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Jon S. Corzine, Governor

FISH IBI REPORT
2004 SAMPLING

Volume 1 of 2

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FISH IBI REPORT
2004 SAMPLING

Volume 1 – Summary

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EXECUTIVE SUMMARY

Historically, the health of aquatic systems was monitored primarily through chemical means. However, chemical monitoring provides only a “snapshot” of conditions at the time of sampling and may fail to detect acute pollution events (e.g., runoff from heavy rain, spills), non-chemical pollution (e.g., habitat alteration) and non-point source pollution.

In order to address the limitations of chemical monitoring, DEP supplements chemical monitoring with biological monitoring which is based on the premise that biological communities are shaped by the long-term conditions of their environment and more accurately reflect the health of an ecosystem. Currently, the Bureau of Freshwater and Biological Monitoring (BFBM), within the Water Monitoring and Standards program, monitors benthic macroinvertebrate assemblages (aquatic insects, worms, clams, etc.) at over 800 stream stations throughout New Jersey.

Benthic macroinvertebrate assemblages are generally reflective of short-term and local impairment. In order to assess environmental conditions on a larger spatial and temporal scale, BFBM began to supplement benthic macroinvertebrate monitoring with a fish index of biotic integrity (FIBI) during summer 2000. A FIBI is an index that measures the health of a stream based on multiple attributes of the resident fish assemblage. Each site sampled is scored based on its deviation from reference conditions (i.e., what would be found in an unimpacted stream) and classified as “poor”, “fair”, “good” or “excellent”. In addition, habitat is evaluated at each site and classified as “poor”, “marginal”, “suboptimal” or “optimal”.

The data provided by the FIBI is becoming another component of the DEP's suite of environmental indicators. The data will help to measure water quality use attainment and the Department's success in attaining the Clean Water Act goal of "fishable" waters as elaborated in the New Jersey Integrated Water Quality Monitoring and Assessment Report. IBI data will also be used to develop biological criteria, prioritize sites for further studies, provide biological impact assessments, and assess status and trends of the state's freshwater fish assemblages. Currently, FIBI data collected from northern New Jersey is used in an approach to nominate candidate waters for upgrade to a Category One antidegradation classification (NJAC 7:9B) based on exceptional ecological significance.

In 2004, the fifth year of sampling, 20 sites were sampled. Six sites were rated “excellent”, six were “good”, eight were “fair”, and no sites received a “poor” rating.

With the completion of this 2004 sampling season, the DEP has established a 100 station Fish IBI monitoring network in northern New Jersey. Thereafter, stations will be visited once every five years as part of the BFBM’s ambient monitoring efforts. Data are currently being collected for the planned expansion of the network to include both portions of southern New Jersey and the state’s headwater streams, with the goal of having a statewide 200 station network.

INTRODUCTION

Monitoring the health of aquatic systems is a critical component of watershed management. Historically, aquatic systems were monitored primarily through chemical means. Unfortunately, chemical monitoring provides only a “snapshot” of conditions at the time of sampling and may fail to detect acute pollution events (e.g. runoff from heavy rain, spills) and non-chemical pollution (e.g. habitat alteration). In order to address the shortcomings of chemical monitoring, the New Jersey Department of Environmental Protection supplements chemical monitoring with biological monitoring. Biological monitoring is based on the premise that biological communities are shaped by the long-term conditions of their environment and more accurately reflect the health of an ecosystem.

The monitoring of stream fish assemblages is an integral component of many water quality management programs for a variety of reasons (See Table 1), and its importance is reflected in the aquatic life use support designations adopted by many states. Narrative expressions such as "maintaining coldwater fisheries", "fishable", or "fish propagation" are prevalent in many state standards. In New Jersey, surface water quality criteria are closely aligned with descriptors such as *trout production, trout maintenance* and *non-trout* waterways. Fish assemblages can be stand-alone indicators of a waterbody’s health and/or fishability. In addition, they may be combined with other biological and chemical indicators to assist in the nomination of waters for upgrade to Category One antidegradation classification (NJAC 7:9B) based on exceptional ecological significance.

The general methodology[1] currently employed in the compilation of these studies and reports is the Rapid Bioassessment Protocol described in Barbour et al. (1999) with some modifications for regional conditions (Kurtenbach 1994). The principal evaluation mechanism utilizes the technical framework of the *Index of Biotic Integrity (IBI),* a fish assemblage approach developed by Karr (1981). The IBI incorporates the zoogeographic, ecosystem, community and population aspects of the fish assemblage into a single ecologically based index. Calculation and interpretation of the IBI involves a sequence of activities including: fish sample collection, data tabulation, and regional modification[1] and calibration of metrics and expectation values. This concept has provided the overall multimetric index framework for rapid bioassessment in this document.

Data provided by the IBI have become another component of the DEP's suite of environmental indicators. The data help to measure water quality use attainment and the Department's success in attaining the Clean Water Act goal of "fishable" waters as elaborated in the New Jersey Integrated Water Quality Monitoring and Assessment Report. The Department anticipates developing an assessment methodology that uses the results from the Fish IBI. The results of these decisions will be reflected in the 2006 Methods Document that is used to prepare the 2006

[1] The IBI methodology presently being used in these studies was modified from Plafkin et al. (1989) to meet the regional conditions of New Jersey (not all of the state, however, is covered, see Fig. 1) based on work by Kurtenbach (1994). It should be noted, however, that an enumeration of fish assemblages, regardless of whether an IBI is calculated or not, is still a useful ***environmental indicator*** capable of providing stand alone information to determine whether the affected stream(s) are capable of providing some secondary contact recreation such as fishing.

Integrated List and Report.

IBI data will also be used to develop biological criteria, provide biological impact assessments, and assess status and trends of the state's freshwater fish assemblages. Current uses of IBI data collected from northern New Jersey include prioritizing sites for further studies and nominating candidate waters for upgrade to a Category One antidegradation classification (NJAC 7:9B) based on exceptional ecological significance.

Table 1. Advantages of using fish as indicators of environmental health.

1. Fish are good indicators of long-term (several years) effects and broad habitat conditions because they are relatively long-lived and mobile (Karr et al. 1986). 2. Fish assemblages generally include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, and piscivores). They tend to integrate effects of lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health. 3. Fish are at the top of the aquatic food chain and are consumed by humans, making them important subjects in assessing contamination. 4. Fish are relatively easy to collect and identify to the species level. Most specimens can be sorted and identified in the field and released unharmed. ▪ Environmental requirements of common fish are comparatively well known. ▪ Life history information is extensive for most species. ▪ Information on fish distributions is commonly available. 5. Aquatic life uses (water quality standards) are typically characterized in terms of fisheries (e.g. coldwater, coolwater, warmwater, sport, forage). ▪ Monitoring fish assemblages provides direct evaluation of "fishability", which emphasizes the importance of fish to anglers and commercial fisherman. 6. Fish account for nearly half of the endangered vertebrate species and subspecies in the United States (Warren and Burr 1994).

FIELD COLLECTION PROCEDURES

Primary objectives of the fish collections are to obtain samples with representative species and abundances, at a reasonable level of effort. Sampling effort is standardized by using similar stream lengths, collection methods, and habitat types. Stream segments selected for sampling are representative of the habitat of the reach. In addition, sample sites will be representative of the habitat of the reach and will have a riffle, run, and pool sequence where possible.

Table 2. Requirements for fish sampling based on stream size.

	A	B	C
Stream Size	Moderate to large streams and rivers (5^{th} order or greater)	Wadeable streams (3^{rd} and 4^{th} order)	Headwater streams (1^{st} and 2^{nd} order)
Sampling Distance (meters)	500 m	150 m	150 m
Electrofishing Gear	12' boat	2 Backpacks or barge electrofishing unit	1-2 Backpack electrofisher(s)
Power Source	5000 watt generator	24 volt battery or 2500 watt generator	24 volt battery

Streams with drainage areas less than 5 square miles are presently excluded from IBI scoring because of naturally occurring low species richness. Often streams classified as trout production waters fall into this category. More appropriate assessment methods for these streams include the measurement of trout abundance and/or young of the year production. Benthic macroinvertebrate assessments are also a viable alternative. In addition, atypical habitats such as dams and mouths of tributaries are avoided, unless the intent of the study is to determine the influence these habitats have on the fish assemblage. Most often, sampling atypical habitats results in the collection of fish species not represented in typical stream reaches. Sampling intermittent streams is also avoided. These streams require the development of a separate set of IBI scoring criteria. The Fish IBI was developed for waters in northern New Jersey from Trenton to Raritan Bay (Figure 1).

Fish are sampled primarily with electrofishing gear using pulsed direct current (DC) output. This method of collection has proved to be the most comprehensive and effective single method for collecting stream fishes. Direct current is safer, more effective, especially in turbid water, and less harmful to the fish. In waters with low conductivity (less than 75 µmhos/cm) it may be necessary to use an AC unit (Lyons 1992). Selection of the appropriate electrofishing gear is dependent on stream size (Table 2). A typical sampling crew consists of four to seven people (Figure 2), depending on the gear being utilized. A minimum of two people are required for netting the stunned fish. Electrofishing is conducted by working slowly upstream for 150 meters and placing the electrodes in all available fish habitat. Stunned fish are netted at and below the electrodes as they drift downstream. Netters attempt to capture fish representing all size classes. All fish captured are immediately placed in water filled containers strategically located along the stream bank in order to reduce fish mortality.

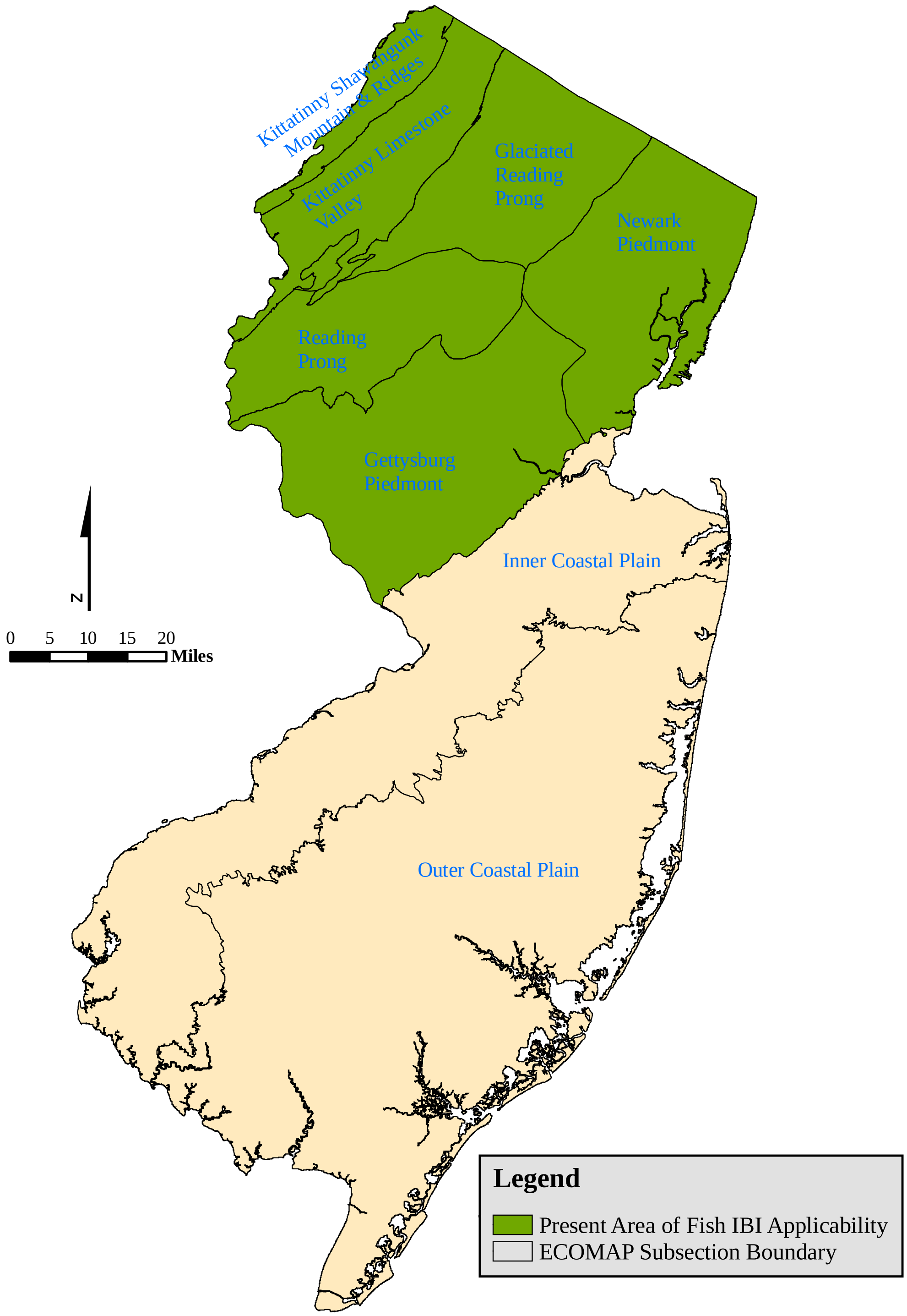

Figure 1. Map of New Jersey Ecoregions and region of Fish IBI applicability.

Figure 2. A typical fish sampling operation using the electrofishing barge.

Sampling time generally requires 1.5 to 2 hours per station. This includes the measurement of chemical and physical parameters. Sampling is conducted during daylight hours, June through early October, under normal or low flows, and never under atypical conditions such as high flows or excessive turbidity caused by heavy precipitation. Fish collections made in the summer and early fall are easier, safer and less likely to disturb spawning fish.

SAMPLE PROCESSING

Fish are identified to the species level, counted, examined for disease and anomalies, measured (game fish), released and recorded on fish data sheets in the field. The sampling protocol employed is ineffective in capturing a representative sample of smaller fish because they are difficult to see and tend to congregate. Consequently, only fish greater than 25 mm in length are counted. Reference specimens and difficult to identify individuals are placed in jars containing 10 percent formaldehyde and later confirmed at the laboratory using taxonomic keys (Werner 1980; Eddy and Underhill 1983; Smith 1985; Page and Burr 1991; Jenkins and Burkhead 1993). Species particularly difficult to identify are forwarded to fisheries experts outside the Bureau of Freshwater and Biological Monitoring for confirmation (at present, the Philadelphia Academy of Natural Sciences).

MEASUREMENT OF PHYSICAL AND CHEMICAL PARAMETERS

Physical and chemical measurements (e.g. pH, conductivity, temperature, dissolved oxygen, depth, and flow) of existing stream conditions are recorded on physical characterization/water quality field data sheets and later summarized.

HABITAT ASSESSMENT

Habitat assessments are conducted at every sampling site and all information is recorded on field sheets (Barbour et al. 1999). Habitat assessments provide useful information on probable causes of impairment to instream biota when water quality parameters do not indicate a problem. The habitat assessment consists of an evaluation of the following physical features along the 150 meter reach: substrate, channel morphology, stream flow, bank stability, canopy, and stream side cover. Individual parameters within each of these groups are scored and summed to produce a total score, which is assigned a habitat quality category (see Appendix 3).

QUALITY ASSURANCE/QUALITY CONTROL

A Quality Assurance/Quality Control plan is approved by the DEP Office of Quality Assurance prior to sampling. A copy of this plan is available by contacting the BFBM.

CALCULATING THE IBI[2]

Once the fish from each sample collection have been identified, counted, examined for disease and anomalies, and recorded, several biometrics are used to evaluate biological integrity. Fish assemblage analysis is accomplished using a regional modification of the original IBI (Karr 1981), developed by Kurtenbach (1994). Consistent with Karr et al. (1986), a theoretical framework is constructed of several biological metrics that are used to assess a fish assemblage's richness, trophic composition, abundance and condition, and compared to fish assemblages found in regional reference streams.[3, 4] The modified IBI uses the following 10 biometrics:
1) total number of fish species, 2) number of benthic insectivorous species,
3) number of trout and sunfish species, 4) number of intolerant species, 5) proportion of individuals as white suckers, 6) proportion of individuals as generalists (carp, creek chub, goldfish, fathead minnow, green sunfish and banded killifish), 7) proportion of individuals as insectivorous cyprinids, 8) proportion of individuals as trout or proportion of individuals as piscivores (top carnivores) - excluding American eels, 9) number of individuals in the sample and 10) proportion of individuals with disease or anomalies, excluding blackspot disease (see Appendices 1 and 2).

Quantitative scoring criteria were developed for each biometric based upon the degree of deviation; 5 (none to slight), 3 (moderately), and 1 (significantly) from appropriate ecoregional reference conditions. Scores for the individual biometrics at each sampling location are summed to produce a total score, which is then assigned a condition category. The maximum possible IBI score is 50, representing excellent biological integrity. A score of less than 29 indicates a stream has poor biological integrity. 10 is the lowest score a site can receive. Further descriptions of all of the metrics used in the IBI calculations are presented below:

SPECIES RICHNESS AND COMPOSITION

Four biometrics require the use of Maximum Species Richness (MSR) lines. MSR lines relate species richness to stream size and environmental quality. For streams with drainage areas over 5 square miles in northern New Jersey, species richness is expected to increase with higher environmental quality. Additionally, in a stream with a given level of environmental quality, species richness should increase with stream size. Thus, large sized streams with good water quality should have significantly more species than a small stream with good water quality. MSR lines (See Appendix 3) were developed to show the relationship between species richness and waterbody size in New Jersey. Using the procedure described in Karr et al. (1986), MSR lines for each richness metric were drawn by Kurtenbach (1994) with slopes fit by eye to include 95% of the data points. The area under the MSR line is trisected by two diagonal lines.

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[2] Narrative for this section taken largely from Kurtenbach (1994)
[3] For regional reference conditions Kurtenbach (1994) used historical fisheries data collected by the New Jersey Division of Fish, Game and Wildlife (unpublished) at 126 stream sites located in the Delaware, Passaic, and Raritan River watersheds. The fish collection methods and the stream lengths sampled in these historical studies were compatible with Kurtenbach's work.
[4] Trophic guilds, pollution tolerances and origins (native or introduced) of each fish species utilized by Kurtenbach to calculate the IBI were assigned using several fisheries publications (Stiles, 1978: Smith, 1985; Hocutt et al. 1986; Karr et al. 1986; Ohio EPA, 1987; Miller et al. 1988).

Points located near the MSR line represent species richness approaching that expected for an unimpacted stream. Points falling within the lowest trisected area, furthest from the MSR line, represent the greatest deviation from an ecoregional reference condition. For example, using the "total number of fish species" graph in Appendix 3, a sample collection resulting in the capture of five total fish species in a stream with a drainage area of 10 square miles, would receive a score of three and have an intermediate deviation from the expected condition.

1. Total number of fish species:

This metric is simply a measure of the total number of fish species identified from a sample collection. A reduction of taxonomic richness may indicate a pollution problem (e.g., organic enrichment, toxicity) and/or physical habitat loss. Fish species with the least tolerance to environmental change, typically are the first to become absent when water degradation occurs. Although freshwater fish species richness in New Jersey is less than half that of the Midwest region where the IBI was first developed (Karr et al. 1986; Ohio EPA 1987; Lyons 1992), effectiveness of this metric is comparable to regions with richer fish faunas.

2. Number of benthic insectivorous species:

This metric is a modification of several metrics used in the original IBI (Karr 1981). Darter and sucker species make up a relatively small component of the New Jersey fish fauna. However, several other benthic species require clean gravel or cobble substrate for reproduction and/or living space. Degradation of this habitat from siltation is often reflected by a loss of benthic species richness (Karr et al. 1986) and abundance (Berkman and Rabeni 1987). Several benthic fish require quiet pool bottoms and may decline when benthic oxygen depletion occurs (Ohio EPA 1987). Further, reductions of some benthic insectivorous fish may indirectly indicate a toxics problem. Benthic macroinvertebrates are an important food source for benthic insectivorous fish and their sessile mode of life make them particularly susceptible to toxicant effects.

3. Number of trout and sunfish species:

This metric was adopted as a hybrid for warmwater and coldwater streams. The metric is similar to that used in a combined coldwater-warmwater version of an IBI developed in Ontario (Steedman 1988), but designed for high-gradient rather than low gradient streams. Both sunfish and trout are water-column species sensitive to habitat degradation and loss of instream cover (Gammon et al. 1981; Angermeier 1983). In coldwater streams where sunfish are typically absent, trout fill a similar ecological niche and may be used to replace sunfish. Trout are equally, if not more sensitive to habitat degradation. The relationship between trout populations and habitat is well documented (Peters 1967; Hunt 1969; Meehan 1991).

4. Number of intolerant species:

This metric provides a measure of fish species most sensitive to environmental degradation. The absence of some fish species occurs with subtle environmental changes caused by anthropogenic disturbances. Fish species assigned as intolerant should have historical distributions significantly greater than presently occurring populations and be restricted to streams that have exceptional water quality (Karr et al. 1986).

5. Proportion of individuals as white suckers:

The white sucker has been chosen to replace green sunfish as a more regionally appropriate tolerant species in the northeast (Miller et al. 1988; Langdon 1992). In New Jersey, the white sucker is commonly found in small and large streams representing a wide range of water quality conditions. White suckers adapt well to changing environmental conditions and often become dominant at disturbed sites. This metric is generally useful in distinguishing moderately and severely impaired conditions.

TROPHIC COMPOSITION

Trophic composition metrics, unlike the richness metrics, are scored based on a percentage of the total numbers of individual fish captured. The influence of stream size on trophic composition has not been determined for New Jersey streams. However, in Illinois and Wisconsin streams (Karr 1981; Lyons 1992), trophic composition was not strongly influenced by stream size. Based on these findings, fixed scoring criteria are used on all stream sizes found in New Jersey, with the exception of large rivers.

6. Proportion of individuals as generalists (carp, creek chub, goldfish, fathead minnow, green sunfish and banded killifish):

This metric replaces the omnivore metric used in the original IBI (Karr 1981). Use of the omnivore metric was determined to be inappropriate in New Jersey because omnivores are naturally depauperate. Generalists, as defined here, are species with flexible feeding strategies and broad habitat requirements. Often a shift from predominantly specialist groups to generalist groups occurs as water quality becomes degraded (Leonard and Orth 1986; Ohio EPA 1987). Due to broad feeding and habitat requirements, species included for use in this metric are considered tolerant of environmental degradation.

7. Proportion of individuals as insectivorous cyprinids:

Like many streams found in North America, cyprinids are the dominant insectivorous fish in New Jersey (excluding Pineland streams). A shift from specialized invertebrate feeders to generalists with flexible foraging behaviors often indicates poor conditions associated with water quality and/or physical habitat degradation (Karr et al. 1986). Similar to the benthic insectivore metric, insectivorous cyprinids in some instances, may indirectly measure the effects of toxicity.

8. Proportion of individuals as trout or proportion of individuals as piscivores (top carnivores) - excluding American eel (whichever gives higher score):

Streams with slight or moderate water quality impairment generally contain several top predator fish species. In cold water streams of New Jersey, predator fish such as bass and pickerel are depauperate and typically replaced by trout. Thus, a metric is required which measures both groups of top carnivores. A metric fulfilling this requirement is currently used on Vermont streams (Langdon 1992) and has been adopted for use in New Jersey. American eels are excluded from use in this metric. The ubiquity of American eels in streams that have a wide range of water quality and habitat conditions, limits their use as an indicator of aquatic health.

FISH ABUNDANCE AND CONDITION

9. Numbers of individuals in the sample:

This metric measures the abundance of fish captured from a specified area or stream reach and is used to distinguish streams with severe water quality impairment. Like the original IBI (Karr 1981), catch per unit effort is used to score this metric. Severe toxicity and oxygen depletion are examples of perturbations often responsible for extremely low fish abundances.

10. Proportion of individuals with disease or anomalies (excluding blackspot disease):

This metric provides a relative measure of the condition of individual fish. Similar to metric nine, this metric is especially useful in distinguishing streams with serious water quality impacts. This metric is intended to detect impacts in streams highly contaminated by chemicals. A significant relationship between the incidence of blackspot disease and environmental quality has not been established for New Jersey streams. As a result, blackspot disease is excluded from use in this metric (Figure 3).

Figure 3. Multiple fish species from the same stream affected by blackspot disease.

RESULTS

In 2004, the fifth and final year of the first round of sampling, 20 sites were sampled. Six sites were rated “excellent”, six were “good”, eight were “fair” and none were “poor” (Figure 4). The habitat ratings for the 2004 sites consisted of four sites with “optimal” habitat, fifteen “sub-optimal” and one site with “marginal” habitat.

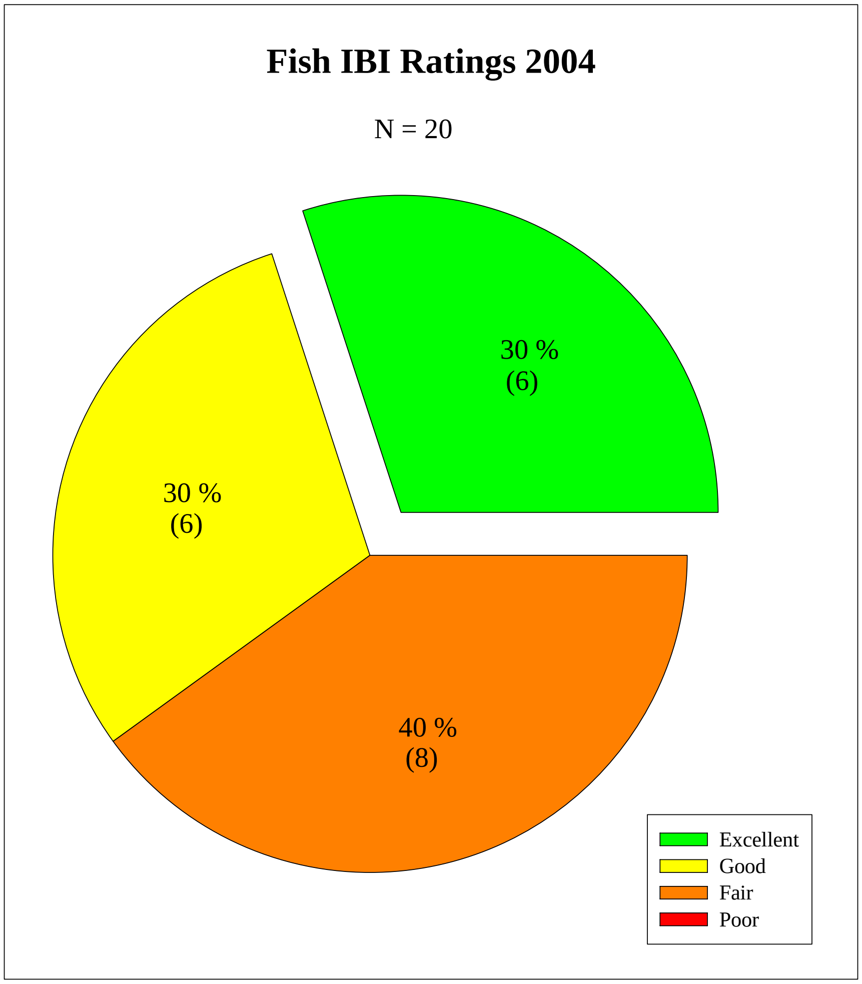

Figure 4. Summary of the 2004 ratings for 20 sites in northern New Jersey.

DISCUSSION OF 2004 RESULTS

The fish IBI monitoring network is one of the Department's newer rapid bioassessment protocols, designed to detect impacts to biological communities - in this case, fish assemblages. When impacts are suspected, additional investigation would be warranted. This can be accomplished with either more intensive field surveys and sampling, or a desk review of other Department records, or a combination of both. For purposes of discussion here, impacts are suspected at sites with a FIBI rating of "fair". Sites with an FIBI rating of "poor" are considered to be impacted significantly enough that, for purposes of the Department's Water Quality Monitoring and Integrated Assessment Report [IA](40 CFR 130.7 and N.J.A.C. 7:15-6 f), they will be categorized as "impaired". It is important to note that the use attainment status of the overall biological community is based upon a suite of indicators which include fish and benthic macroinvertebrate communities, and associated physical/chemical data.

In this round of sampling, suspected impacts were found at eight (8) sites (FIBI 082, 083, 084, 085, 090, 091, 092, 096); no impaired sites were identified in 2004 (Figure 5; Table 3). The drainage size calculation was revised using GIS following the 2004 sampling season. This resulted in the elimination of 3 sites, including one classified as "fair" (FIBI085) and two classified as "good" (FIBI094 and FIBI097), due to a drainage size less than 5 square miles. The data from these three sites has been included in the report, but will not be used in future analysis or monitoring.

Those sites with suspected impacts all had sub-optimal habitat ratings and many have high percent urban land cover/use within their contributing watershed. Increasing urbanization has been shown to result in a reduction, and even loss, of sensitive fish species, an increased rate of native species replacement by introduced species, as well as a general decline in species richness and abundance (Wang & Lyons, 2003). The following is a discussion of possible causes for the suspected impacts.

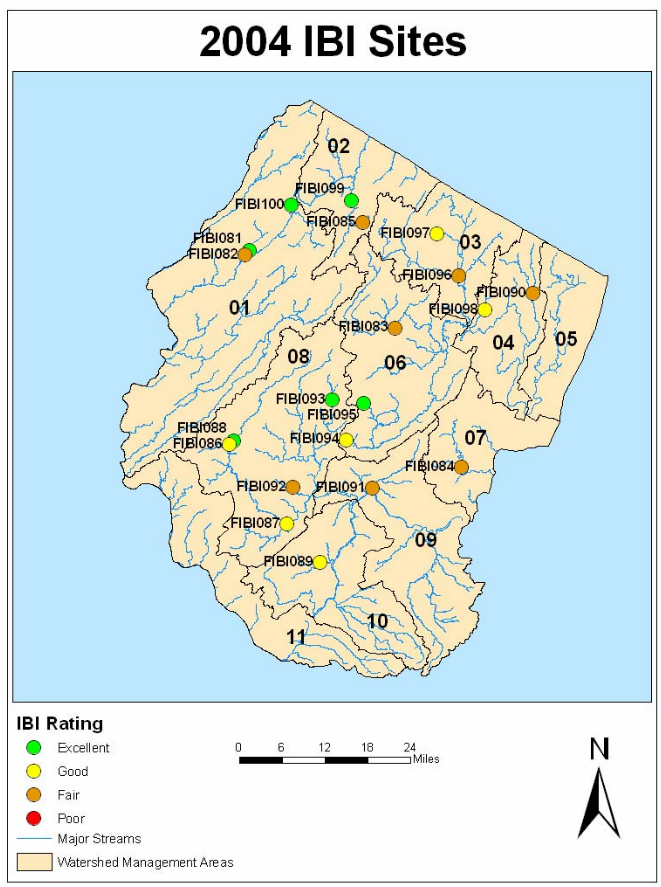

Figure 5. Location of 2004 Fish IBI sites.

Table 3. Results of 2004 Fish IBI sampling[1].

FIBI Site	Waterbody	County	Habitat Rating	IBI Score	IBI Rating
FIBI081	Troy Brook	Sussex	Suboptimal	46	Excellent
FIBI082	Paulins Kill	Sussex	Suboptimal	36	Fair
FIBI083	Rockaway River	Morris	Suboptimal	36	Fair
FIBI084	Robinsons Brook	Union	Suboptimal	34	Fair
FIBI085*	Franklin Pond Creek	Sussex	Optimal	34	Fair
FIBI086	Raritan River S.B.	Hunterdon	Suboptimal	42	Good
FIBI087	Nashanic River	Somerset	Suboptimal	40	Good
FIBI088	Raritan River S.B.	Hunterdon	Suboptimal	46	Excellent
FIBI089	Beden's Brook	Somerset	Suboptimal	40	Good
FIBI090	Saddle River	Bergen	Suboptimal	30	Fair
FIBI091	Green Brook	Middlesex	Suboptimal	36	Fair
FIBI092	Holland Brook	Hunterdon	Suboptimal	34	Fair
FIBI093	Raritan River N.B.	Morris	Optimal	48	Excellent
FIBI094*	Dead River	Somerset	Optimal	38	Good
FIBI095	Passaic River	Morris	Optimal	48	Excellent
FIBI096	Wanaque River	Passaic	Suboptimal	30	Fair
FIBI097*	West Brook	Passaic	Suboptimal	42	Good
FIBI098	Preakness Brook	Passaic	Marginal	42	Good
FIBI099	Walkill River	Sussex	Suboptimal	46	Excellent
FIBI100	Dry Brook	Sussex	Suboptimal	46	Excellent

[1]Sampling maps and data for each site can be found in volume 2 of this report.
*Sites were dropped from future FIBI monitoring due to drainage < 5 sq. miles.

Paulins Kill - FIBI082

Although the source of the suspected impact at the Paulins Kill site (FIBI082) is unclear, habitat and substrate alterations have likely altered the fish community within the reach. Flooding has reduced the bank stability of both banks and increased the fine sediment load in the stream. The habitat survey conducted in August 2004 noted a high degree of embeddedness (50-75%), slightly turbid water clarity, high conductivity, and substrate composed mainly of fine sediments (60%); fine sediments can smother benthic organisms and can be detrimental to the aquatic life of a stream. This stretch also lacked riffle habitat, which can effectively reduce fish diversity and species richness. Overall fish abundance, species richness, and abundance of benthic species were relatively high, indicating water clarity did not hinder sampling efficiency. Species diversity[5], on the other hand was relatively low (H` = 1.75), as the sample was dominated by two species, white sucker (*Catostomus commersoni*) and tessellated darter (*Etheostoma Olmstedi*), which can be an indication of population imbalance.

[5] The Shannon Diversity Index (H`) is an ecological index which is based on species richness and evenness in the community. A value of 0 indicates only one species is present and a maximum value indicates all species are represented by the same numbers of specimens (Ludwig and Reynolds 1988).

Although some habitat and water quality impacts are evident, a total of 40 intolerant specimens were collected including margined madtom (*Noturus insignis*) and cutlips minnow (*Exoglossum maxillingua*) which are both indicative of good water quality. The dominant abundance of white suckers which are a tolerant species able to thrive under adverse conditions, the lack of insectivorous cyprinids, and low piscivore abundance reduced the overall score and indicates some level of community imbalance. Stream restoration, including bank stabilization methods would help reduce sediment loading which may enhance the fish community.

Rockaway River – FIBI083

The Rockaway River has likely been impacted by a combination of habitat degradation and some urbanization (29%). The stream lacks adequate bank vegetation and riparian buffer, leaving this stretch of river susceptible to erosion and anthropogenic disturbances. Riparian buffers as little as 10-30 m wide have proven effective in reducing the transport of fine sediments and nutrients (Karr and Schlosser 1978). The stream is characterized by low flow and lacks riffle habitat; the habitat rating was sub-optimal habitat. The lack of overhead cover and riffle habitat can increase the amount of light penetration in streams (Allan 1995), which has likely led to the moderate periphyton growth and warm water temperature.

The fish community within this stretch of the Rockaway River is reflective of the aforementioned habitat and water quality impacts. Overall fish abundance, richness, and species diversity (H` = 1.30) were low; in addition no insectivorous cyprinids were collected. The loss of specialized feeders, such as insectivorous cyprinids, often is indicative of water quality or habitat degradation (Karr et al. 1986).

Ambient Biological Monitoring (AMNET) site AN0248, co-located with FIBI083 received a non-impaired rating in 1993 and 1998 and a moderately impaired rating in 2003. In addition, the site received a sub-optimal habitat rating in 1998 and an optimal rating in 2003. In 2003, the dominant taxon increased significantly compared to previous years, as riffle beetles (Elmidae) comprised 62 percent of the sample. In addition, the number of EPT taxa which are typically indicative of good water quality, exhibited a sharp decline compared to previous surveys.

Robinson's Brook – FIBI084

The fish assemblage at Robinson's Brook lacked several trophic guilds and no intolerant species were collected. The cause of the depauperate fish assemblage is likely the influence of urbanization, as 78% of the surrounding watershed land cover/use is urban. The site received a sub-optimal habitat score, despite having a good mixture of riffles, runs, and pools; in addition, the site also had good substrate composition consisting of 46% gravel/sand and 48% cobble. The stream banks did show signs of instability, although sediment run-off and substrate embeddedness were not observed. Although the riparian buffer zone is narrow, the stream did have good overhead cover (in addition to good flow), which limits light penetration and can decrease stream temperatures (Barton et al. 1985). The relatively warm water temperature and low dissolved oxygen concentration observed in mid-July are more likely a result of a warm water discharge from an upstream impoundment (Middlesex Reservoir). The reservoir is located approximately 1.5 miles upstream of the sample location and could not only be the cause of warm water temperatures and low dissolved oxygen during summer, but could influence downstream fish assemblages as a result of the passage of lentic species over the spillway (Figure 6).

Figure 6. The location Middlesex Reservoir in relation to FIBI084.

Overall, fish abundance and species diversity (H` = 1.92) were high, but species richness was relatively low. The sample was dominated by a catadromous species, American eel (*Anguilla rostrata*), while the remaining fish community consisted mainly of warmwater (redbreast sunfish *Lepomis auritus*, pumpkinseed *Lepomis gibbosus*, largemouth bass *Micropterus salmoides*) and generalist (green sunfish *Lepomis cyanellus*, banded killifish *Fundulus diaphanus*, goldfish *Carassius auratus*) species, which may be an influence of Middlesex Reservoir. Several metrics are indicative of a depauperate fish community, including the low abundance of intolerant species, insectivorous cyprinids, and piscivores.

An Ambient Biological Monitoring site, AN0199 is located approximately .23 miles downstream of the Fish IBI sampling location. This site has received moderately impaired ratings (1992, 1999, & 2004) along with sub-optimal habitat ratings. Throughout the AMNET monitoring at this site, the dominant taxa collected consisted of species typically found below large impoundments including members of Hydropsychidae, Asellidae, and Gammaridae.

Franklin Pond Creek – FIBI085

A refinement of the drainage calculation using GIS resulted in elimination of Franklin Pond Creek (FIBI085) from the Fish IBI Monitoring Program. Although the data has been included as part of this report, the Northern New Jersey Fish IBI was not developed for streams with a drainage less than 5 square miles and it is likely that the resulting score is not indicative of the fish assemblage and water quality of the creek.

Saddle River - FIBI090

The "Fair" Fish IBI rating for Saddle River is reflective of human impacts in the region, as 99.9 percent of the land use/cover is urban. Throughout most of the stretch, the eastern bank is bordered by housing developments which can increase the discharge of nutrients and pollutants into the stream via run-off during storm events. In addition, a small impoundment is adjacent to the southeastern portion of this stretch of river (Figure 7). While conducting sampling in late July, a period in which stream flows are typically low, we noted water flowing from the impoundment into the Saddle River.

Figure 7. Location of an impoundment in relation to FIBI090.

The habitat rating for this stretch of river is sub-optimal and consists of mainly slow runs with few riffles. There is some evidence of erosion on both banks along with sediment deposition in the form of sand and gravel bars. In addition, rock revetment has been used to stabilize the left descending bank. Despite clear water clarity and a lack of siltation, the conductivity was high (442 μmhos) and heavy periphyton growth was observed, which can be indicative of excessive nutrient inputs.

White suckers, a species tolerant of disturbance and degradation, was the most abundant species collected comprising 45 percent of the total catch; fish abundance and richness were high, but species diversity was relatively low (H` = 1.60). Several brown trout (*Salmo trutta*), a species sensitive to disturbances and degradation, were collected in the young-of-the-year and age 1+ size range (70-100 mm), indicating adequate water quality and substrate for survival and reproduction. This section of the Saddle River lacked trophic diversity, as the number of insectivorous cyprinids and piscivores were limited, which is an indication of trophic imbalance. The observed impacts to the stream appear complex and restoration would be difficult due to the surrounding land use.

Green Brook - FIBI091

Suspected impacts at Green Brook are likely related to a high percent urban use (70.8 %) of the surrounding watershed. In addition to urban impacts, this site received a sub-optimal habitat rating and lacks stream habitat diversity, as the site is comprised mainly of pool habitat (60%). Evidence of water quality impacts include turbid water clarity, high conductivity (480mmhos/cm), high fine sediment composition (60%), and heavy periphyton growth. Heavy algal growth may have contributed to the dissolved oxygen concentration near saturation (86%) at the time of sampling, but could rapidly decline at night. Bank erosion was evident on both banks which can add to the sediment load, the amount of sediment deposition, and the degree of embeddedness (Figure 8).

Figure 8. Turbidity and sediment deposition in Green Brook.

The overall fish abundance and species richness were high, but the species diversity was relatively low. The system was dominated by cyprinids, American eels, and benthic species. The fish community lacked intolerant species and piscivores, which may be a result of the habitat and water quality impacts. The high fine sediment load in the stream may be impacting the local fish community, as simple lithophilic spawning species are susceptible to siltation (Berkman and Rabeni 1987; Ohio EPA 1987).

An ambient biological monitoring site (AN0426) is located 0.34 miles upstream of the Fish IBI location. This site received a severe rating in 2004 and a marginal habitat rating. The macroinvertebrate assemblage was dominated (72%) by blood red chironomids, an indicator of poor water quality. These members of the subfamily Chironominae are typically found in systems devoid of oxygen, an indication that nocturnal dissolved oxygen concentrations may be low or fine sediments may be smothering other macroinvertebrates.

<u>Holland Brook - FIBI092</u>

This section of Holland Brook appears to have some impacts as a result of human activities. Almost one third of the land use in the surrounding watershed is urban (31%), along with agricultural (27.5%) and forested (36.4%) land use/cover. Human impacts are evident in this stretch with an active storm water outfall flowing into the stream on the left descending bank along with abundant amounts of debris (car parts, tires, etc.). Several discharges are present within the sample stretch and downstream of the sample location (Figure 9). The slightly turbid water clarity observed on July 14, 2004, is likely a result of a recent storm event and discharge from storm water outfalls (Figure 10). The substrate in this section consists of a large percentage of fine sediment (45%), which are likely dispersed throughout the water column during high flow events. The habitat was rated as sub-optimal with substrate prone to disturbance and removal, along with some bank erosion on the right descending bank. In addition, shallow slow runs comprise the majority of the habitat within the stretch, with few deep pools or riffles.

Figure 9. Active storm water outfall in Holland Brook.

Figure 10. Turbidity shown along with the predominant run habitat in Holland Brook.

Overall, fish species richness and diversity were relatively high. Evidence of some impacts to the fish community are evident in several metrics, including the proportional dominance of white suckers (36%) (the regional tolerant species), and the low proportional abundance of insectivorous cyprinids. The low proportional abundance of insectivorous cyprinds is likely a result of the lack of riffle habitat and habitat diversity, low flow, and high fine substrate composition within the sample stretch. Although some habitat and water quality degradation is apparent, a single brook trout (*Salvelinus fontinalis*) was collected. The specimen appeared to be either wild or a holdover fish, which is indicative of adequate water quality to allow year-round survival of this sensitive species.

Ambient Biological Monitoring site AN0343, located 2.7 miles downstream of the Fish IBI site, received a non-impaired rating in 1994 and moderately impaired ratings in 1999 and 2004. The dominant taxa for this site shifted from mayflies in 1994 to worms and midges in 1999 and 2004. In addition, the percent EPT taxa exhibited a sharp decline from 66% in 1994 to 19% in 1999 and 6% in 2004, further indicating a potential water quality impairment. The habitat for AN0343 was rated as marginal in 1999 and sub-optimal in 2004.

Wanaque River - FIBI096

The source of suspected impacts at the Wanaque River site is unclear, but an upstream impoundment (Lake Inez) likely influences the habitat, nutrient load, water chemistry, and fish/macroinvertebrate assemblages within this stretch. The site had adequate bank vegetation and overhead cover, as evidence of the land use in the surrounding watershed (97.8% forest). Although the site received a sub-optimal habitat rating and lacked adequate riffle habitat (Figure 11), the substrate consisted mainly of a good mixture of gravel/sand and cobble. The water clarity was slightly turbid and some fine sediments were identified in the reach.

The fish community contained few intolerant species and insectivorous cyprinids. Overall fish abundance, species richness, and species diversity did not indicate an impacted fish

Figure 11. The lack of riffle habitat in Wanaque River.

community, but the abundance of warmwater species is likely an influence of Lake Inez. The warmwater fish community and low IBI score reflect the lack of habitat complexity and flow regime.

AMNET site AN0257 is located 0.74 miles upstream and received a non-impaired rating in 1998 and moderately impaired ratings in 1990 and 2003. The habitat for this site received a sub-optimal rating in 1998 and a marginal rating in 2003. The family Hydropsychidae dominated all three rounds of sampling, as these caddisflies comprised 72% of the 2003 sample. These net spinning caddisflies are commonly found below impoundments, which substantiates the influence of Lake Inez.

SUMMARY OF RESULTS FROM THE FIRST MONITORING CYCLE (2000-2004)

The close of the 2004 sampling season marks the completion of the first round of Fish IBI sampling (Figure 12). Round 1 sampling of the 100 site FIBI network resulted in 20 “Excellent”, 48 “Good”, 30 “Fair”, and 2 “Poor” sites (Figure 13). The observed impacts and potential impacts often appear related to the habitat quality and the land use/land cover of the surrounding watershed. Vegetative cover and riparian buffers are important in maintaining natural stream function necessary to sustain a healthy stream community. Studies have demonstrated the adverse impacts to fish community structure and function as a result of loss of riparian cover due to agriculture and urbanization (Roth et al. 1996; Goldstein et al. 2002; Talmage et al. 2002). Linear regression analysis of NJ Fish IBI data indicates a positive linear relationship between Fish IBI and habitat scores (Figure 14). Similarly, Roth et al. (1996) found a direct correlation between fish IBI and habitat quality in the Midwest.

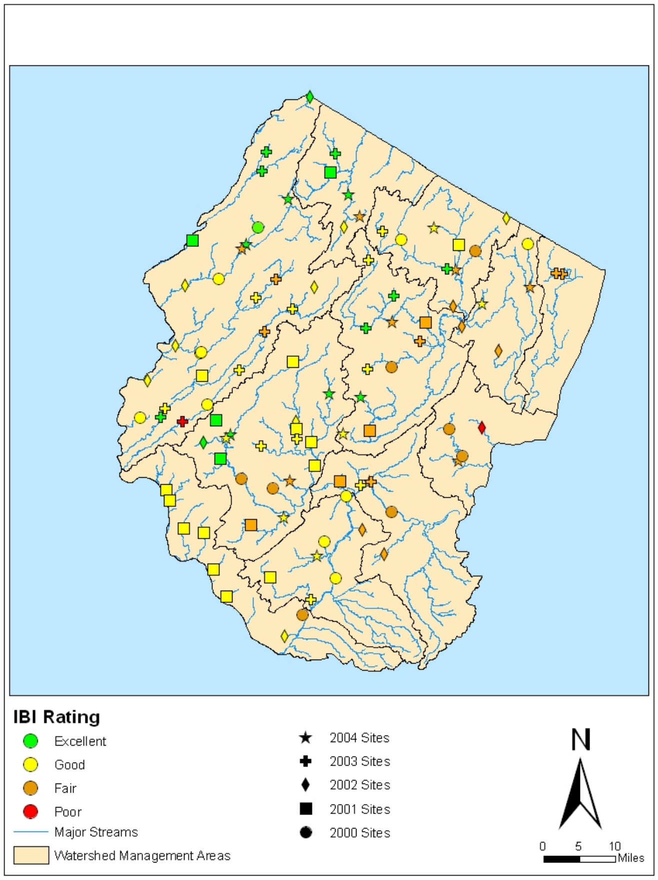

Figure 12. Location of Round 1 sites.

In addition, there is a significant inverse relation between the percent urban land use and Fish IBI score (Figure 15). Stream impacts resulting from urban land use can be complex in nature and difficult to discern. Urban impacts to a stream are wide ranging and include changes to stream hydrology, geomorphology, water temperature, water chemistry, fish communities, and macroinvertebrate communities. Analysis of data on the effects of urbanization on New England streams indicated degradation was most apparent in the following biotic metrics: EPT taxa for macroinvertebrates, cyprinid taxa for fish, and diatom taxa for periphyton (Coles et al. 2004). Water chemistry and stream habitat impacts were most apparent in levels of alkalinity, conductivity, nitrogen, water depth, and water temperature.

Preliminary analysis of the NJ Fish IBI data suggests several community metrics appear responsive to urbanization, including loss of trophic guilds and intolerant species. The most common trophic level changes include loss and often absence of top carnivores (piscivores) and insectivorous cyprinids.

Although an index of biotic integrity provides valuable input into the health of a lotic ecosystem, accurate interpretation of the data is essential. According to Angermeier and Karr (1986) " the IBI cannot be used in a "cookbook" fashion…When used in conjunction with measures of physical and chemical quality, it can provide a comprehensive evaluation of ecological integrity."

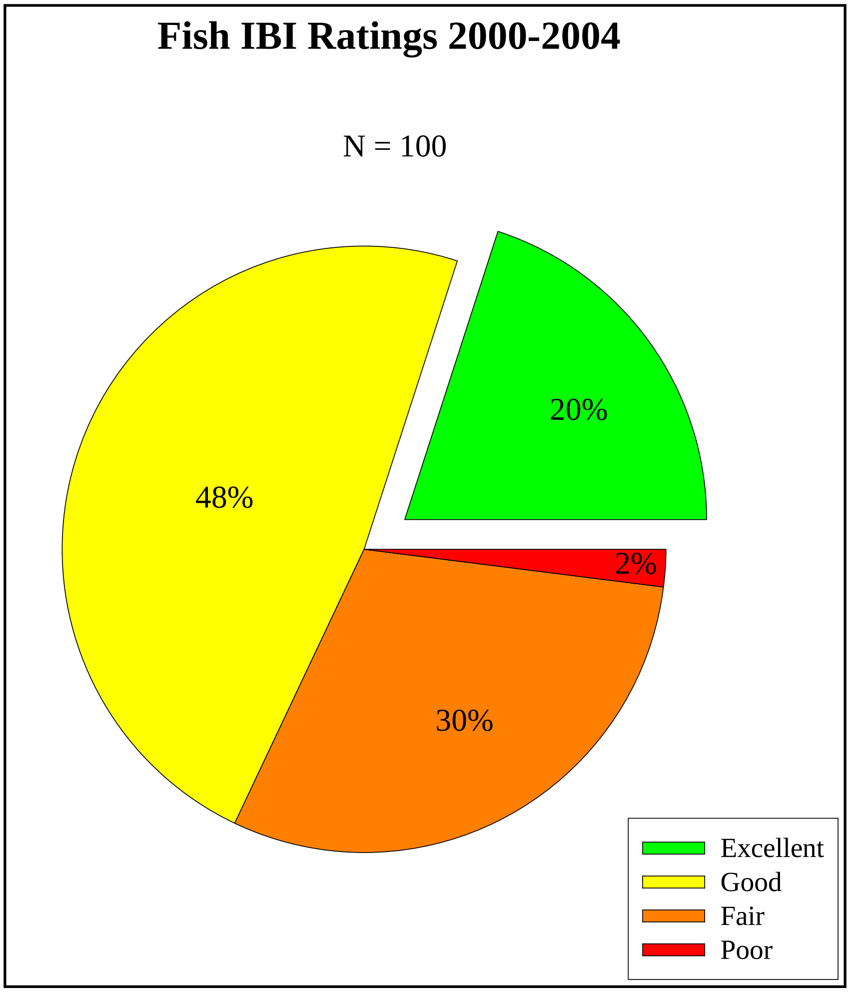

Figure 13. Summary of 1st round IBI ratings for 100 sites in northern New Jersey.

With the completion of Round 1, the Fish IBI Program will be evaluated to determine appropriateness in all northern ecoregions and to determine the need for recalibration. In an effort to determine the applicability of the Fish IBI Program in the Northern Piedmont Ecoregion, data will be analyzed to determine whether significant differences in fish community structure and function exist between regions. Should differences exist, land use/land cover will be analyzed to determine if these discrepancies are attributable to changes in land use/land cover. Recalibration involves analyzing each individual metric using Round 1 data to determine sensitivity to anthropogenic impacts and to evaluate scoring criteria.

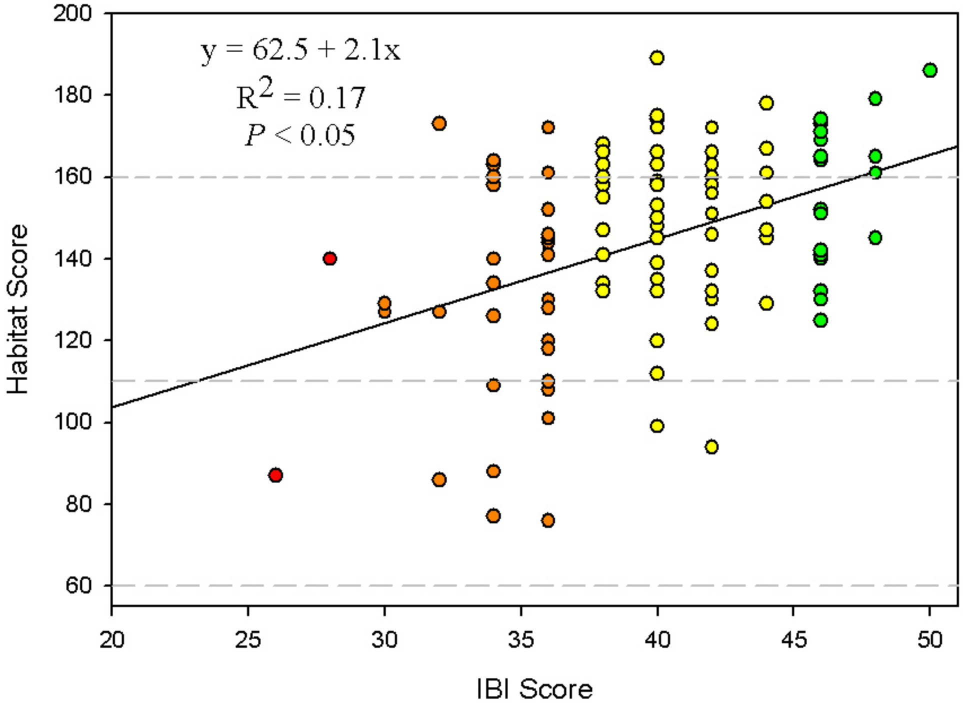

Figure 14. Linear regression comparing IBI and habitat scores.

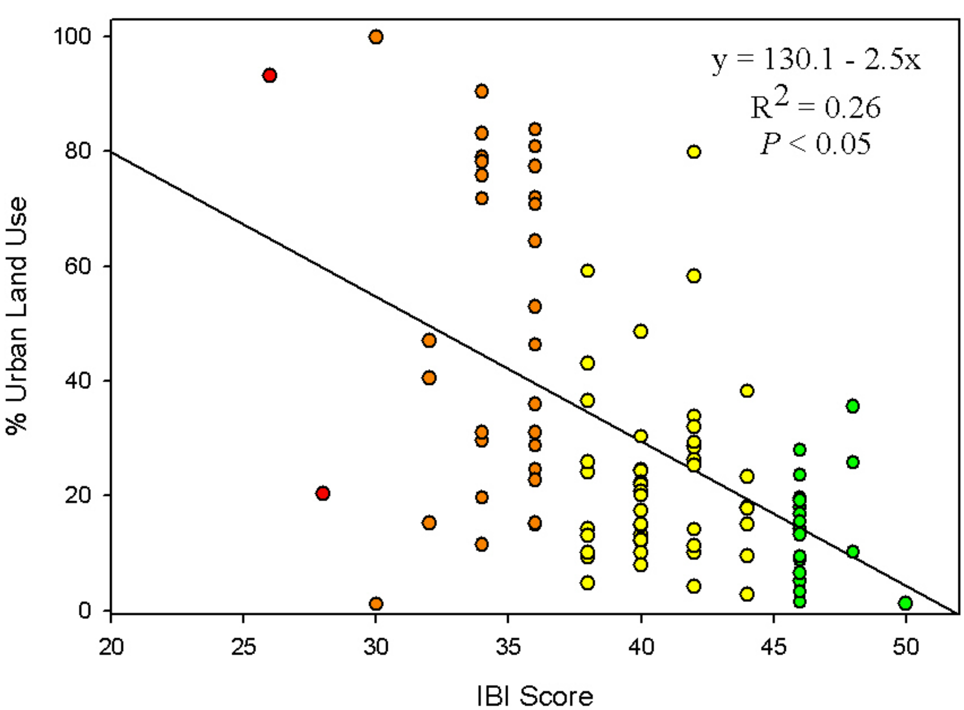

Figure 15. Linear regression comparing urban land use and IBI score.

FURTHER INFORMATION

The current report summarizes the fifth year of IBI sampling. The network established a total of 100 stations in northern New Jersey (an IBI for southern New Jersey is currently being evaluated). Stations will be visited every five years as part of the Bureau's monitoring efforts.

Reports and data for the first four years of the IBI can be obtained on the Bureau of Freshwater and Biological Monitoring's web page: http://www.state.nj.us/dep/wmm/bfbm/fishibi.html or by calling 609-292-0427.

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APPENDIX 1
Second Revised List of New Jersey Freshwater Fishes

	Trophic Guild	Tolerance	Historical Presence
Petromyzontidae:			
American Brook Lamprey (*Lampetra appendix*)	NF	IS	N
Sea Lamprey (*Petromyzon marinus*)	PF	--	N
Acipenseridae:			
Atlantic Sturgeon (*Acipenser oxyrhynchus*)	BI	--	N
Shortnose Sturgeon (*A. brevirostrum*)	BI	IS	N
Lepisosteidae:			
Longnose Gar (*Lepisosteus osseus*)	P	--	EX
Amiidae:			
Bowfin (*Amia calva*)	P	--	NN
Anguillidae:			
American Eel (*Anguilla rostrata*)	P	--	N
Clupeidae:			
Blueback Herring (*Alosa aestivalis*)	PL	--	N
Hickory Shad (*A. mediocris*)	I/P	--	N
Alewife (*A. pseudoharengus*)	PL	--	N
American Shad (*A. sapidissima*)	PL	--	N
Gizzard Shad (*Drosoma cepedianum*)	O	--	N
Salmonidae:			
Rainbow Trout (*Oncorhynchus mykiss*)	I/P	IS	NN
Brown Trout (*Salmo trutta*)	I/P	IS	E
Brook Trout (*Salvelinus fontinalis*)	I/P	IS	N
Lake Trout (*S. namaycush*)	P	--	NN
Osmeridae:			
Rainbow Smelt (*Osmerus mordax*)	I	--	N
Umbridae:			
Eastern Mudminnow (*Umbra pygmaea*)	I	--	N
Esocidae:			
Redfin Pickerel (*Esox americanus*)	P	--	N
Northern Pike (*E. lucius*)	P	--	NN
Muskellunge (*E. masquinongy*)	P	--	NN
Chain Pickerel (*E. niger*)	P	--	N
Cyprinidae:			
Goldfish (*Carassius auratus*)	O	--	E
Grass Carp (*Ctenopharyngodon idella*)	H	--	E
Satinfin Shiner (*Cyprinella analostana*)	I	--	N
Spotfin Shiner (*C. spiloptera*)	I	--	N
Common Carp (*Cyprinus carpio*)	O	--	E
Cutlips Minnow (*Exoglossum maxillingua*)	BI	IS	N
Eastern Silvery Minnow (*Hybognathus regius*)	H	--	N
Common Shiner (*Luxilis cornutus*)	I	--	N
Golden Shiner (*Notemigonus crysoleucas*)	O	--	N
Comely Shiner (*Notropis amoenus*)	I	--	N

	Trophic Guild	Tolerance	Historical Presence
Bridle Shiner (*N. bifrenatus*)	I	--	N
Ironcolor Shiner (*N. chalybaeus*)	I	--	N
Spottail Shiner (*N. husdonius*)	I	--	N
Swallowtail Shiner (*N. procne*)	I	--	N
Bluntnose Minnow (*Pimephales notatus*)	O	--	NN
Fathead Minnow (*P. promelas*)	O	--	NN
Blacknose Dace (*Rhinichthys atratulus*)	BI	--	N
Longnose Dace (*R. cataractae*)	BI	--	N
Creek Chub (*Semotilus atromaculatus*)	I	--	N
Fallfish (*S. corporalis*)	I	--	N
Cobitidae:			
Oriental Weatherfish *(Misgurnus anguillicaudatus)*	BI	--	E
Catostomidae:			
Quillback *(Carpiodes cyprinus)*	O	--	N
White Sucker (*Catostomus commersoni*)	BI	--	N
Creek Chubsucker (*Erimyzon oblongus*)	BI	--	N
Northern Hog Sucker (*Hypentelium nigricans*)	BI	IS	N
Ictaluridae:			
White Catfish (*Ameiurus catus*)	I/P	--	N
Black Bullhead (*A. melas*)	BI	--	NN
Yellow Bullhead (*A. natalis*)	BI	--	N
Brown Bullhead (*A. nebulosus*)	BI	--	N
Channel Catfish (*Ictalurus punctatus*)	I/P	--	NN
Tadpole Madtom (*Noturus gyrinus*)	BI	--	N
Margined Madtom (*N. insignis*)	BI	IS	N
Flathead Catfish *(Pylodictis olivaris)*	P	--	NN
Aphredoderidae:			
Pirate Perch (*Aphredoderus sayanus*)	I	--	N
Cyprinodontidae:			
Banded Killifish (*Fundulus diaphanus*)	I	--	N
Mummichog (*F. heteroclitus*)	I	--	N
Poeciliidae:			
Western Mosquitofish (*Gambusia affinis*)	I	--	NN
Eastern Mosquitofish (*G. holbrooki*)	I	--	N
Gasterosteidae:			
Fourspine Stickleback (*Apeltes quadracus*)	I	--	N
Threespine Stickleback (*Gasterosteus aculeatus*)	I	--	N
Ninespine Stickleback (*Pungitius pungitius*)	I	--	N
Moronidae:			
White Perch (*Morone americana*)	I/P	--	N
Striped Bass (*M. saxatilis*)	P	--	N
Centrarchidae:			
Mud Sunfish (*Acantharchus pomotis*)	I	--	N
Rock Bass (*Ambloplites rupestris*)	I/P	--	NN
Warmouth *(Chaenobryttus gulosus)*	I/P	--	NN

	Trophic Guild	Tolerance	Historical Presence
Blackbanded Sunfish (*Enneacanthus chaetodon*)	I	--	N
Bluespotted Sunfish (*E. gloriosus*)	I	--	N
Banded Sunfish (*E. obesus*)	I	--	N
Redbreasted Sunfish (*Lepomis auritus*)	I	--	N
Green Sunfish (*L. cyanellus*)	I/P	--	NN
Pumpkinseed (*L. gibbosus*)	I	--	N
Bluegill (*L. macrochirus*)	I	--	NN
Smallmouth Bass (*Micropterus dolomieu*)	I/P	--	NN
Largemouth Bass (*M. salmoides*)	P	--	NN
White Crappie (*Pomoxis annularis*)	I/P	--	NN
Black Crappie (*P. nigromaculatus*)	I/P	--	NN
Percidae:			
Swamp Darter (*Etheostoma fusiforme*)	BI	IS	N
Tessellated Darter (*E. olmstedi*)	BI	--	N
Yellow Perch (*Perca flavescens*)	I/P	--	N
Shield Darter (*Percina peltata*)	BI	IS	N
Walleye (*Sander vitreus*)	P	IS	NN
Cottidae:			
Slimy Sculpin (*Cottus cognatus*)	BI	IS	N

Abbreviations:

BI	Benthic Insectivore or Invertivore	IS	Intolerant Species
E	Exotic	N	Native
EX	Extirpated (no longer found in NJ)	O	Omnivore
NF	Nonparasitic filterer	P	Piscivore (top carnivore)
PF	Parasitic / Filterer	PL	Planktivore
H	Herbivore	NN	Non Native (introduced)
I	Insectivore		

APPENDIX 2
IBI for Northern New Jersey
(Metrics and Scoring Criteria)

	SCORING CRITERIA		
	5	**3**	**1**
SPECIES RICHNESS AND COMPOSITION:			
1) Total Number of Fish Species	VARIES WITH STREAM SIZE		
2) Number and Identity of benthic insectivorous species	VARIES WITH STREAM SIZE		
3) Number and identity of trout and/or sunfish species	VARIES WITH STREAM SIZE		
4) Number and identity of intolerant species	VARIES WITH STREAM SIZE		
5) Proportion of individuals as white suckers	<10%	10-30%	>30%
TROPHIC COMPOSITION:			
6) Proportion of individuals as generalists (carp, creek chub, goldfish, fathead minnow, green sunfish, banded killifish)	<20%	20-45%	>45%
7) Proportion of individuals as insectivorous cyprinids	>45%	20-45%	<20%
8) Proportion of individuals as trout	>10%	3-10%	<3%
OR (whichever gives better score)			
Proportion of individuals as piscivores (excluding American eel)	>5%	1-5%	<1%
FISH ABUNDANCE AND CONDITION:			
9) Number of individuals in the sample	>250	75-250	<75
10) Proportion of individuals with disease and anomalies (excluding blackspot disease)	<2%	2-5%	>5%

Condition Categories (modified from Karr et al. 1986)

45-50 Excellent Comparable to the best situations with minimal human disturbance: all regionally expected species for the habitat and stream size, most intolerant forms are present and there is a balanced trophic structure.

37-44 Good Species richness somewhat below expectation, especially due to the loss of some intolerant species; some species present with less than optimal abundances or size distributions; trophic structure shows some signs of stress (increasing frequency of generalists, white suckers and other tolerant species).

29-36 Fair Signs of additional deterioration include fewer species, loss of most intolerant species, highly skewed trophic structure (high frequency of generalists, whites suckers and other tolerant species); older age classes of trout and/or top carnivores may be rare.

10-28 Poor Low species richness, dominated by generalists, white suckers or other tolerant species, few (if any) trout or top carnivores, individuals may show signs of disease/parasites and site may have overall low abundance of fish.

Species to be included in each of the metrics used by the NJDEP:

Benthic Insectivores (Metric 2) – Sturgeon, Cutlips Minnow, Dace, Suckers, Bullheads, Madtoms, Darters and Sculpins

Trout* and Sunfish (Metric 3, 8) – All species in the families Salmonidae and Centrarchidae

Intolerant Species (Metric 4) – American Brook Lamprey, Shortnose Sturgeon, All Trout species, Cutlips Minnow, Northern Hog Sucker, Margined Madtom, Swamp Darter, Shield Darter, Walleye and Slimy Sculpin

Insectivorous Cyprinids (Metric 7) – All minnows (Family Cyprinidae) in the following genera: *Cyprinella, Exoglossum, Luxilus, Notropis, Rhinichthys* and *Semotilus*

Piscivores (Metric 8)[+]

* Streams that have been stocked with trout are sampled during July and August. Both stocked and resident trout found during these months are counted in the IBI scoring. The ability of a stream to support trout during these harsh months (high temperature, low dissolved oxygen) is indicative of good water quality and habitat.

[+]The current form of the New Jersey IBI (Kurtenbach 1994) requires the classification of fish species into trophic categories prior to scoring metric #8. However, many fish species fall into multiple categories as a function of size and life stage. Consequently, the bureau has used available literature (Turner and Kraatz, 1921; Keast and Webb, 1966; Goldstein, 1993), stomach content analysis (Margolis, unpublished data) and best professional judgement to designate trophic guilds for these species for the 2001 IBI. These designations, which only affect Metric #8, are as follows:

Green Sunfish	Insectivorous
Rock Bass	Insectivorous
Smallmouth Bass	> 90 mm - Piscivorous
Largemouth Bass	> 90 mm - Piscivorous
Yellow Perch	>150 mm - Piscivorous

Literature Cited

Goldstein, R.M. 1993. *Size selection of prey by young largemouth bass.* Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 47:596-604.

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Keast, A. and D. Webb. 1966. *Mouth and body form relative to feeding ecology in the fish fauna of a small lake, Lake Opinicon, Ontario.* J. Fish. Res. Bd. Canada. 23(12):1845-1874.

Kurtenbach, J.P. 1994. *Index of biotic integrity study of northern New Jersey drainages.* U.S. EPA, Region 2, Division of Environmental Science and Assessment, Edison, NJ.

Turner, C.L. and W.C. Kraatz. 1921. *Food of young large-mouth black bass in some Ohio waters.* Trans. Am. Fish. Soc. 50:372-380.

APPENDIX 3

IBI AND HABITAT SCORING SHEETS/GRAPHS

LABEL

IBI SCORING SHEET

Scorer 1	
Date	
Scorer 2	
Date	

Excellent Good Fair Poor

Excellent Good Fair Poor

	Scorer 1	Scorer 2
# of Fish Species		
# of Benthic Insectivorous Species (BI)		
# of Trout and Centrarchid Species (trout, bass, sunfish, crappie)		
# of Intolerant Species (IS)		
Proportion of Individuals as White Suckers		
Proportion of Individuals as Generalists (carp, creek chub, banded killifish, goldfish, fathead minnow, green sunfish)		
Proportion of Individuals as Insectivorous **Cyprinids** (I and BI)		
Proportion of Individuals as Trout OR Proportion of Individuals as Pisciviores (Excluding American Eel)*		
Number of Individuals in Sample		
Proportion of Individuals w/disease/anomalies (excluding blackspot)		
Total		

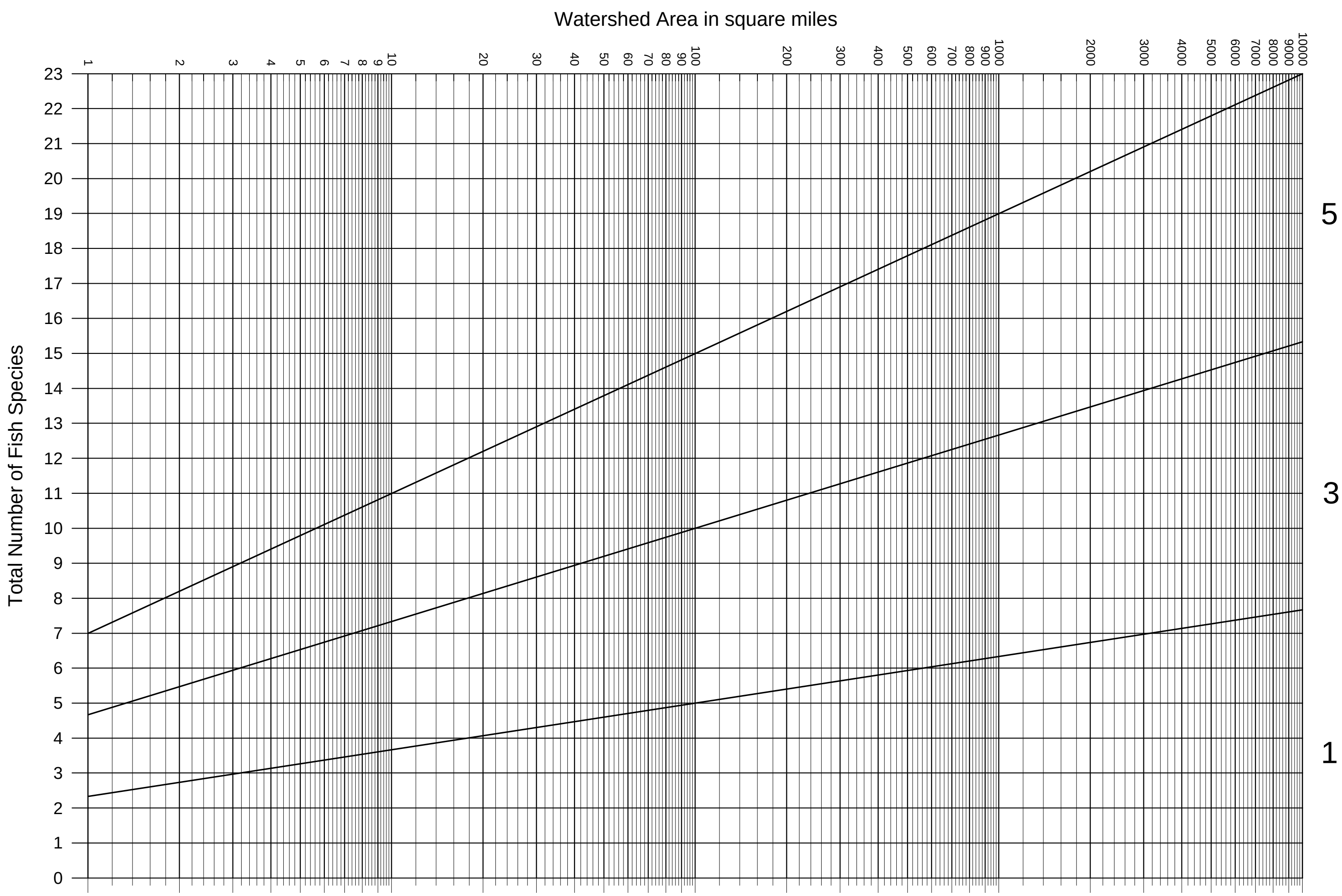
*whichever gives better score

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate /Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ______ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ______ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ______ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ______ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ______ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ______ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

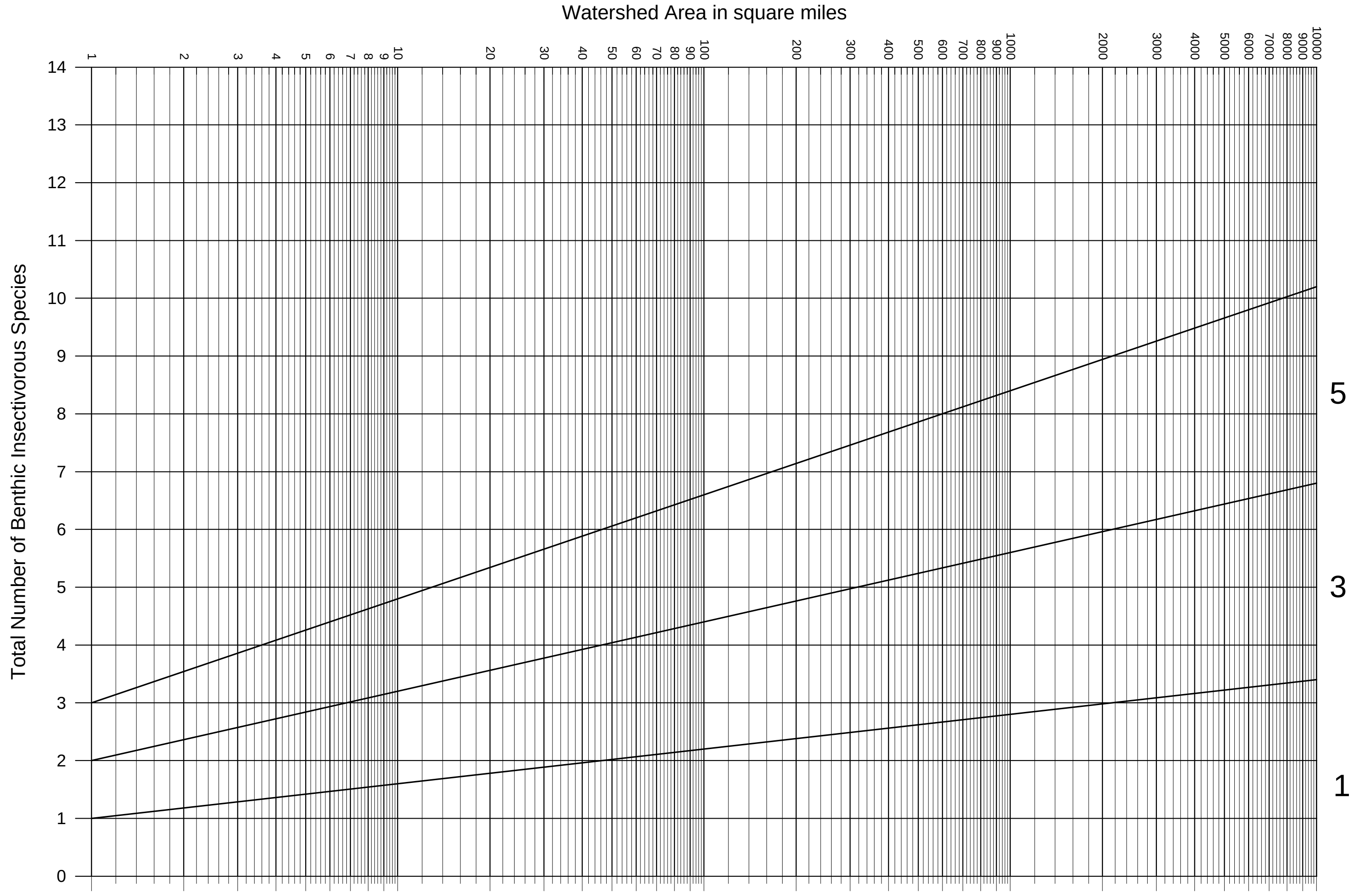
HABITAT SCORE

HABITAT SCORES	VALUE
OPTIMAL	160 X 200
SUB-OPTIMAL	110 X 159
MARGINAL	60 X 109
POOR	< 60

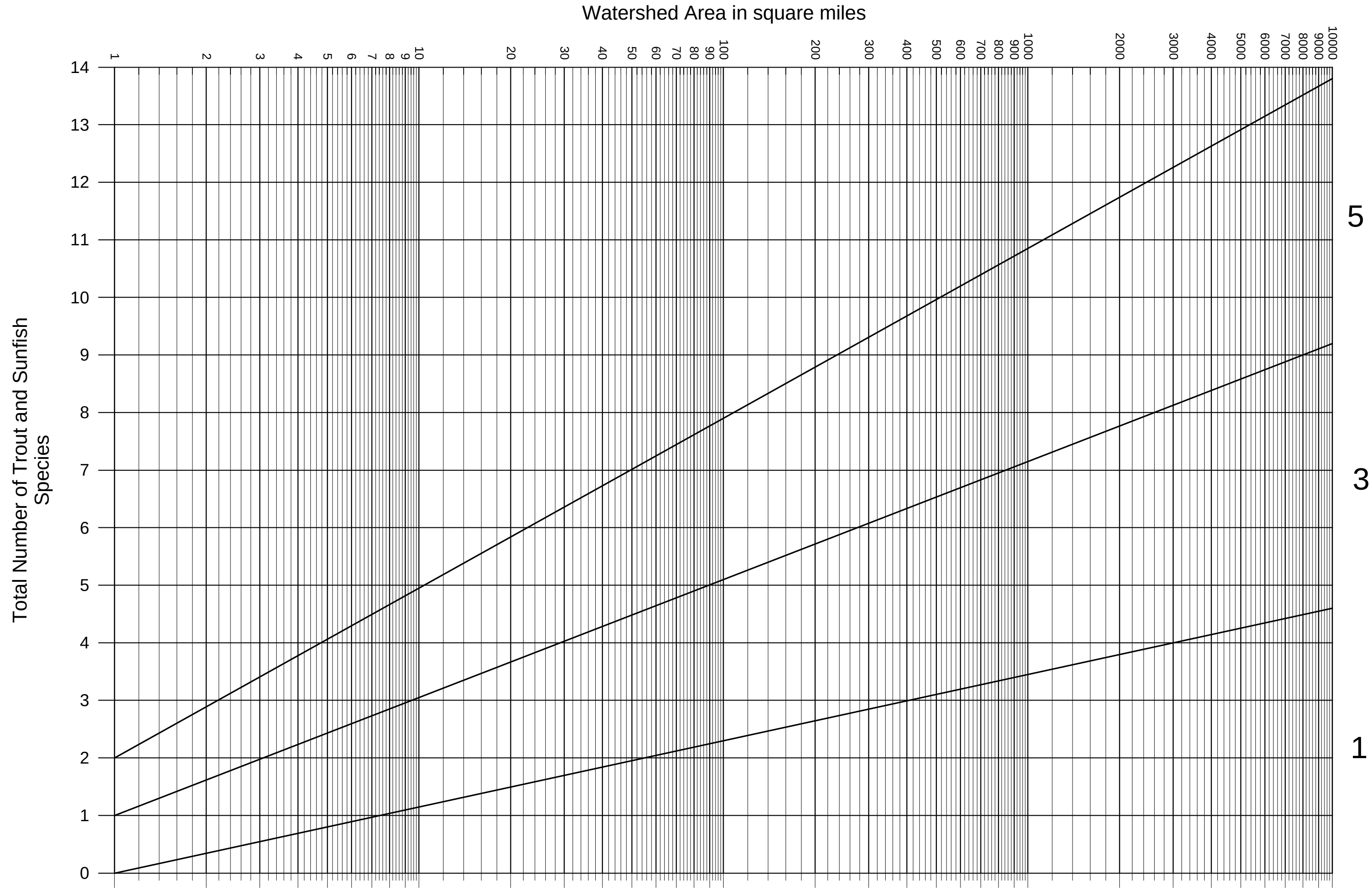
Total number of fish species versus watershed area for New Jersey ecoregion reference sites



Total number of benthic insectivorous fish species versus watershed area for New Jersey ecoregion reference sites



Total number of trout and sunfish species versus watershed area for New Jersey ecoregion reference sites



Total number of intolerant fish species versus watershed area for New Jersey ecoregion reference sites