

EFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)	
)	
MARATHON PETROLEUM)	
COMPANY, LP)	
)	
Petitioner,)	
)	
v.)	PCB No. 2018-049
)	
ILLINOIS ENVIRONMENTAL)	
PROTECTION AGENCY,)	
)	
Respondent.)	

NOTICE OF FILING

TO:

Don Brown, Clerk of the Board
Illinois Pollution Control Board
100 W. Randolph Street, Suite 11-500
Chicago, Illinois 60601
Don.brown@illinois.gov
(VIA ELECTRONIC MAIL)

Carol Webb, Hearing Officer
Illinois Pollution Control Board
1021 North Grand Avenue East
Springfield, Illinois 62794-9274
Carol.Webb@illinois.gov
(VIA ELECTRONIC MAIL)

(SEE PERSONS ON ATTACHED SERVICE LIST)

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board a MOTION FOR EXTENSION TO FILE THE ILLINOIS DEPARTMENT OF NATURAL RESOURCES'S REPLY TO THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY RECOMMENDATION, dated September 10, 2014, a copy of which are herewith served upon you.

Respectfully submitted,

ILLINOIS DEPARTMENT OF NATURAL RESOURCES,

By: 
Virginia J. Yang, Legal Counsel

Dated: September 28, 2018

Illinois Department of Natural Resources
One Natural Resources Way
Springfield, Illinois 62702-1271
217-782-1809 (general)
847-608-3107 (direct)

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ILLINOIS ENVIRONMENTAL)	
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Respondent,)	

**MOTION FOR EXTENSION TO FILE
THE ILLINOIS DEPARTMENT OF NATURAL RESOURCES'S REPLY TO
THE ILLINOIS ENVIRONMENTALPROTECTION AGENCY RECOMMENDATION**

NOW COMES the Illinois Department of Natural Resources (IDNR), an Interested Party to the above referenced proceedings, by and through one of its Attorneys, Virginia I. Yang, and files MOTION FOR EXTENSION TO FILE THE ILLINOIS DEPARTMENT OF NATURAL RESOURCES'S REPLY TO THE ILLINOIS ENVIRONMENTALPROTECTION AGENCY RECOMMENDATION, dated September 10, 2018, as follows:

1. On December 15, 2017, Marathon Petroleum Company, LLC (Marathon) file its Petition to Approve Alternative Thermal Effluent Limitation (Petition) in this proceeding.
2. On January 26, 2018, the IDNR reopened its consultation proceeding with the Illinois Environmental Protection Agency (IEPA) pursuant the Illinois Endangered Species Protection Act [520 ILCS 10/110], the Illinois Natural Areas Preservation Act [525 ILCS 30/17], and Title 17 Illinois Administrative Code Part 1075.
3. On February 14, 2018, the IDNR met representatives from the IEPA and from Marathon to discuss the IDNR consultation process, the presence of the Illinois state listed endangered **bigeye chub** (*Hybopsis amblops*) in the vicinity of Marathon's Outfall 001 on Robinson Creek, and various regulatory options to avoid an unauthorized "take", as defined, of an Illinois endangered species under Title 17 Illinois Administrative Code Part 1080.
4. On February 27, 2018, Marathon filed an Addendum to Exhibit 4 of its Petition to Approve Alternative Thermal Effluent Limitation and Addendum to its Technical Support Documentation for Alternative Thermal Effluent Limitations.

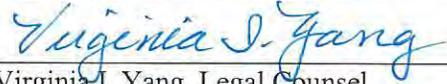
5. On March 29, 2018, IDNR issued to the IEPA, with copy to Marathon, its consultation letter containing four recommendations, specifically concerning a bioassay of the upper thermal tolerance limits of the **bigeye chub**. *See* Letter from Keith M. Shank, IDNR, to Scott Twait, Illinois EPA, dated March 29, 2018. (Attachment A)
6. On June 6, 2018, IDNR met with IEPA to discuss a resolution to IDNR's consultation letter and recommendations concerning Marathon's Petition.
7. On June 12, 2018, to facilitate discussions with Marathon and IEPA concerning IDNR's consultation letter and its recommendations, IEPA filed a motion for extension of time for filing IEPA's Recommendation until September 10, 2018. The Board granted IEPA's motion for extension with no objection from Marathon or from IDNR.
8. On August 14, 2018, Marathon filed its Response to the IDNR Consultation Letter, March 29, 2018.
9. On September 10, 2018, IEPA filed its Recommendation to Grant Marathon's Petition in this proceeding. Notwithstanding its Recommendation to Grant, IEPA reserved its finding and rendered no opinion regarding the IDNR March 29, 2018 consultation letter. Additionally, IEPA reserved its findings and rendered no opinion regarding Marathon's Response to the IDNR Consultation Letter.
10. On September 12, 2018, IDNR met with representatives from IEPA and from Marathon to further discuss IDNR Consultation letter's recommendations, and to advise the parties about ongoing technical discussions with Dr. Cory Suski, PhD. of the Department of Natural Resources and Environmental Sciences at the University of Illinois at Champaign-Urbana, Illinois (UIUC) concerning a proposal for bioassay to define the thermal limits of the Illinois listed **bigeye chub** (UIUC Proposal). *See* UIUC Proposal Entitled Thermal Tolerance Limits of Bigeye Chub, to IDNR dated August 6, 2018. (Attachment B).
11. Under the authority of IDNR and IDNR's scientific research permit for study of Illinois listed threatened and endangered species issued pursuant to 520 ILCS 10/4, the UIUC study would include collection of the Illinois **bigeye chub** from the Vermilion River basin (Wabash River drainage) with assistance from the IDNR, holding the collected fish in UIUC laboratory facilities, and testing to determine the non-lethal and lethal thermal tolerances of the collected fish.
12. The UIUC Proposal period extends through August 1, 2019 to facilitate UIUC evaluation and analysis, peer review of study findings, and preparation for publication in a designated scientific journal.

13. The raw data from the UIUC tests on the thermal tolerance of the Illinois **bigeye chub** would be available for IDNR evaluation by November, 2018.
14. The UIUC test data and IDNR technical evaluation would be relevant to the IDNR's Reply to the IEPA Recommendation, dated September 10, 2018, and to Marathon's Response to IDNR Consultation Letter, dated August 14, 2018.

WHEREFORE, Illinois Department of Natural Resources respectfully requests the Board grant an additional 90 days (Monday, December 31, 2018) for IDNR preparation and filing of its Reply to the IEPA Recommendation and to Marathon's Response to the IDNR Consultation Letter.

Respectfully submitted,

Illinois Department of Natural Resources

By: 
Virginia I. Yang, Legal Counsel
Illinois Department of Natural Resources
2050 West Stearns Road
Bartlett, Illinois 60103
Virginia.Yang@illinois.gov

DATED: September 28, 2018

Illinois Department of Natural Resources
Office of Legal Affairs
One Natural Resources Way
Springfield, Illinois 62702-1271
271-782-1809 (general)
847-608-3107 (direct)

CERTIFICATE OF SERVICE

I, Virginia I. Yang, Legal Counsel for the Illinois Department of Natural Resources, herein certify that I have served a copy of the foregoing MOTION TO EXTEND TIME TO FILE THE ILLINOIS DEPARTMENT OF NATURAL RESOURCES'S REPLY TO THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY RECOMMENDATION, dated September 10, 2018, via electronic mailing upon:

Dan Brown Clerk of the Board
Illinois Pollution Control Board
100 W. Randolph Street (11-500)
Chicago, IL 60603
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Respectfully submitted,

ILLINOIS DEPARTMENT OF NATURAL
RESOURCES

By: 
Virginia I. Yang, Legal Counsel
Illinois Department of Natural Resources
2050 West Stearns Road
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Virginia.Yang@illinois.gov

DATED: September 28, 2018

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Attachment A

IDNR 1075 Consultation Letter, March 29, 2018



Illinois Department of
Natural Resources

One Natural Resources Way Springfield, Illinois 62702-1271
www.dnr.illinois.gov

Bruce Rauner, Governor
Wayne A. Rosenthal, Director

March 29, 2018

Mr. Scott Twait
Illinois Environmental Protection Agency
1021 North Grand Avenue East
PO Box 19276
Springfield, IL 62794-9276

RE: Alternative Thermal Effluent Limitations, Section 316(a) of the Clean Water Act and 35 Ill. Adm. Code 304.141(c), Marathon Petroleum Company LP Refinery Endangered Species Consultation Program EcoCAT Review #1808455

Dear Mr. Twait:

The Department has received your information for this project for the purposes of consultation pursuant to the *Illinois Endangered Species Protection Act* [520 ILCS 10/11], the *Illinois Natural Areas Preservation Act* [525 ILCS 30/17], and Title 17 *Illinois Administrative Code* Part 1075. Additionally, the Department may offer recommendations for species covered under the *Fish & Aquatic Life Code* [515 ILCS 5, *et seq.*]; the *Illinois Wildlife Code* [520 ILCS 5, *et seq.*]; and the *Herptiles-Herps Act* [510 ILCS 69].

The proposed action is the development of Illinois Environmental Protection Agency (Agency) recommendations to the Illinois Pollution Control Board in Case PCB 2018-049, a request for Alternative Thermal Effluent Limitations (Petition) by Marathon Petroleum Company (Marathon) for its petrochemical refinery plant in Robinson, Crawford County, Illinois. The Department has focused its evaluation on Exhibit 4 supporting Marathon's Petition.¹

In its review of the Petition and its supporting documents, the Department noted the fish assemblage data report² (Report) documented the occurrence of four individual Illinois state-listed endangered **bigeye chub** (*Hybopsis amblops*) in Robinson Creek, two of them at Marathon's Outfall 001 and one upstream and one downstream from Outfall 001 in Robinson

¹ Exhibit 4: *Technical Support Documentation for Alternative Thermal Effluent Limitations under Section 316(a) of the Clean Water Act and 35 Ill. Adm. Code 304.141(c) for the Marathon Petroleum Company LP Refinery located in Robinson, Illinois.*

² *Biological and Water Quality Assessment of Robinson and Sugar Creeks and Tributaries 2016 (Midwest Biodiversity Institute, 2017)*

Creek. Four additional individual **bigeye chubs** were documented in a nearby stream known as LaMotte Creek. The **bigeye chub** is an Illinois state-listed endangered species. However, the **bigeye chub** was not identified as a state-listed endangered species in the Report when it was prepared nor in other documents filed to support the Petition before the Illinois Pollution Control Board. After discussions with this Department, Marathon filed an Addendum to its Petition with the Illinois Pollution Control Board acknowledging the occurrence of the **bigeye chub** in Marathon's thermal outfall into its receiving waters (i.e., Robinson Creek).³

The Department has reviewed the Petition and its Addendum and believes that neither document satisfies *Title 35 Environmental Protection Code Part 106 Subpart K*, specifically Section 106.1130 (e)(4) provisions concerning "criteria and methodology used to assess whether a balanced indigenous community of shellfish, fish and wildlife will be maintained in the receiving waters and the protection of threatened and endangered species."

Based on available information, the Department believes the Petition does not demonstrate the proposed Alternative Thermal Effluent Limits will protect endangered species present in the receiving waters and will support a balanced indigenous community pursuant to Section 106.1130(e).⁴ Furthermore, Section 106.1105 requires a demonstration "to assure the protection and propagation of a balanced, indigenous population...in and on the body of water into which the discharge is to be made."

Published scientific research on the thermal tolerance of the **bigeye chub** is limited to a single test performed on a single animal.⁵ While this test can be criticized on several grounds such as, non-regional location of the study area, the Lutterschmidt/Hutchinson test currently constitutes the best evidence of the thermal upper tolerance limits and such effects upon this species.⁶ Among these effects are spasm and the inability of the **bigeye chub** to "right" itself (i.e., to turn upright) when in waters with upper thermal temperatures.

The Department notes that a single test on a single animal does not provide a statistical confidence level; reliance on a single study or test is insufficient. Thermal tolerance testing on a larger sample of **bigeye chubs** taken from a regional watershed, such as the Illinois Wabash River or the Illinois Vermilion River, would provide greater confidence about the thermal tolerance of this endangered fish population.

³ *Motion for Leave to File an Addendum to Exhibit 4 of the Petition to Approve Alternative Thermal Effluent Limitations and Addendum to Technical Support Documentation for Alternative Thermal Effluent Limitations (Electronic Filing)*; filed February 28, 2018; granted March 14, 2018.

⁴ *Title 35 Environmental Protection Code Part 106 Subpart K, Section 106.1130(e)(4)* requires the petition to demonstrate "a balanced indigenous community, as defined, of shellfish, fish and wildlife will be maintained in the receiving waters and that threatened and endangered species will be protected."

⁵ "The Critical Thermal Maximum: Data to Support the Onset of Spasms as the Definitive Endpoint," William I. Lutterschmidt and Victor H. Hutchinson, *Canadian Journal of Zoology*, February 1997, pp.1553-1560.

⁶ As reported, Loss of Righting Response occurred at 30.1°C (86.18°F); Onset of Spasms occurred at 31.7°C (89.06°F).

The Department also believes that supporting thermal data for the Petition indicate temperatures in the study area which exceed those temperatures tolerated by the **bigeye chub**.⁷ When such temperature exceedances occur during summer months, any **bigeye chubs** present in Robinson Creek, whether at, below and above Outfall 001, would be forced to vacate the affected reaches of Robinson Creek. If any **bigeye chubs** in Robinson Creek were unable to escape such temperatures, injury or death from thermal shock would likely occur.

The Department believes that any of the above survival behaviors to avoid thermal exceedances attributed to thermal discharges from Outfall 001 would constitute a “take” (i.e., harass, harm, or injury) which is prohibited by the *Illinois Endangered Species Protection Act* [520 ILCS 10/3].⁸ As defined by law, “Take” means, in reference to animals and animal products, to harm, hunt, shoot, pursue, lure, wound, kill, destroy, harass, gig, spear, ensnare, trap, capture, collect, or to attempt to engage in such conduct.⁹

The *Illinois Endangered Species Protection Act* empowers the Department to authorize any “taking” otherwise prohibited if that “taking” is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.¹⁰ Providing the Department can determine the “taking” will not reduce the likelihood of the survival or recovery of the **bigeye chub** in the wild in Illinois, an *Incidental Take Authorization* could be sought and obtained by Marathon pursuant to 17 Ill. Adm. Code 1080. The Department may authorize the “taking” of listed species for purposes of scientific research.¹¹ The Department may issue the necessary “scientific research permit” upon approval of a detailed research proposal for a thermal bioassay of the **bigeye chub**.

The Department further notes that the current thermal discharge levels for Outfall 001 may be a contributing factor to the unusually-high rate of Deformities, Eroded fins, Lesions, and Tumors (DELTS) documented in the aquatic community by Midwest Biodiversity Institute (MBI), environmental contractor for Marathon. Although MBI observed no DELTs on the **bigeye chub**, the high rate of DELTs on other fish found in the study area indicate an adverse impact to the “balanced indigenous community” of fish, as well as a risk to the **bigeye chub**. Lesions on fish are often related to bacterial infections; placing additional thermal stress on fish already affected by chemical stressors is likely to aggravate existing pathological conditions. The Department is concerned that the proposed alternative thermal limitation will increase the incidence of DELTS, thus harming the “balanced indigenous community.” The Department believes the proposed Alternative Thermal Effluent Limits warrant additional assessment of the impacts to all indigenous fish.

The Department also questions the location of the stations where compliance will be measured. Given the large segments of Robinson Creek which will be included (1.7 miles and, currently, four miles), further data is needed demonstrating that these distances below Outfall 001 are

⁷ *Motion for Leave to File an Addendum to Exhibit 4 of the Petition to Approve Alternative Thermal Effluent Limitations and Addendum to Technical Support Documentation for Alternative Thermal Effluent Limitations (Electronic Filing)*; filed February 28, 2018; granted March 14, 2018; Figure 2, p. 6.

⁸ “Sec. 3. It is unlawful for any person: (1) to possess, take, transport, sell, offer for sale, give or otherwise dispose of any animal or the product thereof of any animal species which occurs on the Illinois List;”

⁹ 520 ILCS 10/2.

¹⁰ 520 ILCS 10/5.5 and 17 Ill. Adm. Code Part 1080.

¹¹ 520 ILCS 10/4 and 17 Ill. Adm. Code Part 1070.

necessary to achieve compliance with the proposed alternative thermal effluent limitations. The Department believes that thermal compliance measured at Outfall 001, or as close as feasible to the discharge point, will avoid or minimize disruption of the “balanced indigenous community.”

For the reasons stated above, the Department offers the following:

*Recommendation #1: The Department recommends the need for a bioassay of the upper thermal tolerance limits of the Illinois Wabash Valley population of the endangered **bigeye chub** to establish whether the proposed Alternative Thermal Effluent Limits are protective of endangered species known to be present in receiving waters. The test subjects should be taken from the same population which will be subject to the proposed Alternative Thermal Effluent Limits to address the possibility that different populations of this species may have developed higher or lower tolerances. The research should seek to establish the temperatures which stimulate avoidance behavior (harassment), loss of righting response (harm), onset of spasms (injury), and death. Any proposed bioassay should follow standards and procedures approved by the Department pursuant to the “1070” research permit issued under the *Illinois Endangered Species Protection Act*.*

Recommendation #2: The Department recommends the need for a bioassay of representative fish species is warranted to identify the character and likely causes of observed DELTs and to determine whether granting the Alternative Thermal Effluent Limits is likely to increase the incidence and/or severity of DELTs on fish in the receiving waters.

*Recommendation #3: The Department recommends that compliance with the Alternative Thermal Effluent Limits should be measured at Outfall 001, or as near as feasible, rather than the proposed point 1.7 miles farther downstream on Robinson Creek, to minimize disruption of the “balanced indigenous community,” including the stated-listed **bigeye chub**.*

*Recommendation #4: The Department recommends the need for Marathon to seek and obtain an Incidental Take Authorization for the endangered **bigeye chub** from the Department.*

Consultation on the part of the Department is closed, unless the Illinois Environmental Protection Agency desires additional information or advice related to these recommendations. Pursuant to 1075.40(h), please notify the Department of the Agency’s disposition of these recommendations. Consultation for Part 1075 is valid for two years unless new information becomes available which was not previously considered; the proposed action is modified; or additional species, essential habitat, or Natural Areas are identified in the vicinity. If the recommended action has not been implemented within two years of the date of this letter, or any of the above listed conditions develop, a new consultation is necessary.

The Department’s natural resource review reflects the information existing in the Illinois Natural Heritage Database at the time of the project submittal, and should not be regarded as a final statement on the project being considered, nor should it be a substitute for detailed site surveys or field surveys required for environmental assessments. If additional protected resources are unexpectedly encountered during the project’s implementation, the applicant must comply with the applicable statutes and regulations.

Please contact me with any questions about these recommendations.

Sincerely,

A handwritten signature in black ink that reads "Keith M. Shank". The signature is written in a cursive style with a large, stylized 'K' and 'S'.

Keith M. Shank, Chief
Impact Assessment Section
Department of Natural Resources
(217) 785-4984
keith.shank@illinos.gov

Attachment B

UIUC Proposal for Thermal Tolerance Limits of Bigeye Chub, August 6, 2018

Proposal Entitled

THERMAL TOLERANCE LIMITS OF BIGEYE CHUB

For Submission TO:

Illinois Department of Natural Resources
Attn: Mr. Nathan Grider
Assistant Manager, Consultation Services
Office of Realty & Capital Planning
Illinois Dept. of Natural Resources
One Natural Resources Way
Springfield, IL 62702-1271
nathan.grider@illinois.gov
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Submitted BY:

Cory Suski, PhD.
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1102 S. Goodwin Ave.
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Fax: 217-244-3219

Project Dates: September 20, 2018 – August 31, 2019

Submission Date: August 6, 2018

The bigeye chub (*Hybopsis amblops*) is a species of slender, silvery minnow native to previously glaciated areas within the Lake Erie and Ohio River drainages of the Central Highlands region of eastern North America (Berendzen et al. 2008). This species can typically be found in clear, gravel-bottomed streams with permanent flow and little silt, preferring to reside at the base of riffles or in quiet pools (Pfleiger 1975).

Unfortunately, over the past several decades, the bigeye chub has been disappearing throughout its native range. For example, the species is believed to have been extirpated from both Michigan (Michigan Natural Features Inventory 2007), and Virginia (Angermeier 1995), and is currently listed as State Endangered within Illinois (IESPB 2015). The reasons for this decline can likely be attributed to human-mediated factors related to agriculture such as habitat loss, siltation, fertilizers and pesticides (Page and Retzer 2002).

Another human-induced stressor that can lead to mortality in fishes is thermal stressors (i.e., extreme temperatures) - both natural or human-induced. Water temperature is the most important abiotic factor influencing a fish's biology. Body temperature has a major impact on short-term performance (e.g., swimming ability for predator avoidance), and eventually on its survival and fitness. Thermal performance can be described by a curve that rises gradually with temperature from a critical thermal minimum (CT_{min}) to an optimum temperature (T_{opt}), and then drops rapidly to the critical thermal maximum (CT_{max}) (see Figure 1). Previous work has shown that elevated temperature can lead to outcomes such as elevated energy consumption, stress, impaired swimming and ultimately death as animals approach their CT_{max} , and the ability of an organism to remain active under extreme conditions is a significant component of fitness. Therefore, determining the limits to activity is an important first step in understanding the ways that thermal stressors influence survival and fitness, and population viability.

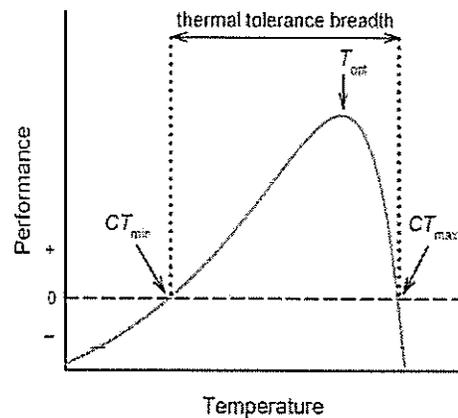


Figure 1. Thermal performance curve of an animal across a range of temperatures.

Typically, thermal limits have been assessed using either dynamic or static methods (Lutterschmidt & Hutchison 1997; Beitinger and Lutterschmidt 2011). Briefly, the dynamic (ramping) method involves changing temperature at a constant rate and assessing variables related to the temperature of physiological failure, such as equilibrium loss or the onset of spasms (often referred to as CTL or critical thermal limit); this approach can also continue until mortality occurs in 50 % of test subjects (LD-50). Alternatively, the static method involves holding temperature constant and acutely transferring test organisms into the stressful temperature, with responses related to incapacitation recorded, including the time to onset of spasms or time to equilibrium loss; these protocols can again continue until an LD-50 point is reached. It is also possible to quantify recovery times following the onset of these responses to ascertain the duration of impairment. Of the two techniques, the dynamic method is particularly appealing because it provides a direct estimate of the target variables (e.g., CT_{max}), it provides an indication of the activity range for a population under acute exposure conditions, is considered to be ecologically relevant, and rates of thermal change can be adjusted to render ecologically realistic values (Lutterschmidt & Hutchison 1997; Beitinger and Lutterschmidt 2011).

At present, virtually no information exists on the thermal limits of bigeye chub. Comprehensive literature searches revealed only a single study related to thermal tolerance in bigeye chub (Lutterschmidt & Hutchison 1997), and this study used a single fish to identify 30.1° C and 31.7° C as the temperatures at which animals lost equilibrium and experienced spasms (respectively) during a dynamic thermal challenge following acclimation to 10° C. Unfortunately, it is difficult to broadly apply results from this single study and make recommendations related to thermal limits for bigeye chub as (1) results from this single study might not be representative of all animals across the range of this species, (2) the sample size in this single study was 1 individual, meaning there is no replication on fish, and (3) the upper thermal limit of ectotherms is heavily influenced by acclimation temperature, with upper limits increasing with higher acclimation temperature (e.g., both upper and lower lethal temperatures of fishes increase during the transition from winter to summer – see Figure 2). As such, additional work is needed with bigeye chub to define thermal limits and ecologically relevant endpoints related to thermal stressors, particularly for animals acclimated to different water temperatures.

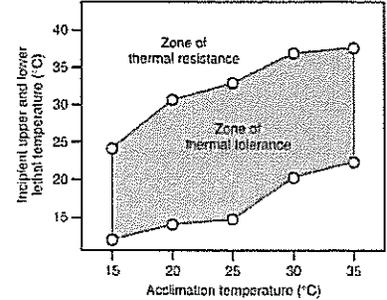


Figure 2. Upper and lower lethal temperatures following a thermal challenge test for a hypothetical fish acclimated to different temperatures. At higher acclimation temperatures, animals can tolerate elevated temperatures in thermal tests.

Based on this background, the goal of this proposal is to *define the thermal limits of bigeye chub following thermal challenge assays*. Concurrent with work on bigeye chub, we also plan on collecting creek chubs (*Semotilus atromaculatus*) and conducting identical experiments with creek chubs for the purposes of ‘ground truthing’ our techniques and comparing the data we generate on creek chubs with known, published data on this species. As such, experiments below refer to ‘chubs’, which represents a combination of both creek chubs and bigeye chubs. When taken together, data generated from this proposal will provide critical information on the thermal limits of a threatened, data-deficient fish species, and where thermal changes result in animals being harmed or killed.

Methods

Animal Collection

Chubs for this study (both creek chubs and bigeye chubs) will be collected with the assistance of the Illinois Department of Natural Resources (DNR) from the Vermilion River basin (Wabash River drainage) using commonly accepted techniques that have minimal impact on fish (e.g., backpack electroshocking or seine netting). Preliminary discussions have occurred with DNR personnel, and a **total collection of 40 individuals** for this work should be possible, and permission to harvest this state endangered species should be granted. Concurrent with the collection of bigeye chub, an equal number of minnows will also be collected (likely creek chub), and the thermal tolerance of creek chubs will be conducted along with bigeye chubs to validate study protocols and improve confidence in data outputs; thus, for the remainder of the document, when methods refer to ‘chubs’, both bigeye and creek chubs are implied as they will be assayed concurrently.

Animal holding

Following collection, chubs will be returned to the Aquatic Research Facility in Urbana, IL. Animals will be held in indoor aquaria that have been outfitted with necessary equipment for fish holding (e.g., ultraviolet water filters, temperature control, etc.). Extreme care will be taken to ensure optimum holding conditions to minimize stress when in tanks.

At the outset, a small subset of animals ($n = 2-4$) will be collected and brought into the lab for preliminary feeding trials, and the water temperature at the time of collection will be noted. Suski's lab group has previous experience holding and feeding creek chubs, successfully transitioning them to feed on goldfish flakes, including 1 study successfully holding creek chubs across two different temperatures (20° C and 25° C) for 6 weeks (Blevins et al. 2013; Blevins et al. 2014). Based on this experience, it is therefore believed that both creek chubs and bigeye chubs will transition to feeding during laboratory (likely commercially available fish food such as goldfish flakes). Both species of chubs will also be presented with invertebrate food such as frozen brine shrimp, earth worms, meal worms, wax worms or similar to assist with feeding efforts.

Experiment 1 – Non-lethal thermal tolerance during a dynamic (ramping) assay ($n = 40$ bigeye chub)

Thermal tolerance and non-lethal responses of chubs would be generated using a dynamic (ramping) assay. The dynamic assay better replicates the ecological conditions under which thermal stress would be encountered in the wild, and requires a smaller number of fish (better suited for this endangered species) and will provide useful estimates of tolerance to acute, but not chronic, thermal stress.

Briefly, the experiment consist of heating chubs at constant temperature (ΔT) and quantify as the temperature at which locomotory activity becomes disorganized and the animal loses its ability to escape from conditions that could lead to death (for example, when an animal would become vulnerable to predation). The endpoint that would be measured here is the non-lethal, **Critical Thermal Maximum** (CT_{max}).

The keys to this test include (1) consistent ΔT during trials, (2) the choice of an obvious, repeatable near-lethal but sublethal endpoint, and (3) ΔT should be fast enough to prevent reacclimation during a trial and slow enough to allow body temperature to track external temperatures without a time lag (usually 0.3°C-0.5°C /minute). Two factors will be considered when defining the rate of temperature increase: (1) ecological relevance of expected thermal changes in the wild, and (2) maintaining a heating rate that is sufficiently fast to avoid confounding effects of holding and/or confinement stress.

Ideally, chubs that have been acclimated to multiple temperatures for at least 30 days would be used in this experiment, allowing data on the influence of acclimation temperature on tolerance to be generated (as in Figure 2). Following introduction to the lab, 2 acclimation temperatures would be used, with one temperature being approximately 26° C, and the second being cooler (likely around 20-22° C). This upper temperature corresponds to the 75th percentile of summer water temperatures for the location where fish will be collected. Immediately following transfer to the laboratory, chubs would be held at the temperature at which they were collected, and brought to the target acclimation temperatures at a rate of 1° C/day. Once at these target temperatures, animals would be held for at least 30 days to ensure thermal acclimation, and lighting in the room where animals were being held would use a timer to ensure a 12 h on, 12 h off cycle.

During the ramping thermal trial, approximately 6-10 chubs of each species would be assayed concurrently, and the following data would be collected: (1) the temperature at which animals begin to exhibit 'erratic behaviors' (e.g., accelerated swimming, surface gasping, etc.), and (2) the temperature at which animals lose equilibrium. Once chubs lose equilibrium, the experiment for that individual would cease, the animal would be returned to water at their acclimation temperature and their ability to recover will be quantified, defined as returning to an active, upright and informed swimming behavior. As only 6-10 animals would be assayed at a time, this would result in 4-6 replicate trials.

No effort will be made to maintain dissolved oxygen concentration during trials. Dissolved oxygen will likely start at or near 100 % saturation, and would be monitored continuously throughout the trial using a submersed dissolved oxygen meter. It is expected that dissolved oxygen will decline as temperatures increase; the reality is that, in a natural setting, this decline in dissolved oxygen concurrent with increased temperature would be expected, thus coupling reduced oxygen with elevated temperature.

At present, this proposal does not include any studies that intentionally target death as an endpoint (i.e., upper lethal temperature). Work is currently ongoing to obtain permission from the University of Illinois Institutional Animal Care and Use Committee (IACUC) to conduct studies that include lethal endpoints. Should permission for lethal endpoint studies be granted, the study would occur as described above, but would continue until 50 % of fish of each species within a replicate trial have died, allowing determination of the upper lethal temperature across the 2 acclimation temperatures.

Following the conclusions of this work, data would be made available to IDNR personnel through (1) an Executive Summary, and (2) a full, comprehensive final report. Efforts would also be made to publish the results in a peer-reviewed journal outlet.

When taken together, results from this work will provide critical data on the thermal tolerance of bigeye chub, as well as the thermal conditions that result in animals being harmed and killed.

Proposed Budget

Category	Amount
Personnel	\$ 7,350
Fringe Benefits	\$ 589
Travel	\$ 661
Materials & Supplies	\$ 1,948
Contractual Services	\$ 300
Publication Costs	\$ 1,500
Sub-total	\$ 12,349
Indirect Costs	\$ 5,032
Total Cost	\$ 17,381

Budget Narrative

- This work would be carried out by a PhD student. Suski currently has a current PhD student starting in Fall 2018 that has agreed to take lead on the field/lab components of this study. The rate for pre-prelim, PhD students holding a 50 % grad research assistantship is \$2,450/month; fringe benefits are

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assessed at the current University of Illinois Rate outlined at <https://www.obfs.uillinois.edu/common/pages/DisplayFile.aspx?itemId=922087>. Note that tuition remission is **NOT** being charged for this student.

- Travel consists of two categories: (1) mileage to/from collection sites, and (2) hotel for the graduate student to attend the annual meeting of the IL Chapter of the American Fisheries Society (IL AFS) to share research findings with other fisheries professionals in the state.
 - Suski currently has an F150 pickup truck that would be ideal for this project, and its 3 trips to the Vermillion River basin for collections have been budgeted (mileage rate is \$0.517/mile).
 - Attending conferences is critical for sharing results from the study, informing managers/biologists of findings and for professional development of students. The IL AFS meeting is a popular event for fisheries professionals in the state, and many individuals that attend this meeting would be interested in the results of this study. Funds for 2 nights of hotel stay (\$125/night) have been budgeted.
- Materials and supplies consist of items required to collect fish, hold fish, and generate data for the specific items and their costs are in the following table:

Item	Cost
Heater/chiller	\$ 838.99
Immersion heater	\$ 305.59
Aerator	\$ 256.99
Air stones	\$ 37.78
Tubing	\$ 50.00
Nets	\$ 20.00
Coolers	\$ 200.00
Bait aerators × 2	\$ 63.00
Fish food	\$ 50.00
MS222	\$ 125.89
Total	\$1,948.24

- Briefly, a heater/chiller is required to ensure stable temperatures during laboratory acclimation; an immersion heater is required for thermal challenges; an aerator/air stones ensures animals have oxygen during holding; coolers are required for transporting animals from the field; MS222 is required for euthanizing animals.
- A total of \$300 for contractual services has been budgeted to pay for conference registration for IL AFS for the student
- A total of \$1,500 has been requested for publication fees. Publication in peer-reviewed outlets is critical for obtaining scientific validation of results and ensuring that the study receives rigorous, outside reviews by impartial, qualified scientists; it is also needed to ensure the wide distribution of the findings from this study. The target journal for this work is *Endangered Species Research* (<https://www.int-res.com/journals/esr/about-the-journal/>), which specializes in publishing studies of endangered life forms (including those of local or regional concern). This outlet would also be sensitive to the limited number of animals that can be used for the study. This journal has an open access format, and page charges for publishing are €1,300, or approximately \$1,500 USD.

- Indirect costs have been charged at **40.75 %** as per the FY 2019 State of Illinois Facilities and Administrative Rate Schedule at <https://www.obfs.uillinois.edu/common/pages/DisplayFile.aspx?itemId=921222>.

Timeline

	Fall 2018	Winter 2018	Spring 2018	Summer 2018
Fish Collection				
Data Generation				
Analyses				
Manuscript preparation & dissemination				

General Compliance

Information from this project will be utilized by the IDNR, United States Geological Survey and other Federal/State agencies to assist with the enhancement and rehabilitation of native fish stocks. Data will help define thermal limits and the impact of thermal stressor son bigeye chub in Illinois.

All planned activities will be in compliance with NEPA, the Endangered Species Act, as well as the U.S. Fish and Wildlife Service protocols for section 7. Appropriate Endangered Species Permits will be obtained from the Illinois Department of Natural Resources prior to commencing any work, and all studies will receive prior approval from the University of Illinois Institutional Animal Care and Use Committee (IACUC) in advance of animal handling.

All planned activities will also be in compliance with the National Historic Preservation Act and the Council on Historic Preservation Act.

Character and Design

This proposal is substantial in character and design with the needs of protecting and enhancing native fish populations in Illinois. This project will provide, in part, needed information through a thorough and planned approach, using accepted laboratory and statistical approaches, regarding the thermal limits and the impact of thermal stressors on bigeye chub.

Relationship to Other Grants

This proposal is somewhat unique and distinct to other projects that Dr. Suski has ongoing in his research group. Dr. Suski and his research group are currently asking questions related to the impacts of agricultural land use on the abundance and distribution of fishes in the Kaskaskia River Basin (funded by USDA-NIFA), constraints impeding sustainable fisheries policy and management (funded by USDA-NIFA), the energetic consequences of restoration practices on stream fishes (funded by Illinois-Indiana Sea

Grant), as well as work to prevent the spread of Asian carp into the Great Lakes (funded by US EPA, Great Lakes Restoration Initiative).

Multipurpose projects (benefits multiple programs)

This is not a multipurpose project.

Program income

This project will not generate any program income.

Useful Life

The project has no capital improvements. No funds are requested for equipment in excess of \$5000, and the entire budget is allocated for laboratory/field supplies, personnel or travel. All supplies will be used for their useful life on similar research projects, and for their intended purpose.

Geographic location

Fish collections will occur within the Vermillion River Basin (Wabash River drainage), using DNR staff. It is challenging to identify specific sampling locations at this time as collection of this rare species can be unpredictable.

Literature Cited

Angermeier, P.L., 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. *Conservation Biology*, 9(1), pp.143-158.

Beitinger, T. L. and W. I. Lutterschmidt. 2011. Measures of thermal tolerance. Pages 1695-1702 in *Encyclopedia of Fish Physiology*. Edited by A. P. Farrell. Academic Press.

Berendzen, P.B., Gamble, T. and Simons, A.M. 2008. Phylogeography of the bigeye chub *Hybopsis amblops* (Teleostei: Cypriniformes): early Pleistocene diversification and post-glacial range expansion. *Journal of Fish Biology*, 73(8), pp.2021-2039.

Blevins, Z. W., D. H. Wahl and C. D. Suski. 2014. Reach-scale land use drives the stress responses of a resident stream fish. *Physiological and Biochemical Zoology* 87:113-124

Blevins, Z., E. Effert, D. H. Wahl and C. D. Suski. 2013. Land use drives the physiological properties of a stream fish. *Ecological Indicators* 24: 224-235.

Illinois Endangered Species Protection Board (IESPB). 2015. Checklist of endangered and threatened animals and plants of Illinois. Illinois Endangered Species Protection Board, Springfield. 20 pp.

Lutterschmidt, W.I. and Hutchison, V.H., 1997. The critical thermal maximum: data to support the onset of spasms as the definitive end point. *Canadian Journal of Zoology*, 75(10), pp.1553-1560.

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at <http://mnfi.anr.msu.edu/explorer> [Accessed Jul 27, 2018]

Page, L.M. and Retzer, M.E., 2002. The status of Illinois' rarest fishes and crustaceans. *Transactions of the Illinois State Academy of Science*, 95(4), pp.311-326.

Pfleiger, W. L. 1975. *The fishes of Missouri*. Missouri Department of Conservation. Western Publishing Co.