Lakewide Assessment Plan for Lake Michigan Fish Communities, Version 2.0

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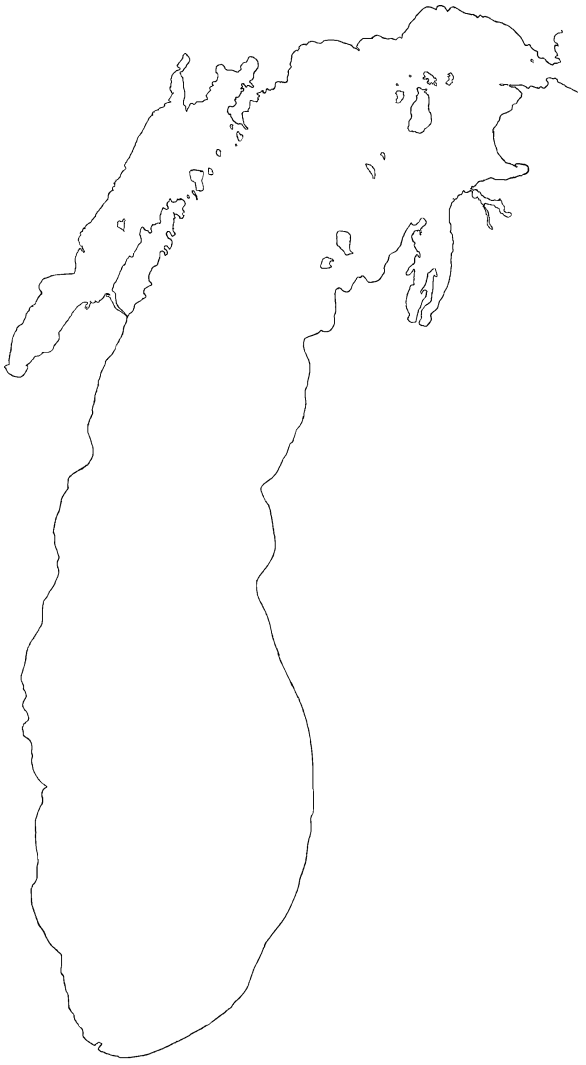

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INTRODUCTION

Management of the Lake Michigan fish community is the shared responsibility of the four states surrounding the lake and the Chippewa/Ottawa Resource Authority. The Lake Trout Working Group (LTWG), convened by the Lake Michigan Committee, was comprised of agency representatives to develop an integrated and comprehensive management strategy for lake trout. Formulation of management strategies (Dexter et al. 2011) primarily relied on spring and fall (spawn) multiagency gill net surveys designed to collect basic mortality, growth, diet, and disease data. However, surveys did not adhere to a standardized lakewide format until 1998 when Lake Wide Assessment Plan (LWAP; Schneeberger et al. 2001) protocols were enacted. Since standardization, LWAP surveys have been instrumental in evaluating the progression of lake trout restoration, reported annually in LTWG reports (recent versions found on the GLFC Lake Michigan Committee webpage: http://www.glfc.org/lake-michigan-committee.php). While LWAP surveys have enabled effective monitoring of lake trout restoration, the original protocols recognized LWAP methods needed to "be modified and improved as they are used and tested; future revisions will also contain assessment plans for important forage and inshore fish stocks including benthivores and planktivores."

Standardized LWAP methods originally targeted lake trout and burbot, but agencies have also used spring LWAP effort to monitor trends of other important species including yellow perch, lake whitefish, lake herring, and lake sturgeon. While this multispecies focus was consistent with the LWAP vision, it led to agency-specific modification of LWAP protocols. For example, some agencies added a shallow (<50') depth bin and modified nets to include small mesh (1.5 - 2") for fish communities in nearshore waters. Conversion from multifilament to monofilament nylon gill nets is another agency-specific modification aimed at increasing coregonid catches while maintaining similar lake trout catch rates (Smith et al. 2022). Meanwhile, a parallel effort, the fishery independent whitefish survey (FIWS; Ebener 2002), began in the early 2000s to monitor lake whitefish within the 1836 Treaty Waters. Given the similarity between survey methods (mesh sizes, depth bins, etc.), spring FIWS surveys are now routinely consolidated with spring LWAP to increase the effort and spatial scale of survey coverage. Consequently, LWAP methods have evolved since their inception due to the ongoing efforts to improve monitoring of the fish community at a lake-wide scale.

In March of 2019, the Lake Michigan Committee recognized the need to revisit current LWAP practices and tasked the LMTC to conduct a "review of the LWAP document that would identify changes deemed appropriate to achieve plan objectives and add value to the data collected". This process started with a questionnaire of contributing agencies current survey methods to identify differences from documented LWAP protocols (Appendix 1). Subsequently, the LWAP Review Team (LRT) evaluated the integrity of the spring data time-series and whether protocol modifications, specifically depth bins and timing (month) of survey effort, affected the original LWAP objective to index lake trout abundance. The review found lake trout catch rates generally did not differ among depth bins provided survey effort was executed during the early spring when the water column is not stratified. The inclusion of small mesh (1.5 - 2") to net design improved the survey's utility to detect trends in juvenile lake trout and the broader fish community. Lastly, partial conversion from multifilament to monofilament nets does not appear to impair comparisons of lake trout abundance trends but this conversion is undergoing external peer review. As more data becomes available, these analyses along with others will continue to inform the LWAP data

collection process.

Although the review generally supported the LWAP survey efforts currently in place, several recommendations were offered to improve the spring LWAP's value as a multi-species survey to meet current management needs. Foremost, statistical catch-at-age models now extend beyond the 1836 Treaty waters and there is now an emphasis on ensuring age estimates are reported for all lake trout (hatchery and wild origin). The necessity of reporting age estimates is also extended to the broader fish community of interest including: burbot, cisco, lake whitefish, and yellow perch. The adoption of a 'multi-species' survey will also require all agencies to ensure surveys report accurate catch rates for the expanded species-of-interest, and more generally a commitment to provide complete gear and biodata records is required to enable continued revisions of LWAP protocols to better meet management needs. Here we refresh the complete LWAP protocols with the 'review team' additions and clarifications. This will help to reunify LWAP methods among participating agencies and continue to improve data which will aid fisheries management for many species in the future.

PLAN OBJECTIVES

The primary objective of the original LWAP was to provide a sampling design to determine the relative abundance of two key predators: lake trout, and burbot. This updated plan will also provide data on several other species of interest including lake whitefish, cisco and yellow perch. Targeted sampling,detailed later in this document, will be conducted and summarized annually.

The secondary objective is to collect data to determine growth, population mortality, movement, genetic strain, age-specific diet, juvenile recruitment, and general physical health for species of interest. Pertinent data will be collected each year but may not necessarily be summarized on an annual basis.

DATA ANALYSIS AND REPORTING RESPONSIBILITY

Data analysis, summarization, and reporting is the responsibility of the Lake Michigan Technical Committee but is currently delegated to the Lake Trout Working Group. Each agency provides raw assessment data in a standardized electronic data base format to the identified data manager (currently USFWS Green Bay) on an annual basis in time to create the annual Lake Trout Working Group report (current deadline February 15). Currently the USFWS Green Bay compiles data and produces the annual LTWG report in coordination with LTWG chair. LWAP data is currently submitted by contributors as part of the GLFC Sea Lamprey Wounding Database currently maintained by USFWS Green Bay. The reporting format and specific data to be reported is determined by the Lake Michigan Committee but has remained relatively constant over time.

LAKEWIDE ASSESSMENT SAMPLING DESIGN

The sections below describe the updated methodologies to be used in LWAP sampling with the following lists outlining the changes to original protocols that resulted from the LWAP Review.

Changes included in LWAP 2.0 sampling design:

- Inclusion of net sets in the <50' depth range if resources allow.
- Inclusion of use of monofilament nets to maximize catch of coregonids while maintaining similar lake trout catch rates.
- Optimally complete LWAP surveys by end of May if possible, as catches decline into June.
- Record catch by net box and panel if possible, for further data exploration.
- Record transect identifier to allow for analysis of spatial variation.
- Remove requirement for recording percent cloud cover, wave height, wind speed and direction, precipitation, and secchi disk reading. Agencies can keep records on these fields within their data structures if desired.
- Encourage the use of depth profiler instruments to collect information on temperature, turbidity, DO, etc. throughout the water column when nets are set.

Changes included in LWAP 2.0 Biological data collection:

- Addition of lake whitefish, cisco, and yellow perch to the list of Targeted Species for which all biological information is collected.
- Commitment to age all lake trout, and other target species if possible, utilizing collaborative efforts if needed.
- Remove requirement of necropsies for all fish, in favor of noting abnormalities. If new or substantial abnormalities are observed, communicate with the Fish Health group to determine need for additional testing or other recommendations.
- Rely on the newly formed Diet Team to provide guidance on stomach collections.
- Ensure that at minimum, counts of all species captured are included in data submissions.

Design of bottom set gill nets

Standard LWAP nets used to sample lake trout and burbot will be 2 m (6.5 ft) deep and will have 30-m (100-ft) panels of eight different mesh sizes (range = 64 -152 mm [2.5 - 6 in] stretched) arranged from smallest to largest (Table 1). Two such nets will be combined, creating a net totaling 488 m (1,600 ft); refer to 'replicative net design' section below. Floats will measure 127 mm (5 in) by 44 mm (1 ¾in) with a 10-mm (3/8-in) hole and will be either aluminum or plastic. Bottom lines will be either leadline (30-50 lb) or leads which can be either 76 mm (3 in) pipe leads with 10-mm (3/8-in) holes or 76 mm (3 in) by 19 mm (3/4 in) clamp on leads with a weight of 6.6 per kg (3 per lb). Bottom nets will not represent a navigational hazard, so nets will be left in the water for overnight.

Replicative Net Design

The original protocols outlined two-box sets in each depth range on each transect; apparently the rationale was based on low lake trout densities at the time and 1600' nets were deemed necessary to capture an adequate number of lake trout for biological measurements. However, lake trout densities have increased in recent years and there is now concern that catch from 2-box gangs is unnecessary. The review team considered alternative options employing 1-box gangs;

implementing this recommendation has been deferred until additional data can be evaluated on how this change may influence catch-per-effort and the associated age compositions. Agencies are requested to continue setting two-box gangs but record catches by box and panel (if possible) to allow for further analysis.

Table 1. Multi-filament (top) and monofilament (bottom) net specifications for lakewide assessment.

Multi-filament net specs

Mesh size (stretched)	38 mm	51 mm	64 mm	76 mm	89 mm	102 mm	114 mm	127 mm	140 mm	152 mm
	(1.5 in)	*(2.0 in)*	*(2.5 in)*	*(3.0 in)*	*(3.5 in)*	*(4.0 in)*	*(4.5 in)*	*(5.0 in)*	*(5.5 in)*	*(6.0 in)*
Thread size (nylon)	210/2	210/2	210/2	210/2	210/2	210/3	210/3	210/3	210/3	104
Phase size	190 mm	190 mm	190 mm	190 mm	222 mm	203 mm	229 mm	190 mm	210 mm	229 mm
	(7.5 in)	*(7.5 in)*	*(7.5 in)*	*(7.5 in)*	*(8.75 in)*	*(8.0 in)*	*(9.0 in)*	*(7.5 in)*	*(8.25 in)*	*(9.0 in)*
Ties between leads	11	11	11	11	10	11	9	11	10	9
No. of leads per net	14	14	12	12	12	12	13	12	13	13
No. of meshes per tie	10	8	6	5	5	4	4	3	3	3
No. of meshes deep	54	40	32	27	23	20	18	16	14	13

Monofilament net specs

Mesh size (stretched)	38 mm	51 mm	64 mm	76 mm	89 mm	102 mm	114 mm	127 mm	140 mm	152 mm
	(1.5 in)	*(2.0 in)*	*(2.5 in)*	*(3.0 in)*	*(3.5 in)*	*(4.0 in)*	*(4.5 in)*	*(5.0 in)*	*(5.5 in)*	*(6.0 in)*
Thread size (mono)	210/2	210/2	210/2	210/2	210/2	210/2	210/2	104	104	104
Phase size	190 mm	190 mm	190 mm	190 mm	222 mm	203 mm	229 mm	190 mm	210 mm	229 mm
	(7.5 in)	*(7.5 in)*	*(7.5 in)*	*(7.5 in)*	*(8.75 in)*	*(8.0 in)*	*(9.0 in)*	*(7.5 in)*	*(8.25 in)*	*(9.0 in)*
Ties between leads	11	11	11	11	10	11	9	11	10	9
No. of leads per net	14	14	14	14	14	14	14	14	14	14
No. of meshes per tie	10	8	6	5	5	4	4	3	3	3
No. of meshes deep	54	40	32	27	23	20	18	16	14	13

Sampling Design

Sampling will be conducted each year at a minimum of 11 selected sites (two refuge sites and nine port sites) around Lake Michigan. Six sets (each set using the 488 m (1600') of graded-mesh gill net described above) will be made each year at each site (8 sets if also sampling the <50' depth bin). Additional sets may be made if time allows. Although the 11 sites will remain the same for the foreseeable future, set locations at each site will be randomly selected each year to increase the statistical robustness of the sampling design (see below). Sampling will be performed during early spring when the water column is not stratified and bottom temperatures at fishing depths are greater than 4ºC (39ºF). Sampling will be different at refuge and port sites.

Port sites: At each of nine port sites, researchers will superimpose a base line that is roughly parallel to shore, has the port as its center, and measures 56 km (30 nautical miles) in length (see representation in Figure 2). Thirty-one potential sampling vectors will be spaced at 1.8 km (1 nautical mile) intervals perpendicular to the base line (Figure 2). Each year, two vectors will be selected at random, and sampling will be performed by setting gill nets cross-contour along the vector. Nets will be set in waters at each of three different depth ranges: 15-30 m (50-100 ft); 31-45 m (101-150 ft); and 46-60 m (151-200 ft). Researchers, captains, and crew will have discretion as to where to set nets within any given depth range along chosen vectors. Annual sampling along two vectors will amount to a total of six net sets, with two sets at each of the three different depth ranges. If the fourth depth range (<15m or 50') is able to be sampled, this will result in a total of 8 nets sets, 2 sets at each of the 4 ranges. Agencies are requested to stay within depth bins whenever possible and, when necessary to set 1-box gangs to achieve this (e.g. steep banks).

Refuge sites: Netting locations at the Southern or Midlake Refuge will be determined by superimposing a grid system that subdivides surrounding waters into 1 x 1minute cells (see representation in Figure 3). Each year, nets will be set within a minimum of six randomly chosen cells within the Midlake Refuge. Netting locations may also be selected according to lake levels, weather conditions, and any other criteria deemed relevant by researchers. To determine netting locations within the West Beaver Island, East Beaver Island, and Charlevoix reef complexes, the following protocol will be used. Each year, two sites within each of the abovenamed three reef complexes will be randomly chosen. At each of the selected sites, sampling at two fixed vector transects will be performed, with one gill net set in the 15-30 m depth range, one gill net set in the 31-45 m depth range, and one gill net set in the 46-60 m depth range at each transect. See Table 3 in Appendix 1 for a list of sites at each of the three reef complexes.

Manistique, Washington Island, Waukegan, and Michigan City are four port sites that present special problems because all depth ranges (especially the 46-60 m range) may not be attainable along all potential vectors, or if they do exist, these depth ranges may lie at such distances from port that sampling is considered impractical. Follow the steps below for these sites:

1) Randomly select two vectors as described above.
2) Set nets at all depth ranges represented along selected vectors.
3) If any of the three depth ranges is NOT represented along a vector, randomly select additional vectors until one is selected where the missing depth range is represented (unless site has no vectors where missing depth range is represented or where missing depth range is beyond practical distance from port).

4) Set net within the missing depth range along the new vector.
5) If necessary, repeat steps 3 and 4 for the second original vector selected in step 1.

Physical Data

For each set, record the collection number, transect number, date, vessel, and site (see Table 2). At both ends of the net record latitude-longitude coordinates as well as fishing depths. For both set and lift, record the time and temperature (top, mid, bottom, air). A depth profile is preferred but is not always possible.

Table 2. Routine sampling sites for lakewide assessment.

Site	Name
1	Manistique
2	Northern Refuge
3	Washington Is. (Green Bay)
4	Leland
5	Sturgeon Bay
6	Arcadia
7	Sheboygan
8	Midlake Refuge[a]
9	Saugatuck
10	Waukegan
11	Michigan City

[a] Currently, WI DNR samples Northeast Reef every year, and East Reef and Sheboygan Reef are sampled on an alternate year basis.

Biological Data

This section outlines methods for biological data collection, along with justifications of changes instituted in this new version of LWAP. Target species include lake trout, burbot, lake whitefish, cisco and yellow perch. Biological data will be obtained from fish as follows (see also Table 3):

- Target Species:
    - Obtain individual lengths (mm) and weights (g), and determine sex and maturity (immature, mature, unknown) if possible.
    - Collect age structures from all target species as indicated in Age Structure table below (Table 4). Record all tags, fin clips or marks and freeze heads of coded wire tagged (CWT) fish. AD clipped should be wanded to determine presence of CWT and if none is indicated, it should be noted in the CWT data field (ND for not detected, etc). Unclipped fish should also be wanded in the case that a fin clip was not applied.

- Non-Target Species: At a minimum, obtain counts, group weights (nearest 50 g), and length ranges (mm) for all non-target fish species. If possible, individual length information along with counts is preferrable

- Lamprey wounding (according to King & Edsall 1979, Ebener et al. 2006) should be recorded for all species thought to be susceptible to lamprey attack.

- Stomachs and other tissues will be collected based on the needs of individual studies that will be communicated and discussed within the Lake Trout Working Group.

Accurate aging of sampled fish is the keystone for achieving the primary and secondary objectives in this assessment plan. But in the LWAP time series, fish age data are incomplete. In some cases, fish age was only reported from coded wire tagged (CWT) lake trout whereas age estimates derived from annuli counts of calcified structures have not been determined for many hatchery origin lake trout marked with a rotational fin-clip nor for fish of wild origin. The updated LWAP protocol now emphasizes agencies to report age estimates for all species of interest (lake trout, burbot, lake whitefish, cisco, and yellow perch). Species and size-class specific age estimation methods may vary by agency; recommended aging structures for lake trout include otoliths or maxillary bones (lake trout), and use of fin-rays or scales should only be used for short lived species.

Analysis of diet data for predators was fairly limited early in the LWAP, with most studies focused on a specific area of the lake. Since 2017, many partners have been contributing predator stomachs to an ongoing study by the Roth lab at Michigan State University looking at predator diets in Lakes Michigan and Huron which also incorporates stomachs from anglers. There also have been several studies that examined diets using stable isotopes and other methods. For this reason, the LRT has decided to remove the guidance on diet sampling in favor of supplying samples to targeted studies, with collection requests for diet samples being shared with all contributors prior to the sample collection time.

The LRT decided to omit necropsies, estimates of percent mesenteric fat, and carotene color

although agencies will continue to note abnormalities or lesions on fish bodies, skin, gills, eyes, abdominal cavities, hearts, digestive tracts, spleens, livers, kidneys, and gonads. If persistent issues arise, they will be brought to the attention of the LTWG who will initiate contact with the Fish Health group to determine a course of action. If samples are desired by an outside group to address fish health issues, contributors will be asked to collect samples if possible. Agencies are free to collect any additional health and condition data that they are desire.

Additionally, during the time since the LWAP has been in use, monitoring of fish health parameters has not been widely practiced, mainly due to time and resource limitations. The LRT agreed to remove the requirement of fish health evaluations (though keeping notes of abnormalities) in favor of increased communication among LWAP contributors and a commitment to reaching out to the Fish Health group if new or substantial issues arise.

Table 3. Summary of general biological data to be collected from fish caught in LWAP nets.

	Species			
Parameter	Lake Trout	Burbot	Other Target Species	All other species
Count				All
Group Weight				All
Length Range				All
Length (mm)	All	All	All	If possible
Weight (g)	All	All	All	
Sex	All	All	All	
Maturity	All	All	All	
Age Structures	See Table 4	See Table 4	See Table 4	
Clip/CWT	All		*If present*	*If present*
Lamprey Wounds	All	All	All	If susceptible
Stomachs	As needed	As needed	As needed	As needed

Table 4. Age structure hierarchy for each species, some agencies utilize variety of structures based on fish size.

Species	**Aging Structure Hierarchy**		
Lake Trout	CWT	Otolith/Maxillae*	
Burbot	Otolith		
Lake Whitefish	Otolith	Scales	
Cisco	Otolith	Scales	
Yellow Perch	Otolith	Ray/Spines	Opercles

*Paired with rotational fin clip information when available.

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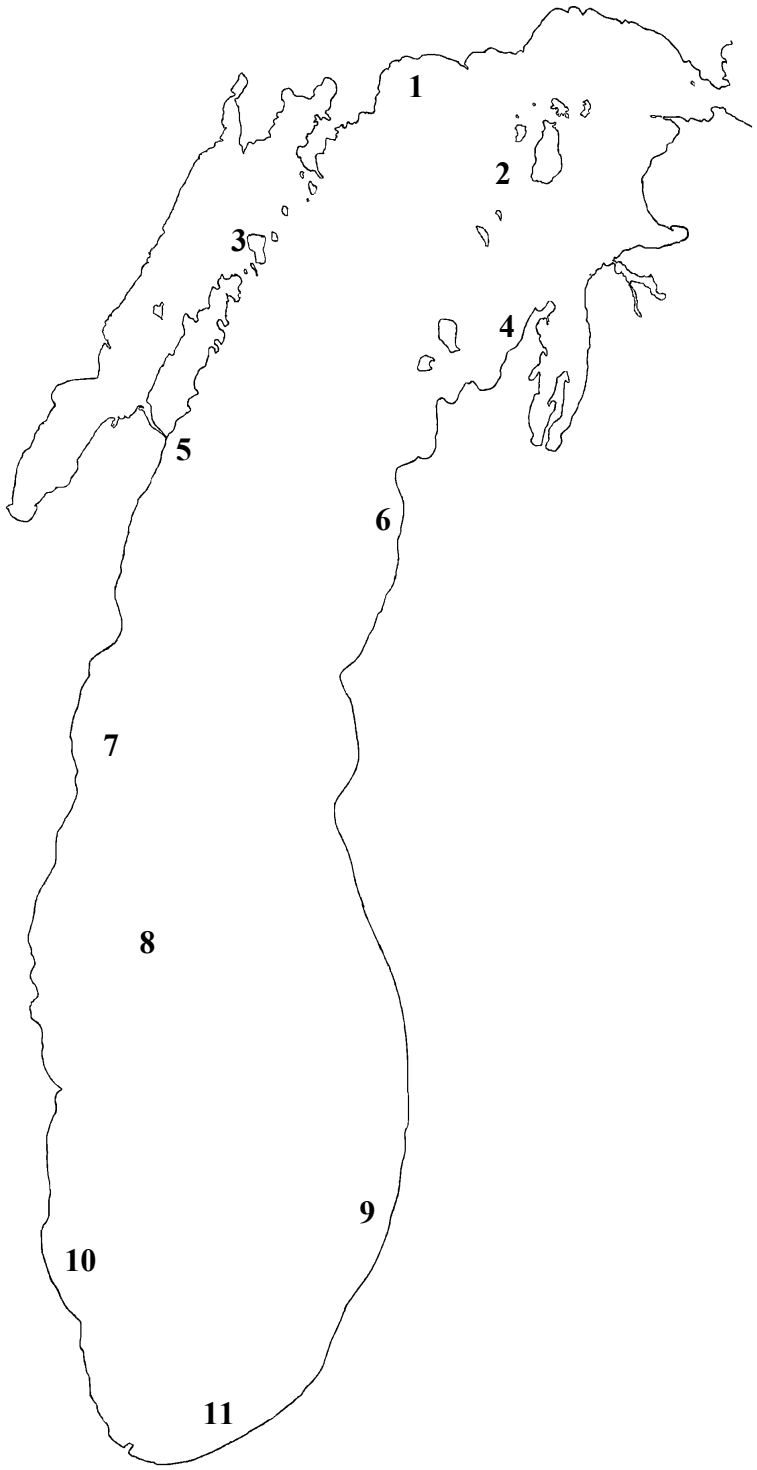

Figure 1. Approximate locations of 11 sampling sites for lakewide assessment in Lake Michigan.

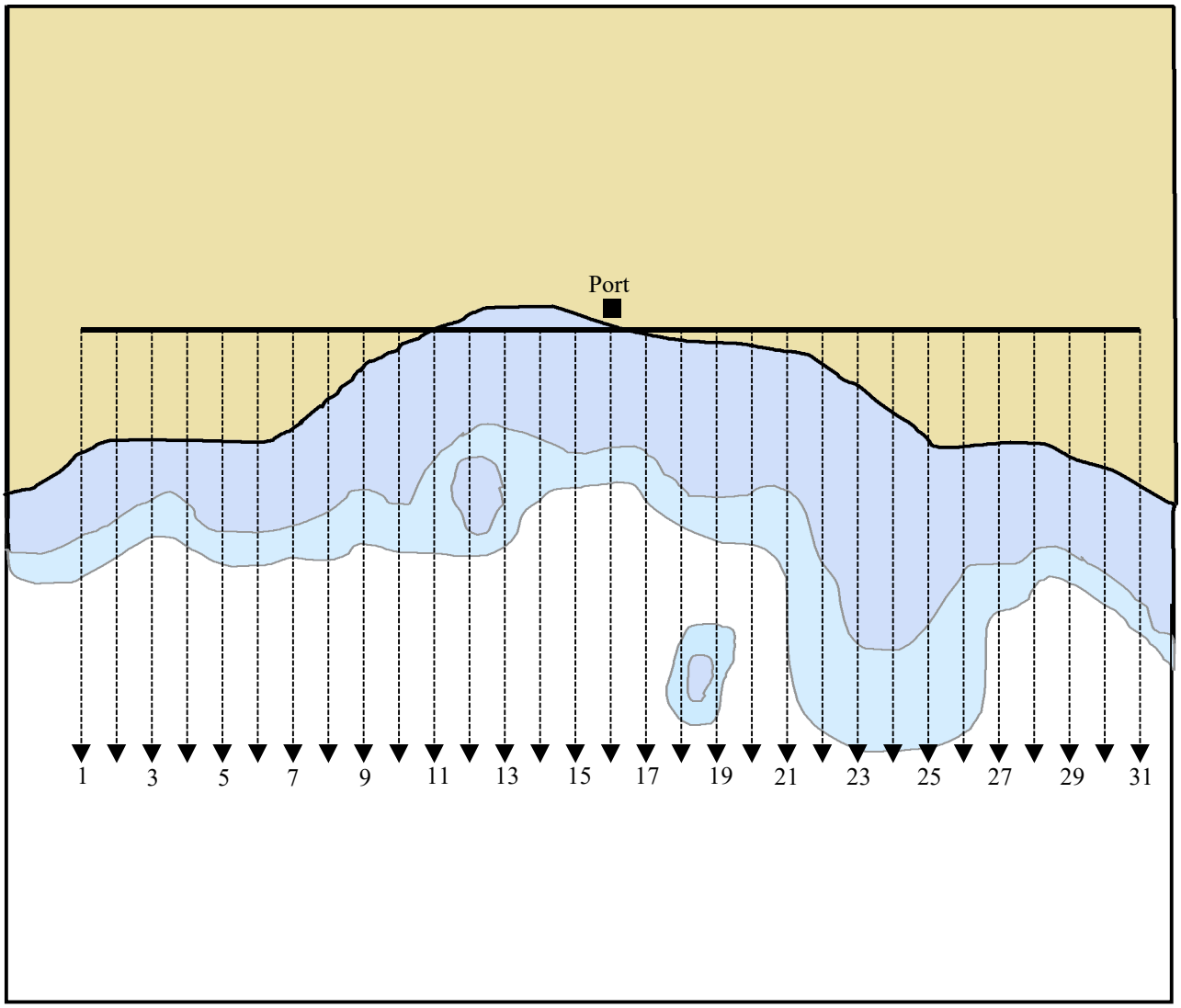

Figure 2. Generalized illustration of 31 possible sampling vectors originating from a base line drawn through a stylized port location. The thick black line runs roughly parallel to the shoreline with the port at its center. Vectors are 1.8 km apart and run perpendicular to the base line. Each year, sampling nets will be set within three depth ranges (15-30 m; 31-45 m; and 46-60 m) along two randomly selected vectors.

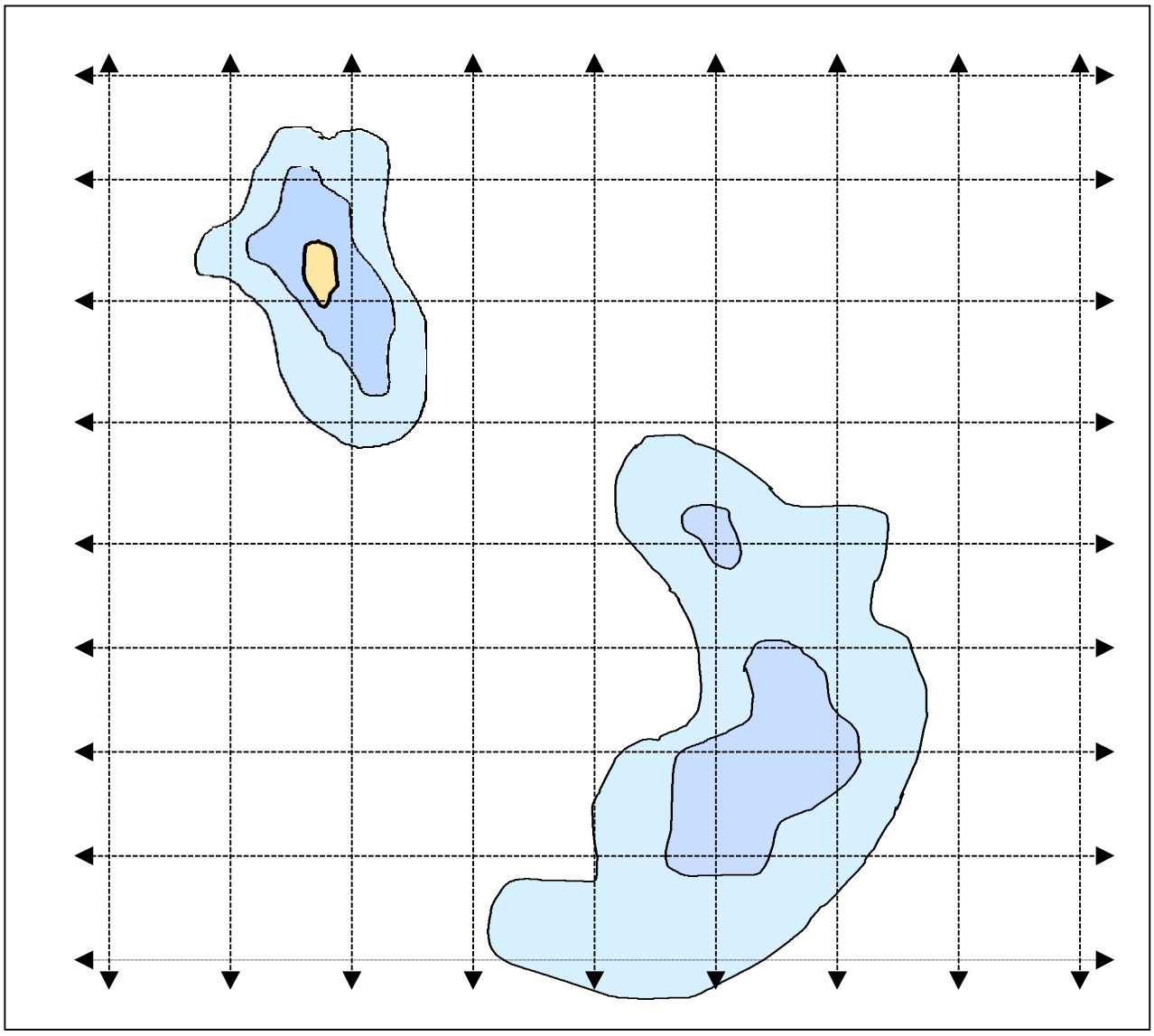

Figure 3. Generalized illustration of a refuge site with a grid superimposed over the area creating 1 x 1 minute cells. Refuge site sampling nets will be set within six randomly selected cells each year.

Appendix 1

2019 Summary of current Lakewide assessment practices for lake trout and burbot

A review of agency protocols for the lake trout and burbot portion of the Lakewide Assessment Plan for Lake Michigan Fish Communities (Schneeberger et al. 1998) was conducted in February 2019. Following the structure of Appendix 1in the 1998 LWAP, this addendum affirms that agencies are adhering to the original protocols or notes where deviations occur.

Design of bottom nets

Changes to net design and materials have occurred since 1998. Some agencies now utilize additional mesh sizes to expand sampling effort for other species or life stages (Table 1). In addition, there has been a transition to monofilament netting by some agencies over time. Paired studies of monofilament and multifilament nylon have found no difference in catches of lake trout between the 2 gears; lake whitefish catches were three times higher in monofilament (Smith et al. 2022). Table 2 includes gill net design characteristics to ensure at least some degree of uniformity for monofilament gill net construction during the transition.

Table 1. Mesh sizes, order, net material, and net components.

Agency	Mesh sizes	Mesh Order	Net material	Floats and leads
US Fish and Wildlife Service	2.5” to 6” (0.5” incr.)	smallest to largest	multifilament nylon	plastic floats and leads
Illinois DNR	2.5” to 6” (0.5” incr.)	smallest to largest	multifilament nylon	plastic floats and leads
Grand Traverse Band	2.0” to 6” (0.5” incr.)	fixed randomized order (3.0", 4.0", 2.5", 3.5", 2.0", 5.0", 6.0", 4.5", 5.5")	multifilament nylon and monofilament	plastic floats and lead line
Little River Band Odawa Indians	2.0” to 6” (0.5” incr.)	smallest to largest	multifilament nylon	plastic floats and lead line
Indiana DNR	1.5” to 6” (0.5” incr.)	smallest to largest	multifilament nylon	plastic floats and leads
Michigan DNR	1.5” to 6” (0.5” incr.)	smallest to largest	monofilament	plastic floats and leads / lead line
Wisconsin DNR	2.5” to 6” (0.5” incr.)	fixed randomized order	multifilament nylon	plastic floats and lead line
Little Traverse Bay Band	2.0” to 6” (0.5” incr.)	smallest to largest	monofilament	plastic floats and lead line
US Geological Survey	2.5” to 6” (0.5” incr.)	smallest to largest	multifilament nylon	plastic floats and leads

Table 2. Monofilament net specifications for lakewide assessment of lake trout and burbot.

Mesh size (stretched measure)	38 mm (1.5 in)	51 mm (2.0 in)	64 mm (2.5 in)	76 mm (3.0 in)	89 mm (3.5 in)
Thread size	210/2	210/2	210/2	210/2	210/2
Phase size	190 mm (7.5 in)	190 mm (7.5 in)	190 mm (7.5 in)	190 mm (7.5 in)	222 mm (8.75 in)
Ties between leads	11	11	11	11	10
No. of leads per net	14	14	14	14	14
No. of meshes per tie	10	8	6	5	5
No. of meshes deep	54	40	32	27	23

Mesh size (stretched measure)	102 mm (4.0 in)	114 mm (4.5 in)	127 mm (5.0 in)	140 mm (5.5 in)	152 mm (6.0 in)
Thread size	210/2	210/2	104	104	104
Phase size	203 mm (8.0 in)	229 mm (9.0 in)	190 mm (7.5 in)	210 mm (8.25 in)	229 mm (9.0 in)
Ties between leads	11	9	11	10	9
No. of leads per net	14	14	14	14	14
No. of meshes per tie	4	4	3	3	3
No. of meshes deep	20	18	16	14	13

Proposed Sampling Design

Eleven sampling sites were included in the 1998 protocol; sampling occurred at two refuges and nine ports. Sampling has been expanded to include additional sites and sampling at the Midlake Refuge was changed from Sheboygan Reef and Northeast Reef to East Reef and Northeast Reef (Table 3).

Table 3. Sampling sites for lakewide assessment of lake trout and burbot.

Site Name	Original Sampling Site	Statistical District	Agency
Sheboygan	Y	WM5	US Fish and Wildlife Service
Sturgeon Bay	Y	WM3	US Fish and Wildlife Service
Washington Island	Y	MM1, MM2, WM2, WM3	US Fish and Wildlife Service
Waukegan	Y	ILL	Illinois DNR
Ingalls Point		MM4	Grand Traverse Band
Lee Point		MM4	Grand Traverse Band
Old Mission		MM4	Grand Traverse Band
East Bay Reef		MM4	Grand Traverse Band
Muskegon		MM7	Little River Band Ottawa Indians
Ludington		MM6	Little River Band Ottawa Indians
Manistee		MM6	Little River Band Ottawa Indians
Michigan City	Y	MM8, IND	Indiana DNR
St. Joseph		MM8	Michigan DNR
South Haven		MM8	Michigan DNR
Saugatuck	Y	MM8	Michigan DNR
Grand Haven		MM7	Michigan DNR
Arcadia	Y	MM5	Michigan DNR
Leland	Y	MM5	Michigan DNR
Elk Rapids		MM4	Michigan DNR
Charlevoix		MM3	Michigan DNR
Midlake Refuge		WM5	Wisconsin DNR
Northeast Reef			
East Reef	Y		
Little Traverse Bay		MM3	Little Traverse Bay Band
Manistique	Y	MM2	US Geological Survey/USFWS
West Beaver Island	Y	MM3	US Geological Survey
Boulder Reef			
Gull Island Reef			
Trout Island Shoal			
High Island			
North Fox Island			
South Fox Island			
East Beaver Island		MM3	US Geological Survey
Hog Island Reef			
Ile aux Gilets			
Dahlia Shoal			
Charlevoix Group		MM3	US Geological Survey
Irishman's Ground			
Fisherman's Reef			
Big Reef			
Middle Ground			

Reef sites:
Sampling continues to differ between refuge and port sites. The random cell method is utilized at Northeast Reef and East Reef in the Midlake Refuge (Table 4). Netting locations at the Midlake refuge sites are determined by superimposing a grid system that subdivides surrounding waters into 1 x 1minute cells. The range in depth strata is great enough within these cells that vectors containing the three depth strata are often employed. Thus, only two cells are typically sampled at each reef in alternate years which is a deviation from the original protocol which called for sampling of 6 cells (one net per cell). Sampling for the West Beaver Island East Beaver Island and Charlevoix reef complexes is now conducted by setting nets along vectors which contain the depth strata and overlap with past and current stocking locations.

Table 4. Methodology and depth strata for refuge sites

Site Name	Method	Nets Total	Depth Strata	Sampling Date Range
Midlake Refuge	random cell	6 total at each reef each year	50-100, 101-150, 151-200	early to mid-May
Northeast Reef				
East Reef				
West Beaver Island	fixed vector	6 each at 2 randomly chosen sites	50-100, 101-150, 151-200	early-May to mid-May
Boulder Reef				
Gull Island Reef				
Trout Island Shoal				
High Island				
North Fox Island				
South Fox Island				

Port sites:
Most agencies continue to follow the original protocol for port sites. Several additional port sites are now sampled as part of the annual assessment (Table 3). At each port site, vectors spaced at 1.8 km (1-nautical mile) intervals, perpendicular to shore, are sampled. Two vectors are chosen at random, with the exception of Illinois where two pairs of fixed vectors are sampled in alternate years (Table 5). The three original depth strata are sampled at all sites where bottom depth permits. Some agencies have added a shallow depth strata (<15m) that was not included in the original protocol and three vectors are sampled in Little Traverse Bay.

Table 5. Methodology and depth strata for port sites and for East Beaver Island and Charlevoix Group reef complexes.

Site Name	Method	Number of Transects	Nets Set Cross-contour	Depth Strata	Sampling Date Range
Sheboygan	random vector	2	yes	50-100, 101-150, 151-200	mid-April to mid-June
Sturgeon Bay	random vector	2	yes	50-100, 101-150, 151-200	mid-April to mid-June
Washington Island	random vector	2	yes	50-100, 101-150, 151-200	mid-April to mid-June
Manistique	random vector	2	yes	50-100, 101-150, 151-200	mid-April to mid-June
Waukegan	4 fixed vectors	2	weather dependent	50-100, 101-150, 151-200	3rd week in May
Ingalls Point	random vector	2	yes	0-50, 50-100, 101-150, 151-200	mid-May to end of June
Lee Point	random vector	2	yes	0-50, 50-100, 101-150, 151-200	mid-May to end of June
Old Mission	random vector	2	yes	0-50, 50-100, 101-150, 151-200	mid-May to end of June
East Bay Reef	random vector	2	yes	0-50, 50-100, 101-150, 151-200	mid-May to end of June
Muskegon	random vector	2	yes	50-100, 101-150, 151-200	mid-April to end of June
Ludington	random vector	2	yes	50-100, 101-150, 151-200	mid-April to end of June
Manistee	random vector	2	yes	50-100, 101-150, 151-200	mid-April to end of June
Michigan City	random vector	2	no	0-50, 50-100, 101-150, >150	mid-April to end of May
St. Joseph	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
South Haven	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Saugatuck	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Grand Haven	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Arcadia	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Leland	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Elk Rapids	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Charlevoix	random vector	2	yes	30-50, 50-100, 100-150, >150	mid-April to end of June
Little Traverse Bay	random vector	3	yes	50-100, 101-150, 151-200	May - June
East Beaver Island Hog Island Reef Ile aux Gilets Dahlia Shoal	fixed vector	2 @ 2 sites	yes	50-100, 101-150, 151-200 (only at Dahlia Shoal)	early-May to mid-May
Charlevoix Group Irishman's Ground Fisherman's Island Big Reef Middle Ground	fixed vector	2 @ 2 sites	yes	50-100, 101-150, 151-200	early-May to mid-May

Physical data

Procedures for collection of physical and meteorological information in association with net set and retrieval were outlined in the original protocol (Table 6). There is wide disparity in collection of this information among the participants. A possible reason may be that this information is rarely utilized in analyses and often only serves as a reference that net deployment procedures are being followed correctly.

Table 6. Physical data collected in association with sample collection.

Agency	Moon Phase	Depths at both ends of net	Water Temperature	Air Temperature	Percent Cloud Cover	Wave Height	Wind Speed	Wind Direction	Precipitation	Secchi reading	Depth Profiler
US Fish and Wildlife Service	N	Y	Y	Y	N	Y	Y	Y	N	N	Y
Illinois DNR	N	Y	lift only	Y	Y	Y	Y	Y	Y	lift only	N
Grand Traverse Band	N	Y	Y	N	N	N	N	N	N	N	Y
Little River Band Ottawa Indians	N	Y	Y	Y	N	N	Y	N	N	N	N
Indiana DNR	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Michigan DNR	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Wisconsin DNR	N	Y	Y	Y	N	Y	Y	Y	N	N	N
Little Traverse Bay Band	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
US Geological Survey	N	Y	Y	N	Y	Y	Y	Y	Y	N	Y

Biological data

General

Biological data collection from non-target fish constituted counts, group weights (nearest 50 g), and length ranges (mm) in the original protocol. Most agencies have begun measuring all individuals collected in sampling efforts (Table 7). Agencies have also transitioned to otoliths as the primary structure collected for age estimation. There is mixed adherence to the collection of stomachs for diet analyses, primarily based on the agency's ability to process the stomachs in a laboratory setting.

Table 7. General biological data collection.

Agency	Count, Group Weight, and Length Range for Non-target Fish	Individual Lengths and Weights for Non-target Fish	Individual Lengths and Weights for all Lake Trout, Burbot, and Chinook	Age Estimation Structures Collected	Tags or Marks Recorded; CWT Heads Collected	Lamprey Wounds/Scars Recorded	Species for which Stomachs from 10 fish/day are collected [1]
US Fish and Wildlife Service	N	Y	Y	otoliths (LAT, BUT, LWF & other spp of interest)	Y	Y	LAT, BUT, LAW
Illinois DNR	Y	N	Y	otoliths (LAT)	Y	Y	none
Grand Traverse Band	N	Y	Y	maxillae (LAT); otoliths (all others)	Y	Y	first 10 of all species, except rough fish
Little River Band Ottawa Indians	N	Y	Y	otoliths, maxilla, spines, scales	Y	Y	none
Indiana DNR	N	Y	Y	otoliths (all species)	Y	Y	on occasion
Michigan DNR	N	Y	Y	otoliths (LHR, BUT, Lg LWF); maxilla (LAT); spines (YEP, Sm LWF, bass, others)	Y	Y	LAT, BUT, LAW
Wisconsin DNR	N	Y	Y	otoliths (all species)	Y	Y	LAT
Little Traverse Bay Band	N	Y	Y	Scales on all, OTO (BUT, LAH, LWF>490), Maxilla NC LAT, Fin rays (WAE, YEP, Suckers)	Y	Y	YEP, LAW, LAH, LAT, BUT, Salmons, ROW, WAE, dead fish, suckers (subsample)
US Geological Survey	N	Y	Y	maxilla (unclipped LAT)	Y	Y	on occasion

[1] BUT = Burbot; LAH = lake herring; LAT = lake trout; LAW = lake whitefish; ROW = round whitefish; WAE = Walleye; YEP = yellow perch

Fish health

The original protocol included necropsies for all fish brought to shore as follows: all lake trout, burbot and Chinook salmon will be examined for abnormalities or lesions on their bodies, skin, gills, eyes, abdominal cavities, hearts, digestive tracts, spleens, livers, kidneys, and gonads. No evaluation of carotenes in the flesh has conducted by any of the participants.

Table 8. Fish health data collection.

Agency	Necropsy performed on all lake trout, burbot, and Chinook brought to shore	Percent mesenteric fat estimate	Carotene color estimate
US Fish and Wildlife Service	No, but gross abnormalities noted	N	N
Illinois DNR	No, but gross abnormalities noted	rated as high, medium, or low	N
Grand Traverse Band	No, but gross abnormalities noted	Y	N
Little River Band Ottawa Indians	No, but gross abnormalities noted	N	N
Indiana DNR	No, but gross abnormalities noted	Y	N
Michigan DNR	No, but gross abnormalities noted	Y	N
Wisconsin DNR	Y (all lake trout)	N	N
Little Traverse Bay Band	No, but gross abnormalities noted	Y (lake whitefish only)	N
US Geological Survey	No, but gross abnormalities noted	N	N

Sampling strategy topics not covered by the 1998 sampling plan

Although not in the original protocol, most agencies record catch by mesh size. To date, there has not been an effort to collectively analyze catch data by mesh size. Also, polling of the participants revealed that all attempt to net fish at the side of the boat that have fallen out of the net. How and if these fish are noted in data varies across agencies, often in the comments.