F-81-R-5, Michigan
Study 230737 **New Study: 2003-04**

Name of Study: Status and trends of fish populations and community structure in Michigan streams.

A. Problem: A spatially and temporally extensive sampling program is needed to effectively protect and manage Michigan streams. For example, limited data suggest that concurrent changes in salmonid abundances across watersheds may be attributable to both regional- and site-scale factors. Spatially and temporally extensive quantitative data are needed to better describe the status and trends of Michigan's stream fish communities, and to determine the extent that patterns in fish abundances result from site-, local-, and regional factors. Description of status and detection of change in these systems is best accomplished through a systematic long-term monitoring (sampling) program. Accordingly, the Fisheries Division of the Michigan Department of Natural Resources (MDNR) initiated the Stream Status and Trends Program (SSTP) during the spring of 2002. The division-wide SSTP incorporates standardized sampling methods in an effort to collect and evaluate data from a state-wide perspective. These data include fisheries information from electrofishing, habitat measurements, and water quality sampling that will be used to monitor statewide status and trends of streams as well as to evaluate stocking and other management activities in streams. Support is needed to ensure further data collection and analysis, and to oversee continued coordination and maintenance of this new program.

B. Objectives: The objectives of this study are to:

1. Characterize fish community structure and the abundance, presence, and distribution of fish populations in a variety of stream types across the state.
2. Quantify the baseline level of variation in fish population abundance and community structure in a variety of stream types for use in interpreting individual field samples.
3. Describe long-term trends in fish community structure and fish population abundance in valuable trout and smallmouth bass streams and representative small coldwater streams across the state.
4. Track changes in survival and growth of salmonids and smallmouth bass over time.
5. Examine the relation between temporal changes in fish population size and structure and instream habitat.
6. Identify appropriate spatial scales for describing regional trends (if any exist) in fish community structure and fish population abundance.
7. Compare temporal patterns in resident salmonid abundance, growth, and recruitment among and between land-locked and potamodromous coldwater streams.
8. Oversee continued implementation, coordination, and maintenance of the SSTP.

C. Justification: Michigan's streams are a valuable, productive, and sustainable resource. For example, Michigan's "top quality" coldwater streams alone support wild populations of brook and brown trout estimated at over 10.7 million fish (based on Anonymous 1967; Gowing and Alexander 1980). The number of naturally-reproduced age-1 brook and brown trout in these streams (estimated at over 2.7 million fish) is about 3.4 times that annually produced by MDNR Fisheries Division hatcheries for stocking in streams (MDNR Fisheries Division 1995). In addition, many of these streams and others serve as important spawning and rearing grounds for other highly prized salmonids (e.g., steelhead, chinook salmon, and coho salmon) and numerous potamodromous fishes caught primarily in the Great Lakes. Abundant natural production of wild fishes provides forage for many species of wildlife (Alexander 1977) and humans. Each year, Michigan's lakes and streams provide recreation for over 277,000 trout and salmon anglers (average of 277,479 for 1991-95; Michigan License Control Commission). In addition, many warmwater streams provide highly valued fisheries, primarily for smallmouth bass (Lockwood et al. 1995).

Analyses of data from long-term studies suggest that relatively frequent sampling is needed to describe variation and trends in fish populations at spatial and temporal scales pertinent to fishery managers, and that present sampling efforts may be too infrequent. Present efforts to monitor Michigan streams involve periodically revisiting index stations (at 5-10 year intervals), with the assumption that each sample represents more or less "typical" conditions for the period between samples. However, the dynamic nature of wild salmonid populations suggests that such samples may provide little information beyond describing the status of fish populations at the moment when sampling occurred. Studies of Au Sable River salmonid populations by Wiley et al. (1997) emphasized their inherent variability, suggesting that roughly 10+ generations of sampling may be needed to define the actual range of variability in their populations. Long-term data on fish populations are needed to provide a baseline mean and range of variation in abundance against which individual samples can be compared (Elliott 1990). With baseline data, one can determine if currently perceived "trends" reflect typical fluctuations in abundance or unusual changes requiring management attention. Such data should be collected from representative stream types and geographic locations.

Long-term data have played an important role in directing research and management of Michigan streams. Long-term sampling of salmonid populations presently occurs on a few streams in Michigan, namely Hunt Creek and the North, Main, and South branches of the Au Sable River. Thirty or more years of annual trout population estimate data have been collected at these sites. Though long-term data have been collected at only a few sites, these data provide the basis for and/or have documented the effects of sediment input and removal (Alexander and Hansen 1988), changes to fishing regulations (Shetter and Alexander 1965; Shetter and Alexander 1966; Alexander and Ryckman 1976; Clark and Alexander 1985; Clark and Alexander 1992), and changes in water quality (Merron 1982) and quantity (Nuhfer et al. 1994; ongoing study 655, The effects of different levels of summer dewatering and a validation test of the Instream Flow Incremental Methodology (IFIM) in a Michigan brook trout stream). Monitoring of smallmouth bass populations in the Huron River began in 1985 and has already proved valuable for evaluating regulation changes and documenting the effects of spring floods on smallmouth bass recruitment (Lockwood et al. 1995).

Recent trends in fish populations at some sites emphasize the need to determine the spatial extent of patterns in fish abundance. Long-term monitoring efforts on much of the Au Sable River have shown declines in brown trout abundance over about the last 25 years. As a result, there has been much concern and speculation as to their cause or causes. Observed patterns in salmonid abundance are often interpreted as resulting from site-specific changes such as the effects of beaver activities or sedimentation. However, concurrent changes in salmonid populations occurring across systems, such as apparent declines in brown trout on the Au Sable mainstem and North Branch, suggest that larger-scale factors (e.g. regional changes in climate or water quality) or changes occurring across the landscape (e.g. statewide increases in land development, beaver or predator populations, or sedimentation) may play important roles in explaining abundance patterns. Data collected concurrently on other coldwater streams are needed to determine the spatial extent of present population trends.

The mission of the Michigan Department of Natural Resources, Fisheries Division, is "to protect and enhance the public trust in populations and habitat of fishes and other forms of aquatic life, and promote optimum use of these resources for benefit of the people of Michigan" (Anonymous 1997). If the Fisheries Division's goal is protection of fish populations and stream habitats, data need to be collected on factors hypothesized to be most important in regulating their abundance. With the exception of a few studies (e.g., Hinz and Wiley 1997, 1998), few data other than the fish population estimates have been collected. Consequently, little information is available for testing hypotheses regarding presently observed trends in population levels. An example of this is the Au Sable River, where the lack of a clear explanation for recent declines in brown trout populations, and speculation as to their cause or causes, has generated much controversy as to what, if any, management action is needed.

Long-term data need to be collected concurrently from representative streams dispersed across the state to effectively describe the spatial extent of temporal patterns in fish abundance and identify the potential mechanisms responsible for them. Comparisons of abundance patterns between systems can be used to interpret observed patterns at individual sites and to identify factors at the appropriate spatial and temporal scales for further investigation (Levin 1992; Wiley et al. 1997). This will help in answering the following important questions: What is the status of Michigan's stream fish communities? What trends have occurred (or are occurring) in Michigan's stream fish communities? Do present population levels represent permanent or only temporary deviations from long-term averages, i.e. is management action needed? Do they result from short- or long-term factors? Do they result from local-, regional-, or larger-scale factors? Such data will improve a manager's ability to interpret the significance of the findings of an individual fisheries survey, determine what factors may be responsible for those findings, decide whether management action is needed, and identify the types of management actions most likely to have the desired effects.

Fisheries Division's responsibility for managing and protecting aquatic resources extends to all of the state's aquatic resources. Temporally and spatially extensive data describing the status of various types of streams in Michigan are needed to accomplish these aspects of Fisheries Division's mission. Consequently, these data are needed for types including, but not limited to, warmwater and coldwater streams containing significant populations of gamefishes, streams fragmented to varying degrees by dams and those connected to the Great Lakes, and small streams with little gamefish potential. A sampling program coordinated at the state-wide level is necessary to accomplish this, given the Division's limited financial and human resources.

Protection and management of Michigan's stream systems is needed to ensure that they remain valuable and productive into the future. More recently, both the angling and much of the non-angling public have begun to view resident stream communities as indicative of the quality of their local environment. Fisheries Division's success at maintaining high quality stream systems rests on our ability to describe their status, detect adverse changes to them, and respond through management action. Description of status and detection of change in these systems is best accomplished through a systematic long-term monitoring (sampling) program. Such a program was identified as a priority in the 1994 version of the Division's Strategic Plan (Inland Fishery Resources Program, resource inventory and management experiments and evaluations sections). In 1995, the Fisheries Division created the Resource Inventory Planning (RIP) committee to formulate and implement a standardized, statewide sampling plan for streams. This was accomplished in 2002 with the initiation of the SSTP.

As the data from a long-term study accumulates, their value increases, because hypotheses relating to changes (whether expected or unexpected) in the fish community can be tested. By having pre-data on parameters such as fish growth, survival, distribution, and abundance, researchers and managers will be in a position to evaluate the effects of various changes to aquatic systems. Such changes may include watershed development or increased protection, changes to riparian habitats, instream habitat enhancement, fishing regulations changes, changes in forestry practices, changes in water quality standards, changes in dam operation, dam removal, movement or removal of sea lamprey barriers, and global climate change. With information documenting human impacts on aquatic communities, managers will be better equipped for protecting aquatic systems and identifying types of corrective measures needed.

D. Background: Michigan's coldwater stream fisheries have always been, and will probably continue to be, highly valued resources subject to intensive management and study. Knowledge has been obtained regarding the influences of trophic interactions (Merron 1982), predation (Alexander 1977), competition (Waters 1983; Larsen and Moore 1985), fishing regulations (Shetter and Alexander 1965; Shetter and Alexander 1966; Alexander and Ryckman 1976; Clark and Alexander 1985; Clark and Alexander 1992), habitat attributes (Becker 1983; Trautman 1981), sedimentation (Alexander and Hansen 1988), and abiotic disturbances (Poff and Ward 1989; Strange et al. 1992; Nuhfer et al. 1994) on fish community structure, particularly in regards to salmonid abundance levels. However, with the exception of data being collected on Hunt Creek and the Au Sable River system, no long-term monitoring of coldwater streams is occurring in Michigan. In addition, data collection efforts on these streams have focused on evaluations of the effects of specific management actions such as regulation changes or habitat manipulations on brook and brown trout populations. Variables not monitored were assumed not to have an important influence on population levels during the study, or their effects were accounted for with control and treatment sample reaches. There is presently no state-wide sampling plan for assessing the status of and describing trends in fish communities in Michigan streams.

Though variability of fish populations in warmwater streams has been well-documented (Coon 1987; Schlosser 1985; Grossman et al. 1982; Moyle and Li 1979; Starrett 1951), abundances of fishes in Michigan's coldwater streams were often thought to be relatively constant, reflecting the stable, groundwater-dominated flow regimes of these streams, with numbers of salmonids largely being controlled by deterministic processes (Chapman 1965). Long-term data collected for populations of stream salmonids, however, demonstrates their dynamic nature (Wiley et al. 1997; Elliott 1994; Alexander and Nuhfer 1993; Strange et al. 1992). For example, Wiley et al. (1997) suggested that at least 10 generations of sampling (i.e. 10 years for brook trout, 20 years for brown trout) were needed in order to effectively differentiate what proportions of the variance in population levels were due to spatial versus temporal factors. Elliott (1994) pointed out that misinterpretation of the variability of natural populations in short-term manipulation studies could easily lead to erroneous conclusions. Therefore, annual population surveys conducted at 5-10 year intervals at index stations may provide little information beyond documenting the status of the fish community at the time of sampling.

Recent studies demonstrate the role of hydrology in shaping community structure of stream fishes. Poff and Ward (1989) hypothesized that a stream's hydrologic characteristics (e.g. the constancy of streamflow and the predictability of floods and droughts) determined its community composition, species attributes, and population and community dynamics through time. Nuhfer et al. (1994) found that year class strength of brown trout in the South Branch of the Au Sable River was strongly influenced by spring flood events that affected the survival of recently emerged fry. Strange et al. (1992) found that fish community structure in a coldwater stream in California was influenced by storm-induced flood events that impacted recruitment. Differential responses to floods by species with contrasting life histories and ongoing deterministic processes (e.g. predation and competition) explained observed patterns in community structure. Preliminary modeling of brown trout populations in the South Branch of the Au Sable River suggests that spring discharges in that river have a major influence on temporal variation in population levels (Zorn et al., unpublished data).

Collecting data on variables influencing growth and survival of fishes is also critical to understanding temporal and spatial patterns in population levels and community structure. Models, such as that of Strange et al. (1992), assume constant growth, age at maturity, fecundity, and survival rates for fishes beyond their first year. Studies and anecdotal observations suggest that this assumption may not be true in many cases. Merron (1982) documented the decline in growth of brown trout in the Au Sable River after termination of sewage discharge from treatment plants. Growth declined apparently in response to lowered benthic invertebrate production. Such changes could lead to later maturity, reduced fecundity, and poorer survival of fish. Increased sedimentation has also been shown to reduce salmonid production and standing crops (Alexander and Hansen 1988). Changes in stream habitats, such as increased sedimentation of pools and loss of large woody debris, are also hypothesized to influence survival, particularly of larger fishes. Clearly, these variables need to be included in a long-term study to evaluate changes in them relative to patterns in fish abundance and community structure. Differential development patterns throughout Michigan may affect fish communities by various mechanisms including changes in hydrology, physical habitats, trophic productivity, or different combinations of factors. Comparing and contrasting changes in a number of independent, concurrently sampled areas will provide insight into cause and effect relationships between these factors and fish community structure.

Changing global climate may affect Michigan’s fisheries through changes in the physical and biotic environment of streams. Climate models project that the mean annual temperature in the Great Lakes Basin will increase by 3.2-4.8 °C in the next 40-50 years (Meisner et al. 1987). Such changes would warm streams, including those fed by groundwater, probably causing changes in their overall productivity, species composition, and growth of fishes (Pielou 1991; Tonn 1990; Meisner et al. 1987). Streams presently stocked with salmonids may become thermally unsuitable, and growth, survival, and reproductive success in streams with naturally reproducing populations may change. Temperature characteristics of streams need to be included in a long-term monitoring program to differentiate between the thermal effects on fish communities and those caused by other factors. Some historic stream temperature data exist, and data that are presently being collected could serve as baselines for later comparisons.

Spatially and temporally extensive data are needed for the various types of streams under Fisheries Division’s jurisdiction. Recent hydropower relicensing agreements have dramatically improved the prospects for restoring connections between landlocked rivers and the Great Lakes, but controversy exists among fishery managers and the public regarding the pros and cons of de-fragmenting rivers. Comparable data from landlocked and potamodromous streams are needed to: 1) provide a context for interpreting the findings of controlled experiments evaluating the effects of introduced salmonids on stream resident salmonids (e.g. ongoing Study 654, Evaluation of brown trout and steelhead competitive interactions in Hunt Creek, Michigan); 2) evaluate relationships between population dynamics of resident and potamodromous fishes at multiple spatial scales; and 3) gain insight into the effects of restoring Great Lakes connections to landlocked stream community structure and population dynamics. Numerous small streams, many with low sport fishery potential, exist that are in need of protection, both to prevent degradation of the stream communities themselves and those of larger downstream reaches. Given the limited resources of Fisheries Division, an alternative means of collecting information to improve our understanding and ability to protect small streams is needed.

E. Procedures: The general approach of this study is to sample stream communities representative of streams across the state. However, data need to be collected over a sufficient period of time to address each study objective. Therefore, the design of this study incorporates two different, yet complementary, types of sampling. A stratified random sampling design will be used primarily for general resource inventory and to provide information to compare different valley segments and stream systems. We will use fixed sites for specifically looking at trends in important resources (i.e., coldwater and smallmouth bass streams) and testing hypotheses. Research reports for the SSTP will be completed on a six-year rotation to accommodate the sampling cycle at fixed sites (see description below). This will ensure that each report covers the entire duration of a completed sampling cycle. The following paragraphs discuss each type of sampling in more detail.

Stratified random sampling.–We will use a stratified random design for describing the status of our stream resources. The primary use of these data will be in characterizing different types of streams in the state, and for answering questions best answered by comparing different streams. These data will also provide a low-resolution (yet statistically robust) means for evaluating temporal trends among different types (strata) of streams. However, differences among sites and streams within strata will add considerable variation to the "mean condition" for the year, making it difficult to detect subtle changes. We will allocate approximately 55% of the Fisheries Division's SSTP sampling effort toward this design. The primary sampling unit will be the river valley segment, stratified according to management unit, stream size (defined by drainage area), and temperature class (as described by Seelbach et al. (1997) for Michigan's Lower Peninsula, and ongoing Study 662, Inventory and classification of Michigan rivers and river fish communities, for Michigan's Upper Peninsula (Table 1). The criteria in Table 1 are used to define a matrix of sampling strata from which sites sampled for the random site portion of the SSTP are drawn.

Table 1.–July temperature regime and drainage area size criteria used to define a matrix of sampling strata from which random sampling sites are selected.

July weekly mean temperature °C			
Cold	Cool	Warm	
<19	19-22	>22	
July weekly temperature fluctuation °C			
Low	Moderate	High	
<6	6-11	>11	
Drainage area size mi^2			
Small	Medium	Large	Very large
<25	25-250	250-620	>620

Small, warmwater streams typically have little sport fishery potential, but are important resources in need of understanding and protection. Given Fisheries Division's limited resources, we will sample small warmwater streams at a reduced level (roughly 5% of our sampling effort). These somewhat cursory samples will provide us with additional information needed to protect these streams, such as fish species composition. Habitat characteristics at all random sites will be collected under a separate component of the SSTP.

Fixed site sampling.–We will use a network of fixed sites (rather than a stratified random sampling approach) for obtaining the high-resolution picture of temporal trends needed in stream types supporting valuable fisheries. Use of fixed sites will allow us to control for river- and site-level characteristics (e.g. river hydrology, local channel characteristics, woody debris abundance) that exert consistent, and often considerable, influence on fish abundance. For example, by using fixed sites to control for differences among rivers, 50% percent changes in brown trout abundance in 4 Michigan streams (South Branch Paint River and North and South branches and mainstem Au Sable River) could be detected with 3, 3, 4, and 9 years of before and after data. More than 15 years of similar data would be needed to detect the same change if random sampling had occurred (Zorn, unpublished data). Among Michigan streams with long-term data on trout abundance, 48% of the variation in brown trout levels and 22% of the variation in brook trout abundance was due to characteristics of the sites being sampled (Wiley et al. 1997). Brown trout trend data for the South Branch of the Au Sable River show that sites sampled within a stream segment show similar patterns in fish abundance through time. In addition, these data show that actual abundances vary considerably and fairly consistently among sites, i.e. some sites were always “better” for brown trout than others were. These data also show that if one randomly chose 1 of these 4 sites each year for trend monitoring, considerable site-level variation would be added to the data, making it difficult to discern if temporal trends were actually common to all sites. The use of fixed sites in our status and trends sampling will help to control for such differences and increase our ability to detect and describe temporal trends in fish abundance.

We will use networks of fixed sites within strata to provide additional resolution for describing temporal trends in and increasing our understanding of stream types supporting valuable fisheries (e.g. better quality, wadeable, wild trout and smallmouth bass streams, Table 2). The focus of fixed-site sampling will be on describing long-term trends and baseline variation in lotic systems and ecosystem study (hypothesis testing regarding trends). Stocked streams were not included as a sampling stratum because we judged that evaluations of populations in these streams would be more efficient in the context of management or stocking evaluations. Approximately 40% of Fisheries Division’s SSTP sampling effort will be put towards fixed site sampling. Fixed sites will be sampled in a 3 years “on”, 3 years “off” rotation to provide broader geographic coverage.

Table 2.–Selected strata for fixed sampling sites.

Strata	Small, landlocked, wild trout	Small, Great Lakes, wild trout	Medium, landlocked, wild trout	Medium, Great Lakes, wild trout	Medium, Smallmouth bass
Drainage area mi^2	<25	<25	25-250	25-250	25-250
Accessibility	Landlocked	Great Lakes access	Landlocked	Great Lakes access	May be either landlocked or have Great Lakes access
Key species of interest	Salmonids	Salmonids	Salmonids	Salmonids	Smallmouth bass

Fixed sampling sites will be dispersed throughout the state with the sampling effort for each stratum being proportional to the geographic distribution of stream types. In other words, northern Michigan will have proportionately more trout sites, while southern Michigan would have more bass sites. Population estimates will be made for salmonids to maintain continuity and comparability of data over time, and catch per unit effort data will be collected for all other species. Data on other parameters will be collected under a habitat component of the SSTP for testing hypotheses regarding how these systems function. Locations having existing data collection programs, such as United States Geological Survey (USGS) gages and long-term population estimate stations, will be favored as fixed sites.

Additional status and trends data may be desired for important events that happen at other times of the year. For example, the need to monitor trends in natural reproduction (or smolt production) of species such as lake sturgeon and chinook salmon may arise. Such targeted sampling efforts will be addressed as special projects or on an as-needed basis.

Data management, analysis, and dissemination.–Implementing and maintaining a sampling program for describing the status and trends of Michigan's stream resources is a major and important undertaking. As such, we feel that an overall plan and commitment to timely information assembly, analysis, and dissemination is critical to program success through time.

All fisheries data collected by the Fisheries Division is currently entered into a statewide database known as the Fish Collection System (FCS). The FCS was introduced in 1996. Recently, the FCS was upgraded to accommodate the wide range of fisheries variables collected by management units for SSTP sampling. In addition to storing fisheries data, the FCS is capable of limited data analysis, such as population estimates. Since all data collected since 1996 (and some of the data collected prior to 1996) are stored in the FCS, and because all Fisheries Division management and research biologists and technicians have access to the database from their offices, we will continue to use the FCS as the primary means of data assembly and storage.

Although the FCS has some data analysis options, they are limited to within-system analyses. Conducting data analyses within the FCS to compare fisheries data across multiple systems is currently impossible. Yet, many of the questions that we hope to address require this ability. For example, a manager may wish to know if changes in fish populations are unique to one stream of interest, or if they are common among other streams in the region or state. Such questions require the ability to conduct data analysis and comparisons across multiple stream systems and types at different regional scales.

Upgrading the FCS to conduct data analysis across systems and regions is important to providing the information Fisheries Division personnel need for effective management of Michigan's stream resources. This information should be provided in a manner that is easily accessible and simple to utilize. We propose to collaborate with Fisheries Division database personnel in charge of the operation and maintenance of the FCS to provide an easily accessible, user-friendly, web-based interface to the database. The ability of the FCS to query, analyze, and provide output from data of interest within and across systems will be of great utility to managers as well as the public concerned with the quality of stream resources. In addition to addressing complex questions requiring comparisons among systems, such an interface will allow managers to easily address questions received from the public regarding a single stream of interest. These questions often include: What types of fish live in this stream reach? Why is a certain species not found in this stream? Why are trout not stocked in this stream? How have fish populations changed through time in this stream? Further development of the FCS will allow managers, researchers, and the public convenient access to the information needed to address such issues.

Job 1. Develop and refine sampling protocols for the SSTP. Update the Fisheries Division's survey manual (Schneider 2000) to include a chapter for SSTP protocols.

Job 2. Coordinate annual fall population electrofishing surveys at random and fixed stream sites throughout Michigan to collect abundance, age, and growth data of key species (all salmonids and smallmouth bass). Record incidental observations of amphibian and reptile species. Ensure that data collection and reporting protocols for the SSTP are consistently applied.

Job 3. Work to upgrade data analysis, summarization, and display capabilities of the FCS.

Job 4. Explore opportunities to collaborate with the USGS, MDEQ, and universities to collect pertinent biological, physical, chemical, and contaminant data.

Job 5. Analyze data collected from random stream site surveys to characterize the fish community structure and status of fish populations in a variety of stream types throughout the state. At multiple spatial scales, compare population characteristics of salmonids and smallmouth bass relative to habitat attributes (abiotic and biotic) collected from the habitat component of the SSTP.

Job 6. Analyze data collected from fixed stream site surveys to describe long-term trends in fish community structure and fish population recruitment, abundance, survival, and growth in a variety of stream types throughout the state. Develop growth indices based on factors such as region of the state, thermal regime, or productivity (as reflected by nutrient levels).

Job 7. *This job will be scheduled to occur following the second six-year cycle.* Compare fish community structure, total salmonid abundance, and temporal patterns in resident salmonid (brook or brown trout) abundance, growth, and recruitment among and between land-locked and potamodromous coldwater streams. Data collected will be used to evaluate possible influences of potamodromous fishes on population characteristics and dynamics of resident salmonids, and gain insight regarding how land-locked fish communities may change if connections to the Great Lakes are restored.

Job 8. *This job will be scheduled to occur following the second six-year cycle*. Quantify baseline level of variation in fish population abundance and community structure for each type of stream. Determine whether there are geographic patterns in the baseline amount of variability in populations.

Job 9. Write annual performance reports.

Job 10. Write research manuscript(s) based on previous six years of work.

Job 11. Write study renewal for next six-year cycle.

Job 12. Publish research manuscript(s) as journal article or Fisheries Division technical document.

G. Geographical Location: Sampling and monitoring sites will be located throughout the state of Michigan. Data entry will be conducted at various field and research stations throughout the state. Data analysis and report writing will be completed at the Hunt Creek Fisheries Research Station, Marquette Fisheries Research Station, and the Institute for Fisheries Research.

H. Personnel: Todd C. Wills and Andrew J. Nuhfer, Fisheries Research Biologists, Hunt Creek Fisheries Research Station, Lewiston; Troy G. Zorn, Fisheries Research Biologist, Marquette Fisheries Research Station, Marquette; Management Unit staff, Fisheries Division, Michigan Department of Natural Resources; Information Technology staff, Fisheries Division, Michigan Department of Natural Resources; support staff.

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