Summary of the Chicago Area Waterway System Habitat Evaluation

CAWS Habitat Evaluation and Improvement Study

November 20, 2009

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CAWS Fish/Water Quality Analysis: Contents

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CAWS Habitat Evaluation: CAWS Orientation

CAWS Habitat Evaluation: Orientation

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CAWS Habitat Evaluation: Orientation

- Study area included more than 75 miles of managed reaches of the CAWS.
- Of this, 75% are manmade, excavated waterways.
- The rest has been heavily modified by straightening, deepening, widening and bank armoring.

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CAWS Habitat Evaluation: Orientation

- Every reach in the Study was either manmade or has been completely altered from its original condition.

Waterway	Length (mi)	Construction History
North Shore Channel	7.7	Completely manmade; excavated 1907-1910
North Branch Chicago River	7.8	Straightened, widened, deepened; 1904 onward
North Branch Canal	1.1	Completely manmade; excavated 1850s
Chicago River	1.6	Mouth modifications; widened, deepened; focus of development since time of first settlement; flow reversed; modifications 1816-1939
South Branch Chicago River	4.6	Straightened, widened, deepened; flow reversed; major straightening in 1928-29; West Fork completely filled in 1920-1930s
Bubbly Creek	1.5	Straightened, widened, deepened, rerouted, tributaries filled; 1860s-1920s
Chicago Sanitary and Ship Canal	31.3	Completely manmade; excavated 1892-1900
Calumet-Sag Channel	16.1	Completely manmade; excavated 1911-1922
Little Calumet River	6.1	Straightened, widened, deepened; flow reversed; modifications started in the 1870s

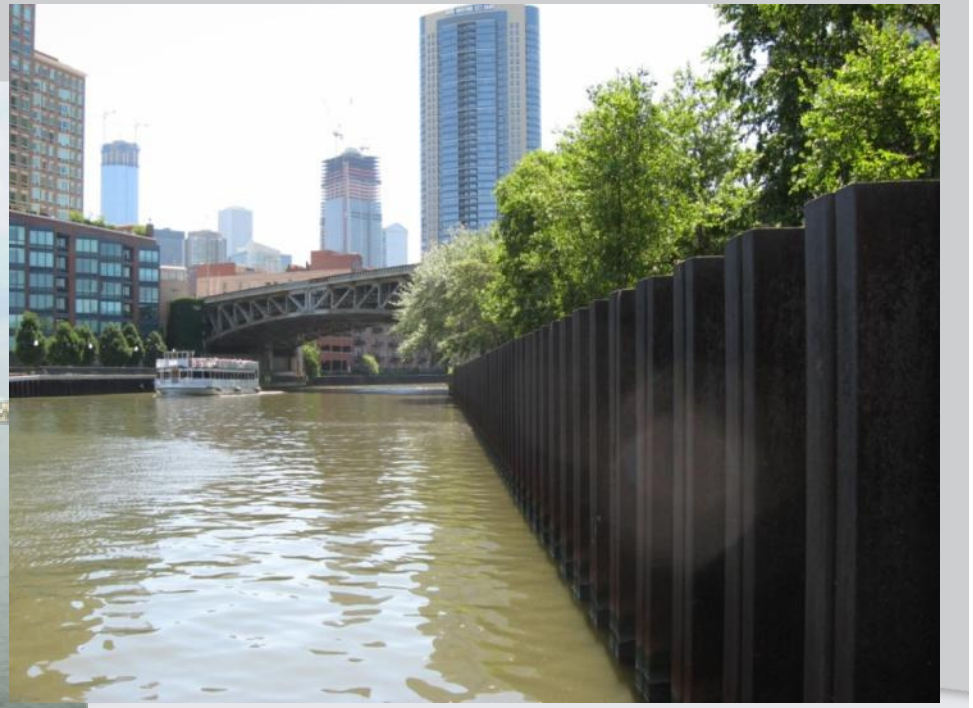
CAWS Habitat Evaluation: Orientation

Uses of the CAWS – why are these waterways the way they are?

- Effluent conveyance
  - Drainage reversed from Lake Michigan to Mississippi River basin
  - The majority of flow through the CAWS is treated effluent from Water Reclamation Plants
- Commercial navigation
  - Millions of tons of cargo are shipped through the CAWS annually.
- Flood control
  - Water levels are manipulated to accommodate storm runoff from metro Chicago

CAWS Habitat Evaluation: Orientation

- The constructed nature of the CAWS has a significant impact on physical habitat, on top of impacts associated with most urban waterways.



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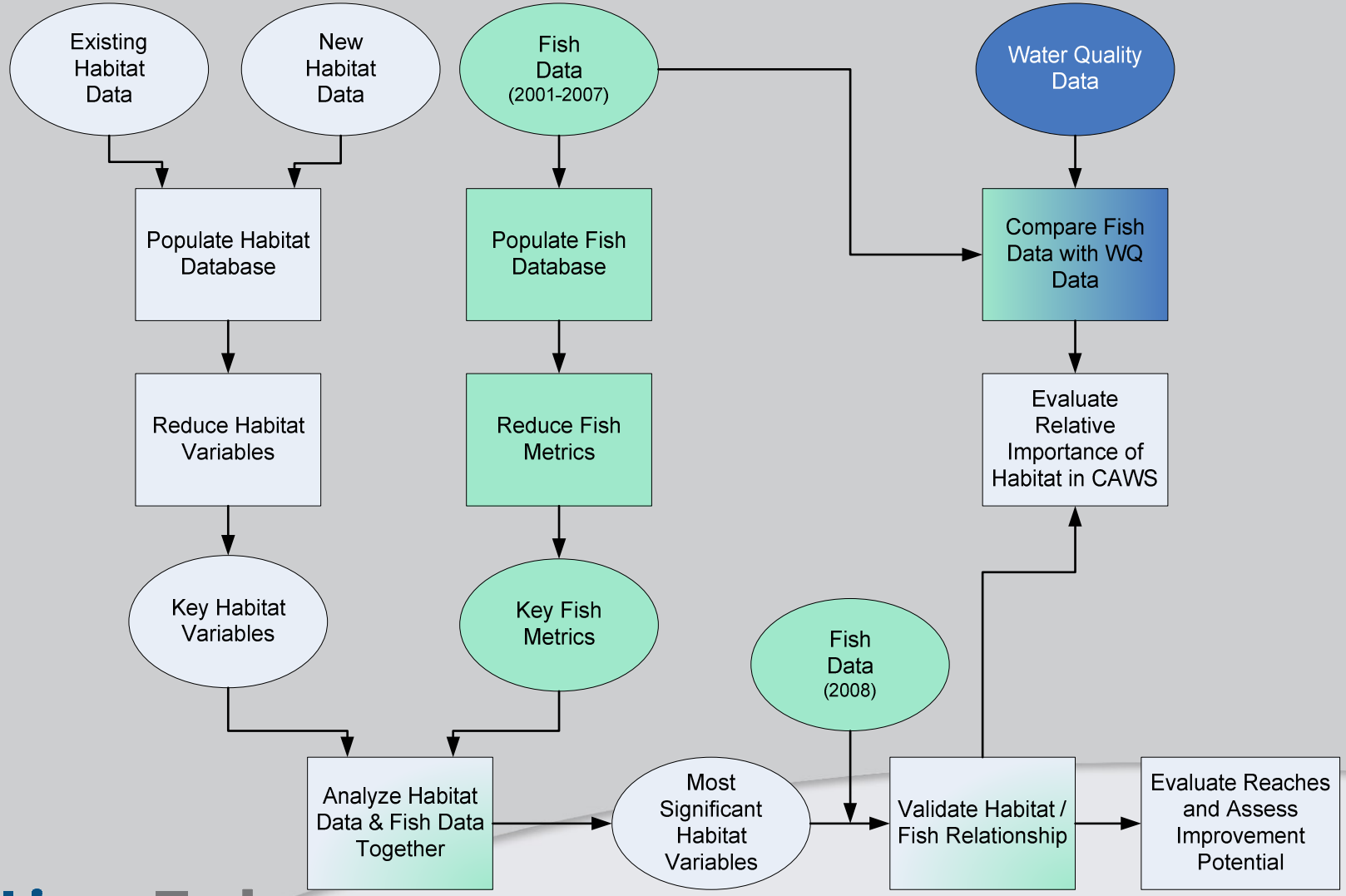
CAWS Habitat Evaluation: Objectives

CAWS Habitat Evaluation: Objectives

1. Determine physical habitat characteristics for reaches of the CAWS within the Study area.
2. Determine the importance of physical habitat to fish in the CAWS, relative to water quality.
3. Evaluate the potential for significant habitat improvement in the CAWS.

CAWS Habitat Evaluation: Process Overview

CAWS Habitat Evaluation: Process



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CAWS Habitat Evaluation: Data Collection

CAWS Habitat Evaluation: Data Collection

Overview

- District has collected data for several years (fish, invertebrate, habitat, water quality
- Existing data from 2001 through 2007 were compiled and entered into a geo-spatial database for use in the Study.
- Supplemental data collection activities were conducted in 2008 as part of the Study.

CAWS Habitat Evaluation: Data Collection

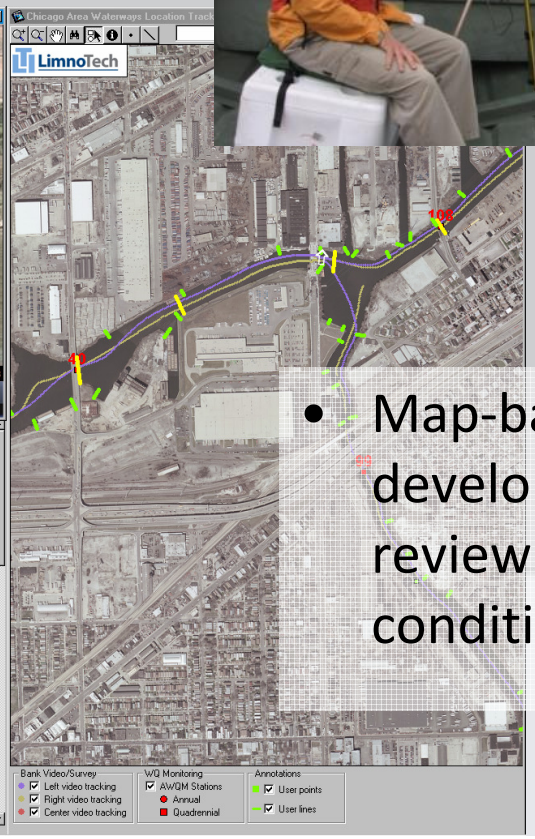
Supplemental data collection:

- Digital video inventory of entire system
- Existing data from 2001 through 2007 were compiled and entered into a geo-spatial database for use in the Study.
- Supplemental data collection activities were conducted in 2008 as part of the Study.

CAWS Habitat Evaluation: Data Collection

Digital video inventory:

- GPS-linked for accurate positioning
- Allowed characterization of bank condition and riparian area (land use, vegetation, etc.) for entire system



- Map-based viewer developed for review of system conditions.

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CAWS Habitat Evaluation: Data Collection

Supplemental sampling:

- Detailed habitat measurements at 28 stations
- Supplemental fish and invertebrate sampling at 14 stations (in addition to 8 annual stations sampled by District)

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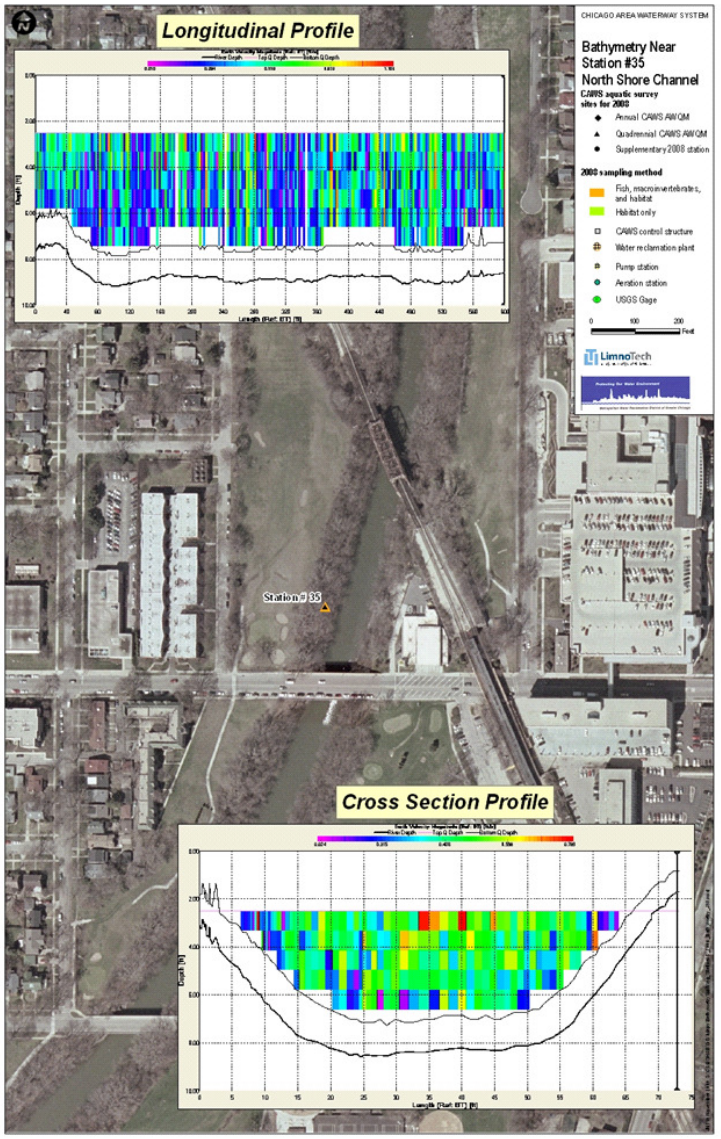
CAWS Habitat Evaluation: Data Collection

Bathymetric surveying:

- Acquired USACE data where available, incorporated into project GIS
- Conducted ADCP surveys in reaches where detailed bathymetry was not available



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CAWS Habitat Evaluation: Data Collection

Aerial photography:

- Acquired latest available aerial photography, incorporated into project GIS for additional characterization of riparian condition

CAWS Habitat Evaluation: Data Collection

Subsurface structure:

- Attempted underwater digital video – too turbid
- Pilot tested side scan sonar in four reaches

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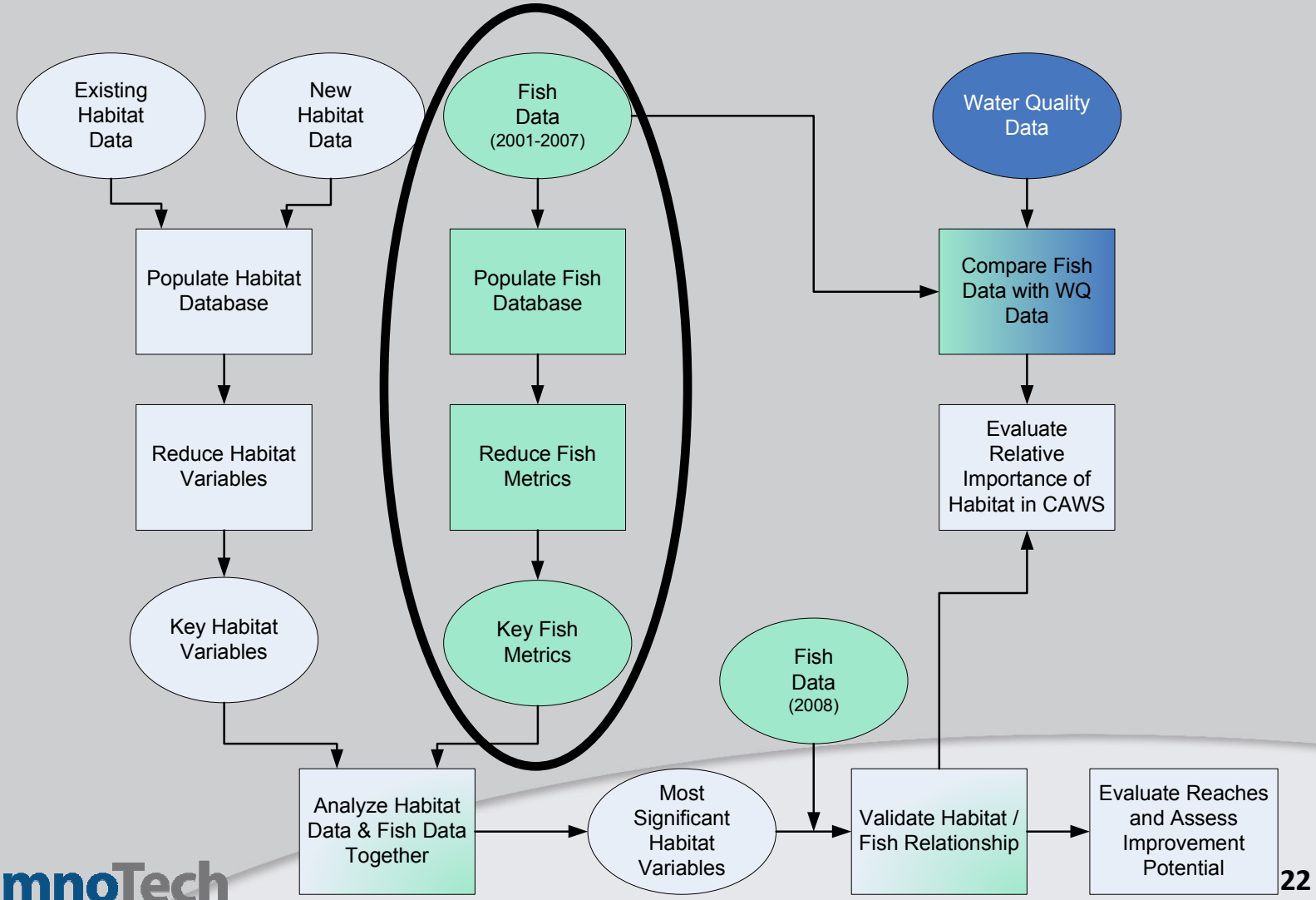
CAWS Habitat Evaluation: Development of a CAWS-specific fish metric

CAWS Habitat Evaluation: Process

Reduction of fish data



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CAWS Habitat Evaluation: Process

Reduction of fish data

- Needed a “simple” metric to represent fish data.
- Existing indices not applicable to CAWS
  - Developed for wider range of conditions, indexed to specific goals
  - Would not likely provide sufficient differentiation (needed a gradient)
- Represented fish data using conventional metrics (46)
- Reduced metrics using process commonly used for developing fish IBIs (Lyons et al. 2001; Karr, 1981)

CAWS Habitat Evaluation: Process

Reduction of fish data

- Fish metrics were screened for:
  - No data
  - Range: eliminate metrics with which 2 or fewer species are associated
  - Redundancy: used Pearson's correlation to eliminate statistically related metrics (0.6 or higher)
  - Variability: used to select between "count" and "weight" metrics. Selected metric with higher coefficient of variation.
- Wanted representative metric from 5 ecological function categories

CAWS Habitat Evaluation: Results

Reduction of fish data

- Final list of metrics selected

Fish Metric	Ecological Function Category
% Diseased or with eroded fins, lesions, or tumors	Abundance and condition metric (ACM)
catch per unit effort	Abundance and condition metric (ACM)
% lithophilic spawners by count	Reproductive function metric (RFM)
% insectivores by count	Trophic function metric (TFM)
% top carnivores by weight	Trophic function metric (TFM)
proportion of Illinois tolerant species	Indicator species metric (ISM)
IL ratio of non tolerant coarse-substrate spawners	Reproductive function metric (RFM)
number of IL native minnow species	Species richness and composition metric (SRC)
number of IL native sunfish species	Species richness and composition metric (SRC)
IL ratio of generalist feeders	Trophic function metric (TFM)
% intolerant species by count	Indicator species metric (ISM)
% moderately intolerant species by weight	Indicator species metric (ISM)

CAWS Habitat Evaluation: Process

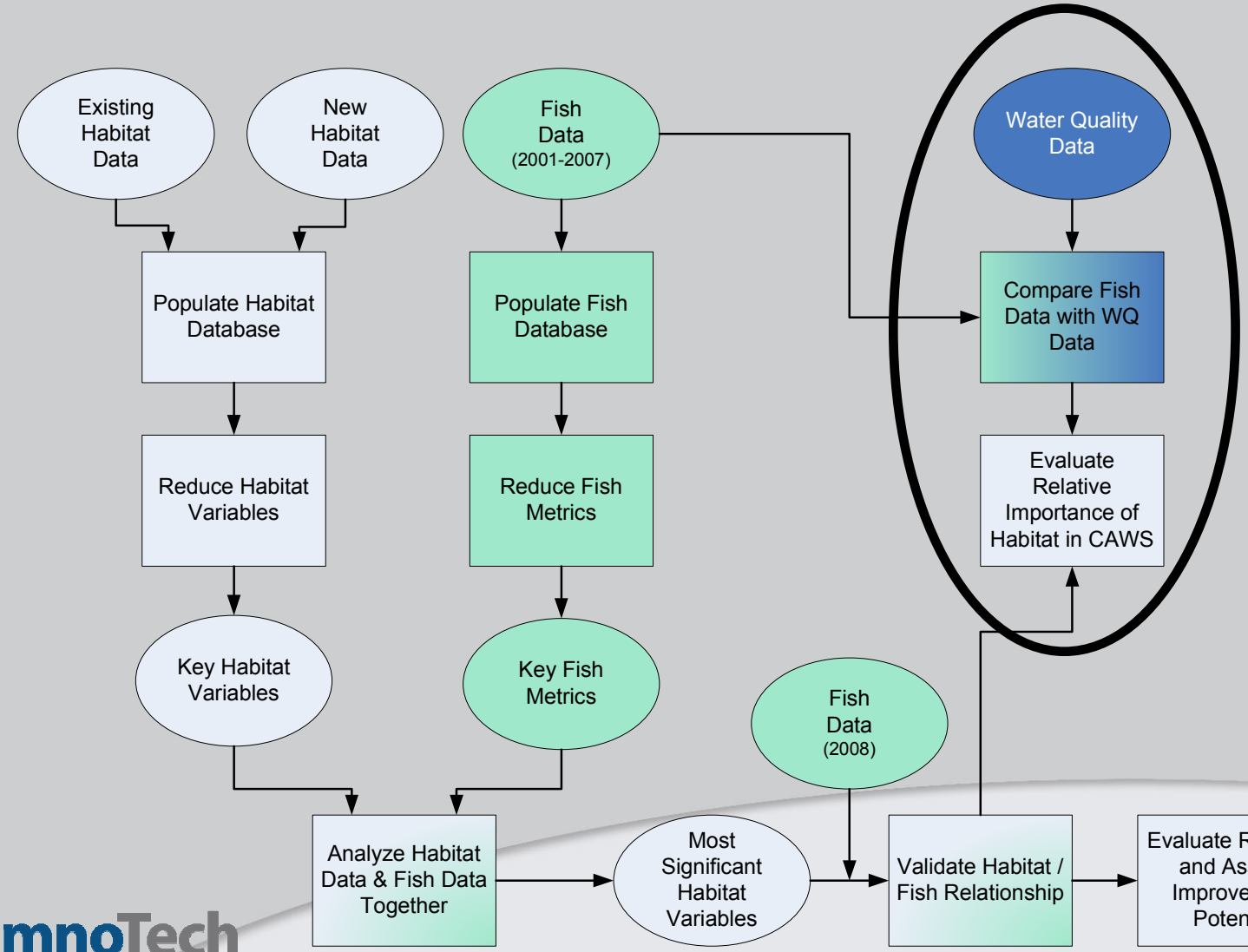
Reduction of fish data

- Weighting of metrics to define a true CAWS fish IBI would require some identification of desired condition:
  - Reference reach: often used to represent 'pristine' or unimpacted conditions…not available in CAWS.
  - Management objective: anthropogenic statement of desired condition…not available in CAWS.
- Definition of the desired condition will determine upper end of index scale
- In lieu, we used an unweighted sum of the metrics (each metric equally weighted)

CAWS Habitat Evaluation: Evaluation of fish response to water quality changes

CAWS Habitat Evaluation: Process

Importance of water quality to fish



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CAWS Habitat Evaluation: Process

Importance of water quality to fish

- Do the data suggest a correlation between fish metrics and water quality
  - Measures of temperature and dissolved oxygen
  - Attainment of current or proposed water quality standards for dissolved oxygen
  - Other water quality parameters
- How much variability in fish data can be explained by water quality alone?

CAWS Habitat Evaluation: Process

Importance of water quality to fish

- Evaluated dissolved oxygen (DO) and temperature against key fish metrics.
- Compared “attainment” and “non-attainment” fish populations (using water quality standards).
- Compared fish at “attainment of existing standards” locations with fish at “attainment of proposed standards” locations.

CAWS Habitat Evaluation: Process

Importance of water quality to fish

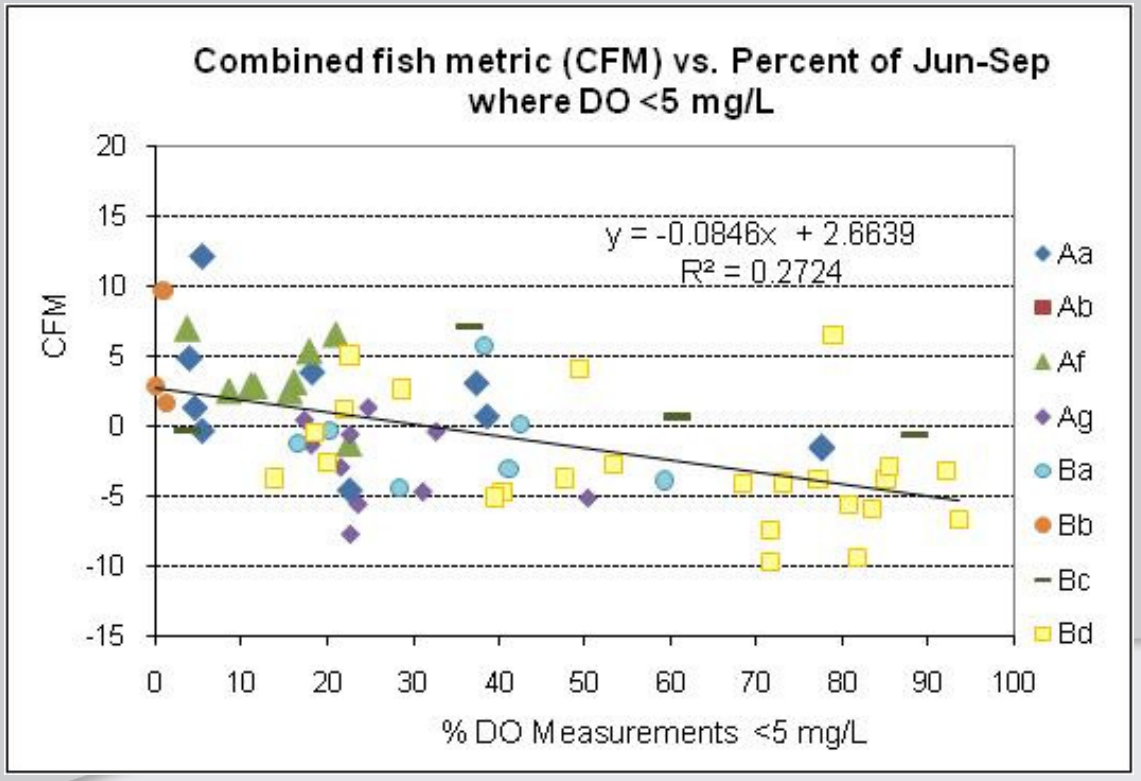
Findings:

- When fish metrics were compared between stations where WQ standards are being attained and where they are not, some metrics were slightly better for attainment than non-attainment stations, but most differences were not statistically significant.
- More fish metrics had statistically significant relationships to attainment of existing standards than to proposed stds.
- Using linear regression, DO explained up to 27% of variation in fish data as represented by the combined fish metric (r^2 = 0.27), but most regressions were much weaker than this.

CAWS Habitat Evaluation: Results

Importance of water quality to fish

- Strongest correlation was with % of time June – September that DO is less than 5 mg/L



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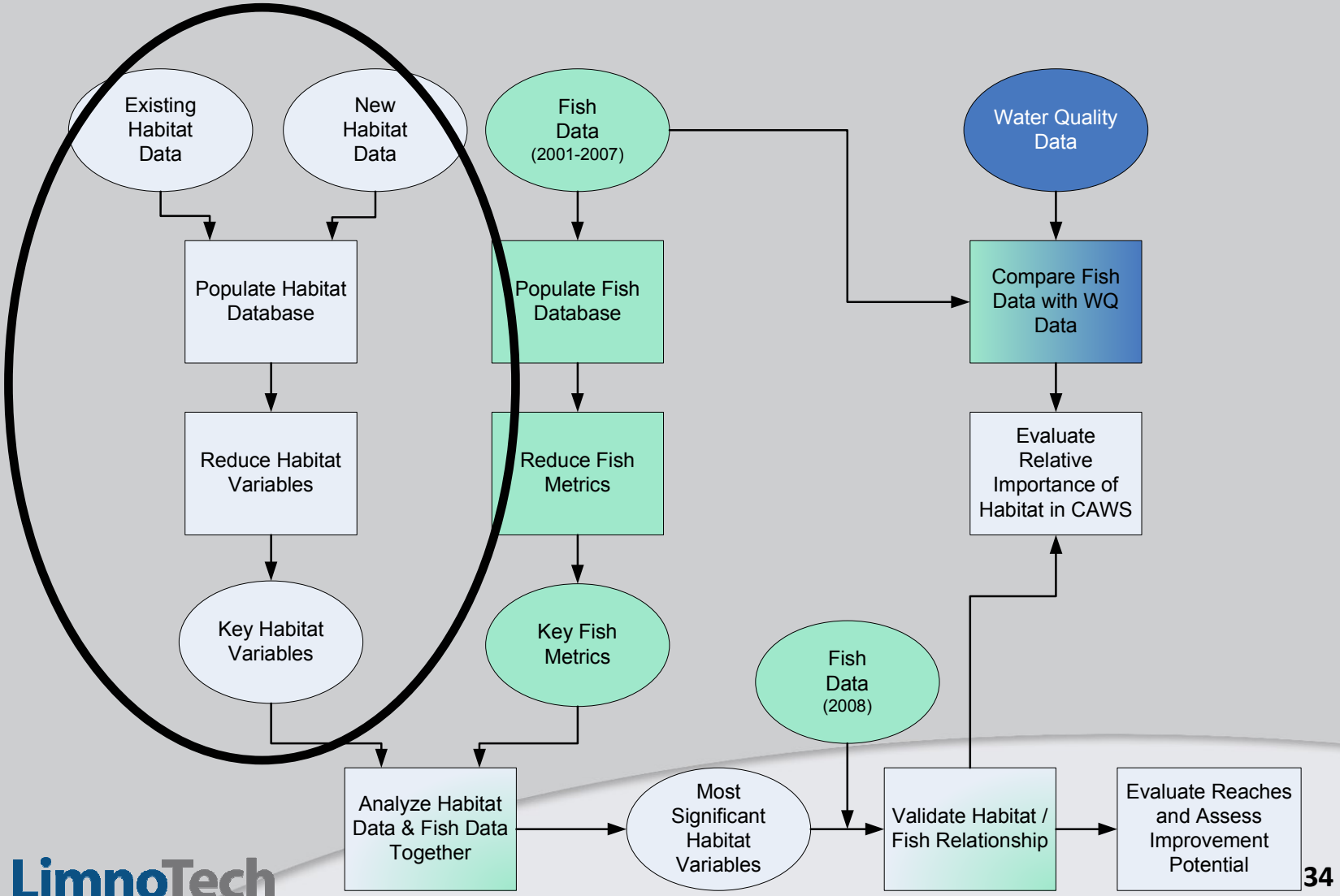
CAWS Habitat Evaluation: Identification of key habitat variables

CAWS Habitat Evaluation: Process

Reduction of habitat variables



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CAWS Habitat Evaluation: Process

Reduction of habitat variables

Objective: screen 241 habitat variables

- Started with 241 habitat variables; many from literature, some CAWS-specific
- Needed to reduce number to achieve good data:variable ratio for multiple linear regression (targeted <20 variables)
- Followed general process used to develop Michigan Non-Wadeable Habitat Index (Wilhelm et al., 2005)

CAWS Habitat Evaluation: Process

Reduction of habitat variables

Multi-Step Process:

- Professional judgment (e.g., sinuosity): 241 to 66
- Correlation analysis (Spearman's 0.7 or greater, within categories): 66 to 44
- Combination of paired, similar variables: 44 to 39
- Principle components analysis (within categories): 39 to 23
- Correlation analysis (Spearman's 0.6 or greater, across categories): 23 to 16

CAWS Habitat Evaluation: Results

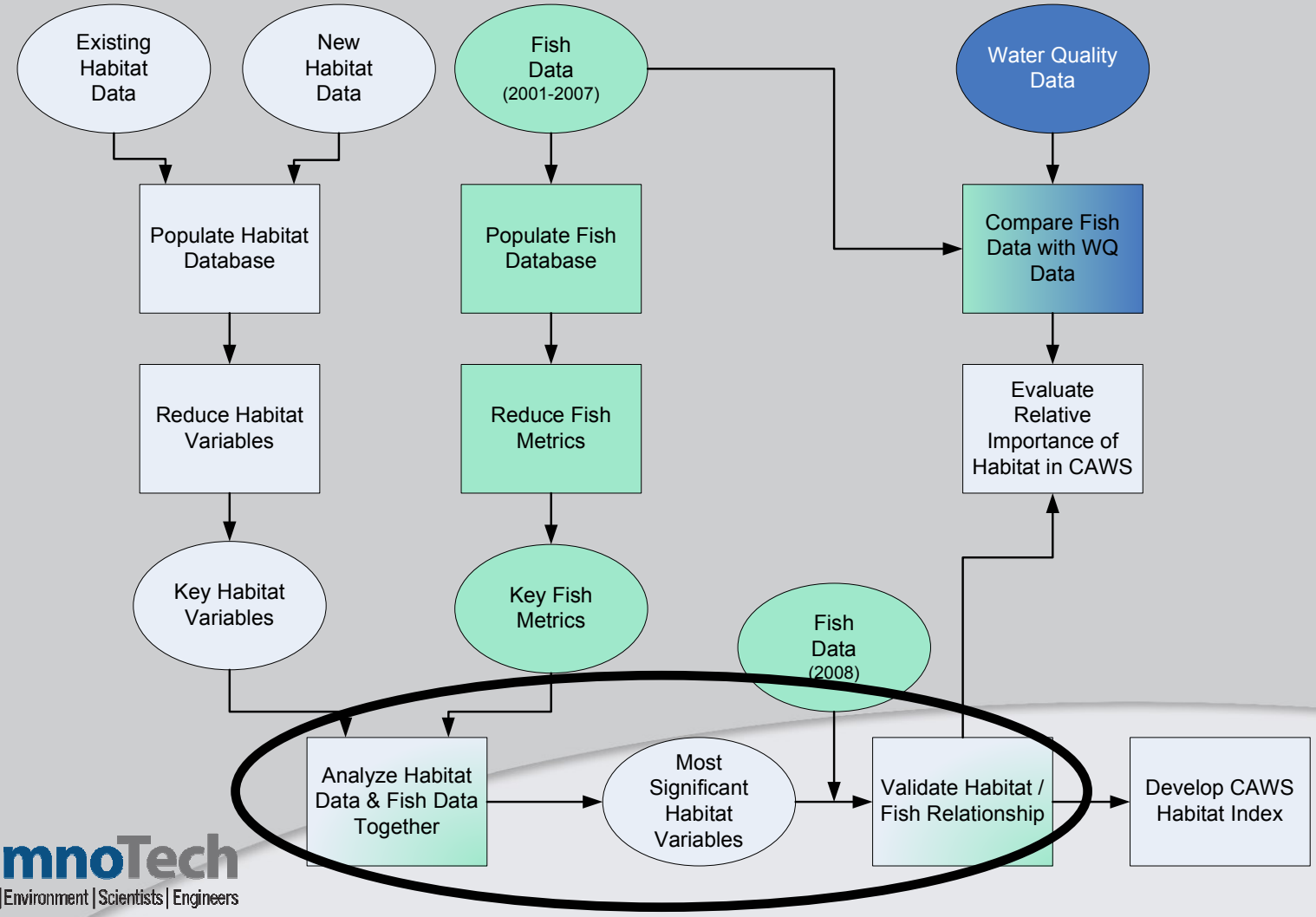
Reduction of habitat variables

Variable Category	Habitat Variable
Geomorphology & Hydrology	Flashiness index Wetted perimeter of channel Maximum depth in reach Number of off-channel bays Bank “pocket” areas
Sediment & Substrate	% Gravel, cobbles, boulders, shallow % Gravel, cobbles, boulders, deep % Plant debris on bed % Organic sludge
In-Stream Cover	Average macrophyte cover In-stream cover present Secchi depth
Bank & Riparian Condition	Dominant riparian land use % Vertical walled banks in reach % Riprap banks in reach
Anthropogenic Impacts	Manmade structures

CAWS Habitat Evaluation: Evaluation of fish response to physical habitat variables

CAWS Habitat Evaluation: Process

Fish response to physical habitat variables



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CAWS Habitat Evaluation: Process

Fish response to physical habitat variables

- Used multiple linear regression (MLR) to compare habitat variables with fish data.
- MLR has been used in developing other habitat indices including:
  - MI Non-Wadeable Habitat Index
  - QHEI
  - MD Physical Habitat Index
- Used best subsets MLR to allow inspection of regression equations, rather than automated selection.

CAWS Habitat Evaluation: Results

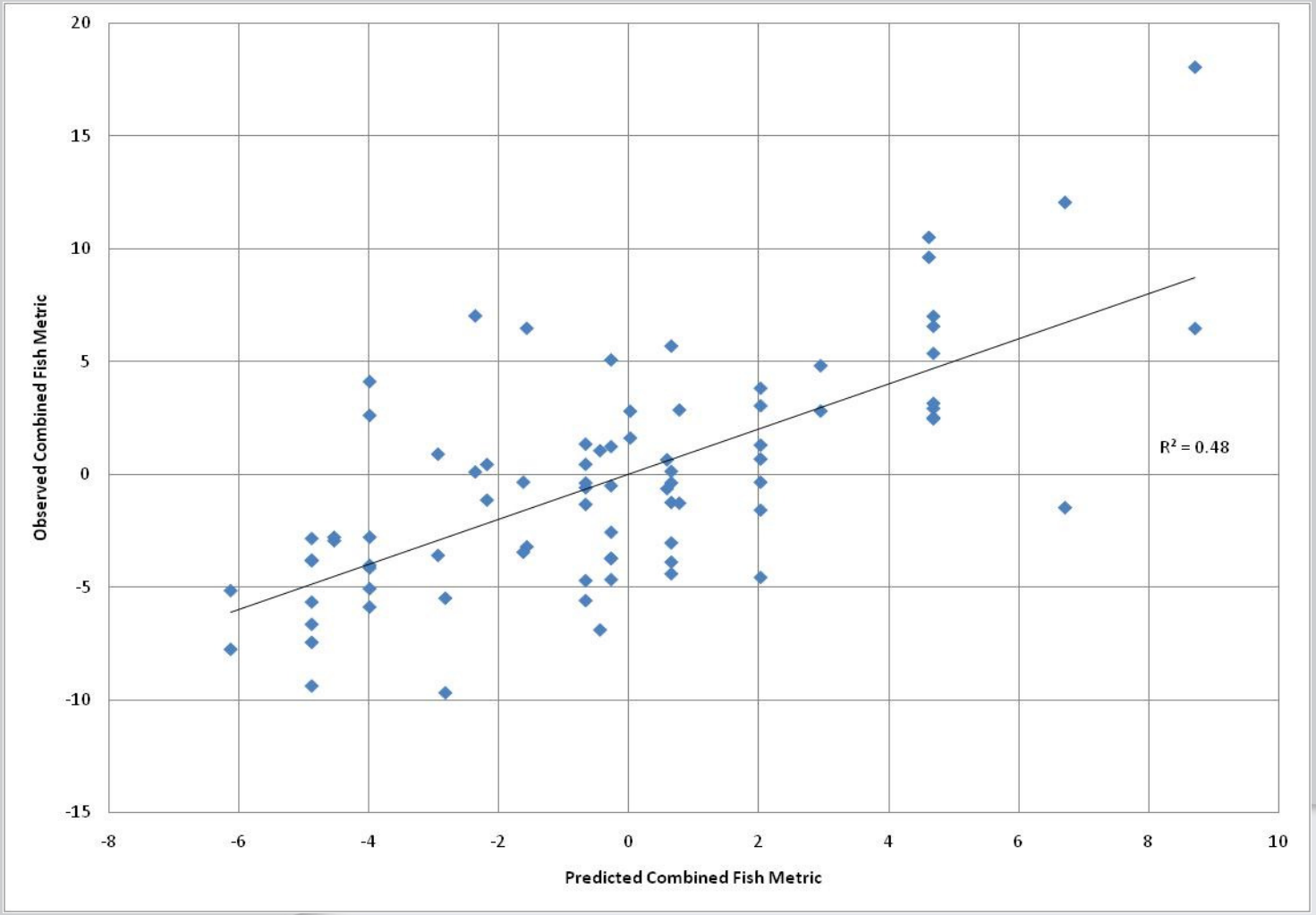
Fish response to physical habitat variables

Six key habitat variables identified:

- Maximum depth of channel
- Off-channel bays
- Percent of vertical wall banks in reach
- Percent of riprap banks in reach
- Manmade structures in reach
- Percent macrophyte cover in reach

CAWS Habitat Evaluation:

Fish response to physical habitat variables



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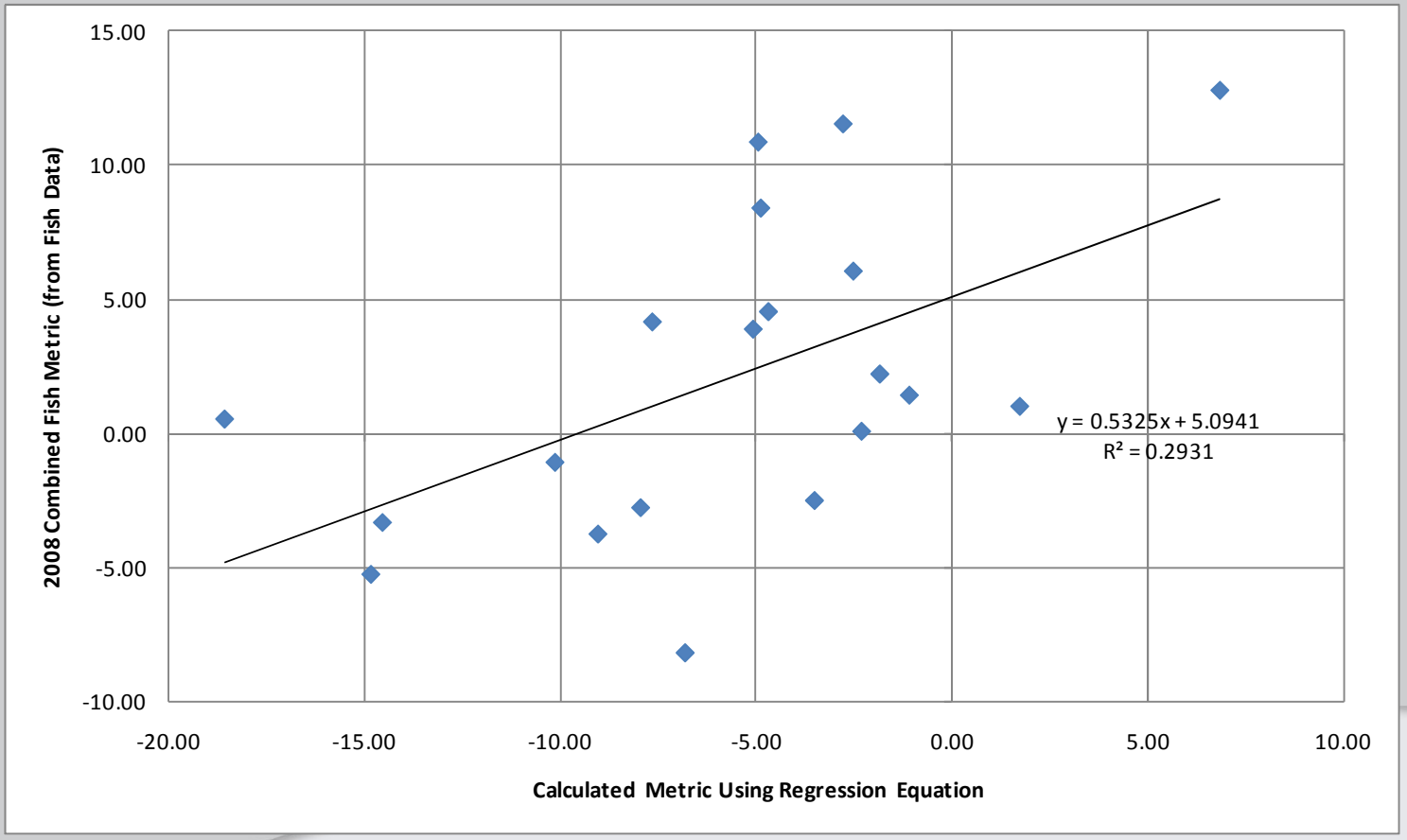
CAWS Habitat Evaluation: Results

Fish response to physical habitat variables

- Results validated with 2008 fish data: **r^2 = 0.29**



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CAWS Habitat Evaluation: Results

Fish response to physical habitat variables

- Best regression of DO with fish (2001-07): **r^2 = 0.27**
  - Dissolved oxygen can explain 27% of variation in fish data.
- Regression of habitat with fish (2001-07): **r^2 = 0.48**
  - Key habitat variables can explain 48% of variation in fish data.
- Combining DO with key habitat variables only improves r^2 by 0.04 over key habitat variables alone.

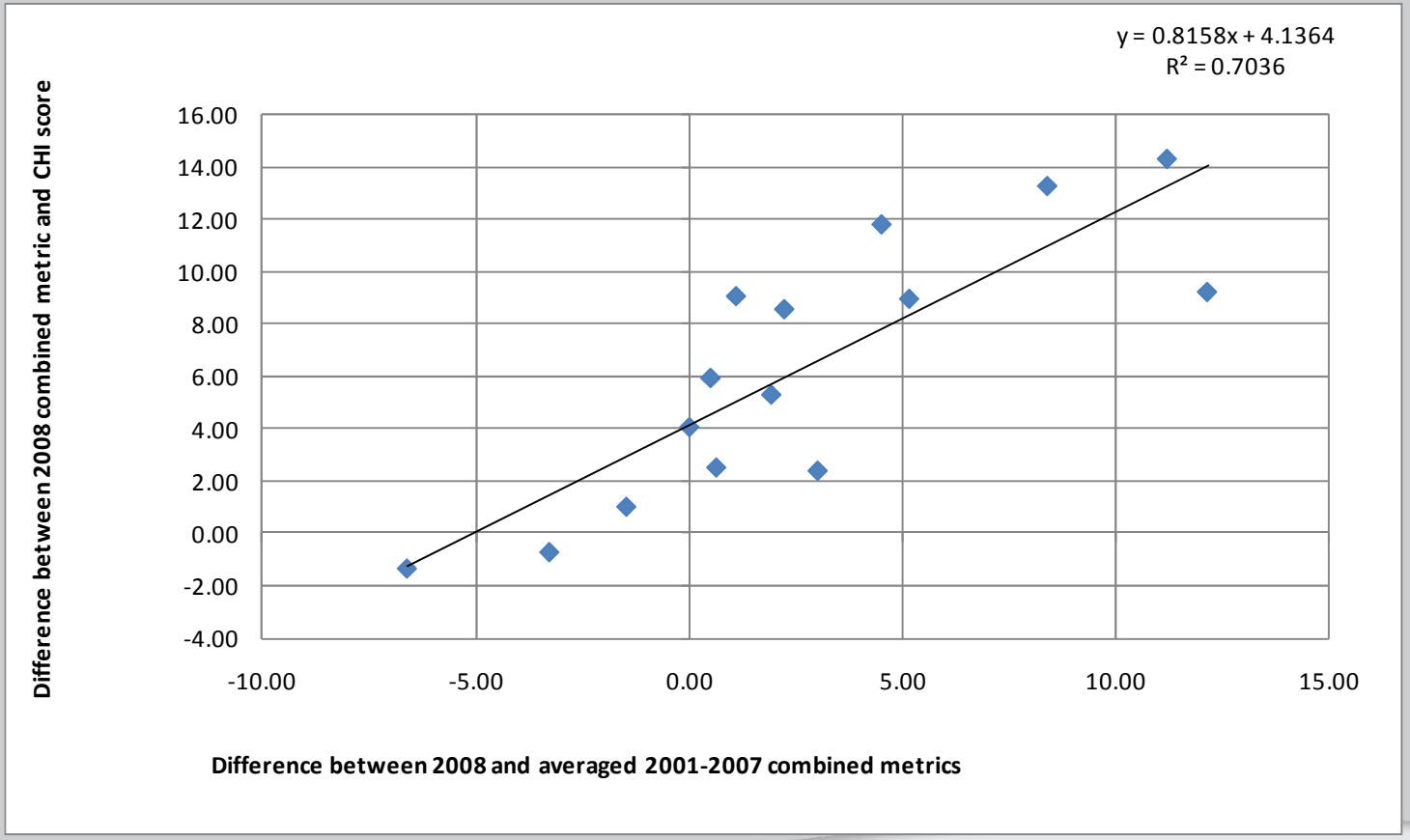
CAWS Habitat Evaluation: Results

Fish response to physical habitat variables

- If physical habitat can explain about half of the variability in fish data from the CAWS and the addition of DO improves that to slightly more than half, what explains the rest of the uncertainty?
- Noted high variability in fish data at stations between events.

CAWS Habitat Evaluation: Results

Fish response to physical habitat variables



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CAWS Habitat Evaluation: Results

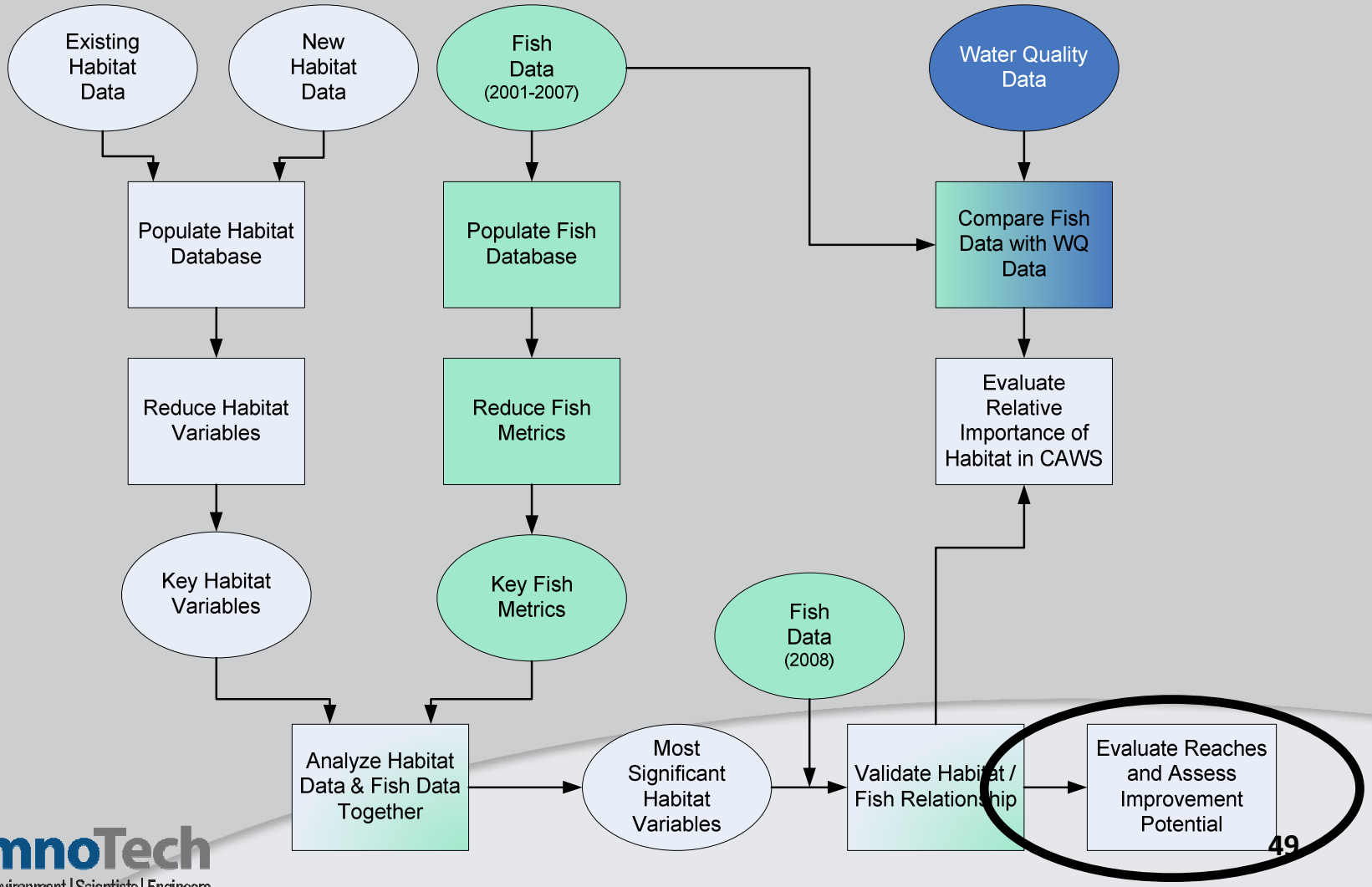
Fish response to physical habitat variables

- This indicates that the variability in fish data at a given location over time significantly limits the ability to define fish response to environmental variables.
- Variability may be the result of fish mobility, sampling efficiency, and/or some other factor.
- Explaining about half the fish variability is about as good as you can do and is comparable to other studies that examined the response of fish to environmental variables such as habitat and water quality.

CAWS Habitat Evaluation: Evaluate reaches and assess improvement potential

CAWS Habitat Evaluation: Process

Index development & validation



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CAWS Habitat Evaluation: Process

Assessment of improvement potential

Some aspects of physical habitat cannot be altered in the CAWS

- The CAWS are mostly manmade and are unlike natural waterways by design (for effluent disposal, commercial navigation, and flood control).
- Some aspects of the system simply cannot practically be changed
  - Channelization
  - Many vertical walled banks
  - Substrate (fine and contaminated)
  - Floodplain disconnection

CAWS Habitat Evaluation: Process

Assessment of improvement potential

<u>It may not be feasible to make physical habitat improvements on a scale sufficient to have an impact</u>

- It may be possible to improve some significant habitat variables locally:
  - "Naturalization" of banks
  - Enhancement of macrophytes
  - Increase overhanging riparian vegetation
- It is likely, however, that these improvements will only be feasible on a local scale, the benefit of which is questionable.

CAWS Habitat Evaluation: Process

Assessment of improvement potential

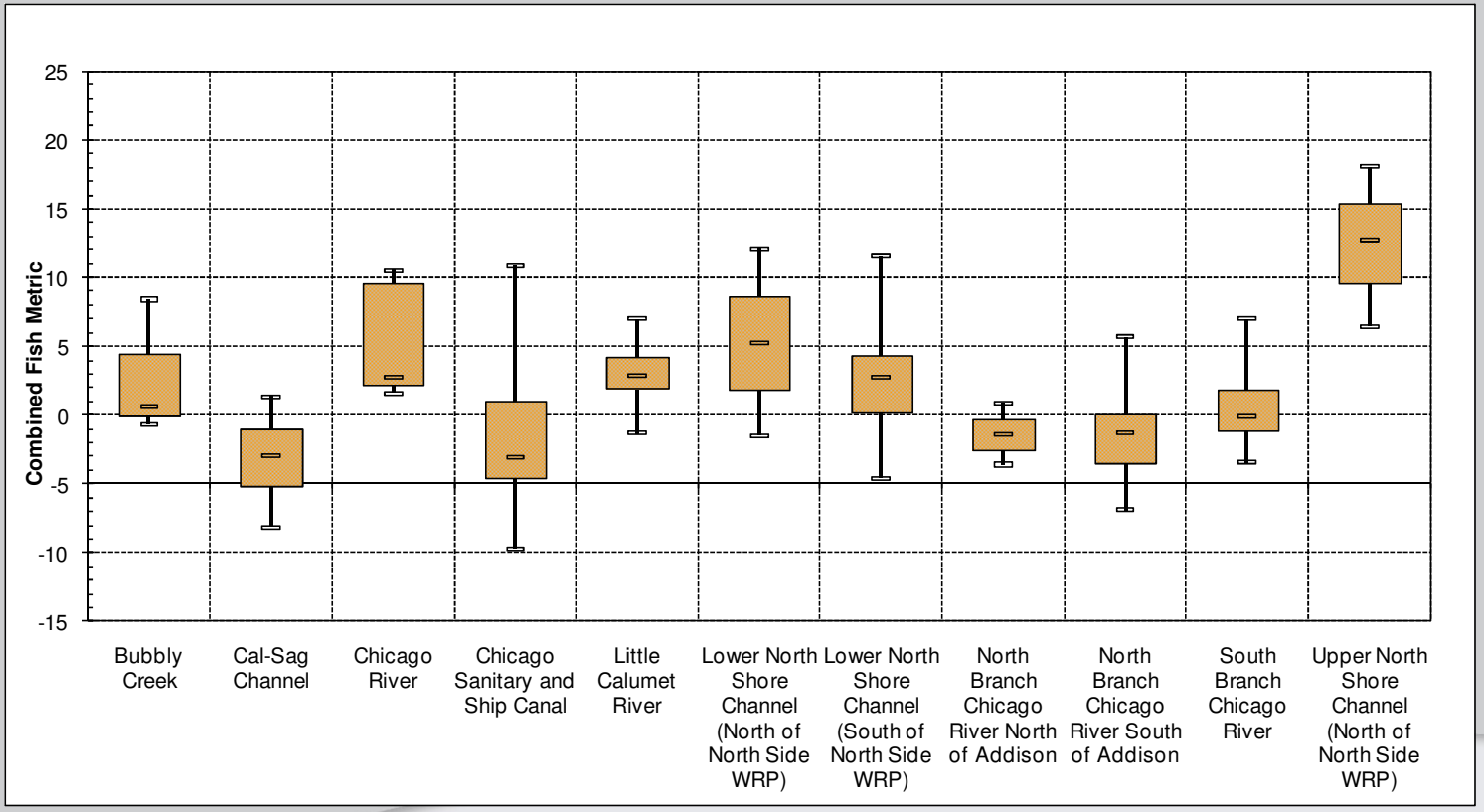
The presence of commercial navigation in much of the system will continue to be a limiting factor for aquatic ecosystem improvement.

- The impacts of navigation on aquatic biota are well-documented in the literature.
- The indirect impacts in the form of channel modification are obvious in the CAWS.
- This Study was not designed to differentiate or quantify the specific impacts of navigation on fish, but the data suggest navigation has a major impact.

CAWS Habitat Evaluation: Process

Assessment of improvement potential

Where habitat improvements can be made, it may be difficult to measure changes in fish due to their inherent variability.



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CAWS Habitat Evaluation: Summary of Findings

CAWS Habitat Evaluation: Process
Summary of findings

Key findings:

1. Aquatic habitat is inherently limited in the CAWS by the system's form and function.
    - The CAWS are mostly manmade and are unlike natural waterways by design.
    - The major uses of effluent disposal, commercial navigation, and flood control have both indirect and direct effects on aquatic biota.
    - Many of the factors that create these effects are unlikely to change and, therefore, the system's biotic potential will continue to be limited.

CAWS Habitat Evaluation: Process
Summary of findings

Key findings:

2. Physical habitat is relatively more important to fish in the CAWS than dissolved oxygen.

   - Physical habitat alone can explain as much as 47% of the variability in CAWS fish data.
   - Dissolved oxygen alone (the water quality parameter to which fish were most responsive) can explain up to 27% of the variability in CAWS fish data.

CAWS Habitat Evaluation: Process

Summary of findings

Key findings:

3. Some of the physical habitat variables to which fish in the CAWS are most sensitive are variables that have limited potential for improvement.

   - It is impractical to expect that channel depth, vertical bank walls, and the presence of manmade structures will change on a scale sufficient to have a major impact on biota.
   - Although some habitat variables may be improved, it is unclear whether their improvement alone will be sufficient to have a major impact on biota

CAWS Habitat Evaluation: Process

Summary of findings

Key findings:

4. Even if limited habitat improvements can be made, it may not be possible to measure an effect on fish and expectations should be moderated.

    - Fish data are highly variable (coefficients of variation more than 500% in some cases).
    - Even if biotic improvements result from habitat improvements, there is no way of knowing how long it will take.
    - In a system with so many stressors, improving one habitat variable may simply result in a different limiting factor rising to the top.

Summary of the Chicago Area Waterway System Habitat Evaluation

Discussion