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Jon S. Corzine, Governor

FISH IBI REPORT
2006 SAMPLING
Round 2, Year 2 of 5

Volume 1 of 2

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FISH IBI REPORT 2006 SAMPLING Round 2, Year 2 of 5

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.

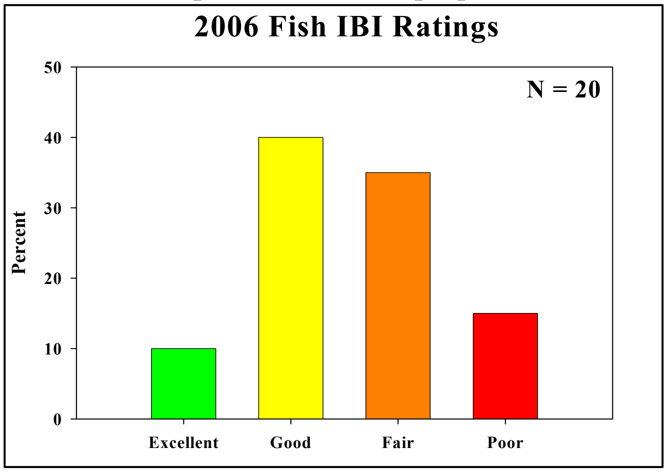
In order to address the limitations of chemical monitoring, DEP supplemented its chemical monitoring with biological monitoring which is based on the premise that biological communities are shaped by the long-term conditions of their environment and more accurately reflect the health of an ecosystem. Originally, Water Monitoring and Standards' (WM&S) Bureau of Freshwater and Biological Monitoring (BFBM) only monitored 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 in 2000 began to supplement benthic macroinvertebrate monitoring with a new sampling program called the fish index of biotic integrity (FIBI). 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".

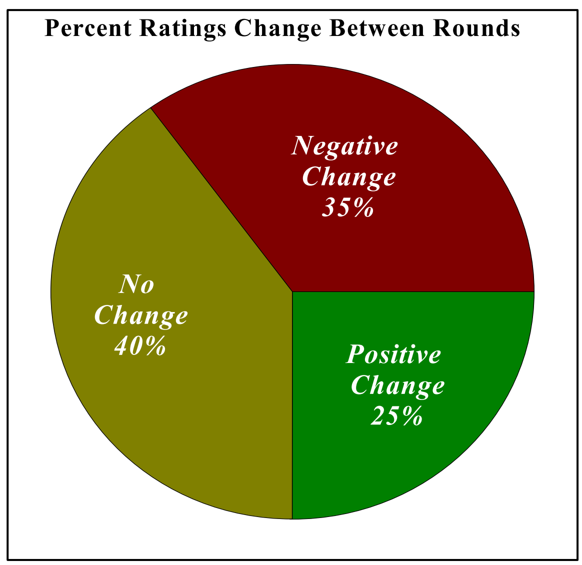
The data provided by the FIBI has become another component of the DEP's suite of environmental indicators. The data help to measure water quality use attainment and the Department's success in attaining the Clean Water Act goal of "fishable" waters as elaborated in the New Jersey Integrated Water Quality Monitoring and Assessment Report. 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 part, to identify candidate waters for upgrade to a Category One antidegradation classification (NJAC 7:9B), based on exceptional ecological significance.

With the completion of the 2004 sampling season, the DEP finalized a 100 station Fish IBI monitoring network in northern New Jersey. Stations will be visited once every five years as part of the WM&S' ambient monitoring efforts. Data are currently being collected for the planned expansion of the network to include portions of southern New Jersey and the state's headwater streams, with the goal of having a statewide 200 station network.

The 2006 season marked year two of the second round of sampling, in which we returned to those network sites originally sampled in 2001 and 2002. In an effort to ensure sensitivity to anthropogenic stressors, the Northern Fish IBI was re-evaluated in 2005 using Round 1 data (2000-2004). This recalibration resulted in modifications in scoring criteria and species lists for several metrics (see Table 3, later in this document, for list of refined metrics). Refinements also included the replacement of the proportional abundance of white suckers metric with the proportional abundance of tolerant species. The 2006 season is the second year in which the revised metrics were utilized. Previous years' data (2000-2004) will be rescored only for the purposes of conducting trends analysis; not for the purpose of revisiting the listing process under the Integrated Water Monitoring and Assessment Report, as those sites will be revisited in this second round. In 2006, the seventh year of sampling, 20 sites were sampled. Two sites were rated "excellent", eight were "good", seven were "fair", and three sites received a "poor" rating.



Overall, ratings from Rounds 1 and 2 for the same 20 sites were similar when Round 1 sites were rescored utilizing the new metrics. In Round 1, 55% of sites were rated "fair" or "poor" compared to 50% in Round 2. In addition, the number of "excellent" sites dropped slightly from 20% to 10% in 2006 with a subsequent increase in the proportion of "good" sites from 25% in Round 1 to 40% in 2006. As a result, a quarter of the sites exhibited a positive rating increase, while the ratings for 40% of sites remained unchanged (for further information see Trends Analysis section).



*Round 1 sites were re-scored using newly re-calibrated metrics for comparative analysis. These re-calculated Round 1 scores will only be used for the purposes of trends analysis and will not be used for regulatory uses.

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 chronic 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 identification 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 has developed an assessment methodology that uses the results from the Fish IBI. The results of these decisions were used in the 2006 Methods Document that was used to prepare the 2006 Integrated List and

[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.

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 identifying 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).

METHODS

Field Sampling

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 (5th order or greater)	Wadeable streams (3rd and 4th order)	Headwater streams (1st and 2nd 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).

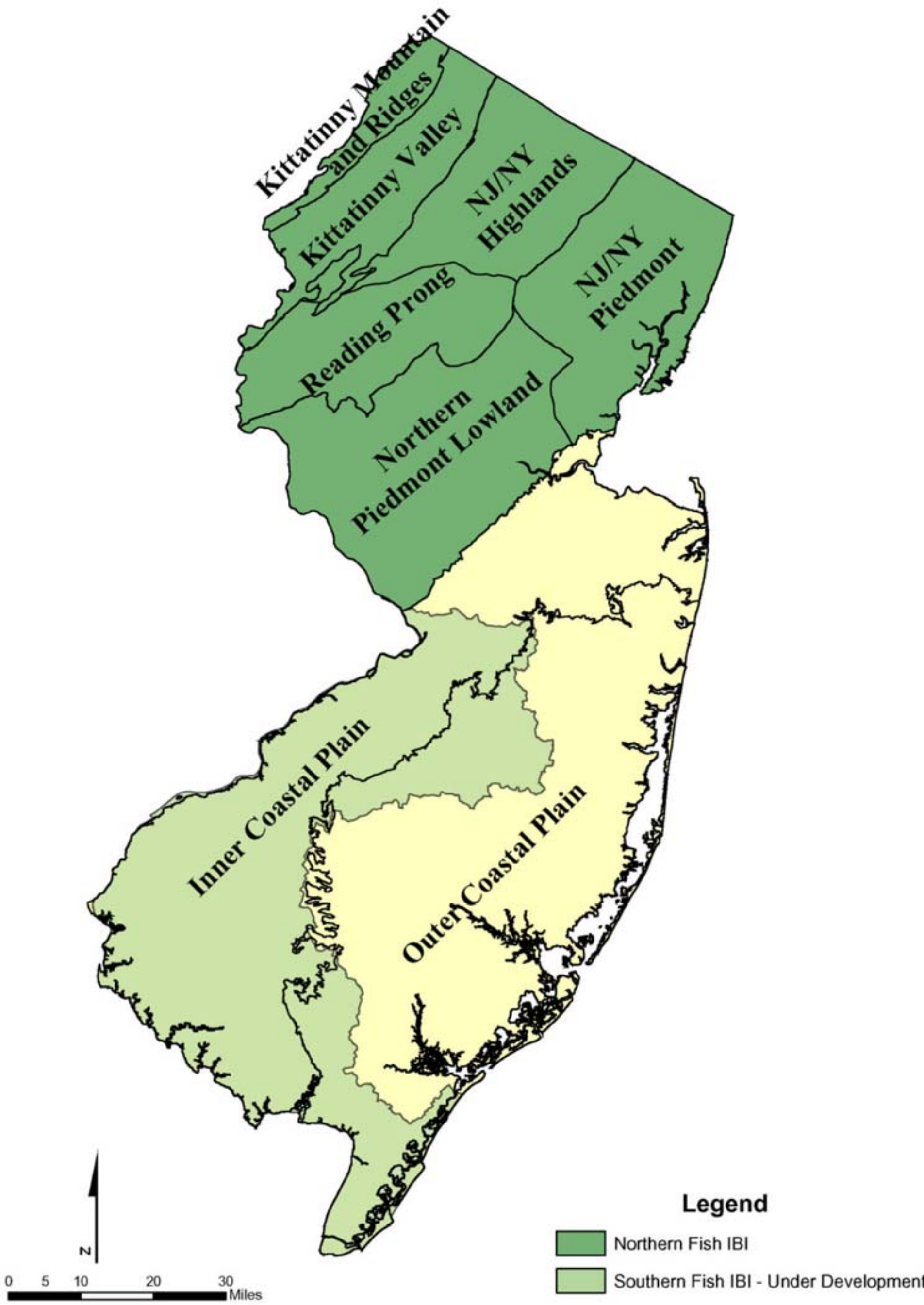


Figure 1. Map of New Jersey Ecoregions and region of Fish IBI applicability.

Electrofishing

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

Sampling time generally requires 4 to 5 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 WM&S' Bureau of Freshwater and Biological Monitoring for confirmation (at present, Eco-Analysts, Inc).

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. Potential stressors, such as storm sewer outfalls, are identified and marked using GPS.

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 WM&S' BFBM.

IBI METRICS

Metric Refinement

In an effort to ensure sensitivity to common urban and agricultural stressors, the Northern Fish IBI metrics were re-evaluated using data from Round 1 (2000-2004). Metric refinements led to changes in scoring criteria, species lists, and the selection of a replacement metric (Table 3). Metric recalibration analysis mirrored those techniques used by Ohio EPA and Maryland Department of Natural Resources (Emery et al. 2003; Rankin and Yoder 1999; Roth et al. 2000). The analysis and final results were reviewed by members of the NJ Fish IBI Workgroup which includes members from WM&S, NJ Fish and Wildlife, USEPA Region 2, USGS, and the Philadelphia Academy of Natural Sciences. Each metric was examined individually to ensure sensitivity to urban and agricultural land uses, statistically significant separation between least impaired and most impaired sites, adequate scoring distribution, and correlation with habitat scoring. Linear regression models were used to assess drainage correlation and the need for scoring modification.

Table 3. Refined Fish IBI Metrics.

Metric	Recalibration Results
1. Total Number of Fish Species	Revised Maximum Species Richness Scoring Lines
2. Number of Benthic Insectivorous Species	Eliminated white sucker & bullheads
3. Number of Trout and/or Sunfish Species	Eliminated green sunfish & bluegill
4. Number of Intolerant Species	No refinement needed
5. Proportion of Tolerant Individuals	Replacement metric for Proportion White Suckers
6. Proportion of Generalists	Revised species list
7. Proportion of Insectivorous Cyprinids	No refinement necessary
8. Proportion of Piscivores	Removed size limits
8. Proportion of Trout	No refinement necessary
9. Number of Individuals in Sample	Removed Tolerant Species
10. Proportion of DELT Anomalies	No refinement at this time

Using surrounding watershed land use/land cover and site habitat scores from Round 1, a subset of sites were divided into least impaired and most impaired. The following criteria were used to classify sites: least impaired < 35% combined urban/agricultural land use and habitat score ≥ 160; most impaired > 65% urban land use. A total of 32 sites (17 least impaired; 15 most impaired) were analyzed using analysis of covariance (ANCOVA) and Mann-Whitney nonparametric U-test (Table 4).

In addition, each metric was analyzed for classification efficiency to ensure minimal overlap between least impaired and most impaired sites (Table 4). The classification efficiency was calculated as the proportion of least impaired sites with individual metric scores greater than or equal to 3 and the proportion of most impaired sites with individual metric scores less than 3 (Roth et al. 2000). Metric classification efficiencies ranged from 59 to 91 percent for Round 1 data and 54 to 90 percent using an independent dataset from USEPA. The mean classification efficiency for refined metrics was 66 percent compared to the 56 percent efficiency using previous metrics. Final metric refinements were validated using the USEPA Region 2 dataset and redundancy among metrics was examined using Pearson's correlation analysis (Table 5). Correlation among metrics ranged from 0.01 to 0.67 and although several metrics were statistically significant, values were below the 0.75-0.80 redundancy threshold (Mundahl and Simon 1999; Emery et al. 2003).

Table 4. Results of metric analysis and classification efficiency for impaired vs. non-impaired sites.

	Fish IBI Metrics	ANCOVA (*p*-value)	Mann-Whitney (*p*-value)	Round 1 Classification Efficiency (%)	Independent Data Classification Efficiency (%)
Species Richness & Composition			--		
1.	Number of Species	0.042	--	59%	73%
2.	Number of Benthic Insectivorous Species	<0.001	--	69%	78%
3.	Number of Trout and/or Sunfish Species	0.036	--	59%	54%
4.	Number of Intolerant Species	<0.001	--	91%	90%
5.	Proportion of Tolerant Species	--	0.021	75%	73%
Trophic Composition					
6.	Proportion of Generalists	--	<0.001	75%	70%
7.	Proportion of Insectivorous Cyprinids	--	0.004	72%	73%
	Proportion of Trout	--	0.007		
8.	OR			63%	76%
	Proportion of Piscivores	--	0.61		
Fish Abundance & Condition					
9.	Number of Fish	--	0.14	59%	66%
10.	Proportion of Fish with anomalies	N/A	N/A	N/A	N/A

Table 5. Pearson Correlation matrix for revised Fish IBI metrics.

	No. Species	Abund-Tol	% Piscivores	% Trout	%Ins. Cyprinids	% Generalists	% Tolerants	No. Intolerants	No. Trout&Sun
No.Benthic Ins.	**0.52**	0.39	-0.29	0.07	0.42	-0.42	-0.23	**0.65**	0.28
No.Trout&Sun	**0.59**	-0.05	-0.008	0.21	-0.11	-0.04	-0.02	**0.55**	1
No.Intolerants	0.30	0.12	-0.04	0.29	0.26	-0.42	-0.29	1	
%Tolerants	0.10	-0.39	-0.18	-0.27	**-0.56**	**0.67**	1		
%Generalists	0.003	-0.33	-0.02	-0.26	**-0.66**	1			
%Ins.Cyprinids	0.02	**0.53**	-0.25	0.06	1				
%Trout	-0.11	0.01	0.06	1					
%Piscivores	-0.16	-0.22	1						
Abund-Tol	0.24	1							

Finally, Pearson's correlation analysis was used to evaluate the response of each metric to land use, habitat score, and IBI score (Table 6). Overall, each metric with the exception of proportion of piscivores, exhibited a significant predicted response at $P < 0.05$. The number of benthic insectivores, number of intolerants, and proportion of insectivorous cyprinids metrics exhibited significant decreasing trends with urban and urban/agriculture land use and significant increasing trends with habitat score and IBI score. In contrast, proportion of tolerant and generalist species metrics exhibited significant predicted responses; both increased with urban and urban/agriculture land use and decreased with an increase in habitat and IBI score.

Table 6. Pearson correlation analysis of revised metrics with land use, habitat, and IBI scores. Correlations in bold are significant at $P < 0.05$.

Metric	Urban Land Use	Urban/Ag Land Use	Habitat Score	IBI Score
No. Species	**-0.32**	-0.15	0.11	**0.38**
No. Benthic Ins.	**-0.49**	**-0.33**	**0.40**	**0.67**
No. Trout&Sun	**-0.32**	**-0.32**	0.15	**0.38**
No. Intolerants	**-0.48**	**-0.48**	**0.37**	**0.62**
% Tolerants	**0.32**	**0.38**	**-0.30**	**-0.66**
% Generalists	**0.42**	**0.42**	**-0.52**	**-0.68**
% Ins Cyprinids	**-0.37**	**-0.28**	**0.37**	**0.67**
% Trout	-0.05	-0.14	**0.23**	**0.35**
% Piscivores	-0.09	-0.18	0.002	-0.04
Abund-Tol	**-0.25**	-0.01	0.11	**0.44**

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) and later recalibrated by WM&S' Bureau of Freshwater and Biological Monitoring in 2005. 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, as compared to fish assemblages found in regional reference streams.[3, 4] The recent metric recalibration has resulted in the selection of a new metric proportion of tolerant individuals in place of the prior proportion of white suckers metric. 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 tolerant individuals, 6) proportion of individuals as generalists, 7) proportion of individuals as insectivorous cyprinids, 8) proportion of individuals as trout or proportion of individuals as piscivores (top carnivores), 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:

<u>Species Richness and Composition</u>

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. These MSR lines have recently been evaluated and modified when necessary

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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).

as part of WM&S' Bureau of Freshwater and Biological Monitoring's Fish IBI refinement. The area under the MSR line is trisected by two diagonal lines.

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 ten 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 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. Metric recalibration has resulted in the elimination of white suckers and bullheads, as these species are designated as tolerant by the USEPA (Plafkin et al 1989).

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). Metric recalibration has resulted in the elimination of green sunfish and bluegill, as these species are designated as tolerant by the USEPA (Plafkin et al 1989).

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 tolerant individuals:

This metric was selected as a replacement for the percentage of white sucker as a more regionally appropriate tolerant group in the northeast (Miller et al. 1988; Langdon 1992). In New Jersey, a number of tolerant species are commonly found in small and large streams representing a wide range of water quality conditions. These tolerant species 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:

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.

<u>Fish Abundance and Condition</u>

9. Numbers of individuals in the sample – excluding tolerant species:

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 abundance. Tolerant species have been excluded from this metric, as often these species thrive and are numerous under degraded conditions (Ohio EPA 1988).

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

This metric provides a relative measure of the condition of individual fish (Figure 3). 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.

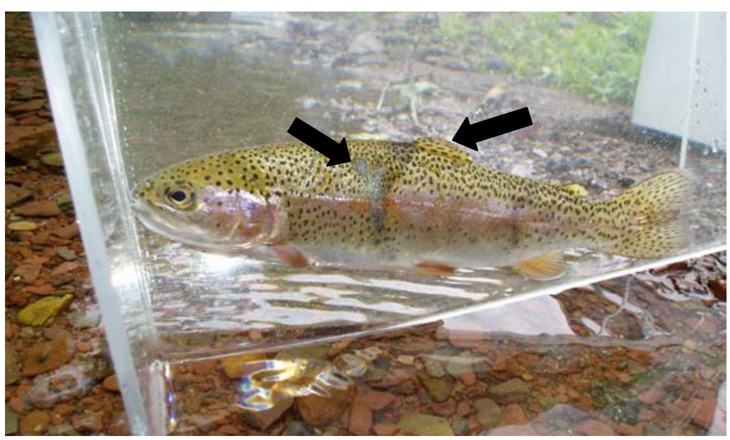

Figure 3. Stocked rainbow trout with multiple anomalies.

RESULTS

In 2006, the second year of Round 2 of sampling, 20 sites were sampled. Two sites were rated "excellent", eight were "good", seven were "fair" and three were "poor" (Figure 4). The habitat ratings for the 2006 sites consisted of seven sites with "optimal" habitat, eleven "sub-optimal", and two sites with "marginal" habitat.

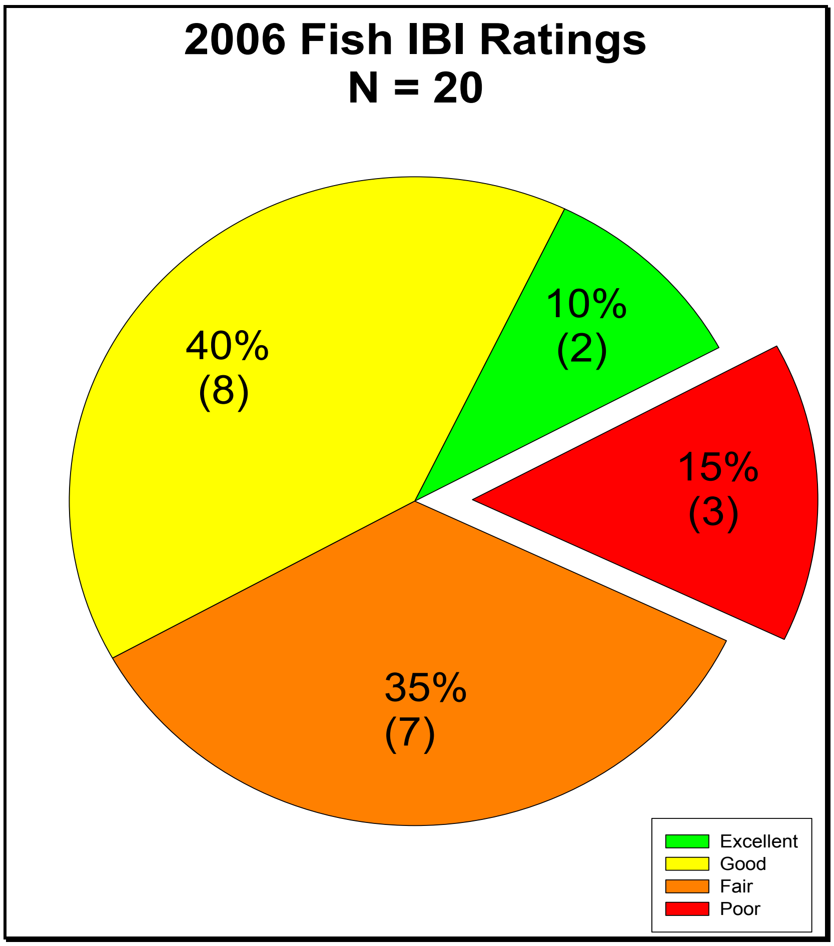

Figure 4. Summary of the 2006 ratings for 20 sites in northern New Jersey.

DISCUSSION

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, a total of three (3) impaired sites were identified (FIBI 021, 025, 035) (Figure 5; Table 7). Of these three sites Rockaway River (FIBI021) and Peters Brook (FIBI025) were identified as having water quality impairments, likely a result of anthropogenic stressors. Poor biotic integrity at Plum Brook (FIBI035), however, is likely a result of the natural hydrology of the stream which in 2005 resulted in intermittent flow. In addition, seven (7) sites were classified as "fair" and are suspected of having impacts.

Except for Plum Brook (FIBI035), those sites classified as "impaired" and "potentially impaired" all had "marginal" or "sub-optimal" habitat ratings and several 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 2006 Fish IBI sites.

Table 7. Results of 2006 Round 2 Fish IBI sampling[1].

FIBI Site	Waterbody	County	Habitat Rating	IBI Score	IBI Rating
FIBI021	Rockaway River	Morris	Suboptimal	24	Poor
FIBI022	Six Mile Run	Somerset	Suboptimal	34	Fair
FIBI023	Neshanic River	Hunterdon	Suboptimal	34	Fair
FIBI024	Passaic River	Morris/Somerset	Marginal	32	Fair
FIBI025	Peters Brook	Somerset	Marginal	28	Poor
FIBI026	Nishisakawick Creek	Hunterdon	Optimal	48	Excellent
FIBI027	Lockatong Creek	Hunterdon	Suboptimal	38	Good
FIBI028	Moore Creek	Mercer	Suboptimal	30	Fair
FIBI029	Alexauken Creek	Hunterdon	Optimal	40	Good
FIBI030	Stony Brook	Mercer	Suboptimal	42	Good
FIBI031	NB Raritan River	Somerset	Suboptimal	36	Fair
FIBI032	Lamington River	Somerset	Suboptimal	40	Good
FIBI033	Pohatcong Creek	Warren	Optimal	44	Good
FIBI034	Harihokake Creek	Hunterdon	Suboptimal	44	Good
FIBI035	Plum Brook	Hunterdon	Optimal	20	Poor
FIBI036	Spruce Run	Hunterdon	Suboptimal	34	Fair
FIBI037	Drakes Brook	Morris	Optimal	40	Good
FIBI038	Middle Brook	Somerset	Suboptimal	30	Fair
FIBI039	Van Campens Brook	Warren	Optimal	46	Excellent
FIBI040	WB Papakating Creek	Sussex	Optimal	42	Good

[1]Sampling maps and data for each site can be found in volume 2 of this report.

Potentially Impaired Sites

Six Mile Run - FIBI022

Impacts to Six Mile Run in Franklin Township appear related to the hydrology of the stream and surrounding watershed. The stream likely experiences severe flash flooding, as evidenced by erosion scars on both banks, heavy fine sediment deposition in runs and pools, and formation of new sediment bars along both banks (Figure 6). Although the water clarity was slightly turbid, visibility quickly declined once the streambed was disturbed, as 40% of the substrate was estimated as silt. Overall, the habitat was rated "sub-optimal" (130) mainly due to sediment deposition and lack of suitable fish habitat. The stream has good bank vegetation, riparian buffer, and overhead cover.

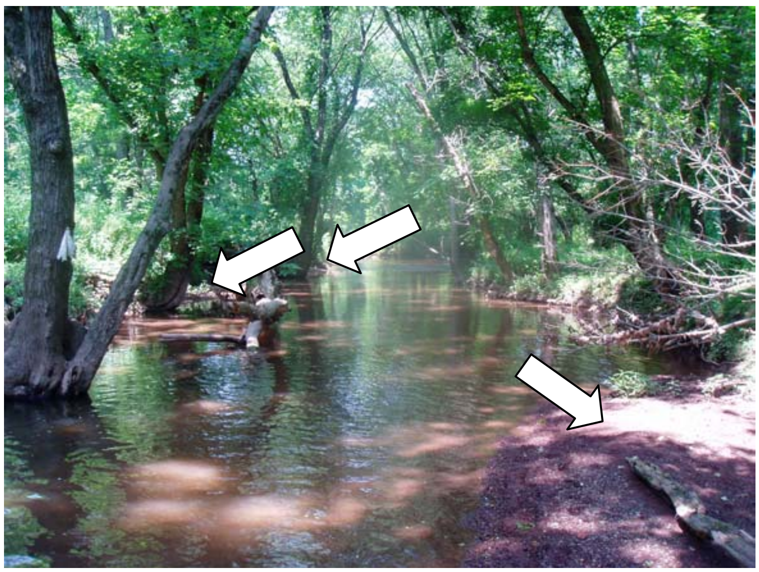

Figure 6. Newly formed sediment bars on Six Mile Run.

Impairments within the fish community appear related to substrate degradation. Insectivorous cyprinids and benthic insectivores were present, but were low in abundance.

Ambient Biological Monitoring station AN409 has been rated moderately impaired for all three rounds of monitoring. Rounds 2 and 3 have been dominated by Gammaridae a freshwater crustacean which scavenges on the stream bottom.

Neshanic River - FIBI023

Impacts to the fish community and habitat of the Neshanic River are primarily related to hydrology and land use of the surrounding watershed. Within the sample stretch, the right descending bank has been severely eroded and there is some evidence of nutrient loading based on the heavy periphyton growth. Although the stream contains good substrate, flow, and habitat complexity, the stream lacks adequate bank vegetation to reduce erosion and riparian buffer to reduce allochthonous material from entering the stream (Figure 7). The majority of the land use/land cover surrounding the stream consists of agriculture and urbanization. According to the 2002 land use, over 62% of the surrounding watershed is classified as agriculture and/or urban.

Obvious anthropogenic impacts within the sample reach include two stormwater outfalls and a golf course which borders the stream on the right descending bank.

Figure 7. Severe bank erosion on the Neshanic River

A total of 1,142 fish were collected, which was the highest catch of any network site sampled in 2006. In addition, 20 species were collected, although tolerant species and generalist feeders comprised much of the assemblage. Over 70% of the fish collected were generalists with white sucker the most common (N = 288). The specimens collected were in good condition, as less than one percent had external deformities. Despite collecting a number of benthic insectivore and insectivorous cyprinid species, abundance and subsequent proportional abundance of each group were low.

Ambient Biological Monitoring Station AN0333, located just downstream of the Fish IBI station received moderately impaired ratings in each of the three rounds of monitoring. Each sample was dominated by midge larvae or worms with very few EPT taxa.

Passaic River - FIBI024

This stretch of the Passaic River has numerous habitat and water quality impairments which have likely impacted the resident fish community. Water chemistry measurements indicated low dissolved oxygen (4.85 mg/l) and high conductivity (409 µmhos) in addition to a number of habitat impacts. A high percentage (20%) of the substrate was made up of fine sediments with a high degree of embeddedness. The stretch had poor habitat complexity and overhead cover, with the stream characterized as mostly run habitat with open canopy. Slower moving runs with a lot of open canopy allow a great deal of light penetration which can quickly increase water temperatures during summer. In addition, 3 large storm water outfalls, along with a concrete sluice which diverts run-off directly into the stream, were present near the start (Figure 8). A number of erosion control structures were in place including concrete, rock revetment, bio-logs, and engineered walls (Figure 9). The overall habitat was rated “marginal” (106) as a result of the aforementioned habitat impairments.

Figure 8. Concrete sluice below several storm water outfalls on the Passaic River

Figure 9. Erosion control structures around a storm sewer outfall on the Passaic River.

A number of fish specimens showed signs of stress, as several redbreast sunfish and a margined madtom were severely emaciated. Over half of the fish collected (56%) were generalist feeders, while abundance of specialized feeders, such as insectivorous cyprinids, was low (6%).

Ambient Biological Monitoring Station AN0224, located approximately 1.1 miles downstream of the Fish IBI station, was rated "non-impaired" in Rounds 1 and 2, but was recently listed as moderately impaired in 2003. Results from this third round of sampling indicate EPT taxa dropped from six in previous samples to just two.

Moores Creek - FIBI028

Potential impacts at Moores Creek are likely related to water quality and/or lack of suitable fish habitat. The stream is bordered by Pleasant Valley Road throughout much of the stretch reducing bank and riparian vegetation. Although the conductivity was not high (225 μmhos) and the dissolved oxygen was not low (7.84 mg/l), heavy periphyton growth was observed (Figure 10). This heavy periphyton growth could result in low oxygen concentrations at night. In addition, the bedrock substrate does not provide suitable substrate for macroinvertebrate colonization.

Figure 10. Heavy periphyton growth in Moores Creek

The fish community lacked intolerant species, while tolerant species comprised over 50 percent of the fish collected. White suckers and green sunfish had numerous external deformities with fin erosion being the most common DELT observed.

Ambient Biological Monitoring station AN0101 is located almost one mile downstream of the Fish IBI station. Results for this site varied throughout the three rounds of sampling. Surveys in 1992 resulted in a moderately impaired rating, 1997 "non-impaired", and the 2003 survey resulted in a severely impaired rating. Members of the family Chironomidae were the dominant organism collected in the 1997 and 2003 surveys.

North Branch Raritan River - FIBI031

The habitat and substrate composition differed drastically between the beginning and end of the sampled reach of the North Branch of the Raritan River in Bedminster Township. Near the beginning, the river was heavily channelized with a lot of fine sediments. The habitat of the stream changes around 50-60 meters upstream with fewer deep holes, more riffle habitat, and a bedrock substrate. In addition, the lower stretch is more open with little overhead cover, while the upper section is largely shaded. The river was 100 feet wide with 47% open canopy at the start (0 meters) compared to 45 feet wide with 20% open canopy at the finish (150 meters) (Figures 11 and 12).

Figure 11. Downstream view showing open canopy and channelization near bridge.

Figure 12. Upstream view showing overhead cover and riffles.

The stretches with mainly bedrock substrate provided little habitat and refugia for fish and subsequently were relatively devoid of fish. Insectivorous cyprinid abundance was low, as these specialized feeders made up slightly over 7% of the total catch. Generalist feeders, on the other hand were the most numerous feeding guild at 63% of the overall catch. Redbreast sunfish were the most abundant species collected and also had the most external deformities. Despite an imbalance in trophic structure, there were no other indications of impairments within the fish community. In addition, several intolerant species were collected including margined madtom and shield darter.

Through three rounds of sampling, no impairments have been identified within the aquatic macroinvertebrate community at Ambient Biological Monitoring Station AN0351. The assemblages from Rounds 1 (1990) and 2 (1999) consisted mainly of EPT taxa, while chironomids comprised most of the Round 3 (2004) sample. Despite the dominance of midges in the 2004 sample and a subsequent drop in EPT proportional abundance and richness compared to previous samples, the site was rated as "non-impaired".

Spruce Run - FIBI036

Potential stressors at Spruce Run are likely related to the changing hydrology of the stream. The only observed impairments were bank erosion on both banks near the beginning of the sampled reach and the lack of riparian buffer along the right descending bank, which is bordered by state highway Route 31. In addition, a large amount of sand/gravel/cobble had been deposited along the left descending bank in Glen Gardner Park (Figure 13).

Figure 13. Sediment deposition along Spruce Run.

Despite collecting a large number of wild brown trout, including numerous yearling and young-of-the-year, impairments were noted within the fish community. Among these impairments were low richness of benthic insectivores and insectivorous cyprinids proportional abundance. Overall, a high proportion of top predators were collected, while prey species, such as darters, dace, and shiners were lacking or absent.

Ambient Biological Monitoring Station AN0319, located less than a half mile downstream of the Fish IBI site, exhibited a steady decrease in NJIS scores since 1994. The site was rated "non-impaired" in Rounds 1 (1994) and 2 (1999) and moderately impaired in Round 3 (2004). In addition, Baetid mayflies, the dominant family in Round 1 (91%), have been replaced by chironomids in subsequent samples. Many intolerant genera collected in Round 1 have disappeared while tolerant taxa such as Tubificidae and blood red chironomids have appeared in Rounds 2 and 3.

Middle Brook - FIBI038

Impairments to the habitat of Middle Brook appear related mostly to substrate and habitat complexity. The habitat of the stretch consisted mainly of runs and deep pools with little riffle habitat. A heavy silt layer blanketed the substrate throughout much of the stretch. The stream was slightly turbid from suspended solids, which decreased visibility and made fish collection difficult once the bottom sediments were disturbed. Several pools were deep (~5 foot) which, along with poor visibility, made electrofishing difficult (Figure 14).

Figure 14. Turbid water clarity of Middle Brook.

The fish community exhibited good diversity and species richness, but overall fish abundance was relatively low. Despite a number of pools and large woody debris present throughout the stretch creating excellent habitat for lay and wait predators, only two piscivores were collected. In the absence of top predator species, generalists were the most abundant feeding guild. One margined madtom was collected and represented the only intolerant specimen, compared to tolerant species which comprised almost half (47%) of the total catch.

Ambient Biological Monitoring Site AN0355 was rated moderately impaired in 1994 and "non-impaired" in 1999 and 2004. Despite the differences in scores between rounds, little has changed with EPT taxa richness or proportional abundance. In addition, the dominant taxa, Chironomidae, has remained unchanged but the proportional abundance has decreased each year from 69% in 1994 to 25% in 2004.

Impaired Sites

Rockaway River - FIBI021

Numerous impacts to the Rockaway River from the surrounding watershed were noted in 2006 which led to a "sub-optimal" habitat rating (121) and a "poor" (24) Fish IBI rating. These impairments included: siltation, embeddedness, bank erosion, several storm sewer outfalls, high conductivity, and channelization. The relatively high conductivity (595 µmhos) is likely a result of inputs from the 4 storm sewer outfalls within the sampling stretch and nearby road crossings (Figure 15). The river is heavily channelized by the Knoll Road bridge crossing with heavy sediment deposition in the surrounding pools. In addition, a strong smell of sewage was noted while sampling on July 20, 2006 which was likely coming from Rockaway Valley Sewage Authority just 1.7 miles upstream (Figure 16).

Figure 15. Storm sewer outfalls near the start on the Rockaway River

The fish assemblage lacked trophic structure with a relatively high proportion of generalist feeders (48%) and low proportions of specialists, such as piscivores (0.4%) and insectivorous cyprinids (21%). A total of eighteen specimens had external deformities, with fin erosion being the most commonly observed abnormality, especially in white sucker and yellow bullhead. The fish community is likely influenced by Boonton Reservoir, just upstream of the Fish IBI sample station. Several alewives were collected in late July and are likely escapees from the reservoir, as alewife spawning migration typically occurs in early spring (Smith 1985).

Ambient Biological Monitoring station AN0251, located 1.4 miles upstream received moderately impaired ratings in all three survey rounds (1993, 1998, and 2003). The macroinvertebrate assemblage is likely influenced by a combination of nutrient loading from Rockaway Valley Sewage Authority, which is less than 0.3 miles upstream of the AMNET site and plankton enrichment from Boonton Reservoir, which is located less than a mile upstream of the AMNET site. In addition, each survey was dominated by relatively tolerant members of the caddisfly family Hydropsychidae, which are commonly collected below impoundments.

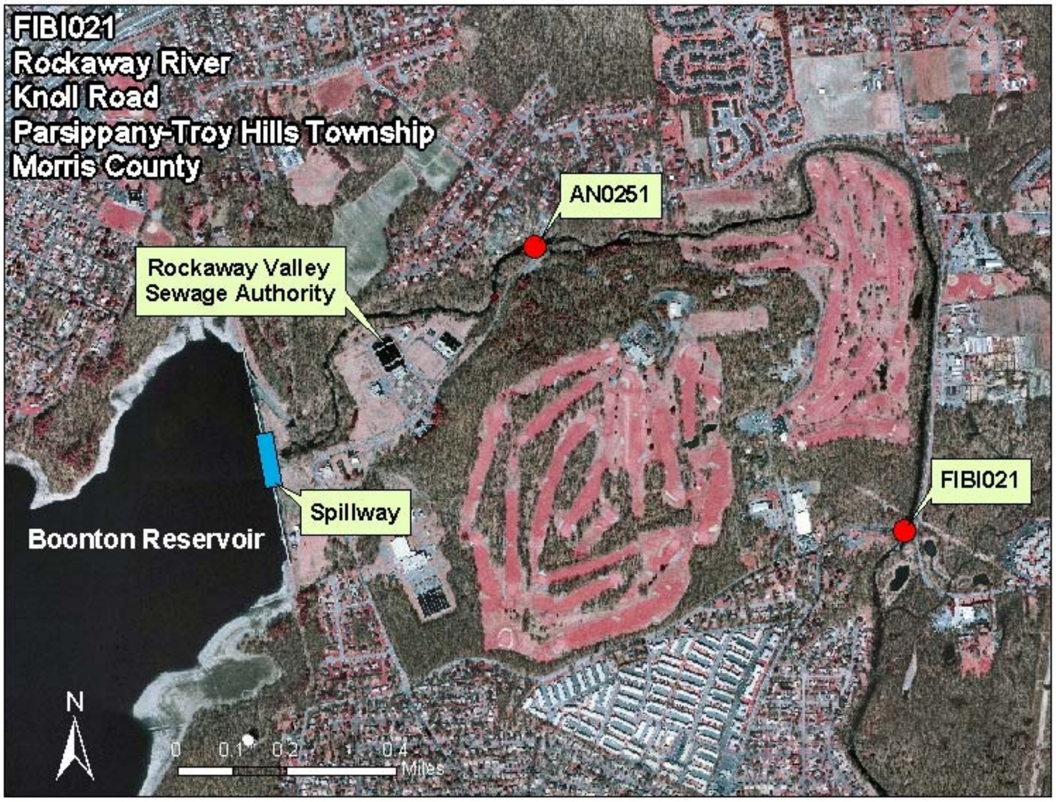

Figure 16. Location of Boonton Reservoir and Rockaway Valley Sewage Authority in relation to biological monitoring stations

Peters Brook - FIBI025

Numerous impacts to the habitat and water chemistry of Peters Brook were noted while sampling in mid-June 2006. Three storm sewer outfalls were noted within and just upstream of the sampled reach (Figure 17). The substrate of the lower stretch was covered with fine sediments and debris (plywood, trash, etc.). Much of the stream bank consisted of mowed grass providing little riparian buffer, bank protection, or overhead cover (Figure 18). Additional evidence of impacts to the stream were noted in the water chemistry measurements, as a relatively high conductivity (850 μmhos) was measured. The habitat was rated "marginal" for both Rounds 1 and 2 of Fish IBI sampling (109 and 102, respectively).

Figure 17. Storm sewer outfall near end of stretch on Peters Brook.

Figure 18. Storm sewer outfall and mowed grass along banks of Peters Brook.

The fish community of the stream consisted mainly of generalist and tolerant species able to adapt and survive under adverse conditions. Overall, 57% and 85% of the catch consisted of tolerants and generalists, respectively. In addition, no cyprinids were collected; an indication that the surrounding land use, water quality, and embeddedness may be impacting the benthic macroinvertebrate community upon which many cyprinids feed. Swallowtail shiners, blacknose dace, common shiners, satinfin shiners, comely shiners, and spottail shiners were all collected in 2001 but not in 2006. Green sunfish and banded killifish, both designated as tolerant and generalist feeders, increased in proportional abundance from 24 to 40% from 2001 to 2006.

Ambient Biological Monitoring station AN0376, located just downstream of the Fish IBI station, received moderately impaired ratings in all three rounds of sampling (1993, 1998, 2004). The proportion of EPT in 1998 and 2004 was five percent and zero, respectively. Although the 1993 sample contained a high proportion of EPT taxa (71%), all of these organisms were members of Hydropsychidae, a relatively tolerant caddisfly family.

Plum Brook - FIBI035

The impacts to the fish community of Plum Brook are likely a result of intermittent low or no flows and not a water quality or habitat impairment. A total maximum daily load (TMDL) Bacteriological (Bac'T) Monitoring was postponed at all three sites on Plum Brook in September 2005 due to low flow, dry stream conditions. TMDL Bac'T Monitoring site 63 is located approximately 2.3 miles upstream of the Fish IBI station, while the remaining TMDL stations were further upstream.

In addition, while conducting Fish IBI sampling in 2006, no macroinvertebrates or other aquatic life were observed throughout this stretch indicating perhaps the stream had recently been dry. Despite severe erosion and scouring along the left descending bank, the available habitat and water chemistry did not indicate any obvious impairment. The habitat was rated as "optimal" (162), with good substrate, overhead cover, and velocity/depth regimes.

In contrast to Round 1 sampling, only a few blacknose dace were collected in 2006. This benthic insectivore was the dominant fish collected in 2001 comprising almost 71 percent of the total catch. Overall species diversity and fish abundance were extremely low, with the community dominated by opportunistic species. This site will be re-sampled in 2007 to determine if the aquatic community has recovered from the dry conditions in 2005.

Ambient Biological Monitoring Station AN0093 received "non-impaired" ratings in 1992 and 2003, but was rated as moderately impaired in 1997. Similar to Fish IBI habitat results, no impairments were noted and the habitat was rated as "optimal" each survey year.

Other Important Findings

Nishisakawick Creek - FIBI026
Nishisakawick Creek is listed as a Non-Trout C1 stream according to the NJDEP's Surface Water Quality Standards. A single young-of-the-year brown trout was collected during the July 10, 2006 Fish IBI sampling event. Nishisakawick Creek is listed as non-trout throughout its entire length and all upstream tributaries share this designation. Future monitoring should be conducted to assess the stream and its tributaries for natural trout reproduction.

Figure 19. Young-of-the-year brown trout from Nishisakawick Creek.

Pohatcong Creek - FIBI033
Within the Fish IBI sample reach, Pohatcong Creek is listed as Trout Maintenance C1. A number of wild brown and rainbow trout were collected, including a single young-of-the-year brown trout. Approximately 3.2 miles upstream of the Fish IBI station, the stream is listed as "Trout Production". Although it is possible this fish traveled downstream or was flushed downstream during a storm event, the stream should be re-evaluated to determine the extent of natural reproduction. The habitat was rated "optimal" (175) and did not appear to have any impairments within the stretch, except for some fine sediment deposition in slower runs and pools.

Drakes Brook - FIBI037
Throughout much of the reach, Drakes Brook is designated as Non-Trout C1. Fish IBI network monitoring in late September 2006 collected a number of wild brook and brown trout, including young-of-the-year (Figure 20) and one stocked rainbow trout. The Fish IBI sampling location is near the confluence with the Raritan River, which is designated as trout production. Although it is possible for fish to travel upstream via the Raritan, only one young-of-the-year brown trout and no brook trout were collected while sampling in this region of the Raritan River in July 2006. In addition, several upstream tributaries are classified as trout production; however the middle reaches of Drakes Brook are being investigated for impairments by the WM&S' Stressor

Identification Program and it is therefore unlikely these fish traveled downstream to the lower reaches of the brook. The habitat of this lower reach was rated as "optimal" (169) with no obvious impairments. In addition to trout, three other intolerant species were collected which included margined madtom, slimy sculpin, and brook lamprey.

Figure 20. Young-of-the-year brook trout from Drakes Brook.

West Branch Papakating Creek - FIBI040

The West Branch Papakating Creek is classified as Non-Trout C2 through its entire reach. A total of 9 stocked brook, brown, and rainbow trout were collected on July 18, 2006, indicating the stream provides adequate habitat and water quality for salmonid survival (Figure 21). The site was rated "Good" (42) with "optimal" (163) habitat, but likely fits the criteria of an "Excellent" stream based on fish community results. The large population of crayfish present in the stream is likely responsible for the high proportion of the observed fin erosion in the fish specimens collected. As a result of their abundance, crayfish were collected as bi-catch and subsequently held in livewells along with the fish. These crustaceans were observed feeding on dead and immobile fish which resulted in a high percentage of DELT anomalies which lowered the overall Fish IBI score. Based on the 2006 survey, this stream would meet the criteria for upgrade to "Trout Maintenance" and C1 designation, based on exceptional ecological significance.

Figure 21. Stocked brook trout from WB Papakating Creek.

SUMMARY

The observed impacts and potential impacts often appear related to the habitat/water 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 Round 2 data indicates a significant positive linear relationship between Fish IBI and habitat scores (R^2 = 0.48; Figure 22). Similarly, Roth et al. (1996) found a direct correlation between fish IBI and habitat quality in the Midwest.

In addition, there is a significant inverse relation between the percent urban land use and Round 2 Fish IBI score (R^2 = 0.26; Figure 23). 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."

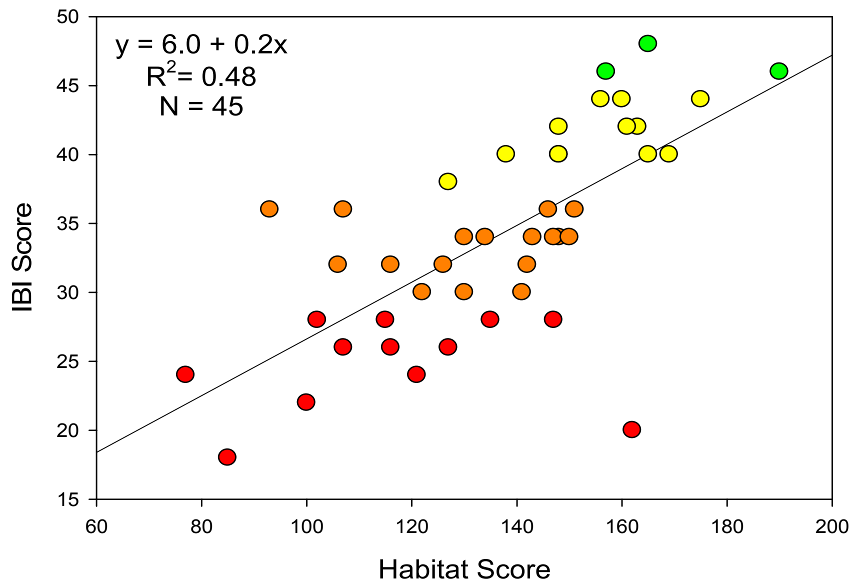

Figure 22. Linear regression comparing IBI and habitat scores.

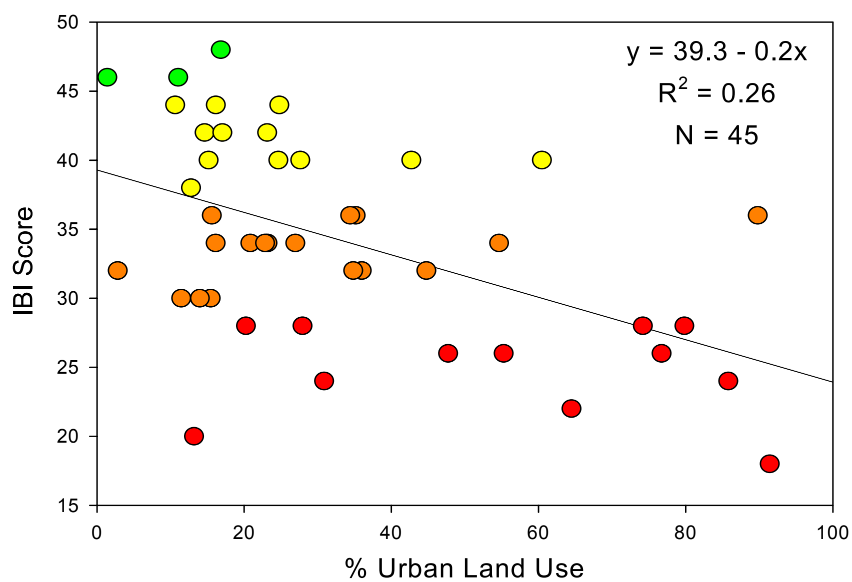

Figure 23. Linear regression comparing urban land use and IBI score.

TRENDS ANALYSIS

The completion of the 2006 sampling season marks the second year of the second round of Fish IBI sampling. The majority of those sites sampled in 2006 were originally sampled in 2001. Those sites sampled in 2001 and 2002 were re-scored using the re-calibrated metrics in order to compare results over time (Table 8).

Table 8. Comparison of Round 1 and 2 results using newly calibrated metrics.

		Round 1 Results*		2006 Results	
FIBI Site	**Waterbody**	**IBI Score**	**IBI Rating**	**IBI Score**	**IBI Rating**
FIBI021	Rockaway River	28	Poor	24	Poor
FIBI022	Six Mile Run	32	Fair	34	Fair
FIBI023	Neshanic River	32	Fair	34	Fair
FIBI024	Passaic River	32	Fair	32	Fair
FIBI025	Peters Brook	28	Poor	28	Poor
FIBI026	Nishisakawick Creek	42	Good	48	Excellent
FIBI027	Lockatong Creek	34	Fair	38	Good
FIBI028	Moore Creek	42	Good	30	Fair
FIBI029	Alexauken Creek	36	Fair	40	Good
FIBI030	Stony Brook	36	Fair	42	Good
FIBI031	NB Raritan River	40	Good	36	Fair
FIBI032	Lamington River	46	Excellent	40	Good
FIBI033	Pohatcong Creek	44	Good	44	Good
FIBI034	Harihokake Creek	36	Fair	44	Good
FIBI035	Plum Brook	36	Fair	20	Poor
FIBI036	Spruce Run	40	Good	34	Fair
FIBI037	Drakes Brook	46	Excellent	40	Good
FIBI038	Middle Brook	36	Fair	30	Fair
FIBI039	Van Campens Brook	50	Excellent	46	Excellent
FIBI040	WB Papakating Creek	46	Excellent	42	Good

*Round 1 sites were re-scored using newly re-calibrated metrics for comparative analysis. These re-calculated Round 1 scores will only be used for the purposes of trends analysis and will not be used for regulatory uses.

The proportion of sites rated as “fair” and “poor” remained relatively constant from Round 1 to Round 2 (Figure 24). The number of “excellent” sites dropped from 20% to 10% with a subsequent increase in the proportion of “good” sites from 25% in Round 1 to 40% in Round 2.

Significant scoring and/or rating changes occurred at several sites including the following: Moores Creek (028), Stony Brook (030), Lamington River (032), Harihokake Creek (034), Plum Brook (035), Spruce Run (036), and Drakes Brook (037) (Figure 25). Two of these changes were positive changes and five indicated degradation in biological integrity. The following is a description of trends at these individual sites over time.

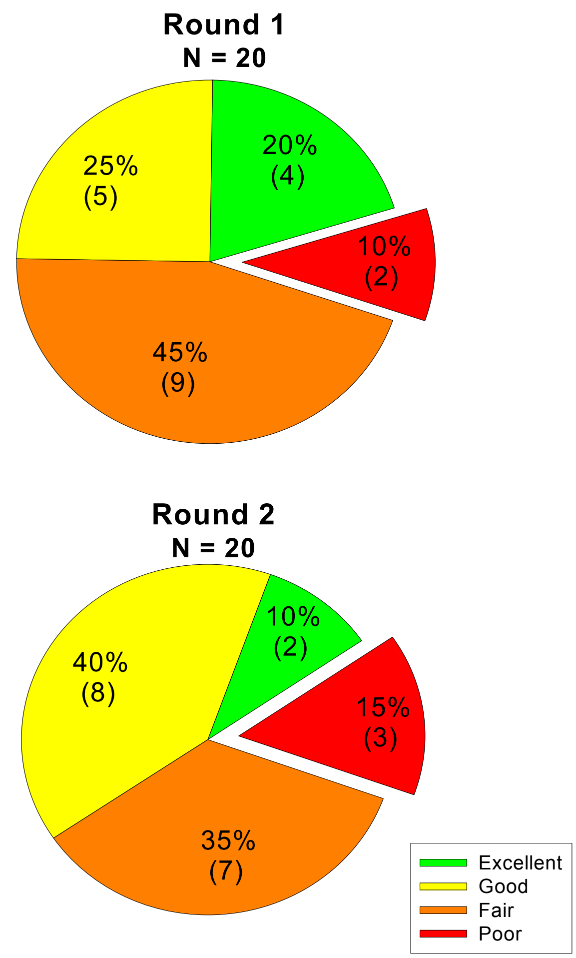

Figure 24. Ratings comparison for Rounds 1 and 2.

<u>Moores Creek – FIBI028</u>

Moores Creek exhibited a sharp decline in biological integrity from the year 2001 to 2006. Utilizing the newly re-calibrated metrics, this site would have received a score of 42 -“good” based on 2001 data, but recently declined sharply in 2006 with a score of 30 -“fair”.

The reason for the dramatic change in scores is unclear, but may be related to the stream’s hydrology and/or land use/land cover. Several minnow species were numerous in the 2001 sampling event, but were less common in this latest round, while tolerant species increased from 34% in Round 1 to 50% in Round 2. Creek chub and longnose dace represented a quarter of the total catch in 2001, but made-up just 5% of the 2006 collection. Green sunfish on the other hand, increased in proportional abundance from 5% to 19% between rounds. This trophic change from specialized feeding groups to more generalized feeders like green sunfish, is a common response usually related to degradation of riffle habitat, substrate composition, or impairments within the macroinvertebrate community.

The Ambient Biological Monitoring Network has two stations on Moores Creek, one 0.8 miles downstream (AN0101) of the Fish IBI site and a station 1.5 miles upstream (AN0100). Comparing the latest data collected in 2003, the assemblages differ dramatically. The upstream site was rated “non-impaired” with 57% EPT taxa, while the downstream site was rated severely impaired and had only 8% EPT taxa. In addition, six intolerant taxa were collected at the upstream site compared to just one at the downstream location and 88% of the organisms collected downstream were chironomids and worms compared to 40% at the upstream site.

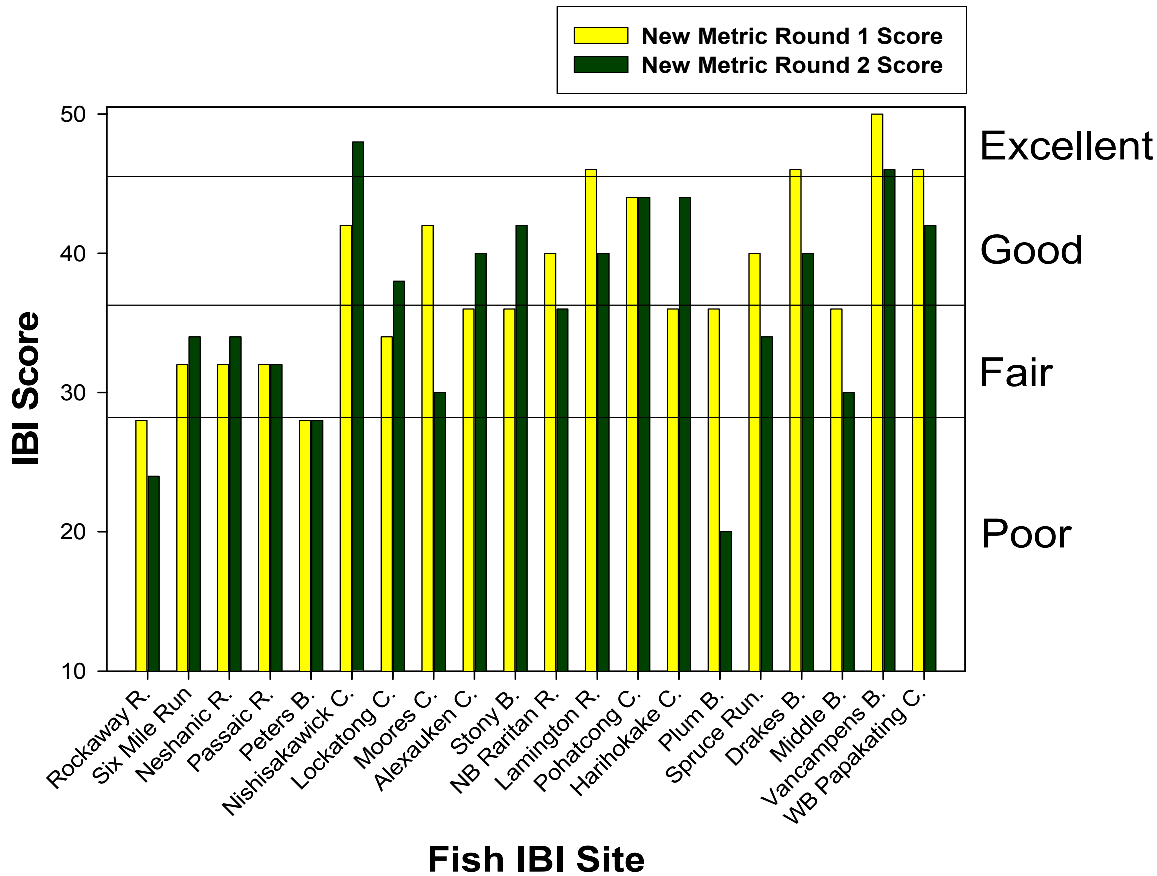

Figure 25. Comparison of ratings for Rounds 1 and 2 at individual sites.

<u>Stony Brook – FIBI030</u>

The scoring and rating for Stony Brook increased from "fair" (36) in 2001 to "good" (42) in 2006. The difference in scores between Rounds 1 and 2 is directly related to the collection of two intolerant species. No intolerant species were collected in 2001, while two margined madtoms and one stocked rainbow trout were collected in the 2006 sample. The rainbow trout was collected in a large deep pool near the end of the sample stretch, which was difficult to sample. The collection of stocked trout in this FW-2 Non-trout stream can be extremely variable and is strongly dependent on factors independent of biological integrity including: number of trout stocked, trout species stocked, fishing pressure, and fishing success. The two margined madtoms are indicative of good water quality, substrate, and habitat. Although the collection of these two intolerant species resulted in an increase in scoring, the biological integrity decreased for several metrics. Green sunfish were infrequently collected in 2001, with 0.3% of the sample comprised of these invasive species, while in 2006 green sunfish amounted to almost 5% of the total catch. Based on trends at other sites, green sunfish are likely to continue to increase in proportional abundance over time. In addition, the percent tolerant species increased from 24% to 35% and the percent generalist feeders increased from 32% to 42% between Rounds 1 and 2 respectively.

Ambient Biological Monitoring Station AN0391, concurrently located at the FIBI030 site, was rated "moderately impaired" in 1994 and 1999, but was "non-impaired" in 2004. The percent

EPT taxa increased over this period from 26% in Round 1 to 44% in Round 3. The most recent sample was a mix of tolerant and intolerant taxa making it difficult to determine if the stream is in a state of recovery or decline. A total of 4 relatively tolerant taxa, totaling 9 specimens, were identified compared to 3 relatively intolerant taxa totaling 3 specimens.

Lamington River – FIBI032

The Lamington River would have been rated as "excellent" (46) in Round 1 using the re-calibrated metric, but declined to "good" (40) in Round 2. Overall, the fish community was similar between rounds with a few exceptions; tolerant species and generalist feeders were more abundant in 2006, while insectivorous cyprinids decreased. Several generalist species, such as bluegill, pumpkinseed, green sunfish, and eastern mudminnow were not collected in Round 1, but accounted for the large increase in generalist proportional abundance between the years from almost 7% to 21%. Insectivorous cyprinids declined substantially, from 55% in 2001 to 24% in 2006. Blacknose and longnose dace accounted for 42% of the sample in Round 1, but decreased in proportion to just 11% in this last round of sampling. This change in the fish community conflicts with the available habitat within the sample stretch, as 70% of the reach was estimated as riffles, but riffle species such as dace were replaced by run/pool dwelling sunfish. The habitat did show signs of decline as the rating and score changed from "optimal" (161) in Round 1 to "sub-optimal" (148) in Round 2. Among the changes were epifaunal substrate/available cover and sediment deposition. However, this second round of monitoring on the Lamington River represented the largest collection of shield darters, an intolerant species, since the program was initiated in 2000.

Ambient Biological Monitoring Station AN0363 is located approximately 1.1 miles downstream of the Fish IBI site. Through three rounds of monitoring, this station did not exhibit any signs of impairment or degradation, as EPT taxa comprised the bulk of each sample. Similar to the changes observed within the Fish IBI Program, the AMNET habitat rating and score declined from "optimal" (178) in 1999 to "sub-optimal" (156) in 2004.

Harihokake Creek – FIBI034

Comparisons between rounds indicated a positive increase in biological integrity for Harihokake Creek in Alexandria Township. This site would have been rated "fair" (36) in 2001 using the re-calibrated metrics and recently was rated "good" (44). Although the habitat scores, ratings, and water chemistry parameters were relatively the same for both rounds, the fish assemblages differed. A number of cyprinid species were collected in 2006, but not in 2001 including: cutlips minnow, fallfish, satinfin shiner, and Eastern silvery minnow. These cyprinid species increased the scores for several metrics including the number of intolerant species, proportion of insectivorous cyprinids, and overall fish abundance. Results from this last round of sampling indicate a healthy warmwater fish community with good fish diversity and balance.

This stretch of Harihokake Creek has good habitat complexity with limited impairments. Impairments to the stream are mostly related to the hydrology. Severe flooding in June and July 2006 appears to have altered the stream and the surrounding habitat. Several newly downed trees and large woody debris were present throughout much of the stretch (Figure 26). Large woody debris provides excellent fish habitat, especially for warmwater communities. The right descending bank was fairly devoid of vegetation, likely a result of scouring from the recent flood. A large percentage of the channel substrate was exposed (Figure 27). The stream channel had likely been altered as a result of sediment transport and deposition, as well as the location of large woody debris.

Figure 26. Large woody debris from Harihokake Creek.

Figure 27. Exposed channel substrate on Harihokake Creek

Plum Brook – FIBI035

The rating and score for Plum Brook significantly decreased from "fair" (36) in 2001 using the new metrics to "poor" (20) in 2006. In 2005, sections upstream of the Fish IBI station were extremely dry and could not be sampled in September 2005 by WM&S BFBM staff for the purposes of TMDL Bacteriological Monitoring. During this period, Plum Brook had very little flow with most of the stream in this reach consisting of isolated pools. If similar conditions existed at the Fish IBI station, it is likely the fishery has not recovered, as most of the community sampled in 2006 consisted of opportunistic and tolerant species along with low overall fish abundance and richness. This site will be re-sampled in 2007 and will be re-evaluated based on these findings.

Spruce Run – FIBI036
The impairments causing the rating/scoring change from "good" (40) in 2001 to "fair" (34) are unclear, but may be related to the upstream bridge construction. This bridge construction was located just 0.2 miles upstream of the Fish IBI station on Sanatorium Road. Although a number of brown trout were collected including young-of-the-year, several benthic and insectivorous species were low in abundance. In 2001, blacknose dace, longnose dace, and tessellated darter represented almost 65% of the sample, but these species comprised just 21% of the 2006 sample. These fish species are directly impacted by changes to the macroinvertebrate community and substrate which can result from increased sediment loading and siltation (Figure 28). The latest Ambient Biological Monitoring sample at AN0319, approximately 0.42 miles downstream of the Fish IBI station, indicates some degradation as ratings and scores have steadily decreased from "non-impaired" (27) in 1994 to the recent "moderately impaired" (21) in 2004.

Figure 28. Sediment deposition in Spruce Run over time.

Drakes Brook – FIBI037
The biggest change in the fish community of Drakes Brook is within the coldwater fishery. A total of 141 fewer trout were collected in 2006 compared to 2001 resulting in a rating change from "excellent" (46) to "good" (40). Round 1 sampling resulted in the collection of 132 brook trout, while only 10 brook trout were collected in Round 2. In addition, green sunfish increased in abundance from just 7 in Round 1 to 53 in Round 2.

The reach upstream of AN0311 was identified as impaired for aquatic life support and was recently sampled in 2006 as part of WM&S' Stressor Identification Program (Figure 29). The program identified numerous impairments upstream of AN0311 which have severely degraded the upper and middle reaches of Drakes Brook. These impairments included: inactive landfills, dischargers from nearby shopping malls, neglected erosion control structures, and faulty detention basins.

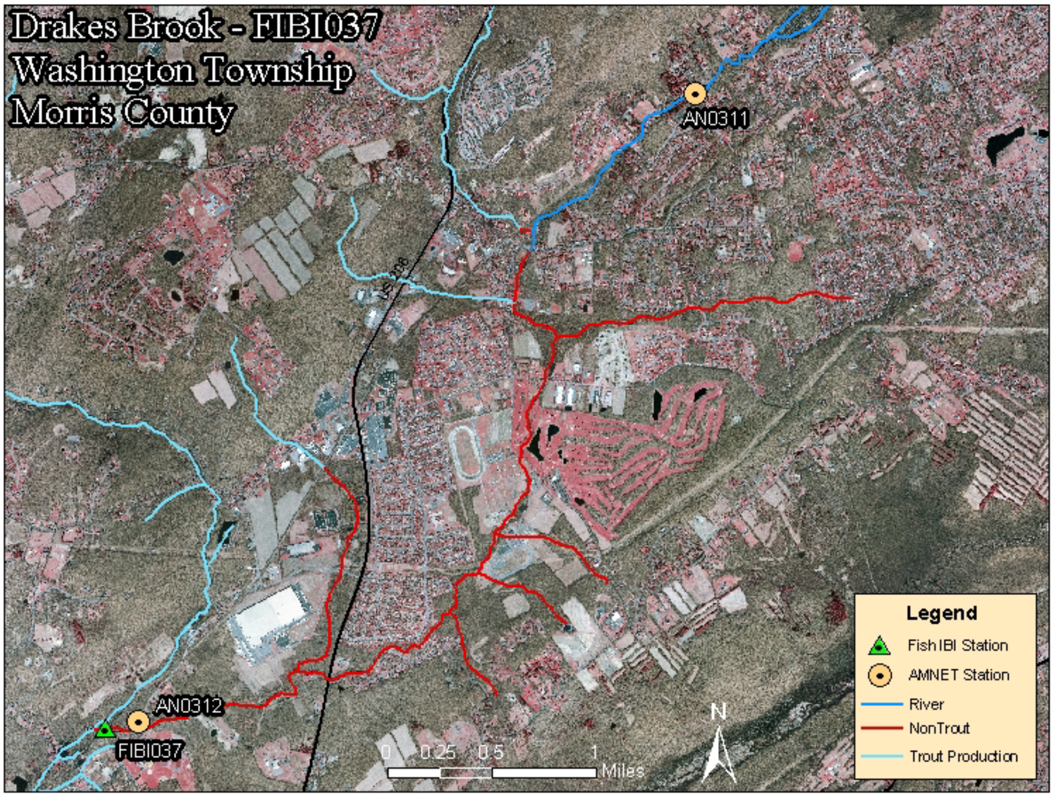

Figure 29. Aerial map of Drakes Brook showing AMNET and Fish IBI sampling locations.

FURTHER INFORMATION

The current report summarizes the seventh 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 five years of the IBI can be obtained on the WM&S 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	TS	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*)	G	--	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*)	G	--	E
Grass Carp (*Ctenopharyngodon idella*)	H	--	E
Satinfin Shiner (*Cyprinella analostana*)	I	--	N
Spotfin Shiner (*C. spiloptera*)	I	--	N
Common Carp (*Cyprinus carpio*)	G	--	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*)	G	TS	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*)	G	--	NN
Yellow Bullhead (*A. natalis*)	G	--	N
Brown Bullhead (*A. nebulosus*)	G	--	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*)	G	TS	N
Mummichog (*F. heteroclitus*)	G	TS	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*)	G	--	N
Green Sunfish (*L. cyanellus*)	G	TS	NN
Pumpkinseed (*L. gibbosus*)	G	--	N
Bluegill (*L. macrochirus*)	G	TS	NN
Smallmouth Bass (*Micropterus dolomieu*)	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*)	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	TS	Tolerant Species
G	Generalist		

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 tolerant individuals	<20%	20-45%	>45%
TROPHIC COMPOSITION:			
6) Proportion of individuals as generalists	<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 and 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 and tolerant species); older age classes of trout and/or top carnivores may be rare.

10-28 Poor Low species richness, dominated by generalists and 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, Madtoms, Darters and Sculpins **(Not including white sucker or bullheads)**

Trout* and Sunfish (Metric 3, 8) – All species in the families Salmonidae and Centrarchidae **(Not including green sunfish or bluegill)**

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

Proportion of Tolerant Individuals (Metric 5) – Green Sunfish, Bluegill, White Sucker, Banded Killifish, Mummichog, American Eel

Proportion of Generalist Individuals (Metric 6) – Redbreast Sunfish, Green Sunfish, Banded Killifish, Pumpkinseed, Bluegill, Mummichog, Eastern Mudminnow, Yellow Bullhead, Brown Bullhead, White Sucker, Common Carp, Goldfish

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

Piscivores (Metric 8) – Largemouth Bass, Smallmouth Bass, Yellow Perch, Walleye, Chain Pickerel, Redfin Pickerel, Northern Pike, Bowfin

- 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.

Number of Individuals (Metric 9) – (Not including Tolerant Species – Green Sunfish, Bluegill, White Sucker, Banded Killifish, Mummichog, American Eel)

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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 Tolerant Individuals		
Proportion of Individuals as Generalists		
Proportion of Individuals as Insectivorous **Cyprinids** (I and BI)		
Proportion of Individuals as Trout OR Proportion of Individuals as Piscivores (Excluding American Eel)*		
Number of Individuals in Sample		
Proportion of Individuals w/disease/anomalies (excluding blackspot)		
Total		

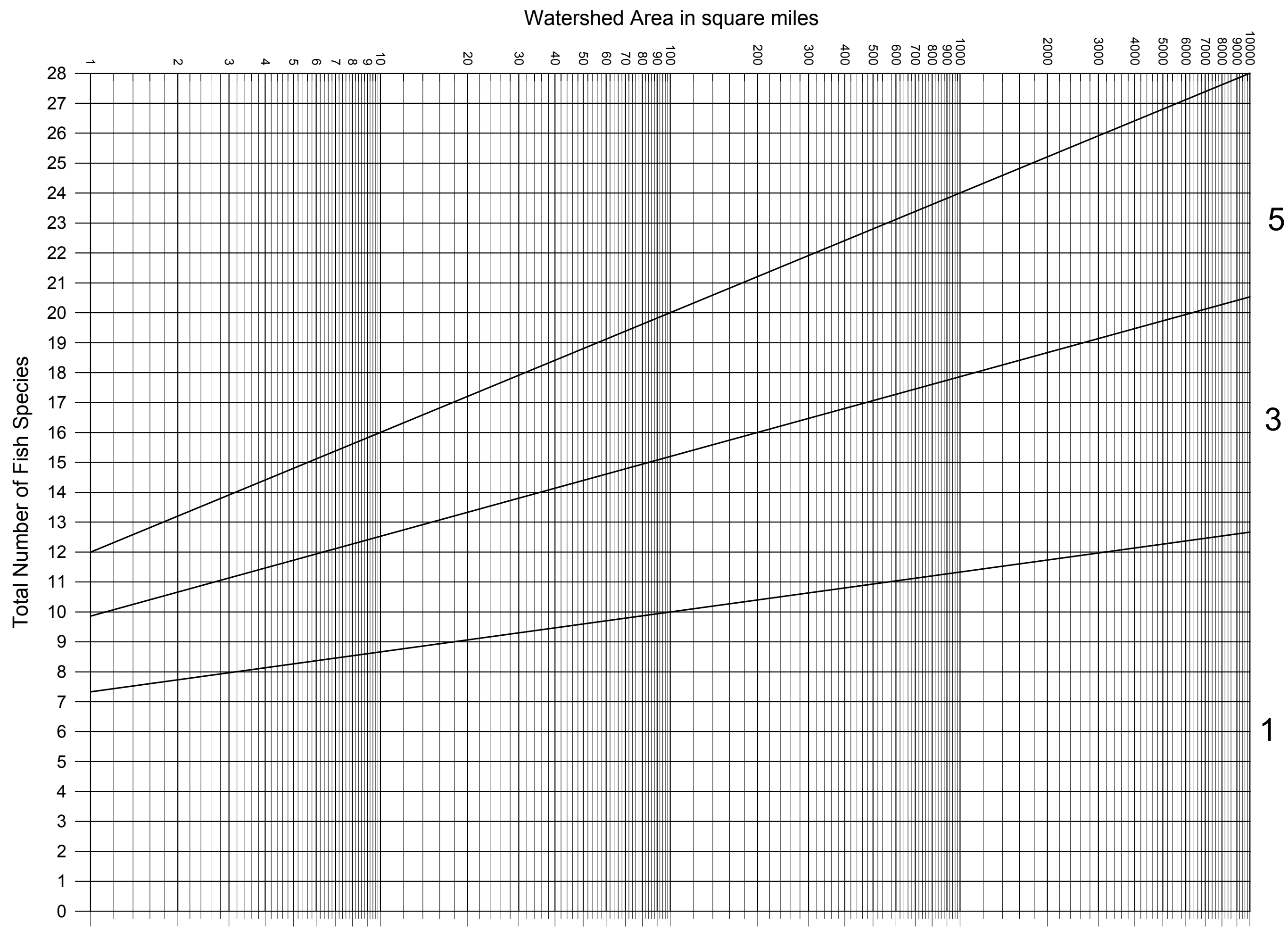
*whichever gives better score

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 not new fall and not 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

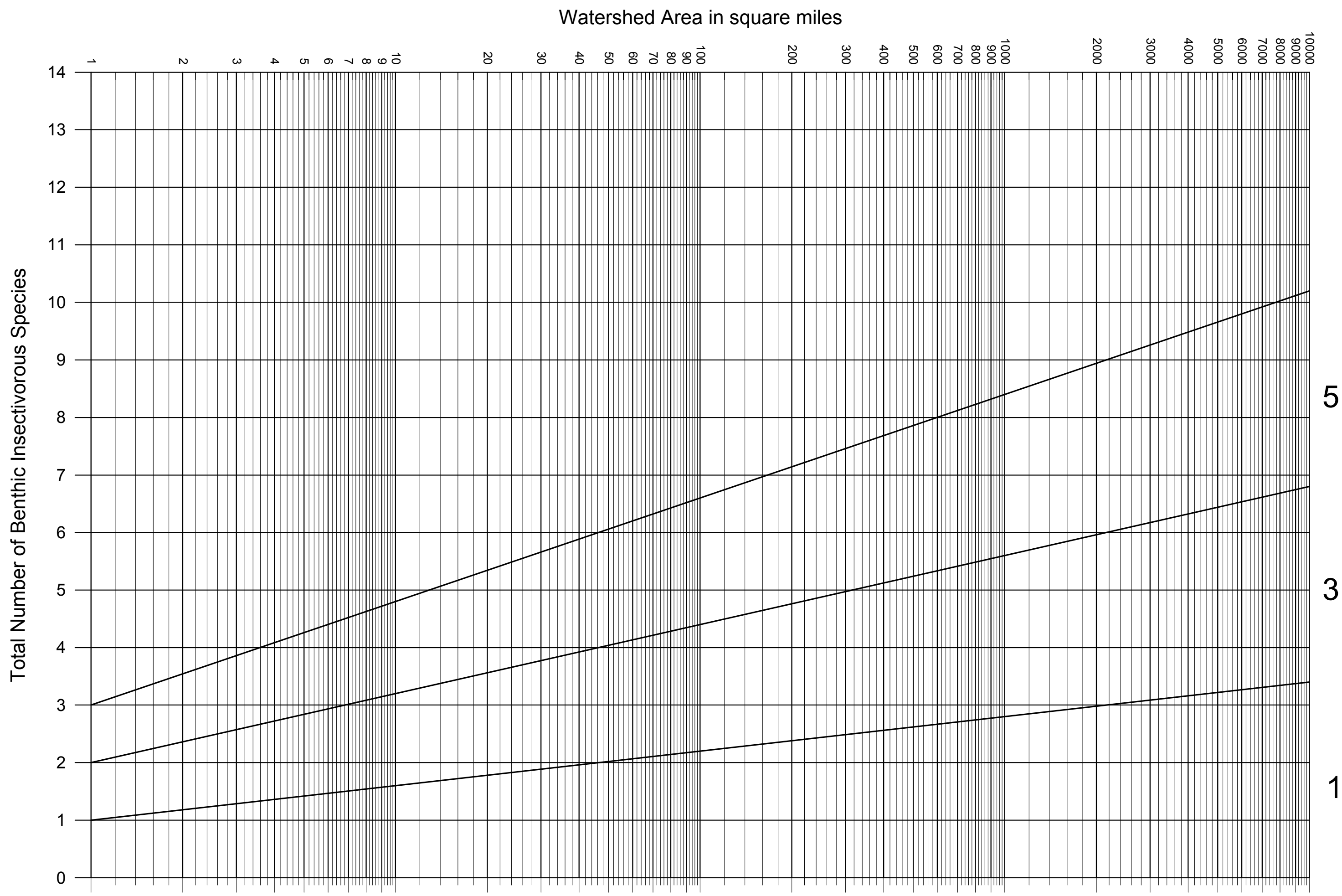
HABITAT SCORE

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

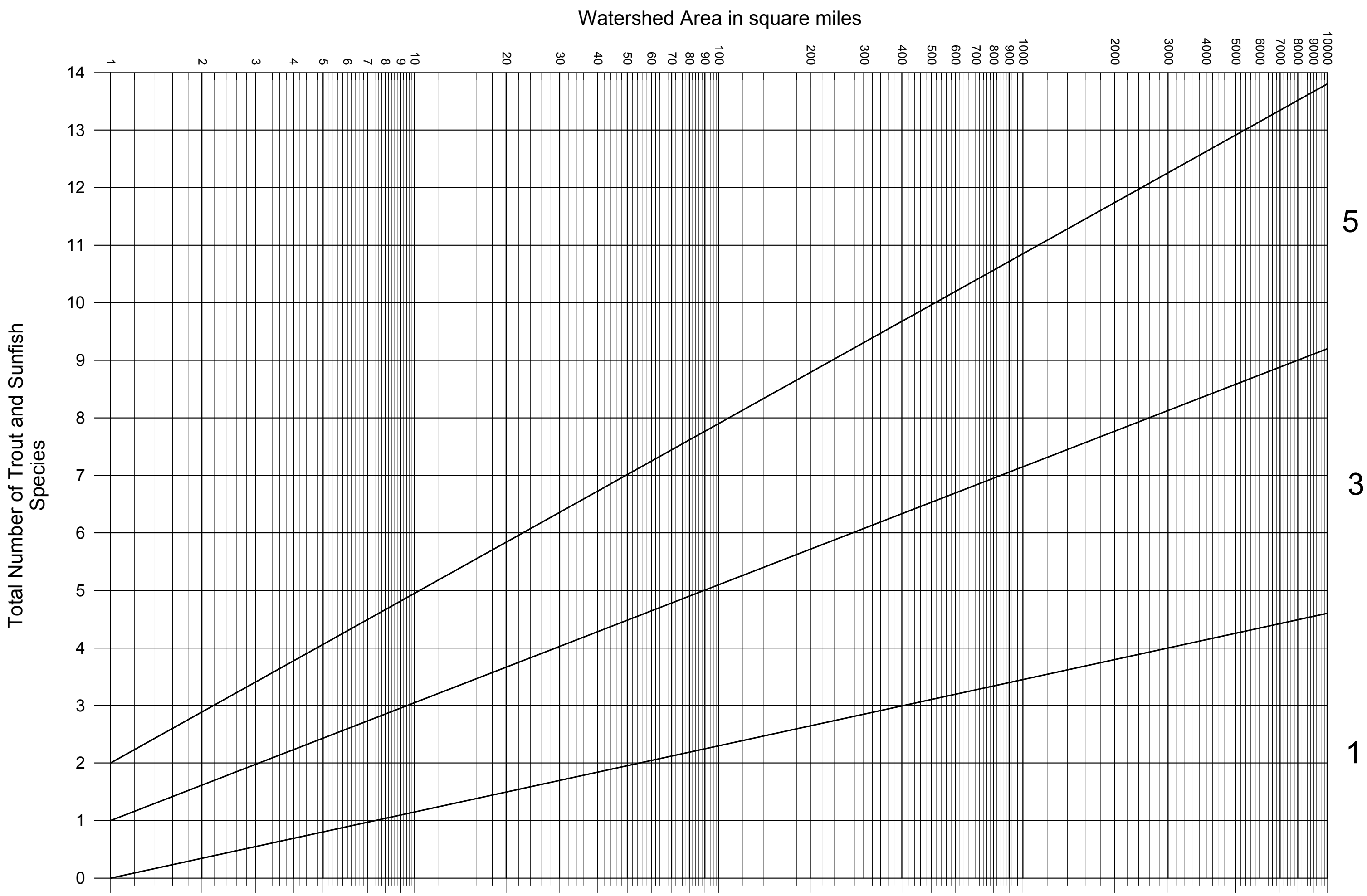
Total number of fish species versus watershed area for New Jersey ecoregion reference sites



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