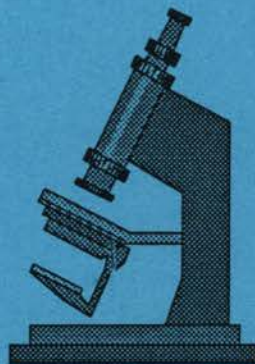


DUP

# **The 1997 Presque Isle Bullhead Tumor Study**



**Pennsylvania Department of Environmental Protection**

**Pennsylvania Animal Diagnostic Laboratory System (PADLS)**

**The Animal Diagnostic Laboratory**

**Department of Veterinary Science**

**The Pennsylvania State University**

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# **PRESQUE ISLE BAY**

## **BULLHEAD TUMOR STUDY**

### **1997**

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## ACKNOWLEDGMENTS

There are many people we would like to thank for contributing to the success of this project. Eric Obert, Pennsylvania Department of Environmental Protection, Biologist, was constantly on the scene coordinating the efforts of all participants. Bob Wellington, Erie County Health Department, Biologist, was also helpful in many aspects of the project. Other DEP employees participating in this effort include Kelly Burch, Ray Hasse, Joann Mukherjee, Jim Rozakis, and Judy Taylor. Also, contributing significantly were Dave Parker, Manager of Presque Isle Canoe Rental and Harry Leslie of the Pennsylvania Department of Conservation and Natural Resource. Pennsylvania Animal Diagnostic Laboratory employees including Toni Auman, Lore Boger, Beverly Ditzler, Roberta Horner, Amber Itle, Audrey Smith, and Jenny Vondenichar, played an important role in completing the project. Without assistance from these individuals, the 1997 Presque Isle Bullhead Tumor Study would not have been possible.

## THEORY

The first part of the paper is devoted to a review of the literature on the topic. The second part presents the theoretical framework of the study. The third part describes the methodology used in the study. The fourth part presents the results of the study. The fifth part discusses the implications of the study. The sixth part presents the conclusions of the study.

# 1997 PRESQUE ISLE BULLHEAD TUMOR STUDY

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# 1997 PRESQUE ISLE BULLHEAD TUMOR STUDY

## Characterization of the Population of Bullheads Collected

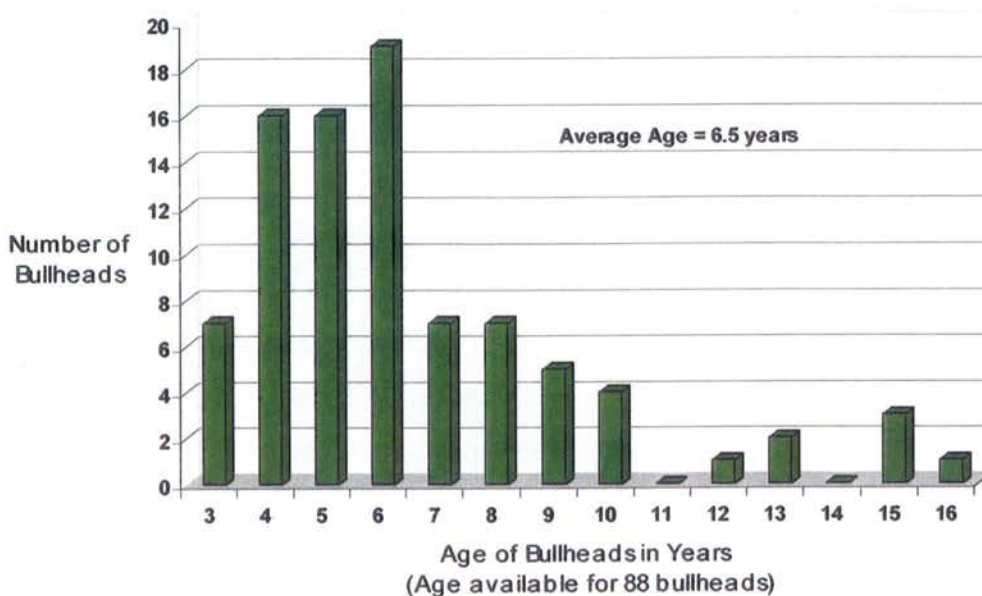
Ninety four bullheads were captured from 7 different sites: Eaton Reservoir, Lagoons, the Point, Misery Bay, Mill Creek, Leboeuf Lake and Sara's Cove. Seventy five were brown bullheads. Nineteen were yellow bullheads. Forty three were male. Forty nine were female. Two were immature and the sex could not be determined. Sex and color (other than average age) were not further evaluated as variables due to low numbers of yellow bullheads and relatively even distribution of sex through the different groups of fish. Twenty six bullheads were obtained from Eaton Reservoir and 5 were obtained from Leboeuf Lake. Eaton Reservoir and Leboeuf Lake are inland waters separate from Lake Erie. At the start of this study, both sites were considered to be low in industrial pollution and were to serve as reference populations (see below: Site Evaluation: Reference vs. Study). Due to high concentrations of polycyclic aromatic hydrocarbon (PAH) metabolites naphthalene, phenanthracene, and benzo-a-pyrene in the bile of bullheads taken from Leboeuf Lake, only the 26 bullheads from Eaton Reservoir will serve as the reference population.

Bullhead populations collected at the 7 sites are described according to number and age of bullheads (Table 1). Age ranged from 3-16 years with a larger number of younger (3-8 years) evident in the study versus older bullheads (9 years and above) (Table 2, Fig. 1). The average age of bullheads was comparable at 5 of the 7 collection sites with bullheads collected at Leboeuf Lake and the Point being considerably younger than bullheads collected at other sites. Young bullheads were collected at all sites.

Seventy five brown bullheads and nineteen yellow bullheads were collected. The average age of brown bullheads, 6.8 years, was slightly greater than that of yellow bullheads, 5.1 years. In Eaton Reservoir, the average age of brown and yellow bullheads was 8.5 years and 6.0 years, respectively. This was slightly greater than the average age of brown and yellow bullheads, 6.4 years and 4.0 years respectively, collected from all

other locations. Due to the similar biology and behavior of brown and yellow bullheads, relative similarities in ages, and the small number of yellow bullheads collected, data from brown and yellow bullheads were combined into the single category of bullhead.

**Figure 1. Bullhead Age Frequency - 1997 Presque Isle Bullhead Tumor Study**



#### **Site Evaluation: Reference vs. Study**

Eaton Reservoir and Leboeuf Lake were identified as reference sites to be compared to Lake Erie sites. Thirty one of 94 (33.0%) bullheads were collected from the reference sites: 5 from Leboeuf Lake and 26 from Eaton Reservoir. Table 1 demonstrates the age of bullheads collected from each site. The 5 bullheads from Leboeuf Lake were young, ranging in age from 3-5 years. Fish from Eaton Reservoir ranged in age from 4-15 years of age and had the highest average age. Table 3 demonstrates bile chemical concentration by site. By inspection, bile collected from bullheads from Eaton Reservoir had the lowest average concentrations of phenanthrene, naphthalene, and benzo-a-pyrene for any group of bullheads segregated by site. Bullheads from Leboeuf Lake had the highest average level of naphthalene, the 2<sup>nd</sup> highest level of phenanthrene and the 3<sup>rd</sup> highest level of benzo-a-pyrene. Based on bile concentration data, Leboeuf Lake is not a



good candidate as a reference non-polluted site. Eaton Reservoir had the lowest average levels of bile PAH metabolite concentration and does qualify as a good reference site. For the purposes of discussion, only the bullheads from Eaton Reservoir were considered to be the reference population.

### **Gross Observations**

Gross post-mortem examinations were performed on 100 fish (94 bullheads and 6 bowfins) and necropsy findings were recorded (see appendix A). The whole body and liver weight and body length of each fish were also determined. Otoliths were removed from each of the bullheads and submitted for age determination. Bile was recovered from the gallbladder of each fish and submitted for determination of polycyclic aromatic hydrocarbon metabolite concentration (naphthalene, phenanthrene, benzo-a-pyrene). Sections of skin, mouth/lip/barbel, skeletal muscle, anterior and posterior intestine, spleen, gonad, urinary bladder, gas bladder, anterior and posterior stomach, heart, cranial and caudal kidney, Corpuscle of Stannius, liver, pancreas and gallbladder were removed from each fish and immediately placed in 10% buffered formalin for fixation purposes. The fixed tissues were then forwarded to the Animal Diagnostic Laboratory, Pennsylvania State University for histologic evaluation.

Gross observations were made at time of capture and are recorded on the individual fish data record sheets (see appendix A). In general, bullheads were in good condition. Mild gross lesions were present on the exterior of some bullheads. The majority were minor skin lesions including unusual pigmentation, active and healed ulcers or lacerations, fin or tail lesions, broken or absent barbels, etc. Observations of internal organs were also recorded. Abnormal gross observations served as an indicator for tissue collection and subsequent histologic evaluation. By inspection, no noticeable trends for gross lesions in internal organs were present.

### **Microscopic Evaluations**

The sections of skin, mouth/lip/barbel, skeletal muscle, anterior and posterior intestine, spleen, gonad, urinary bladder, gas bladder, anterior and posterior stomach,



heart, cranial and caudal kidney, Corpuscle of Stannius, liver, pancreas and gallbladder obtained at gross post-mortem examination were fixed in 10% buffered formalin for one week. The tissues were then trimmed, placed in labeled cassettes and processed using standard procedures. The tissues were paraffin embedded, sectioned at 5 um, placed on glass slides and stained using hematoxylin and eosin. Each of the three pathologists (Dr. Drake, Dr. Weinstock and Dr. Hattel) were assigned specific organ systems to evaluate histologically. For QA/QC procedures, 10 % of all slides (randomly chosen) in each organ system were re-evaluated by a pathologist other than the pathologist originally assigned to examine that specific organ system (peer review).

Results are recorded on individual fish record sheets (see appendix A). Histologic changes were sporadically present in a variety of organs. The rate, distribution, and character of lesions observed were not considered unusual or significant except as noted below. Further discussion focuses on parasitism, which was present at a high rate, and liver and skin tumors and hyperplasia, which are target organs for changes due to chemical pollutants.

#### **Selection of Tissues for Tumor Studies**

Selection of skin and liver as target organs for indication of environmental pollution is based on previous observations by others (Baumann, 1996, Hayes, 1990, Krahn, 1986). These studies report that tumor rates in these organs were elevated in wild fish from heavily polluted areas. It is hypothesized that pollutants in sediment play a role in development of tumors. Wild benthic (bottom dwelling) fish, such as bullheads, have therefore been proposed as sentinels for assessment of environmental pollution by carcinogenic chemicals. Baumann et al. suggests that a rate of skin (orocutaneous) tumors above 25% and liver tumors above 5% in bullheads is an "indicator of environmental degradation".

The mechanism of pollution induced tumors in fish is an area of active research. It has been proposed that hyperplasia and inflammation may be indicators or contributors to the process of pollution induced tumor formation. In the liver, inflammation such as chronic cholangiohepatitis and cholangiofibrosis has been reported in fish with tumors.

However, these same inflammatory lesions are present in the livers of fish from non-polluted areas. Even so, inflammation may play a role in the development of tumors by making cells more vulnerable to the effects of pollutants. It has been proposed that some pollutants may cause tumors by having a significant effect on cells during cell replication. Cell replication and regeneration commonly occur as a natural part of the process of inflammation and repair. Tumor formation occurs when the growth of replicating cells becomes completely unregulated. In contrast, hyperplasia is a histologic lesion that indicates altered, but not unregulated, cell replication. In toxicity studies using rodents, hyperplasia and changes in cellular morphology (foci of alteration) were considered indicators of toxicity associated with tumor formation. The 1995 Presque Isle bullhead study suggested that bile duct hyperplasia following inflammation may be a morphologic indicator of the effect of environmental pollutants. Therefore, bullheads in this study were evaluated for the presence of hyperplasia in the liver and skin for a possible association with tumor formation.

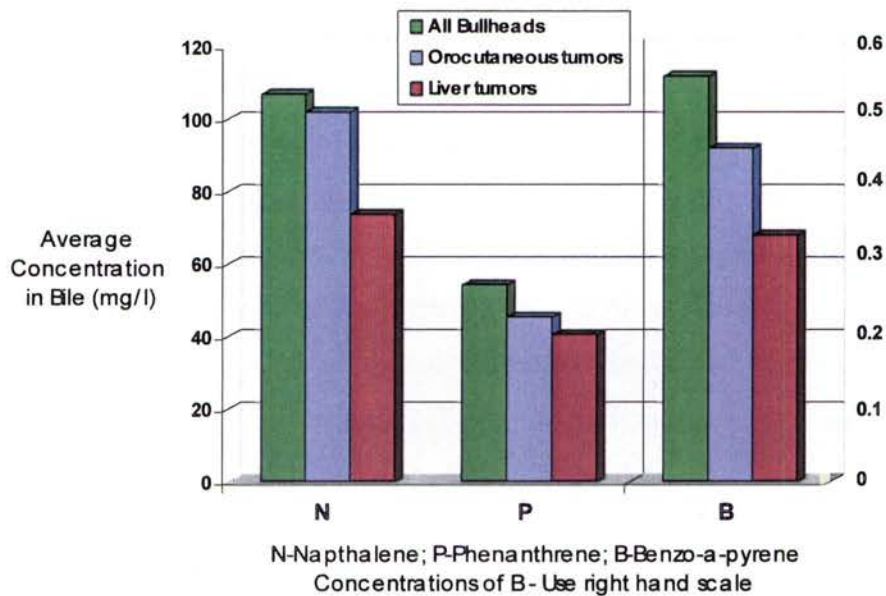
Bile chemical concentration was evaluated as an indicator of bullhead exposure to environmental pollutants. Chemicals in the bile hypothesized to play a role in hepatic tumor formation that were evaluated in the present study were the PAH metabolites naphthalene, phenanthrene, and benzo-a-pyrene. While the mechanism of orocutaneous tumor formation is not as actively investigated as hepatic tumor formation, it is assumed that similar mechanisms are involved. It is also important to note that a background level of tumors exists in all populations and it is only increased rates of tumors above baseline that are indicative of pollution induced tumor formation.

### **Liver Tumors and Hyperplasia**

Data on bullheads with liver tumors and hyperplasia are presented in Tables 4 and 5. Liver tumors were present in 3 of the 4 oldest fish in the study (15-16 years of age). Two were obtained from the Lagoons (study site) and 1 was obtained from Eaton Reservoir (reference site). Table 6 and Fig. 2 demonstrate average bile concentrations of PAH metabolites for the 3 bullheads with liver tumors to be lower than the average bile chemical concentration for all bullheads.

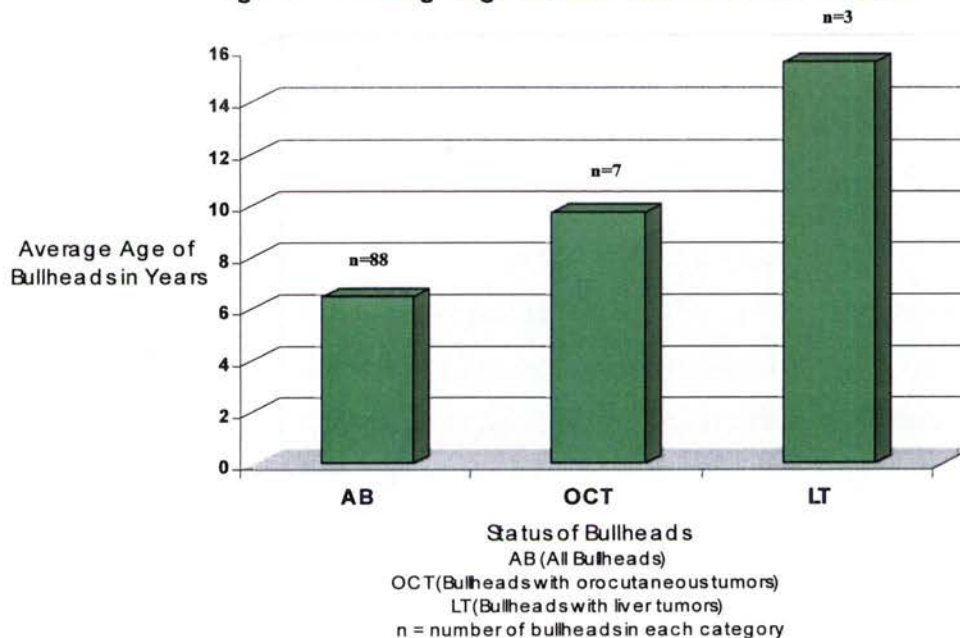


**Figure 2. Average Bile Concentration of PAH Metabolites in Bullheads Versus Tumor Status**



Advanced age was the common factor among the 3 fish with tumors (Fig. 3). A previous study identified age as a factor associated with liver tumors (Baumann, 1992). The rate of liver tumors for all bullheads in this study, 3.2 % (3/94), was below the approximate 5% prevalence proposed by Baumann et al. 1996 as an indicator of environmental degradation.

**Figure 3. Average Age of Bullheads Versus Tumor Status**

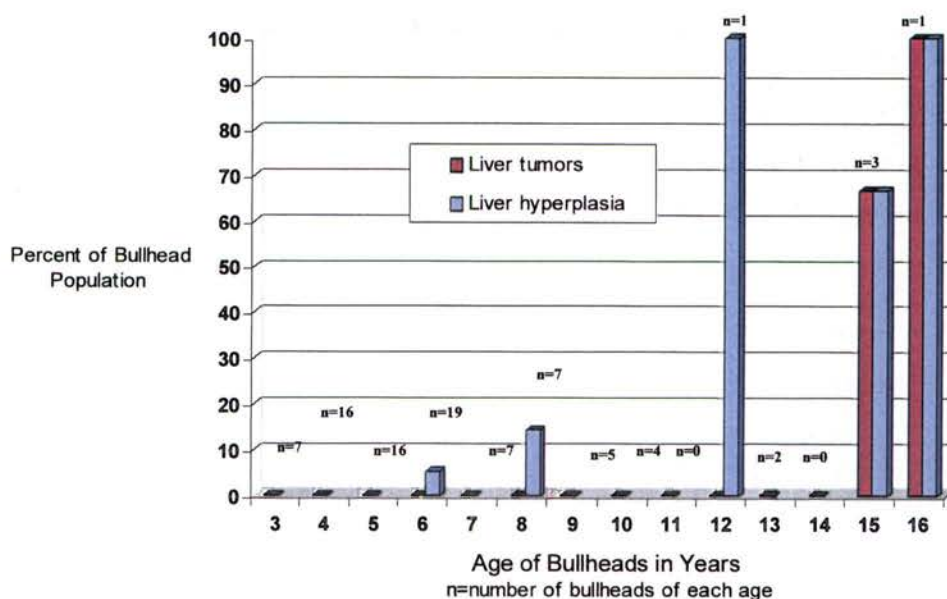




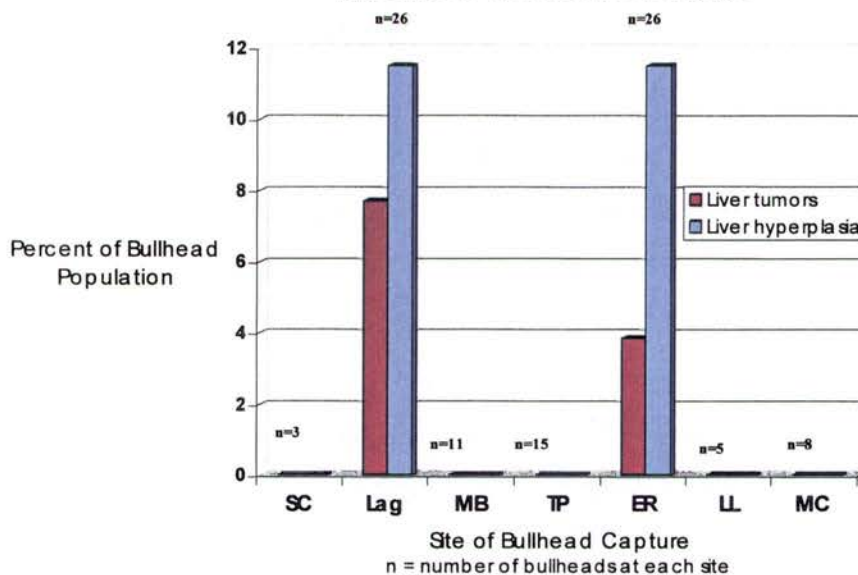
When liver tumor rate by site was evaluated (Table 5), bullheads from the Lagoons were a unique group with a rate of 7.7% (2/26). This was the only study site where liver tumors were seen in bullheads. The tumor rate was above the suggested approximate 5% prevalence indicative of environmental degradation. The liver tumor rate for Eaton Reservoir (reference site) was 3.9%. The rate of liver tumors at Lagoons and Eaton Reservoir can be explained by advanced age of the bullheads, not by bile PAH metabolite concentration. Individual fish with liver tumors were 15 to 16 years of age and had bile PAH metabolite concentrations lower than the average bile PAH metabolite concentration of bullheads without tumors (Table 7). Grouping by site, average bile concentration of PAH metabolites in bullheads from Eaton Reservoir and Lagoons were found to be generally lower compared to other sites (Table 3). Bullheads from Lagoons and Eaton Reservoir have the highest average age compared to other sites (Table 1). In summary, liver tumors observed in this study were most likely due to advanced age and not to environmental pollution.

Liver hyperplasia follows the same trends as liver tumors (Fig. 4). Liver hyperplasia occurred in all 3 bullheads with liver tumors and within bullheads from the same sites as bullheads with liver tumors: Eaton Reservoir and Lagoons (Table 5, Fig. 5). Rates of liver hyperplasia were higher than rates of liver tumors at both sites. The average age of bullheads with liver hyperplasia, 12.0 years, was greater than the average age of all bullheads, 6.46 years, but was less than the average age of bullheads with liver tumors, 15.5 years (Table 4). Average bile concentrations of PAH metabolites in bullheads with liver hyperplasia was lower than average concentrations from the total population of bullheads (Table 6). Bullheads from Lagoons and Eaton Reservoir, sites where bullheads with liver hyperplasia were collected, had lower average bile PAH metabolite concentrations compared to the average of all bullheads (Table 3). Taken together, this suggests that the liver hyperplasia observed in this study is associated with age, not environmental pollution. Insufficient data was present to evaluate whether liver hyperplasia and liver tumors are associated with each other or occur independently.

**Figure 4. Percent of Bullhead Population with Liver Tumors or Liver Hyperplasia Versus Age**



**Figure 5. Percent of Bullhead Population With Liver Tumors or Liver Hyperplasia Versus Site of Capture**



### Other Liver Lesions

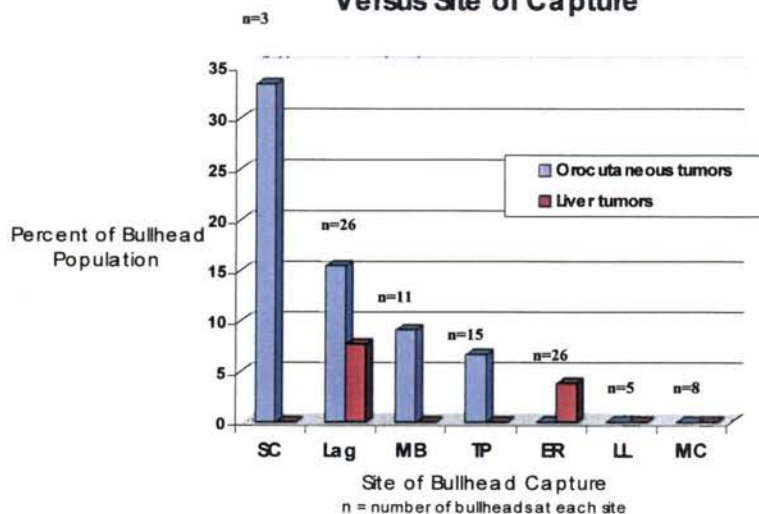
Rates of microscopic liver lesions are presented (Table 8). Foci of alteration are discussed because they are considered to be indicators of hepatic toxicity. Hepatic

inflammation rate is also presented since it has been proposed that inflammation induces repair that may ultimately lead to hyperplasia and possibly the formation of tumors. Relatively low rates of these lesions are present with the exception of parasitism and bile duct and hepatocytic inflammation. Parasitism was present at a relatively high rate in the liver. The parasites were distributed both in the liver parenchyma and within bile ducts and resulted in inflammation at both sites. No obvious association between the microscopic liver lesions and tumors was apparent.

### **Orocutaneous Tumors and Hyperplasia**

Data on bullheads with orocutaneous tumors and moderate hyperplasia are presented (Tables 4 and 5). The orocutaneous tumor rate in all bullheads was 7.45% (7/94). This rate is well below the suggested prevalence of approximately 25% indicative of environmental degradation (Baumann et al. 1996). When segregated by site, bullheads from Eaton reservoir (reference population) had a 0% orocutaneous tumor rate. Orocutaneous tumor rates at study sites ranged from 0% - 33% (Table 5, Fig. 6). Only Sara's Cove had a high rate of orocutaneous tumors, 33%. This data may be biased since only 3 bullheads were collected from Sara's Cove. The sample size was too small for the prevalence to be meaningful. It may be significant that no bullheads (0/26) from Eaton Reservoir (reference site) had orocutaneous tumors.

**Figure 6. Percent of Bullhead Population with Tumors Versus Site of Capture**

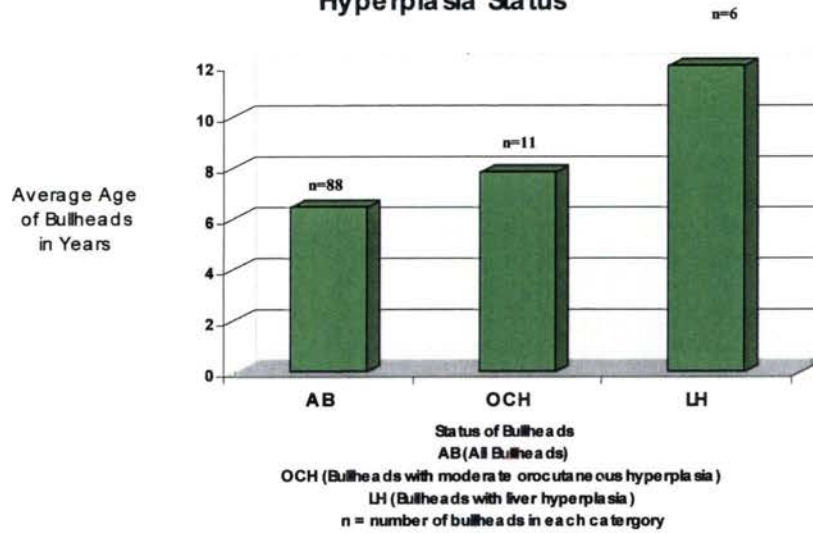




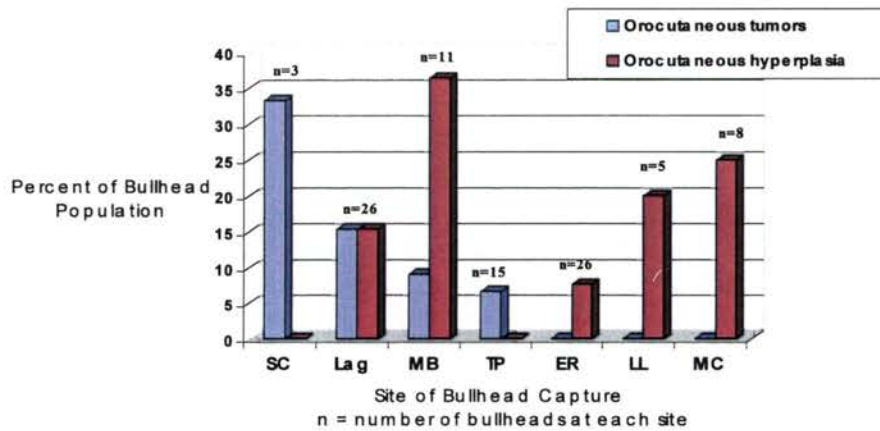
Bullheads with orocutaneous tumors ranged in age from 5-16 years. The average age of bullheads with orocutaneous tumors was 9.7 years (Table 4, Fig. 3) compared to the average age for all bullheads of 6.5 years (Table 1). The average bile chemical concentration of PAH metabolites in bullheads with orocutaneous tumors was lower than the average of all bullheads (Table 6, Fig. 2) but higher than the average of bullheads from Eaton Reservoir (Table 3). Orocutaneous tumors occurred in bullheads from 4 study sites, but did not occur in bullheads from Mill Creek and Leboeuf Lake (study sites), or Eaton Reservoir (reference site) (Table 5). In summary, orocutaneous tumors occurred at a lower rate than that suggestive of environmental degradation with no clear association with age, bile PAH metabolite concentration, or site of collection.

Only moderate or severe orocutaneous hyperplasia is considered in this discussion. Hyperplasia occurred in 13.83% (13/94) of all bullheads (Table 5). Ages of affected bullheads ranged from 3-16 years of age (Table 4). The average age of affected bullheads was 7.82 years compared to the average of 6.46 years for all bullheads (Fig. 7). Orocutaneous hyperplasia occurred in bullheads at both study and reference sites (Table 5). Rates of orocutaneous hyperplasia varied from 0% - 36.4% at the study sites. Orocutaneous hyperplasia occurred at a low rate, 7.7%, in bullheads from Eaton Reservoir. High rates of orocutaneous hyperplasia at specific sites were not directly associated with high rates of orocutaneous tumors in bullheads collected at those same sites (Fig. 8). Additionally, orocutaneous hyperplasia was absent in bullheads from sites where orocutaneous tumors occurred: the Point (orocutaneous tumor rate of 6.7%), and Sara's Cove (orocutaneous tumor rate of 33.3%). Average concentrations of bile PAH metabolites were higher in bullheads with orocutaneous hyperplasia than in bullheads from Eaton Reservoir (reference population), but were comparable or lower than the average concentration in bullheads from all sites (Tables 3 and 6). In summary, orocutaneous hyperplasia does not appear to be directly associated with orocutaneous tumors nor is it associated with site, age, or high bile PAH metabolite concentrations.

**Figure 7. Average Age of Bullheads Versus Hyperplasia Status**



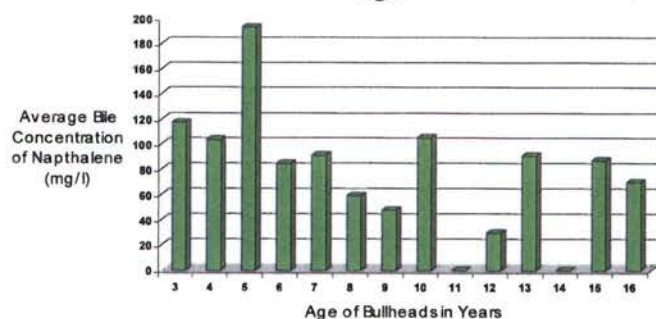
**Figure 8. Percent of Bullhead Population with Orocutaneous Tumors or Hyperplasia Versus Site of Capture**



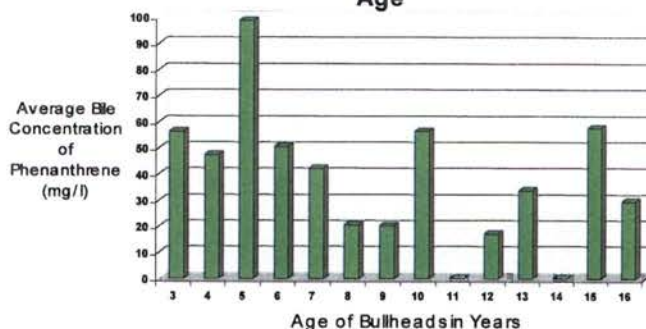
### Average concentration of PAH metabolites in bile from bullheads versus age

Data on bullhead average bile concentration of PAH metabolites demonstrates no definitive trend with respect to age (Table 9, Figs. 9, 10, 11). There may be a tendency for the three metabolites to decline with increasing age. Data are highly variable in

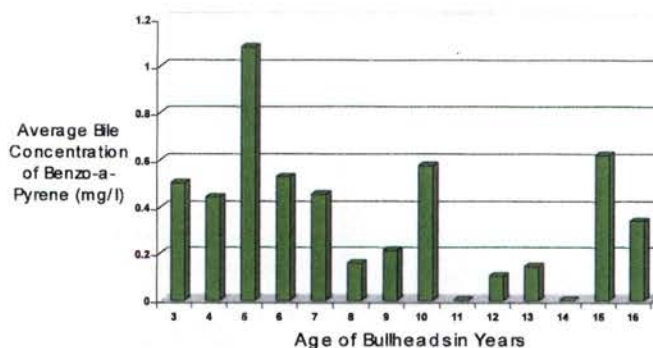
**Figure 9. Average Bullhead Bile Concentration of Napthalene by Bullhead Age**



**Figure 10. Average Bullhead Bile Phenanthrene Concentration by Bullhead Age**



**Figure 11. Average Bullhead Bile Benzo-a-Pyrene Concentration by Bullhead Age**



bullheads above 9 years of age possibly due to the small numbers of bullheads in those groups. There is an apparent correlation among the metabolites in an age group to rise and fall in tandem with each other. This may indicate that generation of the three metabolites is similarly dependent on the environmental PAH exposure for each group.

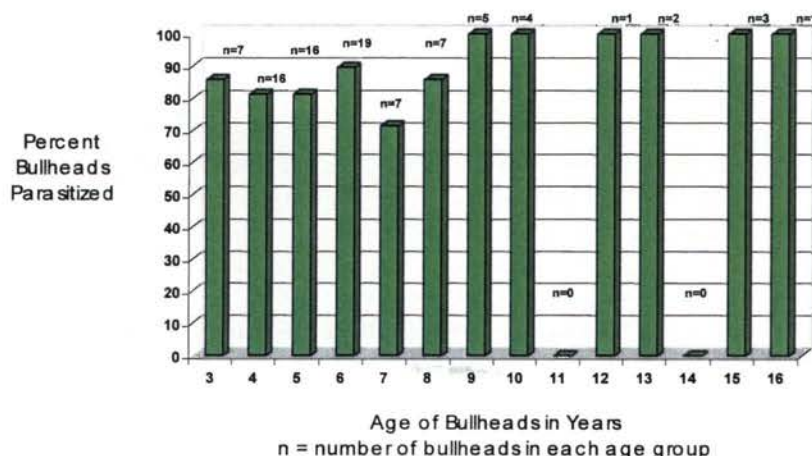


No consistent trend for bile PAH metabolite concentration is seen in bullheads with tumors or hyperplasia when they are segregated by age (Table 7). These observations reaffirm that liver and orocutaneous hyperplasia and tumor rates do not appear to be associated with bile PAH metabolite concentration.

### Parasitism

Parasitism was present at a high level in bullheads from all sites. Parasites were present in many different organs but predominantly in the gastrointestinal tract and gas bladder. Rate of parasitism increased with age so that by 9 years of age, all bullheads had some parasite burden (Fig. 12).

**Figure 12. Percent of Bullhead Population Parasitized Versus Age**



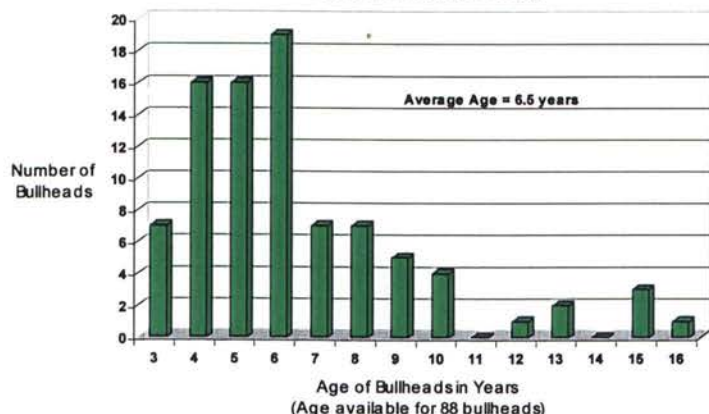
### Comparison of this Study (1997) and 2 Previous Studies (1992, 1995)

Data are summarized from previous tumor studies of Presque Isle bullheads (Obert, 1992; Obert et al., 1995) and the present study (1997), (Tables 10 and 11). Rates of orocutaneous and liver tumors in bullheads decreased from 1992 to 1995 and further decreased from 1995 to 1997. Bullheads from Eaton Reservoir, the reference population in 1995 and 1997, show a background level of liver tumor rate due to aging. All bullheads in both studies from Eaton Reservoir with liver tumors were 15-16 years of age. Age is therefore clearly indicated as a factor associated with the occurrence of liver

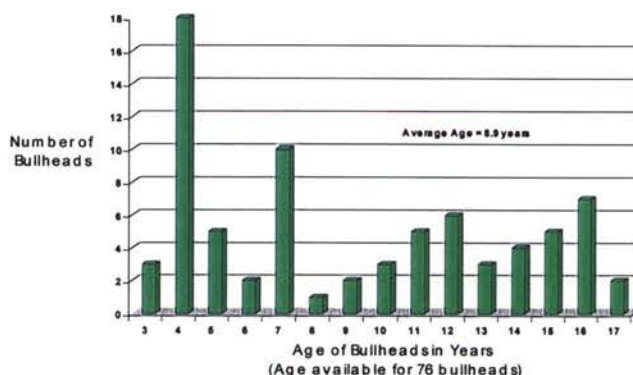
tumors. Age distribution of bullheads collected for each study is presented (Table 11, Figs. 1,13,14). Bullheads in the 1992 study were markedly older than bullheads in the 1995 study which in turn were older than bullheads in the 1997 study. The reason for the different ages of the bullheads collected for the different studies is unknown.

The oldest study population, 1992, had the highest tumor rates while the youngest study population, 1997, had the lowest tumor rates (Table 11). Age therefore seems to be an important factor for development of tumors.

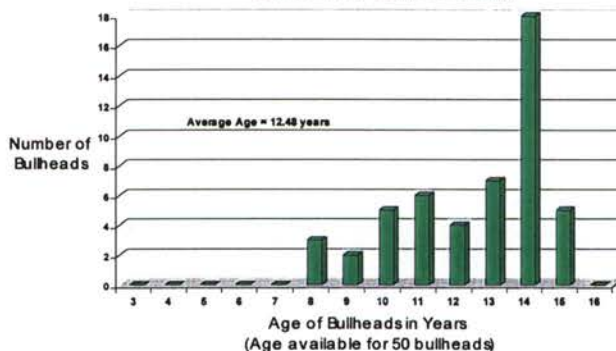
**Figure 1. Bullhead Age Frequency - 1997 Presque Isle Bullhead Tumor Study**



**Figure 13. Bullhead Age Frequency - 1995 Presque Isle Bullhead Tumor Study**



**Figure 14. Bullhead Age Frequency - 1992 Presque Isle Bullhead Tumor Study**



Bile PAH metabolite data from the 3 Presque Isle studies is presented (Table 12). The 1992 study shows higher bile PAH concentrations in bullheads with tumors versus bullheads without tumors. Small numbers of bullheads were evaluated in each group,



especially the no tumor group. A reference population was not collected in that study. In the 1995 study, bullheads with tumors had higher concentrations of 2 of 3 bile PAH metabolites than bullheads without tumors. However, the differences in bile PAH metabolite concentrations were not nearly as marked as in the 1992 study. In the 1997 study, bullheads with tumors did not have higher bile PAH metabolite concentrations than bullheads without tumors. Comparison of bile PAH metabolite concentrations among studies was problematic. Bile PAH metabolite concentration was lower in bullheads with tumors in the 1992 study than in bullheads with no tumors in the 1995 and 1997 studies. Assuming that the methodology for measuring bile PAH metabolite concentration is comparable among the studies, the data suggest that bile PAH metabolite concentration alone is not a good predictor of tumor rates across the 3 studies.

The value of average bile PAH metabolite concentration as a predictor of tumor rate is not clear when comparing the 3 studies. The 1992 study evaluated older bullheads with a high rate of tumors and a demonstrable increase in average bile PAH metabolite concentration in bullheads with tumors versus bullheads without tumors. The 1995 study evaluated an intermediate aged population of bullheads with a lower rate of tumors and higher average bile PAH metabolite concentrations compared to the 1992 study. Increases in 2 of 3 average bile PAH metabolite concentrations were present in bullheads with tumors versus bullheads without tumors but were not as marked as seen in the 1992 study. The 1997 study evaluated a younger population of bullheads with intermediate bile PAH concentrations and a lower tumor rate compared to the 1992 and 1995 studies. In the 1997 study, increases in bile PAH metabolite concentrations in bullheads with tumors versus bullheads without tumors were not apparent. Higher concentrations were present in bullheads with tumors compared to bullheads without tumors when tumor rates are above levels indicating environmental degradation, e.g. the 1992 and 1995 studies, but not in the study with low tumor rates, 1997. Paradoxically, bullheads with tumors in the 1992 study had lower average bile PAH metabolite concentrations than bullheads with no tumors in the 1997 study (Table 12).

Methodology for determination of bile PAH metabolites in the 3 studies should be critically assessed so that the validity of comparison of data among the studies can be



assured. Units of measurement reporting bile PAH metabolite concentrations for the 3 studies were different. Conversions were made to a common unit for purposes of comparison (Table 12).

Baumann et al. 1996 suggests that prevalence of cutaneous papilloma (orocutaneous tumors) above approximately 25% or of liver tumors above approximately 5% should be indicative of environmental degradation. Tumor rates at or above these levels were present in the 1992 and 1995 studies, but not the 1997 study. Raw data from 1992 to 1997 of declining tumor rate in bullheads suggest that the effects of environmental pollution have decreased. However, this is not supported by bile PAH metabolite concentration as an indicator of environmental pollution exposure since levels are higher in the 1997 study than in 1992 study. The data are confounded by the differences in average age of the bullhead populations evaluated in the three studies.

Evaluation and comparison of the methodology used in the 3 studies to measure bile PAH metabolite concentration is suggested to resolve comparison of environmental exposure to pollutants in the bullheads evaluated in the three studies. Other factors in addition to environmental pollution may also affect tumor rate. In addition to age, season of collection may influence rate of observed tumors. Viruses may also be involved in orocutaneous tumors. While it is unlikely that these factors enter into the comparison of the 3 studies, they should be considered in the final analysis.

#### **Significant Points of Current Study (1997):**

- Overall orocutaneous and liver tumor rates in bullheads were low (below suggested levels indicative of environmental degradation and below levels reported in previous studies).
- Average bile PAH metabolite concentrations were not increased in bullheads with tumors versus bullheads without tumors.
- Liver tumors appeared to be associated with age (liver tumors were present only in bullheads 15 years of age or older).
- Liver hyperplasia appeared to be associated with age but insufficient data was present to determine if hyperplasia and tumors in the liver were associated with each other.
- Orocutaneous tumors did not appear to be associated with bile PAH metabolite concentration, site of collection or age of bullhead.

- Orocuteaneous hyperplasia did not appear to be associated with orocuteaneous tumors, bile PAH metabolite concentration, site of collection, or age of bullhead.

#### **Summary of Comparison of the 3 Studies (1992, 1995, 1997):**

- Average age of bullheads evaluated varied greatly among the studies: average age was highest in the 1992 study, intermediate in the 1995 study and lowest in the 1997 study.
- Tumor rates were highest in the 1992 study, intermediate in the 1995 study and lowest in the 1997 study.
- Age seems to be an important factor for development of tumors in bullheads.
- Average bile PAH metabolite concentration alone does not appear to correlate well with tumor rate in bullheads.
- When tumor rates exceed those indicating environmental degradation, bullheads with tumors generally appear to have a higher average bile PAH metabolite concentration than bullheads without tumors.
- When tumor rates are below those indicating environmental degradation, bullheads with tumors do not generally have higher bile metabolite concentrations compared to bullheads without tumors.
- Comparison of bile PAH metabolite concentrations between studies does not appear to be a reliable indicator for tumor rate in bullheads.

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The first of these is the fact that the data are not normally distributed. This is evident from the fact that the distribution of the data is skewed to the right.

The second of these is the fact that the data are not independent. This is evident from the fact that the data are correlated.

The third of these is the fact that the data are not stationary. This is evident from the fact that the data show a clear upward trend.

The fourth of these is the fact that the data are not homogeneous. This is evident from the fact that the data show a clear change in variance over time.

The fifth of these is the fact that the data are not normally distributed. This is evident from the fact that the data are skewed to the right.

The sixth of these is the fact that the data are not independent. This is evident from the fact that the data are correlated.

The seventh of these is the fact that the data are not stationary. This is evident from the fact that the data show a clear upward trend.

The eighth of these is the fact that the data are not homogeneous. This is evident from the fact that the data show a clear change in variance over time.

The ninth of these is the fact that the data are not normally distributed. This is evident from the fact that the data are skewed to the right.

The tenth of these is the fact that the data are not independent. This is evident from the fact that the data are correlated.

The eleventh of these is the fact that the data are not stationary. This is evident from the fact that the data show a clear upward trend.

The twelfth of these is the fact that the data are not homogeneous. This is evident from the fact that the data show a clear change in variance over time.

The thirteenth of these is the fact that the data are not normally distributed. This is evident from the fact that the data are skewed to the right.

The fourteenth of these is the fact that the data are not independent. This is evident from the fact that the data are correlated.

The fifteenth of these is the fact that the data are not stationary. This is evident from the fact that the data show a clear upward trend.

The sixteenth of these is the fact that the data are not homogeneous. This is evident from the fact that the data show a clear change in variance over time.

The seventeenth of these is the fact that the data are not normally distributed. This is evident from the fact that the data are skewed to the right.

The eighteenth of these is the fact that the data are not independent. This is evident from the fact that the data are correlated.

The nineteenth of these is the fact that the data are not stationary. This is evident from the fact that the data show a clear upward trend.



## APPENDIX A

### Gross and Microscopic Post-Mortem Findings

|                                             |                                         |                             |
|---------------------------------------------|-----------------------------------------|-----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                     | FISH #001                   |
| Length: 30.2 cm<br>Collection Site: Lagoons | Weight: 13.5 oz<br>Liver weight: 9.01 g | Sex: Female<br>Age: 13 yrs. |

Gross findings: Large amounts of black slime was evident on the skin. The tail was split. Yellow nodule was noted on lateral aspect of kidney. Multiple small black pigmented foci noted on skin. Multiple foci of thickening evident on lips.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                                                              |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Mild acute epithelial necrosis                                                                                                                                                                                                                              |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation, mild multifocal granulomas; focal ductular epithelial metaplasia with intraductal parasites; multifocal intraductular parasites, mineralized capsular/mesenteric parasites; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                                                                                                                                                                                    |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                                                                      |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                                                                                                                                    |
| Heart                                 | Multifocal granulomas with mild calcification; Lymphoplasmacytic focus with included parasite; focal lymphoplasmacytic epicarditis                                                                                                                          |
| Stomach (anterior)                    | Multifocal parasite sections in the lamina propria                                                                                                                                                                                                          |
| Stomach (posterior)                   | Focal granuloma and focal mineralization in lamina propria                                                                                                                                                                                                  |
| Gas Bladder                           | Moderate chronic granulomatous parasitic sacculitis                                                                                                                                                                                                         |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                                                                      |
| Gonad                                 | Mild multiple foci of pigmentation                                                                                                                                                                                                                          |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                                                                                                                                    |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                                                                      |
| Skin                                  | Moderate chronic epidermitis; moderate epidermal hyperpigmentation; mild chronic dermatitis; mild intraepidermal cytoplasmic vacuolation                                                                                                                    |
| Mouth/Lip/Barbel                      | Carcinoma in situ; moderate chronic epidermitis; moderate focal epidermal hyperpigmentation; multiple epidermal/dermal/hypodermal parasites                                                                                                                 |

|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #002                  |
| Length: 26.1 cm<br>Collection Site: Lagoons | Weight: 9 oz.<br>Liver weight: 4.77 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: The left lateral barbel was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                          |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                                                                             |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; multifocal regional moderate MMC hyperplasia; diffuse vacuolar change in MMC with absence of pigment |
| Caudal Kidney                         | No significant lesions                                                                                                                                  |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                  |
| Cranial Kidney                        | Vacuolar degeneration of MMC                                                                                                                            |
| Heart                                 | Mild lymphoplasmacytic epicarditis                                                                                                                      |
| Stomach (anterior)                    | Focal parasite in lamina propria                                                                                                                        |
| Stomach (posterior)                   | No significant lesions                                                                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                                                  |
| Urinary Bladder                       | No significant lesions                                                                                                                                  |
| Gonad                                 | No significant lesions                                                                                                                                  |
| Spleen                                | No significant lesions                                                                                                                                  |
| Intestine<br>(posterior and anterior) | Dilated, attenuated villi, multifocal epithelial mineralization                                                                                         |
| Skeletal Muscle                       | Scattered mild myolysis                                                                                                                                 |
| Skin                                  | No significant lesions                                                                                                                                  |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                                  |



| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #003                  |
|---------------------------------------------|---------------------------------------|----------------------------|
| Length: 31.0 cm<br>Collection Site: Lagoons | Weight: 16 oz<br>Liver weight: 6.19 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: One small yellow nodule is lateral aspect of posterior kidney. Partial egg absorption was noted. One small focal scar was noted on the upper lip.

| ORGAN                                 | HISTOPATHOLOGY                                                                      |
|---------------------------------------|-------------------------------------------------------------------------------------|
| Gallbladder                           | Focal acute transmural necrosis                                                     |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation, focal nodular pancreatic hyperplasia |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                |
| Corpuscle of Stannius                 | No significant lesions                                                              |
| Cranial Kidney                        | No significant lesions                                                              |
| Heart                                 | Moderate focal lymphoplasmacytic epicarditis                                        |
| Stomach (anterior)                    | No significant lesions                                                              |
| Stomach (posterior)                   | Focal granuloma and parasite section in lamina propria                              |
| Gas Bladder                           | No significant lesions                                                              |
| Urinary Bladder                       | No significant lesions                                                              |
| Gonad                                 | Multiple parasitic granulomas                                                       |
| Spleen                                | No significant lesions; diffuse moderate MMC hyperplasia                            |
| Intestine<br>(posterior and anterior) | No significant lesions                                                              |
| Skeletal Muscle                       | No significant lesions                                                              |
| Skin                                  | No significant lesions                                                              |
| Mouth/Lip/Barbel                      | Moderate focal epithelial ulceration; mild focal submucosal fibrosis                |

|                                             |                                       |                          |
|---------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #004                |
| Length: 31.7 cm<br>Collection Site: Lagoons | Weight: 14 oz<br>Liver weight: 3.87 g | Sex: Male<br>Age: 7 yrs. |

Gross findings: The tail was notched. Multiple foci of cutaneous reddening were noted on the tail. One reddened ulcer was noted on the upper lip. The right dorso-lateral barbel of the mouth was missing

| ORGAN                                 | HISTOPATHOLOGY                                              |
|---------------------------------------|-------------------------------------------------------------|
| Gallbladder                           | Multifocal transmural necrosis                              |
| Liver/Pancreas                        | Dark pigmentation of resident MMC; mild MMC hyperplasia     |
| Caudal Kidney                         | Moderate MMC hyperplasia                                    |
| Corpuscle of Stannius                 | No significant lesions                                      |
| Cranial Kidney                        | Mild MMC hyperplasia                                        |
| Heart                                 | No significant lesions                                      |
| Stomach (anterior)                    | Multifocal granulomas in the serosa                         |
| Stomach (posterior)                   | Focal granuloma in lamina propria                           |
| Gas Bladder                           | No significant lesions                                      |
| Urinary Bladder                       | No significant lesions                                      |
| Gonad                                 | Severe diffuse hyperplasia of lining tubular cells          |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia    |
| Intestine<br>(posterior and anterior) | No significant lesions                                      |
| Skeletal Muscle                       | No significant lesions                                      |
| Skin                                  | Mild focal chronic dermatitis; mild goblet cell hyperplasia |
| Mouth/Lip/Barbel                      | Moderate chronic fibrosing ulcerative stomatitis            |



| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                  | FISH #005                 |
|---------------------------------------------|--------------------------------------|---------------------------|
| Length: 32.5 cm<br>Collection Site: Lagoons | Weight: 14 oz<br>Liver weight: 4.8 g | Sex: Male<br>Age: 10 yrs. |

Gross findings: Multiple foci of brown cutaneous thickening were noted on the ventral surface of the head. Foci of rot were evident on the tail and right lateral fin. Multiple foci of thickening (brown) were noted on the upper lip and ventral oral tissues. One focal ulcer was noted on the ventral lip.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                       |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | NOTE: small section                                                                                                  |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal capsular/mesenteric parasites; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                                             |
| Corpuscle of Stannius                 | No significant lesions                                                                                               |
| Cranial Kidney                        | No significant lesions                                                                                               |
| Heart                                 | No significant lesions                                                                                               |
| Stomach (anterior)                    | No significant lesions                                                                                               |
| Stomach (posterior)                   | No significant lesions                                                                                               |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis                                                                          |
| Urinary Bladder                       | No significant lesions                                                                                               |
| Gonad                                 | Mild multifocal hyperplasia of lining tubular cells                                                                  |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                             |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                               |
| Skeletal Muscle                       | No significant lesions                                                                                               |
| Skin                                  | Multifocal papillomas; mild focal hyperpigmentation                                                                  |
| Mouth/Lip/Barbel                      | Severe focal epidermal ulceration; moderate multifocal epithelial hyperplasia                                        |



|                                             |                                       |                          |
|---------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #006                |
| Length: 28.0 cm<br>Collection Site: Lagoons | Weight: 14 oz<br>Liver weight: 4.71 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: Multiple small nodules were noted in the skin of the tail and upper lip. One small focal cutaneous scar was evident dorsal to the left lateral fin. Multiple small lip erosions were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                           |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                                   |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; multifocal moderate acute hepatitis with single large parenchymal parasite; single moderate granuloma |
| Caudal Kidney                         | No significant lesions                                                                                                                                   |
| Corpuscle of Stannius                 | Not present                                                                                                                                              |
| Cranial Kidney                        | No significant lesions                                                                                                                                   |
| Heart                                 | No significant lesions                                                                                                                                   |
| Stomach (anterior)                    | No significant lesions                                                                                                                                   |
| Stomach (posterior)                   | No significant lesions                                                                                                                                   |
| Gas Bladder                           | Moderate chronic sacculitis                                                                                                                              |
| Urinary Bladder                       | No significant lesions                                                                                                                                   |
| Gonad                                 | Mild hyperplasia - lining tubular cells                                                                                                                  |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                                                     |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                   |
| Skeletal Muscle                       | No significant lesions                                                                                                                                   |
| Skin                                  | Mild multifocal epidermal hyperplasia; mild focal hyperpigmentation                                                                                      |
| Mouth/Lip/Barbel                      | Moderate focal ulcerative granulomatous stomatitis                                                                                                       |

| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #007                  |
|---------------------------------------------|---------------------------------------|----------------------------|
| Length: 27.6 cm<br>Collection Site: Lagoons | Weight: 10 oz<br>Liver weight: 4.92 g | Sex: Female<br>Age: 5 yrs. |

Gross findings: One focus of cutaneous thickening was noted on the ventral aspect of the head. One left antero-lateral fin was split. One focal scar was evident on the tail fin.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                        |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                                 |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation                                                                                                       |
| Caudal Kidney                         | No significant lesions                                                                                                                                |
| Corpuscle of Stannius                 | Not present                                                                                                                                           |
| Cranial Kidney                        | No significant lesions                                                                                                                                |
| Heart                                 | Moderate focal lymphoplasmacytic epicarditis                                                                                                          |
| Stomach (anterior)                    | No significant lesions                                                                                                                                |
| Stomach (posterior)                   | Focal parasite sections in lamina propria                                                                                                             |
| Gas Bladder                           | No significant lesions                                                                                                                                |
| Urinary Bladder                       | No significant lesions                                                                                                                                |
| Gonad                                 | No significant lesions                                                                                                                                |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                                                  |
| Intestine<br>(posterior and anterior) | Diffuse mild edema, focal lamina propria granuloma;<br>minimal diffuse enteritis                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                                                                                |
| Skin                                  | Mild epidermal cytoplasmic vacuolation                                                                                                                |
| Mouth/Lip/Barbel                      | Moderate chronic fibrosing cellulitis; multiple parasitic<br>organisms within peripheral nerves and subepithelial<br>tissues; mild chronic stomatitis |



| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #008                  |
|---------------------------------------------|---------------------------------------|----------------------------|
| Length: 31.1 cm<br>Collection Site: Lagoons | Weight: 13 oz<br>Liver weight: 3.81 g | Sex: Female<br>Age: 7 yrs. |

Gross findings: One focal cutaneous erosion of the left lateral side of the face was noted. Two focal cutaneous scars were evident on the dorsal and ventral aspects of the fish. One focal dorsal lip ulcer was noted. One yellow reticular focus was noted in the liver.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                             |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                                                                                                |
| Liver/Pancreas                        | Localized perivascular fibrosis; focal granuloma; focal moderate cholangiohepatitis; moderate diffuse MMC hyperplasia with dark brown pigment; moderate localized peliosis |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                                                                                                   |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                     |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                                                       |
| Heart                                 | Parasite section in myocardium                                                                                                                                             |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                     |
| Stomach (posterior)                   | No significant lesions                                                                                                                                                     |
| Gas Bladder                           | Moderate chronic sacculitis                                                                                                                                                |
| Urinary Bladder                       | No significant lesions                                                                                                                                                     |
| Gonad                                 | Occasional foci of pigmentation                                                                                                                                            |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                                                   |
| Intestine<br>(posterior and anterior) | Dilated lumen                                                                                                                                                              |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                     |
| Skin                                  | Mild multifocal epidermal erosions; mild goblet cell hyperplasia                                                                                                           |
| Mouth/Lip/Barbel                      | Moderate ulcerative chronic fibrosing stomatitis; mild focal epidermal hyperplasia                                                                                         |



|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #009                  |
| Length: 29.5 cm<br>Collection Site: Lagoons | Weight: 13 oz<br>Liver weight: 5.86 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The liver displayed a diffuse reticular pattern. One scar was noted in the dorso-lateral aspect of the upper lip.

| ORGAN                                 | HISTOPATHOLOGY                                                       |
|---------------------------------------|----------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                          |
| Liver/Pancreas                        | Mild diffuse MMC hyperplasia                                         |
| Caudal Kidney                         | Mild MMC hyperplasia                                                 |
| Corpuscle of Stannius                 | Not present                                                          |
| Cranial Kidney                        | Mild MMC hyperplasia                                                 |
| Heart                                 | Myocardial granuloma                                                 |
| Stomach (anterior)                    | Focal granuloma in the lamina propria                                |
| Stomach (posterior)                   | Multifocal granulomas in lamina propria                              |
| Gas Bladder                           | Mild chronic sacculitis                                              |
| Urinary Bladder                       | No significant lesions                                               |
| Gonad                                 | Occasional foci of pigmentation; mild lymphocytic infiltration       |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia             |
| Intestine<br>(posterior and anterior) | Lamina parasite granuloma; mild multifocal epithelial mineralization |
| Skeletal Muscle                       | No significant lesions                                               |
| Skin                                  | No significant lesions                                               |
| Mouth/Lip/Barbel                      | No significant lesions                                               |

| Species<br>Brown Bullhead                       | STUDY<br>POPULATION                   | FISH #010                   |
|-------------------------------------------------|---------------------------------------|-----------------------------|
| Length: 29.9 cm<br>Collection Site: Sara's Cove | Weight: 14 oz<br>Liver weight: 5.98 g | Sex: Female<br>Age: 10 yrs. |

Gross findings: Multiple cutaneous black foci were noted on the head, dorsum of body, tail and ventral lips. One small clear cutaneous nodule was noted dorsal to the left eye. One focus of cutaneous discoloration was evident dorsal to the left antero lateral fin.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                    |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                            |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; diffuse moderate MMC hyperplasia with dark brown pigment; parenchymal parasite |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                                                              |
| Corpuscle of Stannius                 | Not present                                                                                                                       |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                              |
| Heart                                 | No significant lesions                                                                                                            |
| Stomach (anterior)                    | Focal mineralization in the lamina propria; focal gastritis and parasite section in mucosa                                        |
| Stomach (posterior)                   | Multifocal granulomas in muscularis, cluster of parasite sections in lamina propria                                               |
| Gas Bladder                           | Mild chronic sacculitis                                                                                                           |
| Urinary Bladder                       | No significant lesions                                                                                                            |
| Gonad                                 | Occasional foci of pigmentation                                                                                                   |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                          |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                            |
| Skeletal Muscle                       | No significant lesions                                                                                                            |
| Skin                                  | Mild multifocal epidermal hyperplasia; mild chronic epidermitis; mild dermal hyperpigmentation                                    |
| Mouth/Lip/Barbel                      | Carcinoma; mild hyperplastic stomatitis                                                                                           |



|                                                 |                                       |                            |
|-------------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Brown Bullhead                       | STUDY<br>POPULATION                   | FISH #011                  |
| Length: 28.3 cm<br>Collection Site: Sara's Cove | Weight: 10 oz<br>Liver weight: 3.22 g | Sex: Female<br>Age: 5 yrs. |

Gross findings: The right ventro-medial perioral barbel was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                                     |
|---------------------------------------|----------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                             |
| Liver/Pancreas                        | Lobular periductular fibrosis with regional moderate MMC hyperplasia; mild diffuse MMC hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                             |
| Corpuscle of Stannius                 | Not present                                                                                        |
| Cranial Kidney                        | No significant lesions                                                                             |
| Heart                                 | No significant lesions                                                                             |
| Stomach (anterior)                    | No significant lesions                                                                             |
| Stomach (posterior)                   | No significant lesions                                                                             |
| Gas Bladder                           | No significant lesions                                                                             |
| Urinary Bladder                       | No significant lesions                                                                             |
| Gonad                                 | No significant lesions                                                                             |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                           |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                             |
| Skeletal Muscle                       | Focal, mild myolysis                                                                               |
| Skin                                  | No significant lesions                                                                             |
| Mouth/Lip/Barbel                      | No significant lesions                                                                             |



|                                                 |                                      |                          |
|-------------------------------------------------|--------------------------------------|--------------------------|
| Species<br>Brown Bullhead                       | STUDY<br>POPULATION                  | FISH #012                |
| Length: 24.6 cm<br>Collection Site: Sara's Cove | Weight: 8 oz<br>Liver weight: 3.82 g | Sex: Male<br>Age: 4 yrs. |

Gross findings: A diffuse reticular pattern was noted in the liver.

| ORGAN                                 | HISTOPATHOLOGY                                           |
|---------------------------------------|----------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema    |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation        |
| Caudal Kidney                         | Mild chronic focal interstitial nephritis                |
| Corpuscle of Stannius                 | No significant lesions                                   |
| Cranial Kidney                        | No significant lesions                                   |
| Heart                                 | No significant lesions                                   |
| Stomach (anterior)                    | No significant lesions                                   |
| Stomach (posterior)                   | No significant lesions                                   |
| Gas Bladder                           | Mild chronic sacculitis                                  |
| Urinary Bladder                       | No significant lesions                                   |
| Gonad                                 | Focal intravascular parasite                             |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia     |
| Intestine<br>(posterior and anterior) | Dilated lumen, mild multifocal epithelial mineralization |
| Skeletal Muscle                       | No significant lesions                                   |
| Skin                                  | Mild epidermal hyperplasia; mild goblet cell hyperplasia |
| Mouth/Lip/Barbel                      | Moderate focal chronic - active cheilitis                |

|                                               |                                        |                            |
|-----------------------------------------------|----------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                    | STUDY<br>POPULATION                    | FISH #013                  |
| Length: 30.0 cm<br>Collection Site: Millcreek | Weight: 16 oz<br>Liver weight: 11.46 g | Sex: Female<br>Age: 5 yrs. |

Gross findings: The tail was tattered. The liver displayed a diffuse reticular pattern. Occasional foci of erosion and thickening were noted in the dorsal lip. The left dorso-lateral and right and left lateral barbels were shortened. One small cutaneous nodule (lateral aspect of body) was noted. One focal cutaneous ulcer anterior to the dorsal fin was evident.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                     |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                             |
| Liver/Pancreas                        | Diffuse hepatocellular basophilia; multifocal hepatocellular clear cell vacuolation                                                                |
| Caudal Kidney                         | No significant lesions                                                                                                                             |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                             |
| Cranial Kidney                        | No significant lesions                                                                                                                             |
| Heart                                 | No significant lesions                                                                                                                             |
| Stomach (anterior)                    | No significant lesions                                                                                                                             |
| Stomach (posterior)                   | No significant lesions                                                                                                                             |
| Gas Bladder                           | One focal parasite in fibrous wall of gas bladder                                                                                                  |
| Urinary Bladder                       | No significant lesions                                                                                                                             |
| Gonad                                 | No significant lesions                                                                                                                             |
| Spleen                                | Capsular granuloma; mild diffuse MMC hyperplasia                                                                                                   |
| Intestine<br>(posterior and anterior) | Dilated lumen                                                                                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                                                                             |
| Skin                                  | Moderate chronic epidermitis/dermatitis; moderate multifocal epidermal cytoplasmic vacuolation, necrosis and erosion; mild goblet cell hyperplasia |
| Mouth/Lip/Barbel                      | Mild multifocal epidermal erosions                                                                                                                 |



|                                               |                                        |                             |
|-----------------------------------------------|----------------------------------------|-----------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                    | FISH #014                   |
| Length: 32.8 cm<br>Collection Site: Millcreek | Weight: 19 oz<br>Liver weight: 10.99 g | Sex: Female<br>Age: 15 yrs. |

Gross findings: Multifocal pale hepatic nodules were noted. Linear white streaks and miliary capsular pigmentation was also evident in the liver. Multiple foci of brown pigmentation and thickening were noted in the skin of the tail and head. Foci of brown thickening were noted in the lips. One cutaneous scar and one focus of yellow cutaneous thickening were evident on the ventrum of the head. The tail was partially missing.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation; multifocal severe variably sized hyperplastic (basophilic) foci; multifocal variably sized clear cell focus; multifocal peliosis; moderate diffuse MMC hyperplasia with dark brown pigment; lobular multiple parenchymal parasites, variable pigment in regional hyperplastic MMC; lobular multifocal granulomas (parasite assoc'd, presumptive) |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                                                                                                                                                                                                                                                                                                                        |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                                                                                                                                                                                                                                                                            |
| Heart                                 | Multifocal moderate lymphoplasmacytic epicarditis                                                                                                                                                                                                                                                                                                                                               |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Stomach (posterior)                   | Focal granuloma in muscularis and lamina propria; parasite section in lamina propria                                                                                                                                                                                                                                                                                                            |
| Gas Bladder                           | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Gonad                                 | Occasional foci of pigmentation                                                                                                                                                                                                                                                                                                                                                                 |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                                                                                                                                                                                                                                                                          |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                                                                                                                                                                                                          |
| Skin                                  | Mild multifocal epidermal hyperplasia; mild chronic epidermitis; mild epidermal hyperpigmentation                                                                                                                                                                                                                                                                                               |
| Mouth/Lip/Barbel                      | Moderate multifocal mucosal epithelial hyperplasia; mild multifocal epithelial/subepithelial hyperpigmentation; parasitic organism - dermis                                                                                                                                                                                                                                                     |



| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                     | FISH #015                |
|-----------------------------------------------|-----------------------------------------|--------------------------|
| Length: 27.6 cm<br>Collection Site: Millcreek | Weight: 11.5 oz<br>Liver weight: 7.30 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: No significant lesions.

| ORGAN                                 | HISTOPATHOLOGY                                                                             |
|---------------------------------------|--------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; focal mesenteric multi-parasite granuloma |
| Caudal Kidney                         | Mild focal granulomatous interstitial nephritis                                            |
| Corpuscle of Stannius                 | No significant lesions                                                                     |
| Cranial Kidney                        | NOTE: incorrect tissue - spleen, No significant lesions                                    |
| Heart                                 | Diffuse mild lymphoplasmacytic epicarditis                                                 |
| Stomach (anterior)                    | Focal parasite sections in the lamina propria                                              |
| Stomach (posterior)                   | No significant lesions                                                                     |
| Gas Bladder                           | Moderate granulomatous sacculitis                                                          |
| Urinary Bladder                       | No significant lesions                                                                     |
| Gonad                                 | Mild multifocal tubular lining cell hyperplasia                                            |
| Spleen                                | Erythroid hyperplasia                                                                      |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                     |
| Skeletal Muscle                       | No significant lesions                                                                     |
| Skin                                  | Mild multifocal epidermal erosion                                                          |
| Mouth/Lip/Barbel                      | No significant lesions                                                                     |

|                                               |                                        |                          |
|-----------------------------------------------|----------------------------------------|--------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                    | FISH #016                |
| Length: 31.5 cm<br>Collection Site: Millcreek | Weight: 17 oz<br>Liver weight: 10.29 g | Sex: Male<br>Age: No age |

Gross findings: Occasional small cutaneous scars were noted in the tail. One small focal cutaneous nodule was evident near the dorsal fin. Large amounts of black cutaneous slime were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                      |
|---------------------------------------|---------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema               |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation                     |
| Caudal Kidney                         | No significant lesions                                              |
| Corpuscle of Stannius                 | Not present                                                         |
| Cranial Kidney                        | No significant lesions                                              |
| Heart                                 | No significant lesions                                              |
| Stomach (anterior)                    | No significant lesions                                              |
| Stomach (posterior)                   | Multifocal granulomas in the muscularis                             |
| Gas Bladder                           | Moderate chronic sacculitis                                         |
| Urinary Bladder                       | No significant lesions                                              |
| Gonad                                 | Moderate tubular lining cell hyperplasia                            |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                |
| Intestine<br>(posterior and anterior) | No significant lesions                                              |
| Skeletal Muscle                       | No significant lesions                                              |
| Skin                                  | Moderate chronic fibrosing cellulitis; mild goblet cell hyperplasia |
| Mouth/Lip/Barbel                      | Mild focal chronic stomatitis                                       |



| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #017                |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Length: 34.0 cm<br>Collection Site: Millcreek | Weight: 18 oz<br>Liver weight: 8.45 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: Large amounts of cutaneous black slime were noted. Foci of black cutaneous pigmentation were noted. The tail and the right antero-lateral fin were partially missing. One focus of cutaneous reddening and erosion was noted in the tail. Occasional nodules were noted in the ventral lip and left ventral barbel. The right lateral and medio-ventral barbels were shortened. One focus of ulceration was noted in the tail. One focus of black cutaneous thickening was evident on the ventral aspect of the head.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                  |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                           |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation                                                                                   |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                                                            |
| Corpuscle of Stannius                 | No significant lesions                                                                                                          |
| Cranial Kidney                        | No significant lesions                                                                                                          |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                       |
| Stomach (anterior)                    | No significant lesions                                                                                                          |
| Stomach (posterior)                   | No significant lesions                                                                                                          |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis                                                                                     |
| Urinary Bladder                       | No significant lesions                                                                                                          |
| Gonad                                 | Mild tubular lining cell hyperplasia                                                                                            |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                        |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                          |
| Skeletal Muscle                       | No significant lesions                                                                                                          |
| Skin                                  | Severe ulcerative chronic fibrosing dermatitis/cellulitis;<br>mild goblet cell hyperplasia; mild epidermal<br>hyperpigmentation |
| Mouth/Lip/Barbel                      | Moderate focal epidermal hyperplasia; mild focal<br>epidermal/dermal hyperpigmentation                                          |



|                                               |                                       |                            |
|-----------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #018                  |
| Length: 28.0 cm<br>Collection Site: Millcreek | Weight: 12 oz<br>Liver weight: 7.14 g | Sex: Female<br>Age: 3 yrs. |

Gross findings: A diffuse hepatic reticular pattern was noted. White linear streaks were evident within kidney. Occasional foci of cutaneous black pigmentation and cutaneous nodules were noted. One focal cutaneous erosion was evident caudal to the left antero-lateral fin.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                   |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                           |
| Liver/Pancreas                        | Focal moderate acute hepatocellular necrosis, focal mild subacute cholangitis; multifocal mild acute cholangitis |
| Caudal Kidney                         | No significant lesions                                                                                           |
| Corpuscle of Stannius                 | No significant lesions                                                                                           |
| Cranial Kidney                        | No significant lesions                                                                                           |
| Heart                                 | No significant lesions                                                                                           |
| Stomach (anterior)                    | No significant lesions                                                                                           |
| Stomach (posterior)                   | No significant lesions                                                                                           |
| Gas Bladder                           | Moderate chronic sacculitis                                                                                      |
| Urinary Bladder                       | No significant lesions                                                                                           |
| Gonad                                 | No significant lesions                                                                                           |
| Spleen                                | No significant lesions                                                                                           |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                           |
| Skeletal Muscle                       | No significant lesions                                                                                           |
| Skin                                  | Mild chronic epidermitis                                                                                         |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                           |

|                                               |                                        |                            |
|-----------------------------------------------|----------------------------------------|----------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                    | FISH #019                  |
| Length: 31.5 cm<br>Collection Site: Millcreek | Weight: 14 oz<br>Liver weight: 11.07 g | Sex: Female<br>Age: 7 yrs. |

Gross findings: The ventro-lateral barbel was markedly shortened. One focal erosion was noted in the ventral lip. One focal cutaneous nodule was noted in the tail fin.

| ORGAN                                 | HISTOPATHOLOGY                                                                                           |
|---------------------------------------|----------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                   |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; focal mild acute pericholangial hepatocellular necrosis |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                                     |
| Corpuscle of Stannius                 | No significant lesions                                                                                   |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                     |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                           |
| Stomach (anterior)                    | No significant lesions                                                                                   |
| Stomach (posterior)                   | No significant lesions                                                                                   |
| Gas Bladder                           | No significant lesions                                                                                   |
| Urinary Bladder                       | No significant lesions                                                                                   |
| Gonad                                 | No significant lesions                                                                                   |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                     |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                   |
| Skeletal Muscle                       | No significant lesions                                                                                   |
| Skin                                  | Mild focal dermal edema                                                                                  |
| Mouth/Lip/Barbel                      | Mild focal mucosal epithelial intracellular vacuolation                                                  |



| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                  | FISH #020                  |
|-----------------------------------------------|--------------------------------------|----------------------------|
| Length: 25.4 cm<br>Collection Site: Millcreek | Weight: 8 oz<br>Liver weight: 4.53 g | Sex: Female<br>Age: 3 yrs. |

Gross findings: A diffuse hepatic reticular pattern was noted. The tail was split. One focal notch was evident in the mouth. One focal cutaneous scar was noted (ventrum of body).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                        |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation                                                                       |
| Caudal Kidney                         | No significant lesions                                                                                                |
| Corpuscle of Stannius                 | No significant lesions                                                                                                |
| Cranial Kidney                        | No significant lesions                                                                                                |
| Heart                                 | No significant lesions                                                                                                |
| Stomach (anterior)                    | No significant lesions                                                                                                |
| Stomach (posterior)                   | No significant lesions                                                                                                |
| Gas Bladder                           | No significant lesions                                                                                                |
| Urinary Bladder                       | No significant lesions                                                                                                |
| Gonad                                 | Focal accumulation of parasites with hemorrhage - interstitial tissues                                                |
| Spleen                                | No significant lesions                                                                                                |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                |
| Skeletal Muscle                       | No significant lesions                                                                                                |
| Skin                                  | Moderate granulomatous fibrosing cellulitis/myositis with intralesional refractile material; mild chronic epidermitis |
| Mouth/Lip/Barbel                      | Mild focal chronic stomatitis                                                                                         |

| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #021                |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Length: 30.5 cm<br>Collection Site: The Point | Weight: 10 oz<br>Liver weight: 3.28 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: Tail damage was noted. One focal cutaneous ulcer was noted (ventrum of head). One focal nodule was noted on the left lateral barbel. The ventro-medial barbel was small. The fish was thin and emaciated.

| ORGAN                                 | HISTOPATHOLOGY                                                                                             |
|---------------------------------------|------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                     |
| Liver/Pancreas                        | Focal mild eosinophilic hepatocellular focus                                                               |
| Caudal Kidney                         | No significant lesions                                                                                     |
| Corpuscle of Stannius                 | No significant lesions                                                                                     |
| Cranial Kidney                        | No significant lesions                                                                                     |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                  |
| Stomach (anterior)                    | No significant lesions                                                                                     |
| Stomach (posterior)                   | No significant lesions                                                                                     |
| Gas Bladder                           | Mild parasitic granulomatous sacculitis                                                                    |
| Urinary Bladder                       | No significant lesions                                                                                     |
| Gonad                                 | Mild multifocal tubular lining cell hyperplasia                                                            |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                   |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                     |
| Skeletal Muscle                       | Encapsulated necrotic focus                                                                                |
| Skin                                  | Mild epidermal hyperpigmentation                                                                           |
| Mouth/Lip/Barbel                      | Mild focal epidermal ulceration; mild focal epidermal hyperplasia; mild focal chronic cheilitis/stomatitis |



| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #022                |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Length: 30.6 cm<br>Collection Site: The Point | Weight: 14 oz<br>Liver weight: 4.46 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: Multiple small cutaneous erosions were noted (tail, caudo-ventral fin, dorsal fin). Occasional scars were noted on the dorsal lip. The caudo-ventral fin was partially missing.

| ORGAN                                 | HISTOPATHOLOGY                                                     |
|---------------------------------------|--------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                             |
| Liver/Pancreas                        | Lobular multifocal acute cholangitis; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | No significant lesions                                             |
| Corpuscle of Stannius                 | No significant lesions                                             |
| Cranial Kidney                        | No significant lesions                                             |
| Heart                                 | No significant lesions                                             |
| Stomach (anterior)                    | No significant lesions                                             |
| Stomach (posterior)                   | Parasite section in lamina propria                                 |
| Gas Bladder                           | Mild granulomatous sacculitis                                      |
| Urinary Bladder                       | No significant lesions                                             |
| Gonad                                 | Moderate multifocal tubular lining cell hyperplasia                |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia           |
| Intestine<br>(posterior and anterior) | No significant lesions                                             |
| Skeletal Muscle                       | No significant lesions                                             |
| Skin                                  | Mild chronic cellulitis; mild goblet cell hyperplasia              |
| Mouth/Lip/Barbel                      | No significant lesions                                             |

| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                  | FISH #023                  |
|-----------------------------------------------|--------------------------------------|----------------------------|
| Length: 28.1 cm<br>Collection Site: The Point | Weight: 9 oz<br>Liver weight: 2.46 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: The dorsal fin was notched. Occasional cutaneous scars were noted (fin). Two small cutaneous nodules were noted (dorsal fin, right ventro-lateral barbel). One focus of ulceration was noted (dorsal lip). The right ventro-lateral and left ventro-medial barbels were shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                             |
|---------------------------------------|----------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                     |
| Liver/Pancreas                        | Focal mild eosinophilic hepatocellular focus; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                   |
| Corpuscle of Stannius                 | No significant lesions                                                     |
| Cranial Kidney                        | No significant lesions                                                     |
| Heart                                 | No significant lesions                                                     |
| Stomach (anterior)                    | No significant lesions                                                     |
| Stomach (posterior)                   | Parasite section in lamina propria                                         |
| Gas Bladder                           | No significant lesions                                                     |
| Urinary Bladder                       | No significant lesions                                                     |
| Gonad                                 | Focal parasitic granuloma                                                  |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                   |
| Intestine<br>(posterior and anterior) | Dilated lumen                                                              |
| Skeletal Muscle                       | No significant lesions                                                     |
| Skin                                  | No significant lesions                                                     |
| Mouth/Lip/Barbel                      | Mild focal epidermal ulceration; mild focal epidermal hyperplasia          |



|                                               |                                       |                          |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #024                |
| Length: 33.0 cm<br>Collection Site: The Point | Weight: 18 oz<br>Liver weight: 4.66 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: The right cranio-lateral fin was partially missing. One focus of black cutaneous pigmentation was noted. One cutaneous nodule was noted in the right cranio-lateral fin. Multiple superficial cutaneous foci of reddening were noted (ventrum of head). The left lateral barbel was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                             |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Minimal mononuclear cell cholecystitis                                                                                                                                                     |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation                                                                                                                                              |
| Caudal Kidney                         | No significant lesions                                                                                                                                                                     |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                     |
| Cranial Kidney                        | No significant lesions                                                                                                                                                                     |
| Heart                                 | No significant lesions                                                                                                                                                                     |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                     |
| Stomach (posterior)                   | No significant lesions                                                                                                                                                                     |
| Gas Bladder                           | No significant lesions                                                                                                                                                                     |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                     |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                                                                                   |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                                                                     |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                     |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                     |
| Skin                                  | Moderate erosive epidermitis; moderate chronic fibrosing cellulitis; marked periosteal new bone formation (spine); moderate epidermal/dermal hyperpigmentation; mild epidermal hyperplasia |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                                                                     |

| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #025                  |
|-----------------------------------------------|---------------------------------------|----------------------------|
| Length: 31.0 cm<br>Collection Site: The Point | Weight: 14 oz<br>Liver weight: 5.21 g | Sex: Female<br>Age: 8 yrs. |

Gross findings: The fish was emaciated. A diffuse hepatic reticular pattern was noted. Capsular pigmentation of the posterior kidney was evident. Foci of cutaneous black pigmentation and cutaneous black thickening were noted. The left antero-lateral fin was partially missing. Focal yellow thickening of the dorsal lip was noted.

| ORGAN                                 | HISTOPATHOLOGY                                                            |
|---------------------------------------|---------------------------------------------------------------------------|
| Gallbladder                           | Insufficient sample                                                       |
| Liver/Pancreas                        | Multifocal mild acute suppurative hepatitis; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                  |
| Corpuscle of Stannius                 | No significant lesions                                                    |
| Cranial Kidney                        | No significant lesions                                                    |
| Heart                                 | No significant lesions                                                    |
| Stomach (anterior)                    | No significant lesions                                                    |
| Stomach (posterior)                   | No significant lesions                                                    |
| Gas Bladder                           | Mild chronic parasitic sacculitis                                         |
| Urinary Bladder                       | No significant lesions                                                    |
| Gonad                                 | Occasional foci of pigmentation; mild lymphocytic infiltration            |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                  |
| Intestine<br>(posterior and anterior) | No significant lesions                                                    |
| Skeletal Muscle                       | No significant lesions                                                    |
| Skin                                  | Multifocal papillomas; mild multifocal dermal hyperpigmentation           |
| Mouth/Lip/Barbel                      | No significant lesions                                                    |



|                                               |                                      |                            |
|-----------------------------------------------|--------------------------------------|----------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                  | FISH #026                  |
| Length: 30.9 cm<br>Collection Site: The Point | Weight: 13 oz<br>Liver weight: 4.6 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The tail was partially fragmented. One small white parasite was attached to dorsum of mouth. Capsular pigmentation of the posterior kidney was noted. The left ventro-medial barbel was shortened and contained a focal nodule.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                             |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                     |
| Liver/Pancreas                        | Multifocal moderate granulomatous hepatitis with intracellular protozoans; multifocal mild acute cholangitis; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                                                                     |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                     |
| Cranial Kidney                        | No significant lesions                                                                                                                     |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                                             |
| Stomach (anterior)                    | No significant lesions                                                                                                                     |
| Stomach (posterior)                   | No significant lesions                                                                                                                     |
| Gas Bladder                           | No significant lesions                                                                                                                     |
| Urinary Bladder                       | No significant lesions                                                                                                                     |
| Gonad                                 | Mild lymphocytic infiltration                                                                                                              |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                   |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                     |
| Skeletal Muscle                       | No significant lesions                                                                                                                     |
| Skin                                  | No significant lesions                                                                                                                     |
| Mouth/Lip/Barbel                      | Mild focal chronic stomatitis                                                                                                              |

|                                               |                                      |                            |
|-----------------------------------------------|--------------------------------------|----------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                  | FISH #027                  |
| Length: 25.3 cm<br>Collection Site: The Point | Weight: 8 oz<br>Liver weight: 1.68 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: No significant lesions.

| ORGAN                                 | HISTOPATHOLOGY                                                     |
|---------------------------------------|--------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                             |
| Liver/Pancreas                        | No significant lesions                                             |
| Caudal Kidney                         | No significant lesions                                             |
| Corpuscle of Stannius                 | No significant lesions                                             |
| Cranial Kidney                        | No significant lesions                                             |
| Heart                                 | No significant lesions                                             |
| Stomach (anterior)                    | No significant lesions                                             |
| Stomach (posterior)                   | No significant lesions                                             |
| Gas Bladder                           | Severe granulomatous and hyperplastic parasitic sacculitis         |
| Urinary Bladder                       | No significant lesions                                             |
| Gonad                                 | No significant lesions                                             |
| Spleen                                | Mild multifocal lymphoid hyperplasia; mild diffuse MMC hyperplasia |
| Intestine<br>(posterior and anterior) | No significant lesions                                             |
| Skeletal Muscle                       | No significant lesions                                             |
| Skin                                  | No significant lesions                                             |
| Mouth/Lip/Barbel                      | No significant lesions                                             |



|                                               |                                       |                          |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #028                |
| Length: 28.0 cm<br>Collection Site: The Point | Weight: 10 oz<br>Liver weight: 2.80 g | Sex: Male<br>Age: 4 yrs. |

Gross findings: A diffuse hepatic reticular pattern was noted. White linear streaks were noted on the posterior kidney. The left antero-ventral fin was split. One focal erosion was noted (ventral lip). The right ventro-medial barbel was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                           |
|---------------------------------------|----------------------------------------------------------|
| Gallbladder                           | No significant lesions                                   |
| Liver/Pancreas                        | Focal mild peliosis                                      |
| Caudal Kidney                         | No significant lesions                                   |
| Corpuscle of Stannius                 | Not present                                              |
| Cranial Kidney                        | No significant lesions                                   |
| Heart                                 | No significant lesions                                   |
| Stomach (anterior)                    | No significant lesions                                   |
| Stomach (posterior)                   | No significant lesions                                   |
| Gas Bladder                           | No significant lesions                                   |
| Urinary Bladder                       | No significant lesions                                   |
| Gonad                                 | Moderate tubular lining cell hyperplasia                 |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia |
| Intestine<br>(posterior and anterior) | No significant lesions                                   |
| Skeletal Muscle                       | No significant lesions                                   |
| Skin                                  | Mild goblet cell hyperplasia                             |
| Mouth/Lip/Barbel                      | Mild focal epidermal hyperplasia                         |

| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                  | FISH #029                  |
|-----------------------------------------------|--------------------------------------|----------------------------|
| Length: 28.9 cm<br>Collection Site: The Point | Weight: 9 oz<br>Liver weight: 4.28 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: Occasional erosions were noted in the skin of the ventral aspect of the head and the dorsal lip. A focal cutaneous ulcer was noted (anterior to tail). The left ventro-medial barbel was shortened. The tail was notched.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                 |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                         |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation                                                                                  |
| Caudal Kidney                         | No significant lesions                                                                                                         |
| Corpuscle of Stannius                 | No significant lesions                                                                                                         |
| Cranial Kidney                        | No significant lesions                                                                                                         |
| Heart                                 | No significant lesions                                                                                                         |
| Stomach (anterior)                    | No significant lesions                                                                                                         |
| Stomach (posterior)                   | No significant lesions                                                                                                         |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis                                                                                    |
| Urinary Bladder                       | No significant lesions                                                                                                         |
| Gonad                                 | No significant lesions                                                                                                         |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                       |
| Intestine<br>(posterior and anterior) | Dilated lumen                                                                                                                  |
| Skeletal Muscle                       | No significant lesions                                                                                                         |
| Skin                                  | Severe epidermal ulceration with dermal mineralization;<br>moderate hemorrhagic cellulitis; mild skeletal muscle<br>hemorrhage |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                         |



|                                               |                                       |                          |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #030                |
| Length: 29.4 cm<br>Collection Site: The Point | Weight: 10 oz<br>Liver weight: 3.28 g | Sex: Male<br>Age: 4 yrs. |

Gross findings: One focal cutaneous erosion was noted (ventral tail). One focal reddened cutaneous thickening was noted (caudal to right cranio-lateral fin).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                           |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                    |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation;<br>multifocal minimal granulomatous hepatitis                                         |
| Caudal Kidney                         | No significant lesions                                                                                                                   |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                   |
| Cranial Kidney                        | No significant lesions                                                                                                                   |
| Heart                                 | No significant lesions                                                                                                                   |
| Stomach (anterior)                    | No significant lesions                                                                                                                   |
| Stomach (posterior)                   | No significant lesions                                                                                                                   |
| Gas Bladder                           | No significant lesions                                                                                                                   |
| Urinary Bladder                       | No significant lesions                                                                                                                   |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                                 |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                 |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                   |
| Skeletal Muscle                       | No significant lesions                                                                                                                   |
| Skin                                  | Moderate multifocal chronic ulcerative dermatitis/cellulitis;<br>moderate multifocal hyperplastic granulomatous<br>dermatitis/cellulitis |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                   |

|                                               |                                        |                            |
|-----------------------------------------------|----------------------------------------|----------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                    | FISH #031                  |
| Length: 27.0 cm<br>Collection Site: The Point | Weight: 8.5 oz<br>Liver weight: 3.49 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: Occasional splits were noted in the tail and ventro-caudal fins. One small cutaneous erosion was noted (dorsum of body).

| ORGAN                                 | HISTOPATHOLOGY                                                                           |
|---------------------------------------|------------------------------------------------------------------------------------------|
| Gallbladder                           | Minimal focal mononuclear cell mural cholecystitis; locally extensive mural edema        |
| Liver/Pancreas                        | No significant lesions                                                                   |
| Caudal Kidney                         | No significant lesions                                                                   |
| Corpuscle of Stannius                 | No significant lesions                                                                   |
| Cranial Kidney                        | No significant lesions                                                                   |
| Heart                                 | No significant lesions                                                                   |
| Stomach (anterior)                    | No significant lesions                                                                   |
| Stomach (posterior)                   | No significant lesions                                                                   |
| Gas Bladder                           | Mild chronic parasitic sacculitis                                                        |
| Urinary Bladder                       | No significant lesions                                                                   |
| Gonad                                 | No significant lesions                                                                   |
| Spleen                                | No significant lesions                                                                   |
| Intestine<br>(posterior and anterior) | Two lamina propria parasite cross-sections, villus tip basophilia of undetermined origin |
| Skeletal Muscle                       | No significant lesions                                                                   |
| Skin                                  | Moderate focal chronic ulcerative and necrotizing dermatitis/cellulitis                  |
| Mouth/Lip/Barbel                      | No significant lesions                                                                   |



|                                               |                                      |                            |
|-----------------------------------------------|--------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                    | STUDY<br>POPULATION                  | FISH #032                  |
| Length: 25.5 cm<br>Collection Site: The Point | Weight: 7 oz<br>Liver weight: 3.17 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: the liver was diffusely pale. Multiple small erosions and ulcers were noted on the skin and lips. The left lateral barbel was shortened. The left dorso-lateral barbel was missing. Occasional foci of cutaneous reddening were noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                  |
|---------------------------------------|-------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                          |
| Liver/Pancreas                        | No significant lesions                                                                          |
| Caudal Kidney                         | No significant lesions                                                                          |
| Corpuscle of Stannius                 | Not present                                                                                     |
| Cranial Kidney                        | No significant lesions                                                                          |
| Heart                                 | Multifocal, moderate lymphoplasmacytic epicarditis;<br>microfoci of necrosis, possible parasite |
| Stomach (anterior)                    | No significant lesions                                                                          |
| Stomach (posterior)                   | No significant lesions                                                                          |
| Gas Bladder                           | No significant lesions                                                                          |
| Urinary Bladder                       | No significant lesions                                                                          |
| Gonad                                 | No significant lesions                                                                          |
| Spleen                                | Mild lymphoid depletion                                                                         |
| Intestine<br>(posterior and anterior) | Mesenteric parasitic granuloma - mild                                                           |
| Skeletal Muscle                       | No significant lesions                                                                          |
| Skin                                  | Mild focal chronic epidermitis; mild epidermal hyperplasia;<br>mild goblet cell hyperplasia     |
| Mouth/Lip/Barbel                      | Mild multifocal chronic stomatitis; mild focal acute dermal<br>hemorrhage                       |

| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                  | FISH #033                  |
|------------------------------------------------|--------------------------------------|----------------------------|
| Length: 23.6 cm<br>Collection Site: Misery Bay | Weight: 6 oz<br>Liver weight: 4.33 g | Sex: Female<br>Age: 3 yrs. |

Gross findings: No significant lesions.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                      |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                                                                              |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal moderate granulomatous hepatitis with intracellular protozoans; focal pancreatic islet cell hyperplasia; focal acute mild hepatic necrosis |
| Caudal Kidney                         | No significant lesions                                                                                                                                                                              |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                              |
| Cranial Kidney                        | Moderate hematopoietic hyperplasia                                                                                                                                                                  |
| Heart                                 | No significant lesions                                                                                                                                                                              |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                              |
| Stomach (posterior)                   | Nematode section in stomach lumen                                                                                                                                                                   |
| Gas Bladder                           | Mild chronic sacculitis                                                                                                                                                                             |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                              |
| Gonad                                 | No significant lesions                                                                                                                                                                              |
| Spleen                                | No significant lesions                                                                                                                                                                              |
| Intestine<br>(posterior and anterior) | Multiple luminal parasites                                                                                                                                                                          |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                              |
| Skin                                  | No significant lesions                                                                                                                                                                              |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                                                                              |



|                                               |                                       |                          |
|-----------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                   | FISH #034                |
| Length: 28.1 cm<br>Collection Site: The Point | Weight: 11 oz<br>Liver weight: 2.64 g | Sex: Male<br>Age: 4 yrs. |

Gross findings: Multiple foci of cutaneous pigmentation were noted (left and right ventro-lateral fins). Occasional small cutaneous nodules were noted on the tail.

| ORGAN                                 | HISTOPATHOLOGY                                                                 |
|---------------------------------------|--------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                         |
| Liver/Pancreas                        | Focal moderate acute cholangiohepatitis; focal mild cholangitis                |
| Caudal Kidney                         | No significant lesions                                                         |
| Corpuscle of Stannius                 | No significant lesions                                                         |
| Cranial Kidney                        | No significant lesions                                                         |
| Heart                                 | No significant lesions                                                         |
| Stomach (anterior)                    | Parasite sections in the lumen                                                 |
| Stomach (posterior)                   | Nematode section in lumen; parasite section in lamina propria and muscularis   |
| Gas Bladder                           | No significant lesions                                                         |
| Urinary Bladder                       | No significant lesions                                                         |
| Gonad                                 | Mild tubular lining cell hyperplasia; focal parasitic granuloma - interstitium |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                           |
| Intestine<br>(posterior and anterior) | Dilated lumen                                                                  |
| Skeletal Muscle                       | No significant lesions                                                         |
| Skin                                  | Mild goblet cell hyperplasia                                                   |
| Mouth/Lip/Barbel                      | Mild chronic multifocal stomatitis                                             |

| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #035                |
|------------------------------------------------|---------------------------------------|--------------------------|
| Length: 32.0 cm<br>Collection Site: Misery Bay | Weight: 15 oz<br>Liver weight: 6.16 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: The majority of the left antero-ventral fin was missing. Focal yellow cutaneous pigmentation was noted (ventrum of head). The spines of the tail fin were thickened. A focal abnormal growth pattern was noted in the tail fin.

| ORGAN                                 | HISTOPATHOLOGY                                                                                      |
|---------------------------------------|-----------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                              |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; focal mild capsular/mesenteric parasitic granuloma |
| Caudal Kidney                         | No significant lesions                                                                              |
| Corpuscle of Stannius                 | No significant lesions                                                                              |
| Cranial Kidney                        | No significant lesions                                                                              |
| Heart                                 | No significant lesions                                                                              |
| Stomach (anterior)                    | No significant lesions                                                                              |
| Stomach (posterior)                   | No significant lesions                                                                              |
| Gas Bladder                           | No significant lesions                                                                              |
| Urinary Bladder                       | No significant lesions                                                                              |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                            |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                            |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                              |
| Skeletal Muscle                       | No significant lesions                                                                              |
| Skin                                  | Mild multifocal epidermal hyperplasia; mild goblet cell hyperplasia                                 |
| Mouth/Lip/Barbel                      | Mild multifocal goblet cell hyperplasia                                                             |



|                                                |                                       |                          |
|------------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #036                |
| Length: 30.2 cm<br>Collection Site: Misery Bay | Weight: 13 oz<br>Liver weight: 4.25 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: One focal cutaneous erosion was noted (tail). One small cutaneous focus of reddening was noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                         |
|---------------------------------------|--------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                  |
| Liver/Pancreas                        | Focal mild pancreatic hyperplasia; diffuse mild MMC hyperplasia; multifocal mild periductular fibrosis |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                               |
| Corpuscle of Stannius                 | No significant lesions                                                                                 |
| Cranial Kidney                        | No significant lesions                                                                                 |
| Heart                                 | No significant lesions                                                                                 |
| Stomach (anterior)                    | No significant lesions                                                                                 |
| Stomach (posterior)                   | No significant lesions                                                                                 |
| Gas Bladder                           | Severe granulomatous parasitic sacculitis                                                              |
| Urinary Bladder                       | No significant lesions                                                                                 |
| Gonad                                 | Focal intratubular seminoma; mild tubular lining cell hyperplasia                                      |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                 |
| Intestine<br>(posterior and anterior) | Minimal diffuse edema                                                                                  |
| Skeletal Muscle                       | No significant lesions                                                                                 |
| Skin                                  | Moderate chronic ulcerative dermatitis/cellulitis; mild goblet cell hyperplasia                        |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis                                                                                |

| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                     | FISH #037                  |
|------------------------------------------------|-----------------------------------------|----------------------------|
| Length: 31.8 cm<br>Collection Site: Misery Bay | Weight: 11.5 oz<br>Liver weight: 4.27 g | Sex: Female<br>Age: 5 yrs. |

Gross findings: Small foci of cutaneous reddening were noted (ventrum of head and body). Two focal ulcers were noted (dorsal and ventral lip). Focal erosion and thickening of the left lateral lip was noted. One focal cutaneous scar was noted (right side of body). One focus of cutaneous erosion was evident (tail fin).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                                                                         |
| Liver/Pancreas                        | Multifocal moderate hepatic granulomas; diffuse moderate MMC hyperplasia; multiple parenchymal parasites; multifocal mild acute hepatitis; focal mild capsular/mesenteric parasitic granuloma |
| Caudal Kidney                         | No significant lesions                                                                                                                                                                        |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                        |
| Cranial Kidney                        | No significant lesions                                                                                                                                                                        |
| Heart                                 | No significant lesions                                                                                                                                                                        |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                        |
| Stomach (posterior)                   | No significant lesions                                                                                                                                                                        |
| Gas Bladder                           | Mild granulomatous sacculitis                                                                                                                                                                 |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                        |
| Gonad                                 | Mild multifocal pigmentation; mild multifocal lymphocytic infiltration                                                                                                                        |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                                                                      |
| Intestine<br>(posterior and anterior) | Dilated lumen                                                                                                                                                                                 |
| Skeletal Muscle                       | Focal granuloma                                                                                                                                                                               |
| Skin                                  | Severe focal epidermal ulceration                                                                                                                                                             |
| Mouth/Lip/Barbel                      | Moderate focal epidermal ulceration; mild focal chronic dermatitis; focal intra-skeletal musculature parasite                                                                                 |



| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #038                |
|------------------------------------------------|---------------------------------------|--------------------------|
| Length: 29.8 cm<br>Collection Site: Misery Bay | Weight: 14 oz<br>Liver weight: 8.09 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: A reticular pattern was noted in the liver. Multiple cutaneous reddening was noted (head). Focal cutaneous erosion was evident (dorsum of body). One focus of yellow discoloration was noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Minimal focal cholecystitis                                                                                   |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; single clear cell focus; focal mesenteric parasite granuloma |
| Caudal Kidney                         | No significant lesions                                                                                        |
| Corpuscle of Stannius                 | No significant lesions                                                                                        |
| Cranial Kidney                        | No significant lesions                                                                                        |
| Heart                                 | No significant lesions                                                                                        |
| Stomach (anterior)                    | No significant lesions                                                                                        |
| Stomach (posterior)                   | No significant lesions                                                                                        |
| Gas Bladder                           | No significant lesions                                                                                        |
| Urinary Bladder                       | No significant lesions                                                                                        |
| Gonad                                 | Severe tubular lining cell hyperplasia; spermatogenesis                                                       |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                      |
| Intestine<br>(posterior and anterior) | Dilated lumen; minimal diffuse edema                                                                          |
| Skeletal Muscle                       | No significant lesions                                                                                        |
| Skin                                  | Moderate goblet cell hyperplasia                                                                              |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                        |

| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #039                |
|------------------------------------------------|---------------------------------------|--------------------------|
| Length: 28.4 cm<br>Collection Site: Misery Bay | Weight: 11 oz<br>Liver weight: 3.49 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: White linear streaks were noted in the posterior kidney. The gas bladder contained a concretion. Multiple small cutaneous nodules were noted (tail and ventro-caudal fin). One focal cutaneous erosion was noted (right side of face). Focal reddening and thickening of the ventral lip was noted. Focal cutaneous black pigmentation (per-oral skin) was noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                 |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Focal submucosal melanomacrophage aggregate                                                                                    |
| Liver/Pancreas                        | Multifocal mild MMC hyperplasia with mild pigmentation; multiple parenchymal parasites; single mild subcapsular lipocyte focus |
| Caudal Kidney                         | Mild focal granulomatous interstitial nephritis                                                                                |
| Corpuscle of Stannius                 | No significant lesions                                                                                                         |
| Cranial Kidney                        | Mild focal granulomatous interstitial nephritis                                                                                |
| Heart                                 | No significant lesions                                                                                                         |
| Stomach (anterior)                    | No significant lesions                                                                                                         |
| Stomach (posterior)                   | No significant lesions                                                                                                         |
| Gas Bladder                           | No significant lesions                                                                                                         |
| Urinary Bladder                       | No significant lesions                                                                                                         |
| Gonad                                 | Severe tubular lining cell hyperplasia                                                                                         |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                       |
| Intestine<br>(posterior and anterior) | Congestion                                                                                                                     |
| Skeletal Muscle                       | Multifocal granulomas                                                                                                          |
| Skin                                  | Mild focal epidermal hyperplasia                                                                                               |
| Mouth/Lip/Barbel                      | Carcinoma; moderate focal epidermal ulceration; numerous epithelial and subepithelial pigmented fungal organisms               |



| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #040                  |
|------------------------------------------------|---------------------------------------|----------------------------|
| Length: 29.5 cm<br>Collection Site: Misery Bay | Weight: 11 oz<br>Liver weight: 4.15 g | Sex: Female<br>Age: 7 yrs. |

Gross findings: Multiple small yellow nodules noted in liver. Multiple foci of black pigmentation were noted (ventral lip). Focal thickening of the ventral lip was noted. Multifocal cutaneous reddening/erosion and reddening were noted (ventrum of head). The left ventro-lateral barbel was missing. One focal cutaneous scar was noted (near tail).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                               |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                       |
| Liver/Pancreas                        | Multifocal moderate chronic cholangitis; diffuse moderate MMC hyperplasia                                                                    |
| Caudal Kidney                         | No significant lesions                                                                                                                       |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                       |
| Cranial Kidney                        | No significant lesions                                                                                                                       |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                                               |
| Stomach (anterior)                    | No significant lesions                                                                                                                       |
| Stomach (posterior)                   | Multifocal parasite sections in lamina propria                                                                                               |
| Gas Bladder                           | Severe granulomatous and fibrosing parasitic sacculitis with mineralization and pigmentation                                                 |
| Urinary Bladder                       | No slide                                                                                                                                     |
| Gonad                                 | No significant lesions                                                                                                                       |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                     |
| Intestine<br>(posterior and anterior) | Congestion                                                                                                                                   |
| Skeletal Muscle                       | Focal, chronic degeneration                                                                                                                  |
| Skin                                  | Moderate focal epidermal hyperplasia; severe focal epidermal ulceration with dermal vascular congestion; mild focal dermal hyperpigmentation |
| Mouth/Lip/Barbel                      | Mild focal epidermal/dermal hyperpigmentation; mild multifocal goblet cell hyperplasia                                                       |

| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #041                  |
|------------------------------------------------|---------------------------------------|----------------------------|
| Length: 28.7 cm<br>Collection Site: Misery Bay | Weight: 11 oz<br>Liver weight: 3.38 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: One small yellow nodule was evident in the liver. Multiple cutaneous red foci were noted (ventrum of head). Occasional foci of cutaneous white thickening were noted (tail).

| ORGAN                                 | HISTOPATHOLOGY                                                                    |
|---------------------------------------|-----------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                            |
| Liver/Pancreas                        | Multifocal acute suppurative cholangiohepatitis; diffuse moderate MMC hyperplasia |
| Caudal Kidney                         | No significant lesions                                                            |
| Corpuscle of Stannius                 | No significant lesions                                                            |
| Cranial Kidney                        | No significant lesions                                                            |
| Heart                                 | No significant lesions                                                            |
| Stomach (anterior)                    | No significant lesions                                                            |
| Stomach (posterior)                   | Multifocal parasite sections in lamina propria and muscularis                     |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis with mineralization                   |
| Urinary Bladder                       | Moderate submucosal edema                                                         |
| Gonad                                 | Mild multifocal lymphocytic infiltration                                          |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                          |
| Intestine<br>(posterior and anterior) | Diffuse edema; congestion                                                         |
| Skeletal Muscle                       | No significant lesions                                                            |
| Skin                                  | Mild focal chronic epidermitis/dermatitis                                         |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis                                                           |



| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                     | FISH #042                 |
|------------------------------------------------|-----------------------------------------|---------------------------|
| Length: 31.5 cm<br>Collection Site: Misery Bay | Weight: 15.5 oz<br>Liver weight: 6.32 g | Sex: Male<br>Age: 10 yrs. |

Gross findings: Multiple foci of cutaneous black pigmentation were noted (dorsum and tail of body). Multiple ulcers were noted (ventrum of mouth; skin of dorsal spine, and left lateral barbel). Occasional cutaneous scars were noted (tail). A focus of yellow thickening was noted (ventral lip). The left ventro-medial barbel was missing. The right lateral barbel was blunted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                 |
|---------------------------------------|------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                         |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; diffuse mild MMC hyperplasia                |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                           |
| Corpuscle of Stannius                 | No significant lesions                                                                         |
| Cranial Kidney                        | No significant lesions                                                                         |
| Heart                                 | No significant lesions                                                                         |
| Stomach (anterior)                    | No significant lesions                                                                         |
| Stomach (posterior)                   | Multifocal parasite sections in lamina propria                                                 |
| Gas Bladder                           | Mild chronic parasitic sacculitis                                                              |
| Urinary Bladder                       | No significant lesions                                                                         |
| Gonad                                 | Moderate multifocal tubular lining cell hyperplasia                                            |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                       |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                         |
| Skeletal Muscle                       | No significant lesions                                                                         |
| Skin                                  | Moderate multifocal epidermal hyperpigmentation; mild focal goblet cell hyperplasia            |
| Mouth/Lip/Barbel                      | Severe multifocal ulcerative chronic stomatitis; moderate focal mucosal epithelial hyperplasia |

| Species<br>Brown Bullhead                      | STUDY<br>POPULATION                   | FISH #043                |
|------------------------------------------------|---------------------------------------|--------------------------|
| Length: 30.0 cm<br>Collection Site: Misery Bay | Weight: 13 oz<br>Liver weight: 3.58 g | Sex: Male<br>Age: 4 yrs. |

Gross findings: Foci of black pigmentation were noted on the periphery of the posterior kidney. The left and right antero-ventral fins were split.

| ORGAN                                 | HISTOPATHOLOGY                                           |
|---------------------------------------|----------------------------------------------------------|
| Gallbladder                           | No significant lesions                                   |
| Liver/Pancreas                        | Focal mild mesenteric multi-parasite granuloma           |
| Caudal Kidney                         | No significant lesions                                   |
| Corpuscle of Stannius                 | No significant lesions                                   |
| Cranial Kidney                        | No significant lesions                                   |
| Heart                                 | Multifocal lymphoplasmacytic myocarditis                 |
| Stomach (anterior)                    | No significant lesions                                   |
| Stomach (posterior)                   | Focal granuloma in lamina propria                        |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis              |
| Urinary Bladder                       | No significant lesions                                   |
| Gonad                                 | Severe tubular lining cell hyperplasia                   |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia |
| Intestine<br>(posterior and anterior) | Dilated lumen, multifocal epithelial mineralization      |
| Skeletal Muscle                       | No significant lesions                                   |
| Skin                                  | Mild myofiber degeneration                               |
| Mouth/Lip/Barbel                      | Multiple hypodermal parasitic organisms                  |



| Species<br>Brown Bullhead                       | STUDY<br>POPULATION                  | FISH #044                |
|-------------------------------------------------|--------------------------------------|--------------------------|
| Length: 24.35 cm<br>Collection Site: Misery Bay | Weight: 7 oz<br>Liver weight: 6.51 g | Sex: Male<br>Age: 3 yrs. |

Gross findings: Multiple small white nodules were noted in the liver. One focal cutaneous erosion was noted (ventrum of body). Multiple scars were noted on the dorsal lip.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                            |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | NOTE: small section                                                                                                                       |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; multifocal mild perivascular hepatitis; focal moderate capsular parasite granuloma       |
| Caudal Kidney                         | Mild multifocal interstitial nephritis                                                                                                    |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                    |
| Cranial Kidney                        | No significant lesions                                                                                                                    |
| Heart                                 | Multifocal, mild lymphoplasmacytic myocarditis and epicarditis                                                                            |
| Stomach (anterior)                    | No significant lesions                                                                                                                    |
| Stomach (posterior)                   | Intestinal section - no stomach                                                                                                           |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis                                                                                               |
| Urinary Bladder                       | Multifocal, mild inflammation and ulceration of the mucosa                                                                                |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                                  |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                  |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                    |
| Skeletal Muscle                       | Focal, chronic myositis                                                                                                                   |
| Skin                                  | Moderate focal epidermal hyperplasia; moderate focal chronic fibrosing dermatitis; mild focal chronic myositis with myofiber degeneration |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                    |

| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                    | FISH #045                               |
|-----------------------------------------------|----------------------------------------|-----------------------------------------|
| Length: 21.3 cm<br>Collection Site: The Point | Weight: 3.5 oz<br>Liver weight: 1.53 g | Sex: Immature - No Gonad<br>Age: 6 yrs. |

Gross findings: Focal cutaneous ulceration was noted (ventrum of body). One focal cutaneous erosion was noted (ventrum of head). The right lateral barbel was split.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                              |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Diffuse subacute cholecystitis                                                                                                              |
| Liver/Pancreas                        | Lobular multifocal moderate granulomatous hepatitis with parenchymal parasites; focal acute mild hepatic necrosis with parenchymal parasite |
| Caudal Kidney                         | No significant lesions                                                                                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                      |
| Cranial Kidney                        | Mild hematopoietic hyperplasia                                                                                                              |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                                              |
| Stomach (anterior)                    | No significant lesions                                                                                                                      |
| Stomach (posterior)                   | No significant lesions                                                                                                                      |
| Gas Bladder                           | Moderate granulomatous sacculitis                                                                                                           |
| Urinary Bladder                       | No significant lesions                                                                                                                      |
| Gonad                                 | Fish immature; no gonad located                                                                                                             |
| Spleen                                | No significant lesions                                                                                                                      |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                                                                      |
| Skin                                  | Moderate multifocal chronic ulcerative dermatitis/cellulitis; mild epidermal necrosis                                                       |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                      |



|                                               |                                      |                                         |
|-----------------------------------------------|--------------------------------------|-----------------------------------------|
| Species<br>Brown Bullhead                     | STUDY<br>POPULATION                  | FISH #046                               |
| Length: 18.4 cm<br>Collection Site: The Point | Weight: 3 oz<br>Liver weight: 1.07 g | Sex: Immature - No Gonad<br>Age: No age |

Gross findings: A focus of cutaneous white thickening was noted (left side of tail).

| ORGAN                                 | HISTOPATHOLOGY                                                           |
|---------------------------------------|--------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                   |
| Liver/Pancreas                        | Focal mild acute pancreatic necrosis                                     |
| Caudal Kidney                         | No significant lesions                                                   |
| Corpuscle of Stannius                 | No significant lesions                                                   |
| Cranial Kidney                        | Moderate hematopoietic hyperplasia                                       |
| Heart                                 | No significant lesions                                                   |
| Stomach (anterior)                    | No significant lesions                                                   |
| Stomach (posterior)                   | No significant lesions                                                   |
| Gas Bladder                           | No significant lesions                                                   |
| Urinary Bladder                       | Moderate submucosal edema                                                |
| Gonad                                 | Fish immature; no gonad located                                          |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                     |
| Intestine<br>(posterior and anterior) | No significant lesions                                                   |
| Skeletal Muscle                       | No significant lesions                                                   |
| Skin                                  | Mild multifocal epidermal erosions; mild focal<br>granulomatous myositis |
| Mouth/Lip/Barbel                      | No significant lesions                                                   |

| Species<br>Brown Bullhead                           | STUDY<br>POPULATION                  | FISH #047                |
|-----------------------------------------------------|--------------------------------------|--------------------------|
| Length: 25.3 cm<br>Collection Site:<br>Leboeuf Lake | Weight: 7 oz<br>Liver weight: 2.45 g | Sex: Male<br>Age: 3 yrs. |

Gross findings: The liver displayed a diffuse reticular pattern. Multiple white nodules were evident in the posterior kidney. Focal cutaneous reddening was noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                       |
|---------------------------------------|----------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                               |
| Liver/Pancreas                        | No significant lesions                                               |
| Caudal Kidney                         | No significant lesions                                               |
| Corpuscle of Stannius                 | No significant lesions                                               |
| Cranial Kidney                        | Moderate hematopoietic hyperplasia                                   |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                            |
| Stomach (anterior)                    | Parasite sections in mucosa                                          |
| Stomach (posterior)                   | No significant lesions                                               |
| Gas Bladder                           | No significant lesions                                               |
| Urinary Bladder                       | No significant lesions                                               |
| Gonad                                 | Severe tubular lining cell hyperplasia                               |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia             |
| Intestine<br>(posterior and anterior) | No significant lesions                                               |
| Skeletal Muscle                       | No significant lesions                                               |
| Skin                                  | Mild focal chronic dermatitis; mild multifocal epidermal hyperplasia |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis                                              |



| Species<br>Brown Bullhead                           | STUDY<br>POPULATION                   | FISH #048                |
|-----------------------------------------------------|---------------------------------------|--------------------------|
| Length: 29.4 cm<br>Collection Site:<br>Leboeuf Lake | Weight: 12 oz<br>Liver weight: 4.32 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: The tail fin was partially fragmented. The spleen was markedly enlarged. Multiple yellow-red nodules were noted in the anterior kidney. The right lateral barbel was shortened. Focal cutaneous reddening was noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                          |
|---------------------------------------|-------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                  |
| Liver/Pancreas                        | Multifocal minimal acute hepatitis; pancreatic multinodular hyperplasia |
| Caudal Kidney                         | Mild MMC hyperplasia                                                    |
| Corpuscle of Stannius                 | No significant lesions                                                  |
| Cranial Kidney                        | Mild MMC hyperplasia                                                    |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                          |
| Stomach (anterior)                    | Focal granuloma in the lamina propria                                   |
| Stomach (posterior)                   | No significant lesions                                                  |
| Gas Bladder                           | No significant lesions                                                  |
| Urinary Bladder                       | No significant lesions                                                  |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                |
| Intestine<br>(posterior and anterior) | No significant lesions                                                  |
| Skeletal Muscle                       | No significant lesions                                                  |
| Skin                                  | Mild focal epidermal hyperplasia                                        |
| Mouth/Lip/Barbel                      | Moderate chronic stomatitis                                             |

| Species<br>Brown Bullhead                           | STUDY<br>POPULATION                  | FISH #049                  |
|-----------------------------------------------------|--------------------------------------|----------------------------|
| Length: 27.4 cm<br>Collection Site:<br>Leboeuf Lake | Weight: 8 oz<br>Liver weight: 2.83 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: The liver was pale. Two cutaneous scars were noted (right side of body and head). Focal cutaneous erosion was noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                           |
|---------------------------------------|----------------------------------------------------------|
| Gallbladder                           | No significant lesions                                   |
| Liver/Pancreas                        | No significant lesions                                   |
| Caudal Kidney                         | No significant lesions                                   |
| Corpuscle of Stannius                 | No significant lesions                                   |
| Cranial Kidney                        | Mild hematopoietic hyperplasia                           |
| Heart                                 | No significant lesions                                   |
| Stomach (anterior)                    | No significant lesions                                   |
| Stomach (posterior)                   | No significant lesions                                   |
| Gas Bladder                           | No significant lesions                                   |
| Urinary Bladder                       | No significant lesions                                   |
| Gonad                                 | No significant lesions                                   |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia |
| Intestine<br>(posterior and anterior) | Locally extensive acute enteritis; luminal parasite      |
| Skeletal Muscle                       | No significant lesions                                   |
| Skin                                  | No significant lesions                                   |
| Mouth/Lip/Barbel                      | Moderate multifocal epidermal erosion and ulceration     |



| Species<br>Yellow Bullhead                          | STUDY<br>POPULATION                  | FISH #050                  |
|-----------------------------------------------------|--------------------------------------|----------------------------|
| Length: 26.5 cm<br>Collection Site:<br>Leboeuf Lake | Weight: 8 oz<br>Liver weight: 3.31 g | Sex: Female<br>Age: No age |

Gross findings: The tail was partially fragmented. Focal duodenal constriction and vascular congestion was noted. The liver was pale and displayed a reticular pattern. Focal thickening of the dorsal lip was noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                         |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                                                                                                 |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation; pancreatic multinodular hyperplasia, multifocal acute pancreatic necrosis; focal moderate locally extensive granuloma; focal mild granulomatous peritonitis (mesentery) |
| Caudal Kidney                         | No significant lesions                                                                                                                                                                                                 |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                                 |
| Cranial Kidney                        | No significant lesions                                                                                                                                                                                                 |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                                                                                                              |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                                                 |
| Stomach (posterior)                   | Multifocal parasite sections in lamina propria                                                                                                                                                                         |
| Gas Bladder                           | No significant lesions                                                                                                                                                                                                 |
| Urinary Bladder                       | No slide                                                                                                                                                                                                               |
| Gonad                                 | No significant lesions                                                                                                                                                                                                 |
| Spleen                                | No significant lesions                                                                                                                                                                                                 |
| Intestine<br>(posterior and anterior) | Luminal and laminal propria parasites                                                                                                                                                                                  |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                                 |
| Skin                                  | Moderate focal epidermal hyperplasia; mild focal chronic cellulitis; mild goblet cell hyperplasia                                                                                                                      |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                                                                                                 |

| Species<br>Yellow Bullhead                  | STUDY<br>POPULATION                  | FISH #051                  |
|---------------------------------------------|--------------------------------------|----------------------------|
| Length: 25.5 cm<br>Collection Site: Lagoons | Weight: 7 oz<br>Liver weight: 3.57 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: The liver was pale. The stomach was dilated with air. Constriction of the base of the tail fin was noted. Focal ulceration of the dorsal lip was noted. Focal cutaneous reddening was noted (ventrum of head). The left ventro-medial barbel was missing.

| ORGAN                                 | HISTOPATHOLOGY                                                                              |
|---------------------------------------|---------------------------------------------------------------------------------------------|
| Gallbladder                           | Mild multifocal cholecystitis                                                               |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal mild mesenteric parasite granuloma |
| Caudal Kidney                         | No significant lesions                                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                                      |
| Cranial Kidney                        | No significant lesions                                                                      |
| Heart                                 | No significant lesions                                                                      |
| Stomach (anterior)                    | Multifocal granulomas in the lamina propria; foreign body in one                            |
| Stomach (posterior)                   | Multifocal granulomas in the lamina propria                                                 |
| Gas Bladder                           | No significant lesions                                                                      |
| Urinary Bladder                       | No significant lesions                                                                      |
| Gonad                                 | Mild lymphocytic infiltration                                                               |
| Spleen                                | No significant lesions                                                                      |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                      |
| Skin                                  | No significant lesions                                                                      |
| Mouth/Lip/Barbel                      | Moderate chronic fibrosing dermatitis; mild chronic stomatitis                              |



|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                  | STUDY<br>POPULATION                   | FISH #052                  |
| Length: 26.0 cm<br>Collection Site: Lagoons | Weight: 10 oz<br>Liver weight: 5.24 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: The liver was pale and displayed a reticular pattern. The tail and caudo-ventral fins were split and partially fragmented.

| ORGAN                                 | HISTOPATHOLOGY                                                                               |
|---------------------------------------|----------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                       |
| Liver/Pancreas                        | Focal multinodular pancreatic hyperplasia; diffuse moderate hepatocellular clear vacuolation |
| Caudal Kidney                         | Severe tubular epithelium eosinophilic drop formation                                        |
| Corpuscle of Stannius                 | No significant lesions                                                                       |
| Cranial Kidney                        | No significant lesions                                                                       |
| Heart                                 | No significant lesions                                                                       |
| Stomach (anterior)                    | No significant lesions                                                                       |
| Stomach (posterior)                   | No significant lesions                                                                       |
| Gas Bladder                           | Moderate chronic active sacculitis                                                           |
| Urinary Bladder                       | No significant lesions                                                                       |
| Gonad                                 | No significant lesions                                                                       |
| Spleen                                | No significant lesions                                                                       |
| Intestine<br>(posterior and anterior) | Lamina propria edema - moderate, locally extensive                                           |
| Skeletal Muscle                       | No significant lesions                                                                       |
| Skin                                  | Mild goblet cell hyperplasia                                                                 |
| Mouth/Lip/Barbel                      | No significant lesions                                                                       |

| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                     | FISH #053                |
|---------------------------------------------|-----------------------------------------|--------------------------|
| Length: 32.2 cm<br>Collection Site: Lagoons | Weight: 17.5 oz<br>Liver weight: 4.08 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: Two yellow foci were noted in the liver. Multiple cutaneous foci of reddening (ventrum of head, near tail fin) and black pigmentation (near tail fin) were noted. Multiple focal gray cutaneous nodules were noted (right side of body). The right ventro-medial barbel was missing. Multiple focal cutaneous ulcers were noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                            |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                               |
| Liver/Pancreas                        | Focal mild lobular fibrosis; multifocal moderate mesenteric multi-parasite granuloma                      |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                                                    |
| Cranial Kidney                        | No significant lesions                                                                                    |
| Heart                                 | No significant lesions                                                                                    |
| Stomach (anterior)                    | No significant lesions                                                                                    |
| Stomach (posterior)                   | No significant lesions                                                                                    |
| Gas Bladder                           | Mild chronic parasitic sacculitis                                                                         |
| Urinary Bladder                       | Mild, submucosal edema                                                                                    |
| Gonad                                 | No significant lesions                                                                                    |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                      |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                    |
| Skeletal Muscle                       | No significant lesions                                                                                    |
| Skin                                  | Mild focal epidermal erosion; mild epidermal hyperplasia; mild multifocal acute dermal hemorrhage         |
| Mouth/Lip/Barbel                      | Focal papilloma; mild multifocal epithelial/subepithelial hyperpigmentation; mild focal epidermal erosion |



|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                  | STUDY<br>POPULATION                   | FISH #054                  |
| Length: 28.5 cm<br>Collection Site: Lagoons | Weight: 12 oz<br>Liver weight: 6.56 g | Sex: Female<br>Age: 3 yrs. |

Gross findings: All fins were partially fragmented. The spleen was moderately enlarged. The liver was pale and displayed a diffuse reticular pattern. The caudo-ventral fin was split. One focal erosion was noted (dorsal lip).

| ORGAN                                 | HISTOPATHOLOGY                                                                             |
|---------------------------------------|--------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                     |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal mild pancreatic hyperplasia       |
| Caudal Kidney                         | Mild focal interstitial nephritis; moderate tubular epithelium eosinophilic drop formation |
| Corpuscle of Stannius                 | No significant lesions                                                                     |
| Cranial Kidney                        | No significant lesions                                                                     |
| Heart                                 | No significant lesions                                                                     |
| Stomach (anterior)                    | Parasite and diffuse chronic inflammation in lamina propria                                |
| Stomach (posterior)                   | Focal parasite sections in lamina propria                                                  |
| Gas Bladder                           | No significant lesions                                                                     |
| Urinary Bladder                       | No significant lesions                                                                     |
| Gonad                                 | No significant lesions                                                                     |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                       |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                     |
| Skeletal Muscle                       | No significant lesions                                                                     |
| Skin                                  | No significant lesions                                                                     |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis; mild goblet cell hyperplasia                                      |

| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                     | FISH #055                  |
|---------------------------------------------|-----------------------------------------|----------------------------|
| Length: 29.4 cm<br>Collection Site: Lagoons | Weight: 12.5 oz<br>Liver weight: 6.97 g | Sex: Female<br>Age: 8 yrs. |

Gross findings: Large amounts of black cutaneous slime were noted. Multiple yellow granular plaques were noted on liver and serosa of stomach and small intestine. The liver was pale and displayed a reticular pattern. Linear dark streaks were noted (gills). Multiple cutaneous pigmented foci (body, head) and erosion (lower lip) were noted. Severe opacity of the left eye was evident. The right eye was small and yellow. The left and right lateral barbels were missing. The ventral barbels were shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                       |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                                                                                |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; focal moderate hepatic granuloma; focal mild acute hepatitis; multifocal moderate mesenteric multi-parasite granuloma; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | Moderate MMC hyperplasia, mild focal pyelonephritis                                                                                                                                                  |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                               |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                                                                                 |
| Heart                                 | No significant lesions                                                                                                                                                                               |
| Stomach (anterior)                    | Foreign body granuloma in lamina propria                                                                                                                                                             |
| Stomach (posterior)                   | No significant lesions                                                                                                                                                                               |
| Gas Bladder                           | No significant lesions                                                                                                                                                                               |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                               |
| Gonad                                 | No significant lesions                                                                                                                                                                               |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                                                                                                 |
| Intestine<br>(posterior and anterior) | Lamina propria edema - moderate, diffuse                                                                                                                                                             |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                               |
| Skin                                  | Moderate multifocal epidermal hyperpigmentation; mild acute dermal hemorrhage                                                                                                                        |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis                                                                                                                                                                              |



|                                             |                                       |                          |
|---------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #056                |
| Length: 30.5 cm<br>Collection Site: Lagoons | Weight: 14 oz<br>Liver weight: 4.74 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: Multiple foci of cutaneous reddening (body, ventrum of head), ulceration (body) and erosion (lower lip/mouth) were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                  |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                          |
| Liver/Pancreas                        | Diffuse mild MMC hyperplasia; focal mild mesenteric parasite granuloma                                                                          |
| Caudal Kidney                         | No significant lesions                                                                                                                          |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                          |
| Cranial Kidney                        | Insufficient sample                                                                                                                             |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                                       |
| Stomach (anterior)                    | No significant lesions                                                                                                                          |
| Stomach (posterior)                   | No significant lesions                                                                                                                          |
| Gas Bladder                           | Mild chronic fibrosing serositis                                                                                                                |
| Urinary Bladder                       | Parasite in lumen                                                                                                                               |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                                        |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                        |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                          |
| Skeletal Muscle                       | No significant lesions                                                                                                                          |
| Skin                                  | Severe focal epidermal ulceration; moderate chronic fibrosing dermatitis/cellulitis; moderate acute multifocal dermal and hypodermal hemorrhage |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                          |

| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #057                |
|---------------------------------------------|---------------------------------------|--------------------------|
| Length: 32.3 cm<br>Collection Site: Lagoons | Weight: 15 oz<br>Liver weight: 5.87 g | Sex: Male<br>Age: 9 yrs. |

Gross findings: Large amounts of black cutaneous slime were noted. The urinary bladder was markedly enlarged. Multiple foci of cutaneous black pigmentation (body, fins and mouth) were noted. Focal thickening of the dorsal and ventral lips was noted. Focal yellow thickening of the mouth was noted. One focal cutaneous nodule was noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                    |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                             |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation; multifocal intravascular parasites; multifocal mild mesenteric parasite granulomas |
| Caudal Kidney                         | No significant lesions                                                                                                            |
| Corpuscle of Stannius                 | No significant lesions                                                                                                            |
| Cranial Kidney                        | No significant lesions                                                                                                            |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                                    |
| Stomach (anterior)                    | Multiple granulomas, mineralized foci in the lamina propria                                                                       |
| Stomach (posterior)                   | Multifocal granulomas in lamina propria                                                                                           |
| Gas Bladder                           | No significant lesions                                                                                                            |
| Urinary Bladder                       | No significant lesions                                                                                                            |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                          |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                              |
| Intestine<br>(posterior and anterior) | Partial section - posterior intestine, lamina propria edema - moderate                                                            |
| Skeletal Muscle                       | No significant lesions                                                                                                            |
| Skin                                  | Moderate multifocal epidermal hyperpigmentation                                                                                   |
| Mouth/Lip/Barbel                      | Mild chronic hyperplastic stomatitis; moderate focal epidermal hyperpigmentation; mild multifocal epidermal hyperplasia           |



|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #058                  |
| Length: 34.1 cm<br>Collection Site: Lagoons | Weight: 19 oz<br>Liver weight: 9.50 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The dorsal fin was torn. Multiple cutaneous erosions were noted (body, ventrum of head). One focal nodule was noted in the left lateral barbel.

| ORGAN                                 | HISTOPATHOLOGY                                                                              |
|---------------------------------------|---------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                      |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal mild mesenteric parasite granuloma |
| Caudal Kidney                         | No significant lesions                                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                                      |
| Cranial Kidney                        | No significant lesions                                                                      |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                   |
| Stomach (anterior)                    | Cluster of parasite sections in the lamina propria                                          |
| Stomach (posterior)                   | No significant lesions                                                                      |
| Gas Bladder                           | Mild granulomatous parasitic sacculitis                                                     |
| Urinary Bladder                       | No significant lesions                                                                      |
| Gonad                                 | No significant lesions                                                                      |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                    |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                      |
| Skin                                  | Mild multifocal goblet cell hyperplasia; mild multifocal acute dermal hemorrhage            |
| Mouth/Lip/Barbel                      | No significant lesions                                                                      |

|                                             |                                       |                          |
|---------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #059                |
| Length: 29.5 cm<br>Collection Site: Lagoons | Weight: 14 oz<br>Liver weight: 4.59 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: The tail and left caudo-lateral fin were partially fragmented. The left caudo-lateral fin was split. Focal yellow cutaneous discoloration was noted (left cranio-lateral fin). The liver displayed a diffuse reticular pattern.

| ORGAN                                 | HISTOPATHOLOGY                                                                                   |
|---------------------------------------|--------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                      |
| Liver/Pancreas                        | Focal mild eosinophilic hepatocellular focus; multifocal mild acute and chronic perivascularitis |
| Caudal Kidney                         | No significant lesions                                                                           |
| Corpuscle of Stannius                 | No significant lesions                                                                           |
| Cranial Kidney                        | No significant lesions                                                                           |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                        |
| Stomach (anterior)                    | No significant lesions                                                                           |
| Stomach (posterior)                   | No significant lesions                                                                           |
| Gas Bladder                           | Mild chronic sacculitis with hemosiderosis                                                       |
| Urinary Bladder                       | No significant lesions                                                                           |
| Gonad                                 | Severe tubular lining cell hyperplasia                                                           |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                             |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                           |
| Skeletal Muscle                       | No significant lesions                                                                           |
| Skin                                  | Focal parasitic organism in hypodermis (fin)                                                     |
| Mouth/Lip/Barbel                      | Dermal parasite                                                                                  |



|                                             |                                       |                             |
|---------------------------------------------|---------------------------------------|-----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #060                   |
| Length: 32.9 cm<br>Collection Site: Lagoons | Weight: 18 oz<br>Liver weight: 6.11 g | Sex: Female<br>Age: 10 yrs. |

Gross findings: Multiple yellow nodules were noted in the liver. Focal cutaneous reddening (ventrum of head) and ulceration (dorsal lip) was noted. The right dorso-lateral barbel was missing.

| ORGAN                                 | HISTOPATHOLOGY                                                              |
|---------------------------------------|-----------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                       |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | No significant lesions                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                      |
| Cranial Kidney                        | No significant lesions                                                      |
| Heart                                 | No significant lesions                                                      |
| Stomach (anterior)                    | Parasite section in the lamina propria                                      |
| Stomach (posterior)                   | Focal parasite section in lamina propria                                    |
| Gas Bladder                           | Moderate granulomatous sacculitis                                           |
| Urinary Bladder                       | Mild, submucosal edema                                                      |
| Gonad                                 | No significant lesions                                                      |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                    |
| Intestine<br>(posterior and anterior) | Lamina propria edema - mild, focal                                          |
| Skeletal Muscle                       | No significant lesions                                                      |
| Skin                                  | Mild multifocal acute dermal hemorrhage                                     |
| Mouth/Lip/Barbel                      | No significant lesions                                                      |

|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                  | STUDY<br>POPULATION                   | FISH #061                  |
| Length: 27.1 cm<br>Collection Site: Lagoons | Weight: 10 oz<br>Liver weight: 3.59 g | Sex: Female<br>Age: 3 yrs. |

Gross findings: The liver was diffusely pale. The stomach was moderately dilated with air. Focal cutaneous reddening (ventrum of head) was noted. The right dorso-medial barbel was shortened. The left dorso-medial barbel was missing.

| ORGAN                                 | HISTOPATHOLOGY                                                                              |
|---------------------------------------|---------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                      |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation; multifocal mild acute perivascular hepatitis |
| Caudal Kidney                         | No significant lesions                                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                                      |
| Cranial Kidney                        | No significant lesions                                                                      |
| Heart                                 | No significant lesions                                                                      |
| Stomach (anterior)                    | No significant lesions                                                                      |
| Stomach (posterior)                   | No significant lesions                                                                      |
| Gas Bladder                           | Moderate granulomatous parasitic sacculitis                                                 |
| Urinary Bladder                       | No significant lesions                                                                      |
| Gonad                                 | No significant lesions                                                                      |
| Spleen                                | No significant lesions                                                                      |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                      |
| Skin                                  | Moderate multifocal epidermal hyperplasia                                                   |
| Mouth/Lip/Barbel                      | No significant lesions                                                                      |



| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #062                 |
|---------------------------------------------|---------------------------------------|---------------------------|
| Length: 32.7 cm<br>Collection Site: Lagoons | Weight: 16 oz<br>Liver weight: 5.37 g | Sex: Male<br>Age: 16 yrs. |

Gross findings: The urinary bladder was dilated. Multiple yellow plaques and nodules were noted in the abdominal cavity, pericardial sac and gills. Multiple cutaneous foci of black pigmentation, thickening and nodules were noted (body and head). Multiple yellow cutaneous nodules were noted (base of tail, lateral fins). Focal thickening of the dorsal and ventral lips was noted. The tail fin was split. On focal yellow plaque was evident in the right lateral lip/mouth. The posterior kidney contained white striations.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                                                                                   |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                                                                                                                                                                                                      |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; infiltrative sclerosing well-differentiated bile duct carcinoma; multifocal variably sized moderate eosinophilic foci (10+ foci); focal mild hepatocellular nodular hyperplasia; multifocal moderate multiparasite granulomas |
| Caudal Kidney                         | Severe MMC hyperplasia; mild multifocal chronic glomerulonephritis                                                                                                                                                                                                               |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                                                                                           |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                                                                                                                                                         |
| Heart                                 | No significant lesions                                                                                                                                                                                                                                                           |
| Stomach (anterior)                    | Cluster of parasite sections in lamina propria                                                                                                                                                                                                                                   |
| Stomach (posterior)                   | No significant lesions                                                                                                                                                                                                                                                           |
| Gas Bladder                           | Mild multifocal granulomatous parasitic sacculitis                                                                                                                                                                                                                               |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                                                                                           |
| Gonad                                 | Multifocal seminomas                                                                                                                                                                                                                                                             |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                                                                                                                                                         |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                                                                                           |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                                                                                           |
| Skin                                  | Focal papilloma; mild focal epidermal hyperpigmentation                                                                                                                                                                                                                          |
| Mouth/Lip/Barbel                      | Moderate focal mucosal epithelial hyperplasia; mild chronic stomatitis; focal papilloma                                                                                                                                                                                          |

| Species<br>Bowfin                           | STUDY<br>POPULATION                         | FISH #063                  |
|---------------------------------------------|---------------------------------------------|----------------------------|
| Length: 62.5 cm<br>Collection Site: Lagoons | Weight: 5 lbs 2 oz<br>Liver weight: 29.86 g | Sex: Female<br>Age: No age |

Gross findings: Multifocal hepatic nodules were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                    |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Mild multifocal cholecystitis                                                                                     |
| Liver/Pancreas                        | Diffuse severe MMC hyperplasia with dark pigmentation                                                             |
| Caudal Kidney                         | Multifocal and locally extensive suppurative interstitial nephritis; severe MMC hyperplasia with marked melanosis |
| Corpuscle of Stannius                 | No significant lesions                                                                                            |
| Cranial Kidney                        | No slide                                                                                                          |
| Heart                                 | Focal myocardial granuloma                                                                                        |
| Stomach (anterior)                    | No significant lesions                                                                                            |
| Stomach (posterior)                   | No slide                                                                                                          |
| Gas Bladder                           | No significant lesions                                                                                            |
| Urinary Bladder                       | No significant lesions                                                                                            |
| Gonad                                 | Mild multifocal pigmentation; mild multifocal lymphocytic infiltration                                            |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                              |
| Intestine<br>(posterior and anterior) | Mild diffuse acute submucosal enteritis                                                                           |
| Skeletal Muscle                       | No significant lesions                                                                                            |
| Skin                                  | No significant lesions                                                                                            |
| Mouth/Lip/Barbel                      | Mild multifocal epidermal ulceration                                                                              |



|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #064                  |
| Length: 28.0 cm<br>Collection Site: Lagoons | Weight: 12 oz<br>Liver weight: 5.88 g | Sex: Female<br>Age: No age |

Gross findings: Multiple cutaneous red erosions were noted (left lateral fin, dorsal and ventral lips). A large amount of visceral fat was noted. The liver displayed a diffuse reticular pattern.

| ORGAN                                 | HISTOPATHOLOGY                                                                   |
|---------------------------------------|----------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                      |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation; focal mild pancreatic hyperplasia |
| Caudal Kidney                         | No significant lesions                                                           |
| Corpuscle of Stannius                 | No significant lesions                                                           |
| Cranial Kidney                        | No significant lesions                                                           |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                   |
| Stomach (anterior)                    | Parasite sections in the lamina propria                                          |
| Stomach (posterior)                   | Focal parasite section in lamina propria                                         |
| Gas Bladder                           | Mild chronic sacculitis                                                          |
| Urinary Bladder                       | Parasite in lumen                                                                |
| Gonad                                 | No significant lesions                                                           |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                             |
| Intestine<br>(posterior and anterior) | No significant lesions                                                           |
| Skeletal Muscle                       | No significant lesions                                                           |
| Skin                                  | No significant lesions                                                           |
| Mouth/Lip/Barbel                      | No significant lesions                                                           |

| Species<br>Bowfin                           | STUDY<br>POPULATION                          | FISH #065                  |
|---------------------------------------------|----------------------------------------------|----------------------------|
| Length: 61.0 cm<br>Collection Site: Lagoons | Weight: 4 lbs 11 oz<br>Liver weight: 18.51 g | Sex: Female<br>Age: No age |

Gross findings: Numerous intestinal tapeworms were noted. Multiple parasitic organisms were attached to the oral mucosa.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                       |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Fibrosis with focal inflammation                                                                                     |
| Liver/Pancreas                        | Diffuse moderate MMC hyperplasia with dark pigmentation                                                              |
| Caudal Kidney                         | Severe multifocal locally extensive suppurative interstitial nephritis; severe MMC hyperplasia with marked melanosis |
| Corpuscle of Stannius                 | No significant lesions                                                                                               |
| Cranial Kidney                        | No slide                                                                                                             |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                       |
| Stomach (anterior)                    | No significant lesions                                                                                               |
| Stomach (posterior)                   | No slide                                                                                                             |
| Gas Bladder                           | No significant lesions                                                                                               |
| Urinary Bladder                       | Mild, submucosal edema                                                                                               |
| Gonad                                 | No significant lesions                                                                                               |
| Spleen                                | No significant lesions                                                                                               |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                               |
| Skeletal Muscle                       | No significant lesions                                                                                               |
| Skin                                  | No significant lesions                                                                                               |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                               |



|                                             |                                              |                            |
|---------------------------------------------|----------------------------------------------|----------------------------|
| Species<br>Bowfin                           | STUDY<br>POPULATION                          | FISH #066                  |
| Length: 50.6 cm<br>Collection Site: Lagoons | Weight: 2 lbs 14 oz<br>Liver weight: 26.16 g | Sex: Female<br>Age: No age |

Gross findings: One tapeworm was noted in the lumen of the stomach. Multiple parasites were noted on the oral mucosa.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                          |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Acute multifocal cholecystitis                                                                                                          |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; diffuse mild MMC hyperplasia with dark pigmentation; multifocal mild acute hepatitis |
| Caudal Kidney                         | Moderate subacute interstitial nephritis, moderate MMC hyperplasia with marked melanosis                                                |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                  |
| Cranial Kidney                        | No slide                                                                                                                                |
| Heart                                 | No significant lesions                                                                                                                  |
| Stomach (anterior)                    | No significant lesions                                                                                                                  |
| Stomach (posterior)                   | No slide                                                                                                                                |
| Gas Bladder                           | Moderate chronic - active sacculitis                                                                                                    |
| Urinary Bladder                       | No significant lesions                                                                                                                  |
| Gonad                                 | Multifocal granulomas                                                                                                                   |
| Spleen                                | No significant lesions                                                                                                                  |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                  |
| Skeletal Muscle                       | No significant lesions                                                                                                                  |
| Skin                                  | Moderate chronic - active dermatitis/cellulitis                                                                                         |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                  |

|                                             |                                       |                             |
|---------------------------------------------|---------------------------------------|-----------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #067                   |
| Length: 29.1 cm<br>Collection Site: Lagoons | Weight: 12 oz<br>Liver weight: 5.13 g | Sex: Female<br>Age: 12 yrs. |

Gross findings: The liver displayed a diffuse reticular pattern. Multiple cutaneous nodules (dorsal fin, left lateral fin, tail fin) and erosions (body, ventrum of head, dorsal lip) were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                               |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Insufficient sample                                                                                                                                                                                          |
| Liver/Pancreas                        | Diffuse mild MMC hyperplasia; mild focal mesenteric multiparasite granuloma; multifocal locally extensive moderate hepatocellular necrosis with nodular regeneration; focal moderate bile duct proliferation |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                                                                                                                                     |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                       |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                                                                                     |
| Heart                                 | No significant lesions                                                                                                                                                                                       |
| Stomach (anterior)                    | SI tissue on slide                                                                                                                                                                                           |
| Stomach (posterior)                   | Multifocal mineralization in lamina propria                                                                                                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                                                                                                       |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                       |
| Gonad                                 | No significant lesions                                                                                                                                                                                       |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                                                                                       |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                       |
| Skeletal Muscle                       | Focal, chronic degeneration                                                                                                                                                                                  |
| Skin                                  | Two parasites noted in hypodermis                                                                                                                                                                            |
| Mouth/Lip/Barbel                      | Mild chronic hyperplastic stomatitis                                                                                                                                                                         |



|                                             |                                              |                          |
|---------------------------------------------|----------------------------------------------|--------------------------|
| Species<br>Bowfin                           | STUDY<br>POPULATION                          | FISH #068                |
| Length: 57.2 cm<br>Collection Site: Lagoons | Weight: 2 lbs 13 oz<br>Liver weight: 19.75 g | Sex: Male<br>Age: No age |

Gross findings: Numerous intestinal tapeworms were noted. One full thickness perforation of the intestine (fishing hook) with associated intestinal and adjacent splenic capsular fibrosis was noted. Numerous parasites were noted in the oral cavity. The right anterior gill was eroded.

| ORGAN                                 | HISTOPATHOLOGY                                                                      |
|---------------------------------------|-------------------------------------------------------------------------------------|
| Gallbladder                           | Multifocal severe granulomatous mural cholecystitis with plant foreign bodies       |
| Liver/Pancreas                        | Diffuse moderate MMC hyperplasia; focal moderate hepatocellular hyperplasia         |
| Caudal Kidney                         | Severe diffuse interstitial nephritis; severe MMC hyperplasia with marked melanosis |
| Corpuscle of Stannius                 | Diffuse atrophy                                                                     |
| Cranial Kidney                        | No slide                                                                            |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                      |
| Stomach (anterior)                    | No significant lesions                                                              |
| Stomach (posterior)                   | No slide                                                                            |
| Gas Bladder                           | Mild chronic sacculitis with moderate submucosal edema                              |
| Urinary Bladder                       | Lymphoplasmacytic inflammation of serosal surface                                   |
| Gonad                                 | Not gonadal tissue                                                                  |
| Spleen                                | Multifocal severe splenic abscesses locally extensive severe capsular fibrosis      |
| Intestine<br>(posterior and anterior) | Minimal acute focal enteritis                                                       |
| Skeletal Muscle                       | No significant lesions                                                              |
| Skin                                  | No significant lesions                                                              |
| Mouth/Lip/Barbel                      | No significant lesions                                                              |

|                                             |                                       |                           |
|---------------------------------------------|---------------------------------------|---------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #069                 |
| Length: 33.3 cm<br>Collection Site: Lagoons | Weight: 19 oz<br>Liver weight: 8.87 g | Sex: Male<br>Age: 15 yrs. |

Gross findings: Multiple yellow hepatic granular nodules were noted. One focal hepatic white nodule was also noted. One focal scar was noted on the left lateral lip. The left ventro-medial barbel was missing.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                   |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                                                                                            |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; diffuse moderate MMC hyperplasia; multifocal bile duct hyperplasia and fibrosis; multifocal biliary adenoma; focal moderate mesenteric multi-parasite granuloma |
| Caudal Kidney                         | Moderate MMC hyperplasia                                                                                                                                                                                         |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                           |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                                                                                         |
| Heart                                 | No significant lesions                                                                                                                                                                                           |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                                           |
| Stomach (posterior)                   | Multifocal mineralization and granulomas in lamina propria                                                                                                                                                       |
| Gas Bladder                           | Mild granulomatous sacculitis                                                                                                                                                                                    |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                           |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                                                                                                         |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                                                                                           |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                           |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                           |
| Skin                                  | No significant lesions                                                                                                                                                                                           |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                                                                                           |



|                                             |                                       |                          |
|---------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Bowfin                           | STUDY<br>POPULATION                   | FISH #070                |
| Length: 38.4 cm<br>Collection Site: Lagoons | Weight: 17 oz<br>Liver weight: 9.17 g | Sex: Male<br>Age: No age |

Gross findings: One focal cutaneous scar was noted (right body). Numerous intestinal tapeworms were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                          |
|---------------------------------------|-----------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                  |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; diffuse mild MMC hyperplasia           |
| Caudal Kidney                         | Moderate diffuse interstitial nephritis; moderate MMC hyperplasia with marked melanosis |
| Corpuscle of Stannius                 | Not present                                                                             |
| Cranial Kidney                        | No slide                                                                                |
| Heart                                 | No significant lesions                                                                  |
| Stomach (anterior)                    | No slide                                                                                |
| Stomach (posterior)                   | Parasite in the lumen                                                                   |
| Gas Bladder                           | Moderate chronic sacculitis                                                             |
| Urinary Bladder                       | Moderate submucosal edema                                                               |
| Gonad                                 | No recognizable gonadal tissue evident                                                  |
| Spleen                                | No significant lesions                                                                  |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                  |
| Skeletal Muscle                       | No significant lesions                                                                  |
| Skin                                  | No significant lesions                                                                  |
| Mouth/Lip/Barbel                      | No significant lesions                                                                  |

|                                             |                                              |                            |
|---------------------------------------------|----------------------------------------------|----------------------------|
| Species<br>Bowfin                           | STUDY<br>POPULATION                          | FISH #071                  |
| Length: 64.0 cm<br>Collection Site: Lagoons | Weight: 5 lbs 12 oz<br>Liver weight: 32.35 g | Sex: Female<br>Age: No age |

Gross findings: The liver was diffusely pale and green. One focal parasitic nodule was noted in the wall of the stomach. Focal cutaneous erosion of the left antero-lateral fin was noted. Multiple cutaneous nodules were noted on the tail fin.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                               |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Acute multifocal cholecystitis                                                                                               |
| Liver/Pancreas                        | Diffuse severe hepatocellular clear vacuolation; diffuse mild MMC hyperplasia; multifocal mild hepatocellular mineralization |
| Caudal Kidney                         | Moderate multifocal locally extensive interstitial nephritis; moderate MMC hyperplasia with marked melanosis                 |
| Corpuscle of Stannius                 | Not present                                                                                                                  |
| Cranial Kidney                        | No slide                                                                                                                     |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                    |
| Stomach (anterior)                    | No significant lesions                                                                                                       |
| Stomach (posterior)                   | No significant lesions                                                                                                       |
| Gas Bladder                           | No significant lesions                                                                                                       |
| Urinary Bladder                       | No significant lesions                                                                                                       |
| Gonad                                 | Focal granuloma                                                                                                              |
| Spleen                                | No significant lesions                                                                                                       |
| Intestine<br>(posterior and anterior) | Moderate diffuse enteritis, mild focal enteritis                                                                             |
| Skeletal Muscle                       | No significant lesions                                                                                                       |
| Skin                                  | Severe focal epidermal ulceration                                                                                            |
| Mouth/Lip/Barbel                      | Mild focal chronic and hemorrhagic stomatitis                                                                                |



|                                             |                                       |                          |
|---------------------------------------------|---------------------------------------|--------------------------|
| Species<br>Brown Bullhead                   | STUDY<br>POPULATION                   | FISH #072                |
| Length: 28.9 cm<br>Collection Site: Lagoons | Weight: 11 oz<br>Liver weight: 3.62 g | Sex: Male<br>Age: No age |

Gross findings: Multiple white nodules were noted on the liver. The gill was hemorrhagic. The tail fin was partially fragmented. Multiple cutaneous black and red pigmented foci were noted (body, ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                          |
|---------------------------------------|-------------------------------------------------------------------------|
| Gallbladder                           | Insufficient sample                                                     |
| Liver/Pancreas                        | Diffuse mild hepatocellular clear vacuolation                           |
| Caudal Kidney                         | No significant lesions                                                  |
| Corpuscle of Stannius                 | No significant lesions                                                  |
| Cranial Kidney                        | No significant lesions                                                  |
| Heart                                 | No significant lesions                                                  |
| Stomach (anterior)                    | Focal granuloma in lamina propria                                       |
| Stomach (posterior)                   | No significant lesions                                                  |
| Gas Bladder                           | Mild multifocal granulomatous parasitic sacculitis                      |
| Urinary Bladder                       | No significant lesions                                                  |
| Gonad                                 | Mild tubular lining cell hyperplasia                                    |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                    |
| Intestine<br>(posterior and anterior) | Parasite granuloma - lamina propria                                     |
| Skeletal Muscle                       | No significant lesions                                                  |
| Skin                                  | Moderate goblet cell hyperplasia; mild multifocal epidermal hyperplasia |
| Mouth/Lip/Barbel                      | No significant lesions                                                  |

|                                             |                                       |                            |
|---------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                  | STUDY<br>POPULATION                   | FISH #073                  |
| Length: 27.9 cm<br>Collection Site: Lagoons | Weight: 11 oz<br>Liver weight: 8.52 g | Sex: Female<br>Age: 4 yrs. |

Gross findings: The tail fin was partially fragmented. Focal cutaneous black pigmentation (body) and reddening (ventrum of head) was noted. The right caudo-lateral fin was missing.

| ORGAN                                 | HISTOPATHOLOGY                                                                                  |
|---------------------------------------|-------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                          |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation;<br>multifocal nodular pancreatic hyperplasia |
| Caudal Kidney                         | Moderate tubular epithelium eosinophilic drop formation                                         |
| Corpuscle of Stannius                 | Not present                                                                                     |
| Cranial Kidney                        | No significant lesions                                                                          |
| Heart                                 | No significant lesions                                                                          |
| Stomach (anterior)                    | Cluster of parasite sections in lamina propria                                                  |
| Stomach (posterior)                   | No significant lesions                                                                          |
| Gas Bladder                           | No significant lesions                                                                          |
| Urinary Bladder                       | No significant lesions                                                                          |
| Gonad                                 | No significant lesions                                                                          |
| Spleen                                | No significant lesions                                                                          |
| Intestine<br>(posterior and anterior) | Parasite - muscularis and mesentery                                                             |
| Skeletal Muscle                       | Focal chronic myositis                                                                          |
| Skin                                  | Mild epidermal hyperplasia                                                                      |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis                                                                         |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                     | FISH #074                |
|--------------------------------------------------------|-----------------------------------------|--------------------------|
| Length: 36.0 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 19.5 oz<br>Liver weight: 6.37 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: The liver displayed a diffuse reticular pattern. Multiple foci of cutaneous reddening were noted (body, head, ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                   |
|---------------------------------------|--------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                            |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation                                                |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                             |
| Corpuscle of Stannius                 | No significant lesions                                                                           |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                             |
| Heart                                 | No significant lesions                                                                           |
| Stomach (anterior)                    | Cluster of parasite sections in lamina propria                                                   |
| Stomach (posterior)                   | Focal parasite section in lamina propria                                                         |
| Gas Bladder                           | No significant lesions                                                                           |
| Urinary Bladder                       | No significant lesions                                                                           |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                         |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                           |
| Intestine<br>(posterior and anterior) | Attached mucosal parasite, no significant lesions                                                |
| Skeletal Muscle                       | No significant lesions                                                                           |
| Skin                                  | Mild focal chronic epidermitis/dermatitis; mild focal epidermal ulceration and dermal hemorrhage |
| Mouth/Lip/Barbel                      | No significant lesions                                                                           |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #075                 |
|--------------------------------------------------------|---------------------------------------|---------------------------|
| Length: 39.3 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 24 oz<br>Liver weight: 7.06 g | Sex: Male<br>Age: 15 yrs. |

Gross findings: The tail fin was partially fragmented. The liver contained multiple yellow nodules and white linear foci. The urinary bladder was enlarged. The dorsal fin was abnormal. One focal cutaneous nodule was noted (right side of body). Uneven coloration of the liver was noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                                                                                                                                                                                                                                                                                 |
| Liver/Pancreas                        | Focal sclerosing well differentiated biliary adenocarcinoma; focal biliary hyperplasia with fibrosis; multifocal parenchymal parasites with and without acute suppurative hepatitis; focal intrabiliary parasite; multifocal periportal acute necrosis; lobar multifocal cholangitis; lobar nodular hepatocellular hyperplasia; multifocal severe eosinophilic foci; diffuse moderate MMC hyperplasia |
| Caudal Kidney                         | Moderate MMC hyperplasia; mild multifocal chronic interstitial nephritis                                                                                                                                                                                                                                                                                                                              |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                                                                                                                                                                                                                                                                              |
| Heart                                 | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Stomach (posterior)                   | Multifocal parasite sections in lamina propria                                                                                                                                                                                                                                                                                                                                                        |
| Gas Bladder                           | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Gonad                                 | Severe tubular lining cell hyperplasia; focal seminoma                                                                                                                                                                                                                                                                                                                                                |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                                                                                                                                                                                                                                                                              |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                                                                                                                                                                                                                |
| Skin                                  | Moderate multifocal dermal edema; mild chronic epidermitis; mild focal goblet cell hyperplasia                                                                                                                                                                                                                                                                                                        |
| Mouth/Lip/Barbel                      | Dermal parasite                                                                                                                                                                                                                                                                                                                                                                                       |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #076                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 33.8 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 16 oz<br>Liver weight: 5.08 g | Sex: Male<br>Age: 8 yrs. |

Gross findings: The tail fin was partially fragmented and split. Focal erosion (dorsum of body) and reddening (ventrum of head) was noted. Focal reddening of the ventrum of the mouth was noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                               |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                                                                  |
| Liver/Pancreas                        | Focal mild mesenteric parasite granuloma; focal mild pancreatic hyperplasia; diffuse mild MMC hyperplasia                                    |
| Caudal Kidney                         | Moderate MMC hyperplasia, moderate locally extensive interstitial nephritis                                                                  |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                       |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                     |
| Heart                                 | No significant lesions                                                                                                                       |
| Stomach (anterior)                    | No significant lesions                                                                                                                       |
| Stomach (posterior)                   | No significant lesions                                                                                                                       |
| Gas Bladder                           | No significant lesions                                                                                                                       |
| Urinary Bladder                       | No significant lesions                                                                                                                       |
| Gonad                                 | Mild tubular lining cell hyperplasia                                                                                                         |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                       |
| Intestine<br>(posterior and anterior) | Lamina propria edema - moderate, multifocal; acute enteritis - moderate, diffuse                                                             |
| Skeletal Muscle                       | Mild, scattered myolysis                                                                                                                     |
| Skin                                  | Moderate focal epidermal ulceration; mild chronic epidermitis with mild focal epidermal/dermal hyperpigmentation; mild focal dermal fibrosis |
| Mouth/Lip/Barbel                      | Mild focal epidermal hyperplasia                                                                                                             |

| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                   | FISH #077                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 27.1 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 10 oz<br>Liver weight: 2.74 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: The liver was diffusely pale. Multifocal sites of white cutaneous discoloration were noted (body, head). One focus of cutaneous ulceration (dorsal fin) was noted. One focal scar was also noted (dorsal lip).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                             |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | NOTE: small section                                                                                                                        |
| Liver/Pancreas                        | No significant lesions                                                                                                                     |
| Caudal Kidney                         | No significant lesions                                                                                                                     |
| Corpuscle of Stannius                 | Not present                                                                                                                                |
| Cranial Kidney                        | No significant lesions                                                                                                                     |
| Heart                                 | No significant lesions                                                                                                                     |
| Stomach (anterior)                    | No significant lesions                                                                                                                     |
| Stomach (posterior)                   | No significant lesions                                                                                                                     |
| Gas Bladder                           | No significant lesions                                                                                                                     |
| Urinary Bladder                       | No significant lesions                                                                                                                     |
| Gonad                                 | Mild tubular lining cell hyperplasia                                                                                                       |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                   |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                     |
| Skeletal Muscle                       | Focal parasite section                                                                                                                     |
| Skin                                  | Moderate chronic multifocal epidermitis/dermitis/cellulitis;<br>moderate goblet cell hyperplasia; mild multifocal epidermal<br>hyperplasia |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                     |



| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                   | FISH #078                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 29.0 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 10 oz<br>Liver weight: 3.40 g | Sex: Male<br>Age: 9 yrs. |

Gross findings: Marked vascular dilation and congestion of stomach and intestine was noted. Multiple foci of cutaneous ulceration (dorsal fin and head) and erosion (tail fin) were noted. One focal cutaneous scar was noted (head). One focal cutaneous nodule and focus of thickening were noted (ventrum of head). The right ventro-medial barbel was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                      |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                              |
| Liver/Pancreas                        | No significant lesions                                                                                              |
| Caudal Kidney                         | Mild tubular epithelium eosinophilic drop formation                                                                 |
| Corpuscle of Stannius                 | No significant lesions                                                                                              |
| Cranial Kidney                        | No significant lesions                                                                                              |
| Heart                                 | No significant lesions                                                                                              |
| Stomach (anterior)                    | Parasite section in lamina propria                                                                                  |
| Stomach (posterior)                   | Focal parasite section in lamina propria                                                                            |
| Gas Bladder                           | No significant lesions                                                                                              |
| Urinary Bladder                       | Parasite in lumen                                                                                                   |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                            |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                |
| Intestine<br>(posterior and anterior) | Parasite cross-section - mesentery, intestinal lumen                                                                |
| Skeletal Muscle                       | Mild, scattered myolysis                                                                                            |
| Skin                                  | Moderate chronic fibrosing granulomatous cellulitis with intralesional foreign material; two parasites in hypoderma |
| Mouth/Lip/Barbel                      | Moderate chronic ulcerative dermatitis                                                                              |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                  | FISH #079                  |
|--------------------------------------------------------|--------------------------------------|----------------------------|
| Length: 35.4 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 18 oz<br>Liver weight: 6.0 g | Sex: Female<br>Age: 8 yrs. |

Gross findings: Foci of cutaneous reddening were noted on the ventrum of the head. The tail fin was split.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                           |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                                                                                                                                                    |
| Liver/Pancreas                        | Diffuse moderate MMC hyperplasia; multifocal parenchymal parasites; focal nodular hepatocellular hyperplasia, multifocal mild hepatitis; focal mild mesenteric granuloma; focal mild chronic cholangitis |
| Caudal Kidney                         | Mild multifocal acute interstitial nephritis                                                                                                                                                             |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                   |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                                                                                     |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                                                                                                |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                                   |
| Stomach (posterior)                   | No significant lesions                                                                                                                                                                                   |
| Gas Bladder                           | No significant lesions                                                                                                                                                                                   |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                   |
| Gonad                                 | Mild multifocal pigmentation                                                                                                                                                                             |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                                                                                                                                                 |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                                                                                                   |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                   |
| Skin                                  | No significant lesions                                                                                                                                                                                   |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                                                                                   |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #080                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 36.0 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 17 oz<br>Liver weight: 6.34 g | Sex: Male<br>Age: 8 yrs. |

Gross findings: Multiple cutaneous nodules (near tail, ventrum of head), ulcers (dorsal fin, ventrum of head), erosion (ventral lip) and scar (body) and foci of reddening (ventrum of head) and white discoloration (body) were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                          |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Focal necrosis and fibrosis with adjacent subacute cholecystitis; locally extensive mural edema                                         |
| Liver/Pancreas                        | Diffuse mild MMC hyperplasia; focal eosinophilic focus; focal mild mesenteric parasite granuloma; multifocal moderate capsular peliosis |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                                                                    |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                  |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                    |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                                          |
| Stomach (anterior)                    | No significant lesions                                                                                                                  |
| Stomach (posterior)                   | No significant lesions                                                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                                  |
| Urinary Bladder                       | Edema of mucosal folds                                                                                                                  |
| Gonad                                 | Moderate tubular lining cell hyperplasia; multifocal seminomas                                                                          |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                  |
| Intestine<br>(posterior and anterior) | Attached mucosal parasites - diffuse edema                                                                                              |
| Skeletal Muscle                       | No significant lesions                                                                                                                  |
| Skin                                  | Moderate focal granulomatous cellulitis; moderate multifocal epidermal erosion; mild epidermal hyperplasia                              |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                  |

| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                    | FISH #081                |
|--------------------------------------------------------|----------------------------------------|--------------------------|
| Length: 26.2 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 9.5 oz<br>Liver weight: 2.98 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: The liver was pale. One focal cutaneous scar was noted (ventrum of body).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                           |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                   |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal mild intraductular parasite; multifocal mild foci of hepatocellular hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                                                                   |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                   |
| Cranial Kidney                        | No significant lesions                                                                                                                   |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                                           |
| Stomach (anterior)                    | Focal granuloma with parasites in lamina propria                                                                                         |
| Stomach (posterior)                   | Focal parasite in lumen                                                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                                   |
| Urinary Bladder                       | No significant lesions                                                                                                                   |
| Gonad                                 | Moderate tubular lining cell hyperplasia; focal intravascular parasite                                                                   |
| Spleen                                | No significant lesions                                                                                                                   |
| Intestine<br>(posterior and anterior) | Attached parasites - mild diffuse enteritis                                                                                              |
| Skeletal Muscle                       | No significant lesions                                                                                                                   |
| Skin                                  | Mild goblet cell hyperplasia                                                                                                             |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                                   |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #082                 |
|--------------------------------------------------------|---------------------------------------|---------------------------|
| Length: 39.0 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 22 oz<br>Liver weight: 7.67 g | Sex: Male<br>Age: 13 yrs. |

Gross findings: Multifocal tail fin fragmentation was noted. The dorsal fin and left lateral barbel were missing. The right cranio-lateral fin was fragmented. Foci of cutaneous ulceration (dorsum of body), erosion (dorsal lip) and reddening (ventrum of head) were noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                                                               |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Insufficient sample                                                                                                                                                                                                                          |
| Liver/Pancreas                        | Diffuse moderate MMC hyperplasia; diffuse severe parenchymal parasites with and without acute and chronic hepatitis; multifocal granulomatous hepatitis; multifocal locally extensive capsular/mesenteric parasite granulomatous peritonitis |
| Caudal Kidney                         | Moderate locally extensive acute interstitial nephritis; moderate MMC hyperplasia                                                                                                                                                            |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                                                                       |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                                                                                                                                                                     |
| Heart                                 | No significant lesions                                                                                                                                                                                                                       |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                                                                       |
| Stomach (posterior)                   | Multifocal foreign body granulomas in lamina propria                                                                                                                                                                                         |
| Gas Bladder                           | No significant lesions                                                                                                                                                                                                                       |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                                                                       |
| Gonad                                 | Multifocal seminomas                                                                                                                                                                                                                         |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                                                                                                                       |
| Intestine<br>(posterior and anterior) | Attached parasites - diffuse edema                                                                                                                                                                                                           |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                                                                       |
| Skin                                  | Moderate epidermal intracytoplasmic vacuolation; mild multifocal epidermal erosion                                                                                                                                                           |
| Mouth/Lip/Barbel                      | Mild focal ulcerative dermatitis                                                                                                                                                                                                             |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #083                  |
|--------------------------------------------------------|---------------------------------------|----------------------------|
| Length: 34.2 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 15 oz<br>Liver weight: 6.84 g | Sex: Female<br>Age: No age |

Gross findings: The tail fin was notched. Foci of cutaneous nodule (tail fin), ulcer (tail fin) and reddening (right body, ventrum of head) were noted. The right dorso-medial barbel was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                       |
|---------------------------------------|--------------------------------------------------------------------------------------|
| Gallbladder                           | Mild focal chronic peritonitis                                                       |
| Liver/Pancreas                        | Diffuse moderate/severe MMC hyperplasia; focal mild periportal hepatitis             |
| Caudal Kidney                         | Mild MMC hyperplasia                                                                 |
| Corpuscle of Stannius                 | No significant lesions                                                               |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                 |
| Heart                                 | Multifocal, moderate lymphoplasmacytic epicarditis                                   |
| Stomach (anterior)                    | Focal mineralization in lamina propria                                               |
| Stomach (posterior)                   | No significant lesions                                                               |
| Gas Bladder                           | No significant lesions (small amount of tissue)                                      |
| Urinary Bladder                       | No significant lesions                                                               |
| Gonad                                 | Mild multifocal pigmentation                                                         |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                               |
| Intestine<br>(posterior and anterior) | Attached parasite                                                                    |
| Skeletal Muscle                       | No significant lesions                                                               |
| Skin                                  | Mild multifocal epidermal/dermal hyperpigmentation; mild focal epidermal hyperplasia |
| Mouth/Lip/Barbel                      | No significant lesions                                                               |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #084                  |
|--------------------------------------------------------|---------------------------------------|----------------------------|
| Length: 34.1 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 10 oz<br>Liver weight: 5.93 g | Sex: Female<br>Age: 9 yrs. |

Gross findings: The liver displayed a diffuse reticular pattern and contained parasites. Foci of renal pigmentation were noted. Multiple cutaneous ulcers (tail fin, dorsal lip) and foci of reddening (ventrum of head) were noted. The caudo-ventral fin was split.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                        |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, diffuse mural edema                                                                           |
| Liver/Pancreas                        | Diffuse moderate MMC hyperplasia; multifocal moderate parenchymous parasites; multifocal mild granulomatous hepatitis |
| Caudal Kidney                         | Moderate acute locally extensive interstitial nephritis                                                               |
| Corpuscle of Stannius                 | No significant lesions                                                                                                |
| Cranial Kidney                        | No significant lesions                                                                                                |
| Heart                                 | Multifocal, mild lymphoplasmacytic epicarditis                                                                        |
| Stomach (anterior)                    | No significant lesions                                                                                                |
| Stomach (posterior)                   | Focal parasite section in muscularis                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                |
| Urinary Bladder                       | No significant lesions                                                                                                |
| Gonad                                 | Focal leiomyoma; moderate multifocal pigmentation                                                                     |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                |
| Intestine<br>(posterior and anterior) | No significant lesions                                                                                                |
| Skeletal Muscle                       | No significant lesions                                                                                                |
| Skin                                  | Mild multifocal epidermal erosion                                                                                     |
| Mouth/Lip/Barbel                      | Moderate focal epidermal erosion                                                                                      |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #085                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 36.2 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 17 oz<br>Liver weight: 4.28 g | Sex: Male<br>Age: 7 yrs. |

Gross findings: Notches/tears were noted in the left cranio-lateral fin and the caudo-ventral fin. Foci of cutaneous reddening were noted (ventrum of head).

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                          |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Locally extensive cholecystitis; diffuse mural edema                                                                                                    |
| Liver/Pancreas                        | Diffuse mild MMC hyperplasia; multifocal mild parenchymous parasites with and without mild hepatitis; focal mild capsular/mesenteric parasite granuloma |
| Caudal Kidney                         | Mild acute locally extensive interstitial nephritis                                                                                                     |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                  |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                                    |
| Heart                                 | No significant lesions                                                                                                                                  |
| Stomach (anterior)                    | No significant lesions                                                                                                                                  |
| Stomach (posterior)                   | No significant lesions                                                                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                                                  |
| Urinary Bladder                       | Edema of mucosal folds                                                                                                                                  |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                                                |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                                                  |
| Intestine<br>(posterior and anterior) | Mild diffuse edema - luminal parasite; diffuse villus tip edema - luminal parasite                                                                      |
| Skeletal Muscle                       | No significant lesions                                                                                                                                  |
| Skin                                  | No significant lesions                                                                                                                                  |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis                                                                                                                                 |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #086                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 36.8 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 21 oz<br>Liver weight: 7.26 g | Sex: Male<br>Age: 8 yrs. |

Gross findings: Multiple small cutaneous red and white foci were noted (head, body).  
The right cranio-lateral fin was notched.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                           |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | Minimal multifocal cholecystitis; locally extensive mural edema                                                          |
| Liver/Pancreas                        | Focal nodular MMC hyperplasia; focal mild capsular/mesenteric parasite granuloma; focal moderate granulomatous hepatitis |
| Caudal Kidney                         | Mild acute locally extensive interstitial nephritis                                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                                                                   |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                     |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                |
| Stomach (anterior)                    | No significant lesions                                                                                                   |
| Stomach (posterior)                   | Focal parasite section in lamina propria                                                                                 |
| Gas Bladder                           | No significant lesions                                                                                                   |
| Urinary Bladder                       | No significant lesions                                                                                                   |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                 |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                                                   |
| Intestine<br>(posterior and anterior) | Diffuse edema - luminal parasites                                                                                        |
| Skeletal Muscle                       | No significant lesions                                                                                                   |
| Skin                                  | Mild acute multifocal dermal hemorrhage                                                                                  |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                   |

| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                   | FISH #087                  |
|--------------------------------------------------------|---------------------------------------|----------------------------|
| Length: 26.2 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 10 oz<br>Liver weight: 5.26 g | Sex: Female<br>Age: 5 yrs. |

Gross findings: Two spines on the cranio-lateral fins were shortened. The caudo-ventral fin was partially fragmented. The liver was pale and displayed a reticular pattern. The posterior kidney was multifocally pigmented. Foci of cutaneous erosion were noted (body, left cranio-lateral fin).

| ORGAN                                 | HISTOPATHOLOGY                                                                                      |
|---------------------------------------|-----------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                              |
| Liver/Pancreas                        | Diffuse hepatocellular regeneration                                                                 |
| Caudal Kidney                         | Cyst                                                                                                |
| Corpuscle of Stannius                 | Not present                                                                                         |
| Cranial Kidney                        | No significant lesions                                                                              |
| Heart                                 | Focal lymphoplasmacytic myocarditis                                                                 |
| Stomach (anterior)                    | No significant lesions                                                                              |
| Stomach (posterior)                   | Focal parasite section in lamina propria                                                            |
| Gas Bladder                           | No significant lesions                                                                              |
| Urinary Bladder                       | Hyperemic serosa                                                                                    |
| Gonad                                 | No significant lesions                                                                              |
| Spleen                                | Moderate lymphoid depletion                                                                         |
| Intestine<br>(posterior and anterior) | Attached luminal parasites                                                                          |
| Skeletal Muscle                       | No significant lesions                                                                              |
| Skin                                  | Moderate focal granulomatous dermatitis/myositis;<br>numerous parasitic organisms within the dermis |
| Mouth/Lip/Barbel                      | No significant lesions                                                                              |



|                                                        |                                       |                            |
|--------------------------------------------------------|---------------------------------------|----------------------------|
| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                   | FISH #088                  |
| Length: 27.6 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 11 oz<br>Liver weight: 5.49 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The liver was pale. Several pale nodules were noted in the kidney. The dorsal fin was split and contained cutaneous erosions. The right cranio-lateral fin was separated from the associated bone.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                   |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                                           |
| Liver/Pancreas                        | Diffuse hepatocellular regeneration; basophilic focus; mild clear cell focus; multifocal mild capsular/mesenteric parasite granuloma; focal parenchymal parasite |
| Caudal Kidney                         | Mild tubular epithelium eosinophilic drop formation                                                                                                              |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                           |
| Cranial Kidney                        | No significant lesions                                                                                                                                           |
| Heart                                 | No significant lesions                                                                                                                                           |
| Stomach (anterior)                    | Multifocal granulomas with foreign material                                                                                                                      |
| Stomach (posterior)                   | Focal granuloma in lamina propria                                                                                                                                |
| Gas Bladder                           | No significant lesions                                                                                                                                           |
| Urinary Bladder                       | No significant lesions                                                                                                                                           |
| Gonad                                 | No significant lesions                                                                                                                                           |
| Spleen                                | No significant lesions                                                                                                                                           |
| Intestine<br>(posterior and anterior) | Attached luminal parasites                                                                                                                                       |
| Skeletal Muscle                       | No significant lesions                                                                                                                                           |
| Skin                                  | No significant lesions                                                                                                                                           |
| Mouth/Lip/Barbel                      | Mild focal chronic dermatitis                                                                                                                                    |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                    | FISH #089                  |
|--------------------------------------------------------|----------------------------------------|----------------------------|
| Length: 37.6 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 27 oz<br>Liver weight: 17.05 g | Sex: Female<br>Age: 9 yrs. |

Gross findings: Foci of tan capsular iridescence was noted (liver). Multiple white linear foci on the liver were noted. Capsular iridescent pigment was noted (posterior kidney). Multiple cutaneous nodules (near tail), ulcers (near tail, left caudo-lateral and cranio-lateral fins), erosion (ventral lip), yellow discoloration (ventrum of head), raised reddened sites (body, ventrum of body) and foci of edema (ventrum of body) were noted. The caudo-ventral fin was notched. The left cranio-lateral fin was shortened.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                                                                                                   |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                                                                                           |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; multifocal mild capsular/mesenteric parasite granuloma; multifocal severe parenchymous parasites; multifocal moderate granulomatous hepatitis |
| Caudal Kidney                         | Mild tubular epithelium eosinophilic drop formation; mild multifocal acute interstitial nephritis                                                                                                |
| Corpuscle of Stannius                 | No significant lesions                                                                                                                                                                           |
| Cranial Kidney                        | Mild MMC hyperplasia                                                                                                                                                                             |
| Heart                                 | No significant lesions                                                                                                                                                                           |
| Stomach (anterior)                    | No significant lesions                                                                                                                                                                           |
| Stomach (posterior)                   | Focal granuloma with parasite in lamina propria                                                                                                                                                  |
| Gas Bladder                           | No significant lesions                                                                                                                                                                           |
| Urinary Bladder                       | No significant lesions                                                                                                                                                                           |
| Gonad                                 | No significant lesions                                                                                                                                                                           |
| Spleen                                | Parasite cross-section; moderate diffuse MMC hyperplasia                                                                                                                                         |
| Intestine<br>(posterior and anterior) | Moderate multifocal enteritis - attached luminal parasites                                                                                                                                       |
| Skeletal Muscle                       | No significant lesions                                                                                                                                                                           |
| Skin                                  | Moderate focal epidermal ulceration; mild acute focal dermal hemorrhage                                                                                                                          |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis; moderate focal epidermal ulceration                                                                                                                                     |



| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                  | FISH #090                |
|--------------------------------------------------------|--------------------------------------|--------------------------|
| Length: 26.5 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 9 oz<br>Liver weight: 2.41 g | Sex: Male<br>Age: 4 yrs. |

Gross findings: The liver displayed a diffuse reticular pattern. The caudo-ventral fin was split.

| ORGAN                                 | HISTOPATHOLOGY                                        |
|---------------------------------------|-------------------------------------------------------|
| Gallbladder                           | No significant lesions                                |
| Liver/Pancreas                        | Multifocal nodular pancreatic hyperplasia             |
| Caudal Kidney                         | No significant lesions                                |
| Corpuscle of Stannius                 | Not present                                           |
| Cranial Kidney                        | No significant lesions                                |
| Heart                                 | No significant lesions                                |
| Stomach (anterior)                    | Focal granuloma with parasite sections                |
| Stomach (posterior)                   | Multifocal granulomas and parasites in lamina propria |
| Gas Bladder                           | No significant lesions                                |
| Urinary Bladder                       | No significant lesions                                |
| Gonad                                 | Severe tubular lining cell hyperplasia                |
| Spleen                                | Lymphoid depletion                                    |
| Intestine<br>(posterior and anterior) | Attached luminal parasite; mesenteric granuloma       |
| Skeletal Muscle                       | No significant lesions                                |
| Skin                                  | No significant lesions                                |
| Mouth/Lip/Barbel                      | No significant lesions                                |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                      | FISH #091                  |
|--------------------------------------------------------|------------------------------------------|----------------------------|
| Length: 32.0 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 15 oz<br>Liver weight: Not Given | Sex: Female<br>Age: 6 yrs. |

Gross findings: The tail fin was split. The left caudo-lateral fin was partially missing. The right dorso-lateral barbel and right cranio-lateral fin were missing.

| ORGAN                                 | HISTOPATHOLOGY                                                                           |
|---------------------------------------|------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                   |
| Liver/Pancreas                        | Lobar mild to moderate hepatocellular clear vacuolation;<br>diffuse mild MMC hyperplasia |
| Caudal Kidney                         | Mild locally extensive interstitial nephritis                                            |
| Corpuscle of Stannius                 | No significant lesions                                                                   |
| Cranial Kidney                        | Moderate MMC hyperplasia                                                                 |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                |
| Stomach (anterior)                    | Focal granuloma with foreign material                                                    |
| Stomach (posterior)                   | Focal foreign body granuloma in lamina propria                                           |
| Gas Bladder                           | No significant lesions                                                                   |
| Urinary Bladder                       | No significant lesions                                                                   |
| Gonad                                 | Mild multifocal pigmentation                                                             |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                                   |
| Intestine<br>(posterior and anterior) | Attached luminal parasite                                                                |
| Skeletal Muscle                       | No significant lesions                                                                   |
| Skin                                  | No significant lesions                                                                   |
| Mouth/Lip/Barbel                      | No significant lesions                                                                   |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                    | FISH #092                  |
|--------------------------------------------------------|----------------------------------------|----------------------------|
| Length: 34.2 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 18 oz<br>Liver weight: 10.19 g | Sex: Female<br>Age: 7 yrs. |

Gross findings: Foci of cutaneous reddening (body, head), ulceration (left caudo-lateral, caudo-ventral, right cranio-lateral fins and head) and erosion (ventrum of head) were noted. The liver displayed a diffuse reticular pattern.

| ORGAN                                 | HISTOPATHOLOGY                                                                  |
|---------------------------------------|---------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions, locally extensive mural edema                           |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; diffuse mild MMC hyperplasia |
| Caudal Kidney                         | No significant lesions                                                          |
| Corpuscle of Stannius                 | No significant lesions                                                          |
| Cranial Kidney                        | No significant lesions                                                          |
| Heart                                 | No significant lesions                                                          |
| Stomach (anterior)                    | Multifocal granulomas, one with parasite sections                               |
| Stomach (posterior)                   | Multifocal parasite and granuloma in lamina propria                             |
| Gas Bladder                           | No significant lesions                                                          |
| Urinary Bladder                       | No significant lesions                                                          |
| Gonad                                 | No significant lesions                                                          |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia                        |
| Intestine<br>(posterior and anterior) | No significant lesions                                                          |
| Skeletal Muscle                       | No significant lesions                                                          |
| Skin                                  | Moderate multifocal epidermal erosion                                           |
| Mouth/Lip/Barbel                      | No significant lesions                                                          |

| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                  | FISH #093                  |
|--------------------------------------------------------|--------------------------------------|----------------------------|
| Length: 27.5 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 9 oz<br>Liver weight: 3.65 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The tail and caudo-ventral fins were split. Foci of cutaneous white erosions (body) and ulceration (near caudo-ventral fin) were noted. The right lateral barbel was deformed. The liver displayed a diffuse reticular pattern.

| ORGAN                                 | HISTOPATHOLOGY                                                              |
|---------------------------------------|-----------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                      |
| Liver/Pancreas                        | Diffuse hepatocellular regeneration                                         |
| Caudal Kidney                         | No significant lesions                                                      |
| Corpuscle of Stannius                 | No significant lesions                                                      |
| Cranial Kidney                        | No significant lesions                                                      |
| Heart                                 | No significant lesions                                                      |
| Stomach (anterior)                    | No significant lesions                                                      |
| Stomach (posterior)                   | Nematode parasite in the lumen                                              |
| Gas Bladder                           | No significant lesions                                                      |
| Urinary Bladder                       | No significant lesions                                                      |
| Gonad                                 | No significant lesions                                                      |
| Spleen                                | No significant lesions                                                      |
| Intestine<br>(posterior and anterior) | Attached luminal parasite; multifocal enteritis - attached luminal parasite |
| Skeletal Muscle                       | No significant lesions                                                      |
| Skin                                  | Moderate focal dermal fibrosis                                              |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis with intralesional plant material                   |



| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #094                  |
|--------------------------------------------------------|---------------------------------------|----------------------------|
| Length: 33.9 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 17 oz<br>Liver weight: 4.54 g | Sex: Female<br>Age: 9 yrs. |

Gross findings: The tail fin was notched, ulcerated and partially missing. The left cranio-lateral fin contained a broken spine. The dorsal fin was broken. Foci of cutaneous reddening (ventrum of head) were noted. One focal scar was noted (right lateral lip).

| ORGAN                                 | HISTOPATHOLOGY                                              |
|---------------------------------------|-------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                      |
| Liver/Pancreas                        | Diffuse moderate MMC hyperplasia                            |
| Caudal Kidney                         | Moderate MMC hyperplasia, mild focal interstitial nephritis |
| Corpuscle of Stannius                 | No significant lesions                                      |
| Cranial Kidney                        | Moderate MMC hyperplasia                                    |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                   |
| Stomach (anterior)                    | No significant lesions                                      |
| Stomach (posterior)                   | Parasite in the lumen                                       |
| Gas Bladder                           | No significant lesions                                      |
| Urinary Bladder                       | No significant lesions                                      |
| Gonad                                 | Mild multifocal pigmentation                                |
| Spleen                                | No significant lesions, moderate diffuse MMC hyperplasia    |
| Intestine<br>(posterior and anterior) | No significant lesions                                      |
| Skeletal Muscle                       | No significant lesions                                      |
| Skin                                  | No significant lesions                                      |
| Mouth/Lip/Barbel                      | Mild multifocal chronic dermatitis with epidermal erosion   |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #095                  |
|--------------------------------------------------------|---------------------------------------|----------------------------|
| Length: 33.0 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 14 oz<br>Liver weight: 8.95 g | Sex: Female<br>Age: 8 yrs. |

Gross findings: Foci of cutaneous reddening (head) and ulceration (dorsal fin, caudo-ventral fin, near tail) were noted. One focal cutaneous nodule was noted (ventrum of head). The right cranio-lateral and left cranio-lateral fins contained shortened spines.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                        |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; diffuse mild MMC hyperplasia; focal nodular pancreatic hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                                                |
| Corpuscle of Stannius                 | No significant lesions                                                                                                |
| Cranial Kidney                        | No significant lesions                                                                                                |
| Heart                                 | No significant lesions                                                                                                |
| Stomach (anterior)                    | Focal, chronic inflammation in lamina propria                                                                         |
| Stomach (posterior)                   | Parasite section in lamina propria                                                                                    |
| Gas Bladder                           | No significant lesions                                                                                                |
| Urinary Bladder                       | No significant lesions                                                                                                |
| Gonad                                 | Mild multifocal pigmentation                                                                                          |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                  |
| Intestine<br>(posterior and anterior) | Mild diffuse edema - luminal parasite; mild multifocal enteritis                                                      |
| Skeletal Muscle                       | No significant lesions                                                                                                |
| Skin                                  | Moderate focal epidermal ulceration; mild focal dermal vascular congestion                                            |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                                |



| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                  | FISH #096                  |
|--------------------------------------------------------|--------------------------------------|----------------------------|
| Length: 24.8 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 8 oz<br>Liver weight: 4.15 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The caudo-ventral fin was notched. One white cutaneous focus was noted (head). One focal cutaneous ulcer was noted (ventral lip). The liver was diffusely yellow/green.

| ORGAN                                 | HISTOPATHOLOGY                                                           |
|---------------------------------------|--------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                   |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation                        |
| Caudal Kidney                         | No significant lesions                                                   |
| Corpuscle of Stannius                 | Not present                                                              |
| Cranial Kidney                        | No significant lesions                                                   |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                |
| Stomach (anterior)                    | No significant lesions                                                   |
| Stomach (posterior)                   | No significant lesions                                                   |
| Gas Bladder                           | No significant lesions                                                   |
| Urinary Bladder                       | No significant lesions                                                   |
| Gonad                                 | No significant lesions                                                   |
| Spleen                                | No significant lesions                                                   |
| Intestine<br>(posterior and anterior) | Multiple luminal parasites; mild multifocal enteritis                    |
| Skeletal Muscle                       | No significant lesions                                                   |
| Skin                                  | Moderate multifocal epidermal hyperplasia; mild focal chronic cellulitis |
| Mouth/Lip/Barbel                      | No significant lesions                                                   |

| Species<br>Brown Bullhead                              | STUDY<br>POPULATION                   | FISH #097                |
|--------------------------------------------------------|---------------------------------------|--------------------------|
| Length: 31.7 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 14 oz<br>Liver weight: 3.84 g | Sex: Male<br>Age: 6 yrs. |

Gross findings: The tail fin was split. The dorsal fin was partially missing. Foci of cutaneous reddening (head, body) erosion (head, left cranio-lateral fin) was noted. One focus of ulceration (right lateral lip) was noted.

| ORGAN                                 | HISTOPATHOLOGY                                                                                                               |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                                                       |
| Liver/Pancreas                        | Focal acute moderate cholangitis; multifocal moderate granulomatous hepatitis; focal moderate nodular pancreatic hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                                                       |
| Corpuscle of Stannius                 | Not present                                                                                                                  |
| Cranial Kidney                        | Moderate MMC hyperplasia with vacuolar degeneration of MMC                                                                   |
| Heart                                 | Focal, mild lymphoplasmacytic epicarditis                                                                                    |
| Stomach (anterior)                    | No significant lesions                                                                                                       |
| Stomach (posterior)                   | Parasite section in the lumen                                                                                                |
| Gas Bladder                           | No significant lesions                                                                                                       |
| Urinary Bladder                       | No significant lesions                                                                                                       |
| Gonad                                 | Moderate tubular lining cell hyperplasia                                                                                     |
| Spleen                                | No significant lesions, mild diffuse MMC hyperplasia                                                                         |
| Intestine<br>(posterior and anterior) | Diffuse edema and local enteritis - parasite in lamina propria                                                               |
| Skeletal Muscle                       | No significant lesions                                                                                                       |
| Skin                                  | No significant lesions                                                                                                       |
| Mouth/Lip/Barbel                      | Mild focal chronic dermatitis                                                                                                |



| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                  | FISH #098                |
|--------------------------------------------------------|--------------------------------------|--------------------------|
| Length: 23.1 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 6 oz<br>Liver weight: 2.66 g | Sex: Male<br>Age: 7 yrs. |

Gross findings: The tail fin was notched. Foci of cutaneous yellow discoloration (head, body) and erosion (near ventral lip) were noted. One focal red nodule was noted (ventral lip). One focal scar was noted (dorsal lip). The liver was pale.

| ORGAN                                 | HISTOPATHOLOGY                                                                                   |
|---------------------------------------|--------------------------------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                                           |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation; focal moderate nodular pancreatic hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                           |
| Corpuscle of Stannius                 | Not present                                                                                      |
| Cranial Kidney                        | No significant lesions                                                                           |
| Heart                                 | No significant lesions                                                                           |
| Stomach (anterior)                    | No significant lesions                                                                           |
| Stomach (posterior)                   | No significant lesions                                                                           |
| Gas Bladder                           | No significant lesions                                                                           |
| Urinary Bladder                       | No significant lesions                                                                           |
| Gonad                                 | Mild tubular lining cell hyperplasia                                                             |
| Spleen                                | No significant lesions                                                                           |
| Intestine<br>(posterior and anterior) | Mild diffuse enteritis - luminal parasites                                                       |
| Skeletal Muscle                       | Mild, focal chronic myositis                                                                     |
| Skin                                  | Mild goblet cell hyperplasia                                                                     |
| Mouth/Lip/Barbel                      | No significant lesions                                                                           |

| Species<br>Yellow Bullhead                             | STUDY<br>POPULATION                  | FISH #099                  |
|--------------------------------------------------------|--------------------------------------|----------------------------|
| Length: 25.4 cm<br>Collection Site:<br>Eaton Reservoir | Weight: 8 oz<br>Liver weight: 3.83 g | Sex: Female<br>Age: 6 yrs. |

Gross findings: The left and right cranio-lateral fins were split. The liver was pale and displayed a diffuse reticular pattern. The kidney contained multiple yellow foci.

| ORGAN                                 | HISTOPATHOLOGY                                                                                           |
|---------------------------------------|----------------------------------------------------------------------------------------------------------|
| Gallbladder                           | NOTE: small section                                                                                      |
| Liver/Pancreas                        | Diffuse moderate hepatocellular clear vacuolation;<br>multifocal moderate nodular pancreatic hyperplasia |
| Caudal Kidney                         | No significant lesions                                                                                   |
| Corpuscle of Stannius                 | Not present                                                                                              |
| Cranial Kidney                        | No significant lesions                                                                                   |
| Heart                                 | Multifocal, moderate lymphoplasmacytic epicarditis                                                       |
| Stomach (anterior)                    | Focal granuloma in lamina propria                                                                        |
| Stomach (posterior)                   | No significant lesions                                                                                   |
| Gas Bladder                           | No significant lesions                                                                                   |
| Urinary Bladder                       | No significant lesions                                                                                   |
| Gonad                                 | No significant lesions                                                                                   |
| Spleen                                | No significant lesions                                                                                   |
| Intestine<br>(posterior and anterior) | Minimal acute multifocal enteritis                                                                       |
| Skeletal Muscle                       | No significant lesions                                                                                   |
| Skin                                  | No significant lesions                                                                                   |
| Mouth/Lip/Barbel                      | No significant lesions                                                                                   |



| Species<br>Yellow Bullhead                          | STUDY<br>POPULATION                   | FISH #100                |
|-----------------------------------------------------|---------------------------------------|--------------------------|
| Length: 30.6 cm<br>Collection Site:<br>Leboeuf Lake | Weight: 13 oz<br>Liver weight: 4.24 g | Sex: Male<br>Age: 5 yrs. |

Gross findings: The tail fin was notched. Multiple foci of ulceration were noted (right lateral lip).

| ORGAN                                 | HISTOPATHOLOGY                                                             |
|---------------------------------------|----------------------------------------------------------------------------|
| Gallbladder                           | No significant lesions                                                     |
| Liver/Pancreas                        | Multifocal mild acute hepatocyte necrosis                                  |
| Caudal Kidney                         | No significant lesions                                                     |
| Corpuscle of Stannius                 | Not present                                                                |
| Cranial Kidney                        | Mild MMC hyperplasia                                                       |
| Heart                                 | No significant lesions                                                     |
| Stomach (anterior)                    | No significant lesions                                                     |
| Stomach (posterior)                   | Multifocal parasite sections in lamina propria                             |
| Gas Bladder                           | No significant lesions                                                     |
| Urinary Bladder                       | No significant lesions                                                     |
| Gonad                                 | Mild tubular lining cell hyperplasia                                       |
| Spleen                                | No significant lesions, severe diffuse MMC hyperplasia                     |
| Intestine<br>(posterior and anterior) | Mild diffuse edema; mild diffuse edema                                     |
| Skeletal Muscle                       | No significant lesions                                                     |
| Skin                                  | Mild goblet cell hyperplasia                                               |
| Mouth/Lip/Barbel                      | Mild chronic stomatitis; mild focal intraepidermal cytoplasmic vacuolation |





## APPENDIX B

### Tables

**Table 1. Number and Ages of Bullheads at Designated Sites.**

| Site            | Number of bullheads<br>at site | Age - high<br>(years) | Age - low<br>(years) | Average age<br>(years) |
|-----------------|--------------------------------|-----------------------|----------------------|------------------------|
| Eaton Reservoir | 26                             | 15                    | 4                    | 7.48                   |
| Lagoons         | 26                             | 16                    | 3                    | 7.25                   |
| The Point       | 15                             | 8                     | 4                    | 4.86                   |
| Misery Bay      | 11                             | 10                    | 3                    | 5.36                   |
| Mill Creek      | 8                              | 15                    | 3                    | 6.29                   |
| Lebeouf Lake    | 5                              | 5                     | 3                    | 4.25                   |
| Sara's Cove     | 3                              | 10                    | 4                    | 6.33                   |
| <b>Totals</b>   | <b>94</b>                      |                       |                      | <b>6.46</b>            |

**Table 2. Number and Age of Bullheads**

| Age of Bullheads | Number of Bullheads | Age of Bullheads | Number of Bullheads |
|------------------|---------------------|------------------|---------------------|
| 3 yrs            | 7                   | 9 yrs            | 5                   |
| 4 yrs            | 16                  | 10 yrs           | 4                   |
| 5 yrs            | 16                  | 12 yrs           | 1                   |
| 6 yrs            | 19                  | 13 yrs           | 2                   |
| 7 yrs            | 7                   | 15 yrs           | 3                   |
| 8 yrs            | 7                   | 16 yrs           | 1                   |
| Unknown Age (6)  |                     |                  |                     |



**Table 3. Bullhead Bile PAH Metabolite Concentrations by Location**

| Location                | Napthalene (mg/l) | Phenanthrene (mg/l) | Benzo-a-pyrene (mg/l) |
|-------------------------|-------------------|---------------------|-----------------------|
| <b>Eaton Reservoir*</b> |                   |                     |                       |
| High                    | 110.406           | 56.173              | 1.095                 |
| Low                     | 2.535             | 7.932               | 0.053                 |
| Average                 | 53.839            | 27.378              | 0.261                 |
| <b>Lagoons**</b>        |                   |                     |                       |
| High                    | 231.465           | 234.870             | 1.777                 |
| Low                     | 6.348             | 4.363               | 0.055                 |
| Average                 | 89.036            | 51.979              | 0.521                 |
| <b>Misery Bay</b>       |                   |                     |                       |
| High                    | 202.158           | 99.107              | 0.871                 |
| Low                     | 31.855            | 13.275              | 0.035                 |
| Average                 | 102.948           | 42.402              | 0.364                 |
| <b>The Point*</b>       |                   |                     |                       |
| High                    | 264.333           | 198.753             | 1.577                 |
| Low                     | 84.110            | 18.454              | 0.053                 |
| Average                 | 123.100           | 51.804              | 0.432                 |
| <b>Mill Creek*</b>      |                   |                     |                       |
| High                    | 270.905           | 197.541             | 1.989                 |
| Low                     | 111.248           | 57.077              | 0.758                 |
| Average                 | 161.950           | 100.111             | 1.269                 |
| <b>Lebeouf Lake*</b>    |                   |                     |                       |
| High                    | 853.408           | 296.704             | 3.732                 |
| Low                     | 92.914            | 35.173              | 0.217                 |
| Average                 | 303.350           | 107.798             | 1.143                 |
| <b>Sara's Cove</b>      |                   |                     |                       |
| High                    | 388.893           | 392.630             | 4.183                 |
| Low                     | 143.071           | 57.847              | 0.573                 |
| Average                 | 239.074           | 181.454             | 2.064                 |
| <b>All Bullheads</b>    |                   |                     |                       |
| High                    | 853.408           | 392.630             | 3.732                 |
| Low                     | 2.535             | 4.363               | 0.035                 |
| Average                 | 106.869           | 54.292              | 0.556                 |

\* Data not available for 1 bullhead

\*\* Data not available for 3 bullheads

**Table 4. Number and Age of Bullheads with Tumors and Hyperplasia**

| <b>Orocutaneous Tumors</b>           |                            | <b>Orocutaneous Hyperplasia (Moderate)</b> |                            |
|--------------------------------------|----------------------------|--------------------------------------------|----------------------------|
| <u>Age of Bullheads</u>              | <u>Number of Bullheads</u> | <u>Age of Bullheads</u>                    | <u>Number of Bullheads</u> |
| 5 yrs                                | 1                          | 3 yrs                                      | 2                          |
| 6 yrs                                | 1                          | 5 yrs                                      | 2                          |
| 8 yrs                                | 1                          | 6 yrs                                      | 2                          |
| 10 yrs                               | 2                          | 7 yrs                                      | 1                          |
| 13 yrs                               | 1                          | 10 yrs                                     | 2                          |
| 16 yrs                               | 1                          | 15 yrs                                     | 1                          |
|                                      |                            | 16 yrs                                     | 1                          |
|                                      |                            | Unknown Age                                | 2                          |
| <b><u>Average Age = 9.71 yrs</u></b> |                            | <b><u>Average Age = 7.82 yrs</u></b>       |                            |
| <b>Liver Tumors</b>                  |                            | <b>Liver Hyperplasia</b>                   |                            |
| <u>Age of Bullheads</u>              | <u>Number of Bullheads</u> | <u>Age of Bullheads</u>                    | <u>Number of Bullheads</u> |
| 15 yrs                               | 2                          | 6 yrs                                      | 1                          |
| 16 yrs                               | 1                          | 8 yrs                                      | 1                          |
|                                      |                            | 12 yrs                                     | 1                          |
|                                      |                            | 15 yrs                                     | 2                          |
|                                      |                            | 16 yrs                                     | 1                          |
| <b><u>Average Age = 15.5 yrs</u></b> |                            | <b><u>Average Age = 12.0 yrs</u></b>       |                            |



**Table 5. Bullhead Tumor and Hyperplasia Rates by Location**

| <b>Orocutaneous Tumors</b>         |                            |                   | <b>Orocutaneous Hyperplasia (Moderate)</b> |                            |                         |
|------------------------------------|----------------------------|-------------------|--------------------------------------------|----------------------------|-------------------------|
| <u>Location</u>                    | <u>Number of Bullheads</u> | <u>Tumor Rate</u> | <u>Location</u>                            | <u>Number of Bullheads</u> | <u>Hyperplasia Rate</u> |
| Sara's Cove                        | 1                          | 33.0 %            | Misery Bay                                 | 4                          | 36.4 %                  |
| Lagoons                            | 4                          | 15.4 %            | Mill Creek                                 | 2                          | 25.0 %                  |
| Misery Bay                         | 1                          | 9.1 %             | Lebeouf Lake                               | 1                          | 20.0 %                  |
| The Point                          | 1                          | 6.7 %             | Lagoons                                    | 4                          | 15.4 %                  |
| Eaton Reservoir                    | 0                          | 0.0 %             | Eaton Reservoir                            | 2                          | 7.7 %                   |
| Lebeouf Lake                       | 0                          | 0.0 %             | The Point                                  | 0                          | 0.0 %                   |
| Mill Creek                         | 0                          | 0.0 %             | Sara's Cove                                | 0                          | 0.0 %                   |
| <u>Overall Tumor Rate</u> = 7.45 % |                            |                   | <u>Overall Hyperplasia Rate</u> = 13.83 %  |                            |                         |

| <b>Liver Tumors</b>                |                            |                   | <b>Liver Hyperplasia</b>           |                            |                         |
|------------------------------------|----------------------------|-------------------|------------------------------------|----------------------------|-------------------------|
| <u>Location</u>                    | <u>Number of Bullheads</u> | <u>Tumor Rate</u> | <u>Location</u>                    | <u>Number of Bullheads</u> | <u>Hyperplasia Rate</u> |
| Lagoons                            | 2                          | 7.7 %             | Lagoons                            | 3                          | 11.5 %                  |
| Eaton Reservoir                    | 1                          | 3.9 %             | Eaton Reservoir                    | 3                          | 11.5 %                  |
| Lebeouf Lake                       | 0                          | 0.0 %             | Lebeouf Lake                       | 0                          | 0.0 %                   |
| Mill Creek                         | 0                          | 0.0 %             | Mill Creek                         | 0                          | 0.0 %                   |
| Misery Bay                         | 0                          | 0.0 %             | Misery Bay                         | 0                          | 0.0 %                   |
| Sara's Cove                        | 0                          | 0.0 %             | Sara's Cove                        | 0                          | 0.0 %                   |
| The Point                          | 0                          | 0.0 %             | The Point                          | 0                          | 0.0 %                   |
| <u>Overall Tumor Rate</u> = 3.19 % |                            |                   | <u>Overall Tumor Rate</u> = 6.38 % |                            |                         |

Table 6. Bullhead Bile PAH Metabolite Concentrations

|                                                 | Napthalene (mg/l) | Phenanthrene (mg/l) | Benzo-a-pyrene (mg/l) |
|-------------------------------------------------|-------------------|---------------------|-----------------------|
| <b>Group A * (All Bullheads): 86</b>            |                   |                     |                       |
| High                                            | 853.408           | 392.630             | 3.732                 |
| Low                                             | 2.535             | 4.363               | 0.035                 |
| Average                                         | 106.869           | 54.292              | 0.556                 |
| <b>Group B (Liver Tumors): 3</b>                |                   |                     |                       |
| High                                            | 148.605           | 83.826              | 0.610                 |
| Low                                             | 2.535             | 7.932               | 0.053                 |
| Average                                         | 73.731            | 40.471              | 0.335                 |
| <b>Group C** (Orocutaneous Tumors): 7</b>       |                   |                     |                       |
| High                                            | 143.071           | 73.230              | 1.055                 |
| Low                                             | 26.661            | 18.454              | 0.053                 |
| Average                                         | 101.860           | 45.380              | 0.457                 |
| <b>Group D (Liver Hyperplasia): 6</b>           |                   |                     |                       |
| High                                            | 148.605           | 83.826              | 0.610                 |
| Low                                             | 2.535             | 7.932               | 0.053                 |
| Average                                         | 57.324            | 30.640              | 0.244                 |
| <b>Group E** (Orocutaneous Hyperplasia): 13</b> |                   |                     |                       |
| High                                            | 152.546           | 99.107              | 1.202                 |
| Low                                             | 26.661            | 18.006              | 0.090                 |
| Average                                         | 91.441            | 46.115              | 0.551                 |

\* Data not available for 8 bullheads.

\*\* Data not available for 1 bullhead.



**Table 7. Average Bile PAH metabolite concentration of bullheads with tumors and hyperplasia listed by age**

| age                                                                 | n | Napthalene (mg/l) | Phenanthrene (mg/l) | Benzo-a-pyrene (mg/l) |
|---------------------------------------------------------------------|---|-------------------|---------------------|-----------------------|
| <b>Liver Neoplasms:</b>                                             |   |                   |                     |                       |
| 15                                                                  | 2 | 75.570            | 45.880              | 0.332                 |
| 16                                                                  | 1 | 70.052            | 29.654              | 0.342                 |
| <b>Liver Hyperplasia:</b>                                           |   |                   |                     |                       |
| 6                                                                   | 1 | 47.104            | 19.880              | 0.233                 |
| 8                                                                   | 1 | 45.799            | 25.196              | 0.121                 |
| 12                                                                  | 1 | 29.849            | 17.321              | 0.104                 |
| 15                                                                  | 2 | 75.570            | 45.880              | 0.332                 |
| <b>Orocutaneous Tumors:</b>                                         |   |                   |                     |                       |
| 5                                                                   | 1 | 131.573           | 63.137              | 0.493                 |
| 6                                                                   | 1 | 107.259           | 73.230              | 1.055                 |
| 8                                                                   | 1 | 132.544           | 18.454              | 0.053                 |
| 10                                                                  | 2 | 84.866            | 43.900              | 0.400                 |
| 13                                                                  | 1 | no data available | no data available   | no data available     |
| 16                                                                  | 1 | 70.052            | 29.654              | 0.342                 |
| <b>Orocutaneous Hyperplasia (moderate or greater):</b>              |   |                   |                     |                       |
| 3                                                                   | 2 | 79.740            | 22.060              | 0.130                 |
| 5                                                                   | 2 | 92.230            | 38.020              | 0.565                 |
| 6                                                                   | 2 | 83.600            | 46.400              | 0.602                 |
| 7                                                                   | 1 | 152.550           | 99.110              | 0.871                 |
| 10                                                                  | 2 | 78.980            | 45.770              | 0.402                 |
| 15                                                                  | 1 | 111.250           | 81.410              | 1.200                 |
| 16                                                                  | 1 | 70.050            | 29.650              | 0.342                 |
| unknown ages (2)                                                    |   |                   |                     |                       |
| <b>All Bullheads Not Exhibiting Neoplasms (liver/orocutaneous):</b> |   |                   |                     |                       |
| 5.950 (Ave. age)                                                    |   | 108.058           | 55.540              | 0.569                 |

n - Number of bullheads

Data presented is average concentration if n = 2

**Table 8. Summary of Histologic Lesions in Liver and Orocutaneous Tissues of Bullheads**

| <u>Neoplasm Type</u>                       | <u>Number of Bullheads Affected</u> | <u>Percent</u> |
|--------------------------------------------|-------------------------------------|----------------|
| All liver and orocutaneous tumors          | 9/94                                | 9.6 %          |
| Orocutaneous tumors                        | 7/94                                | 7.4 %          |
| Liver tumors                               | 3/94                                | 3.2 %          |
| Simultaneous liver and orocutaneous tumors | 1/94                                | 1.1 %          |
| Liver Neoplasms                            |                                     |                |
| Biliary adenoma                            | 1/94                                | 1.1 %          |
| Biliary carcinoma                          | 2/94                                | 2.1 %          |

**Other Histopathologic Lesions Occurring in the Liver of All Bullheads:**

| <u>Lesion</u>                        | <u>Number of Bullheads Affected</u> | <u>Percent</u> |
|--------------------------------------|-------------------------------------|----------------|
| Foci of Alteration                   |                                     |                |
| Eosinophilic                         | 6/94                                | 6.4 %          |
| Basophilic                           | 1/94                                | 1.1 %          |
| Clear cell                           | 2/94                                | 2.1 %          |
| Peliosis                             | 4/94                                | 4.3 %          |
| Necrosis/inflammation                | 38/94                               | 40.4 %         |
| Parasites                            | 30/94                               | 31.9 %         |
| Bile duct inflammation (cholangitis) | 15/94                               | 16.0 %         |
| Bile duct hyperplasia                | 3/94                                | 3.2 %          |



**Table 9. Average Bile PAH Metabolite Concentration by Age**

| Age    | n    | Napthalene (mg/l) | Phenanthrene (mg/l) | Benzo-a-pyrene (mg/l) |
|--------|------|-------------------|---------------------|-----------------------|
| 3 yrs  | 7*   | 117.432           | 56.389              | 0.503                 |
| 4 yrs  | 16** | 103.627           | 47.431              | 0.444                 |
| 5 yrs  | 16*  | 193.275           | 98.856              | 1.082                 |
| 6 yrs  | 19*  | 84.890            | 50.693              | 0.530                 |
| 7 yrs  | 7    | 91.443            | 42.300              | 0.456                 |
| 8 yrs  | 7    | 59.320            | 20.652              | 0.160                 |
| 9 yrs  | 5    | 47.946            | 20.386              | 0.214                 |
| 10 yrs | 4    | 105.323           | 56.553              | 0.578                 |
| 12 yrs | 1    | 29.849            | 17.321              | 0.104                 |
| 13 yrs | 2*   | 90.876            | 33.885              | 0.147                 |
| 15 yrs | 3    | 87.463            | 57.722              | 0.622                 |
| 16 yrs | 1    | 70.052            | 29.654              | 0.342                 |

\* Bile PAH data not available for 1 bullhead.

\*\* Bile PAH data not available for 3 bullheads.

n = Number of bullheads

**Table 10. Bullhead Tumor Rates in 3 Separate Presque Isle Studies**

| <u>Year</u> | <u>n</u> | <u>Study Population</u> |              | <u>n</u> | <u>Reference Population<br/>(Eaton Reservoir)</u> |              |
|-------------|----------|-------------------------|--------------|----------|---------------------------------------------------|--------------|
|             |          | <u>Orocutaneous</u>     | <u>Liver</u> |          | <u>Orocutaneous</u>                               | <u>Liver</u> |
| 1992        | 100      | 64 %                    | 22 %         |          | ND                                                | ND           |
| 1995        | 69       | 28 %                    | 10 %         | 10       | 0 %                                               | 20 %         |
| 1997        | 68       | 10 %                    | 3 %          | 26       | 0 %                                               | 4 %          |

n = Number of bullheads per group  
ND = Not done

**Table 11. Bullhead Tumor Rate and Average Age in 3 Separate Presque Isle Studies**

|      | <u>n</u> | <u>Avg. Age (yrs)</u> | <u>Tumor Rate</u>   |              |
|------|----------|-----------------------|---------------------|--------------|
|      |          |                       | <u>Orocutaneous</u> | <u>Liver</u> |
| 1992 | 100      | 12.5 <sup>a</sup>     | 64.0 %              | 22.0 %       |
| 1995 | 79       | 8.9 <sup>b</sup>      | 24.0 %              | 11.0 %       |
| 1997 | 94       | 6.5 <sup>c</sup>      | 7.5 %               | 3.2 %        |

a = Age data calculated on 50 random bullheads.

b = Age data calculated on 76 bullheads.

c = Age data calculated on 88 bullheads.



**Table 12. Average Bile PAH Metabolite Concentrations in Bullheads with Tumors  
in 3 Separate Presque Isle Studies**

|                   | <u>n</u>        | <u>Napthalene</u> | <u>Phenanthrene</u> | <u>Benzo-a-pyrene</u> |
|-------------------|-----------------|-------------------|---------------------|-----------------------|
| 1992 Tumors       | 14              | 99,071            | 34,571              | 244                   |
| No tumors         | 3               | 41,667            | 11,567              | <113                  |
| 1995 Liver tumors | 9               | 173,442           | 65,638              | 241                   |
| Skin tumors       | 19              | 178,145           | 63,307              | 628                   |
| No tumors         | 59 <sup>a</sup> | 160,445           | 37,060              | 723                   |
| 1997 Liver tumors | 3               | 73,731            | 40,471              | 335                   |
| Skin/mouth tumors | 7 <sup>b</sup>  | 101,860           | 45,380              | 457                   |
| No tumors         | 85 <sup>c</sup> | 108,058           | 55,540              | 569                   |
| All bullheads     | 94 <sup>d</sup> | 106,870           | 54,292              | 556                   |

Bile PAH metabolite concentration reported in mg/l. Units converted from previous studies

a = Data on 53 bullheads (data not available for 6 bullheads)

b = Data on 6 bullheads (data not available for 1 bullhead)

c = Data on 78 bullheads (data not available for 7 bullheads)

d = Data on 86 bullheads (data not available for 8 bullheads)

Table 1. Average body weight (kg) of experimental bulls and the number of spermatozoa per ejaculate (x10<sup>6</sup>)

| Experimental group    | Body weight (kg) | Spermatozoa (x10 <sup>6</sup> ) |
|-----------------------|------------------|---------------------------------|
| Control               | 450              | 1.2                             |
| Experimental group 1  | 450              | 1.2                             |
| Experimental group 2  | 450              | 1.2                             |
| Experimental group 3  | 450              | 1.2                             |
| Experimental group 4  | 450              | 1.2                             |
| Experimental group 5  | 450              | 1.2                             |
| Experimental group 6  | 450              | 1.2                             |
| Experimental group 7  | 450              | 1.2                             |
| Experimental group 8  | 450              | 1.2                             |
| Experimental group 9  | 450              | 1.2                             |
| Experimental group 10 | 450              | 1.2                             |
| Experimental group 11 | 450              | 1.2                             |
| Experimental group 12 | 450              | 1.2                             |
| Experimental group 13 | 450              | 1.2                             |
| Experimental group 14 | 450              | 1.2                             |
| Experimental group 15 | 450              | 1.2                             |
| Experimental group 16 | 450              | 1.2                             |
| Experimental group 17 | 450              | 1.2                             |
| Experimental group 18 | 450              | 1.2                             |
| Experimental group 19 | 450              | 1.2                             |
| Experimental group 20 | 450              | 1.2                             |

The data presented in this table are the average values of the experimental bulls. The number of spermatozoa per ejaculate was determined by the method of [1]. The body weight of the bulls was determined by the method of [2].



## APPENDIX C

### Glossary of Terms

## GLOSSARY OF TERMS

|                                |                                                                                                                                                                                                                                                |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Adenocarcinoma:</b>         | Malignant neoplasm of glandular epithelial cell origin.                                                                                                                                                                                        |
| <b>Adenoma:</b>                | Benign neoplasm of glandular epithelial cell origin.                                                                                                                                                                                           |
| <b>Aspermatogenesis:</b>       | Lack of spermatogenesis (lack of sperm production).                                                                                                                                                                                            |
| <b>Atrophy:</b>                | Decrease in the size of a cell, tissue, organ or part.                                                                                                                                                                                         |
| <b>Basophilic:</b>             | Staining a dark blue with hematoxylin stain.                                                                                                                                                                                                   |
| <b>Basophilic focus:</b>       | Microscopic lesion of the liver in which a distinct group of cells display a dark blue change in color. In rodent toxicity studies, this lesion is considered indicative of toxicity and a possible precursor to tumor formation in the liver. |
| <b>Benthic fish:</b>           | Bottom dwelling fish.                                                                                                                                                                                                                          |
| <b>Bile:</b>                   | Fluid secreted by the liver into the small intestine via the bile ducts.                                                                                                                                                                       |
| <b>Biliary adenocarcinoma:</b> | Malignant neoplasm of bile duct origin.                                                                                                                                                                                                        |
| <b>Biliary adenoma:</b>        | Benign neoplasm of bile duct origin.                                                                                                                                                                                                           |
| <b>Carcinogenesis:</b>         | The production of carcinomas.                                                                                                                                                                                                                  |
| <b>Carcinogenic:</b>           | Producing carcinomas.                                                                                                                                                                                                                          |
| <b>Carcinoma:</b>              | Malignant neoplasm of epithelial cell origin.                                                                                                                                                                                                  |
| <b>Carcinoma in situ:</b>      | Carcinoma confined to the site of origin that has not invaded neighboring tissues.                                                                                                                                                             |
| <b>Cellular alterations:</b>   | Changes noted at the cellular level.                                                                                                                                                                                                           |
| <b>Cellulitis:</b>             | Inflammation of the subcutaneous tissue.                                                                                                                                                                                                       |
| <b>Cheilitis:</b>              | Inflammation of the lips.                                                                                                                                                                                                                      |
| <b>Cholangiofibrosis:</b>      | Formation of scar tissue at and near the bile ducts.                                                                                                                                                                                           |



|                            |                                                                                                                                                                                                                                              |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cholangiohepatitis:</b> | Inflammation of the bile ducts and adjacent liver cells.                                                                                                                                                                                     |
| <b>Cholangitis:</b>        | Inflammation of the bile ducts.                                                                                                                                                                                                              |
| <b>Cholecystitis:</b>      | Inflammation of the gallbladder.                                                                                                                                                                                                             |
| <b>Clear cell focus:</b>   | Microscopic lesion of the liver in which a distinct group of cells display a change to a clear focus. In rodent toxicity studies, this lesion is considered indicative of toxicity and a possible precursor to tumor formation in the liver. |
| <b>Dermatitis:</b>         | Inflammation of the dermal tissues of the skin.                                                                                                                                                                                              |
| <b>Edema:</b>              | Presence of large amounts of extracellular fluid.                                                                                                                                                                                            |
| <b>Enteritis:</b>          | Inflammation of the small intestine.                                                                                                                                                                                                         |
| <b>Eosinophilic:</b>       | Readily stainable with the stain eosin.                                                                                                                                                                                                      |
| <b>Eosinophilic focus:</b> | Microscopic lesion of the liver in which a distinct group of cells display a red change in color. In rodent toxicity studies, this lesion is considered indicative of toxicity and a possible precursor to tumor formation in the liver.     |
| <b>Epicarditis:</b>        | Inflammation of the epicardium of the heart.                                                                                                                                                                                                 |
| <b>Epidermitis:</b>        | Inflammation of the epidermis (upper layer) of the skin.                                                                                                                                                                                     |
| <b>Erythroid:</b>          | Pertaining to the development of red blood cells.                                                                                                                                                                                            |
| <b>Fibrosis:</b>           | Formation of fibrous connective tissue (scar tissue).                                                                                                                                                                                        |
| <b>Formalin:</b>           | Compound commonly used to fix tissues for histologic examination.                                                                                                                                                                            |
| <b>Gastritis:</b>          | Inflammation of the stomach.                                                                                                                                                                                                                 |
| <b>Glomerulonephritis:</b> | Inflammation of the glomeruli of the kidney.                                                                                                                                                                                                 |
| <b>Gonad:</b>              | A gamete-producing organ (ovary or testis).                                                                                                                                                                                                  |
| <b>Granuloma:</b>          | Chronic inflammatory lesion.                                                                                                                                                                                                                 |
| <b>Granulomatous:</b>      | Composed of granulomas.                                                                                                                                                                                                                      |

|                              |                                                                                                |
|------------------------------|------------------------------------------------------------------------------------------------|
| <b>Hematopoietic:</b>        | Pertaining to the development of blood cells.                                                  |
| <b>Hemosiderosis:</b>        | Increase in tissue iron stores without tissue damage.                                          |
| <b>Hepatic:</b>              | Pertaining to the liver.                                                                       |
| <b>Hepatitis:</b>            | Inflammation of the liver.                                                                     |
| <b>Hepatocyte:</b>           | A parenchymal liver cell.                                                                      |
| <b>Hepatocellular:</b>       | Pertaining to liver cells.                                                                     |
| <b>Histology:</b>            | The study of the minute structure, composition and function of tissues.                        |
| <b>Hyperpigmentation:</b>    | Abnormally high levels of pigmentation.                                                        |
| <b>Hyperplasia:</b>          | Increase in number of normal cells in normal arrangements.                                     |
| <b>Hypodermis:</b>           | Beneath the skin.                                                                              |
| <b>Intrabiliary:</b>         | Within bile ducts.                                                                             |
| <b>Intravascular:</b>        | Within a vessel.                                                                               |
| <b>Lamina propria:</b>       | Tissue beneath the epithelium (uppermost layer) of mucosa (lining layer of a hollow organ).    |
| <b>Lipocyte:</b>             | Fat cell.                                                                                      |
| <b>Lymphoid depletion:</b>   | Depletion of lymphoid cells.                                                                   |
| <b>Lymphoplasmacytic:</b>    | Containing lymphocytes and plasma cells.                                                       |
| <b>Melanomacrophage,MMC:</b> | Macrophage which contains pigment.                                                             |
| <b>Melanosis:</b>            | Abnormal pigmentary deposits.                                                                  |
| <b>Mesenteric:</b>           | Pertaining to the mesentery.                                                                   |
| <b>Mesentery:</b>            | A membranous peritoneal fold attaching various organs to the body wall.                        |
| <b>Metaplasia:</b>           | A change in the type of adult cells in a tissue to a form which is not normal for that tissue. |



|                        |                                                               |
|------------------------|---------------------------------------------------------------|
| <b>Mural:</b>          | Pertaining to the wall of a structure.                        |
| <b>Myocarditis:</b>    | Inflammation of the heart musculature.                        |
| <b>Myocardium:</b>     | Musculature of the heart.                                     |
| <b>Myofiber:</b>       | Fiber of musculature.                                         |
| <b>Myolysis:</b>       | Degeneration of muscle tissue.                                |
| <b>Myositis:</b>       | Inflammation of muscle tissue.                                |
| <b>Necrosis:</b>       | Cellular death.                                               |
| <b>Nematode:</b>       | Pertaining to a nematode parasite.                            |
| <b>Nephritis:</b>      | Inflammation of the kidney.                                   |
| <b>Orocutaneous:</b>   | Oral tissues and skin.                                        |
| <b>Otolith:</b>        | A calcereous mass within the inner ear.                       |
| <b>Papilloma:</b>      | Branching or lobulated benign mass of epithelial cell origin. |
| <b>Parenchymal:</b>    | The essential and functional cells of an organ.               |
| <b>Peliosis:</b>       | Abnormally dilated blood vessels within an organ.             |
| <b>Pericholangial:</b> | Surrounding bile ducts.                                       |
| <b>Periductular:</b>   | Surrounding ducts.                                            |
| <b>Periosteal:</b>     | Tissue surrounding bone.                                      |
| <b>Peritonitis:</b>    | Inflammation of the peritoneal surfaces.                      |
| <b>Protozoan:</b>      | Pertaining to unicellular organisms.                          |
| <b>Pyelonephritis:</b> | Inflammation of the kidney and pelvis of the kidney.          |
| <b>Refractile:</b>     | The ability to bend or deviate light.                         |
| <b>Sacculitis:</b>     | Inflammation of a sac like organ (gas bladder).               |

|                     |                                                                  |
|---------------------|------------------------------------------------------------------|
| <b>Seminoma:</b>    | Tumor of the testis originating from primitive gonadal cells.    |
| <b>Sentinel:</b>    | Organism or object that indicates the onset or end of a process. |
| <b>Suppurative:</b> | Producing pus.                                                   |
| <b>Transmural:</b>  | Involving the entire wall of a structure.                        |





