Based on an analysis of 1187 electrofishing samples where time fished was compared to various catch results (lwb, numbers, weight, species) that are sensitive to the relative level of effort expended. Inspection of the results show that *at least* 1300 to 1600 seconds should be spent sampling any 0.5 km boat electrofishing zone. This time will likely increase to more than 2000 seconds in slower flowing zones that have numerous downed trees, logs, and other submerged structure. Moderately fast to swift flowing zones may also take longer to sample since the boat must be maneuvered back upstream to cover such areas thoroughly.

Netters are required to wear a pair of polarized sunglasses to facilitate seeing stunned fish in the water during each electrofishing run. An exception to this is with night sampling where sunglasses are not worn. A boat net with an 2.5m long handle and 7.62mm Atlas mesh knotless netting is used to capture stunned fish as they are attracted to the anode array and/or stunned. An effort is made to capture every fish sighted by both the netter and driver.

Captured fish are immediately placed in an on-board livewell for later processing. Water is replaced regularly in warm weather to maintain adequate dissolved oxygen levels in the water and to minimize mortality.

A field crew consists of a minimum of three persons (whenever possible), a boat driver, a netter, and a support vehicle driver. Limited access to most rivers and streams requires the electrofishing boat to be launched at an upstream point with a two person crew. The third crew member is responsible for maintaining contact with the electrofishing boat and meeting the boat at points downstream. Smaller rivers that are not continuously navigable are sampled by locating put-in-and-take-out access points at each sampling location.

The distance of stream or river covered per day is dependent upon the number of sampling zones and ease of navigation. Generally, four to seven zones can be sampled in a 10 to 20 mile segment each day. Relative abundance data collected with this method is expressed as numbers/km and weight (kg)/1.0 km.

The 18' electrofishing boat can be used with either a standard straight electrode array (sampler type A) or with a circular electrode array (sampler type B). The circular array is outfitted according to the specifications listed in Novotny and Priegel (1974). Anode configuration is circular and can be altered by adding or removing electrodes or changing the surface area exposure of each electrode depending on the conductivity of the water. Anodes are added in very low conductivity water less than (100-150 umhos) or removed in extremely high conductivity water greater than (900 umhos). These sampling methods are being tested in rivers where average sampling zone depth is consistently deeper than 150-200 cm (e.g. Lake Erie river mouths, lower Muskingum River, Ohio River, etc.) and in lakes, reservoirs, and impoundments. In these larger and deeper water bodies sampling is also conducted at night. Otherwise, sampling is conducted essentially the same as the methods just described for smaller rivers and streams.

Wading Electrofishing Methods and Equipment and Sampling Techniques

The Sportyak-generator wading method (Sampler type D) is used to sample smaller, wadable streams where access by a 12' john boat is not possible. The longline-generator (sampler type E) method is used in streams that are too shallow to sample with the Sportyak-generator method. The backpack electrofishing method (sampler type F) may be used in lieu of the longline-generator method in *only* the smallest headwaters streams following the restrictions that were previously stated. The Sportyak-generator

method (Sampler type D) employs a light, plastic boat with the capacity to carry a small portable generator/pulsator, and livewell. The Ohio EPA presently uses a 2.1 m Sportyak to carry a model 1736 DCV T&J combination generator/pulsator pulsed DC electrofishing unit and a 30 gallon plastic holding tank. The T&J electrofishing unit has the capability to supply 125 or 250 volts pulsed DC at a maximum of 1750 watts. At sites which have pool width and depth characteristics that suggest the need for the 12' boat method, but which is not accessible may require the use of the more powerful Smith-Root 3.5 GPP unit rigged for use with the Sportyak. This arrangement provides the additional power needed to efficiently sample pools that are consistently more than 1m deep and wider than 30-40m. A 15.2cm wide by approximately 45.7cm long stainless steel strip attached from the bow of the Sportyak acts as a cathode. Spring cord attached directly to the T&J unit supplies pulsed direct current to the anode. The anode is the net ring attached to a 1.8m long tubular fiberglass net pole. A positive pressure switch mounted on the net pole must be depressed to complete the switch circuit and allow electrical current to the electrodes (see Figure V-4-3 for a diagrammatic description).

Procedures for sampling require a two or three person crew, all wearing chest waders and rubber gloves. The primary netter operates the anode net ring while one crew member guides the Sportyak and the third crew member assists in capturing fish. This method is also diagrammed in Figure V-4-2. All habitat types are thoroughly sampled in an *upstream* direction for a distance of 150-200 m. The primary netter works the net ring beneath undercut banks, in and around brush piles, log jams, large boulders and other submerged structure. An effective technique for capturing fish under such objects is to thrust the anode ring into and under the structure with the current on and then *quickly* withdraw the anode ring in one swift motion. This has the effect of drawing fish out from under such structure making their capture possible. Sampling effort is usually concentrated on one side of the stream and some switching from one stream bank to the other may be necessary to sample all habitat types. In riffle and run areas the primary netter *rakes* the anode ring from upstream to downstream,allowing it to drift with the current. At the same time the assist netter blocks off an area downstream of the anode ring. This minimizes escape and avoidance of the electrical field by riffle species. When the holding tank is full of fish or sampling is completed the fish are processed (see Fish Counting and Weighing Procedures).

Sampling procedures for the longline method (Sampler type E) are similar. The longline-generator method uses the same electrofishing unit as the Sportyak method. The longline consists of 100 meters of heavily insulated 4-insulator wire. The anode is the net ring (as in the Sportyak method). The cathode is a floating aluminum plate attached 3m behind the net pole. The backpack electrofishing units (Sampler type F) used are a design supplied by the Michigan Department of Natural Resources[3] that produces 100 or 200 VDC (pulsed) or a Coeffelt Model BP-2 electrofishing unit[4] that produces a similar output. Both units are powered by a 12 VDC power source (motorcycle battery). The net ring serves as the anode and is attached to the end of a 1.8m net pole. A positive pressure switch mounted on the net pole is used to turn the unit on and off and as a safety switch. The cathode configuration on the Michigan DNR unit consists of a piece of copper that approximates 1000 cm^2. A 2.4m long section of 3.8mm plastic jacketed stainless steel cable with a 0.3m section exposed at the tip serves as the cathode for the Coeffelt unit. Both are trailed behind the backpack unit which is worn by the primary netter. Batteries are recharged daily and one charge is usually adequate for sampling one location, or 2-3 hours, whichever occurs first.

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[3]E. Schultz, P.O. Box 225, Grayling, Michigan 49738

[4] .Coeffelt Electronics Co. Inc., 2019 W. Union Ave., Englewood, Colo. 80110.

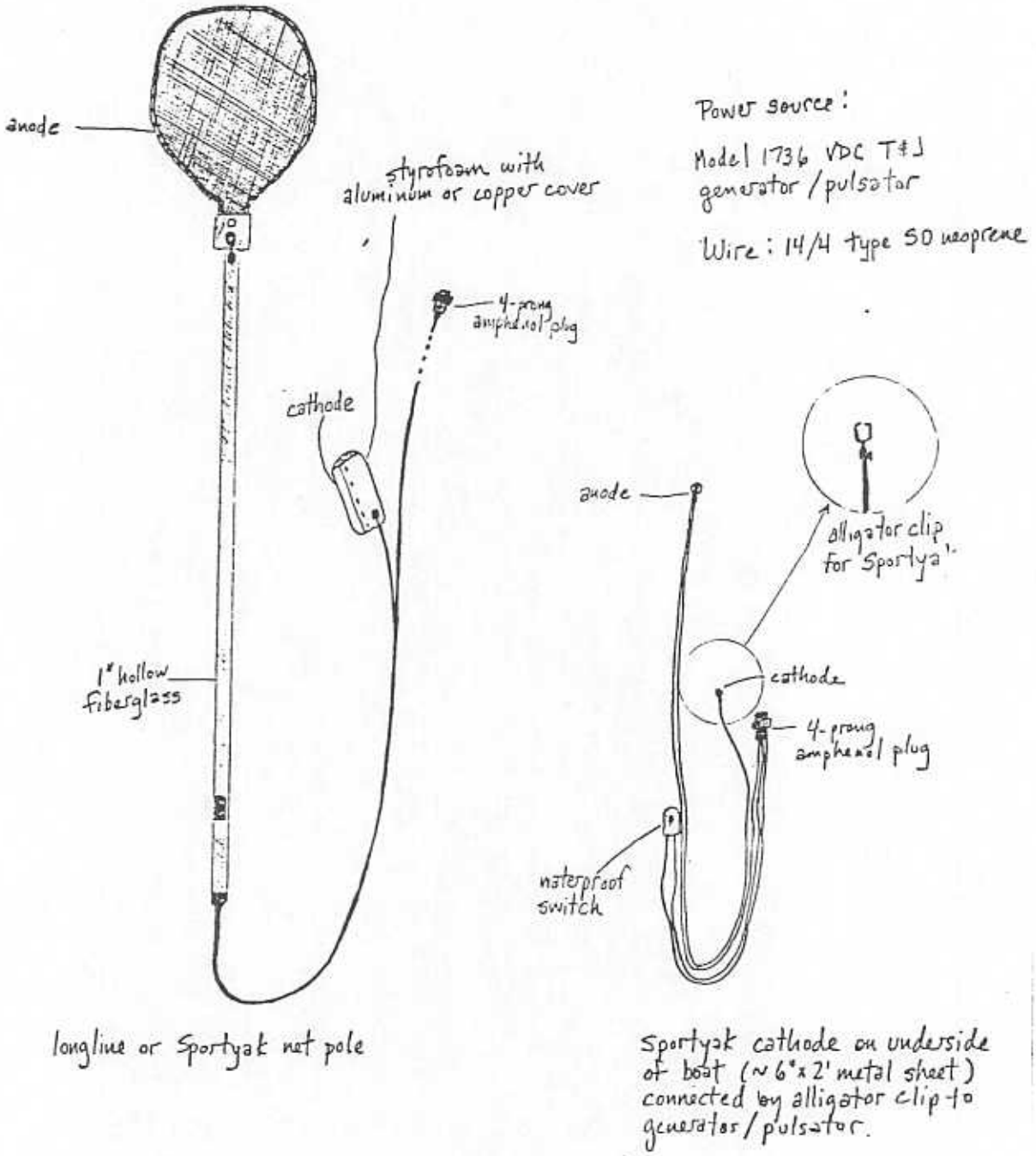

Figure V-4-3. Diagram of the net pole/electrode apparatus used with the Sportyak-generator and long-line electrofishing methods by Ohio EPA to stream fish communities.

Two or three individual sampling passes are preferred with the wading methods although one pass may be sufficient in small streams or certain non-complex situations. The number of passes affects how the catch data and biological indices are used to make environmental evaluations (Ohio EPA 1987). Relative abundance data is expressed in terms of numbers and weight (kg)/0.3km.

Seine Sampling Methods and Equipment and Sampling Techniques

The procedures and equipment used with the backpack electrofishing/seine methods (sampler type G) are generally the same as the backpack electrofishing method (sampler type F), except that seines are used in conjunction with the backpack electrofishing unit. This method was used to generate relative abundance data suitable for calculating the IBI in the years 1977-1981. The use of seines was discontinued in 1982 due to the relatively high degree of variability in the data caused by differing levels of skill between field crews. A detailed description of the methods can be found in earlier versions of this manual. While this method and seines alone may be used by non-Ohio EPA entities to generate fish relative abundance data it may not be acceptable to generate IBI or modified Iwb scores for aquatic life use attainment purposes. This will be evaluated on a case-by-case basis.

c) Passive Gear Methods and Equipment

Passive gear methods are those in which the sampling device is stationary and the capture of fish is dependent on their movements into the sampling device. These methods are not used on a routine basis by Ohio EPA and are considered experimental.

Four types of passive gear (fyke nets, trap nets, modified hoop nets, and gill nets) may be used to supplement boat electrofishing data in large rivers, estuaries, marshes, wetlands, lakes or impoundments. Fyke nets and trap nets are used in shallow water while modified hoop nets and gill nets are used in deep or open water.

Fyke nets (Sampler type I) are used in areas where a side channel can be completely blocked off by the two side leads which "funnel" fish into the net. Locations such as tributaries, marsh channels, or other channels off of the main channel are potential sampling sites. Fyke nets are set by anchoring the cod end just upstream of the channel confluence with the river, with the open end facing the main channel. The two side wings are angled toward the shoreline which blocks as much of the channel as possible. A center lead extends into the main channel helping to guide fish into the net. The Maine fyke net consists of a 4.5m body (11.4mm stretched mesh) supported by five square spring steel frames with three internal throats on the first three frames. Two 9m x 1.2 m wings and one 22.5m center lead are attached to the open end of the net. The cod end and all leads are anchored and floats attached to each anchor.

Trap nets (Sampler type J) are used to sample impoundments and wide river channels with slow velocity conditions. Trap nets are set in structurally complex areas where fish movement and density are anticipated to be highest in order to maximize net catches. One center lead is fastened to shore and the net is set perpendicular to the shore with the cod end anchored and marked with a float. Net dimensions are similar to those of the fyke net except a shorter 15m center lead is used. Modified hoop nets are used when sampling the deeper mid-channel areas. Modified hoop nets have been used to successfully capture fish moving upstream and downstream. By connecting two hoop nets together facing in opposite directions and placing them parallel to the flow, it is possible to discern fish movement in both the upstream and downstream directions. Modified hoop nets are set in

mid-channel parallel to the flow and anchored and marked with floats at both ends.

Gill nets (Sampler type K) are set in open water areas to sample fishes in large rivers, lakes, and impoundments where portions of the fish community are not accessible to shoreline electrofishing. Gill nets can be set at the surface, mid-depth, or on the bottom, depending on the objectives of the sampling and intended target species within the fish community. Gill nets are anchored in open water areas and marked with floats on both ends. Monofilament experimental gill nets are 37.5 m long with 7.5 m panels of 15.2mm, 22.9mm, 25.4mm, 40.6mm, and 50.8mm bar mesh.

All passive gear is checked and emptied 12 to 24 hours after setting. Standard procedures are used to process fish captured by passive gear. Data collected by passive gear can used to determine relative abundance which are expressed as numbers/24 hours and weight (kg)/24 hours. These results *have not* been used by Ohio EPA to calculate IBI and modified Iwb scores for aquatic life use attainment purposes.

3) Field Counting and Weighing Procedures

a) Handling Live Specimens

All sampling methods require placing captured fish in a livewell for processing when sampling each site is complete or when the livewell is full. Water in the livewell is changed as needed to minimize mortality of the captured fish. Fish are released immediately after they are identified *to species*, examined for external anomalies, and, if necessary, weighed. Efforts are made to minimize handling and holding times.

b) Field Identification

The majority of captured fish are identified to species in the field; however, *any* uncertainty about the field identification of individual fish *requires* their preservation for later laboratory identification (see **Part C**). Fish are preserved for future identification in borax buffered 10% formalin and labeled by date, river or stream, and river mile. Identification is required to the *species* level at a minimum and may be necessary to the sub-specific level in certain instances (*e.g.* banded killifish).

The collection techniques used may not be consistently effective for fish less than 15-20 mm in length, thus inclusion in the catch is not recommended. Also, Angermier and Karr (1986) and Angermier and Schlosser (1988) recommend that fish of this size (young-of-the-year) not be included in IBI calculations as they may unduly bias its function as a long-term aquatic ecosystem health measure. Ohio EPA supports this recommendation.

c) Weighing Procedures

For samples of species which are comprised entirely of one size class (*e.g.* adults, juveniles, young-of-the-year), two methods may be used. For larger species (*e.g.* carp, redhorse, most sunfish), where the adult fish are of a similar size, the catch may be weighed as separate individuals *or* in aggregate as a species. All results are recorded on the fish data sheet (Figure V-4-4). For catches with more than 15 individuals per species a *subsample* of 15 fish is weighed as individuals or in aggregate. If there is a *noticeable* variation in sizes between individual fish of a species individual weights should be taken using the subsampling technique if necessary. With smaller species (*e.g.* most minnows and darters) mass weighing in aggregate is recommended. If more than 50 individuals of a species comprise the catch a subsample of at least 50 fish is weighed and the remainder are counted. If extremely high numbers of a particular species are collected and the fish are of a relatively uniform size, the number of individuals may be determined by mass weighing all fish collected and extrapolating the numbers from a counted

Figure V-4-4. Ohio EPA fish field data sheet.

Fish Data Sheet

Collector Recorder

Field Crew: _____ Time of Day: _____ Page ___ of ___

River/Stream: _____ Location: _____

Date: _____

River Code: _____ Sampler Type: ____ Time Fished: '___" ___Total Seconds _____

RM: _____ Depth: _____ Observed Flow: _____

Distance: _____ Data Source: _____ Number of Species: _____

Anomalies: A-anchor worm; B-black spot; C-leeches; D-deformities; E-eroded fins; F-fungus; L-lesions; M-multiple DELT anomalies; N-blind; P-parasites; Y-popeye; S-emaciated; W-swirled scales; T-tumors; Z-other/. [H-Heavy; L-Light are combined with anomalies A, B, and C]

SPECIES	# WEIGHED	TOTAL COUNTED	WEIGHT (GRAMS)	ANOMALIES

OhioEPA
EPA 4508

Mass Weighing Convention: Total Weight (g) 536 (12) Number Weighed

and weighed *subsample*.

Samples that are comprised of two distinct size classes of fish (*e.g.* adults and juveniles) of a species are processed as two, separate size groups. Adults and juveniles are recorded separately on the fish data sheet by adding an "A" to the species code for adults and a "B" for juveniles. For example, if both adult and juvenile white suckers occur in the same sample the adult numbers and weights are recorded as family-species code 40-016A with juvenile numbers and weights recorded as 40-016B. Although each is listed separately on the fish data sheet they are treated as a subsample of the same species in any subsequent data analyses. The FINS (Fish Information System) programs are designed to calculate relative numbers and weight data based on the input of the weighted subsample data.

Individual fish weighing less than 1000 grams (g) are weighed to the nearest 1g on a Homs 1000 spring dial scale (1000g capacity x 2g intervals). Fish weighing more than 1000g are weighed to the nearest 25g on a Universal Accu-weigh spring dial scale M1250 (with air dash pot; 12000 g capacity in 50 g increments). All scales are checked once each week with National Bureau of Standards Class F check weights (up to 2000g in 1g increments) and adjusted as necessary.

d) External Anomalies

All fish that are weighed whether done individually, in aggregate, or subsampled (only the fish that are actually weighed) are examined for the presence of gross external anomalies and their occurrence is recorded on the fish data sheet (Figure V-4-4) and subsequently entered into FINS. In order to standardize the procedure for counting and identifying anomalies the following criteria should be followed.

All fish that are *weighed* are examined for gross external anomalies. These are anomalies that are visible to the naked eye when the fish are captured, identified, sorted, weighed and counted. Table V-4-2 lists the types of anomalies which are recorded on the fish data sheet and subsequently entered into FINS. Exact counts of anomalies present (i.e. the number of tumors, lesions, etc. per fish) are not made; however, light and heavy infestations are noted for certain types of anomalies (Table V-4-2). An external anomaly is defined as the presence of externally visible skin or subcutaneous disorders, and is expressed as percent (weighted) of affected fish among all fish *weighed*. This is computed for each type of anomaly for each species in each sample. It is computed as a weighted number (i.e. based on percent incidence among weighed fish times the total number of that fish species in the sample). Then the total percent anomalies for a specific type of anomaly or group of anomalies can be calculated for one or more sites.

The following is a review of some anomalies commonly encountered in freshwater fishes. These characteristics should be used in determining the types of external anomalies present and in coding the fish data sheet (Fig. V-4-4).

1) *Deformities* - These can affect the head, spinal vertebrae, fins, stomach shape, and have a variety of causes including toxic chemicals, viruses, bacteria (e.g. *Mycobacterium* sp.), infections, and protozoan parasites (e.g. *Myxosoma cerebalis*; Post 1983). Fish with extruded eyes (see Popeye disease) or obvious injuries should not be included.

2) *Eroded fins* - These are the result of a chronic disease principally caused by flexibacteria invading the fins causing a necrosis of the tissue (Post 1983). Necrosis of the fins may also be caused by gryodactylids, a small trematode

parasite. When necrosis occurs in the tissue at the base of the caudal fin it is referred to as peduncle disease. Erosions also occur on the preopercle and operculum and these *should be* included. In Ohio streams and rivers this anomaly is generally absent in least impacted fish communities, but can have a high incidence in polluted areas. It occurs most frequently in areas with multiple stresses, particularly low or marginal D.O. or high temperatures in combination with chronic toxicity (Pippy and Hare 1969; Sniezko 1962).

Table V-4-2. Codes utilized to record external anomalies on fish.

Anomaly Code	Description
D	Deformities of the head, skeleton, fins, and other body parts.
E	Eroded fins.
L	Lesions, ulcers.
T	Tumors.
M	Multiple DELT anomalies (e.g. lesions and tumors, etc.) on the same individual fish.
AL	Anchor worm - Light infestation: fish with five or fewer attached worms and/or previous attachment sites.
AH	Anchor worm - Heavy infestation: fish with six or more attached worms and/or previous attachment sites.
BL	Black Spot - Light infestation: spots do not cover most of the body with the average distance between spots greater than the diameter of the eye.
BH	Black Spot - Heavy infestation: spots cover most of the body and fins with the average distance between spots less than or equal to the diameter of the eye.
CL	Leeches - Light infestation: fish with five or fewer attached leeches and/or previous attachment sites.
CH	Leeches - Heavy infestation: fish with six or more attached leeches and/or previous attachment sites.
F	Fungus.
I	Ich.
N	Blind - one or both eyes; includes missing and grown over eyes (does not include eyes missing due to popeye disease).
S	Emaciated (poor condition, thin, lacking form).
P	External parasites (other than those already specified).
Y	Popeye disease.
W	Swirled scales.
Z	Other, not included above.

3) *Lesions and Ulcers* - These appear as open sores or exposed tissue and can be caused by viral (*e.g. Lymphocystis* sp.) and bacterial (*e.g. Flexibacter columnaris, Aeromonas* spp., *Vibrio* sp.) infections. Prominent bloody areas on fish should also be included. Small, characteristic sores left by anchor worms and leeches should not be included unless they are enlarged by this infection. Obvious injuries, however, should not be included unless they too, are likewise infected. As with eroded fins, lesions often times appear in areas impacted by multiple stresses, particularly marginal D.O. in combination with sublethal levels of toxics.

4) *Tumors* - These result from the loss of carefully regulated cellular proliferative growth in tissue and are generally referred to as neoplasia (Post 1983). In wild fish populations tumors can be the result of exposure to toxic chemicals. Baumann *et al.* (1987) identified polynuclear aromatic hydrocarbons (PAHs) as the cause of hepatic tumors in brown bullheads in the Black River (Ohio). Viral infections (e.g. Lymphocystis) can also cause tumors. Parasites (e.g. *Glugea anomala* and *Ceratomyxa shasta*; Post 1983) may cause tumor like masses, but these *should not* be considered as tumors. Parasite masses can be squeezed and broken between the thumb and forefinger whereas true tumors are firm and not easily broken (P. Baumann, pers. comm.).

5) *Anchor worm (Lernaea cyprinacea)* - This is a common parasitic copepod and can be identified by the presence of an adult female which appears as a slender, worm-like body with the head attached (buried) in the flesh of the fish. A small, characteristic sore is left after the anchor worm detaches. Attachment sites are included in the determination of light and heavy infestations. If the former attachment site becomes infected and enlarged as the result of an infection it should be recorded as a lesion.

6) *Black spot* - This disease is common on fish in Ohio streams and is caused by the larval stage of a trematode parasite (e.g. *Uvulifer ambloplitis* and *Crassiphiala bulboglossa*). They are easily identified as small black cysts (approximately the size of a pin head) on the skin and fins. Black spot has been reported as being most prevalent on fish inhabiting relatively shallow stream and lake habitats which have an abundance of aquatic vegetation with snails and fish eating birds, two of its intermediate animal hosts. It may also increase in frequency in mildly polluted streams or where fish are crowded due to intermittent pooling.

7) *Leeches* - These are parasites belong to the family Piscicolidae and are usually greenish brown in color and 5-25 mm long (Allison *et al.* 1977). Leeches can be identified by the presence of two suckers (one on each end) and the ability to contract or elongate their body. They may occur almost anywhere on the external surface of fish, but are most frequently seen on the anterioventral surface of bullheads (*Ictalurus* sp.). Field investigators should become familiar with the small sores or scars left by leeches as these are included in the determination of light and heavy infestations. If these sores become enlarged and infected they are also regarded as lesions. Leeches are seldom harmful to fish unless the infestation is very heavy.

8) *Fungus* - This is a growth that can appear on a fish's body as a white cottony growth and is most frequently caused by *Saprolegnia parasitica*. This fungus usually attacks an injured or open area of the fish and can eventually cause further disease or death.

9) *Ich or Icthyophthirus multifilis* - This is a protozoan that manifests itself on a fish's skin and fins as a white spotting. This disease rarely occurs in wild fish populations.

10) *Popeye* - This disease is generally identified by bulging eyes and can be caused by gas accumulation in areas where the water is gas supersaturated. It occurs most frequently in Ohio as the result of fluid accumulation from viral infection, nematodes (*Philometra* sp.), or certain trematode larvae (Rogers and Plumb 1977).

Information on external anomalies is recorded because many are either caused or exacerbated by environmental factors and often times indicate the presence of multiple, sublethal stresses. Komanda (1980) found that morphological abnormalities are uncommon in unimpacted, natural fish populations. The effects of temperature, salinity, dissolved oxygen, diet, chemicals, organic wastes, etc., especially during the ontogeny and larval stages of fishes can be the cause of many types of anomalies (Berra and Au, 1981). The presence of anomalies on fish may act as an index of pollution stress. A high frequency of DELT anomalies (deformities, eroded fins, lesions, and tumors) is a good indication of a stress caused by sublethal stresses, intermittent stresses, and chemically contaminated substrates. The percent DELT anomalies is a metric of the IBI (Ohio EPA 1987). Field investigators are urged to refer to texts on fish health for further information and pictures of specific anomalies. If necessary, affected fish should be preserved for laboratory examination.

4) Fish Sampling Site Habitat Evaluation: Qualitative Habitat Evaluation Index (QHEI)

A general evaluation of macrohabitat is made by the *fish field crew leader* while sampling each location using the Ohio EPA Site Description Sheet - Fish (Figure V-4-5). This form is used to tabulate data and information for calculating the **Qualitative Habitat Evaluation Index (QHEI)**. The following guidance should be used when completing the site evaluation form.

Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Qualitative Habitat Evaluation Index (QHEI).

Ohio EPA Site Description Sheet - Fish

QHEI SCORE: ☐

Stream_____ RM_____ Date_____ River Code_____

Location_____ Crew:_____

1] SUBSTRATE (Check *ONLY* Two Substrate *TYPE BOXES; Check all types present*); **SUBSTRATE SCORE:** ☐

TYPE	POOL	RIFFLE
☐-BLDER /SLABS[10]	____	____
☐-BOULDER [9]	____	____
☐-COBBLE [8]	____	____
☐-HARDPAN [4]	____	____
☐-MUCK [2]	____	____
☐-GRAVEL [7]	____	____
☐-SAND [6]	____	____
☐-BEDROCK[5]	____	____
☐-DETRITUS[3]	____	____
☐-ARTIFIC.[0]	____	____

TOTAL NUMBER OF SUBSTRATE TYPES: ☐> 4 [2] ☐— <= 4 [0] ☐-COAL FINES [-2]

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)

COMMENTS_____

Substrate Origin (Check all)
☐-LIMESTONE [1] ☐-RIP/RAP [0] ☐-TILLS [1] ☐-HARDPAN [0] ☐-SANDSTONE [0] ☐-SHALE [-1]

Silt Cover (Check One)
☐-SILT HEAVY [-2] ☐-SILT MODERATE [-1] ☐ - SILT NORMAL [0] ☐ - SILT FREE [1]

Extent Of Embeddness (Check One)
☐—EXTENSIVE [-2] ☐—MODERATE[-1] ☐—LOW[0] ☐—NONE[1]

COVER SCORE: ☐

2] INSTREAM COVER

TYPE (Check *All* That Apply)
☐-UNDERCUT BANKS [1]
☐-OVERHANGING VEGETATION [1]
☐-SHALLOWS (IN SLOW WATER) [1]
☐-DEEP POOLS [2]
☐-ROOTWADS [1]
☐-BOULDERS [1]
☐-OXBOWS [1]
☐-AQUATIC MACROPHYTES [1]
☐-LOGS OR WOODY DEBRIS [1]

AMOUNT(Check *ONLY* One or check 2 and *AVERAGE*)
☐ - EXTENSIVE > 75% [11]
☐ - MODERATE 25-75% [7]
☐ - SPARSE 5-25% [3]
☐ - NEARLY ABSENT < 5% [1]

COMMENTS:_____

3] CHANNEL MORPHOLOGY: (Check *ONLY* One PER Category OR check 2 and *AVERAGE*) **CHANNEL:** ☐

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☐ - NONE [6]	☐ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☐ - MODERATE [3]	☐ - GOOD [5]	☐ - RECOVERED [4]	☐ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☐ - RECOVERING [3]	☐ - LOW [1]	☐ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☐ - BANK SHAPING
				☐ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS:_____

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank) **RIPARIAN:** ☐

River Right Looking Downstream

RIPARIAN WIDTH L R (Per Bank)	EROSION/RUNOFF - FLOOD PLAIN QUALITY L R (Most Predominant Per Bank)	L R (Per Bank)	BANK EROSION
☐☐-WIDE>50m [4]	☐☐-FOREST, SWAMP [3]	☐☐-URBAN OR INDUSTRIAL[0]	☐ ☐-NONE OR LITTLE [3]
☐☐-MODERATE 10-50 [3]	☐☐-OPEN PASTURE/ ROWCROP[0]	☐☐-SHRUB OR OLD FIELD[2]	☐ ☐-MODERATE.[2]
☐☐-NARROW 5-10m [2]	☐☐- RESID.,PARK,NEW FIELD [1]	☐☐-CONSERV. TILLAGE [1]	☐ ☐-HEAVY OR SEVERE[1]
☐☐-VERY NARROW 1-5m [1]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐-NONE[0]			

COMMENTS:_____

POOL/GLIDE AND RIFFLE/RUN QUALITY **POOL:** ☐

MAX. DEPTH (Check 1)
☐- >1m [6]
☐- 0.7-1m [4]
☐- 0.4-0.7m [2]
☐- < 0.4m [1]
☐—<0.2m [Pool = 0]

MORPHOLOGY (Check 1)
☐-POOL WIDTH > RIFFLE WIDTH [2]
☐-POOL WIDTH = RIFFLE WIDTH [1]
☐-POOL WIDTH < RIFFLE W. [0]

POOL/RUN/RIFFLE CURRENT VELOCITY (Check *All* That Apply)
☐-TORRENTIAL[-1] ☐-EDDIES[1]
☐-FAST[1] ☐-INTERSTITIAL[-1]
☐-MODERATE [1] ☐-INTERMITTENT[-2]
☐-SLOW [1]

☐-NO POOL[0]

COMMENTS:_____

RIFFLE: ☐

RIFFLE/RUN DEPTH
☐ - GENERALLY >10 cm,MAX>50 [4]
☐ - GENERALLY >10 cm,MAX<50 [3]
☐ - GENERALLY 5-10 cm [1]
☐ - GENERALLY < 5 cm [Riffle = 0]

RIFFLE/RUN SUBSTRATE
☐-STABLE (e.g.,Cobble, Boulder) [2]
☐-MOD. STABLE (e.g.,Pea Gravel) [1]
☐-UNSTABLE (Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
☐-EXTENSIVE [-1] ☐-MODERATE[0]
☐-LOW. [1] ☐-NONE[2]

☐-NO RIFFLE[0]

COMMENTS_____

GRADIENT: ☐

6] Gradient (feet/mile): _____ %POOL:_____ %RIFFLE:_____ %RUN:_____

EPA 4520

Geographical Information

1) *Stream, River Mile (RM), Date* – The official stream name may be found in the Gazetteer of Ohio Streams (Ohio DNR, 1960) or on USGS 7.5 minute topographic maps. If the stream is unnamed, a name and stream code is assigned by the *Surface Water Section Database Coordinator*. Usually the name of a nearby landmark is used for the stream name. A basin-river code is also assigned from the FINS river code system. The River Mile (RM) designations used are found on 7.5 minute topo maps stored at the Ohio EPA, Office of Planning, 1800 WaterMark Drive (PEMSO RMI maps), one of five Ohio EPA District offices (maps for that district), and Ohio EPA, Division of Water Quality Monitoring Assessment laboratory at 1030 King Avenue.

2) Specific Location

A brief description of the sampling location should include proximity to a local landmark such as a bridge, road, discharge outfall, railroad crossing, park, tributary, dam, etc.

3) Field Sampling Crew

The field crew involved with the sampling is noted on the sheet with the person who filled out the sheet listed first. QHEI information is to be completed by the crew leader *only*.

*4) Habitat Characteristics: **QHEI** Metrics*

The **Qualitative Habitat Evaluation Index (QHEI)** is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic *macrohabitat* characteristics that are important to fish communities. A detailed analysis of the development and use of the QHEI is available in Rankin (1989). The **QHEI** is composed of six principal metrics each of which are described below. The maximum possible **QHEI** site score is 100. Each of the metrics are scored individually and then summed to provide the total **QHEI** site score. This is completed at least once for each sampling site during each year of sampling. An exception to this convention would be when substantial changes to the macrohabitat have occurred between sampling passes.Standardized definitions for pool, run, and riffle habitats, for which a variety of existing definitions and perceptions exist, are essential for accurately using the **QHEI**. For consistency the following definitions are taken from Platts *et al.* (1983). It is recommended that this reference also be consulted prior to scoring individual sites.

Riffle and Run Habitats:

Riffle - areas of the stream with fast current velocity and shallow depth; the water surface is visibly broken.

Run - areas of the stream that have a rapid, non-turbulent flow; runs are deeper than riffles with a faster current velocity than pools and are generally located downstream from riffles where the stream narrows; the stream bed is often flat beneath a run and the water surface is not visibly broken.

Pool and Glide Habitats:

Pool[5] - an area of the stream with slow current velocity and a depth greater than riffle and run areas; the stream bed is often concave and stream width frequently is the greatest; the water surface slope is nearly zero.

Glide - this is an area common to most modified stream channels that do not have distinguishable pool, run, and riffle habitats; the current and flow is similar to that of a canal; the water surface gradient is nearly zero.

The following is a description of each of the six **QHEI**

[5]If a pool or glide has a maximum depth of less than 20 cm, it is deemed to have lost its functionality and the metric is scored a 0.

metrics and the individual metric components. Guidelines on how to score each is presented. Generally, metrics are scored by checking boxes. In certain cases the biologist completing the **QHEI** sheet may interpret a habitat characteristic as being intermediate between the possible choices; in cases where this is allowed (denoted by the term **"Double-Checking"**) two boxes may be checked and their scores averaged.

Metric 1: Substrate

This metric includes two components, *substrate type* and *substrate quality*.

Substrate type

Check the two most common substrate types in the stream reach. If one substrate type predominates (greater than approximately 75-80% of the bottom area *OR* what is clearly the most *functionally* predominant substrate) then this substrate type should be checked twice. **DO NOT CHECK MORE THAN TWO BOXES**. *Note the category for artificial substrates.* Spaces are provided to note the presence (by check marks, or estimates of % if time allows) of *all* substrate types present in pools and riffles that each comprise at least 5% of the site (*i.e.*, they occur in sufficient quantity to support species that may commonly be associated with the habitat type). This section must be filled out completely to permit future analyses of this metric. If there are more than four substrate types in the zone that are present in greater than approximately 5% of the sampling area check the appropriate box.

Substrate quality

Substrate *origin* refers to the "parent" material that the stream substrate is derived from. Check **ONE** box under the substrate origin column *unless* the parent material is from multiple sources (*e.g.*, limestone and tills). **Embeddedness** is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine materials (sand and silt). Substrates should be considered embedded if >50% of surface of the substrates are embedded in fine material. Embedded substrates cannot be easily dislodged. This also includes substrates that are concreted or "armour-plated". Naturally sandy streams are not considered embedded; however, a sand predominated stream that is the result of anthropogenic activities that have buried the natural coarse substrates is considered embedded. Boxes are checked for *extensiveness* (area of sampling zone) of the embedded substrates as follows: **Extensive** — > 75% of site area, **Moderate** — 50-75%, **Sparse** — 25-50%, **Low** — < 25%.

Silt Cover is the extent that substrates are covered by a silt layer (*i.e.*, more than 1 inch thickness). **Silt Heavy** means that nearly all of the stream bottom is layered with a deep covering of silt. **Moderate** includes extensive coverings of silts, but with some areas of cleaner substrate (*e.g.*, riffles). **Normal** silt cover includes areas where silt is deposited in small amounts along the stream margin *or* is present as a "dusting" that appears to have little functional significance. If substrates are exceptionally clean the **Silt Free** box should be checked.

Substrate types are defined as:

a) *Bedrock* - solid rock forming a continuous surface.
b) *Boulder* - rounded stones over 256 mm in diameter(10 in.) or large "slabs" more than 256 mm in length (*Boulder slabs*).
c) *Cobble* - stones from 64-256 mm (2 1/2 - 10in.) in diameter.
d) *Gravel* - mixture of rounded course material from 2-64 mm (1/12 - 2 1/2 in.) in diameter.
e) *Sand* - materials 0.06 - 2.0 mm in diameter, gritty texture when rubbed between fingers.

f) *Silt* - 0.004 - 0.06 mm in diameter, generally this is fine material which feels "greasy" when rubbed between fingers.

g) *Hardpan* - particles less than 0.004 mm in diameter, usually clay, which forms a dense, gummy surface that is difficult to penetrate.

h) *Marl* - calcium carbonate; usually greyish-white; often contains fragments of mollusc shells.

i) *Detritus* - dead, unconsolidated organic material covering the bottom which could include sticks, wood and other partially or undecayed coarse plant material.

j) *Muck* - black, fine, flocculent, completely decomposed organic matter (*does not include* sewage sludge).

k) *Artificial* - substrates such as rock baskets, gabions, bricks, trash, concrete etc., placed in the stream for reasons *OTHER* than habitat mitigation

Sludge is defined as a thick layer of organic matter, that is decidedly of human or animal origin. **NOTE: SLUDGE THAT ORIGINATES FROM POINT SOURCES IS NOT INCLUDED; THE SUBSTRATE SCORE IS BASED ON THE UNDERLYING MATERIAL.**

Substrate Metric Score:

Although the theoretical maximum metric score is > 20 the maximum score allowed for the **QHEI** is limited to **20 points**.

Metric 2: Instream Cover

This metric consists of *instream cover type* and *instream cover amount*. All of the cover types that are present in greater than approximately 5% of the sampling area (i.e., they occur in sufficient quantity to support species that may commonly be associated with the habitat type) should be checked. Cover should not be counted when it is in areas of the stream with insufficient depth (usually < 20 cm) to make it useful. For example a logjam in 5 cm of water contributes very little if any cover, and at low flow may be dry. Other cover types with limited utility in shallow water include *undercut banks* and *overhanging vegetation*, *boulders*, and *rootwads*. Under *amount*, one or two boxes may be checked. *Extensive* cover is that which is present throughout the sampling area, generally greater than about 75% of the stream reach. Cover is *moderate* when it occurs over 25-75% of the sampling area. Cover is *sparse* when it is present in less than 25% of the stream margins (sparse cover usually exists in one or more isolated patches). Cover is *nearly absent* when no large patch of any type of cover exists anywhere in the sampling area. This situation is usually found in recently channelized streams or other highly modified reaches (*e.g.* ship channels). If cover is thought to be intermediate in amount between two categories, *check two boxes and* ***average*** *their scores*. Cover types include: 1) undercut banks, 2) overhanging vegetation, 3) shallows (in slow water), 4) logs or woody debris, 5) deep pools (> 70 cm), 6) oxbows, 7) boulders, 8) aquatic macrophytes, and 9) rootwads (tree roots that extend into stream). Do not check undercut banks AND rootwads unless undercut banks exist *along with* rootwads as a major component.

Cover Metric Score:

Although the theoretical maximum score is > 20 the maximum score assigned for the QHEI for the instream cover metric is limited to **20 points**

Metric 3: Channel Morphology

This metric emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity (*i.e.* the

degree to which the stream meanders), channel development, channelization, and channel stability. One box under each should be checked unless conditions are considered to be intermediate between two categories; in these cases *check two boxes and **average** their scores.*

a) *Sinuosity* - **No** sinuosity is a straight channel. **Low** sinuosity is a channel with only 1 or 2 poorly defined outside bends in a sampling reach, or perhaps slight meandering within modified banks. **Moderate** sinuosity is more than 2 outside bends, with at least one bend well defined. **High** sinuosity is more than 2 or 3 well defined outside bends with deep areas outside and shallow areas inside. Sinuosity may be more conceptually described by the ratio of the stream distance between two points on the channel of a stream and the straight-line distance between these same two points, taken from a topographic map. Check *only* one box.

b) *Development* - This refers to the development of riffle/pool complexes. **Poor** means *riffles* are absent, or if present, shallow with sand and fine gravel substrates; *pools*, if present are shallow. Glide habitats, if predominant, receive a **Poor** rating. **Fair** means riffles are poorly developed or absent; however, pools are more developed with greater variation in depth. **Good** means better defined riffles present with larger substrates (gravel, rubble or boulder); pools have variation in depth and there is a distinct transition between pools and riffles. **Excellent** means development is similar to the Good category except the following characteristics must be present: pools must have a maximum depth of >1m and deep riffles and runs (>0.5m) must also be present. In streams sampled with wading methods, a sequence of riffles, runs, and pools must occur more than once in a sampling zone. Check *one* box.

c) *Channelization* - This refers to anthropogenic channel modifications. **Recovered** refers to streams that have been channelized in the past, but which have recovered most of their natural channel characteristics. **Recovering** refers to channelized streams which are still in the process of regaining their former, natural characteristics; however, these habitats are still degraded. This category also applies to those streams, especially in the Huron/Erie Lake Plain ecoregion (NW Ohio), that were channelized long ago and have a riparian border of mature trees, but still have **Poor** channel characteristics. **Recent** or **No Recovery** refers to streams that were recently channelized or those that show no significant recovery of habitats (*e.g.* drainage ditches, grass lined or rock rip-rap banks, etc.). The specific type of habitat modification is checked in the last two columns but not scored.

d) *Stability* - This refers to channel stability. Artificially stable (concrete) stream channels receive a **High** score. Even though they are generally a negative influence on fish the negative effects are related to features other than their stability. Channels with **Low** stability are usually characterized by fine substrates in riffles that often change location, have unstable and severely eroding banks, and a high bedload that slowly creeps downstream. Channels with **Moderate** stability are those that appear to maintain stable riffle/pool and channel characteristics, but which exhibit some symptoms of instability, *e.g.* high bedload, eroding or false banks, or show the effects of wide fluctuations in water level. Channels with **High** stability have stable banks and substrates, and little or no erosion and bedload.

e) *Modifications/Other* - Check the appropriate box if

impounded, islands present, or leveed (these are not included in the QHEI scoring) as well as the appropriate source of habitat modifications.

The maximum QHEI metric score for Channel Morphology is **20 points**.

Metric 4: Riparian Zone and Bank Erosion

This metric emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion. Each of the three components require scoring the left *and* right banks (looking downstream). The *average* of the left and right banks is taken to derive the component value. One box per bank should be checked unless conditions are considered to be intermediate between two categories; in these cases *check two boxes and* ***average*** *their scores.*

a) *Width of the Floodplain* - This is the width of the riparian (stream side) vegetation. Width estimates are only done for forest, shrub, swamp, and old field vegetation. Old field refers to the a fairly mature successional field that has stable, woody plant growth; this generally does not include weedy urban or industrial lots that often still have high runoff potential. Two boxes, one each for the left and right bank (looking downstream), should be checked and then averaged.

b) *Floodplain Quality* - The two most predominant floodplain quality types should be checked, one each for the left and right banks (includes urban, residential, etc.), and then averaged. By floodplain we mean the areas *immediately outside* of the riparian zone *or greater than 100 feet from the stream*, whichever is wider on each side of the stream. These are areas adjacent to the stream that can have direct runoff and erosional effects during normal wet weather. We do not limit it to the riparian zone and it is much less encompassing than the stream basin.

c) *Bank Erosion* - The following Streambank Soil Alteration Ratings from Platts *et al.* (1983) should be used; check one box for each side of the stream and average the scores. False banks are used in the sense of Platts *et al.* (1983) to mean banks that are no longer adjacent to the normal flow of the channel but have been moved back into the floodplain most commonly as a result of livestock trampling.

1) **None** - streambanks are stable and not being altered by water flows or animals (e.g. livestock) - Score **3**.
2) **Little** - streambanks are stable, but are being lightly altered along the transect line; less than 25% of the streambank is receiving any kind of stress, and if stress is being received it is very light; less than 25% of the streambank is false, broken down or eroding - Score **3**.
3) **Moderate** - streambanks are receiving moderate alteration along the transect line; at least 50 percent of the streambank is in a natural stable condition; less than 50% of the streambank is false, broken down or eroding; false banks are rated as altered - Score **2**.
4) **Heavy** - streambanks have received major alterations along the transect line; less than 50% of the streambank is in a stable condition; over 50% of the streambank is false, broken down, or eroding - Score **1**.
5) **Severe** - streambanks along the transect line are severely altered; less than 25% of the streambank is in a stable condition; over 75% of the streambank is false, broken down, or eroding - Score **1**.

The maximum score for Riparian Zone and Erosion metric is **10 points**.