Report of the Blue Ribbon Panel for Review of Procedures Used to Estimate Percid Harvest in Lake Erie

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Table of Contents

1. **Overview**

The Charge

To evaluate the efficacy, precision and accuracy of current techniques (sampling and statistical analysis) used to estimate total percid (i.e. walleye and yellow perch) harvest by sport and commercial fisheries in Lake Erie and to recommend improvements, if necessary.

The Process

At the request of the Lake Erie Committee, the Great Lakes Fishery Commission assembled a panel of experts (Table 1). Each Lake Erie jurisdiction (New York, Michigan, Pennsylvania,, Ohio and Ontario) documented details of their harvest estimation procedures and this material was distributed to panel members. On Feb 15, 2005 the panel met with representatives of each jurisdiction and heard 30 minute presentations from each jurisdiction. The panel then met in private to discuss issues and assemble a report.

Summary of the Panel's Findings

Overall, the panel thought that the procedures used by to estimate percid harvest were basically sound. All jurisdictions employed creel survey techniques based on probability sampling to estimate sport fishery harvests. Jurisdictions with substantial commercial fisheries (Ontario and Ohio) relied on mandatory reporting of landings to estimate commercial harvest.

For both sport and commercial fisheries, we evaluated potential biases of current methods and concluded that they result in a slight underestimate of the harvest.
This conclusion results partly from how we define harvest. Although harvest is traditionally viewed as just the "kept" fish, we think it should also include "released" fish that die as a result of being captured. This measure of harvest is appropriate given the intended use of the harvest estimates in stock assessments (see Section 2). Although

losses due to handling mortality are probably low at present, these losses increase when size-based regulations are introduced to control the harvest.

Another reason that harvest may be underestimated is the failure to include all sources of landings. The panel noted that some gaps existed in the sport harvest surveys. Some segments of the fishery (e.g. ice fishing, shore fishing, small access points and others) are not assessed annually and are not accounted for in reported estimates of the harvest. Individually these segments are likely small and their exclusion may have little effect on harvest estimates. Collectively, however, the effect is larger and the resulting underestimate of harvest may be appreciable. It is important therefore that assumptions about the size of missed segments be documented and that these assumptions be tested periodically (see Section 3).

Commercial fishery harvests are calculated by summing daily harvest reports that fishers are required to submit when returning to ports. Possible sources of error include inaccurate reporting of legal landings and failure to report landings (i.e. illegal landings). Given that appropriate procedures exist to check the accuracy of reporting and vigilant enforcement exists to discourage illegal landings, the panel believes that reported harvest is a fairly accurate measure of commercial landings. Of more concern is mortality of discarded fish. Procedures for estimating this component of the commercial harvest do not exist (see Section 4).

Creel surveys in Lake Erie typically focussed on major segments of the fishery (e.g. open-water, daytime boat fishing) and were generally well-designed to protect against major sources of bias in estimating harvest from the targeted segment. Some problems in implementing “random sampling” protocols for interviews and biological sampling were noted and current solutions (i.e. instructions to creel clerks) result in “haphazard sampling” that may introduce a bias. These issues and proposed solutions are addressed in Section 6.

Estimates of the age composition of the harvest are typically obtained using an age-length key. Most agencies are using otolith-based age assessments to construct this key. One agency is using scale-based ages. Because scales often underestimate the age of older fish, the panel recommends that all agencies adopt an otolith-based approach (see Section 7).

In the past, agencies have operated independently in designing and conducting surveys. The panel believes this independent approach has costs and that a more coordinated approach (design globally, implement locally) has important benefits. Given that a limited resource is being allocated among several agencies, it is imperative that agencies trust the harvest estimates produced by each agency. Potential sources of conflict can be removed by sharing information about design and methods prior to conducting surveys. Communication of harvest results would be improved if agencies agreed on what segment of the fishery would be assessed annually and how frequently estimates of other (less important) segments would be obtained (e.g., every 5 years). All agencies encounter similar logistical problems in attempting to collect unbiased data: common solutions to these problems will help avoid a differential bias among agencies. Sharing of knowledge and expertise among agencies can help to design more efficient surveys. A more coordinated approach can foster economies of scale. For example, there could be economies of scale in adopting an aerial survey that covered the whole lake. Further, a common data language and data management system facilitates sharing of data and analytical software and reduces the cost of software development and support.

The panel feels strongly that a more coordinated approach has many benefits, not the least of which is that it would greatly facilitate future reviews of harvest estimation procedures. More optimistically, we note that a more coordinated approach might eliminate the perceived need for this type of review. Section 8 promotes this coordinated approach in calling for a lake-wide operational plan and documenting essential components of such a plan.

Although we see advantages in the agencies working more closely together to develop plans, this approach does not necessarily imply that the same survey methodology should apply in all areas of the lake. Currently, most agencies use access-access or their variants (e.g., the "bus route" method in Pennsylvania) and Michigan uses aerial-access methods. These choices are based on differences in coastline that affect the number of potential landing sites. Adopting a lake-wide operational plan would not necessarily eliminate the use of different methods; instead, it could clarify why different methods are needed to survey different areas of Lake Erie. On the other hand, a lake-wide approach may identify a common method which could benefit all agencies. For example, an aerial-access survey over the whole lake may be more efficient than current methods given the undercounting that results from ignoring some access points. Pursuing this option is difficult when the agencies operate independently in designing their surveys, but it would be an obvious candidate to evaluate if agencies took a lake-wide approach.

2. Clear Objectives

There is the need for very clearly written overall objectives for the suite of surveys. This involves the accurate and precise estimation of the lake-wide harvest of Percid species (both commercial and recreational) broken down by age class. These estimates are obtained by combining the estimates from all the individual surveys. The estimates are then used in a lake-wide stock assessment model that leads to population estimates that are then used by fisheries managers to assign the Total Allowable Catch (TAC) to individual jurisdictions. Here we discuss important issues related to the *components of the harvest* estimates, their *age and size composition*, and then the *statistical properties* of the estimates.

Components of the Lake-Wide Harvest

Traditionally fisheries agencies have defined harvest as just the "Kept" fish from the recreational or commercial fishery. However, because of the ultimate use of the harvest estimates in a stock assessment based on overall fishing mortality (plus natural mortality) it is crucial that additional fishing-related sources of mortality be included and an estimate of that component of the harvest be obtained. Evaluation of whether agencies are exceeding harvests allocated to them should be based on the inclusive harvest, not just the “kept” fish.

For the recreational fisheries it is crucial that information on the number and size of *released* fish be obtained, in addition to the *kept* fish. Further, a method of estimating the fraction of *released* fish that die from *“hooking mortality”* needs to be obtained from some auxiliary studies so that an estimate of the total number of fish removed from the lake by recreational anglers can be estimated. The related quantities for the commercial fisheries are the total numbers of fish discarded. Further, an estimate of “*discard mortality*” should be obtained. This then enables the calculation of an estimate of the total number of fish removed from the lake by commercial fishers. To re-emphasize, it is crucial to not only have the kept harvest of recreational and commercial fishers, but also to obtain an estimate of the additional fish removed from the lake as a result of the recreational and commercial fishing processes.

Age and Size Composition

Once the overall estimates of harvest have been obtained they are only useful in the stock assessment if an accurate break down by size (and age) class can be obtained. The survey sampling described to us does this for the kept harvest but it also needs to arrive at acceptable methods of doing this for the additional harvest due to “hooking mortality” (recreational) or “discard mortality” (commercial). We believe that this last point deserves a lot more attention, especially given the increased use of size-based regulations to control the recreational harvest.

Statistical Properties of the Estimates

Accuracy of Estimates - An accurate estimate involves keeping the mean squared error (which is MSE= $\{\text{Standard Error}\}^2 + \{\text{Bias}\}^2$) small. If methods are implemented to ensure that the standard error and the bias are small then this will ensure that accurate estimates are obtained.

Bias of Estimates - Later in the report we discuss a variety of methods for reducing the bias of the harvest estimates. We believe that the reduction of bias is a crucial component of the overall objectives.

Precision of Estimates – The concept of precision applies to recreational fishery statistics where a survey must be conducted to estimate harvest and the precision of this estimate depends on sampling intensity. This concept does not apply to commercial fishery statistics because the estimated harvest is simply the sum of harvests reported by all commercial fishers.

We believe that the current levels of precision, as expressed through the standard errors of the sport harvest estimates, are quite reasonable. Relative standard error was generally less than 20%, implying approximate 95% confidence limits of +- 40%. Several agencies expressed concern that this level of uncertainty is too high and are investigating methods of improving precision without increasing survey costs (e.g. optimal allocation of sampling effort). We applaud this initiative, but are not optimistic that very precise annual estimates of harvest can be obtained without greatly increasing survey costs.

We do think, however, that it would be advisable for the Lake Erie Committee after consultation with the assessment scientists to set a target precision for the lakewide estimates. This would effectively set a standard for jurisdictions with large harvests while allowing less precise estimates from jurisdictions with small harvests.

3. Accounting for all kinds of removals

It is essential that estimates of harvest include all removals from the stock, even those that are difficult to observe and estimate routinely. In the case of commercial catches, the difficult components are unreported (illegal) landings and discard mortality. Mortality of released fish is a quantity that has to be estimated for sport fisheries as well. In addition, for sport fisheries there are some kinds of retained catches — perhaps small — that are not covered by present surveys. These include:

- landings at private docks and low-activity public access sites that are not covered by access-access surveys,
- shore fishing,
- ice fishing,
- fishing in spring/fall months before/after the months when the survey is conducted,
- fishing and/or returning to access locations during hours of the day not covered by the survey (e.g., night fishing), and
- fishing in rivers.

All of these unaccounted commercial and sport removals are thought to be small, and probably are, but in the aggregate they can be significant. It is therefore essential to make some kind of an estimate of each one and include it in the annual total. This may require making an estimate based on nothing more than informed judgment, e.g. for commercial discard mortality.

For most kinds of miscellaneous sport removals it is possible to make at least a rough field estimate of the amount, like Ohio's estimate of shore fishing. Where this sort of exercise shows that a certain kind of removal is in fact small, it is quite sufficient to use the rough estimate for a period of years (like the Ontario sport harvest estimate), rechecking it every five years or so, or sooner if developments in the fishery suggest the need. If the rough estimate is not small, this fishery component should be surveyed more carefully and more often.

It is particularly important to check on the quantity of landings at unsampled access sites in access-access surveys. This can be accomplished by more or less extensive on-water surveys in which the actual distribution of landing sites is estimated by interviewing anglers. At a minimum this will provide a proportion that can be used to scale up the total estimated from the creel survey. If it turns out that the survey is not covering the bulk of the landings, the survey should be expanded, or an aerial-access survey considered as an alternative.

It is believed that a significant number of Lake Erie fish head north (i.e. towards Lake St. Clair and Lake Huron). Harvesting of these fish would not be included in harvest surveys confined to the area of Lake Erie. Nor would they be counted when checking that individual agencies did not exceed agreed upon harvest quotas. This "missed" harvest, however, could be an important component in stock assessment analyses (e.g. statistical catch at age modeling) aimed at estimating stock size. Estimates of this harvest component are difficult to obtain – requiring not only that harvest surveys be conducted in adjoining waters, but also that stock discrimination methods be used to partition this harvest among lakes of origin. Given these difficulties, any current estimate of this "missed" harvest will be very rough. Improved methods of stock discrimination and greater coordination of surveys among agencies will be needed to measure this component accurately.

4. Commercial Harvest Reporting

The jurisdictions with substantial commercial fisheries (Ohio and Ontario) require complete reporting of all commercial landings and enforce the requirement with a variety of measures similar to those taken in well managed commercial fisheries everywhere. The panel believes that these reports are reasonably accurate accounts of all legal landings.

We heard no suggestion of substantial unreported removals by either pirate or licensed operators, and we heard from both the Ohio and Ontario representatives that their enforcement officers were vigilant and active, and violations are prosecuted. Illegal removals always have to be considered in estimating total removals, and the occurrence of some violations shows that they are not nil, but we believe they are probably small.

Of more concern in the commercial fisheries is mortality of discarded fish. Without observers it is extremely difficult to estimate the volume of discards in any commercial fishery, and estimating the proportion of discarded fish that die can be even more difficult. Nevertheless this mortality, too, has to be considered when estimating total removals, even if the best that can be done is to make an informed guess as to its magnitude.

5. Charter Harvest Reporting

Management of charter fisheries differs among the jurisdictions. In some cases, charter operators are treated like commercial fishers and required to report harvests. In other cases, charter operators are treated as sport fishers, in which case data are only obtained from charter boats when they are contacted in a creel survey.

The panel recommends that charter operators be treated like commercial fishers and that mandatory reporting of their harvest should be a condition of the license. This approach is needed to monitor the charter fishery efficiently. In addition to reporting their harvest, charter operators should also report the number and approximate size of released fish so that losses due to hooking mortality can be estimated.

6. Sport Harvest Surveys

6.1 Survey Design

All of the surveys used to estimate sport catches by boat anglers have standard stratified designs and associated standard estimators of point values (e.g., total landings) and variances. Sample surveys of this kind are widely used in all kinds of population research. They are simple and straightforward, and their proper use in recreational fisheries is well explained in a number of standard references cited by the various Lake Erie agencies in their reports and presentations.

In a stratified survey, the entire population is divided into distinct components (strata). Specifically, all sport landings in a state might be prospectively grouped into strata defined by landing site, month, kind of day (weekday or weekend), and time of day (AM or PM shift). The survey is designed so as to obtain data on total landings in each stratum on a sample of days. Random sampling estimators can then be used to estimate the total landings in each stratum and its variance, and these estimates can be summed over strata to obtain the population total. Surveys of this kind are generally quite robust statistically so long as an adequate number of data points is obtained in each stratum, which can normally be arranged in designed surveys.

While straightforward statistically, creel surveys do depend on some strong assumptions. In an access-access survey, it is assumed that all landing sites are surveyed. If not, it is essential to make some estimate of the proportion of landings elsewhere (e.g., at private docks) and apply an appropriate expansion factor. In aerial-access surveys, it is assumed that the catch rates of anglers who land at surveyed landing sites (large public access sites) are the same as those of anglers who land elsewhere (e.g., private docks). It may also be necessary, as in the Michigan survey, to assume (and periodically validate) that the ratio of fishing boats to other pleasure craft in aerial counts is the same as that observed at the surveyed landing sites.

Surveys should be designed so that estimates of the number of released fish could be obtained, in addition to estimates of the number of kept fish. Most surveys were designed with these joint objectives in mind. In some cases, information about the size of released fish was sought. Detailed size information about released fish cannot easily be obtained, but a rough classification by size should be attempted so that estimates of losses due to hooking mortality can be partitioned by size of fish.

6.2 Sampling Issues

The panel thought that surveys were generally well-designed to protect against major sources of bias. However, some issues in basic sample survey design or implementation were identified. These issues are described below along with suggested procedures to address each issue. In some instances, procedures may be difficult to implement immediately and substantial planning efforts may be needed to fully address issues. However in all cases the panel recommends that these problems be documented and all parties individually and jointly seek ways to address each issue

Random Sampling

Random sampling or subsampling is identified in many surveys as a protocol applied in deciding what units would be sampled (e.g., which party to interview, which fish to measure). In many cases the term **random** sampling is misapplied. True random sampling is difficult or impossible to achieve in the field. If sampling units can be identified prior to conducting a survey, then random sampling can usually be applied without too much difficulty. The angling parties exiting the lake at a sampled location on a particular day and time period cannot be randomly sampled without knowing the total number of parties prior to sampling. Additionally, each individual technician often has a different understanding of the term random. The resulting sample obtained from such a selection procedure can be described as haphazard sampling and can result in biased estimates. **The review panel recommends** that in all instances in which true random sampling cannot be achieved, alternative statistically sound sampling procedures be **implemented and documented**. Furthermore, the **panel suggests** that systematic (e.g., every fifth boat party be selected for interview) sampling be the method of choice in the absence of a better alternative.

True random sampling can be implemented for portions of the various survey designs (e.g. times for aerial counts of boats, access location/time-period combinations for sampling exiting boat-parties). However, due to vagaries of chance (e.g. weather, miscommunication, illness, equipment breakdown) sampling events do not always occur as planned. If these events happened to occur in such a manner as to alter substantively the sampling probabilities for each sampling unit then biases can result. For example if aerial surveys are cancelled due to visibility issues more often in the early morning hours --- then the probability of sampling associated with early morning hours will be less than for other hours of the day. Consistently missing the early morning hours could result in biased estimates of effort (and hence catch and harvest as well). Therefore, **the review panel recommends** that past survey data should be evaluated to ascertain the degree of departure from random sampling that has occurred. If the degree of departure is "minor" and can be addressed by remedial parameter estimation procedures (e.g., calculation of post-survey sampling weights to adjust estimates) then re-design of the sampling protocols may not be necessary. If, however, the departure from random sampling is substantive (i.e., cannot be addressed by remedial parameter estimation procedures) then re-design of the sampling protocols will be necessary.

The panel noted that in some instances unequal sampling probabilities were used for selection of time periods to sample within the day. For example in the Ohio access-access creel survey the early-day Period A covered the hours of 1000 through 1800 and Period B covered the hours of 1200 to 2000. The period A and period B samples were drawn with equal probability but due to the overlap of hours in the middle of the day the hours from 1000 to 1200 and 1800 to 2000 were effectively sampled with a lower probability than the hours of 1200 to 1800. Although this sampling design was deemed sound by the panel, the estimation procedures did <u>not</u> adjust for the unequal probability sampling method. **The panel recommends** that estimation procedures be modified to match the study design in all cases. In this example, sampling weights applied to the interview data would depend upon the hour of the interview (effectively increasing the importance of interviews during the hours of 1000 to 1200 and 1800 to 2000). Additionally, the potential impacts of depensatory sampling (outlined below) should be factored into calculation of sampling weights when necessary.

Depensatory Sampling

Most of the “access-access” surveys in Lake Erie involved a prioritization of data collection when sampling at access locations. Highest priority was assigned to counting of fishing boats returning from the lake, then interviewing boat-parties, and then sampling the fish. The impact of this prioritization is to interview parties (and sample harvests) more heavily during periods of low fishing activity. This type of sampling is called depensatory sampling in that sample sizes actually decrease with increasing population size. If values of the parameters being estimated (i.e. catch or harvest per unit effort, length composition of harvested fish) vary with fishing effort, and depensatory sampling is not accounted for during the estimation phase, then a bias in the resulting parameter estimates would result. **The panel recommends** that an evaluation be conducted to determine the extent and nature of this problem. Revised estimates can be calculated by applying adjustment weights as determined from the boat-counts within each sampling stratum (i.e., using the boat-count for the day-period-location in question in comparison to the average boat-count over all sampled periods within the sampling stratum). If depensatory sampling is severe in nature (i.e., no or very few samples taken during very busy periods) then adjustment weights cannot be calculated and the potential bias cannot be eliminated. In this case, a change in survey design will be necessitated in the future.

Assumption Testing

All of the various sample survey or informational-gathering procedures conducted by the separate jurisdictions involved a variety of assumptions that should be addressed by more than just stating that the assumption exists. **The panel recommends** direct testing or evaluation of assumptions from on-going collection of information that addresses each assumption or justification of the validity of the assumption should be provided and supported by either appropriate references to the literature, similar studies, and/or by conducting periodic separate surveys to test for or evaluate the validity of the assumptions (e.g., an aerial-access survey conducted every few years to evaluate the coverage assumptions of an access-access survey).

An example of "direct on-going testing" that could be applied relates to the assumption about length of the fishing day. Access surveys rarely sample the entire 24-hr period, the assumption being that a large proportion of the harvest is landed within a smaller time window. Constructing a frequency chart of the number of landings at each hour of the sampled day allows testing of this assumption. For example, if the number of landings during the last (or first) hour sampled in a day is relatively large, then it is likely that substantial landings occurred after (or before) the period that was sampled.

6.3 Estimation Issues

The review panel identified a few instances where the procedures used to obtain parameter estimates from the data obtained in particular surveys did not necessarily match the design. The unequal probability sampling of periods of the day in the Ohio survey (as identified previously) was not addressed with the estimation equations used for obtaining estimates. This particular instance of a mismatch of estimation procedures and the sampling design would impact the estimates of harvest directly. The other instances of mismatch identified by the panel would impact estimates of the sampling variability of estimates. Two of the identified instances of a mismatch of the estimation procedures with the sampling procedure were as follows (1) the sampling variability due to the adjustment made to the aerial counts made in the Michigan survey (for both the number of private fishing boats and the number of anglers per boat from the interviews) was not incorporated into the overall estimates of variance; and (2) the second-stage variance component was not incorporated into the estimates of variance for the Ontario survey, even though the first-stage finite population correction factor was applied[1]. **The panel recommends** that all estimation procedures fully address the sampling design features of each survey and that <u>all</u> components of sampling error be incorporated into estimates of variances (and hence standard errors and confidence intervals).

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[1] If the 2nd stage variance components are inestimable (due to sampling less than two 2nd stage units per primary sample) then the 2nd stage variance components cannot be incorporated into the overall variance estimation procedures. In this case then the finite population correction (fpc) for the 1st stage sampling process should not be used.

6.4 Post-Survey Activities

Reports of the estimated harvest should always include the standard error and confidence limit of the estimate. A harvest estimate without an estimate of its precision is useless. The harvest estimate traditionally obtained from creel data indicates how many fish were kept. Estimates of the number of released fish should also be reported, together with its standard error and confidence limit. This practice ensures that the required information is available for calculating losses due to hooking mortality. If the number of released fish is very small compared to the number kept, then this calculation may not be necessary.

Reports should always acknowledge components of the annual harvest that were not estimated by the survey (e.g. night fishing, ice-fishing - see Section 3). The rationale for excluding these components and some approximate measure of their size should be stated.

Additional post-survey activities include:

- checking how well implementation of the survey matched the plan.
- comparing realized precision to target levels and make adjustments for future surveys if needed;
- evaluating the efficacy of stratification and other design features.

Circumstances can arise that cause the realized sampling schedule to differ from the planned schedule. For example, aerial-counts of boats may have been cancelled due to weather or visibility issues. Similarly, missed interview shifts might compromise the sampling coverage for both the aerial-access and access-access type of surveys. If departures from equal probability sampling are modest then remedial action can be taken by incorporating adjustment-sampling weights to the collected information. If however, the departures are severe (e.g., little or no coverage of early morning or late evening hours within a stratum), then no adjustments to the estimation procedures can reliably address this type of problem. In this case adjustments to the study design would be necessitated in future implementations of the survey. Similarly, the degree and potential impacts of depensatory sampling if it occurred should be addressed on an on-going basis.

Realized precision of the estimates should be compared to target precision levels so that appropriate adjustments to the design of future surveys can be made. The adjustments may involve increasing overall sample size or applying optimal allocation procedures to distribute the samples among strata.

Evaluation of the efficacy of stratification should also be conducted. Stratification is useful for a variety of purposes in surveys of this type (and the panel notes that the current surveys appear to correctly apply this design feature). One reason to stratify is to obtain estimates for separate segments of the fishery. For example, stratification by month supplies harvest estimates for each month – information that management is probably interested in. A second reason to stratify is to avoid and/or alleviate potential for biases that can and do result from sampling from a population that is "stratified" in nature (for examples weekend days are generally more heavily fished than weekday days). The final reason for stratification is that it can improve the precision of estimates, but not necessarily in all cases. If two separate sampling strata have similar or equal values of the parameters being estimated (for example harvest rate of percid fishes) and overall sample sizes are low then allocating the sample size among these two similar strata instead of directing the entire sample size at a combined strata can result in a total estimate with poorer precision than if the strata were pooled prior to sampling. Accordingly, an evaluation of the efficacy of stratification should be conducted periodically to ensure that the desired end results are achieved.

Another important post-survey activity is to explore whether the survey could have been designed more efficiently. An optimum allocation of sampling effort exists when sample size in each stratum is proportional to stratum size and variability among sample units. Variability is usually proportional to magnitude of the mean. For example, if fishing activity is higher on weekend days relative to weekdays, then variability will be higher on weekend days. Consequently, survey efficiency may be improved by sampling proportionally more weekend days.

7.0 Estimating Age Composition of the Harvest

Estimates of the age composition of the harvest are typically obtained using an age-length key. First, the size composition of the harvest is estimated from a representative sample of harvested fish. Second, a size stratified sample is taken to estimate age composition within each size category (i.e. an age-length key). This key is then applied to the size composition of the harvest to estimate its age composition. Most of the agencies are using otolith-based age assessments to build an age-length key. One agency relies on fish scales. Because scale-based ages typically underestimate ages of older fish, we recommend that all agencies employ otolith-based ages to estimate age composition. In some cases, fish obtained from other sampling programs (e.g. index netting) are used to construct an age-length key because otoliths could not be obtained when sampling the fishery. This method of building an age-length key to estimate age composition is applauded by the panel.

8.0 Lake-Wide Operational Plan

The review panel recommends that an operational plan be developed that would encompass all of the programs directed at obtaining a lake-wide estimate of percid removals and other associated parameter estimates. The operational plan would lay-out the common framework of the programs directed at obtaining information for estimation of removals. The overall goal of such a lake-wide operational plan would be to ensure that information obtained through the individual programs is sufficiently accurate for sound management of the percid fisheries of Lake Erie. The operational planning process should be a cooperative venture involving biologists and other researchers, statisticians, supervisors, and decision-makers from each Lake Erie management agency. The product of the planning process is the operational plan.

The written operational plan is a vehicle for fostering cooperation among agencies. Writing of the plan forces the participants to think about what they propose to do and share ideas. The written plan serves multiple purposes including: 1) facilitates common understanding among all parties; 2) ensures the efficacy of sampling and other information gathering procedures; 3) ensures efficacy of the analytical procedures used to develop estimates; and 4) documents procedures to be followed by each program.

Essential components of the recommended lake-wide operational plan are: introduction, objectives, study design, sampling methods, data collection, data reduction, data analysis, schedules and reports, responsibilities, literature cited, appendices. Details are described below. Additional guidelines that should be considered are identified in Bernard et al. (1993).

Introduction

This section should contain material that provides a context for the program. The management need(s) for the overall program and its benefits should be been covered in this section. The goal of the program should be clearly stated.

Objectives

Objectives concern parameters that must be estimated. These parameters "drive" the program, in the sense that they dictate optimal sampling designs and required sample sizes. Objective statements should begin, therefore, with the infinitive to estimate. Other infinitives, such as "to assess," "to compare," "to determine," "to measure," and "to evaluate" are ambiguous (and have no statistical meaning) and should be avoided.

Objective criteria are attached to each objective statement. For example:
To estimate the lake-wide fishery-related removals of Lake Erie walleye such that the estimate is within *d* units[2] (or *d* percent) of the true level of removals 95 percent of the time. The quality of the desired estimate should be specified through the objective criteria (i.e., the "such that …" portion of the example). These criteria and an *a priori*

[2] Units in this case could be numbers of fish and/or weight or whatever unit "makes sense".

measure of the parameter to be estimated, as well its variance obtained from previous studies, should be used to set sample sizes. **Specification of objective criteria is of paramount importance; this is the means by which appropriate levels of sampling can be determined**. Other ways of specifying objective criteria are acceptable as long as they are understandable and unambiguous[3].

Some estimates or tests will not drive sampling. For instance, harvest of other species of interest (e.g., smallmouth bass) can be estimated at the same time as estimates for the species of interest in a creel survey, but only the parameters related to percid removals are of importance to the issue at hand. If estimates associated with these secondary species (or some similar secondary level parameter estimate) will be calculated, these items are listed as tasks in a separate paragraph in this section of the plan. Determining which activities are objectives and which are tasks is not a trivial exercise because objectives drive sampling designs and sampling levels.

Study Design

The overall framework for achieving the program's objectives should be laid out in this section of the operational plan. It addresses exactly how estimates from each survey or information gathering program will be combined to obtain lake-wide estimates of percid removals, along with the associated estimates of error. The linkage between the overall program's objective criteria (i.e., accuracy of the estimates) and the level of resources directed at obtaining the component estimates from each survey or informational-gathering projects should be outlined in this section.

Sampling designs to be used in the various projects should be listed here and are linked to the objectives of the program. A reference in the literature for each design should be cited as well. Terminology common to the statistical design of surveys should be used. The number and kind of strata, primary units, secondary units (and/or other subsampling units) should be identified. Rationales behind the specific layout of each design should be given. If rationales underlying the design layout is based upon analyses

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3 If populations are censused (every member handled), objectives do not necessarily have criteria because the sample size and the population size are implicitly the same.

of previously collected data, then that analysis should be cited (if published or included in an appendix if not). Sampling dates are also listed in this section, usually in a table or cited in an appendix.

Sample sizes are listed in this section. Literature should be cited on the source of the preliminary statistics (variance, size of removals, etc.) that were used in the setting of sample sizes (if the source is informed professional opinion, a "personal communication" is given). Any rationales behind modifying statistics to make them relevant should be described. Also, the literature should be cited on the methods used to combine objective criteria and preliminary estimates of variation and/or abundance to obtain sample sizes. If an "unpublished" method was used to derive sample sizes, the method should be described in an appendix. Note that if the same sample is used to meet two or more objectives, the sample sizes to achieve each objective should be derived and the larger (or largest) sample should be used in planning.

Assignment of sample sizes among strata should strive to achieve an optimal allocation (Cochran 1977). This allocation requires that the sample size of each stratum be proportional to stratum size and within-stratum variability (i.e., among sampling units). For a given amount of sampling, this allocation results in the most precise estimate. Cost of obtaining samples within each stratum can also be incorporated when applying optimal allocation procedures. See Cochran (1977) for more details about optimal allocation procedures.

If optimal allocation procedures cannot be followed due to either little or unreliable information regarding the expected variability then proportional allocation procedures should be followed (based on the expected size of the populations within strata). Finally, if optimal or proportional allocation procedures cannot be followed due to a lack of information, then equal allocation of sampling units would be the fall-back method of allocation among strata.[4]

[4] Note that in most if not all cases the actual population size of the sampling units in the multi-stage sample survey design of creel surveys is known a priori (for example the number of days in a month that can be sampled are known), and as such the size of the

Allocation of sample sizes among sampling strata will be additionally constrained in situations when estimates of more than one parameter are desired. Most if not all of the surveys are directed at estimating harvests of more than one species of fish, and as such optimal allocations would be expected to differ depending upon the species used to calculate the allocations. In situations such as these, final allocations among strata will have to represent a compromise of competing allocations, with professional judgment and experience factored into the decision-making process. All such judgments should however, be well-identified and documented.

Sampling methods describes the methods and means of collecting data, along with the link between sampling effort and sample size. Expenditure of sampling effort should be linked to capture rates of "samples" to assure that the sampling effort is sufficient to meet sampling goals. This link is based on information from data previously collected or from other situations as cited in the literature or from experience.

Data Collection

This section contains a description of the data collected from each sample or experimental unit and the protocols for collecting them (e.g., every fifth fish handled will be measured to the nearest mm fork length, every other boat-party interviewed, every third tote of fish measured). If a protocol is used that is described in the literature, a citation should be provided. Descriptions of sampling protocols developed specifically for this or similar projects should be provided or can be put in an appendix.

Data Reduction

This section is a description of the path the data will take after they leave the "field". How the data will be edited, how often they will be edited, on what media will the data be "captured" and later transferred, what software will be used to store the data for analysis are all topics in this section. Problems in editing and transferring data are

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population for allocation of samples among strata is generally known. Accordingly, proportional allocation can usually be applied in lieu of equal allocation, although optimal allocation is the preferred method.

described here, along with proposed solutions. This section should also include a description of the methods and means for common data sharing and archival.

Data Analysis

The conditions necessary for obtaining unbiased estimates should be identified in this section. Additionally, procedures that will be used to test for bias and correct estimates should also be listed and cited. If no statistical tests of conditions are possible, rationales as to why conditions will be met, why bias in estimates or tests will be insignificant, or why changes in design will negate this bias should be given.

All but the most basic equations behind the calculations in the analysis should be given in this section[5]. All equations should be consistent with the sampling/experimental designs listed in the *Study Design*. All equations should be cited as to their source in the literature. If multiple statistics from each of the individual component projects are combined in some manner (for example the mathematical form $y = f(x)$) to achieve a final product, the equations that comprise procedure for combination should be included. All notations should be included in this section.

Separate subsections for each component project may be necessary to include in the *Data Analysis* section. Additionally, calculating equations and the necessary literature citations (etc.) associated with the procedures to be used for combining estimates from each of the component projects should be included in this section as well.

Schedules And Reports

This section contains a timetable of the milestone dates and activities for the overall and separate component projects and a list and description of all types of reports that will be developed. Deadlines for sampling events and other field activities, data compilation, and analysis, and report writing should be listed.

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[5] Even what might be considered "standard" and hence basic calculations are not necessarily understood by all parties involved, so erring on the side of possibly excessive detail is recommended.

Responsibilities

Each jurisdiction's agencies and their associated personnel involved in the overall program are identified and their responsibilities listed in this section.

Literature Cited

References to all citations to the scientific literature should be included in this section.

Appendices

Any supplementary appendices as identified above should be included in the plan.

9.0 References

Bernard, D. R., W. D. Arvey, and R. A. Holmes. 1993. Operational planning: the Dall River and rescue of its sport fishery. Fisheries 18(2):6-12.

Cochran, W. G. 1977. Sampling techniques, third edition. John Wiley & Sons, New York.

Table 1. Panel members and GLFC co-ordinators

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