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Selection of Representative Important Species for the Connecticut River in the Vicinity of the Vermont Yankee Electric Generating Facility

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Vermont Yankee cooling water discharge, August 2008

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INTRODUCTION

The purpose of this report is to determine whether the existing selection of Representative Important Species (RIS) in Vermont Yankee's 2004 Demonstration (Normandeau 2004) should be modified based on fish assemblage relative abundance data from an electrofishing survey of the Connecticut River mainstem conducted by Midwest Biodiversity Institute in 2008 and 2009. As explained in detail below, this Report concludes that additional species should be added to the RIS within each of the four river reaches considered herein.

My report addresses the following issues related to the consideration of thermal impacts by the Vermont Yankee nuclear power station:

1) What is the appropriate assemblage of Representative Important Species (RIS) for the mainstem of the Connecticut River ("Recommended RIS")?
2) What are the thermal tolerance attributes for the Recommended RIS?[1]

My experience with RIS and using them in 316(a) demonstrations dates to 1976 when I reviewed 316(a) demonstrations at the Indiana Department of Health, during 1976-1979 while reviewing 316(a) demonstrations for Ohio EPA, and since the mid-1990s for the review and development of temperature criteria for the Ohio River and lower Desplaines River. I also developed criteria for RIS as part of the Ohio EPA temperature criteria development process (Ohio EPA 1978a) and the Ohio EPA 316 guidelines (Ohio EPA 1978b). I further refined those criteria and the selection process for the Ohio River (Yoder et al. 2006) and lower Desplaines River (Yoder and Rankin 2006) projects. I also have experience in using the closely allied Representative Aquatic Species (RAS) concept for the development of water quality criteria as part of the Ohio Water Quality Standards.

The concept of Representative Important Species (RIS) originated with the Clean Water Act Section 316 regulations at 40 CFR Part 125.71. The definitions at 125.71(b) and (c) define RIS and the balanced, indigenous community that they are intended to represent as:

[1] Thermal tolerance attributes will be provided at a later date as an overall product of this project.

> *"(b) Representative important species means species which are representative, in terms of their biological needs, of a balanced, indigenous community of shellfish, fish, and wildlife in the body of water into which the discharge of heat is made."*
>
> *"(c) The term 'balanced, indigenous community' is synonymous with the term 'balanced, indigenous population' in the Act and means a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the Act; and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a)."*

The purpose of the RIS concept was first described in the interagency 316(a) technical guidance manual (U.S. EPA 1977). Clearly at the time of the development of these guidelines (circa 1973-4) there was a need for a tractable and predictive approach for the anticipated volume of 316(a) demonstrations that would be forthcoming in the next few years, each of which would require an individual review and decision by U.S. EPA. RIS play a pivotal role in what is termed a "type II" demonstration, which differs from a "type I" demonstration that emphasizes the interpretation of field data to demonstrate whether "prior appreciable harm" has occurred as the result of an existing thermal discharge. Vermont Yankee performed a "type III" demonstration which blended the use of RIS using the concepts of both type I and II demonstrations.

Representative Important Species

U.S. EPA (1977) states the assumptions of the RIS concept as follows:

1. It is not possible to study in great detail every species at a site; there is not enough time, money, or expertise.

2. Since all species cannot be studied in detail, some smaller number will have to be chosen.

3. The species of concern are those causally[2] related to power plant impacts.

[2] The interagency technical 316 (a) guidance used the term "casually" which I infer to be a typographical error.

4. Some species will be economically important in their own right, e.g., commercial and sports fishes or nuisance species, and thus “important.”

5. Some species termed “representative” will be particularly vulnerable or sensitive to power plant impacts or have sensitivities of most other species and, if protected, will reasonably assure protection of other species at a site.

6. Wide-ranging species at the extremes of their ranges would generally not be considered acceptable as “particularly vulnerable” or “sensitive” representative species but they could be considered as “important.”

7. Often, all organisms that might be considered “important” or “representative” cannot be studied in detail, and a smaller list (e.g., greater than 1 but less than 15) may have to be selected as the “representative and important” list.

8. Often, but not always, the most useful list would include mostly sensitive fish, shellfish, or other species of direct use to man or for structure or functioning of the ecosystem.

9. Officially listed as “threatened or endangered species” are automatically “important”.

The guidelines envisioned a process where RIS selection would be done in consultation with the EPA Regional Administrator and would include defining the far-field study area for each discharge. The number of RIS was envisioned to range from 5-15 (considered “high”) to 2-5 (considered “low”). The guidance for the selection if RIS that can be ferreted out of the interagency technical guidance (U.S. EPA 1977) included the following criteria:

1. Species listed in the state water quality standards (WQS) as requiring protection.

2. Species listed as threatened and endangered.

3. Thermally sensitive species, which includes the most thermally sensitive species in the local area and from a “total aquatic community viewpoint” and in consideration of the species range as being on the northern or southern boundary of their natural range.

4. Commercially or recreationally valuable species.

5. Species that are critical to the structure and function of the ecological system, i.e., those that are necessary in the food chain or as habitat formers for the species included in the criteria above.

6. Species that are potentially capable of becoming nuisance species.

7. Species that are representative of the thermal requirements of important species but which themselves are not important.

The conceptual rationale and criteria for developing a list of RIS and then using it to accomplish a type II 316(a) demonstration was a product of the science and understanding at the time the guidelines were developed. Hence these guidelines are reflective of the technology of the early 1970s and prior to the vast majority of the later field and laboratory derived information that section 316 spurred directly.

Recent Developments in Representative Species Concepts

As with any technical process, especially those that had their beginnings in the very early days of the CWA, the accumulation of additional data, knowledge, and experience can and frequently leads to modifications, refinements, and hopefully improvements. Such has been the case with the concept of representative important species. While the use of the term "important" has the connotation that only those species that we know about are more important than those for which we have lesser knowledge and hence awareness, I have retained the RIS terminology to maintain continuity. Subsequent usage of the representative species framework for the development of water quality criteria and the development of more complete definitions in selected state WQS have employed the term "representative aquatic species" (RAS). Stephan et al. (1985) included what is essentially a representative aquatic species approach in their guidelines for deriving numerical chemical water quality criteria. They assert that "representative species of aquatic animals are necessary so that data available for tested species can be considered a useful indication of the sensitivities of appropriate untested species." While the concept of representative as providing for the surrogate role of species with data to function in the place of species without sufficient data is consistent with the prior 316(a) guidelines, the Stephan et al. (1985) procedure seems focused on taxonomic "equity" among aquatic vertebrate and invertebrate assemblages and includes only those taxa with laboratory toxicity testing data.

Later renditions of the representative species concept utilize the representative aquatic species (RAS) terminology presumably to deemphasize the term "important" and in recognition that no one species is more important than another in terms of CWA protections. Some state WQS utilize formalized definitions exemplified by the following from Ohio EPA (Ohio Administrative Code 3745-1-07):

Representative Aquatic Species - means those organisms, either natural or introduced, which presently exist or have existed in the surface waters of the state prior to July 1,1977, with the exception of those banned species outlined in rule 1501:31-19-01 of the Administrative Code. In addition, it may include any species that are legally introduced into the surface waters of the state. Aquatic species designated as representative shall satisfy one or more of the following:

a) Species which are particularly vulnerable to the existing or proposed environmental impact in question;
b) Species which are commercially or recreationally valuable;
c) Species which are threatened, rare, or endangered;
d) Species which are critical to the structure and function of the aquatic community;

e) Species whose presence is causally related to the existing or proposed environmental impact under examination;
f) Species that are potentially capable of becoming localized nuisance species; or
g) Species that are representative of the ecological, behavioral, and physiological requirements and characteristics of species determined in paragraphs (B)(71)(a)to(B)(71)(f) of this rule, but which themselves may not be representative.

These criteria are conceptually and structurally the same as those originally stated in the U.S. EPA (1977) interagency guidance with some wording modifications to make the criteria more ecologically descriptive. This definition was also followed in the development of the Ohio temperature criteria (Ohio EPA 1978a) and the Ohio 316 guidelines (Ohio EPA 1978b).

More recent uses of the RAS concept to support the development of thermal or temperature criteria include the recent work supported by the Ohio River Valley Water Sanitation Commission (ORSANCO; Yoder et al. 2006) in which a definition similar to the Ohio WQS definition was used. RAS criteria included:

1. species that represent the full range of response and sensitivity to environmental stressors;

2. species that are commercially and/or recreationally important;

3. species that are representative of the different trophic levels;

4. rare, threatened, endangered, and special status species;

5. species that are numerically abundant or prominent in the system;

6. potential nuisance species; and,

7. species that are indicative of the ecological and physiological requirements of representative species that lack thermal data.

Vermont appears to have relied primarily on the 1977 interagency guidance to arrive at the current RIS in the Vermont Yankee 316(a) demonstration. I infer this based on the number of RIS (9 species) being within the suggested range of the 1977 guidance. In contrast the updated RIS criteria used by Ohio and ORSANCO are evidence of technical progress in the representative species concept and practice hence any differences that result are due to using contemporary science in the selection of RIS.

Important Considerations in RIS Selection

Bogardus (1981) reviewed the application of RIS in selected thermal discharge studies and concluded that while it is a practical concept, the reliability and accuracy of a RIS list is only as good as the available data about species occurrences in a particular study area. Thus the extent of a "study area" takes on an element of importance in the selection of RIS. A second consideration that is not specified in any existing guidance documents is about how the RIS will be used to either evaluate thermal impacts and/or establish a protective thermal regime. I have dealt with both issues in the development of temperature criteria for Ohio rivers and streams (Ohio EPA 1978a), the Ohio River (Yoder et al. 2006), and the Lower Desplaines River in Illinois (Yoder and Rankin 2006). In each case the spatial extent of the applicability of the RIS was the first consideration and was interpreted to mean the logical application of a relevant river reach approach that is not constrained by artificial designations of a "study area." In each case ecologically relevant reaches were delineated and used. In Ohio, RIS were determined by major mainstem river segments and major stream drainage basins. For the Ohio River we delineated 3 major mainstem segments that adhered to commonly accepted ecological zonation and which also included "mainstem relevant" vs. "transient" species occurrences. For the lower Desplaines River an additional factor included the recovery process from upstream water pollution sources, i.e., species were included as RIS that were expected to be part of the post-recovery fish assemblage even though they may currently be present in low abundances or absent altogether. In the latter case, data from nearby and acknowledged cleaner rivers were used to assemble the RIS list.

Because I used RIS to support the development of seasonally protective water quality criteria following the Fish Temperature Modeling System (FTMS) methodology of Yoder (2008a), sufficient RIS needed to be included so that the FTMS could be used effectively. The FTMS calculates a set of average and daily maximum summer temperature criteria via an analytical process similar to that first described by Bush et al. (1974). Thermal parameters compiled from various literature sources for 125 freshwater fish species and 6 hybrids are presently included in the primary database for the FTMS (Yoder et al. 2006). This represents a substantial increase in the number of species that were included in the original Ohio EPA (1978a) methodology. These include seven thermal parameters described by Yoder (2008a). The four primary FTMS thermal tolerance input variables (optimum, mean weekly average for growth, upper avoidance, and upper incipient lethal temperature) are then selected from this database as the primary thermal tolerance input variables in the FTMS. Alternative thermal tolerance values for a particular RAS can be substituted and the FTMS results can be maintained as alternate outputs to be used for determining the effect of any species-specific differences on the derivation of summer season thresholds. As such the derivation of temperature criteria is partially dependent on the development of a list of representative fish species, which is one of the primary input variables for the FTMS model. It is a primary assumption of the FTMS that representative species constitute a *subset* of the assemblage for which sufficient thermal tolerance data is available to derive temperature criteria options. Species regarded as being tolerant and intermediately tolerant to a wide variety of environmental impacts are well represented in these databases, which is similar to other water quality criteria databases. As such, there will likely be species members in the actual assemblage that are not represented in the RAS and which are *more sensitive* to the parameter that is being considered, in this case temperature. While the intent of the RAS approach is to represent the entirety of the potential assemblage, it is inherently limited by the extant tolerance databases. As such, the FTMS output will propagate a degree of uncertainty, which can be considered in the eventual derivation and application of the temperature criteria by the custodial entity. Add to this that the original RIS concept was quite limited in the number of species that are included and the problem of sensitive species being underrepresented is only compounded.

Deriving Temperature Criteria Using the FTMS

The tolerance values in the updated FTMS thermal effects database are used in the derivation of summer average and maxima for a specific waterbody or waterbody segment. The procedure is simply one of listing each representative species under each of the four primary thermal parameters adjacent to the whole Fahrenheit temperature when it is exceeded. The cumulative effect of increasing temperature is readily apparent as each species thermal criteria are exceeded. The FTMS produces a table of temperatures at which 100%, 90%, 75% and 50% of the representative fish species for the four thermal thresholds occur. This output shows what proportion of the representative assemblage is protected at a given temperature.
In addition to the four primary thermal tolerance thresholds that are the primary input variables in the FTMS, a value termed the long-term survival temperature is included as a calculated value. This threshold is calculated from the short-term survival (i.e., the UILT) as the UILT minus 2^{o}C. In terms of the recommended process for deriving summer season average and maximum temperature criteria, the long-term survival represents the average and the short-term survival represents the daily maximum (Ohio EPA 1978a; Yoder et al. 2006).

The following guidelines are recommended to derive summer average and maximum temperature criteria.

Averages should be consistent with:

- 100% long-term survival of all representative fish species;
- growth of commercially or recreationally important fish species;
- growth of at least 50% of the non-game fish species;
- 100% long-term survival of all endangered fish species; and
- the observed historical ambient temperature record.

Daily maxima should be consistent with:

- 100% short-term survival of all representative fish species; and
- the observed historical ambient temperature record.

The long and short-term survival thresholds are the first choice for deriving the summer season average and daily maximum criteria options. The short-term survival threshold is consistent with the upper incipient lethal temperature (UILT) of the most sensitive RIS. The long-term survival temperature is simply 2°C less than the UILT which is intended to provide a safety factor for longer term exposures. The other criteria listed above can also be used to modify those criteria if there is a management need to do so. For example, the custodial agency may wish to ensure that growth is protected in certain water bodies thus growth of commercially or recreationally important species may be used to derive the summer season average in lieu of the long-term survival threshold. This is also the point at which the observed historical ambient temperature regime is considered. This is a practical consideration because of the baseline concern about setting temperature criteria that will be exceeded by natural conditions, which could become an issue when the consequences of those exceedences trigger other management and regulatory responses that are out of proportion to the environmental reality of a particular situation. Temperature is one of the parameters that will always carry some risk or incidence of "natural exceedences," but these should be rare from a practical standpoint. The historical temperature record must be complete and representative of ambient conditions. Datasets that are comprised of continuous measurements or multiple grab samples that represent daily fluxes and which span multiple years are the most desirable for this task. Modeled temperature may be useful in places where ambient temperature measurements are not representative of natural conditions.

Connecticut River RIS Options

I used fish assemblage relative abundance data from an electrofishing survey of the Connecticut River mainstem by MBI in 2008 and 2009 that was part of a broader assessment of fish assemblages in large rivers throughout New England to develop updated RIS options for relevant reaches of the Connecticut River. More than 100 individual locations between Third Connecticut Lake and the salt wedge just upstream from I-95 in Connecticut were sampled in 2008 and 2009 following a QAPP approved by U.S. EPA (MBI 2008). In considering this data for deriving RIS for the segment of mainstem affected by the Vermont Yankee thermal discharge I used an iterative process that considered four different reaches (Table 1). I developed a list of fish species that were collected by MBI in these reaches as follows:

1) In the Vernon dam pool and downstream to the New Hampshire-Massachusetts state line that included four (4) sampling locations (River Mile [RM] 92.5 – 83.3);
2) In a segment between Bellows Falls and Turners Falls that included 16 sampling locations (RM 120.9 – 67.9);
3) In a segment between Bellows Falls and Holyoke Dam (RM 120.9-32.3) that included 29 sampling locations; and,
4) In a segment between Third Connecticut Lake and Turners Falls (RM 323.6 – 67.9) that included 59 sampling locations.

As expected the number of species collected increased as the river length and sites increased (Table 1). However, the difference between the first and second segments was only 7 species (20 vs. 27) and only two species were added by extending the latter reach to the Holyoke Dam pool. The fourth and longest segment yielded 42 species which is more than double the first and most spatially restricted segment. The differences between segments 1, 2, and 3 include introduced and managed Salmonid species, rainbow and brown trout, two common warmwater species, tessellated darter and common shiner, and one rare species, longnose dace. The shortest MBI segment included more than twice the number of RIS cited in the 2004 316a demonstration (Normandeau 2004) and includes species that represent the full range of thermal response for the Connecticut River fish assemblage. In addition, thermal data is

Table 1. Candidate representative important species of fish for the upper Connecticut River mainstem in support of thermal impact assessment and temperature criteria development. Species occur in order of numerical abundance in the MBI database for the Third Connecticut lake to Turners Falls reach based on electrofishing samples during 2008-9 (hybrids are excluded).

Species (RIS criterion[1])	Original RIS	MBI - Vernon Pool to NH-MA State Line (RM 92.5-83.3)	MBI – Bellows Falls to Turners Falls (RM 120.9-67.9)	MBI – Bellows Falls to Holyoke Dam (RM 120.9-32.3)	MBI – Third CT lake to Turners Falls RM 330 – 67.9)	Thermal Data Available
Yellow perch (2,3,5)	X[2]	96.9[4]	51.6	31.7	48.4	√
Fallfish (3,5)	X[3]	1.4	15.5	34.2	25.0	√
Smallmouth bass (2,3,5,6)	X[2]	8.2	17.9	26.6	17.7	√
Spottail shiner (3,5)	X[2]	113.0	60.3	44.0	22.5	√
White sucker (3)	X[3]	1.1	4.0	3.5	15.7	√
Tessellated darter (1,3)			0.7	1.7	14.6	*
Common shiner (3,5)			9.1	5.4	12.8	√
Golden shiner (3,5)		24.0	28.1	15.3	9.2	√
Pumpkinseed sunfish (3,5)		7.6	3.8	3.3	7.0	√
Largemouth bass (2,3,5,6)	X[3]	12.3	8.3	5.0	6.1	√
Rock bass (2,3)		1.1	2.3	4.2	5.6	√
Bluegill sunfish (2,3,5)		9.0	15.0	12.3	5.4	√
Slimy sculpin (1,3,5)					5.0	*
Chain pickerel (2,3,5)		9.8	4.9	2.8	2.7	√
Black crappie (2,3,5)		8.2	8.1	4.5	2.6	√
Longnose dace (1,3)				0.5	1.9	√
Yellow bullhead (2,3,5)		26.5	6.3	3.4	1.7	√
Creek chub (7)					1.5	√
Sea Lamprey (3,5)		6.3	2.9	1.2	1.4	√
Round whitefish (1,2,3)					1.2	*
Burbot (1,2,3)					0.6	√

Table 1. (continued).

Species(RIS criterion[1])	**Origi-nal RIS**	**MBI - Vernon Pool to NH-MA State Line (RM 92.5-83.3)**	**MBI – Bellows Falls to Turners Falls (RM 120.9-67.9)**	**MBI – Bellows Falls to Holyoke Dam (RM 120.9-32.3)**	**MBI – Third CT lake to Turners Falls RM 330 – 67.9)**	**Thermal Data Available**
Northern pike (1,2,3,7)			0.2	0.3	0.6	√
Atlantic salmon (1,2,3)	X[2]		0.1	0.4	0.6	√
American shad (1,2,3,5)	X[2]	2.2	2.2	3.7	0.6	√
Brown bullhead (2,3,7)		0.6	0.1	0.1	0.5	√
Brook trout (1,2,3)					0.5	√
Rainbow trout (1,2,3)			0.1	<0.01	0.4	√
Brown trout (1,2,3)			0.1	0.1	0.3	√
E. Blacknose dace (1,3,7)					0.3	*
American eel (1,2,3)		0.6	1.1	3.8	0.3	
N. Redbelly dace (1,3)					0.2	√
White crappie (7)					0.2	√
Common carp (1,3,6)		1.6	0.6	0.4	0.2	√
Longnose sucker (1,3)					0.1	√
Walleye (1,2,3)	X[2]	0.3	0.1	0.1	0.1	√
Alewife (1,2,3)		1.1	0.3	0.1	0.1	√
Bridle shiner (1,3,4)[5]					0.1	*
E. Banded killifish (1,3)					0.1	√
Mimic shiner (3,7)					0.1	√
Bluntnose minnow (7)					<0.01	√
Redbreast sunfish					<0.01	*
White catfish (3,7)			0.1	0.1	<0.01	√
Channel catfish (3,7)				<0.01		√
TOTAL SPECIES	**9**	**20**	**27**	**29**	**42**	**42**

[1] – Following the RIS criteria on p. 5; [2] - one of the six original RIS; [3] – one of the 3 species added to most recent 316a RIS at request of VANR; [4] – number/km for the entire reach; [5] – bridle shiner is threatened in NH; √ - thermal tolerance data available for that species; * - thermal data available for a closely related species.

available for all but one species in all four lists. How each species could satisfy the RIS criteria is also included in Table 1. Some species were rare in the mainstem, but they may also serve the purpose of providing coverage for the full range of response within the fish assemblage, in which case they will be retained when the FTMS process is fully executed. At this time the second and third lists seem to be the most appropriate for this part of the Connecticut River. List 1 is simply too geographically restricted and list 4 includes cold water fish species that are presently assumed by the extant process as not being representative of this part of the Connecticut River. However, this assumption may not adequately reflect the restoration potential of this part of the Connecticut River.

The species listed in Table 1 represent potential additions to the current RIS. While this is based on the 2008-9 MBI surveys, it is not necessarily an exhaustive list of all possible additions. Additional species that were not encountered in the MBI surveys may also fulfill the RIS criteria. For example Atlantic salmon was not collected in the first river reach in Table 1, but it is a logical species to include in the RIS. Hence while our candidate lists are more comprehensive than the current RIS, there could be additional species that will be added based on other data and information sources.

Considering Restoration Potential

A key issue that the referenced MBI REMAP study is intending to clarify is the extent of the potential for the restoration of a cold water fish assemblage in the Connecticut River mainstem. The MBI study has applied an Index of Biotic Integrity (IBI) that was developed and calibrated for cold water riverine fish assemblages in Maine (Yoder et al. 2008b). This IBI was applied to the Connecticut River mainstem in preliminary analyses that are being conducted as part of the New England Rivers REMAP project. The analyses show that this segment of the Connecticut River does not meet the thresholds for the IBI that equate to meeting the protection and propagation goals of the CWA (Section 101[a][2]) and therefore, I assert, the balanced indigenous community goals of Section 316(a). However, this does not mean that this segment of the Connecticut River lacks the *potential* to be restored to a condition such that these thresholds could be attained. Portions of the upper Connecticut River mainstem attain the cold water IBI thresholds and the failure to attain such in the Vernon Dam pool could well be related to the cumulative effects of hydrologic modifications that occur in the upper mainstem. The Vermont Environmental Court's opinion states:

> *"Credible scientific evidence supports the finding, in fact, the main stem in the vicinity of Vernon does not provide resident life cycle habitat for cold water fish species; it only provides habitat for a cold water fish species, the Atlantic salmon during its annual migration (of young smolts downriver to the ocean, and of adults upriver to spawn). Rather this cold water designation as "habitat" for "cold water fish" was included in the VWQS to ensure that discharges to the Connecticut River mainstem would be managed so as to protect the migratory phases of this cold water species' life cycle, especially given major regional efforts to establish this species in the Connecticut River system and the fact the Connecticut River system is at the southern extent of this species range."*

and . . .

"The regulatory consequence of the designation of the Connecticut River near Vernon as cold water habitat is that the "otherwise applicable" effluent limitation for temperature is that: "the total increase from ambient temperature due to all discharges and activities shall not exceed 1.0°F except as provided in [VWQS 3-01(B)(1)(d)."

Such conclusions are typical when designated uses are not specifically enough defined and certainly when assemblage level concepts and information are not considered as seems to be the case in the above conclusions. This level of reasoning reflects the need to modernize the Vermont WQS and the temperature criteria in particular as the current framework is based on concepts that are now more than 40 years old. To be fair, this issue exists with the majority of state temperature standards across the U.S.

The question then remains unanswered about the potential of this segment of the Connecticut River as opposed to setting expectations based solely on its existing condition. The application of a technically more comprehensive and contemporary approach like the Biological Condition Gradient (BCG; Davies and Jackson 2006) would help to clarify what the appropriate goals should be for this segment of the Connecticut River. As I indicated previously in this review, the recovery potential beyond existing quality is a legitimate consideration in the selection of RIS. Hence, following this reasoning the fourth RIS list that includes bonafide stenothermic (cold water) fish species should not yet be dismissed in the derivation of revised temperature criteria for the Connecticut River mainstem.

Initial Conclusions

The temperature criteria implications of the candidate RIS options in Table 1 will be seen in the FTMS outputs, which is the next step in the FTMS approach. The outputs can be varied by different sets of RIS (mostly accomplished by Table 1) and different thermal tolerance thresholds applied to selected RIS. The next task in this process will be to locate thermal data for Connecticut River species that are presently not in the FTMS database. Species with thermal data in that database are indicated in Table 1 with a √ and as an asterisk if a closely related species meets the RIS criteria of Yoder et al. (2006) on p. 5. It is also worth noting that some of the uncommon and rarely occurring species in Table 1 could serve a similar surrogate function.

The key issue that I see in the differences between the RIS of the 2004 316(a) demonstration and the RIS methodology of the FTMS is not only the significantly higher number of species considered by the FTMS approach, but the range of sensitivities that are included in both approaches. The U.S. EPA (1977) guidelines state that:

> *"Some species termed 'representative' will be particularly vulnerable or sensitive to power plant impacts or have sensitivities of most other species and, if protected, will reasonably assure protection of other species at a site."*

However the reality is, and as stated by Yoder (2008a), that species that are tolerant and intermediately tolerant of a wide range of environmental stressors are "well represented" in the extant thermal tolerance databases, while species that are highly intolerant and sensitive are much less well represented and then usually by single studies. This is also true of parameters and stressors other than temperature. As a result, RIS selections tend to focus on those species with the most number of tolerance studies available. While care needs to be taken with the inclusion of any study in the thermal effects database, the inclusion of the most sensitive guilds of the species response spectrum must also be given at least equal weight. It raises the all important issue - how representative of the sensitive species guilds are the U.S. EPA (1977) RIS criteria, which potentially exclude entire tolerance guilds for the sake of meeting a seemingly arbitrary criterion for a "manageable number" of RIS? Restricting RIS determinations to only the most commonly occurring and "important" species has a strong tendency to exclude thermally sensitive and intolerant species, even though the original 316 guidelines expressly assume the opposite.

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