Grand Canyon Monitoring and Research Center (GCMRC)

Fish Monitoring Program (FMP) – Protocol Evaluation Panel (PEP)

8–17 May 2009

Responses to Monitoring Questions for the PEP

Lee's Ferry Trout Monitoring Program

1.1. Are the current monitoring methods providing the information that managers need to manage the fishery, or should different metrics be pursued?

- There is currently virtually no harvest on the population; consequently the management requirements for the fishery are not great.
- Management objectives for the rainbow trout fishery should be re-cast in terms of angling fishery attributes, such as catch rate (number per angler hour) or fish size.
- Monitoring methods provide precise estimates of relative abundance from fishery dependent (creel survey) and fishery independent (electro-fishing survey) surveys.
- Electro-fishing surveys provide additional estimates of size structure (indexed as PSD), body condition (indexed as relative condition), and growth (estimates not provided) and presumably age structure.
- Trends in relative abundance indexed through creel and electro-fishing surveys are consistent, which suggests that trends in population density are indexed accurately.

1.2. Is the current sampling design sufficiently robust enough both spatially and temporally to monitor a change in status and trends in the distribution, condition, and abundance of rainbow trout?

- The current sampling design provides annual estimates of fishery attributes throughout the Lee's Ferry reach of the river, but is probably more intensive than necessary.
- The power analysis suggests that reducing the electro-fishing effort from 3–4 trips per year to 1-2 trips per year would still provide an adequate index of trout population density and recruitment, with only small impact on precision.
- Comparison of fixed and random sites indicates that both designs provide similar indices of population density, suggesting that both are not needed to accurately index trends in population density.
- Therefore, the random sampling design should be retained and the fixed sampling design can be eliminated (saved effort can be reallocated to other parts of the monitoring program).

1.3. Are standard measures of relative abundance, e.g., catch rate, suitable surrogates for calculating absolute annual abundance? What are the relative risks of using CPUE instead of determining annual abundance? Does the PEP panel recommend that absolute annual abundance is needed for managers to make management decisions?

- Catch rate is a suitable surrogate for indexing abundance if catchability is proportional to population density, so the relationship between catch rate and population density must be examined for non-linearity.
- Risk of using catch rate instead of absolute abundance is related to non-constant catchability (i.e., hyper-stability or hyper-depletion), where catch rate declines more or less rapidly than population density as density declines.
- Absolute annual abundance is not needed for managing the fishery if management objectives are re-cast in terms of angling catch rate and if catchability is proportional to abundance. This assumption cannot be explicitly tested because annual estimates of abundance are not available. Elements can also be examined by comparing the angler and electro-fishing CPUE data and considering whether gear saturation occurs at high densities, or if searching behaviour by anglers occurs at low trout densities. The latter is likely in the sports fishery.

1.4. Should a greater emphasis be placed on young-of-year rainbow trout survival, growth and recruitment in this monitoring program?

- Monitoring age-0 survival, growth, and recruitment is needed only if management objectives require such knowledge. The Panel suggests that the management objectives should be recast in metrics appropriate to a recreational fishery, which do not include a juvenile component.
- Recruitment can be indexed through the ongoing fishery independent sampling program, so added survey effort focused on juveniles is not necessary to meet this objective. Better use of age information could result in the development of a recruitment indicator from the regular electro-fishing survey results.
- But juvenile recruitment dynamics may need to be understood if management objectives for the population include addressing the impacts of flow manipulation on the early life history, including attempts to manage the population using flow.

1.5. Is the frequency of Lees Ferry rainbow trout population monitoring suitable for addressing the CMINs?

- See response to question #2 above.
- Surveying the reach 3–4 times each year is not likely needed to adequately monitor status and trends of the trout population in the reach.
- Less intensive survey effort will likely be sufficient if the objective for the survey is changed from estimation of absolute abundance to indexing relative abundance. This is especially the case if there is no harvest on the population and if the angler CPUE and electro-fishing catch rates are sufficient for evaluating long-term trends.
- Simulation studies can be used to determine the required amount of sampling. The stated goal of a Coefficient of Variation (CV) of 10% is far more precise than most assessments, where 20% would be seen as more than adequate.

- If the current fixed sites are deleted some effort can be reallocated to surveillance for non-native fishes (e.g., sampling the 'carp pond', location of previous smallmouth bass catches, etc.) and the remainder used to increase the number of randomly chosen sites sampled per trip.

1.6. What is the best way to monitor downstream movement and fate of rainbow trout? What is the best way to determine if downstream movement is density dependent, or dependent on some other factor?

- Downstream movement can be monitored by tagging trout in the Lee's Ferry reach and then modeling recapture rates of tagged fish in downstream reaches.
- To enable modeling of movement, numbers of fish tagged must be large enough to ensure enough recaptures are observed in downstream reaches. Current sampling effort is not likely sufficient to tag adequate numbers of fish for modeling density dependent movement from Lee's Ferry to other reaches of the river. Thus a power analysis should be undertaken to determine the number of fish that would have to be tagged annually to estimate movement into downstream reaches using this approach.
- Alternatively, downstream movement can be inferred by comparing catch rates of trout species between the Lee's Ferry reach and downstream reaches sampled during mainstem Colorado River monitoring (see below).
- There may be enough information already available in the historical data to evaluate density-dependent movement by 2010 if the apparent large 2008 cohort materializes. Age-specific catch rates in Lee's Ferry and in the 0-60 mile region can be compared by cohort to determine if there is a non-linear or proportional relationship between abundance in Lee's Ferry and further downstream.
- In addition, tagging instead of removing fish in the control reach can be used to identify rates of immigration into the removal reach from upstream or downstream.

Native Fish Monitoring Program

2.1. Are the current monitoring methods and analytical approach employed by GCMRC, AZGFD, USFWS, and other cooperators sufficient to address the CMINs? If not, how should the field and analytical methods be improved to better address the CMINs?

- Current monitoring methods (hoop netting) and analytical approaches (ASMR modeling) are state of the art for the species, especially for the adult fraction of the population in the LCR.
    - Hoop nets are effective for monitoring humpback chub with low incidental mortality.
    - The ASMR model is the best available modeling strategy for available data.
- However, patterns of recruitment indexed through hoop netting and estimated through ASMR modeling are not consistent, evidently because of age-estimation error in the ASMR model.
    - Hoop net catches of fish shorter than 150 mm show strong alternating year classes with dominant year classes in 2002, 2004, 2006 and 2008.
    - Model-based estimates of age-2 recruitment show an increasing recruitment trend, but no biannual fluctuation in year-class strength.

- Consequently, age-estimation error in the ASMR model should be assessed by sacrificing some fish for direct estimation of age and growth.
    - Samples (e.g. anal fin rays, scales, and otoliths) should be collected from a sample of fish over the range of observed lengths for *age verification*.
    - Age estimates from fish tagged at small size (young “known” age) and recaptured over a wide range of years at liberty should be compared for *age validation*.
- Current monitoring and analytical approaches are not likely sufficient for the mainstem of the Colorado River (see **Mainstem Colorado River Monitoring**). We suggest that trammel nets are not appropriate for sampling in the LCR, but could be valuable for use in the eddy fences in the mainstem where water temperatures are cooler.

2.2. The current biological opinion requires an annual update of the ASMR model of the adult humpback chub population. What is the most efficient way to monitor to achieve this annual update?

- Current monitoring methods provide relatively rapid annual updating of stock status, so should provide an early indication of stock status and trends (periodicity of reports suggests that annual updates are obtainable at present levels of effort).
- Standardized reporting of the field programs should be implemented so that results can be compared and time series for all programs are readily available.
- The species is so long lived that annual abundance estimates of the adult population are not needed or warranted.
- Annual updates of field sampling are easier and cheaper than ASMR model updates so should be considered as a replacement for annual updates of the ASMR model. For instance, recruitment can be monitored with empirical catch per unit effort of fish less than 150 mm TL.
- The intensity of effort required for annual updating of the ASMR model would require increased support for the ASMR model, perhaps by hiring a position to maintain the model.
- Even though BO calls for ASMR to be updated annually, the panel does not recommend doing so; a 3-5 year reporting cycle is probably adequate.

2.3. Does the panel agree that parasite monitoring be conducted every 5-6 years as recommended? If not, what alternative monitoring schedule is recommended? How should parasite monitoring data be used?

- The rationale for parasite monitoring on any temporal scale relative to management objectives is not clear and it is difficult to assess how it would be used. This makes it difficult to recommend a time scale for sampling.
- If lethal monitoring is conducted, other tissues should be saved for analysis, especially otoliths, fin rays and other structures for aging and possibly soft tissues for genetic analysis.

- If water temperatures rise, more intensive surveys may be indicated, but these may be the non-lethal sampling methods. External parasites should be monitored opportunistically, in conjunction with other monitoring.

2.4. Can the panel recommend a range of stock assessment options at differing levels of effort and expense so that managers can evaluate the relative range of information to be gained from a range of expenditures? In other words, what are the most precise, most expensive stock assessment methods, and what are the less precise, less expensive methods?

- Current levels of field sampling include large-hoop netting by AZFG in the lower 1,200 meters of the LCR since 1987 (20–30 days each spring) and four small-hoop netting trips by USFWS in the lower 14 km of the LCR since 2000 (2 spring and 2 fall sampling events). The field programs are supported by extensive analytical work on the tag database.
- The evaluation of the HBC programs would benefit from the development of an assessment framework that lays out how the information being collected in the various monitoring programs is used for the assessment of population state. Once the framework is developed it can be used for routine updates on an annual or semi-annual basis. Further, the implications of adding, removing or modifying programs on the capability of the program to monitor state can then easily be evaluated.
- Both hoop netting surveys may provide similar indices of stock status and trends, but comparison of the two surveys has not been attempted and the differing formats of data provided in reports by each agency hinder direct comparison. Therefore, the 2 hoop netting surveys should be compared to determine if sampling effort can be reduced or consolidated to provide more concise assessment of stock status and trends.
- The ASMR model requires data from the field sampling programs and represents a small incremental cost to the field programs. The ASMR analysts should consider their minimum tagging requirements as a lower benchmark of effort for programs tagging HBC.

2.5. Does the panel have any concern over the amount of handling (monitoring) of humpback chub that is currently conducted? Is too much monitoring being conducted now? If so, what handling should be curtailed or eliminated to reduce this concern?

- It was suggested that the monitoring of humpback chub subjects 65 – 80% of all fish in the population to handling at current rates of PIT tagging and sampling although the rate at which individual fish may be handled, especially during spawning season, was not clear.
- Despite this level of handling, the population has been increasing since 2000, which suggests that handling stress is not causing a decline in the population. However, population recovery may have been slowed slightly by handling mortality.

- Handling protocols have been developed for the Colorado River Basin, especially for bonytail chub. It may be desirable to develop written protocols for the Colorado River humpback chub monitoring. A HBC PIT tagging protocol has been established.
- Overall the panel feels that PIT tagging mortality for adult fish is probably low and is pleased that crews tagging in the field in AZ are trained in tagging protocols.
- Tagging mortality should be assessed, especially for the smallest fish. This could be accomplished in live cages during the annual PIT tagging. Native fish held in field should not be held too long, especially in the LCR. Fish held in the LCR should probably not be held longer than 24 hours, and might even be held less than 12 hours.
- Recent studies with Pacific salmon have found that tag expulsion rates of 18% occur when small fish are tagged and are at liberty for a number of years. PIT tagging was also found to cause a 10% increase in long-term mortality. This highlights the potential risks of PIT tagging small HBC.
- It should be a programmatic goal to reduce the handling of any endangered species. The Panel saw the PIT tag antenna array as a potentially useful tool to meet this goal. The intensity of sampling and tagging in the LCR should be evaluated to determine the minimum requirements to meet the assessment needs and surveillance requirements.

Mainstem Colorado River Monitoring

3.1. Given the distribution of humpback chub in Grand Canyon, how should monitoring efforts for this species be distributed?

- The current tag-ASMR program adequately assesses abundance of the LCR/LCR inflow aggregation of chub which is the largest component of the population and thus will be the driver of overall trends.
- Current monitoring programs enable indexing of status and trends of humpback chub throughout the Grand Canyon by:
    - Electro-fishing at 11 sampling reaches from 2000–Present to monitor native and non-native species distribution and population density.
    - Trammel netting for adult native species and hoop netting for juvenile native species in 11 sampling reaches was conducted during 2002–2006 but was discontinued because of concerns about post-handling mortality on humpback chub (particularly in trammel nets).
        - However, recent laboratory studies suggest that trammel netting induces little mortality on a related species at temperatures occurring in the mainstem Colorado River.
        - Therefore, trammel netting can be safely added back into sampling design without risking significant incidental mortality of native species.
- Sampling design is based on random selection within reaches, which is useful for identifying a major change in distribution or the development of a new aggregation, but is not likely to be efficient at monitoring known sites where humpback chub are likely to occur.

- If a program goal is to monitor specific aggregations of HBC in the mainstem, then a fixed sampling design will be needed for these areas and translocation sites.
- Sufficient data likely exist to determine the relation between sampling and precision to evaluate what can be accomplished with a mainstem aggregation monitoring program.

3.2. Given that various levels of monitoring effort are required to assess various levels of fish population changes, and unlimited funding is not available, can the panel recommend one or more processes for determining how to allocate limited resources to native and nonnative fish monitoring?

- The monitoring programs in the LCR and mainstem are mature enough that some thought should be given to how the information from the programs will be used for reporting or decision-making. An assessment or reporting framework for each component of the program should be developed to clearly show how the results from the monitoring activities contribute to the evaluation of status and trends. This type of process would then permit an assessment of the implications of modification to the delivery of status and trend information.
- The current sampling design includes only one active capture method (the electro-fishing surveys), so should be enhanced by addition of passive capture methods, such as trammel and hoop nets, that are known to be effective for sampling native species with little post-handling mortality at temperatures that are likely to occur in the mainstem Colorado River.
- The current sampling design is stratified to encompass 11 reaches within the Colorado River between Lake Powell and Lake Mead, so provides an excellent design for assessing status and trends of relatively abundant native and non-native species throughout the river.
    - However, the design should be modified by adding known points of likely invasion of non-native species based on a risk analysis of species colonization (e.g. tributaries).
    - Similarly, the design should be modified by adding known points of likely populations for native species (e.g. translocation areas and tributaries).
    - These sampling sites for non-native species invasions and native species recovery should be the focus of targeted surveillance sampling (see below).

3.3. Considering the trade-offs between monitoring cost and sampling precision, are there any suggested spatial sampling designs (systematic, random, stratified) that optimize the sampling distribution (e.g., use a multi-level approach that integrates a priori the sampling efforts among existing research and monitoring programs that are presently conducted independently)?

- As stated in response to question #2, available data from trammel netting and electro-fishing surveys can be examined when designing a hybrid sampling program.
    - Systematic sampling at fixed index locations should focus on detecting invasions by non-native species and recovery of native species at known aggregations and translocation sites.
    - Random sampling at stratified-random locations should focus on status and trends of both non-native and native species throughout the Colorado River.
- Staff within the GCMRC have the expertise to design a hybrid sampling program that optimizes across objectives (see 4.1-2).

- Models that employ simulated sampling to test different sampling schemes could be useful for determining how to best allocate sampling effort (e.g., whether to sample a few sites many times or many sites a few times).

3.4. How should the monitoring program allocate sampling effort in the monitoring design that temporally accounts for sampling constraints (e.g., NPS non-motor season) or seasonal differences (e.g., developmental and dispersal histories)?

- Current mainstem sampling protocol for electrofishing likely over-samples at 2 trips per year, so consideration should be given to reducing it to an annual trip. It is reasonable to consider a target CV of 0.2 rather than 0.1 for the precision of the annual CPUE estimates.
- Surveillance monitoring of status and trends can likely be set at a single point within the year, so periodic or seasonal sampling within years is not likely needed; this sampling can be scheduled during the motor season to facilitate logistics.
- Allocation of sampling effort within years is estimable by analysis of existing data from surveys that are conducted multiple times each year.
- Effort saved by reducing the electro-fishing survey protocol can be reallocated for monitoring colonization by non-native species and recovery of native species at fixed sites (see above).
- Monitoring at fixed sites in the mainstem should be scheduled during the motor season because rapid movement among sites will be necessary.

3.5. Should routine monitoring methods be altered to allow detection of nonnative fish invasions and expansions? If so, how? If not, what sampling program should be instituted to allow detection of new invasions or significant expansions?

- See responses to questions #1–4.
- A mixed sampling design of stratified-random and fixed-index sampling locations is needed for monitoring both status and trends of established populations and detecting fish invasions and small populations of recovering native species.
- Local knowledge should be employed to identify “hotspots” such as creekmouths, or below large rapids for the surveillance for new species or changes in the distribution of existing species.

3.6. Given that the primary focus of many GCDAMP management actions is to improve spawning and rearing conditions for native fish in the Colorado River, what metrics should be evaluated for assessing these actions (survival, growth, abundance, distribution) and what are promising sampling designs?

- Spawning and initial rearing success are measured most directly through sampling of native species at an early life age or stage, such as yolk-sac larvae, as is presently done elsewhere in the basin for razorback sucker and bonytail chub.
- Early life-stage sampling is part of the nearshore ecology project, which will help to frame future monitoring needs and methods for the mainstem.

- Detecting recruitment of native species requires a sampling method, such as electro-fishing or hoop netting, to which pre-recruit age classes of native species are vulnerable to capture.
- Detecting recruitment of native species also requires sampling where populations are being established, such as through translocations.
- Successful spawning and production of early life stages can be indexed by age-0 catch rate in an appropriate sampling gear in an appropriate location (e.g. seining in backwaters).
- Alternatively, the ultimate success of management actions can be measured by monitoring adult abundance at locations for population recovery (see above).

3.7. How can monitoring of the humpback chub mainstem aggregations best be conducted to determine if humpback chub are spawning in these locations?

- See response to questions #1 and #6.
- Sampling for larval or juvenile life stages of HBC directly indexes successful spawning and rearing of mainstem populations. However, the determination of recruitment success is probably more important than spawning alone.
- Alternatively, telemetry can be used to determine if adult fish aggregate for spawning (assuming the species aggregate for spawning, which is not known at present).
- For some species there is a predictable cycle of hormones prior to reproduction- it may be possible with small blood samples to evaluate maturation in these aggregations.

3.8. Should GCMRC and cooperators establish separate monitoring for natives and nonnatives, or can the CMINs be addressed if these efforts are conducted together?

- See responses to questions #1–4.
- Established populations of native and non-native species can be monitored for status and trends by the current stratified-random electro-fishing sampling design (and perhaps enhanced by judicious use of trammel and hoop nets; see 3.2).
- Colonization of non-native species and recovery of native species can be monitored for detection by the proposed surveillance sampling design (mixed gears; see below).
- In late summer or autumn, many species are active, so are vulnerable to capture in passive gears that are proposed for use in the targeted sampling design.

3.9. Are there multiple sampling methods and gear types (nets, traps, electrofishing, hydro-acoustics) that could be used in combination (temporally/spatially) that would best inform the monitoring objectives?

- See responses to questions #1–4.

3.10. When allocating sampling effort, should river segments or habitat features be used to stratify the sampling distribution? And if so, should the number of sample units be selected based on the proportion of available strata or evenly distributed among strata?

- The current strategy for stratifying sampling effort (which is based on river segments) is appropriate for monitoring status and trends of relatively abundant species, but is not likely appropriate for detecting invasions by non-native species or recovery of rare native species.
- For surveillance of non-native species colonization, other information about where these species might occur should be used to inform the selection of sites (e.g., through a risk analysis).
- In addition, analysis of existing capture data may be useful to devise habitat associations, from which samples could be drawn.
- Adaptive sampling for non-native fish in target areas may also be useful for detecting new non-native species or small populations of native species.

Non-Native Fish Downstream Monitoring Program

4.1. Is the current sampling design sufficiently robust enough both spatially and temporally to monitor a change in status and trends in the distribution, composition, and abundance of nonnative fish species?

- The current design is adequate for monitoring status and trends of established populations of native and nonnative fish species, but not for rare species. Further, the prescribed level of precision (CV $\leq$ 10%) is likely more restrictive than needed for detecting realistic changes in relative abundance, especially if the surveys are conducted annually.
- The current design should be modified to include surveillance monitoring at likely locations for non-native species colonization and recovery of native species (see above).
- An analysis of the relation between the number of species captured and sampling effort may be helpful in allocating overall effort and choosing among gear types.

4.2. Would using alternate sampling methods or gear types in addition to electrofishing provide greater insight on fish distribution, composition, and abundance?

- Yes. Many species known to be present in the watershed are vulnerable to electro-fishing, so will likely be detected (e.g. Centrarchids and Percids). However, some species known to be present in the watershed are less vulnerable to electro-fishing, so would not be as easily detected (e.g. Ictalurids).
- The mainstem electrofishing survey should continue with surveillance forays at prime locations for non-native species colonization (e.g. carp pond at Lee's Ferry; upstream and downstream reservoirs, and tributary streams).
- A second survey using a mix of passive and active capture methods other than boat electro-fishing (e.g., trammel nets, hoop nets, hooks, and backpack, barge or prepositioned electro-fishing) should focus on prime locations for non-native species colonization; likelihood of detecting rare species increases with repeated samples using multiple gears.

4.3. Should electrofishing effort be quantified by time and/or distance?

- Electrofishing effort can be quantified by either time or distance and is commonly standardized to both metrics of sampling effort.

- Existing survey data can be explored to understand how time and distance relate to one another as measures of sampling effort, but both should be recorded and used as appropriate.

4.4. Should sampling areas be stratified by geomorphic reaches? Or should another type of strata be used in the sampling design?

- Stratified-random sampling design for mainstem electro-fishing survey is correct for monitoring of existing, widespread, populations (i.e., stratification by geomorphic reaches is appropriate).
- However, sampling for monitoring colonization by non-native species should not be randomized, but rather, should be focused in areas where non-native species are likely to be introduced (tributary streams) or in habitats where they are more likely to be found.
- Likely sources for non-native species introductions are already known so should be added to the mainstem monitoring program (see above).

4.5. Would other types of abundance indices (e.g., occupancy rate) be more appropriate for monitoring than conventional catch rate indices?

- Occupancy rate is the fraction of sites visited in a year at which a particular species is captured (detected) in a year.
- This typically requires much more sampling than is presently invested in monitoring, so does not represent a reasonable alternative to catch rate from current sampling, although models that allow for multiple years of sampling should be investigated.
- Detection probability is the likelihood that a particular species will be captured (detected) during a visit to a particular site. Baseline values can be calculated during multiple pass removal or mark-recapture studies.
- If past and future sampling can be used to derive relationships between detection probability and the density of various target species, then confidence values can be derived for the likelihood that a species is indeed absent from a location after repeated samples of non-detection.

4.6. Is the sampling coverage sufficiently representative of this system?

- Sampling effort is allocated throughout the river between Lake Powell and Lake Mead, so seems to be representative of the entire river system for the widely distributed species, but probably not for rarer species. Small populations will not likely be detected by the current stratified-random design, so should be monitored using targeted sampling at likely points of colonization.
- Existing data can be explored to determine if reduced sampling intensity in the stratified-random survey would produce similar estimates of species status and trends (accuracy and precision).

4.7. Can native and non-native fish be concurrently monitored to detect changes in distribution, composition, and abundance?

- Yes. See responses to earlier questions related to mainstem and non-native monitoring.

4.8. What is the best monitoring design to detect newly invading, rare, or evasive non-natives?

- See responses to earlier questions related to mainstem and non-native monitoring.
