Summary from NBS/PG&E/SCE workshop on HSC. (12/6/95). Sacramento, CA

Summary of Workshop Results

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I. Results Concerning Factors Identified in PG&E Report as Affecting HSC.

These are comments and observations that address the five factors identified in the PG&E report. These results can be used to update or revise the report conclusions.

A. Stream Structure

1. "Fish may leave if there are no velocity shelters" (implying that densities should be expected to be different between sites with and without high structure, which implies that HSC will be different between such sites).
   a) Basis: G. Smith comment
2. The report and discussion focused on sites with vs. without high structure, whereas in reality there is a gradient of low to high structure sites.
   a) Basis: unknown
3. Mesohabitat types and their relative abundance, cover, and velocity shelters should be similar among sites for HSC to be transferable.
   a) Basis: C. Stalnaker comment.
4. Standard techniques to remove bias due to habitat availability (e.g., sampling equal areas of each habitat type) do NOT fully account for differences due to stream structure; HSC should not be transfered between sites with major differences in structure.
   a) Basis: T. Payne obs., W. Lifton obs.

B. Season (temperature)

1. High temperature makes trout abandon feeding stations and move to pools, where they do not defend territories. (This movement is most likely to seek refuge in cooler water.)
   a) Basis: J. Stevens field obs. in Merced River.
2. Temperature changes the amount of time spent feeding vs. holding. (Time spent feeding probably increases with temperature, until fish abandon feeding to seek thermal refuge.)
   a) Basis: C. Addley obs.
3. Temperature affects swim speeds, which can affect habitat selection.
   a) Basis: C. Addley (plus bioenergetics literature)
4. Temperature effects on habitat selection can be due to thermal REGIME, not just the instantaneous temperature; temperature effects on swim speed, bioenergetic parameters, etc. are affected by acclimation temperatures.
   a) Basis: W. Lifton comment.

C. Season (other)

1. Seasonal changes in behavior and habitat use include holding or hiding in winter.

   a) Basis: J. Stevens field obs.

2. Seasonal changes in habitat use may include less avoidance of predation in winter under ice. (There is literature showing more use of mid-channel habitat under the ice, apparently in response to the absence of avian predation.)

   a) Basis: T. Payne obs., G. Smith obs.

3. Seasonal changes in activity include amount of time spent holding vs. feeding, presence or magnitude of diurnal changes in activity, and migration; these may be controlled by temperature and/or photoperiod.

   a) Basis: (group discussion)

4. Substrate preference, in addition to depth and velocity, can be affected by season: interstitial space for holding can be an important winter habitat requirement.

   a) Basis: C. Stalnaker, obs. of Trinity River steelhead.

D. Fish Size

1. Smallmouth bass young-of-year have limited ranges of suitable habitat, but these ranges change dramatically over short time periods as fish develop. Therefore, they require a diversity of habitat to survive early life stages.

   a) Basis: D. Orth opening cmts, based on field studies.

2. Fish size dependency in velocity use is determined by swim speed, not by bioenergetic costs of swimming (which are low). Small fish, e.g., use velocities up to the limit of their swim speed; they do not avoid high velocities because of the energy requirement of swimming fast. Therefore, swim speed variation with size should be a better indicator of how fish size affects velocity HSC than should bioenergetic analyses.

   a) Basis: C. Addley modeling studies.

3. Size variation in habitat use is not related to "life stage", once fish are beyond fry. Small adults are not different from large 1-year-old "juveniles". HSC should be linked to fish size, not "life stage" for fish that are fully developed.

   a) Basis: J. Stevens field obs.; T. Studley, T. Lambert field obs.

E. Competition

1. Predation causes fry to shift habitat.

   a) Basis: J. Stevens field obs.

2. Habitat overlaps and competition between life stages of a species occur.

   a) Basis: T. Studley field studies.

3. Habitat overlaps and competition between trout species occur.
   a) Basis: T. Studley field studies.
4. Angling is a form of predation that can affect habitat selection.
   a) Basis: Group discussion.
5. Mechanisms of brown vs. rainbow competition (and resulting habitat shifts) are not clear for adults.
   a) Basis: T. Studley- The PG&E "Altered Flows" study observes adult brown and rainbow trout occupying the same space and time.
   b) Basis: J. Crandall- Observations in NF Stevenson Creek indicate rainbow use feeding stations in day, browns at night.
6. The mechanism for brown vs. rainbow trout competition may occur at the juvenile stage (implying an absence of competition for habitat among 1+ year old trout?). The mechanism may be competition for young-of-year feeding stations (since brown trout emerge earlier, they are bigger and better able to survive the critical period when feeding stations must be obtained). Predation on YOYs may also be a mechanism.
   a) Basis: Group discussion.
7. Total trout HSC are useful when both rainbow and brown trout are the management target.
   a) Basis: Group discussion.
8. Selection of cover habitat is likely to be affected by predation. (Different cover may be selected to avoid avian vs. fish vs. angler predation.)
   a) Basis: Group discussion.

F. Food Availability
1. Higher food availability clearly leads to wider habitat use.
   a) Basis:
      (1) K. Bovee cites Chapman lit.
      (2) J. Nielsen cites Mt. St. Helens lit.
2. Differences in food sources (drift vs. benthic vs. terrestrial) can cause differences in habitat selection.
   a) Basis: Group discussion.
3. Potentially useful measures of food availability include:
      (1) Food base: invertebratess or fish
      (2) Invertebrate food base: benthic vs. drift
      (3) Condition factors
      (4) Stream order, conductance as indicators of productivity.
   b) Basis:
      (1) Group discussion.
      (2) C. Stalnaker cites New York hydro analyses.

II. Summary of New Factors Identified as Affecting HSC

These are the new factors identified in workshop discussions as potentially affecting HSC, in addition to those identified in the PG&E report. This is only a list of the factors with brief background on why they were identified.

A. Activity: The activity fish are conducting when observed can affect HSC, because fish use different habitat for different activities. Activities can change diurnally and seasonally, or spontaneously. Potentially important activities include:

1. Feeding
2. Resting or hiding
3. Spawning
4. Migrating
5. Hiding from high flows
6. Seeking refuge from high temperatures.

B. Methods: The methods used to observe fish and generate curves can affect HSC, because different methods applied at the same site can produce different HSC. Potentially important method differences include:

1. Observation method: electroshocking vs. snorkeling etc.
2. Habitat availability during observations, which depends on
   a) habitat types observed and relative proportion of each type
   b) flow conditions during observations
3. How habitat availability is accounted for: preference vs. habitat use curves, equal area sampling, etc.
4. Curve fitting methods.

C. Density: Total fish density can affect HSC, because density can affect how much marginal habitat is used. (To some extent, the effects of fish density may be reflected in measures of fish size, food availability, and other biological factors.)

D. Turbidity can affect HSC, because fish in turbid water appear to display less predation-avoidance behavior. This factor appears unimportant in Sierra Nevada streams, which are rarely turbid.

E. Trout stock: This factor was mentioned by J. Stevens because hatchery fish obviously behave differently from wild stocks.

1. (Normal practice includes ignoring hatchery fish in developing HSC, so this factor may already be accounted for adequately.
2. No evidence or discussion was presented on possible differences in habitat selection due only to genetic differences between wild stocks.)

III. Results Concerning New Factors Affecting HSC

These are comments and observations that address the new factors listed in Sect. II. These results provide supporting evidence for these new factors.

A. There are diurnal changes in behavior and habitat selection; in particular, many brown trout are hiding and not observable in the day.
   1. Basis:
      a) J. Stevens field obs.
      b) J. Crandall field study, NF Stevenson Creek.
   2. Pertains to new factor: Activity.

B. Different activities can be treated the way different life stages currently are in PHABSIM. All activities must be supported, but the instream flow analysis should focus on the most important activities.
   1. Basis: Group discussion.
   2. Pertains to new factor: Activity.

C. For brown trout, resting/holding can be the activity for which habitat limits abundance (perhaps only when habitat is extremely limited).
   1. Basis:
      a) J. Crandall field observation that brown trout are absent from sites where there are no hiding spots.
      b) K. Bovee observation that hiding habitat is not defended; many trout can use a little habitat, so hiding habitat is rarely likely to limit populations.
   2. Pertains to new factor: Activity.

D. For fry, predation avoidance may be a more important activity than feeding.
   1. Basis: Group discussion.
   2. Pertains to new factor: Activity.

E. Activities closely related to physiology are most definable (most likely to produce a "universal" HSC).
   1. Basis: K. Bovee cmt.
   2. Pertains to new factor: Activity

F. For the feeding activity, drift vs. benthic feeding can result in different habitat selection.
   1. Basis: Group discussion.
   2. Pertains to new factor: Activity.

G. Predation avoidance is always an important activity (and so can't be separated from other activities- e.g., there's no such thing as just feeding, but there is eating while trying to avoid being eaten).

1. Basis: Group discussion.
2. Pertains to new factor: Activity.

H. Whether HSC are "availability" vs. "preference" curves affects their shape.

1. Basis: G. Smith obs.; D. Orth opening cmts.
2. Pertains to new factor: Methods.

I. Methods used to observe fish and fit curves can cause significant differences in HSC; the methods used and their consequences need to be understood before HSC are adapted.

1. Basis: Group discussion.
2. Pertains to new factor: Methods.

J. Stocked trout behave differently than wild fish; there may also be differences among wild strains.

1. Basis: J. Stevens field obs.
2. Pertains to new factor: Trout stock.

IV. Results Concerning HSC Methods

These are comments and observations that concern how the factors we've identified as potentially affecting HSC can be dealt with in developing HSC and using PHABSIM.

A. Habitat availability should be measured; otherwise we do not know if any real habitat preference occurs. Field data often indicate little significant difference between available and used habitat (not surprising since trout are generalists); suitability criteria should not be developed until we can show that habitat use is significantly different from habitat availability.

1. Basis: D. Orth opening cmts.

B. Habitat use (and availability) should not be measured and categorized (in the frequency distribution histograms used to develop HSC) in narrow categories; narrow categories are not appropriate considering the imprecision and uncertainty of measurements. (I.e., drawing HSC from 0.1 ft-wide depth and velocity histograms is not justified considering that we cannot measure habitat to the nearest 0.1 ft or 0.1 ft/sec with any confidence.) Wider histograms should be used and would reduce the uncertainties in HSC and increase the statistical power of distinguishing habitat use from habitat availability.

1. Basis: D. Orth opening cmts.

C. We assume that unobserved fish behave in the same way that observed fish are in developing HSC; this introduces an unknown bias, especially for brown trout, since they often are unobserved.

1. Basis: D. Orth opening cmts.

D. It appears that unsuitable ranges of microhabitat can be identified more consistently among sites than can optimal and marginal ranges.

1. Basis: D. Orth opening cmts, based on transferability studies of smallmouth bass HSC.

E. Habitat requirements of young-of-year can vary dramatically over short time periods (so HSC should reflect the whole range of conditions needed during early life stages?).

1. Basis: D. Orth opening cmts, based on field observations of smallmouth bass.

F. The best (broadest range in) habitat availability occurs at moderate flows; HSC based on observations at moderate flows will best reflect "preference" and be least biased by habitat availability.

1. Basis: J. Thomas obs.

G. There are statistical reasons not to use "preference" curves (ratio of usage to availability).

1. Basis: K. Bovee, IF Paper 12, IF 251 class notes.

H. HSC and PHABSIM modeling for sites with large structure and velocity shear feeding stations can benefit from using adjacent velocity analysis using HABTAV program.

1. Basis: K. Bovee obs.; M. Henry obs.

I. California DFG is interested in (open to) the use of winter habitat criteria (to account for differences in activities and feeding habitat selection between winter and summer). In the absence of winter criteria, DFG assumes that summer or spawning HSC are conservative.

1. Basis: G. Smith.

V. Results Concerning PHABSIM Methods These are comments and concerns about aspects of PHABSIM other than HSC.

These tend to concern changes that are too fundamental to consider as policy issues, but can be considered as ideas for long-term changes in the IFIM.

A. Trout habitat selection is determined by 3-dimensional conditions and connections; it will be hard to explain differences in habitat selection (or to model it well) until these connections are simulated. Field observations show that HSC do not reflect performance measures for smallmouth bass, but the variance in depth and velocity did influence net energy gains.

1. Basis: D. Orth opening cmts, based on field observations of smallmouth bass.

B. Apparent uncertainties in HSC and PHABSIM results may partially be due to measuring inappropriate habitat variables; measuring variables that more directly determine fish performance could reduce uncertainties.

1. Basis: D. Orth opening cmts.

C. Mean column velocity may an inappropriate habitat variable, if fish habitat selection is more dependent on their focal point velocity. As depth increases, focal and mean velocities become more different.

1. Basis: D. Orth opening cmts.

D. Some uncertainties are due to approximating multivariate habitat use using HSC, which are univariate.

1. Basis: D. Orth opening cmts.

E. Habitat simulation should be linked to appropriate measures of fish performance, so we can say more about what usable habitat actually means to a fish population.

1. Basis: D. Orth opening cmts.

VI. Policy Issues Raised

These are issues often addressed in IFIM studies that the workshop identified as needing policy guidance. They are sub-categorized by whether they pertain to HSC or other IFIM issues. The unofficial agency concerns provided by Gary Smith, Jeff Thomas, and Mike Henry are also listed, but should not be included explicitly in the report unless we obtain permission from these people; we must avoid letting them appear to be official agency positions.

A. HSC Policy Issues

1. At what flows should HSC observations be collected?
2. Under what conditions is it more desirable to adapt HSC (from an appropriate site) with vs. without testing them? What conditions at the new study site (degraded habitat or water quality, limited habitat availability) make testing HSC inappropriate?
3. Is it desirable to develop "regional" HSC that are designed to describe "desirable" conditions?
   a) (What does "regional" mean?
   b) To what extent, if any, do regional HSC resolve the issues addressed by this workshop, i.e., that differences between sites cause different behavior and habitat selection?
   c) What does "desirable" mean?
   d) Should HSC be developed at "desirable" sites or at sites that resemble the IFIM study site?)
4. How should young-of-year HSC be developed, to consider the rapid changes in the conditions needed by these fish as they grow?
5. Should the methods used to develop HSC be standardized?
6. How should HSC development methods be documented in each case (whether or not they are standardized)? This includes "meta-data" that describe the conditions under which the HSC data were collected; especially meta-data that describe the ecological factors determined to potentially affect HSC.
7. To what extent should the "quality" of HSC be examined before using them? (What determines quality?)
8. An updated NBS document on HSC development is needed, especially to address why the "habitat use"/"habitat availability" ratio is not used and how equal-area sampling should be used.
9. What are the relative advantages and disadvantages of binary criteria vs. continuous curves? When is either more appropriate?
10. (Given what we know about differences in habitat selection among sites, under what conditions should data from different sites be combined to generate HSC?)

11. What histogram bin widths should be used in drawing HSC from field data, to appropriately reflect the imprecisions and uncertainty in fish observations? (The current practice of using 0.1 ft. bins probably arises from the 1986 HSC guidelines, which recommend measuring depth and velocity to the nearest 0.1 ft.)

B. Other IFIM Policy Issues

1. How should uncertainty be included in PHABSIM results? (Which uncertainties? How?)
2. A clear definition of what an IFIM study includes is needed, from NBS.
3. When is time series analysis an essential part of an IFIM study?
4. What special considerations should be made for spawning habitat if PHABSIM is used to simulate it? Where gravels are sparse, special transects may be needed. Habitat mapping may be more useful.
5. How should the biological judgement used in making instream flow decisions be fully documented?
6. When and how should more emphasis be given to recruitment life stages in IFIM analyses?
7. Should the emphasis be on identifying unsuitable instead of suitable habitat? Unsuitable habitat appears to be more universal among sites. Performance measures (i.e., output variables used as a basis for instream flow decisions) could be based on the consequences of unsuitable conditions.
8. Are species-specific management methods always appropriate? When should communities be the management target? What methods are available for community management?

C. Unofficial Agency Representative Policy Concerns (not to be included without permission of Smith, Thomas, Henry)

1. G. Smith (California DFG)
   a) "Improved IFIM" (?)
   b) Developing properly stratified regional HSC
   c) Field techniques
2. J. Thomas (California FWS)
   a) "Proper application" of IFIM
   b) Developing and testing regional HSC
3. M. Henry (FERC)
   a) Use of regional HSC
   b) Investigating uncertainty due to HSC
   c) Including time series analyses

VII. Research Issues

These are issues identified by the workshop as needing additional study to support policies and IFIM applications. They are also sub-categorized by whether they pertain to HSC or other IFIM issues.

A. HSC Research Issues

1. Determining if and how brown trout cause rainbow trout to shift habitat use.
2. Determining what predation risks cause what significant shifts in habitat selection.
3. Development of methods to predict food availability and its effect on feeding behavior and habitat selection.
4. Establishing methods to determine the relative need for habitat for different activities (e.g., feeding vs. holding). How can we determine when habitat for an activity limits populations?
5. Determining what behaviors (feeding, predation avoidance) cause fry to select their habitat.
6. Determining whether the fish we never sample when making HSC observations do or do not have the same behavior and habitat needs as the observed fish; determining what changes in HSC are needed to accomodate such unobserved fish.

B. Other IFIM Research Issues

1. Use or modification of PHABSIM for simulating velocity shelters, escape cover, and how fish use them.
2. Prediction of flow rates that are high enough to cause recruitment failure.
3. Inclusion of uncertainties in results.
   a) Which uncertainties should be included?
   b) How?
   c) Are uncertainties the result of imprecision in measurement, variability in trout behavior, or because we measure the wrong variables?
4. How best to do IFIM assessment of spawning habitat.
5. Whether the complexity of PHABSIM analyses be reduced by focusing on the most "biologically relevant" activities. Are HSC and PHABSIM results developed only for feeding sites more predictive of population response to flow?
6. Improvement of hydraulic simulation methods. (What improvements are most needed?)
7. Development of habitat indices that represent population or community responses, which may be appropriate for some assessments.

VIII. Considerations for Selecting HSC from Other Sites

These are suggestions for factors that should be similar between sites for HSC to be transferred, from the "role playing" discussion. They are the closest the workshop came to recommending which factors are most important to examine before adapting HSC from another site; however, none were based on extensive discussion. Note that some of the factors suggested for consideration (elevation, gradient, runoff) were probably meant to serve as surrogates for such other, more basic, factors as temperature, season, and habitat structure and availability.

A. Whether the activity fish were conducting when observed to make the HSC is the same activity considered most important at the new site.

B. Whether HSC were developed at a site with comparable stream size, order, and structure.

C. The "quality" of the HSC- the methods and data used to make the HSC.

D. Whether HSC were developed at a similar elevation (elevation as a surrogate for temperature regime, seasonality, other factors?).

E. Whether HSC were developed at a site with similar gradient (gradient as a surrogate for stream structure or habitat availability?).

F. Whether HSC were developed at a site with similar runoff (flow regime as a surrogate for habitat availability?).

IX. Considerations for Developing Site-Specific HSC

These are suggestions from a discussion on HSC development methods. Some address concerns or issues that were not otherwise discussed at the workshop: binary criteria vs. curves, statistical power and other statistical considerations, testing criteria at the same site they were developed at. I would tend, therefore, to consider these are suggestions for review in making policy and not as firm recommendations.

A. Use binary criteria instead of curves (K. Bovee recommendation, not clearly a group consensus).

B. Use equal effort sampling, with careful selection of sites and habitat types to represent available habitat evenly.

C. Stratify criteria by activity, and fish size or life stage.

D. Make adjacent velocity measurements (for use with HABTAV).

E. Record such information as:

1. habitat mapping
2. substrate composition
3. habitat types sampled
4. temperature
5. fish size (at age) and condition
6. population density.

F. Consider statistical issues like adequate randomization (of what?).

G. Sample sufficient variety of habitat to provide the necessary statistical power to distinguish between suitable and unsuitable habitat.

H. Criteria can be tested at the same site under different flows.

I. Spawning habitat can evaluated during habitat mapping. However, spawning can occur in the absence of spawning gravels.

J. Use frequency histograms with a width appropriate to the precision and uncertainty in the field measurements of depth and velocity.

X. Clair's Key Points

A. Seasonal differences in fishs' activities are important to habitat use.

B. Habitat availability clearly needs to be considered in making HSC, but how to do so is still debated.

C. Uncertainties and confidence intervals need to be considered.

D. Guidance on HSC development procedures is needed, perhaps as Standard Operating Procedures for HSC sampling.

E. A report and recommendations from the workshop is needed, perhaps including or leading to new policies.

F. Feeding stations are key to habitat suitability and need to be defined by the instream flow analysis methods.

G. There was not a consensus among all workshop participants on what is best to do in the absence of site-specific HSC.

H. Differences in the methods used to generate HSC are clearly important to their shape.

I. When there are two competing sets of HSC, both can be used and the resulting differences compared.

J. When there are two sets of HSC and it is not clear which is best, additional habitat observations can be made to determine whether one set appears best, or if the two converge.

K. The conditions under which existing HSC should (vs. should not) be tested at a new site is an important question.

L. Spawning habitat needs more consideration in habitat mapping.

M. The HABTAV program has capabilities for modeling velocity shears and cover.

N. The habitat index used for instream flow decision making can be relatively simple, but it is important to use time-series analysis.

O. New policies or standard procedures need input from the workshop participants.

P. California may be a good place to inspire and develop new methods.