HWY 401 bridge. This barrier reduced the available spawning habitat and the amount of stream that will require treatment at the completion of this project. The lower section of stream is also divided approximately in half at 1.5 km by the CN train bridge which has a drop of about 1 m in the summer months. Temperature data loggers are installed in both streams to monitor daily conditions.

Salem Creek, located 15 km west of Brighton, Ontario, was added to the project in the spring of 1999, for one year. This is an open system, providing sea lampreys with approximately 2.8 km of stream before reaching a 2 m high barrier. There are currently four beaver dams on the stream, providing 'natural' sections. The majority of the spawning habitat occurs within 1.5 km of the stream mouth, and a large beaver dam (1.3 m) at 2116 m from the stream mouth is likely a sea lamprey impediment. For these reasons, the majority of the spawning surveys were confined to the area of stream within 1500 m from the estuary. One temperature data logger was installed in Salem Creek to monitor daily conditions.

## Adult additions

### 1998

Grafton Creek, the stream receiving the low-density addition of adults (see research proposal), received 106 males and 100 females in the upper portion of the stream on May 2, 1998<sup>1</sup>. The lampreys were taken from traps on both the Humber River (80%) and Duffins Creek (20%). For both sexes, all were measured ( $\pm 1$  mm) and 60% of the animals were weighed ( $\pm 1$  g) and tagged with an individually numbered cantilever zip tag, and all received a distinctive v-notch clip to differentiate between streams and sexes.

Adult sea lampreys for Port Britain Creek, the stream receiving the high-density addition of adults<sup>2</sup>, were brought from the trap on the Humber River on May 4, 5, and 6. Because of an initial mortality, we counted our total introduction of sea lampreys as those animals surviving on May 9. Thus we introduced a population of 259 males, (147 tagged, 57%) and 231 females, (151 tagged, 65%). The sea lampreys were introduced at the 'top end' of the stream and were again marked with a distinctive v-notch clip to differentiate between streams and sexes.

### 1999

Sea lampreys were transported to Grafton Creek from the Humber River on May 6. The number of adults remained the same as in 1998. An initial mortality between May 6 and May 7 resulted in a final introduction of 178 sea lampreys for 1999. All sea lampreys were sorted by sex and tagged with a distinctive v-notch denoting the sex of the animal and the stream of introduction. In addition, approximately 50% of the sea lampreys were tagged using an individually numbered polyethylene streamer tag (PST); thus, 85 males (46 PST tagged, 54%) and 93 females (46 PST tagged, 49%) were introduced. As well as the PST tags, 10 female sea lampreys received an individually pulse-coded ATS radio transmitter.

In 1999, the number of sea lampreys introduced into Port Britain Creek was reduced to match that of Grafton Creek (100 per sex). Adult sea lampreys were transported from the Humber River and Duffins Creek on May 7. An initial mortality of three male sea lampreys reduced the total number introduced to 201. Approximately 50% of the sea lampreys were tagged with PST tags, and 10 females received individually pulse-coded ATS radio transmitters, for an introduction of 102 females (50 PST tags, 49%) and 99 males (50 PST tags, 51%). Due to

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<sup>1</sup> This number approximates the estimate of the number of spawners required to yield age-1 larval densities of 5/m<sup>2</sup> (0.017 spawning females/m<sup>2</sup> of larval habitat, 100000 eggs/female, 0.01 survival to age-0, 0.4 survival to age-1). This number approximated the minimum number of additions (130) called for in the Sterile Male Release Technique (SMRT) protocol (Twohey et al. 200x).

<sup>2</sup>The number of adult spawners added is estimated to yield age-1 larval densities of approximately 13/m<sup>2</sup> using parameters in footnote 1.

predation of female sea lampreys with radio transmitters, two more were added on May 13, bringing the total number of females introduced to 104. On May 20, a tagged male (from Port Britain Creek) was re-released into the stream and on May 26, 10 male sea lampreys, marked with fin v-notches and PST tagged, were released to into the stream to provide marked animals for an abundance estimate. The total number of males introduced in 1999 was 110, for a stream total of 214 sea lampreys.

## **2000**

On May 10, 2000, adult sea lampreys were introduced into both Port Britain and Grafton creeks. The introduction locations remained the same as in 1998 and 1999, at the upper temporary barriers in both streams. A total of 50 females and 51 males were released in Port Britain (total 101) and 44 females and 58 males in Grafton Creek (total 102). The numbers released were approximately the same in both streams and about half the number of adult sea lampreys released in 1999. Adults were collected in both the Humber and Duffins Creek traps. All animals were measured ( $\pm 1$  mm), and 50% were weighed ( $\pm 1$  g). All adults were marked with unique fin clips denoting the stream of release, sex, and all adults were tagged with an individually numbered PST tag.

## **2001**

Adult sea lampreys were not introduced to either Port Britain or Grafton creek in 2001.

## **Nesting Observations**

In 1998 and 1999 all of the streams were walked on a regular basis by trained observed who looked for evidence of live animals, evidence of nesting and later, presence of sea lamprey carcasses. All 'sea lamprey like' depressions, those areas in riffles, mixed gravel, pebbles and small boulders that appeared cleaned and disturbed, were sampled for the presence of sea lamprey eggs (whether adults were seen on the nest or not). Any nest found to contain sea lamprey eggs was marked with a visible numbered marker. A site map was drawn to show the nest location in the stream, and the eggs were later staged according to Piavis' (1971) embryology key. For any adult sea lampreys located on a nest, the sex of the lamprey and the presence of any individual tag numbers were noted. In order not to disturb the spawning pairs (where located), the nests were marked and then sampled within 24 hrs (after the sea lampreys had left the nest) to determine if egg deposition had occurred.

## 1998

In Grafton Creek, the first sea lamprey nest containing eggs was found on May 18 and the last new nest confirmed nest was located on June 22, however using Piavis' 1971 embryological key determined the nest was approximately six days old (approximate spawning date June 17). A total of 20 nests with eggs were located in the stream during the spawning period (Figure 1). In addition to the nests with eggs, a total of 64 nests that did not contain sea lamprey eggs were found and sampled, for a total of 84 nests. Thus, 76% of the nests found in 1998 were not used by spawning sea lampreys for egg deposition. Only one pair of spawning sea lampreys was observed on a nest (June 11) that was later found to contain sea lamprey eggs. In total, 14 (nine males, four females, one unknown sex) live sea lampreys were observed; 11 were involved in nest building behaviour (two females, seven males, one pair) and three were swimming or resting (no nest associated with the individual).

In Port Britain Creek, the first nest with eggs was located on May 18 and the last on June 22; however, using Piavis' 1971 embryological key, this nest was found to be approximately four days old (approximate spawning date of June 18). A total of 20 nests were located during the spawning period. Two of the nests contained a second spawning, the first on May 23 and the second on May 28, for a total of 22 spawning events by sea lampreys in the stream in 1998 (Figure 2). In addition to the nests with eggs, 63 nests without egg deposition were located, for a total of 85 sea lamprey nests. Overall, 75% of the nests located did not contain sea lampreys eggs in 1998. A total of 94 (20 male, 20 female, remainder sex not determined) live sea lampreys were seen. Only nine paired sea lampreys and one male were observed on nests later found to contain sea lamprey eggs. Only one nest located without egg deposition was observed with a sea lamprey, in this case a lone female. Additionally, 74 sea lampreys were observed either swimming or resting during the spawning period. The number of nests and the dates found for Grafton and Port Britain Creeks are summarized in Figure 3.

## 1999

The first nest in Grafton Creek was located on May 29 and the last was constructed on June 17. A total of 57 nests with eggs were located during the spawning period. Multiple nest use was common in 1999. In total, 45 (79%) were used only once, seven (12%) a second, three (5%) for a third spawning and two (4%) for a fourth spawning. A total of 76 spawning events were confirmed during the spawning period (Figure 4). Sea lampreys were observed in 54 of the 76 nests (71%) in a variety of pairings. Monogamous spawning pairings were observed on 17 (31%), polygamous (one male, two females) on 11 (20%), single males 15 (28%), single females seven (13%), multiple females (three) with one male on two (4%), two females on one (2%) and one

nest with two males and two females (2%). Of the 55 females observed on nests with eggs, 41 (87%) were observed on one nest, four (9%) on two and two (4%) on three separate nests during the spawning period. For the 47 males, 35 (88%) were located on one nest, four (10%) on two, and one (3%) on four nests. In addition to the nests with eggs, a total of 60 nests without egg deposition were sampled, for a total of 136 nests during the spawning period.

The first sea lamprey nest with eggs was located in Port Britain Creek on May 26 and the last was found on June 5, for a total of five nests. A second spawning event was confirmed in one nest, bringing the total spawning events to six (Figure 5). A total of eight nests without egg deposition were located in the stream during the spawning period, bringing the total number of nests to 14. Only three (one male, one female, one unidentified) live sea lampreys were seen in 1999, though none were involved in either nesting or spawning.

Salem Creek was followed for nesting observations at the same time as both Port Britain and Grafton Creeks. The first nest with eggs was located in Salem Creek on May 23 and the last on June 12. A total of 18 nests with eggs were located and one nest was used for a second spawning, for a total of 19 nesting events (Figure 6). Throughout the spawning season, 11 nests without egg deposition were located, for a total of 30 nests. Twenty-three live sea lampreys were seen during the spawning period. The time of nesting on all three streams is compared in Figure 7.

## **2000**

Nest surveys were conducted on June 18 – 21 and June 26, 27, 2000. High water and cooler temperatures occurred in both streams in 2000. No nests were located in Port Britain Creek, though high water (bank damaged indicated flows of at least 1 m above normal levels), may have obliterated any signs of nesting. The recovery of one 1 young of the year larvae, (see larval section), indicates that successful spawning did occur in 2000.

In Grafton Creek, a total of nine nests were located on June 20. Sea lampreys were found on three nests and egg samples from the remaining nests indicated spawning had occurred within two days of nest discovery. A total of 12 sea lampreys were located in 2001, 2 pairs, 5 males and 1 female. Spawning occurred later in 2000 in Grafton Creek, compared to 1998 and 1999 when spawning was completed by approximately June 17. Again, effects from high water were evident in Grafton Creek. Nests were re-examined on June 26, 27. Only five nests were located and surveys took place in conditions of higher water and greater turbidity. The presence of young of the year larvae, (see larval section), again confirmed that successful spawning had taken place.

Table 1: Summary of spring sea lamprey observations for Grafton, Port Britain and Salem creeks for 1998, 1999, 2000.

	Grafton Creek			Port Britain Creek			Salem Creek
	1998	1999	2000	1998	1999	2000	1999
Number of adults released	206	178	102	490	214	101	67 <sup>6</sup>
Total mortality (live release)	61	18 <sup>5</sup>	1	106	18 <sup>5</sup>	N/A	3
Estimated at spawning	112	133	N/A	375	N/A	N/A	36
Number of nests with eggs	20	76 <sup>2</sup>	9	22 <sup>1</sup>	6 <sup>3</sup>	0	19 <sup>4</sup>
Total number of nests	84	136	8	85	14	4	30
Number of live sighting	14	143	12	94	3	0	23
Nests (eggs)/estimated adult	0.179	0.571	0.088	0.059	0.031	0.040	0.528

<sup>1</sup>20 nests found; two confirmed 'double spawns'

<sup>2</sup>57 nests found; 45 (one spawn), seven (two spawns), three (three spawns), two (four spawns)

<sup>3</sup>5 nests found, one confirmed 'double spawn'

<sup>4</sup>18 nests found; one confirmed 'double spawn'

<sup>5</sup> carcasses recovered in stream and 12 radio tagged animals 'removed' in Port Britain and two in Grafton, carcasses not recovered

<sup>6</sup>Schnabel Population Estimate for Salem Creek

### Population Estimates at Spawning

In 1998, Port Britain and Grafton creeks had the population of adults remaining at the time of spawning estimated both by the direct counts of those that emigrated, were removed by predators and those that died prior to spawning and through the use of a Petersen mark/recapture abundance estimate. For the Petersen mark/recapture estimates, large sections of the streams were electrofished, and any sea lampreys collected were measured, weighed, re-marked and re-released. The recapture of marked animals when spawning began was used to estimate the abundance remaining at the time of spawning.

In 1999, an additional stream, Salem Creek, was added to the study as an open system to complement Port Britain and Grafton creeks, where the total number of adults introduced was known. In order to estimate the number of animals in Salem Creek, two portable traps were placed in the stream and a Schnabel population estimate was calculated to estimate the size of the sea lamprey population during the spawning migration.

The use of the direct counts for those that emigrated, were attacked by predators, and those that died prior to spawning, were applied to all three streams during the spawning period in 1999. A Petersen mark/recapture estimate was also undertaken in all three streams at the time of spawning using electrofishing as a method of capturing adults for re-marking purposes. In Port Britain Creek, no adult lampreys were captured, though the entire stream was eventually electrofished. As a result, 10 male sea lampreys (marked) were added on May 26. Portable traps were added to both Port Britain and Grafton creeks in 1999 in an effort to mark more lampreys in



a less stressful manner. The traps fished for approximately 15 days in Grafton and eight days in Port Britain Creek.

## **Direct Estimates of Numbers Remaining at Spawning**

### **Pre-spawning Mortality:**

#### **1998**

In Grafton Creek, we began to find carcasses on May 13, almost two weeks after our initial introduction of adults (Figure 1). A peak in sea lamprey mortality occurred on May 18, coinciding with the discovery of the first confirmed sea lamprey nest. The carcass discovery rate fell sharply after this point but continued to occur throughout the spawning period. The last carcass was found on June 20, a male found in a pool, but the carcass was decomposed. A total of 61 (32 male, 28 female, one unidentified) carcasses were found in 1998.

In Port Britain Creek, observations made after the adult introduction followed a similar pattern to that of Grafton Creek. After an initial mortality at the time of introduction, the first carcass was discovered on May 15 (Figure 2). The first confirmed sea lamprey nest was located on May 18, and a peak in mortality occurred on May 20. The carcass discovery rate continued to fall after this point but continued through the spawning period. The last carcass was found on June 9, and our last nest was found on June 22. A total of 106 (51 male, 52 female and 3 unidentified) were found in 1998.

In 1998, mortality may have been related to the cantilever-zip tag that was used on the sea lampreys as the proportion of tagged lampreys found was significantly greater than those not tagged for both Port Britain and Grafton creeks ( $\chi^2$ ,  $p < 0.05$ ). The ratio of male and female mortalities was the same (1:1) for both tagged and untagged lampreys. The proportion of carcasses collected with tags indicated a total mortality rate of 29% in Port Britain Creek and 41% in Grafton Creek. For the lampreys without tags, the rates are 10 and 13% for the same streams. Carcasses, with and without tags, were collected over the 51 days of the study period.

#### **1999**

In Grafton Creek in 1999, mortality occurred throughout the spawning period and was not associated with the nesting period as in 1998. A total of eight carcasses (five female, three males) were found in the streams and an additional six females and two males were captured. Four females were removed from nests and two were captured in the stream. One male was collected beside a nest and the second was swimming in the stream. Three additional females

thought to be dead were not recovered. The use of radio telemetry indicated three radio signals in inaccessible locations: under the temporary dam, and two in deep undercut banks. It is unknown if the females perished in these locations or if the tags became entangled and pulled off. The first carcass was recovered on June 3 and the last on June 12. The relationship between mortality and nest counts is shown in Figure 4.

Few carcasses were recovered in Port Britain Creek in 1999. A total of six carcasses, five females and one male, were located during the spawning period. The first carcass was located on May 12 and the last on May 25. Mortality did not follow the timing of nest construction, as in 1998 (Figure 5).

In Salem Creek, three carcasses were located during the daily stream walks. One female and two males were collected in the stream during the spawning period in 1999 (Figure 6).

In 1999, mortality did not appear to be related to either the timing of nesting as in 1998, nor did it appear to be tag related for any of the 3 streams. The use of the PST tag was continued in 2000 as a result of the decreased mortality in 1999.

## **2000**

One carcass was recovered in Grafton Creek on June 19, while no carcasses were recovered in Port Britain Creek. Few stream walks (six) were conducted during the time of spawning in 2000 in either stream due to high water and poor visibility.

## **Predation:**

Predation occurred in 1998 and 1999 in both Port Britain and Grafton creeks. Predation was determined in 1998 through the recovery of carcasses in the stream. A total of three sea lampreys were recovered in Port Britain and two in Grafton in 1998.

In 1999, the addition of the radio-telemetry component of the study indicated, at least in Port Britain Creek, that predation may have had a greater effect on spawning sea lamprey populations than previously observed. Based on the radio-telemetry information, predation rates on Port Britain Creek were high, with 11 of the 12 radio-tagged females (92%) removed from the stream by May 26. In eight cases, the transmitter was located on the stream bank with the wiring harness chewed through and the carcasses were not recovered, and for three other sea lampreys, the radio transmitter was tracked to an animal den and neither the tag nor the carcass was recovered. One additional radio tag was recovered in the stream, without the sea lamprey, so was not known how the tag became dislodged. The use of direct counts of carcasses would have led to an underestimation of predation, as only one carcass was recovered in 1999. Thus, it is possible

were marked for a population estimate at the time of spawning. The results of the Salem Creek population estimates are summarized in Table 2.

Table 2: Petersen population estimates, and known sea lamprey removals (mortality, predation, emigration):

	Potential (introduced-known removals)		Petersen Estimate (95% Confidence Limits)		Difference	
	1998	1999	1998	1999	1998	1999
<b>Grafton Creek:</b>						
All sea lampreys:	139(206 – 61)	159 (178-18)	112 (53-236)	133 (83-211)	27	26
All males:	74 (106 – 32)	80 (85 - 5)	55 (21– 121)	74 (38-150)	19	6
All females:	72(100 – 28)	82 (93 – 13)	50 (20-111)	63 (37-111)	22	19
<b>Port Britain Creek:</b>						
All sea lampreys:	380(490-106)	194 (214-18)	375 (203-699)	N/A*	5	N/A*
All males:	208 (259–51)	108 (110-1)	156 (69 – 343)	N/A*	52	N/A*
All females:	179 (231–52)	86 (104-17)	180 (85 – 381)	N/A*	-1	N/A*
	Schnabel Estimate		Petersen Estimate			
<b>Salem Creek:</b>	1998	1999	1998	1999	1998	1999
All sea lampreys		67		36 (13-71)		31

\*Populations estimates could not be calculated as no marked sea lampreys were recovered

## Sea lamprey carcass sampling

### 1998

Of the total (842) sea lampreys transported to the two streams, 318 died. 169 carcasses were frozen at the time of death: 30 from Grafton Creek and 139 from Port Britain Creek. All carcasses were checked for the presence of a tag number, electrofishing clip, sex, and reproductive status. Only one sea lamprey was labeled in the field as spawned, but upon dissection that was not the case (very small female). One sea lamprey was a small, almost undifferentiated male and it was not kept for further analysis.

Of the collected carcasses, 79 sea lampreys were re-weighed and a length taken and 78 (49 from Port Britain and 29 from Grafton) were saved for lipid and caloric analysis. For these sea lampreys, the gonads were removed and weighed separately, and for all females, five egg sub-samples were weighed, counted and used to estimate fecundity. Two of the animals from Port Britain Creek were incorrectly marked as females (1%). One died at release and the second was found later. No animals from Grafton Creek were known to be incorrectly sexed. The ratio of male to female carcasses was approximately 1:1 both creeks. In both locations we found sea lampreys whose sex was indeterminate as only the head portion was found (predation).

### 1999

habitat was reduced by more than seven times the estimated amount in 1999 and Type II was reduced to about the 1998 levels. In 2000, numerous flooding events occurred, as recorded by measurements at the permanent sea lamprey low-head barriers. In total, the lower traps were inoperable for approximately 13 days in each stream due to high water conditions. The floodwater conditions likely removed/redistributed some of the available Type I habitat in both streams compared to previous years. In 2001, following the fall flood events of 2000, low water conditions occurred throughout most of the Great Lakes region. Water levels in Port Britain and Grafton creeks were some of the lowest observed in approximately 20 years (Ganaraska River and Lower Trent Conservation Authorities, personal communications). Though the water levels were lower than in the past during the summer, by fall the mean stream widths were approximately the same as in the previous survey years. Type I and Type II habitat amounts appeared to be more consistent with pre 2000 surveys.

Table 7 summarizes the number and area of Type I and Type II plots surveyed in both streams from 1998 to 2001. Both the number of Type I plots and the total Type I area electrofished increased in 2001 for both streams, while the number of plots and total area of Type II habitat electrofished was consistent with past surveys for 2001.

Table 4: Comparison of stream length, width, and area, 1997 to 2001.

	Stream Length (m)	Mean Stream Width (m)	Total Area (m <sup>2</sup> )
Grafton Creek			
1997 <sup>1</sup>	9289	3.6	33440
1998 <sup>2</sup>	9716	3.4	32743
1999 <sup>3</sup>	8408	3.5	29428
2000 <sup>3</sup>	8190	3.8	31099
2001 <sup>3</sup>	8070	3.5	27842
Port Britain Creek			
1997	3200	5.1	16320
1998	3200	5.2	16672
1999	3229	5.1	16328
2000	3242	5.3	17150
2001	3200	5.2	16640

<sup>1</sup>length excludes the distance from Stn. 13 to Stn. 21 – width measured every 50 m

<sup>2</sup>includes entire stream length up to transect 105, and average width for all transects sampled

<sup>3</sup>length excluded approximately 1 km of the upper tributary, as the creek was less than 1m wide and 3cm deep in the fall.

Table 5: Comparison of % habitat type in SMRT surveys

Year	% Type 1	% Type 2	% Type 3	% Type 4
Grafton Creek				
1997 <sup>1</sup>	8.4	17.1	74.5	N/A
1998	4.4	20.5	73.7	1.4
1999	5.2	15.1	77.0	2.7
2000	2.5	13.4	78.7	5.5
2001	4.9	19.1	71.1	4.9
Port Britain Creek				
1997 <sup>1</sup>	3.8	14.2	82	N/A
1998	6.7	4.5	87.6	1.2
1999	5.8	7.0	86.4	0.8
2000	0.7	5.1	92.8	1.4
2001	8.2	5.6	85.2	0.89

<sup>1</sup>measured every 50 m – not measured between Stn. 13 and 21

Table 6: Total area of habitat types in different years, calculated using Table 5 % habitat estimates.

Stream/Survey Year	Type 1 Habitat (m <sup>2</sup> )	Type 2 Habitat (m <sup>2</sup> )	Type 3 Habitat (m <sup>2</sup> )	Type 4 Habitat (m <sup>2</sup> )
Grafton Creek				
1997	2809	5718	24913	-
1998	1441	6712	24132	458
1999	1526	4442	22657	803
2000	764	4169	24461	1704
2001	1375	5321	19787	1359
Port Britain Creek				
1997	620	2317	13382	-
1998	1117	750	14605	200
1999	943	1152	14109	124
2000	122	866	15919	244
2001	1357	957	14177	149

Table 7: Habitat sampled in Fall SMRT surveys

	Grafton Creek				Port Britain Creek			
	1998	1999	2000	2001	1998	1999	2000	2001
Transects sampled	100 <sup>1</sup>	98 <sup>2</sup>	105	105	100 <sup>1</sup>	99 <sup>2</sup>	108	100
Type 1 plots electrofished	13	17	15	23	26	15	13	32
Type 2 plots electrofished	25	15	24	24	11	11	19	15
Type 1 plots with larvae	9	13	13	18	6	5	1	14
Type 2 plots with larvae	19	10	16	19	1	3	8	4
Area of type 1 plots	33.9 m <sup>2</sup>	43.5 m <sup>2</sup>	35 m <sup>2</sup>	51.5 m <sup>2</sup>	72.4 m <sup>2</sup>	36.5 m <sup>2</sup>	39 m <sup>2</sup>	75 m <sup>2</sup>
Area of type 2 plots	82.5 m <sup>2</sup>	45.5 m <sup>2</sup>	53 m <sup>2</sup>	59 m <sup>2</sup>	22.7 m <sup>2</sup>	22.0 m <sup>2</sup>	58.5 m <sup>2</sup>	27 m <sup>2</sup>

<sup>1</sup>of the 100 targeted transects, 3 in each stream could not be electrofished due to deep water. At one additional transect in Grafton Creek, habitat data was not recorded.

<sup>2</sup> of the 100 targeted transects, 2 on Grafton Creek and 1 on Port Britain Creek were too close together to sample according to the SMRT Protocol.

## Larval Lamprey Sampling

The number of lamprey larvae electrofished in both streams from 1998 to 2001 using the Sterile Male Release Technique (SMRT) survey protocol (Twohey *et al.* 200x) are summarized in Table 8. Both *Petromyzon marinus* and *Lampetra appendix* larvae have been collected in all years in Grafton Creek, while only *P. marinus* have been collected in Port Britain Creek while using the SMRT protocol. In 2001, three *L. appendix* larvae were identified in the collections made for the coded-wire tag marking and release during the summer of 2001. The abundance of adult sea lampreys introduced into each stream along with the subsequent larval year class densities, based on the SMRT population estimates, are summarized in Table 9 for each year of the study. While the density estimates for young-of-the-year (YOY) larvae are considered unreliable, as electrofisher efficiency for YOY's is low, the estimates have been included in the summary table to allow for year class comparisons throughout the duration of the project. The population estimates reported are not corrected for electrofisher sampling efficiency, and are thus an underestimation of true larval lamprey density.

### 1998 Observations

No larval sea lampreys, either age-0 or older, were captured in the SMRT survey of Grafton creek (their presence in Grafton is confirmed by dredge sampling - see below) (Table 11). The SMRT survey found only age-0 sea lampreys in Port Britain Creek (Table 9).

No American brook lampreys, (*L. appendix*), were collected in Port Britain. Both age-0 and age 1+ *L. appendix* were collected in the SMRT survey in Grafton Creek. Age-0 *L. appendix* densities in the stream are greater than 3/m<sup>2</sup> and age 1+ densities are over 2/m<sup>2</sup>. *L. appendix* were not evenly distributed in Grafton. Densities on the order of 20-25 per m<sup>2</sup> were found at plots sampled at 2282 m, 2404 m, and 2729 m. These plots are all downstream of the crossing at Barnum House road south of Highway 2. Other sample plot densities did not exceed 4.8 per m<sup>2</sup>. Between Barnum House Road and Highway 401, little larval habitat was found (only 2 sites electrofished) and only 1 *L. appendix* was captured. *L. appendix* were found between the north-side of Highway 401 up to the temporary barrier location as well as in the eastern split of Grafton Creek to approximately 7000 m. Given that the available habitat above 7000m did not meet the criteria for electrofishing utilizing the SMRT protocol, it is unknown whether *L. appendix* inhabit the area, though it is probably that populations exist in these pockets.

### 1999 Observations

During the SMRT survey of Grafton Creek, both *P. marinus* and *L. appendix* YOY's were collected, though lower numbers of *L. appendix* YOY's were collected than in 1998 (seven vs. 124). YOY electrofishing estimates are considered unreliable, so these numbers were not included in the total larval estimates for 1999. The densities of *L. appendix* in Grafton Creek are higher for both Type I (2.85/m<sup>2</sup> vs. 0.28/m<sup>2</sup>) and Type II (1.16/m<sup>2</sup> vs. 0.22/m<sup>2</sup>) habitats than densities of *P. marinus*. The maximum density of *L. appendix* in 1999 was 14 /m<sup>2</sup>, compared with 25/m<sup>2</sup> in 1998. The maximum density of *P. marinus* was 3.0/m<sup>2</sup> in Type II habitat compared with the maximum of 1.3/m<sup>2</sup> in Type I habitat. For both species, the maximum density in Type I habitat was 14/m<sup>2</sup> and 10/m<sup>2</sup> in Type II habitat. The distribution for *P. marinus* in 1999 occurred from 465 m above the SLCC low head barrier to 6154 m, thus they inhabit almost all of Grafton Creek.

In Port Britain Creek, only age 1 *P. marinus* were collected in the 1999 SMRT survey. YOY's were found during separate sampling events, confirming nesting success. The maximum larval densities found in 1999 were 3.5/m<sup>2</sup> in Type I habitat and 1.0/m<sup>2</sup> in Type II habitats. The distribution for year 1 larval *P. marinus* ranged from 245 m above the SLCC low head barrier to 2685 m. In 1998, the distribution ranged from 977 m to 2915 m above the SLCC barrier.

Salem Creek was not surveyed in 1999 for either larval abundance or habitat distribution. Larval lamprey surveys were not completed in Salem Creek until 2001, when a Quantitative Assessment Survey (QAS) was conducted in June. The total larval abundance (corrected for electrofisher efficiency using ESTR) was 46,096, of which approximately 15,846 are expected to be the product of the 1999 sea lamprey spawning population (19 successful nests).

## 2000

In 2000, in both streams, all lampreys were measured and weighed ( $\pm 0.001$  g) in the field, and those larger than 50 mm were injected with a coded-wire tag. All larval lampreys were marked with a tail clip and released at the location of capture. This was done in order to mark individual sea lampreys for larval growth and movement studies as well as to continue the mark-recapture work started in the summer of 2000 (see Mark/Recapture section).

SMRT surveys were conducted in both Port Britain and Grafton Creeks in the fall of 2000. YOY's were collected in both streams, indicating that successful spawning had occurred. In Port Britain Creek, a total of 63 *P. marinus* larvae were collected during the surveys. The maximum densities in Type I larval habitat were 4/m<sup>2</sup> and 1.2/m<sup>2</sup> in Type II habitat. The larval distribution ranged from 30 m above the low-head barrier to 3000 m in the stream. Large larval sea lampreys were prevalent in Port Britain Creek, with 45 of the lampreys collected greater than

100 mm in length. Two larval sea lampreys appeared to have begun transformation and were removed from the stream. These lampreys were frozen and saved for future statolith aging.

In Grafton Creek, both sea lampreys and American brook lampreys were found in 2000. Maximum densities for sea lampreys reached  $6/m^2$ , while the maximum for American brook lampreys was  $12/m^2$ , for Type I habitat. In Type II habitat, the maximum density for larval sea lampreys was  $2.7/m^2$ , while for brook lampreys the maximum was  $11/m^2$ . A total of 78 sea lampreys and 171 brook lampreys were collected in the stream. Sea lampreys in Grafton Creek were found through most of the stream, ranging from 267m above the low-head barrier to 5934m.

## **2001**

2001 was the final year for SMRT surveys for Port Britain and Grafton creeks. Both streams were surveyed in the fall of 2001. No YOY's were collected in either stream indicating that a breach of the low-head sea lamprey barrier was unlikely to have occurred in either stream. In Port Britain Creek, a total of 56 larval sea lampreys were collected, including 6 tagged lampreys. The majority of the sea lampreys (46) were greater than 100 mm in length, though none of the lampreys collected appeared to be undergoing metamorphosis. The maximum density of larval lamprey in both Type I and Type II habitat was  $2.7/m^2$ . Densities during the fall survey appeared lower than in previous years. The larval distribution ranged from 783 m above the low-head barrier to 3166 m in the stream. Confirmation of larval sea lampreys in habitat closer to the low-head barrier was made, though the sites were not a part of the SMRT survey and as such were not included in the population estimates.

In Grafton Creek, both sea lamprey and American brook lamprey larvae were again captured in the stream during the SMRT survey. A total of 100 larval sea lampreys and 232 American brook lampreys were collected. Six of the sea lampreys and five of the American brook lampreys were recaptures. The maximum density for the sea lamprey larvae were  $4/m^2$ , while the American brook lamprey reached densities of  $17/m^2$  in Type I habitat. In Type II habitat, densities of larval sea lampreys were similar to those of 2000, at  $2.6/m^2$ , while for American brook lampreys, the density was lower at  $3.2/m^2$ . Sea lamprey larvae were again smaller than those collected in Port Britain Creek. Of the 100 sea lampreys collected, only 11 were larger than 100 mm and none appeared to be entering metamorphosis. Sea lamprey larvae were distributed throughout the stream, from 7m above the low-head barrier to 6502m upstream.



Table 8: Number of lampreys, *Petromyzon marinus* and *Lampetra appendix*, electrofished in Type I and Type II habitats, 1998 to 2001.

	Grafton Creek				Port Britain Creek			
	1998	1999	2000	2001	1998	1999	2000	2001
<i>Petromyzon marinus</i> Type I	0	12	44	56	14	11	40	40
<i>Petromyzon marinus</i> Type II	0	10	34	44	3	4	23	16
<i>Lampetra appendix</i> Type I	107	116	122	170	0	0	0	0
<i>Lampetra appendix</i> Type II	227	49	59	62	0	0	0	0
Total lampreys collected Type I	107	128	156	226	14	11	40	40
Total lampreys collected Type II	227	59	93	106	3	4	23	16

Table 9 a: Summary of fall 1998 to 2000 SMRT surveys estimates for Grafton Creek; population estimates are not corrected using either the standard 0.48 correction factor or the logistic model.

	1998			1999		
# <i>P. marinus</i> spawners	100 females/106 males			93 females/85 males		
# females/m <sup>2</sup> TI habitat	0.070			0.061		
Larval lamprey densities	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )
YOY <i>P. marinus</i> larvae	0	0	0	101	0.02	0.01
Age 1+ <i>P. marinus</i> larvae	0	0	0	1405	0.28	0.22
Age 1+ <i>L. appendix</i> larvae	25568	3.45	3.07	9502	2.85	1.16
All age 1 + larval lamprey	25568	3.45	3.07	10907	3.13	1.38

YOY's were not collected in the SMRT sampling for 1998. Dredge sampling confirmed that successful spawning had occurred. As an effective technique for sampling YOY using electrofishing has not been established, only the age 1+ densities are considered a true estimate. YOY 'estimates' are included for interest only.

	2000			2001		
# <i>P. marinus</i> spawners	44 females/58 males			No Adults Introduced		
# females/m <sup>2</sup> TI habitat	0.058					
Larval lamprey densities	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )
YOY <i>P. marinus</i> larvae	56	0.01	0.01	0	0	0
Age 1+ <i>P. marinus</i> larvae	3635	1.26	0.64	5463	1.09	0.75
Age 1+ <i>L. appendix</i> larvae	787	3.2	1.11	10129	3.30	1.05
All age 1 + larval lamprey	11321	4.83	1.83	16735	4.56	1.97

lampreys were collected and those larger than 50 mm (n=148) were coded wire tagged and tail clipped prior to release. Very few large sea lamprey larvae were captured in Grafton Creek, with only seven of the larvae greater than 95mm in length. In addition to the sea lampreys, 575 larval *L. appendix* were collected and marked with a tail clip prior to release.

During the fall SMRT surveys, marked lampreys were collected in both Port Britain and Grafton creeks. Petersen mark/recapture estimates were calculated based on the return of marked larval sea lampreys compared to the catch. Table 10 compares the Petersen mark/recapture and SMRT abundance estimates for 2000. Data was not corrected for electrofisher efficiency for either estimate.

### **Larval Tagging 2001**

In 2001, coded wire tags were again used to individually mark sea lampreys greater than 50 mm in length in both Grafton and Port Britain creeks. In addition to the coded wire tags, Visible Implant Fluorescent Elastomer (VIE) dye was used to mark the sea lampreys. Port Britain Creek was divided into two sections for the dye marking, while Grafton Creek was divided into five. The dye was added to the study in order to visibly mark the sea lampreys by section of the stream in which they were captured. This also provided an easier method of determining which sea lampreys should contain a coded wire tag (in the case of ambiguous mark or lost tag). All sea lampreys collected in both streams were measured ( $\pm 1$  mm) and weighed ( $\pm 0.001$  g), marked with a tail clip and where longer than 50 mm, both a coded-wire tag and a VIE mark.

In Port Britain Creek, larval surveys were conducted from July 9 to 12. A total of 195 sea lampreys were collected and 190 were marked and returned to the stream. The majority of the sea lampreys collected (N=135) were larger than 100 mm, however, none of the sea lampreys collected appeared to be entering metamorphosis. A total of 20 sea lampreys were recaptured from the 2000 marking period. In addition to the sea lampreys, 3 American brook lampreys were also collected in the stream. While American brook lampreys have been collected in the headwaters of the stream in previous surveys, this marks the first collection of *L. appendix* in the lower reaches of the stream during the Compensatory Mechanisms project.

In Grafton Creek, larval surveys were conducted over two time periods. The first, May 29 to June 3, covered the majority of the stream, while the survey from July 12 to 14, completed the remaining sections. A total of 761 sea lamprey larvae were collected during the survey periods, including 15 that had been marked in the previous year. Two of the sea lampreys were retained for coded-wire tag removal. Only 15 of the sea lampreys collected were larger than 100 mm and none appeared to have begun the process of metamorphosis. In addition to the sea lampreys, 919

*L. appendix* larvae were also collected and marked with a tail clip. Forty-two of *L. appendix* were marked with a tail clip from 2000.

During the spring/summer larval surveys, lampreys marked in the 2000 surveys were collected. Petersen mark/recapture estimates were calculated based on the return of marked larval lampreys and over all catch for the spring sampling period. These are compared with the fall SMRT abundance estimates for 2001 in Table 10. In addition to the SMRT and Petersen abundance estimates, the SMRT data has been corrected for electrofisher efficiency using the ESTR model by the SLCC. The ESTR abundance estimate (for sea lampreys only) has also been included in Table 10, with the separation between transformer and larval sea lampreys.

Table 10. Summary of Petersen mark/recapture abundance estimates for Port Britain and Grafton creeks compared to the SMRT abundance estimates. Neither estimate is corrected for electrofisher efficiency.

	Grafton Creek			Port Britain Creek	
	<i>P. marinus</i>	<i>L. appendix</i>	All Larvae	All <i>P. marinus</i>	> 100 mm
<b>2000</b>					
Total Collected	250	575	825	190	134
Total Tagged	148	575	723	185	134
SMRT Estimate	3635	7087	11321	465	351
Petersen Estimate	3924	6192	10739	627	388
(95% C. L.)	(1418–7718)	(3846–9829)	(6846–16658)	(404 – 962)	(241 – 616)
<b>2001</b>					
Total Collected	761	919	1680	195	135
Total Tagged	521	919	1440	190	135
SMRT Estimate	5463	10129	16735	1301	1084
Petersen Estimate –	10668	15982	20984	2277	1166
spring (95% C. L.)	(6626–16933)	(11896–21431)	(16260–27050)	(1499–3431)	(767–1756)
<i>P. marinus</i> only:	Transformers	Ammocoetes		Transformers	Ammocoetes
ESTR Estimate	152	8614		2100	2873

### Dredge pump technique: summary of 1998 fall stream collections

Dredge pump sampling was undertaken, in part, to evaluate this technique for age-0 sea lamprey sampling. Sampling was not random. We choose upstream areas in each stream near adult addition sites and nest sites, we selectively chose habitats to sample, and sometimes we also chose not to dredge sites where preliminary electrofishing indicated no larval sea lampreys.

For all samples, electrofishing was carried out for 22.5 seconds in 0.25 m<sup>2</sup> plots. In Grafton, plastic liners and mesh were laid down to delineate a 0.25 m<sup>2</sup> square plot and to prevent escape of larvae. The plots were then electrofished and the number of larvae seen by the electrofisher was recorded. Single larvae may have been seen and counted more than once,

inflating the estimate of the number of larvae drawn out of the sediments by electrofishing. The larvae returned to the sediments and re-burrowed. Dredging of the plot was then done. In Port Britain, the first two plots were sampled in the same way. Thereafter, plots of 0.25 m<sup>2</sup> were marked out with metal stakes and electrofished. Caught larvae were then held in buckets while the plastic liner and mesh was then laid out in the area electrofished. The caught larvae were marked with a tail fin clip, returned to the plot, and the plot was then dredged to determine the efficiency with which marked larvae were caught again by dredging.

In both streams, frequency distributions are similar for electrofishing versus dredging (Table 11). Summing all plots within Grafton Creek, electrofishing versus dredging yielded 17 versus 18 larvae. For two of the 17 plots, the number of lamprey (both species) seen during electrofishing exceeded the number caught dredging by one and in one plot, the electrofishing sightings exceeded the dredge catch by two. In five other plots one larvae was caught dredging, while none were seen during the electrofishing.

Table 11: Comparison of dredge and electrofishing catches

Catch	Grafton Creek ( <i>P. marinus</i> and <i>L. appendix</i> )				Port Britain ( <i>P. marinus</i> )	
	Electrofishing frequency	Dredge Frequency			Electrofishing frequency	Dredge frequency
		<i>L. appendix</i>	<i>P. marinus</i>	Both species		
0	10	11	11	7	7	6
1	3	3	5	7	4	3
2	2	1	1	1	1	2
3	0	2	0	0	0	1
4	0	0	0	1	1	0
5	2	0	0	1	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	1
<b>Total</b>	<b>17</b>	<b>11</b>	<b>7</b>	<b>18</b>	<b>10</b>	<b>18</b>

Dredging appeared to be less effective in capturing the larger age 1+ larvae due to the depth to which we sampled (<6 cm). In one Grafton plot all five electrofishing sightings were noted to be > 7 cm but only two of these age 1+ larvae were recaptured in the dredge. In another plot it was also noted that five larvae sited during the electrofishing were larger on average than the five captured in the dredge sample. Although the majority of larvae captured in dredge (15 of 18) were age-0, the size of larvae sited in electrofishing was generally not noted. Subtracting the five known sightings of age 1+ larvae from the total electrofishing sightings yields 12 as a

maximum number of age-0 sightings. Thus, for age-0 larvae, the density estimate by electrofishing relative to dredge pumping is a maximum of 12/15, or 80%.

In Port Britain all larvae caught by electrofishing or dredging were age-0 sea lampreys. 10 larvae were caught electrofishing versus 18 by dredge. Thus the density estimate for electrofishing is 10/18, or 56%, of the density estimate made using samples from the dredge pump. However, this may be an underestimate because one plot was likely electrofished for less than 22.5 seconds and at that site eight lampreys were dredged and only four were electrofished.

Mark-recapture results indicate that 11 out of 12 marked age-0 larvae (and possibly 12 of 12) were recaptured in the dredge (Table 12). In all plots for which we used mark-recapture methods, all captured larvae were returned to the plot before dredging. Summing across plots, 11 of the 19 dredge captures were re-marks. The ratio 11/19, or 58%, provides another estimate of the relative difference in density estimates for age-0 larvae via electrofishing versus dredge pumping.

Table 12: Combined *P. marinus* and *L. appendix* age-0 mark-recapture results for dredge pump samples

Creek	Plot #	# captured and marked	dredge captures	Dredge recaptures	marks/recaps	marks/total dredge capture
Grafton	13	2	2	1 <sup>1</sup>	0.5	0.5
Port Britain	3	1	1	1	1	1
Port Britain <sup>2</sup>	5	4	8	4	1	0.5
Port Britain	7	1	1	1	1	1
Port Britain	8	1	2	1	1	0.5
Port Britain	9	2	3	2	1	0.66
Port Britain	10	1	2	1	1	0.5
<b>Total</b>		<b>12</b>	<b>19</b>	<b>11</b>	<b>0.93</b>	<b>0.42</b>
<b>Plot mean</b>					<b>0.92</b>	<b>0.66</b>

<sup>1</sup>May have been 2 recaptures for this plot.

<sup>2</sup>Electrofishing in this plot may have been less than 22.5 s.

### Size of sea lamprey larvae

Throughout the duration of the Compensatory Mechanisms project, the larval sea lampreys collected in Port Britain Creek during the sampling periods have been larger than those collected in Grafton Creek. The larger size has remained consistent throughout the first three years of larval sampling, 1998 to 2000. In 2001, while the sea lampreys collected in Port Britain Creek are larger, visual separation of the year classes became too difficult. At age 1, the sea lampreys in Port Britain are significantly larger in both length (mm) ( $p < 0.05$ ,  $N = 36$ ) and weight (g), ( $p < 0.05$ ,  $N = 36$ ), 1999 SMRT survey data. This continues through the age-2 year class in

- A multi-age class population of *L. appendix* exists in Grafton Creek but no native lampreys were found in Port Britain Creek

## 2000

- Flood water conditions occurred in both streams during the spawning period
- Spawning was later in Grafton Creek in 2000 than in previous years, most likely due to the cooler water temperatures
- Successful spawning occurred in both streams as evidenced through the collection of YOY's in both streams
- Larval sea lampreys are larger in Port Britain Creek than in Grafton, as the number of larvae greater than 100 mm was 135 compared to seven during the CWT application
- Transformation of sea lampreys to the parasitic phase has begun in Port Britain Creek; three transformers were collected and retained for aging, while several other were beginning to develop eye-spots. The population in Port Britain Creek remains low at this time (uncorrected estimate of 465 sea lampreys)
- Of the sea lampreys collected in Port Britain Creek, only 19 met the criteria described by Youson *et al.* (1993) of length >120 mm, weight > 3.0 g, and Fulton's Condition factor ( $W/L^3$ ) of > 1.50. One of the metamorphosing sea lampreys did not meet either the length or weight criteria.

## 2001

- Adult sea lampreys were not introduced into either stream in 2001
- Low water conditions occurred in both streams throughout the summer which may have affected larval lamprey survival
- No YOY sea lampreys were collected in either stream in 2001, indicating that a breach of low-head barrier was unlikely to have occurred in either stream
- Sea lampreys with coded wire tags were recaptured in both streams during the larval surveys – age and growth information will be collected from these individuals
- *L. appendix* larvae were collected in both streams in 2001 for the first time
- Larval sea lampreys are larger in Port Britain Creek than in Grafton Creek, though the population is lower. The majority of the sea lampreys collected in Port Britain Creek (at both sampling periods) are larger than 100 mm (N= 181) compared with Grafton Creek (N=26).
- No metamorphosing sea lampreys were collected in Port Britain Creek in 2001, in either sampling period. While 64 of sea lampreys collected during the coded-wire tagging sampling

period appeared to be developing eye-spots, none appeared to transforming when collected during the fall surveys. Of the sea lampreys collected in the fall of 2001, 22 met the criteria described by Youson *et al.* (1993) as ready to undergo transformation.

- The marked lampreys remaining in the streams will be useful for population estimates, growth and development of larval lampreys in differing stream conditions, and movement throughout the stream.

## Summary

Adult sea lampreys were introduced into 2 similar Lake Ontario tributaries between 1998 and 2000. Adults were introduced in equal sex ratios (1:1), in all years of the study and for two years at the same adult density in Grafton Creek and in varying densities for the remaining years/streams. During the intensive adult population and subsequent nesting surveys of 1998 and 1999, it was found that the adult population at the time of spawning was lower than the numbers introduced. The adult sea lamprey populations were reduced in both years through emigration, predation, and pre-spawning mortality. Predators (raccoon and mink), were found to be responsible for the removal of a large number of adult sea lampreys in Port Britain Creek in 1999. It is possible that predators may play a larger role in the reduction of adults in the streams at the time of the spawning migration than had previously been reported. Nesting success varied both between streams and among years, though at the lower adult sea lamprey abundance, nesting success was higher (Grafton Creek). This was also the case in Salem Creek, a 'wild migration' of sea lampreys, in the third tributary added to the project in 1999. In 2000, nesting occurred almost 1 month later in the streams, likely the result of cooler water temperatures and adverse water conditions (flood events) during the spawning season. The first nests in Grafton Creek were located June 20, while spawning in the previous years had been completed by approximately June 17.

Larval sea lamprey development was followed throughout the four years of the project, 1998 to 2001. Successful spawning was confirmed in each of the streams in all three years of adult additions through larval sea lamprey sampling. The resulting larval population strength follows the nesting success of the adult sea lampreys introduced into the streams. An increase in larval production occurred in Grafton Creek in 1999, following the increased nesting success of the introduced adults, while at the same time, a reduction in the number of larvae occurred in Port Britain Creek. Overall, the age-1 larval sea lampreys in Port Britain Creek were significantly larger in both length (mm) ( $p < 0.05$ ,  $N=36$ ) and weight (g) ( $p < 0.05$ ,  $N=36$ ), compared to those collected in Grafton Creek, 1999 SMRT sampling. The first transformers were collected in Port

Britain Creek in 2000, while those in Grafton Creek do not currently appear large enough to begin the metamorphosing process.

Coded-wire tagged sea lampreys have been released in both Port Britain and Grafton creeks. These sea lampreys can be used in studies of growth and movement within the stream basin over time, as well as information regarding age at length using the statolith aging technique. Samples should be collected, with documented collection sites, prior to the proposed stream treatments of 2002.

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Figure 1: Daily number of carcasses located and nests with eggs found in Grafton Creek, 1998.

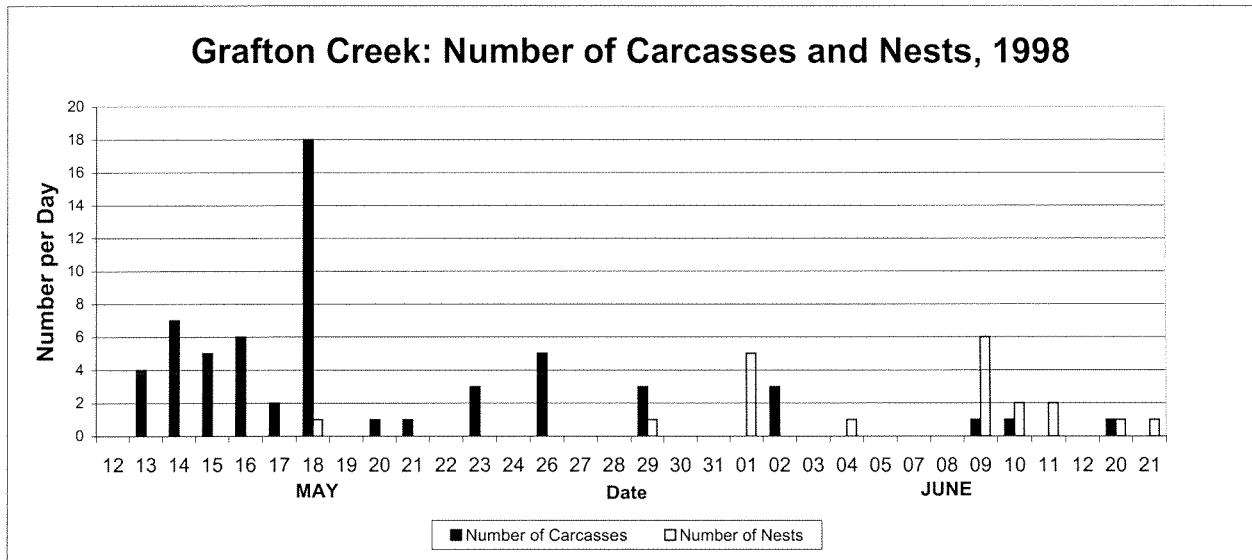


Figure 2: Daily number of carcasses located and nests with eggs found in Port Britain Creek, 1998.

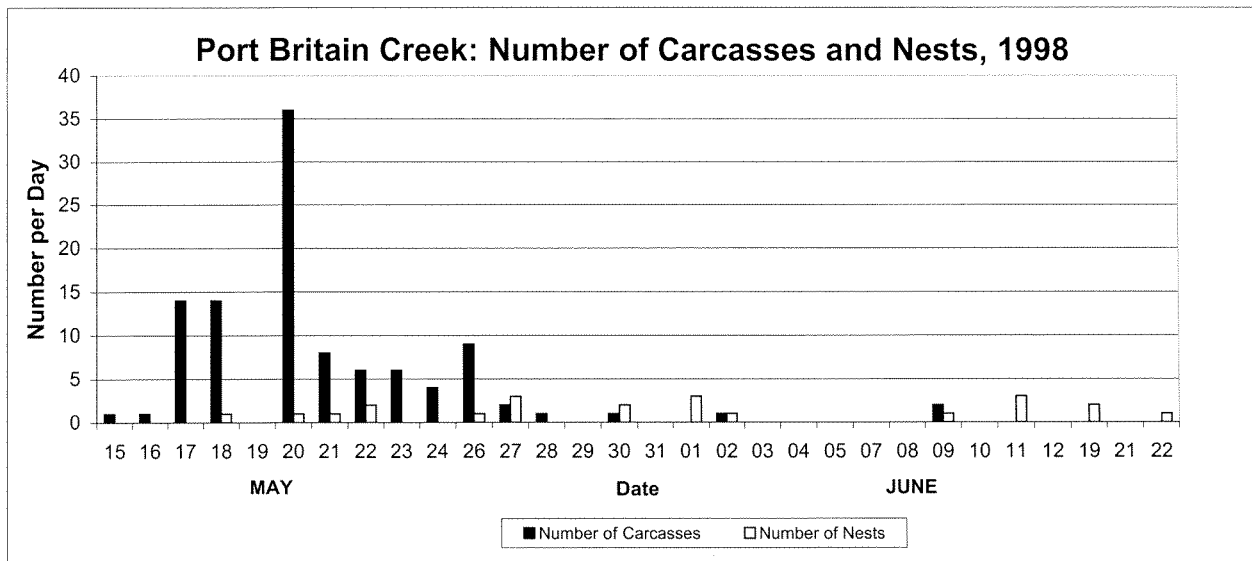


Figure 3: Daily number of nests with eggs found in Grafton and Port Britain creeks, 1998.

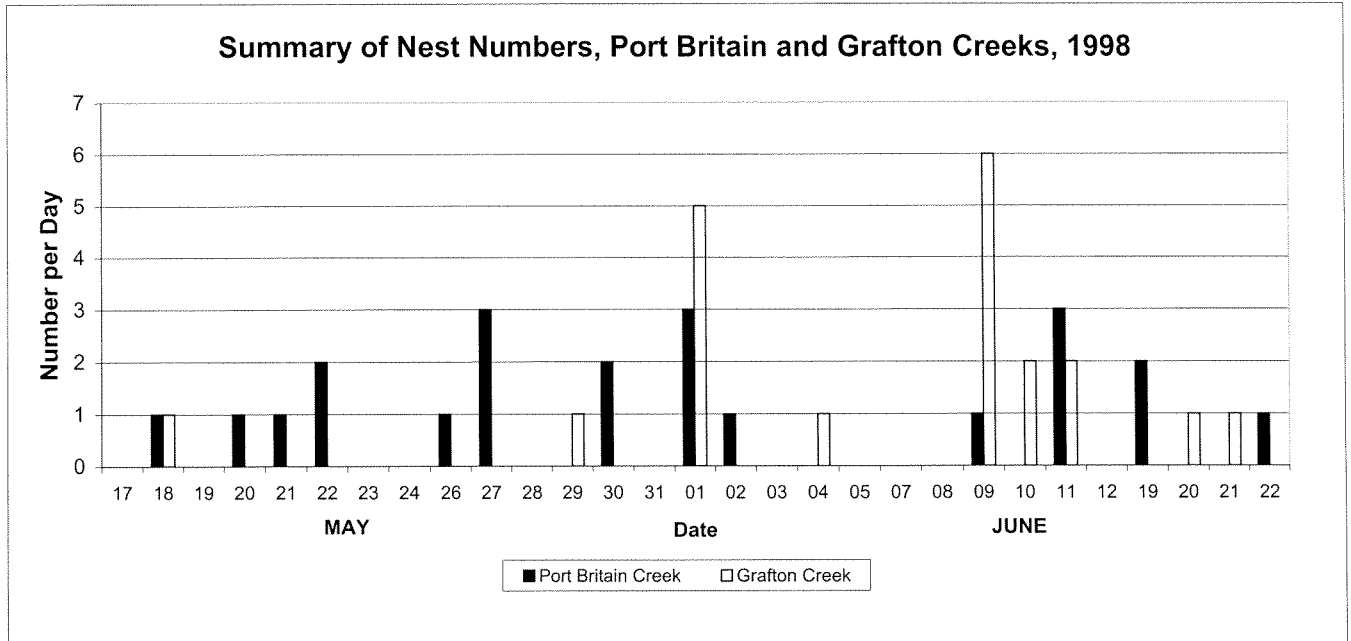


Figure 4: Daily number of carcasses and nests with eggs found in Grafton Creek, 1999.

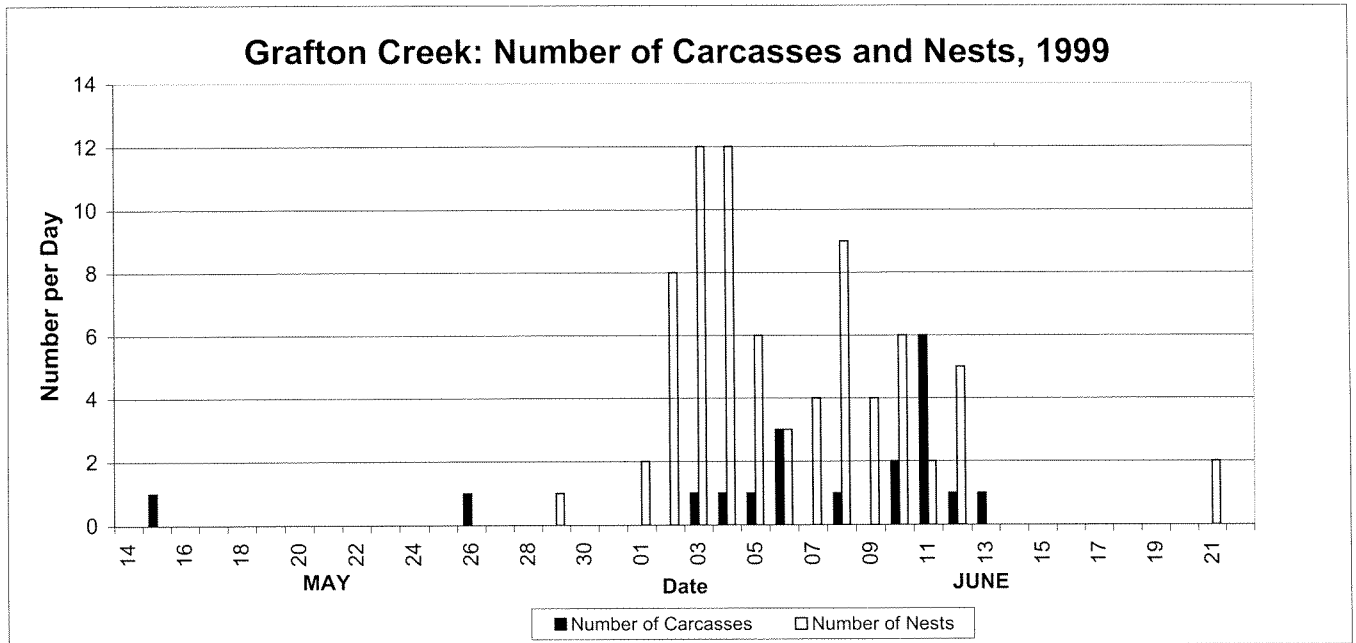


Figure 5: Daily number of carcasses and nests with eggs found in Port Britain Creek, 1999.

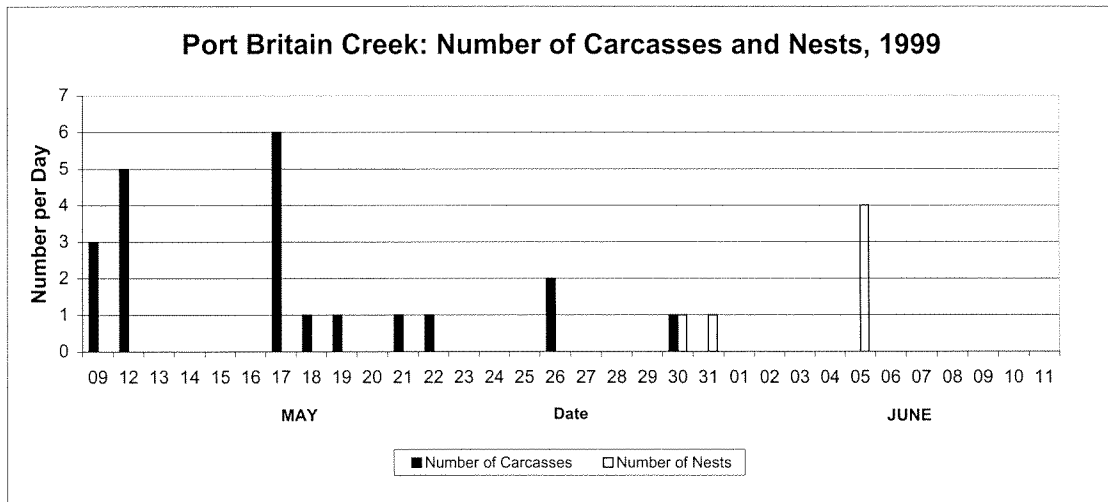


Figure 6: Daily number of carcasses and nests with eggs found in Salem Creek, 1999.

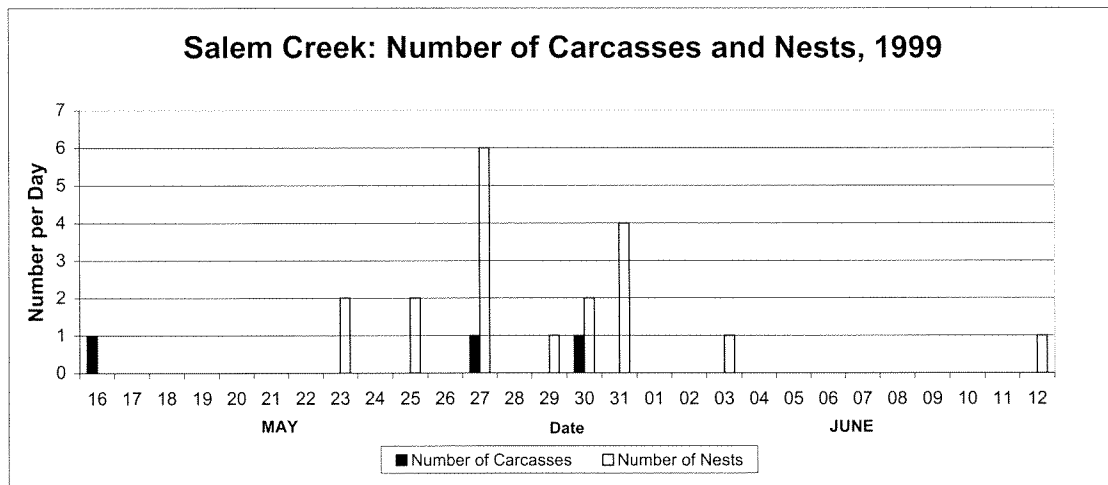


Figure 7: Daily number of nests with eggs found in Grafton, Port Britain, and Salem creeks, 1999.

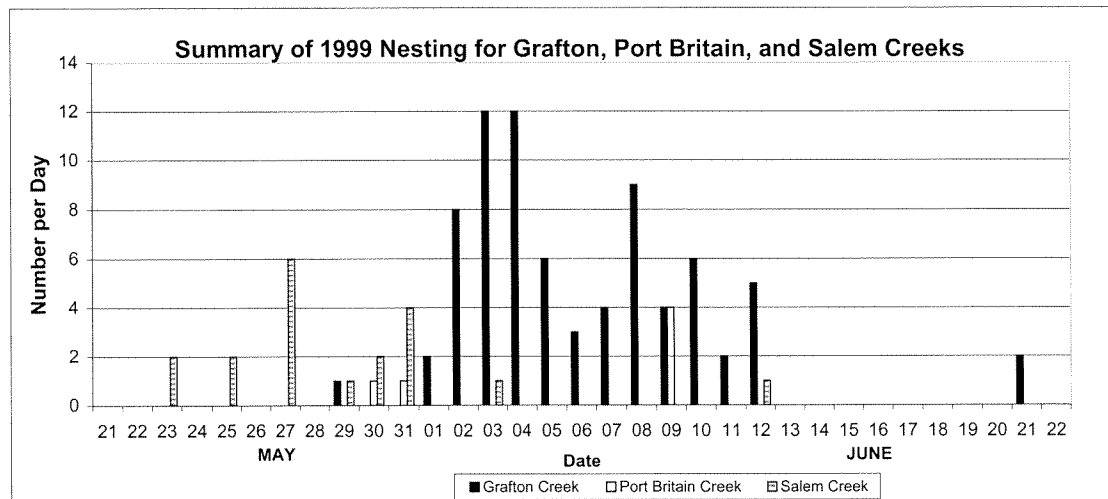
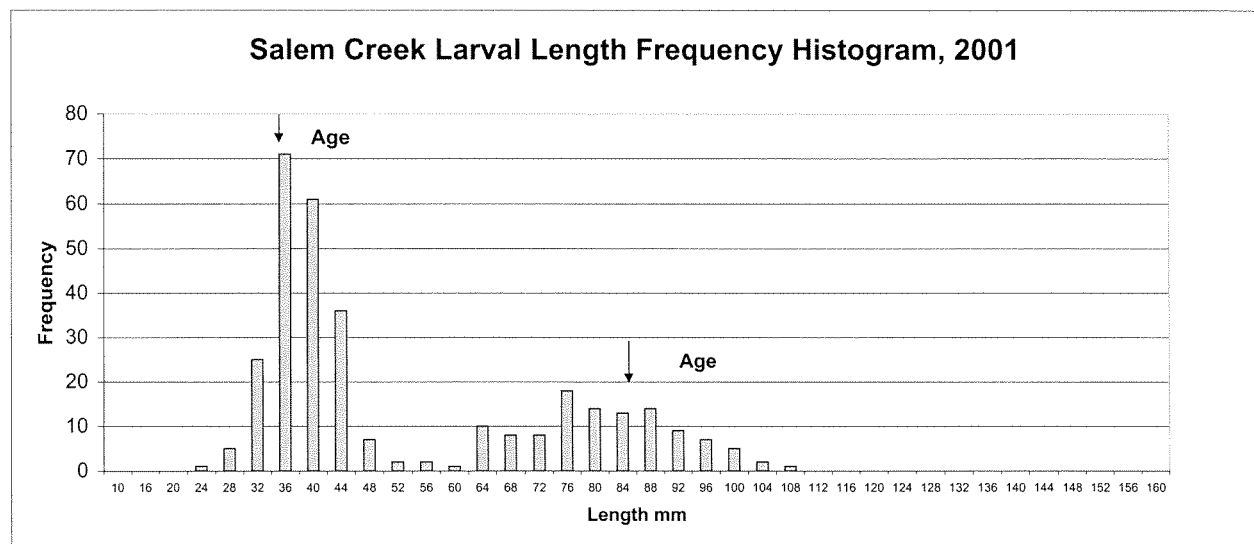
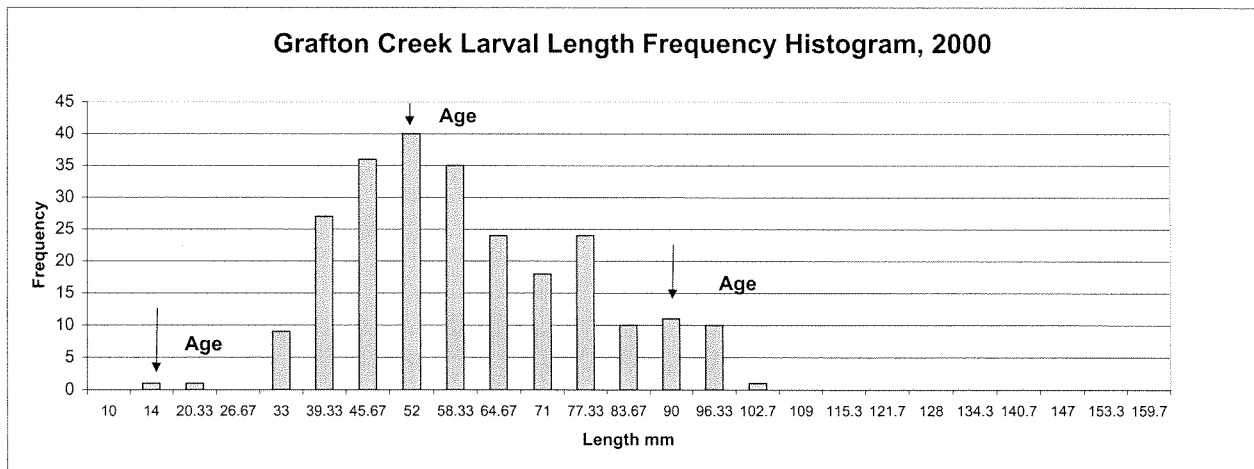
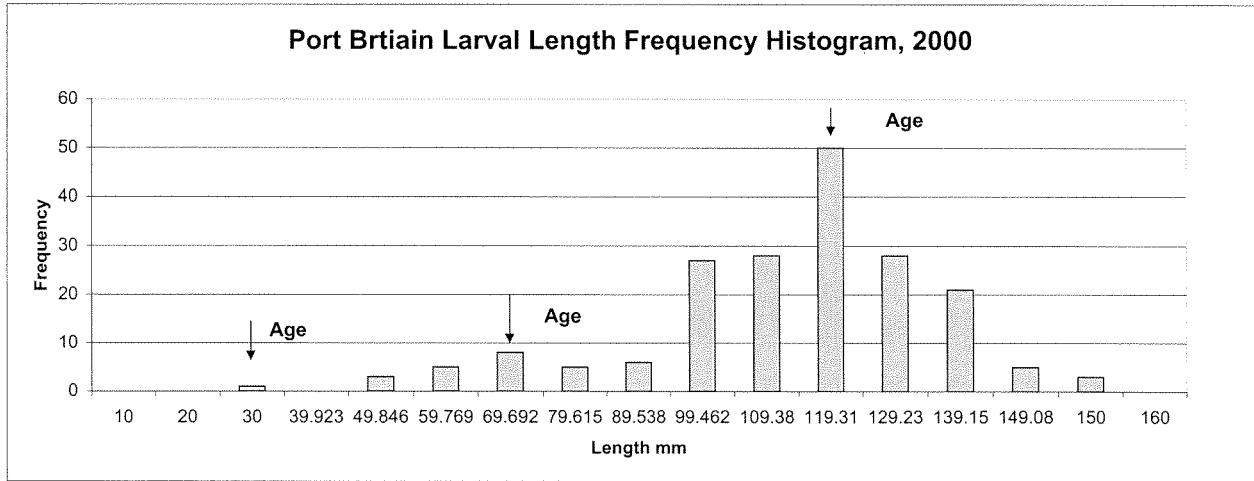


Figure 8: Length frequency histograms for Port Britain, Grafton, and Salem creeks, comparing the size at age for the streams.



2000. In Figure 8, the length frequency histograms for 2000 show the difference in length at 'age' for Port Britain and Grafton creeks. The age assignments are based on a visual observation of the modal distribution and overlaps in lengths between age classes are known to occur. These appear to be the best representations of the potential age classes within the streams. The histogram also provides a visual reference for the increase in larval populations in Grafton Creek in 1999, based on the increased number of nests with eggs in 1999 (see nesting success section), and the lower spawning success in Port Britain Creek for the same year. The Salem Creek length frequency histogram for 2001 has also been included, with the larval length collected in 2001 using QAS sampling. Larval size appears to be closer to that of the Grafton Creek larval populations. The age-2 year class is the product of the adult sea lamprey population followed for nesting success in 1999.

## **Summary and conclusions**

### **1998**

- Mark-recapture estimates of adult sea lamprey abundance correspond reasonably well with the number introduced less the total number of lamprey carcasses.
- The number of sea lamprey nests in each stream is similar, even though a higher number of adult sea lampreys were introduced into Port Britain Creek than Grafton.
- Age-0 sea lamprey were found in both streams in the fall after the spring introductions
- A multi-age class population of *L. appendix* exists in Grafton Creek but no native lampreys were collected from Port Britain.
- Our dredge technique recaptured nearly all the age-0 larvae caught by electrofishing. The age-0 density estimate yielded by electrofishing is estimated to be in the order of 50-80% of the dredge pump estimate.

### **1999**

- Adult mortality was lower in both creeks in 1999
- A population estimation immediately prior to spawning was made for Grafton and Salem Creeks, but not Port Britain Creek
- Nesting success in Grafton Creek was much greater in 1999 than in 1998 (76 vs. 20 nesting events)
- Both male and female sea lampreys were found on multiple nests
- Age-0 sea lamprey were found in both streams in the fall after the spring introductions

Table 9 b: Summary of fall 1998 to 2000 SMRT surveys estimates for Port Britain Creek; population estimates are not corrected using either the standard 0.48 correction factor or the logistic model.

	1998			1999		
# <i>P. marinus</i> spawners added	231 females/259 males			104 females/110 males		
# females/m <sup>2</sup> TI larval habitat	0.207			0.110		
Larval lamprey densities	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	type 2 habitat density (/m <sup>2</sup> )	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )
YOY <i>P. marinus</i> larvae	426	0.19	0.13	0	0	0
Age 1+ <i>P. marinus</i> larvae	0	0	0	284	0.30	0.18
Age 1+ <i>L. appendix</i> larvae	0	0	0	0	0	0
All age 1 + larval lamprey	426	0.19	0.13	494	0.30	0.18

As an effective technique for sampling YOY using electrofishing has not been established, only the age 1+ densities are considered a true estimate. YOY 'estimates' are included for interest only. No YOY *P. marinus* larvae were captured in a SMRT plot in 1999. Additional electrofishing confirmed that successful spawning had occurred in Port Britain Creek.

	2000			2001		
# <i>P. marinus</i> spawners added	50 females/51 males			No Adults Introduced		
# females/m <sup>2</sup> TI larval habitat	0.410 <sup>1</sup>					
Larval lamprey densities	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )	Estimated total number	Type 1 habitat density (/m <sup>2</sup> )	Type 2 habitat density (/m <sup>2</sup> )
YOY <i>P. marinus</i> larvae	10	0.01	0.00	0	0	0
Age 1+ <i>P. marinus</i> larvae	465	1.03	0.39	1301	0.53	0.60
Age 1+ <i>L. appendix</i> larvae	0	0	0	3	0.001	0.001
All age 1 + larval lamprey	465	1.03	0.39	1304	0.53	0.60

1. The ratio of females/m<sup>2</sup> TI larval habitat is large in Port Britain Creek in 2000, due to the small amount of Type I larval habitat estimated during the SMRT surveys. Only 122 m<sup>2</sup> of Type I habitat was estimated compared to 943 m<sup>2</sup> in 1999.

### Coded Wire Marking:

#### Larval Sea Lamprey Tagging 2000

In 2000, individually numbered coded wire tags were applied to larval sea lampreys greater than 50 mm long in Port Britain and Grafton creeks. Port Britain Creek was electrofished for larval sea lampreys August 22 to 24, 2000. A total of 185 larval sea lampreys were tagged with CWT and marked with a tail clip. One transforming larval sea lamprey was collected during the survey of the stream and retained for statolith aging. Of the total larvae collected, 135 were larger than 100 mm in length at the time of tagging.

In Grafton Creek, larval surveys were conducted from August 24 to 28, 2000. Both *L. appendix* and *P. marinus* larvae were collected during this period. A total of 250 larval sea



Of the 431 adult sea lamprey transported to Port Britain and Grafton creeks between May 6 and May 7, a total of 89 died by the time the spawning season was completed. The total includes the 14 radio tagged female sea lampreys removed by predators, where the carcasses were not recovered and one recovered carcass (mutilated by a predator), that was not saved for analysis. A total of 74 carcasses were kept and frozen for further chemical analysis, 57 from Grafton Creek and 17 from Port Britain Creek.

In addition, three carcasses (two males, one female) collected in Salem Creek were also kept for analysis. All sea lampreys collected were checked for an individual tag number, a second mark for population estimation, sex and reproductive condition. In 1999, none of the sea lampreys collected were found incorrectly marked for sex. All preserved (frozen) sea lampreys were dissected and the fecundity of females was estimated using the same methodology as in 1998. The sex ratios for the carcasses found in the stream for Grafton Creek were roughly equal (62% female, 38% male, n=8), but not in Port Britain Creek (83% female, 17% male, n=6).

Table 3: Summary of mortality for Grafton, Port Britain and Salem Creeks:

	Grafton Creek		Port Britain Creek		Salem Creek
	1998	1999	1998	1999	1999
Mortality (from live release <sup>1</sup> )	61	18 <sup>2</sup>	106	18 <sup>3</sup>	N/A
Sea lamprey kept for analysis	29	57	49	17	3
Total number of females	28 (46%)	11(69%)	52 (49%)	17(94%)	1 (33%)
Total number of males	32 (52%)	5(31%)	51(48%)	1 (59%)	2 (67%)
Indeterminate sex	2	0	3	0	0

<sup>1</sup>from all sea lamprey released into the stream, including known predation, but excluding the mortality that occurred in the first three days post-release.

<sup>2</sup>Grafton Creek: 16 carcasses were collected and two radio-transmitted sea lampreys died without carcass recovery

<sup>3</sup>Port Britain Creek: six carcasses were collected and 12 radio-transmitted sea lamprey died without carcass recovery

## SMRT survey results for Grafton and Port Britain

### Habitat Observations

Tables 4, 5, and 6 provide 1997 to 2001 estimates of the percentage of habitat surveyed and the amounts scaled to the streams during the fall SMRT sampling. Between 1997 and 1999, while the amount of Type I and Type II larval habitats was different between years, the changes were relatively small from year to year (Tables 5, 6). In 2000, the amount of Type I habitat estimated as available in Grafton Creek was approximately one half that in 1999, while the amount of Type II was relatively stable. In Port Britain Creek, the estimated amount of Type I



that predation may have been higher than expected in Port Britain Creek in 1999, as sea lampreys that were removed from the stream would not have been detected.

Predation also occurred in Grafton Creek in 1999. Only two radio tagged animals were removed from the stream, the first was removed six days after the introduction and the second 17 days later. Also, a bird may have attacked one sea lamprey, as it was found on shore, alive, during one of the daily stream surveys. Only one carcass exhibiting signs of predation was found in 1999, so, again, predation rates may have been underestimated through the use of recovered carcasses alone.

### **Emigration:**

Emigration occurred in both Port Britain and Grafton creeks in both years. In 1998, the total emigration, as measured by the return of marked animals to a stream with a sea lamprey trap, was 19 individuals. Both Grafton and Port Britain Creek sea lamprey traps captured a total of four animals, while Cobourg Brook, the central stream, recovered 11. Due to problems with records kept by the trap contractor (the same individual operated all three traps), the stream of origin could not be determined for any of the recovered sea lampreys. While it is likely that the sea lampreys in Port Britain and Grafton creeks were introduced to those streams, this can not be determined for certain. In total, approximately 3% of the 696 sea lampreys released in 1998 were recovered in a sea lamprey trap at a barrier.

In 1999, three sea lampreys were recovered during the trapping season. In Port Britain Creek, two sea lampreys (one male, one female), from this stream were recovered on May 19. One male sea lamprey, released into Grafton Creek, was recovered in the Grafton trap on June 14. Using these captures, the emigration rate for 1999 was approximately 1% for both streams.

In 2000, one male sea lamprey released in Grafton Creek was recovered in the Port Britain Creek low-head barrier dam trap. No Port Britain Creek animals were recovered in barrier traps in 2000, thus the known emigration for Grafton Creek was 1% of the total adults released.

### **Population estimates, post-introduction**

#### **1998**

To estimate the number of sea lampreys in the stream, we electrofished a portion of the creek and used a distinctive mark, a fin clip made with pinking shears, for any captured lampreys. On May 12 in Grafton Creek, eight sea lampreys were marked and released and on May 13, 27 sea lampreys were marked and released in Port Britain Creek. The recovery rates among carcasses were four and seven individuals, respectfully. Population estimates from the mark/recapture study for adults remaining at the time of spawning are summarized in Table 2.