FISH PASSAGE CENTER

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<u>MEMORANDUM</u>

TO: Christina Luzier (USFWS),
Howard Schaller (USFWS),
David Wills (USFWS),
Brian McIlraith (CRITFC)

FROM: Jerry McCann, Brandon Chockley,

DATE: November 22, 2011

RE: Results of 2011 lamprey monitoring and request for guidance for 2012

The FPC staff, in collaboration with SMP staff, have summarized the lamprey monitoring data that were gathered as part of the Smolt Monitoring Program in 2011. The summary is provided as a beginning point for discussions of the lamprey monitoring component of the Smolt Monitoring Program for 2012. The FPC staff has put together results of the 2011 lamprey monitoring and ask that the Lamprey Technical Work Group (LTWG) review the results and provide guidance for monitoring in 2012.

In 2010 the FPC was approached with a request to make changes to lamprey monitoring. The LTWG had developed a list of critical monitoring needs, several of which were relevant to the SMP. The LTWG chair met with FPC staff and together developed a list of potential changes to lamprey monitoring that would address those critical needs that were deemed appropriate to the SMP. Among these changes were: 1) adopting a standardized approach to juvenile (and potentially adult) lamprey identification based on methods that the USFWS developed, 2) assigning a sample rate to juvenile lamprey that were sampled at SMP sites (as opposed to handling lamprey as “incidental species” whose counts were not associated with sample rates), and 3) outlining the implementation of a pilot study of condition monitoring. After meetings with USFWS and review by Fish Passage Advisory Committee (FPAC) the FPC adopted and implemented the changes to the monitoring program in 2011.

In addition to the changes outlined above, Fish Passage Center undertook more detailed reporting of lamprey collection data via the FPC website as well as adding data summaries to the FPC weekly reports. These efforts at real time data analysis were in response to requests from FPAC. In response to requests by the ISAB, the FPC will add new data to the 2011 FPC Annual Report focused on lamprey data collected as part of the SMP.

Based on its initial analyses of the 2011 juvenile lamprey data, the FPC poses these questions for the LTWG to discuss for the 2012 sampling season:

- Should the changes adopted by SMP sites in 2011 be continued in future years?
- Should the condition monitoring of juvenile lamprey be expanded to other FCRPS projects? If so, what other projects should implement lamprey condition monitoring in 2012?
- Are there any other foreseeable data needs that may be addressed by the SMP sampling efforts at the dams or traps?

Methods

Lamprey Identification

Juvenile lamprey (and adult lamprey that may be collected in the SMP sample) were identified using guidelines developed by USFWS. Prior to the start of sampling in 2011 the FPC and USFWS held a preseason meeting at which SMP site personnel were trained in new fish identification methods. Prior to 2011, juvenile lamprey were identified as being either “brown”, “silver”, or simply “juvenile”. In 2011, the SMP moved to identifying juvenile lamprey to life-stage and species. The protocol used by the sites for lamprey identification is summarized below.

Lamprey juveniles (or adults) were identified to species and life-stage in 2011. Pacific lamprey (*Entosphenus tridentatus*) and western brook lamprey (*Lampetra richardsoni*) were the two species most likely to be encountered by SMP personnel. When a lamprey ammocoete (larva) was collected a key was used to determine species. Ammocoetes were identified as those lamprey with eyes absent and oral disk absent. If total length (TL) of the ammocoete was less than 70 mm then the fish was identified as unknown lamprey ammocoete. For ammocoetes greater than 70 mm, species could be identified based upon the color pattern of the caudal region (Figure 1). Ammocoetes that had a uniformly dark caudal fin with a caudal ridge that was faded and appeared lighter than the fin were identified as Pacific lamprey. Whereas those ammocoetes that had a mottled caudal fin with broad margins lacking pigment; or that appeared blotchy, peppered or completely clear were identified as western brook lamprey.

If caudal region coloration was not definitive, ventral surface coloration was also used as an additional second characteristic for identification. If the ammocoete had a light ventral surface it could have been identified as a Pacific lamprey, otherwise a mottled or uniformly dark ventral surface was considered an indication of Western Brook lamprey. If no determination was possible based on these criteria, the lamprey was identified as an unknown lamprey ammocoete.

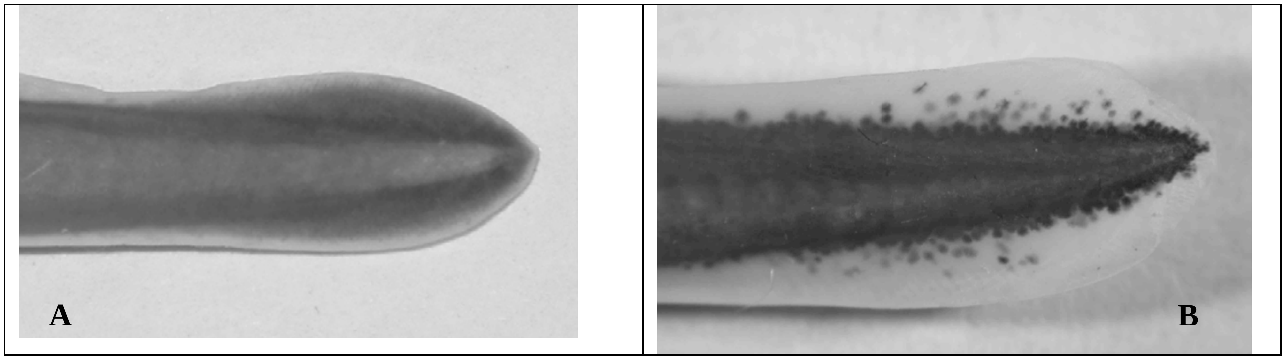


Figure 1. Comparison of caudal region of *Entosphenus tridentatus (A) and Lampetra spp (B)* ammocoete from USFWS lamprey identification guide used by the Smolt Monitoring Program.

Since western brook lamprey do not exhibit a macropthalmia or juvenile life stage the macropthalmia designation was used for lamprey identified as Pacific lamprey juveniles. Macropthalmia are eyed juvenile lamprey with oral disk present and for Pacific lamprey these individuals range in size between 100 and 160 mm. Because Western Brook lamprey adults range between 100 and 200 mm it was important that distinct characteristics were used to identify these different species (and life stages). Based on the USFWS key, the SMP used the relative size of the eye of Pacific lamprey juvenile compared to Western Brook lamprey adults as a key to identifying the different species/life stages (Figure 2). Pacific lamprey macrothalmia were identified by the large eye that was equal in diameter to the distance between the posterior edge of the eye to the first branchial pore. By comparison, the Western Brook lamprey adults were identified by the much smaller eyes on lamprey between 100 and 200 mm (Figure 2).

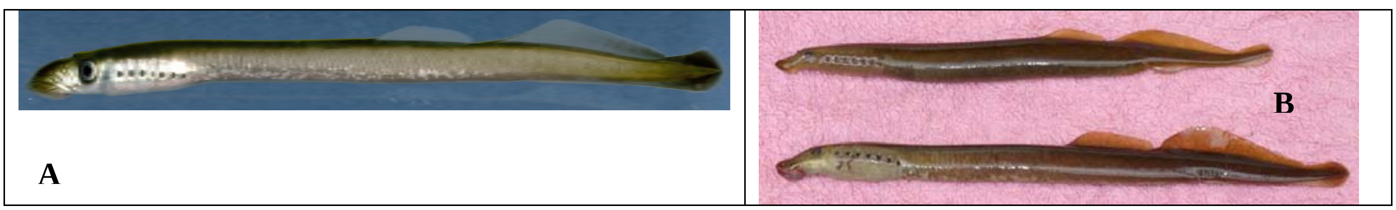


Figure 2. Comparison of the relative eye size of Pacific lamprey macrothalmia (A) and Western Brook lamprey adults (B). Figure from the USFWS key to lamprey identification used by the SMP.

In addition, adult lamprey collected in the SMP samples were identified using USFWS pamphlets as well as the guide book **"**Inland fishes of Washington**:** First Addition" 1979. R. Wydoski and R. Whitney eds.

Lamprey Counts, Passage Timing, and Mortality

The Smolt Monitoring Program implemented a new data entry procedure in 2011 that allowed larval and juvenile lamprey sample data to be directly related to sample rates used in fish collection. In the past, the SMP recorded lamprey as "incidental species" such that all fish in the sample were simply counted and reported and no sample rate information was available. Without sample rate information, estimation of collections was not possible. Under the new procedures developed for 2011, SMP sites were able to report lamprey sample numbers with an associated sample rate similar to what is done for juvenile salmon. This allowed for the estimation of collection counts, based on when and where each juvenile lamprey was sampled (i.e., separate sample rates for different tanks or at different times of the day).

Estimates of collection are made by expanding the sample count based on the sample rate that was being used when the sample was made. Each site has the ability to adjust the sample rate to different tanks and often throughout the day. The sample rate determines how much time the sample gate is open in a given hour. For example, a sample rate of 10% corresponds to having the sample game open for 6 minutes in an hour. Sample rates are chosen by site personnel based on how many total fish are expected to be handled each day. As a general goal, the SMP aims to sample between 300 and 500 total target fish per day. This sampling goal weighs the desire to limit handling while still allowing for the collection of accurate and precise estimates of collection. Table 1 provides an illustration of how the collection count can change based different sample rates.

Table 1. Estimated collection counts based on different sample rates.

Sample Rate	Multiplier	Sample Count	Collection Count
0.05	20	5	100
0.10	10	5	50
0.25	4	5	20
0.5	2	5	10
1.0	1	5	5

In addition, mortality data were required as part of the data recording in 2011. This will allow comparisons of mortality rates between lamprey and other species. In the past, lamprey mortality data had been collected but in a few years it was not collected at all projects.

Lamprey Condition Monitoring

A pilot study was carried out at John Day Dam in 2011 to gather information of the condition of juvenile lamprey entering the bypass systems at the dam. It was the first year and site to record these data so examination and handling protocols were developed by the site personnel as the season progressed. A more detailed explanation of the examination protocol and results are provided later in this report.

Results

2011 Lamprey Counts, Passage Timing, and Mortality

Lamprey Juvenile Counts

Prior to the 2011 SMP season, juvenile lamprey were recorded as incidental species, typically as lamprey silver, lamprey brown, or lamprey juvenile. As mentioned above, the 2011 SMP season is the first sampling season where lamprey juveniles were recorded as target species (similar to salmonids) and were identified to life-stage and species. The four life-stage/species combinations for lamprey juveniles were: 1) Pacific Macropthalmia (MP), 2) Pacific Ammocoete (AP), 3) Western Brook Ammocoete (AB), and 4) Unknown Ammocoete (AS). By treating larval and juvenile lamprey as target species in the SMP, a specific sample rate could be applied to the lamprey juveniles that were sampled. This allows for the expansion of the sample counts to a collection count, based on sub-batch specific sample rates.

Below is a summary of the sample and collection counts that were recorded in 2011 at each of the SMP sites in 2011 (Table 2). Although all SMP sites made the change to including larval and juvenile lamprey as target species in 2011, no larval or juvenile lamprey were sampled at the SMP trap sites in 2011. Furthermore, no western brook lamprey ammocoetes were encountered by SMP site personnel in 2011 (Table 2). At the Lower Columbia and Upper Columbia sites (BON, JDA, MCN, and RIS), the majority of lamprey that were sampled were Pacific lamprey macropthalmia. Pacific lamprey ammocoetes made up the majority of the lamprey sample at LGS and LGR. However, when expanded for sample rates, Pacific macropthalmia made up the majority of the collection at LGS. Very few larval and juvenile lamprey were sampled at LMN in 2011.

Table 2. Total sample and collection counts of larval and juvenile lamprey for 2011 SMP. SMP trap sites did not collect any larval or juvenile lamprey in 2011.

	Sample Counts				Collection Counts			
Site	**MP**	**AP**	**AB**	**AS**	**MP**	**AP**	**AB**	**AS**
BON*	2,209	74	0	0	25,412	721	0	0
JDA*	10,680	1,984	0	0	466,479	28,215	0	0
MCN*	6,567	28	0	2	319,568	1,150	0	40
LMN*	8	1	0	0	1,045	1	0	0
LGS*	320	2,472	0	0	40,682	6,837	0	0
LGR	68	372	0	0	4,418	6,165	0	0
RIS	271	54	0	1	272	55	0	1

* Sample and collection counts were extrapolated for non-sample days at these sites. LMN and LGS sampled every 3rd or 4th day in the early season, MCN had every-other-day sampling from 4/13-7/19, and BON and JDA had some non-sample days in late August-early September due to temperature protocols.

Passage Timing

Some SMP sites (LGS, LMN, MCN) sample fish from two different sample tanks, which can have different sample rates. Other sites (BON, JDA) often change their sample rates throughout the day, depending on whether increased sampling is necessary to collect research fish or for other reasons. Prior to the 2011 sampling season, assessing passage timing of juvenile lamprey was limited to either using raw sample counts or estimating a collection count by expanding on an average daily sample rate. When estimating a collection, the daily average sample rate would be based on salmonid collections at each site. However, depending on the configuration and operations at a particular site, this may have an impact on the estimated collection count.

By incorporating larval and juvenile lamprey as target species in 2011, actual sample rates can be applied to lamprey sample counts, which allows for more reliable estimates of collection. This is particularly important when addressing lamprey passage timing through the hydrosystem, as collection counts are often used to describe passage timing.

To demonstrate the impact of using sample counts versus collection estimates to describe passage timing, the FPC staff estimated the passage timing of Pacific macropthalmia and Pacific ammocoetes in 2011. We estimated passage timing using two methodologies: 1) by using the sample counts and 2) by using the estimated collection counts that were made possible by the changes in 2011 SMP season. We did this for all the sites except Lower Monumental Dam (LMN). Lower Monumental Dam (LMN) was not included because larval and juvenile lamprey were only encountered on four separate days (3 days of Pacific macropthalmia and 1 day of Pacific ammocoetes). Due to the low number of incidences where larval and juvenile lamprey were encountered at LMN, there was no separation between the 10%, 50%, and 90% passage dates (Table 3).

Macropthalmia Timing:

Based on our review of lamprey sample and collection data for macropthalmia, there are significant differences in timing based on sample counts versus collection counts (Table 3, Figure 3). However, there does not seem to be a pattern in these differences. For some sites, the sample counts resulted in later estimated passage timing (see LGR and LGS in Figure 3) while, for other sites, the sample counts resulted in earlier estimated passage timing (see JDA in Figure 3). When using sample counts to estimate passage timing at LGR and LGS, there appeared to be prolonged passage timing for macropthalmia, compared to that for the collection counts. This is likely a reflection of the fact that there were relatively low sample counts of macropthalmia passage at these projects and there were several days at the end of the season where only a few macropthalmia were sampled. During this time, these projects operate at a 100% sample rate, which results in no expansion of these sample counts to collection counts.

Rock Island Dam was the only site where there was very little difference in timing between the sample counts and collection counts (Table 3, Figure 3). This is because the sample rate for RIS is almost always 100% and, therefore, there is very little expansion from sample counts to collection counts.

Table 3. Estimated 10%, 50%, and 90% passage dates for Pacific lamprey macropthalmia in 2011, based on sample counts and collection counts.

	Sample Count			**Collection Count**		
Site	**10%**	**50%**	**90%**	**10%**	**50%**	**90%**
BON	11-Mar	11-Apr	30-May	25-Mar	15-Apr	29-May
JDA	5-Apr	17-Apr	17-June	12-Apr	24-May	16-Jun
MCN	15-Apr	30-May	18-Jun	23-Apr	24-May	16-Jun
LMN	18-May	19-May	1-Sept	18-May	19-May	20-May
LGS	7-Apr	14-Apr	6-Oct	8-Apr	16-Apr	18-May
LGR	2-Apr	15-Apr	12-Oct	6-Apr	8-Apr	17-May
RIS	20-Apr	17-May	8-Jun	19-Apr	17-May	8-Jun

Macropthalmia timing at JDA provides a good illustration of how estimates of timing can be greatly impacted by sample rates. Estimates of timing based on sample counts resulted in earlier estimated 10% and 50% timing dates, when compared to timing based on collection counts (Table 3, Figure 3). This is partially explained by the fact that sample counts of Pacific macropthalmia at JDA were rather high in early to mid-April and also in late May. However, the sample rates during the April period were generally higher (4%) than those used in the May period (0.9%). Although the sample counts in April were high, the higher sample rates during this time resulted in smaller expansions for estimating collection. Because of the lower sample rates in May, the already high sample counts were expanded to even higher collection counts during this period.

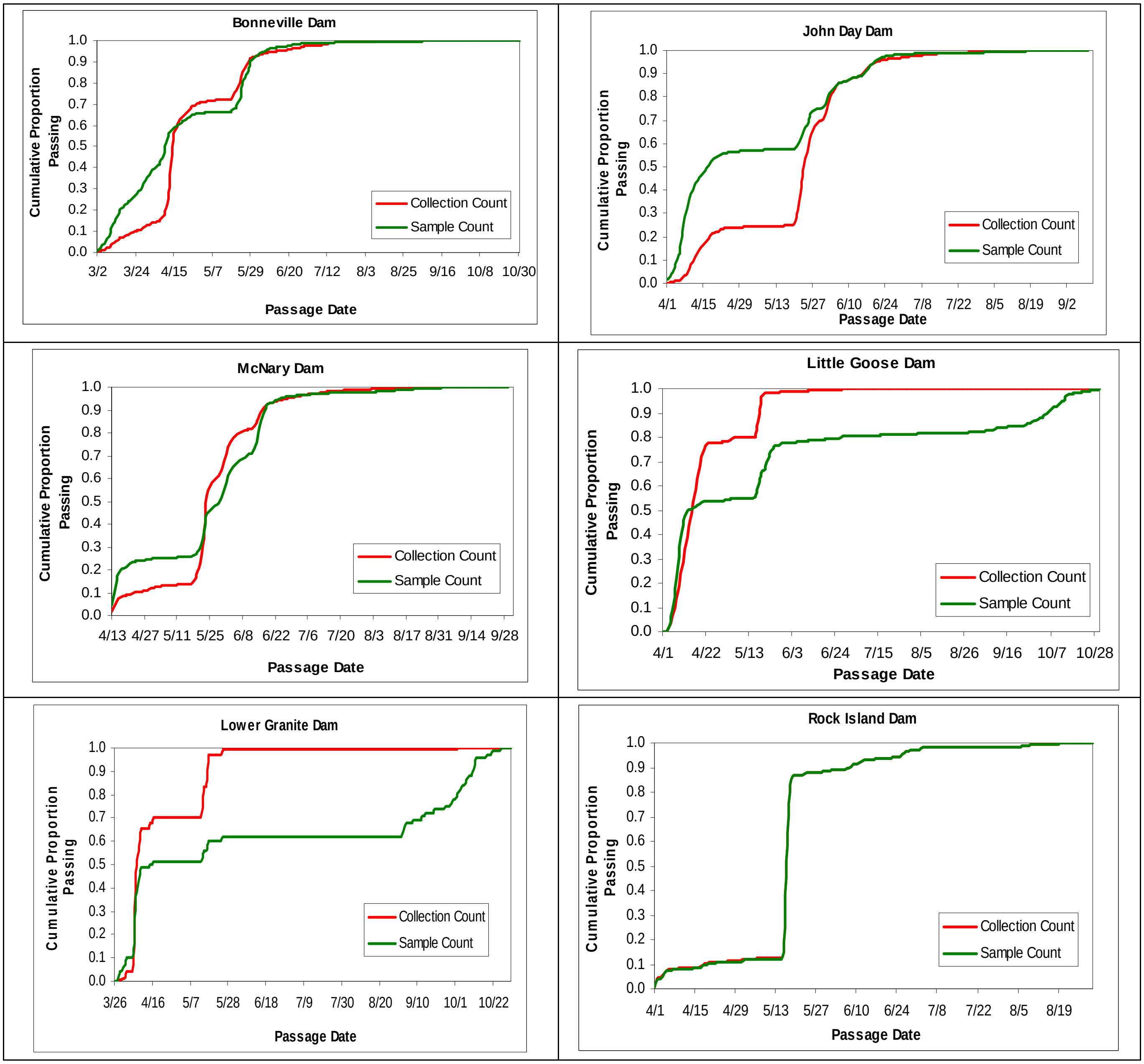


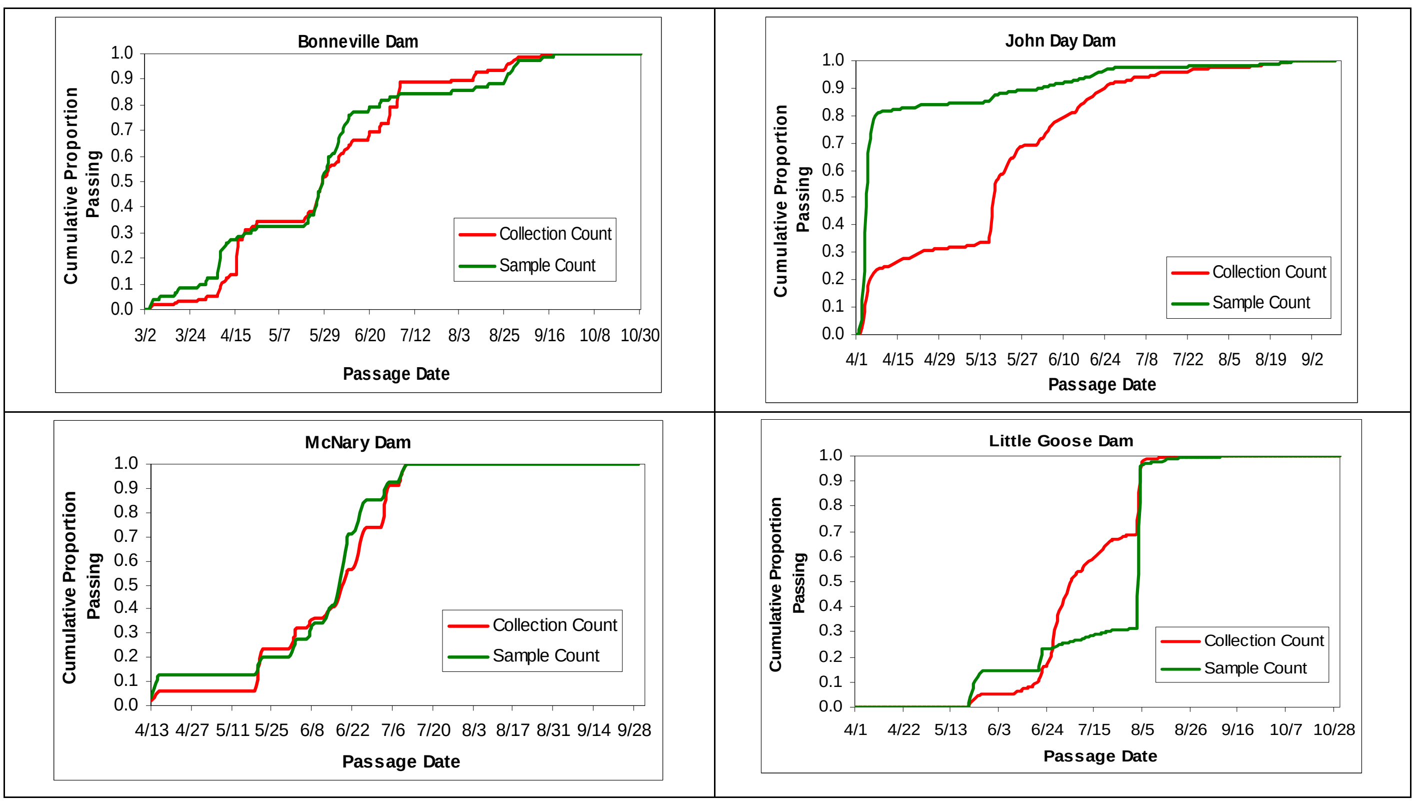
Figure 3. Cumulative passage timing curves for Pacific lamprey macropthalmia at BON, JDA, MCN, LGS, LGR, and RIS for 2011, based on sample counts and collection counts. Note that the x-axes are different given different sampling schedules among sites.

Ammocoete Timing:

There were also significant differences in ammocoete timing based on sample counts versus collection counts (Table 4, Figure 4), particularly for JDA, LGS, and LGR.

Table 4. Estimated 10%, 50%, and 90% passage dates for Pacific lamprey ammocoetes in 2011, based on sample counts and collection counts.

	Sample Counts			Collection Counts		
Site	**10%**	**50%**	**90%**	**10%**	**50%**	**90%**
BON	2-Apr	28-May	26-Aug	9-Apr	28-May	11-Aug
JDA	4-Apr	5-Apr	3-June	5-Apr	18-May	24-May
MCN	15-Apr	18-Jun	4-Jul	20-May	19-Jun	5-Jul
LMN	26-Aug	26-Aug	26-Aug	26-Aug	26-Aug	26-Aug
LGS	24-May	4-Aug	4-Aug	21-Jun	5-Jul	4-Aug
LGR	5-Jul	13-Jul	21-Jul	13-May	8-Jul	17-Jul
RIS	6-May	18-May	21-Jul	30-Apr	18-May	21-Jul



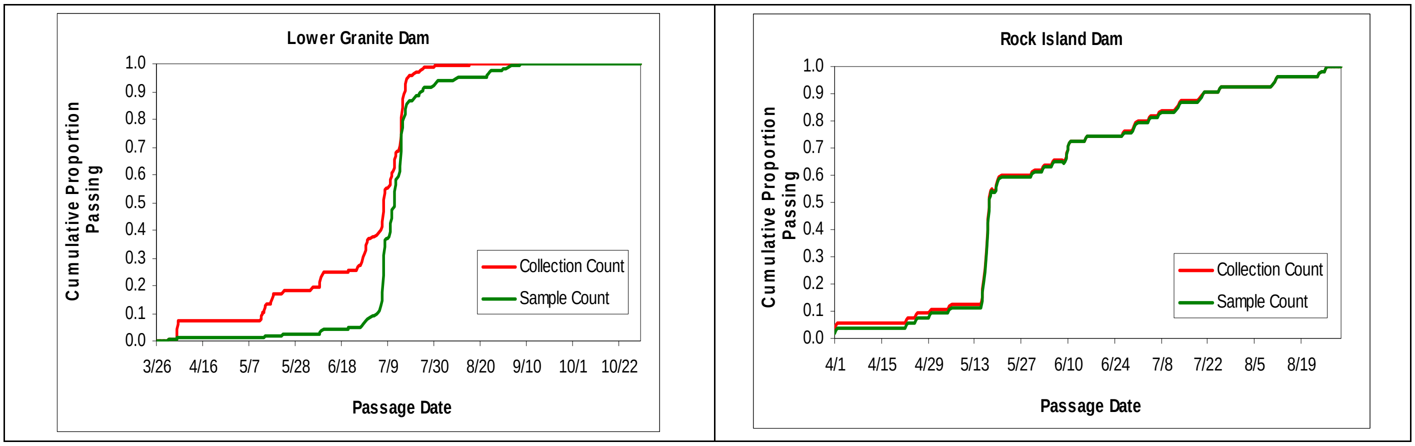


Figure 4. Cumulative passage timing curves for Pacific lamprey ammocoetes at BON, JDA, MCN, LGS, LGR, and RIS for 2011, based on sample counts and collection counts. Note that the x-axes are different given different sampling schedules among sites.

Mortality

To assess mortality rates of lamprey juveniles compared to those of salmonids, the FPC staff compared estimates of sample mortality at three different dams, BON, JDA, and MCN. This analysis was only done at these three dams because these were the only sites where ≥20 lamprey juveniles were routinely encountered throughout the sampling season. John Day Dam was the only site where daily samples of Pacific ammocoetes exceeded 20 individuals. This analysis seems to indicate that Pacific lamprey tended to have a higher incidence of mortality than Chinook salmon examined over the season, especially macropthalmia. This was particularly true at Bonneville Dam (Figure 5) where mortality percentages for Chinook were often near zero while lamprey mortality percentages varied equally between 4% and 20%. A similar pattern of higher proportion of samples with higher mortality rates was also seen at McNary Dam (Figure 7). In general, Pacific ammocetes at JDA had similar incidences of mortality as macropthalmia. However, Pacific ammocoetes had a larger proportion of days where mortality approached the 2.5-3.0% range than did any of the other species (Figure 6).

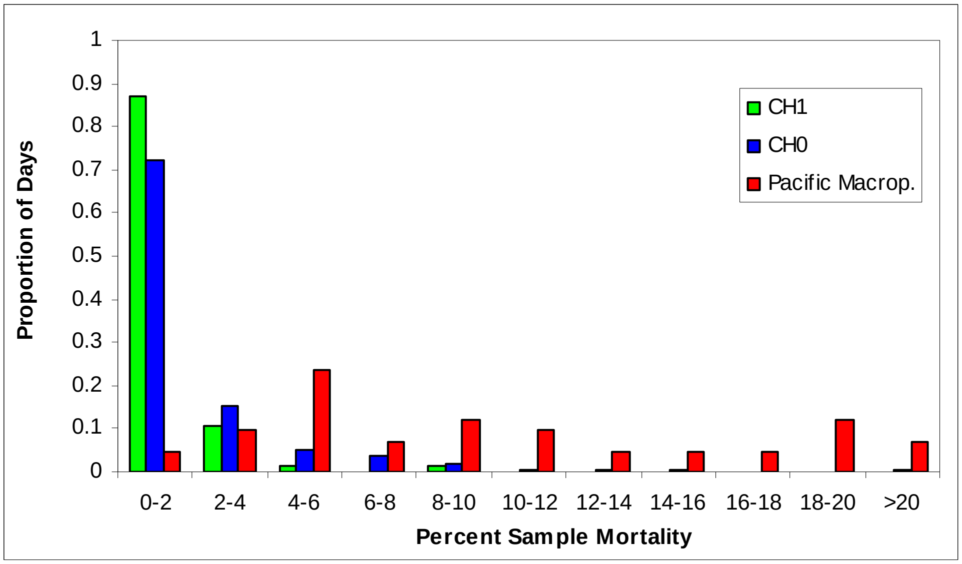


Figure 5. Frequency histogram of percent sample mortality for yearling Chinook, subyearling Chinook, and Pacific lamprey macropthalmia at Bonneville Dam in 2011.

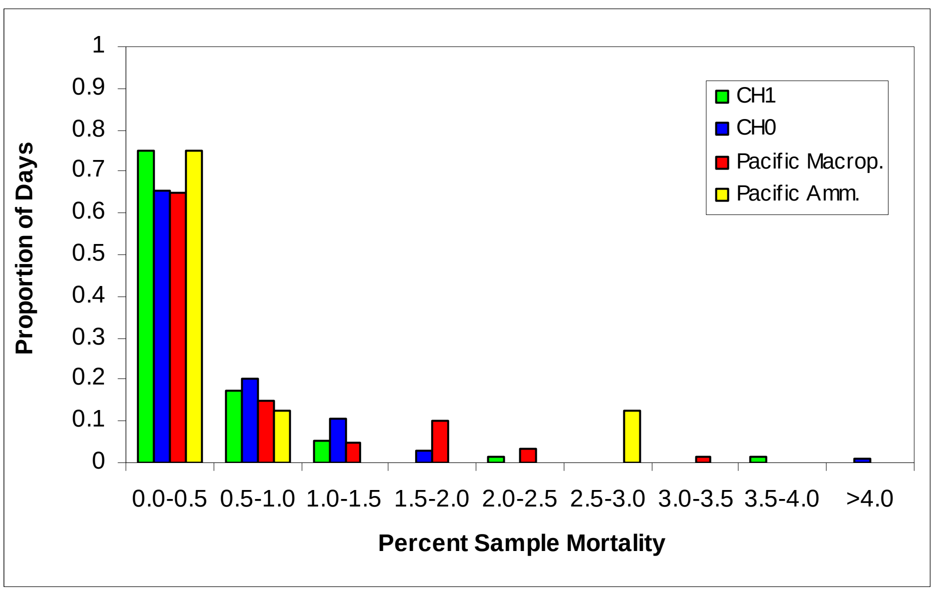


Figure 6. Frequency histogram of percent sample mortality for yearling Chinook, subyearling Chinook, Pacific lamprey macropthalmia, and Pacific lamprey ammocoetes at John Day Dam in 2011.

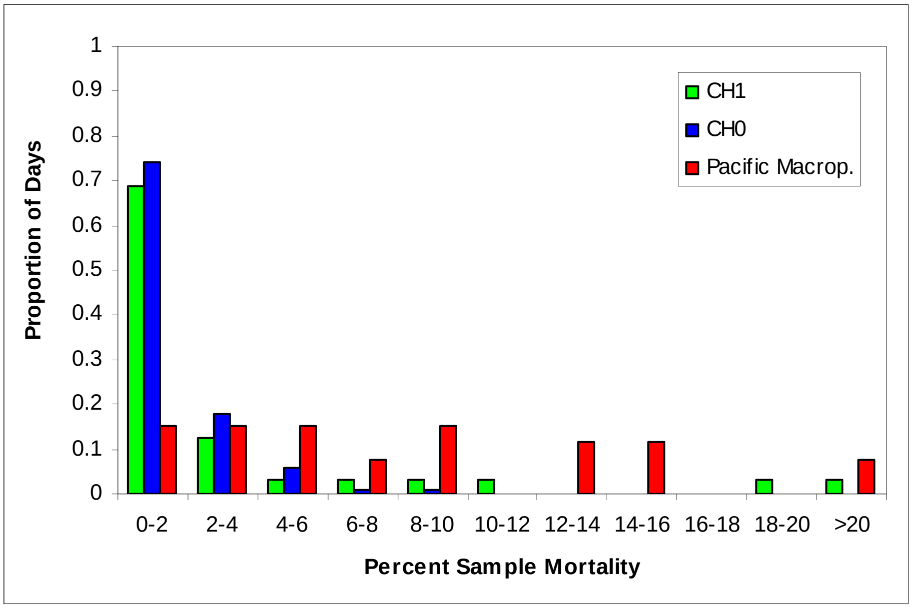


Figure 7. Frequency histogram of percent sample mortality for yearling Chinook, subyearling Chinook, and Pacific lamprey macropthalmia at McNary Dam.

Lamprey Condition Monitoring at John Day Dam 2011

Introduction

In 2011, a pilot study was carried out by the Smolt Monitoring Program at the John Day Dam Smolt Monitoring Facility to gather information on the condition of out-migrating, bypassed juvenile Pacific lamprey (*Entosphenus tridentatus*). Condition exam results represent a combination of in-river baseline conditions such as disease and predation marks and also provide data about injuries incurred while passing through the bypass systems and other routes at the dam(s). As it was the first year of condition exams for juvenile lamprey, handling protocols were developed by the site personnel based on previous observations of juvenile lamprey incidentally sampled, anesthetized, and sorted as part of normal SMP sampling. Handling procedures were modified as the season progressed and as needed.

Handling Methods

At the end of each sample day (0700 hrs.), most juvenile lamprey were removed from the holding tank using several types of small aquarium style dip-nets before the start of sampling smolts. All juvenile lamprey specimens caught in the general SMP sample holding tank were at least identified to species, life stage, and counted (including dead fish). Fish to be examined for condition were placed in buckets of fresh river water and quickly transferred into a 45L temporary holding tank, also supplied with fresh river water. It is difficult to capture and remove all lamprey without disturbing holding conditions for juvenile salmonids, but the lamprey tend to swim along the edges of the tank and also hold in the corners of the holding tank, so there was some amount of natural separation which helped reduce the level of human activity in and around the holding tank. After at least 100 of each type of lamprey were randomly selected from the sample, any extra lamprey were immediately identified, counted, and released to the tailrace as part of the normal SMP sampling activities.

After processing smolts for the day (often between 1000 - 1100 hrs.), no more than 40 individual lampreys at a time were transferred from the temporary holding tank and placed into the sorting trough (42L). These fish were anesthetized using a solution of MS-222 at a rate of 48mg/L for approximately 4 minutes (equal to a 50g/L stock solution). Although some fish were calm enough to begin the exam after about 3 minutes, most of the juvenile lamprey were completely anesthetized after about 4 minutes.

The pattern of data collection on each fish was generally as follows:

- identify the specimen to species and if it was of ammocoete life stage, determine if it was a western brook lamprey (*Lampetra richardsoni*). None were noted at JDA in 2011.
- measure lamprey length with a floating measuring board (used to minimize the amount of time the lamprey is out of the water).
- perform the exam, trying to keep the fish underwater if possible, by looking at each side of the body, head, both eyes, mouth and teeth area, gill openings, and fins. (No magnification was used, but good lighting was always provided.)
- keep fish in hand in the sorting trough water while entering data on touch screen in the event that re-measuring or examining is required
- weigh fish by placing on wetted plastic tray on scale
- release into recovery tank via release tube at sorting trough
- photograph specimens with maladies or characteristics needed for clarification or suitable for training, standardization, etc.

A logbook was used to record anesthetizing times, MS-222 usage, and total examination times. Individual fish examinations ranged from 13 to 22 seconds, but averaged about 15 seconds per fish once a good sample size and anesthetic concentration was established. After the examination and data input, lamprey were held in recovery tanks for at least 30 minutes prior to being released through normal exit routes to the tailrace. This process was repeated until all lamprey were processed and any excess lamprey which had been held in the temporary holding tank were not anesthetized and released.

Condition Category Definitions and Data Input

Standardized descriptive categories were developed to provide a meaningful way of comparing the condition percentages between years and among Smolt Monitoring Program sites if implemented in the future. The goal for condition monitoring of juvenile lamprey was to sub-sample up to 100 lamprey of both ammocoete and macropthalmia life stages per day, if they were present in the SMP sample. Sample rates varied throughout the season and ranged from 0.7% to 35%.

All exams were external and performed while the specimens were fully anesthetized and without the aide of magnification. Fish were measured (mm), weighed (0.1 gr.), and examined for condition on each side of the head and body. As with juvenile salmonids, condition categories were divided into several groups; injuries, diseases, hemorrhaging, predation marks, exophthalmia, parasites, or deformities. Injuries could be recorded as a body injury, eye injury, head injury, or fin injury.   Diseases could be recorded as fungus, columnaris, bacterial kidney disease (BKD), parasites, or a deformity. Predation marks by fish or birds was also a choice and general comments were reserved for conditions or observations not anticipated such as body blotching, missing eyes, black eyes, or shriveled skin. The methods of data entry followed procedures developed for examining juvenile salmonids for condition monitoring and data were input using a modified version of the FPC32.net Data Entry program touch screen (Figure 8) that is currently utilized by the SMP for daily condition data entry.

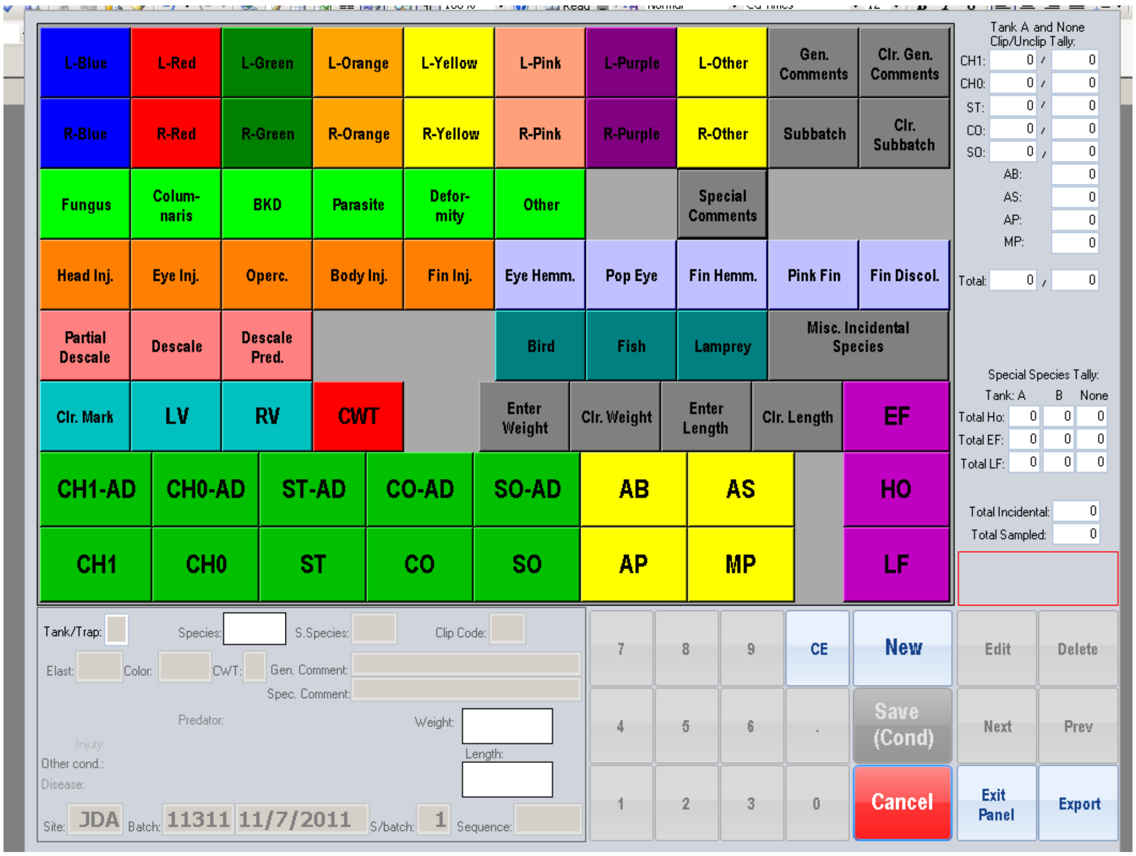


Figure 8. Screen-shot of modified fish condition data entry touch screen for entering lamprey condition data at JDA in 2011.

Injury

The injuries category contains conditions which are often attributed to dam bypass operations or in-river passage conditions (interaction with debris, predators). Obviously old injuries and partially healed injuries should not be recorded as injured.

- **Body injuries** are defined as any injury not on the head or fins. A body injury is considered any cut, abrasion, laceration, swelling, hemorrhaging, or other injury to the body. Body injuries are only those injuries to the body that are not attributed to a disease, parasites, or predators.
- **Eye injuries** are any injury to one or both of the eyes. This includes lacerations, abrasions or clouded tissue, or large amounts of blood indicative of a severe impact.

Note: Popeye (exophthalmia) and eye hemorrhaging are not included in this subcategory but are included in the other conditions category.

- **Head injuries** are defined as that portion of the fish anterior to the gill openings. A head injury is considered any cut, abrasion, laceration, swelling, hemorrhaging, or other injury to the head. Head injuries should only be those injuries that are not confidently attributable to a disease or predator mark.
- **Fin injuries** are defined as those appendages or extensions of tissue on the dorsal and posterior end of the juvenile lamprey. A fin injury is considered any cut, abrasion, laceration, swelling, or other injury to the fins. Fin injuries are only those injuries to the fin that are not attributed to disease, parasites, or predation. Also, this subcategory does not include other conditions associated to the fins such as fin hemorrhaging, fin discoloration, and/or fin inflammation (i.e., fin pinkness). Split fins should only be reported as an injury when the split reaches from the outer margin of the fin to where the fin meets the body.

Disease

The disease category contains conditions which are often attributed to environmental pathogens such as bacteria and viruses. Symptoms of disease are often closely associated with other injuries (columnaris or fungus), but it is not always possible to tell which ailment caused another or if they occur independently. A list of potential diseases follows:

- **Fungus** is usually a white, cottony or fibrous substance attached to the skin of fish. Often observed growing on an older injury or break in the skin or scales.
- ***Columnaris*** bacterial infections are typically visible on the skin of the fish in the form of a yellowish to brownish paste growing on or around an abrasion, lesion, or ulceration.
- **Bacterial Kidney Disease** is usually indicated by a severely bloated body. Secondary symptoms on salmonids include dark pigmentation and pop-eye. It is unknown if juvenile lamprey would exhibit these same symptoms or not.
- **Parasites** which live externally or exhibit external symptoms such as trematodes, copepods, or leeches.
- **Deformities** (those not associated with healed injuries) can include stunted or abnormal growth, misshapen eyes, head, or fins.

Hemorrhaging

This category is defined as the abnormal presence of blood in the external tissues or on the skin of the fish. The location of the hemorrhaging can be indicative of the cause, so this category is divided into the following subcategories:

- **Eye hemorrhaging** is recorded if there is blood on the inside or in the tissues around the eye, but no other apparent damage to the eye or surrounding area.
- **Fin hemorrhaging** is defined as when blood is observed in clear tissues of the fin outside capillaries and blood vessels.
- **Body hemorrhaging** is defined as blood on or in the skin or body area.

Predation Marks

Predation marks can be difficult to distinguish from other types of injuries, especially on juvenile lamprey which are long and thin and do not provide a lot of body surface area that might retain attempted predation evidence. Even so, at least some predation marks are obvious and these can be divided into two distinct groups:

- **Bird predation** can sometimes be determined by observing the paired impressions of a bird beak on each side of the fish.
- **Fish predation** can sometimes be determined by the presence of teeth puncture wounds or impressions and abrasions in the shape of a fish mouth.

Other Conditions

This category includes external symptoms of mostly unknown cause.

- **Popeye** (exophthalmia) is the excessive bulging of one or both eyes
- **Other diseases** includes ailments not mentioned above. Some examples include *Ichthyophthirius multifilis* (white spot disease), cysts, bumps, or tumor-like growths, severe discoloration, or emaciation.

Lamprey Juvenile Condition Results

Sample numbers

Of the over 12,600 total lamprey sampled at JDA in 2011, a subsample of 5,096 (40.3%) were examined for condition. This subsample consisted of 851 ammocoetes and 4,245 macropthalmia and represented approximately 43% of all ammocoetes and 39.8% of all macropthalmia sampled for the year. Most of the ammocoetes were sampled early in the season. There were only 8 days when 20 or more ammocoetes were available for condition sampling. Six of those dates were before April 10 and two dates in mid-May. By contrast there were 51 days when there were 20 or more macropthalmia in the sample stretching from early April through the end of June.

Length and Weight

On average, ammocoetes tended to be slightly longer and heavier than macropthalmia. The average length of ammocoetes was 146 mm and average weight was 5.2 g while macropthalmia averaged 143 mm and weighed 4.2 g (Table 5). The average length and weight for ammocoetes and macropthalmia, with some variation, decreased slightly throughout the season. In April, ammocoete total lengths averaged 148 mm (n = 579) compared to 138 mm (n = 75) during the last half of the sampling season, July through September. Ammocoete average weight was 5.3 g in April compared to 4.7 g during Jul.-Sept. The average total length for macropthalmia in April was 144 mm (n= 2,119) compared to 142 mm (n = 306) during the last half of the sampling season and their average weight in April was 4.3 g down to 4.0 g (n = 306) during July to September, see Figures 9 and 10 below.

Table 5. Weight and length data for macropthalmia and ammocoetes sampled and examined for condition at JDA in 2011.

	Weight (g)	Length (mm)		
	Avg.	Avg.	Min.	Max.
MP (n=4,245)	4.2	143	105	192
AP (n=851)	5.2	146	106	176

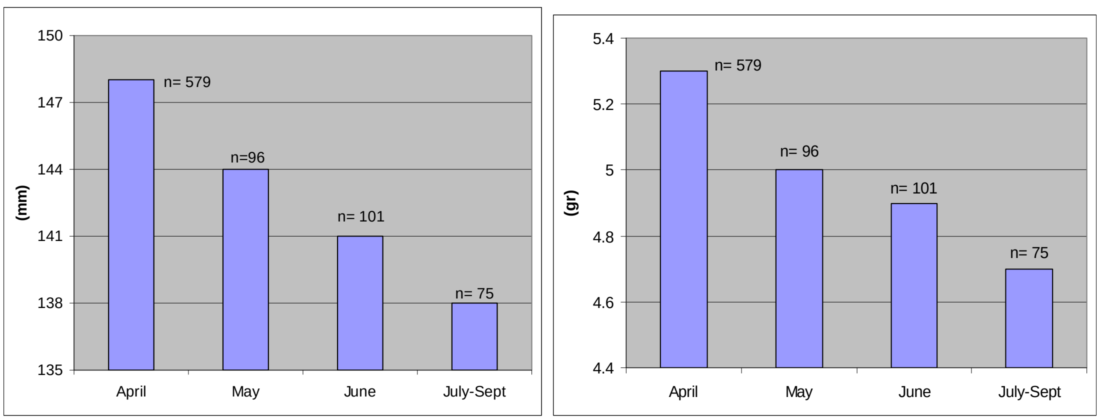


Figure 9. Ammocoete average total length and weight by month, JDA 2011.

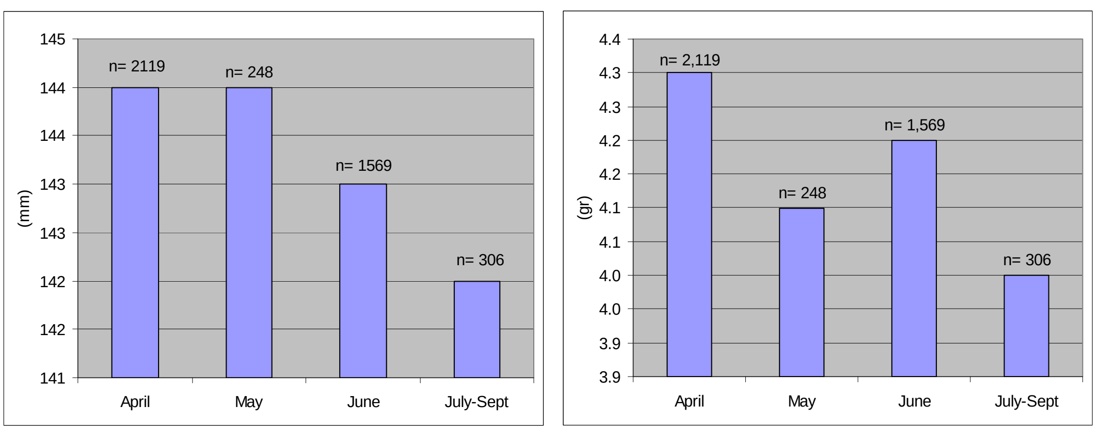


Figure 10. Macropthalmia average total length and weight by month, JDA 2011.

Disease and Injury Results

In addition to providing data on many of the conditions encountered in 2011, this report also includes photographs of these conditions. These photographs will assist in training and standardization if condition exams are performed in the future or at other sampling sites. A summary of condition exam results for ammocoetes (AP) and macropthalmia (MP) can be found in Tables 6-8 below.

Injuries and Predation

Body injuries and fin injuries were the most common type of injury observed on both life stages of juvenile lamprey. Most of these injuries consisted of body or fin "tick marks". These marks were inconsistent in that some were paired (mirrored) on each side of the body, but others were not. Many fish showed marks that appeared to have either more or less healing which suggested that not all the marks are caused during a single event. The cause of the tick marks is unknown but are likely related to the dams, debris, and/or predation. About 6% of the macropthalmia and 5% of the ammocoetes examined had body injuries and 5.8% of the macropthalmia and 0.9% of the ammocoetes had fin injuries (Table 6). Eye and head injuries were less common. Figures 11 through 18 provide an illustration of some of the injuries observed on Pacific macropthalmia.

Table 6. Summary of Pacific lamprey injury and predation results at JDA, 2011.

Life-Stage	Number Examined	Injuries								Predation	
		Body Injury		Eye Injury		Head/Other Injury		Fin Injury		Bird	
		N	%	N	%	N	%	N	%	N	%
MP	4,245	258	6.0	8	0.2	23	0.5	248	5.8	2	0.05
AP	851	45	5.3			6	0.7	8	0.9		
Total	5,096	303	5.9	8	0.2	29	0.56	256	5.0	2	0.04

Figure 11. Macropthalmia with body and tail tick marks.

Figure 12. Tick marks on fin and body (left) and fin injury with fin hemorrhage (right).

Figure 13. Macropthalmia with body tick marks.

Figure 14. Macropthalmia with slight discoloration, minor head injury, and body and fin tick marks.

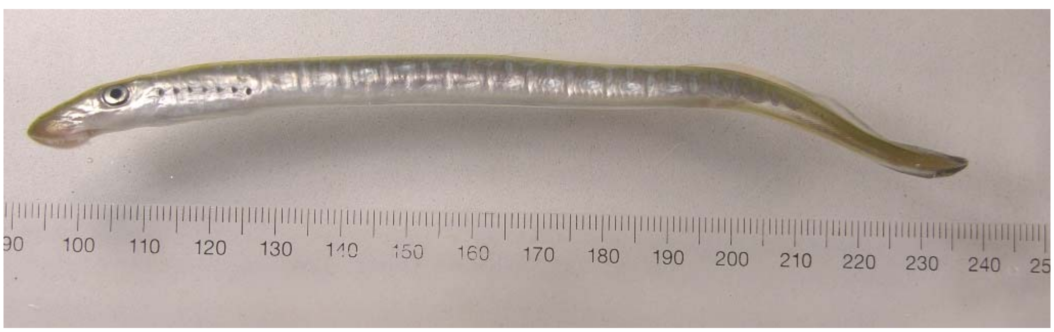


Figure 15. Pattern from submersible travelling screen (STS) mesh on side of macropthalmia.

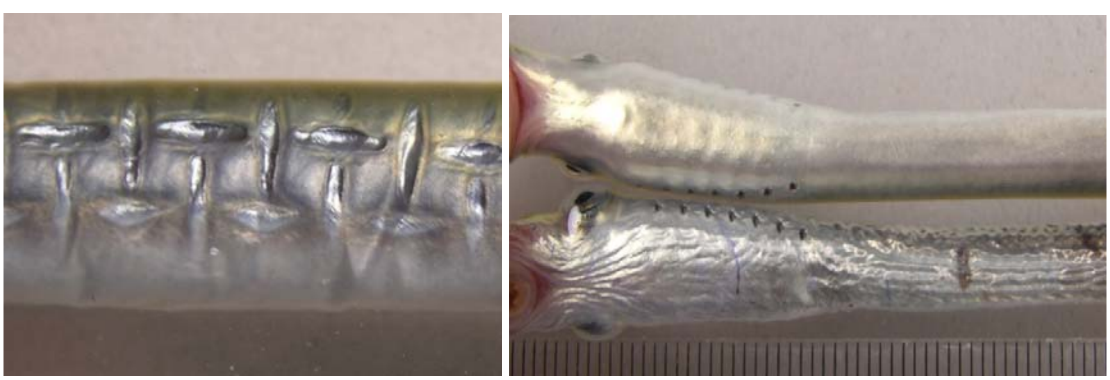


Figure 16. STS mesh impression detail compared to a normal macropthalmia and one with wrinkled skin for comparison.


Figure 17. Macropthalmia head injury (left) and missing eye (right).

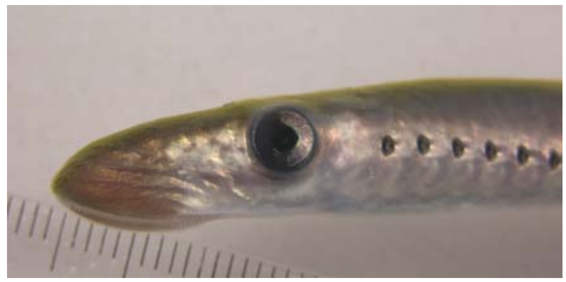



Figure 18. Macropthalmia with black eye (left) and "partial" black eye (right).

Hemorrhaging

Signs of eye and fin hemorrhaging were noted on both ammocoetes and macropthalmia, but were not common on either. Ammocoete fin hemorrhaging was the most commonly observed at 1.29% and macropthalmia fin hemorrhaging was the second most common at about 1.13% (Table 7). Figures 19 through 24 provide an illustration of some of the hemorrhaging observed among the Pacific macropthalmia and ammocoetes examined in 2011.

Table 7. Summary of Pacific lamprey hemorrhaging results at JDA, 2011.

Life Stage	Number Examined	Eye		Fin	
		N	%	N	%
MP	4,245	2	0.05	48	1.13
AP	851	1	0.12	11	1.29
Tot.	5,096	3	0.06	59	1.16


Figure 19. Macropthalmia eye hemorrhaging (left) and eye hemorrhaging with "cataract" (right).

Figure 20. Ammocoete with scattered body and fin hemorrhaging.

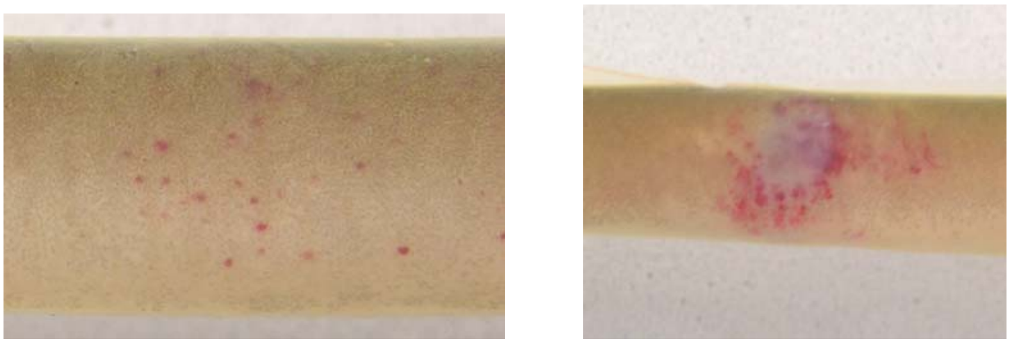


Figure 21. Ammocoete scattered body hemorrhaging detail (left) and body hemorrhage (right).

Figure 22. Ammocoete severe body injuries and associated body hemorrhaging.

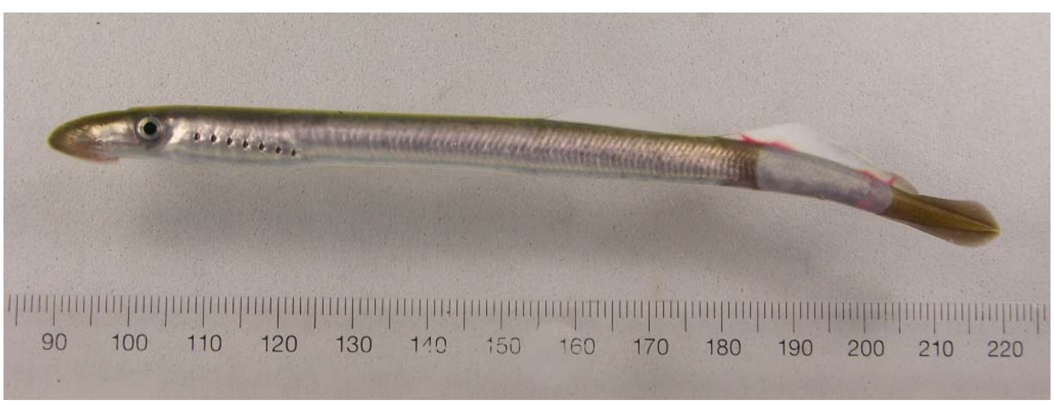


Figure 23. Macropthalmia fin hemorrhage found in association with old injury and fungal or bacterial infection.

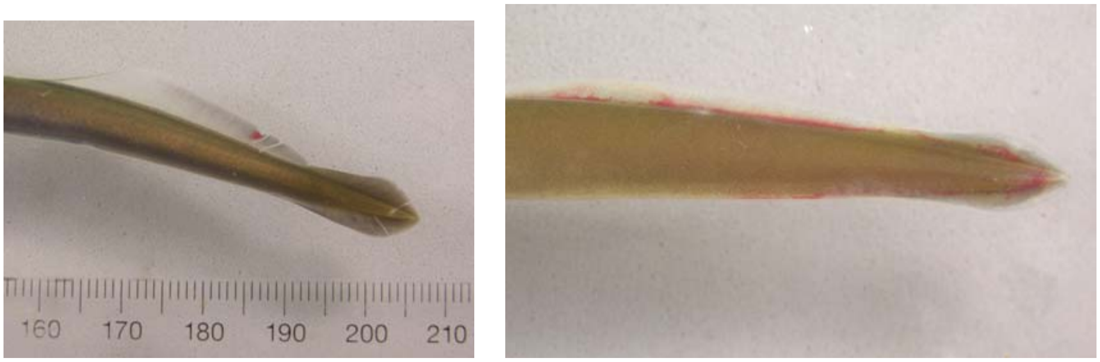


Figure 24. Ammocoete fin hemorrhage with fin injury (left) and fin hemorrhaging without fin injury (right).

Diseases

Observations of external disease were only observed on Pacific macropthalmia but were very rare. Fungus was the most common disease observed on Pacific macropthalmia, but was only observed on 0.24% of those macropthalmia that were examined (Table 8). Columnaris-like symptoms were observed only once on a macropthalmia (Table 8). Figures 25 and 26 provide an illustration of some of the diseases observed on the Pacific macropthalmia that were examined in 2011.

Table 8. Summary of Pacific lamprey hemorrhaging results at JDA, 2011.

Life Stage	**Number Examined**	**Columnaris**		**Fungus**		**Deformity**	
		N	**%**	**N**	**%**	**N**	**%**
MP	4,245	1	0.02	10	0.24	1	0.02
AP	851						
Tot.	5,096	1	0.02	10	0.20	1	0.02

Figure 25. Macropthalmia with some body discoloration and fungal infection.

Figure 26. Possible columnaris-like symptoms with fin hemorrhaging and some body discoloration.

Other Conditions

The most common symptom observed in this category was abnormal body discoloration. These lamprey had a blotchy or mottled appearance, sometimes associated with other injuries or diseases. Other observations included specimens with extremely wrinkled skin that often looked emaciated or dehydrated. Cataract-like cloudy tissue in the iris and pupil area of the eye was noted at least twice and a few juvenile lamprey without a slime layer were also observed. Figures 27 through 32 provide an illustration of some of the “other conditions” observed among the juvenile lamprey examinations in 2011.

Figure 27. Macropthalmia with discoloration possibly due to injury and healing.

Figure 28. Macropthalmia with body discoloration but no apparent healed injury.

Figure 29. Odd light pigmented spots noted on both sides of macropthalmia.

Figure 30. Macropthalmia with odd spots (top) and wrinkled skin appearance (bottom).

Figure 31. Macropthalmia with cataract-like cloudy tissue in eye.

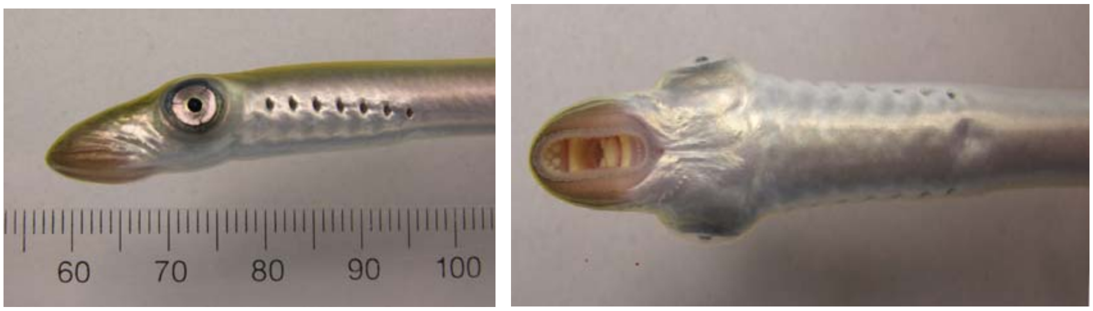


Figure 32. Macropthalmia with exophthalmia (side and ventral view of same individual).

Transforming or Transitional Individuals and Other

Some juvenile Pacific lamprey were sampled exhibiting morphological characteristics of both the ammocoete and macropthalmia life stages. Figures 33 through 36 provide an illustration of these "transitioning" lamprey juveniles.

Figure 33. Two juvenile Pacific lamprey ammocoetes with eyes nearly completely developed.

Figure 34. Ammocoetes with external eyes developing (top) and macropthalmia without fully formed parasitic mouth (bottom).

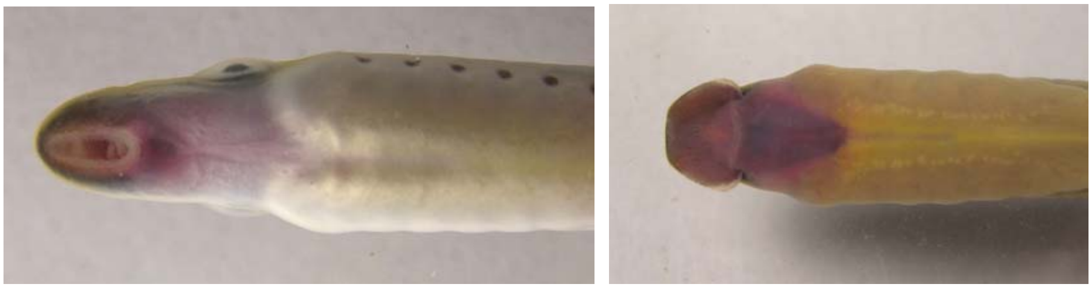


Figure 35. Transitional mouth development (left) compared to ammocoete mouth detail (right).

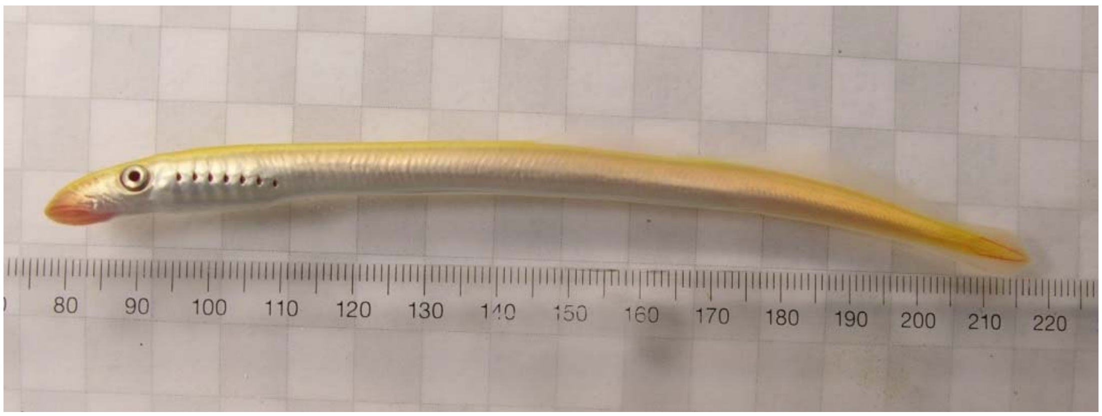


Figure 36. Pacific lamprey macropthalmia without normal pigmentation.