

**APPLICATION OF A DICHOTOMOUS KEY
TO THE CLASSIFICATION OF SEA
LAMPREY MARKS ON GREAT LAKES FISH**



Miscellaneous Publication 2006-02

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**APPLICATION OF A DICHOTOMOUS KEY TO THE CLASSIFICATION OF
SEA LAMPREY MARKS ON GREAT LAKES FISH**

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INTRODUCTION

King and Edsall (1979) developed a field guide to classifying sea lamprey (*Petromyzon marinus*) marks on Great Lakes lake trout (*Salvelinus namaycush*) in response to requests from representatives of various Great Lakes fishery agencies. Standardized marking data were needed to develop more refined indices of the intensity of sea lamprey predation on lake trout stocks throughout the Great Lakes and to facilitate the estimation of sea lamprey-induced mortality. Thereafter, Eshenroder and Koonce (1984) recommended that the King and Edsall classification system should be adopted by all fishery agencies on the Great Lakes. The classification system was subsequently implemented between 1984 and 1986, but no coordinated training of new field staff was held, nor was there any evaluation of how well the classification system had been implemented across the Great Lakes.

The consistency among fishery agencies at classifying sea lamprey marks according to the King and Edsall system came into question during the mid-1990s (Ebener et al. 2003). Two workshops to evaluate the consistency of classifying sea lamprey marks according to the King and Edsall system were held during 1997-1998 with members of the technical committees from Lakes Superior, Huron, and Michigan. Results from the workshops indicated that there was considerable variability in classifying marks between and within fishery agencies (Ebener et al. 2003). Ebener et al. (2003) recommended ways for improving the consistency of classifying sea lamprey marks and for recording and reporting sea lamprey marking statistics based on results of the workshop and other studies. Those recommendations included:

- All agencies should record the number of each type (A or B) and stage (I-IV) of mark and maintain the resulting data in documented databases
- The most recent (i.e., earliest stage) attachment on a sliding mark should be the mark classified and recorded
- The most severe single mark among a group of multiple marks made by the same sea lamprey should be recorded (i.e., Type A over Type B and within-type earliest stage)
- Only large marks, those equal to or larger than a quarter, should be included in the computation of marking statistics for standard late-summer, fall, or spring collections
- An ongoing program of methodology workshops needs to be established

Pursuant to these recommendations, the Great Lakes Fishery Commission (GLFC) sponsored five additional workshops during 2002-2003 to implement recommendations from Ebener et al. (2003):

- Increase the level of consistency at classifying sea lamprey marks
- Make agencies aware of the need to continually train their staffs in classifying sea lamprey marks

The five workshops were attended by 141 people representing 37 fishery agencies and 38 field crews working on the Great Lakes. What became obvious at the workshops was the great amount of variability among individuals and agencies at classifying sea lamprey marks. More encouraging, however, was that the workshop training increased the level of agreement among observers from trial 1 to trial 2. Difficulty in classifying marks included distinguishing Type-A from Type-B marks, recognizing multiple marks caused by the same sea lamprey, and segregating the various stages of marks.

This document augments the dichotomous key created by Ebener et al. (2003) with photographs taken during the 2002 and 2003 workshops, and it is intended to help fishery agencies implement the King and Edsall (1979) protocol for classifying sea lamprey marks. Their illustrations represented the “idealized” types and stages of sea lamprey marks in comparison with the more complicated marks often observed in the field. We combined the original King and Edsall (1979) photographic illustrations with photographs made at the five workshops to create this sequel to the 1979 field guide. A simplification of this document, laminated for field use, is available from the GLFC office.

DEVELOPMENT AND APPLICATION OF CRITERIA

The criteria presented in this guide were developed from an examination of marks produced on more than 300 lake trout attacked by sea lampreys in controlled studies at the Hammond Bay Biological Station during 1976-1978. King and Edsall (1979) photographed and prepared written descriptions of marks present on lake trout from which sea lampreys had spontaneously detached. Each mark was first observed within 8 or 16 hours after the lamprey detached; later records were made at various intervals until the trout died or the mark healed sufficiently to no longer be readily visible to an experienced observer. The criteria developed from these laboratory attacks are based on mark characteristics that can be discerned under field conditions by touching and examining the mark and the surrounding body surface of the trout.

King and Edsall (1979) recommended these criteria for use only with live fish or those freshly killed that retain the coloration typical of the live state. They felt that, although the criteria may also be valid for classifying attack marks on fish that have undergone post-mortem color changes, they had not attempted to develop the data needed to verify this application. Lake trout, lake whitefish (*Coregonus clupeaformis*), lake herring (*C. artedi*), walleye (*Sander vitreus*), chinook salmon (*Oncorhynchus tshawytscha*), and white sucker (*Catostomus commersonii*) were used during the 1997-1998 and 2002-2003 workshops. These fish were frozen immediately after being collected from a Great Lake and were thawed slowly before being used in the workshops. Color of marks did not appear to change as a consequence of being frozen, but the roughness associated with some fresh marks did become less detectable.

MARK CLASSIFICATION

Basic Marks

King and Edsall (1979) defined two basic types of sea lamprey attack marks—Type A and Type B. Each of these two types had four stages (I-IV) of healing identifiable on fish under field conditions. Criteria for their classification system follow.

Type A

Stage I

The lamprey has very recently detached. The detachment may have been spontaneous or caused by the catching of the fish. Specific criteria for a Type-A, Stage-I, mark are:

- The skin at the attachment site is broken exposing the underlying musculature
- The site is rough to the touch and scales (if normally present on the site) have been removed
- A pit in the exposed musculature can be seen and felt
- The skin surrounding the exposed musculature is white, necrotic, ragged, and hemorrhaged but probably not bleeding (see Figs. 1-4)

Some observers in the field, including MPE, have reported seeing bleeding from fresh, lamprey-inflicted attack marks on lake trout. King and Edsall (1979) did not see blood flowing from an attack mark on any of the lake trout in their laboratory study, perhaps because they did not examine most marks immediately after lampreys detached.

Stage II

The entire attachment site is covered with a transparent, membrane-like material and is smooth to the touch. Specific criteria for a Type-A, Stage-II, mark are:

- The exposed musculature is usually pink
- A pit in the exposed musculature can be seen and felt
- Semi-opaque, mucus-like material partly fills the pit
- Unsloughed, white necrotic skin and hemorrhaged tissue are usually visible (Figs. 5-8)

Stage III

The attachment site is generally similar to that described for Stage II, but masses of new, dark-pigmented cells partly cover the exposed musculature. Specific criteria for a Type-A, Stage-III, mark are:

- Pigment cell masses are usually visible first at the edge of the descaled skin surrounding the exposed musculature
- A pit can be felt and sometimes seen at the attachment site (Figs. 9-12)

Stage IV

This attachment site is essentially a healed mark. Specific criteria for a Type-A, Stage-IV, mark are:

- The attachment site appears similar to the adjacent, unaffected body surface of the trout
- Scale regeneration (if the site normally supports scales) has not begun
- A slight pit or indentation can be felt at the site (Figs. 13-16)

Type B

Stage I

The lamprey has very recently left the host. The attachment site is rough to the touch, and scales (if normally present on the site) have been removed. Specific criteria for a Type-B, Stage-I mark are:

- The skin is basically intact and hemorrhaged but probably not bleeding
- The underlying musculature is not exposed
- The site is firm to the touch
- Little or no swelling can be seen, and a pit cannot be felt in the underlying musculature (Figs. 17-20)

This mark, when partially healed, produces a Type-B, Stage-II, mark (see also Type B, Stage I, sloughing mark described below).

Stage II

The attachment site is generally as described for Stage I except that a transparent, membrane-like material covering the entire site makes it smooth to the touch. Hemorrhaged skin tissue is usually confined to the central portion of the site (Figs. 21-24). The skin may slough off from the fish exposing musculature, but there is no pit in the muscle, as described below.

Stage III

The attachment site is smooth to the touch and appears as a lightly pigmented or slightly blanched area. Other criteria for a Type-B, Stage-III, mark are:

- No hemorrhaged tissue is visible
- Scale regeneration (if the site normally supports scales) has not begun (Figs. 25-28)

Stage IV

This attachment site is essentially a fully healed mark. The attachment site is closely similar in appearance to the adjacent, unaffected body surface. Specific criteria for a Type-B, Stage-IV, mark are:

- Repigmentation is complete
- If the site normally supports scales, it will be partly or fully covered with irregularly arranged regenerated scales that may reflect light differently than the body surface immediately surrounding the site (Figs. 29-32)

Type B, Stage I or II, Sloughing

The characteristics of this mark are similar to those described above for the Type-B, Stage-I, mark except:

- The site is swollen
- A pit can be felt beneath the skin in the musculature
- The skin covering the pit will probably slough off exposing the musculature producing what appears to be a Type-A, Stage-I or -II mark (see Box C and Fig. 23).

DICHOTOMOUS KEY TO CLASSIFYING SEA LAMPREY MARKS¹

- 1a. Pit: 2
- Definite opening through skin and into muscle
 - Muscle may or may not be exposed
 - If unsure whether there is a pit, do the following:
 - Make traverse cut across mark into muscle and look for penetration into muscle
 - Cut open fish when marks are made over the body cavity area and from the inside look for a perforated body wall
- 1b. Pit absent: 5
- No perforation through skin
 - Skin may slough off exposing muscle, but no penetration into muscle



A. Example of marks with pits through the skin into muscle and muscle not exposed.



B. Example of marks with pits through the skin into muscle and muscle exposed.



C. Examples of marks with no pit through skin into muscle and muscle exposed.



D. Example of marks with no pit through skin into muscle and muscle not exposed.

¹ Adapted from King and Edsall (1979) and Ebener et al. (2003).

Examples of Type A, Stage I, Sea Lamprey Marks

- | | | | |
|-----|---|--|-----|
| 2a. | Skin rough to touch and white, no healing | <ul style="list-style-type: none"> • Roughness refers to skin around mark, not the opening itself • Scale pockets readily observed • A-I marks result from attacks interrupted by a natural detachment or by manual removal | A-I |
| 2b. | Skin not rough to touch and white, some sign of healing | <ul style="list-style-type: none"> • Healing indicated by white mucus covering exposed muscle • Scale pockets not present | 3 |



Fig. 1. Lake whitefish, Lake Huron—mark on skin white, no healing.



Fig. 2. Lake trout, Lake Ontario—scale pits readily observed, no healing.



Fig 3. Walleye, Lake Ontario—scale pits readily observed, no healing.



Fig. 4. King and Edsall (1979) photo of lake trout—skin white (necrotic), pit in muscle, no healing.

Examples of Type A, Stage II, Sea Lamprey Marks

- | | | | |
|-----|---|---|------|
| 3a. | Muscle exposed and reddish, membrane covering pit | <ul style="list-style-type: none"> • Signs of healing, presence of a membrane over mark • Area around pit smooth • No repigmentation of skin surrounding mark | A-II |
| 3b. | Muscle slightly or not exposed and not reddish, some repigmentation | <ul style="list-style-type: none"> • Considerable healing of the muscle • Some dark or white pigmentation returning to skin around pit depending on amount of natural pigmentation at attack site | 4 |



Fig. 5. Lake herring, Lake Huron—skin not rough to touch, little healing.

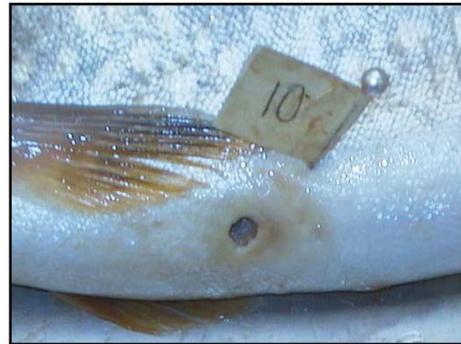


Fig. 6. Lake trout, Lake Huron—skin not rough, some healing.

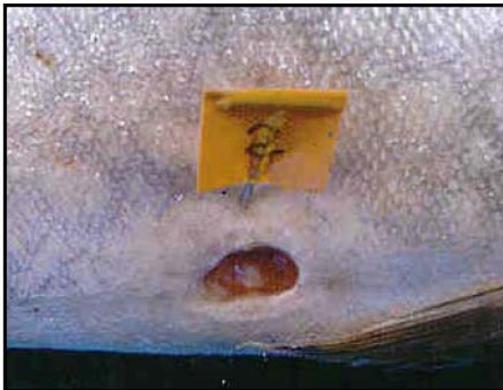


Fig. 7. Lake trout, Lake Huron—exposed muscle with some healing, skin smooth.



Fig. 8. King and Edsall (1979) photo of lake trout taken nine days after detachment—same attack as Fig. 4, skin sloughed in lower left portion of mark exposing more muscle.

Examples of Type A, Stage III, Sea Lamprey Marks

- | | | | |
|-----|---|--|-------|
| 4a. | Muscle somewhat exposed, limited repigmentation | <ul style="list-style-type: none"> • Considerable healing of mark has occurred, particularly of muscle • Pigmentation returning to skin and very evident | A-III |
| 4b. | No exposed muscle, complete repigmentation | <ul style="list-style-type: none"> • A completely healed Type-A mark • Skin and pigments reformed, no scales present over healed pit | A-IV |



Fig. 9. Lake trout, Lake Huron—considerable healing, some muscle exposed, some repigmentation.



Fig. 10. Lake trout, Lake Huron—A-III mark (some exposed muscle, considerable healing) on recaptured fish having had an A-I mark nine months earlier.

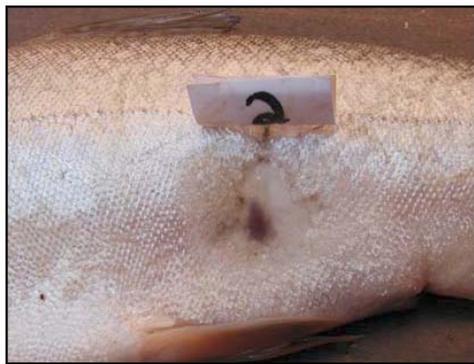


Fig. 11. Lake trout, Lake Superior—considerable healing, some muscle exposed.



Fig. 12. King and Edsall (1979) photo of lake trout taken 30 days after detachment—same attachment site as in Figs. 4, 8.

Examples of Type A, Stage IV, Sea Lamprey Marks



Fig. 13. Lake trout, Lake Huron—completely healed, repigmentation complete.



Fig. 14. Lake trout, Lake Ontario—completely healed, repigmentation complete, no scales.



Fig. 15. Lake trout, Lake Superior—completely healed, no scales, repigmentation complete.



Fig. 16. King and Edsall (1979) photo of lake trout 133 days after detachment—same attachment as Figs. 4, 8, 12.

Examples of Type B, Stage I, Sea Lamprey Marks

- | | | | |
|-----|--|---|-----|
| 5a. | Skin rough to the touch, scales missing | <ul style="list-style-type: none"> • Skin not broken, no exposed muscle • Attachment site rough to touch, scale pockets present • No healing | B-I |
| 5b. | Skin smooth and may or may not be broken, some healing | <ul style="list-style-type: none"> • Attachment site not rough to touch • Limited signs of healing | 6 |



Fig. 17. Lake trout, Lake Ontario—scales missing, rough to touch, slight break in skin.



Fig. 18. Lake trout, Lake Superior—scales missing, scale pockets present, rough to touch.



Fig. 19. Lake trout, Lake Ontario—missing scales, rough to touch, skin not broken.



Fig. 20. King and Edsall (1979) photo of lake trout taken immediately after sea lamprey detached.

Examples of Type B, Stage II, Sea Lamprey Marks

- | | | | |
|-----|-------------------------------|---|-----|
| 6a. | Skin may or may not be broken | <ul style="list-style-type: none"> • Site smooth to touch • Limited signs of healing • Little if any repigmentation | B-2 |
| 6b. | Skin not broken | <ul style="list-style-type: none"> • Substantial repigmentation around mark • Significant signs of healing • No scales | 7 |



Fig. 21. Lake trout, Lake Huron—mucus indicates some healing, no scales, no repigmentation.



Fig. 22. Lake trout, Lake Michigan—little healing, mucus formed over mark, no repigmentation.



Fig. 23. Lake trout, Lake Huron—skin sloughed exposing muscle, but no opening in muscle.

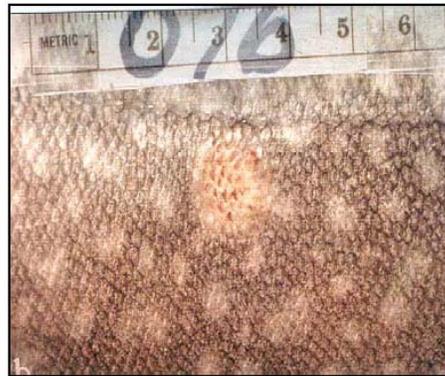


Fig. 24. King and Edsall (1979) photo of lake trout taken 15 days after detachment—same attack as Fig. 20.

Examples of Type B, Stage III, Sea Lamprey Marks

- | | | | |
|-----|---|--|-------|
| 7a. | Pigments returning, no scales | <ul style="list-style-type: none"> • Much repigmentation • Considerable healing has occurred | B-III |
| 7b. | Regenerated scales, repigmentation complete | <ul style="list-style-type: none"> • Completely healed mark | B-IV |



Fig. 25. Lake trout, Lake Ontario—mostly healed mark, no scales, considerable repigmentation.

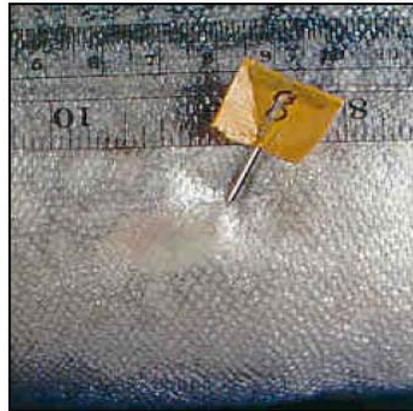


Fig. 26. Lake trout, Lake Superior—pigmentation returning, no scales.



Fig. 27. Lake trout, Lake Huron—considerable repigmentation and healing, no scales.



Fig. 28. King and Edsall (1979) photo of lake trout 29 days after detachment—same attack as Figs. 20, 24.

Examples of Type B, Stage IV, Sea Lamprey Marks

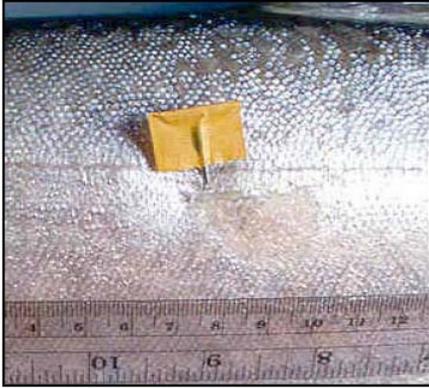


Fig. 29. Lake trout, Lake Huron—repigmentation nearly complete, scales regenerating.



Fig. 30. Lake trout, Lake Huron—completely healed, repigmented, scales regenerated.



Fig. 31. Splake, Lake Huron—completely healed, repigmented, scales regenerated.

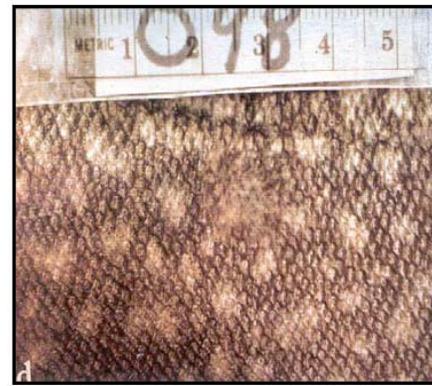


Fig. 32. King and Edsall (1979) photo of lake trout—same attack as Figures 20, 24, 28.

CLASSIFYING MULTIPLE AND SLIDING MARKS

Although a sea lamprey may remain in one location while attached to a fish producing a mark that is relatively simple to classify, it may also change locations often producing both Type-A and Type-B marks, as well as marks in different stages of healing. These complex marks should be classified by that portion of the mark that is in the earliest stage of healing.

Classifying multiple marks and sliding-type marks that appear to be made by the same sea lamprey can be difficult. The tendency in this situation has been to record every type of mark observed. Marking rates are used to estimate sea lamprey attack rates; thus, recording every type and stage of mark caused by a single sea lamprey encounter with an individual fish will inflate attack rates. Because multiple marks caused by a single sea lamprey can appear grotesque, observers may want to classify the mark based on a perceived ability of the fish to survive instead of on King and Edsall (1979) and Eshenroder and Koonce (1984) protocols. Sliding marks can also appear grotesque, because the skin may slough, and they are another example of marks that are overclassified. Examples of multiple and sliding marks caused by a single sea lamprey are illustrated below.



Fig. 33. Multiple marks made by a single sea lamprey as inferred from the trace on the skin of the fish.

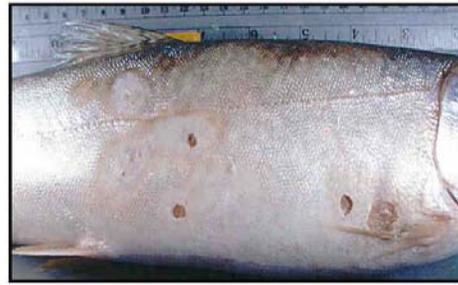


Fig. 34. Multiple marks made by a single sea lamprey as inferred from the trace on the skin of the fish.



Fig. 35. Multiple marks, with no observable trace between marks: one A-II and one A-III mark should be recorded.



Fig. 36. A sliding Type-B attachment with two different stages; a B-I mark in the lower left and B-II marks in the upper right.

Reporting Protocol

The protocol for recording multiple and sliding marks on a fish caused by a single sea lamprey is:

- For multiple marks, record only the most severe mark, and record no more than one mark. Stage-I marks are considered more severe than other stages. For example, in Fig. 33 where the same sea lamprey likely caused A-I, -II, and -IV as well as B-I marks, only the A-I mark should be recorded. For the attachment shown in Fig. 34, one A-2 mark should be recorded. If one portion of the mark displays the characteristics of an A-II while another portion displays B-I, the mark should be designated B-I.
- For sliding marks, record the most recent attachment site and record no more than one mark. Sliding marks are Type B so the most recent would be Stage I followed in order by Stages II, III, and IV. In Fig. 36, the most recent attachment resulted in a B-I mark, so one B-I mark should be recorded.

RECORDING MARK SIZE

At any one time, there are two cohorts of parasitic sea lampreys in a Great Lake. The oldest cohort has typically been in the lake feeding on fish from 1.0-1.5 years, whereas the younger cohort metamorphosed into a juvenile more recently. The younger cohort causes little damage to fish stocks, whereas the older cohort is almost fully grown and is capable of killing adult trout and salmon. Marking rates are calculated and damage is estimated only for the older cohort. Consequently, field personnel must be able to distinguish between marks on fish caused by the two cohorts.

Reporting Protocol

The protocol for separating marks from the two lake-inhabiting cohorts is based on the diameter of the buccal funnel (mouth) of sea lampreys. The protocol is:

- Only large marks with diameters that equal or exceed a quarter coin, about 20 mm, should be included in the computation of marking statistics for standardized late-summer, fall, or spring marking data (Ebener et al. 2003)
- Marks smaller in diameter than a quarter should be recorded in a database but should not be included in standardized marking statistics

The diameter of a sea lamprey mark is measured across the full width of the mark and not just across the opening through the skin or muscle. The following figures provide an example of how to measure mark size.



Fig. 37. Diameter of small-sized lamprey mark on a lake sturgeon (*Acipenser fulvescens*).



Fig. 38. Diameter of a large-sized sea lamprey mark on a lake trout.

NON-SEA LAMPREY MARKS

Interpreting and classifying sea lamprey marks can be difficult because of marks caused by cormorants or by ulcerated lesions caused by pathogens. Cormorant marks and scars are almost always located in the midsection of fish and appear typically as vertical gouges (Fig. 39). Cormorant marks are relatively easy to distinguish after an observer is familiar with them.



Fig. 39. Cormorant marks on lake whitefish captured in northern Lake Michigan.

Ulcers caused by the virus *Pseudomonas flourescens* can be very difficult to distinguish from sea lamprey marks, and many have probably been incorrectly identified (Fig. 40). The unique qualities that distinguish a *Pseudomonas* ulcer from a sea lamprey mark are:

- Deep, red-colored pit in the fish
- Pit with white raised edge with a surrounding reddish-pink band
- No missing scales
- No circular buccal mark characteristic of a sea lamprey attachment

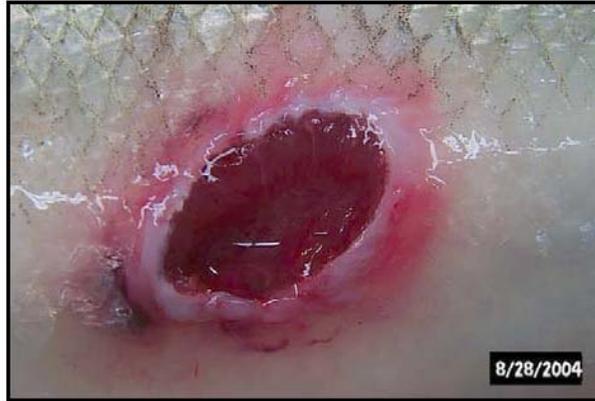


Fig. 40. Ulcerated wound caused by the virus *Pseudomonas flourescens* on a lake whitefish captured in northern Lake Michigan. Photo provided by Mohamed Faisal of Michigan State University.

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- March 2006-01 A mid-decade review of progress under a "Strategic vision of the Great Lakes Fishery Commission for the first decade of the new millennium." 45 p.

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