DEPARTMENT OF NATURAL RESOURCES

Fisheries Management

LAKE SURVEY REPORT

DRAFT VERSION

PRELIMINARY DATA (AS OF 04/15/2021)

Lake Name: Vermilion

Survey Type: Large Lake Survey

DOW Number: 69-0378-00

Survey ID Date: 06/03/2020

Lake Identification

Alternate Lake Name:	N/A	DNR Sounding Map Number:	B0272
Primary Lake Class ID:	2	Alternate Lake Class ID:	N/A

Lake Location

Primary County:	St. Louis	Nearest Town:	Tower

Legal Descriptions

Lake Center:	Township - 62N	Range - 16W	Section - 7
PLS Section Lake Center:	6201607		

All Legal Descriptions:

St. Louis County:	Township - 61N	Range - 15W	Section - 6
	Township - 61N	Range - 16W	Sections - 1, 2, 3
	Township - 62N	Range - 14W	Sections - 6, 7, 18
	Township - 62N	Range - 15W	(Twenty-Eight various sections)
	Township - 62N	Range - 16W	(Twenty-Eight various sections)
	Township - 62N	Range - 17W	Sections - 1, 2, 3, 10, 11, 12
	Township - 63N	Range - 15W	Sections - 30, 31, 32, 33, 34, 35
	Township - 63N	Range - 16W	(Fifteen various sections)
	Township - 63N	Range - 17W	(Twenty-Five various sections)
	Township - 63N	Range - 18W	(Twenty-Three various sections)

Area Office

Area Name:	Tower	ORG Code:	F214
Region Name:	Northeast	Region Number:	2

Lake Access

(Information based on Large Lake Survey dated 04/17/2017)

Station ID	Ownership	Public Use	Type	Location / Comments
AC - 2	City	Open to Public use	Concrete	Located 1 mile northwest of Tower on St. Louis Co. 697 on the south side of Hoodoo Pt. Administered by the city of Tower.
AC - 3	City	Open to Public use	Concrete	Located 1 mile northwest of Tower on St. Louis Co. 697 on the north side of Hoodoo Pt. Double ramp. Administered by the city of Tower.
AC - 4	Township	Fee/Permit needed	Concrete	Located 2 miles north of Tower on on St. Louis Co. 697 on the south shore of McKinley Bay at McKinley Park Campground. Administered by Breitung Township.
AC - 5	DNR	Fee/Permit needed	Concrete	Located 0.75 miles north of Soudan on Twp. Rd. 4598 in Lake Vermilion - Soudan Underground Mine State Park on the south shore of Stuntz Bay. Double ramp. Limited parking. Fees required by the Stuntz Bay Boathouse Association.
AC - 6	US Forest Service	Open to Public use	Concrete	Located 7 miles northeast of Tower on St. Louis Co. 408 on the north shore of Rice Bay. Administered by DNR Parks and Trails.
AC - 7	DNR	Open to Public use	Concrete	Located 4 miles northwest of Tower at the end of St. Louis Co. 414 on the north shore of Everett Bay.
AC - 8	DNR	Open to Public use	Concrete	Located 6 miles northwest of Tower at the end of St. Louis Co. 651 on the north side of Birch Pt. Limited parking.
AC - 9	DNR	Open to Public use	Concrete	Located 7.5 miles northwest of Tower at the end of St. Louis Co. 929/77 at Moccasin Pt. Double ramp. Large concrete platform. Used by barges and contractors.
AC - 10	DNR	Open to Public use	Concrete	Located 8 miles northwest of Tower on St. Louis Co. 949 on the south shore of Black Duck Bay next to Shamrock Landing Marina. Double ramp.
AC - 11	DNR	Open to Public use	Concrete	Located 10 miles northwest of Tower on St. Louis Co. 418 on the south shore of Frazer Bay. Double ramp.
AC - 12	DNR	Open to Public use	Concrete	Located 11 miles northeast of Cook at the end of St. Louis Co. 540 on the west shore of Oak Narrows next to Timbuktu Marina. Double ramp.
AC - 13	DNR	Open to Public use	Concrete	Located 7 miles northeast of Cook at the end of Polley Rd. off St. Louis Co. 540 on the south shore of Wakemup Narrows. Limited parking.

Lake Access (*Continued*)

Station ID	Ownership	Public Use	Type	Location / Comments
AC - 14	DNR	Open to Public use	Concrete	Located 6 miles northeast of Cook off of Center Island Rd off of St. Louis Co. 478 on the southeast shore of Wakemup Bay. Near Wakemup Bay Campground and Day-Use Area. Double ramp.
AC - 15	DNR	Open to Public use	Concrete	Located 10 miles northeast of Cook at the end of St. Louis Co. 595 on the north shore of Norwegian Bay. Limited parking.
AC - 16	DNR	Open to Public use	Concrete	Located 7 miles north of Cook on St. Louis Co. 24 on the west shore of Head of the Lakes Bay.
AC - 17	DNR	Fee/Permit needed	Concrete	Located 2.5 miles northeast of Soudan off of Vermilion Ridge Rd within Lake Vermilion - Soudan Underground Mine State Park on the south shore of Cable Bay. Double ramp.

Lake Characteristics

Lake Area (planimetered acres):	40,557.00	GIS Shoreline Length (miles):	341.49
GIS Lake Area (acres):	39,272.41	Maximum Fetch (miles):	8.40
DOW Lake Area (acres):	49,110.00	Fetch Orientation (degrees):	315
Littoral Area (acres):	15,006.00	USGS Quad Map Number:	G20b
Area in MN (acres):	39,272.41	USGS Quad 24K GIS Index:	1239
Maximum Depth (feet):	76.0		
Mean Depth (feet):	N/A		

Watershed Characteristics

Major Watershed

Name: Vermilion River
Watershed Number: 73
Watershed size (acres): 661,296

Minor Watershed

Name: Vermilion L
Watershed Number: 50
Watershed size (acres): 95,109

Surveys and Investigations

Population Assessment: 05/04/2005, 06/08/2004, 06/10/2003, 05/11/2002, 05/05/2001, 07/03/2000, 06/14/1999, 06/22/1998, 06/16/1997, 06/17/1996, 06/21/1995, 06/20/1994, 09/29/1993, 09/04/1992, 09/06/1991, 09/06/1990, 09/14/1989, 09/09/1988, 09/04/1987, 09/05/1986, 09/06/1985, 09/14/1984, 08/29/1983, 07/09/1982, 08/26/1981, 08/27/1979, 08/22/1977, 09/03/1975, 09/13/1973, 08/30/1971, 08/05/1968, 07/23/1953.

Special Assessment: 09/12/2014, 09/12/2013, 09/17/2012, 09/15/2011, 09/14/2010.

Large Lake Survey: 06/03/2020, 07/08/2019, 06/12/2018, 04/17/2017, 06/07/2016, 06/10/2015, 06/10/2014, 06/10/2013, 04/23/2012, 05/09/2011, 06/01/2010, 06/03/2009, 06/09/2008, 06/11/2007, 04/26/2006.

Targeted Survey: 09/15/2020, 09/12/2019, 05/08/2019, 09/11/2018, 09/12/2017, 10/06/2016, 09/13/2016.

Fish Diseases and Parasites

Species Examined	Number of Fish Examined			Examination Results	
	Internally	Externally	In Lab	Condition Observed	Number of Fish
largemouth bass	3	-	-	Tapeworm	2
				Neascus (Black Spot)	2
				Yellow grub	1
smallmouth bass	181	-	-	None observed	40
				Tapeworm	132
				Neascus (Black Spot)	32
				Yellow grub	2
				Physical Injury	1
walleye	422	-	-	None observed	19
				Lymphocystis	1
yellow perch	204	-	-	Yellow grub	1

Notes: Fish were collected for Viral Hemorrhagic Septicemia (VHS) analysis on 05/27/2020. Sampling occurred in Greenwood Bay via boat electrofishing and samples were shipped the same day to the MN DNR Fish Pathology Lab for analysis. Water temperatures ranged from 62 to 65.5 F during sampling. A total of 154 fish were collected in roughly 60 minutes of electrofishing on-time. Following VHS sampling protocols, the kidneys and spleens from 70 bluegills (70-150 mm), 19 yellow perch (103-178 mm), and 6 pumpkinseeds (90-130 mm) were removed for analysis. Additionally, 59 small yellow perch (50-90 mm) were submitted as whole samples. It took approximately 2 hours to process the fish in the Tower Lab prior to shipment. In the future, quarter-inch-mesh trap nets may be more efficient for VHS collections. Ultimately, VHS was not detected in the sample. The Pike River Hatchery was not operated in 2020 due to the COVID-19 pandemic, therefore VHS samples from female walleyes were not taken.

Bass captured during spring electrofishing were closely examined for diseases and parasites during the collection of biological information in the lab. Of the 181 smallmouth bass captured, 132 (73%) had some level of bass tapeworm infestation. This is often identified by a proliferation of connective tissue in the abdomen resulting in an indistinguishable tangle of organs and tissue. Other parasites observed in smallmouth bass included Neascus (18%) and yellow grub (1%). Only 40 fish (22%) had no observable parasites or disease and these generally tended to be smaller fish. Two largemouth bass collected during spring electrofishing were also examined and they both had bass tapeworm and Neascus. One also had yellow grub. Due to time constraints with increased sample collection, very limited examination for disease and parasites occurred for all species captured during gill netting.

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Dissolved Oxygen and Temperature Profile of Lake Water

Station ID	Sampling Date	Bottom Depth (Feet)	Sample Depth (Feet)	Water Temperature (°F)	Dissolved Oxygen (ppm)
WQ - 1	08/03/2020	72.2	Surface	71.8	8.4
			3.3	71.8	8.3
			6.6	71.8	8.3
			9.8	72.0	8.2
			13.1	72.0	8.1
			16.4	72.0	8.1
			19.7	72.0	8.1
			23.0	72.0	8.1
			26.2	72.0	8.1
			29.5	72.0	8.0
			32.8	72.0	8.0
			36.1	72.0	8.0
			39.4	72.0	8.0
			42.7	71.2	3.8
			45.9	70.9	2.9
			49.2	70.5	2.5
			52.5	69.8	1.8
			55.8	65.8	0.0
			59.1	62.6	0.0
			62.3	61.2	0.0
			65.6	60.6	0.0
			68.9	60.3	0.0
WQ - 2	08/03/2020	20.3	Surface	73.0	8.1
			3.3	73.2	8.1
			6.6	73.2	8.1
			9.8	73.2	8.0
			13.1	73.2	7.9
			16.4	73.2	7.8
			19.7	73.2	7.3
WQ - 3	08/03/2020	40.4	Surface	72.5	9.2
			3.3	72.3	9.1
			6.6	72.3	9.1
			9.8	72.3	9.0
			13.1	72.1	8.8
			16.4	72.1	8.5
			19.7	72.0	8.4
			23.0	71.8	8.3
			26.2	71.6	6.9
			29.5	68.7	1.9
			32.8	67.1	0.1
			36.1	66.6	0.0
			39.4	66.2	0.0
WQ - 4	08/03/2020	35.1	Surface	73.6	9.5
			3.3	73.0	9.3
			6.6	72.7	8.9
			9.8	72.7	8.8
			13.1	72.7	8.7
			16.4	72.7	8.6
			19.7	72.7	8.6
			23.0	72.5	8.5
			26.2	72.5	8.4
			29.5	69.6	1.8
			32.8	66.4	0.0

Dissolved Oxygen and Temperature Profile of Lake Water (*Continued*)

Station ID	Sampling Date	Bottom Depth (Feet)	Sample Depth (Feet)	Water Temperature (°F)	Dissolved Oxygen (ppm)
~~WQ - 4~~					
WQ - 5	08/03/2020	47.2	Surface	73.2	9.3
			3.3	73.0	9.3
			6.6	72.7	9.3
			9.8	72.3	8.8
			13.1	72.1	8.6
			16.4	72.1	8.6
			19.7	72.1	8.6
			23.0	72.1	8.6
			26.2	71.4	5.9
			29.5	70.0	3.6
			32.8	67.1	0.0
			36.1	66.6	0.0
			39.4	65.7	0.0
			42.7	64.8	0.0
			45.9	64.0	0.0

Field Measurements of Water Quality

Station ID	Sampling Date	Sample Depth (Feet)	Secchi Depth (Feet)	Field pH	Alkalinity (ppm)	Water Color	Color Cause
WQ - 1	08/03/2020	1.5	7.0	N\A	N/A	Brown Grn	Bog-stain
WQ - 2	08/03/2020	1.5	6.0	N\A	N/A	Brown Grn	Bog-stain
WQ - 3	08/03/2020	1.5	7.0	N\A	N/A	Brown Grn	Bog-stain
WQ - 4	08/03/2020	1.5	6.0	N\A	N/A	Green	Algae
WQ - 5	08/03/2020	1.5	5.0	N\A	N/A	Green	Algae

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Laboratory Analysis of Water Chemistry

Station ID	Sampling Date	Analysis Date	Sample Depth (ft)	Chemical Parameter	Chemical Value
WQ - 1	08/03/2020	08/06/2020	1.5	Sulphate ion	12.1 ppm
				Total phosphorus	0.023 ppm
				Total alkalinity	43 ppm
				Total dissolved solids	100 ppm
				Chlorophyll-a trichromatic method calculation	11.7 ppb
				Conductivity	140 :S/cm
				pH	7.45 pH
				Chlorophyll-a corrected for pheophytin	9.85 ppb
				Calcium	11.60 ppm
				Magnesium	5.68 ppm
WQ - 2	08/03/2020	08/06/2020	1.5	Sulphate ion	7.9 ppm
				Total phosphorus	0.020 ppm
				Total alkalinity	35 ppm
				Total dissolved solids	82 ppm
				Chlorophyll-a trichromatic method calculation	13.1 ppb
				Conductivity	112 :S/cm
				pH	7.39 pH
				Chlorophyll-a corrected for pheophytin	10.50 ppb
				Calcium	9.61 ppm
				Magnesium	4.33 ppm
WQ - 3	08/03/2020	08/06/2020	1.5	Sulphate ion	9.2 ppm
				Total phosphorus	0.020 ppm
				Total alkalinity	38 ppm
				Total dissolved solids	104 ppm
				Chlorophyll-a trichromatic method calculation	11.9 ppb
				Conductivity	122 :S/cm
				pH	7.69 pH
				Chlorophyll-a corrected for pheophytin	9.20 ppb
				Calcium	10.40 ppm
				Magnesium	4.75 ppm
WQ - 4	08/03/2020	08/06/2020	1.5	Sulphate ion	7.2 ppm
				Total phosphorus	0.040 ppm
				Total alkalinity	35 ppm
				Total dissolved solids	76 ppm
				Chlorophyll-a trichromatic method calculation	19.6 ppb
				Conductivity	105 :S/cm
				pH	7.77 pH
				Chlorophyll-a corrected for pheophytin	16.60 ppb
				Calcium	9.01 ppm
				Magnesium	4.01 ppm
WQ - 5	08/03/2020	08/06/2020	1.5	Sulphate ion	4.6 ppm
				Total phosphorus	0.027 ppm
				Total alkalinity	26 ppm
				Total dissolved solids	68 ppm
				Chlorophyll-a trichromatic method calculation	22.4 ppb
				Conductivity	76 :S/cm

Laboratory Analysis of Water Chemistry (*Continued*)

Station ID	Sampling Date	Analysis Date	Sample Depth (ft)	Chemical Parameter	Chemical Value
WQ - 5 (*Continued*)	08/03/2020	08/05/2020	1.5	pH	7.61 pH
				Chlorophyll-a corrected for pheophytin	18.60 ppb
				Calcium	6.55 ppm
				Magnesium	2.67 ppm

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Net Catch Summary by Numbers for GN

Standard gill net sets

Number of Sets: 20
First Set Date: 08/31/2020
Last Lift Date: 09/15/2020
Target Species: N/A

Abbr	Species	Total Fish	Number Per Set	Quartiles for Lake Class 2* 25%	50%	75%
BLC	Black Crappie	11	0.55	0.19	0.30	0.78
BLG	Bluegill	24	1.20	N/A	N/A	N/A
BRB	Brown Bullhead	1	0.05	0.28	0.35	0.60
LKW	Lake Whitefish	4	0.20	0.10	0.16	3.00
LMB	Largemouth Bass	1	0.05	N/A	0.09	N/A
NOP	Northern Pike	12	0.60	1.06	1.62	2.35
PMK	Pumpkinseed	1	0.05	N/A	N/A	N/A
RKB	Rock Bass	23	1.15	0.60	0.90	1.55
SMB	Smallmouth Bass	12	0.60	0.21	0.35	0.58
TLC	Tullibee (Cisco)	347	17.35	1.15	5.18	10.11
WAE	Walleye	408	20.40	3.61	6.32	10.79
WTS	White Sucker	50	2.50	1.43	2.00	3.00
YEP	Yellow Perch	697	34.85	1.43	4.53	6.80
		Total Fish/Set:	79.55	* Quartiles for Number Per Set		

Net Catch Summary by Weight for GN

Standard gill net sets

Abbr	Species	Total Weight (Pounds)	Pounds Per Set	Mean Weight	Quartiles for Lake Class 2* 25%	50%	75%
BLC	Black Crappie	4.17	0.21	0.38	0.19	0.31	0.56
BLG	Bluegill	5.12	0.26	0.21	N/A	N/A	N/A
BRB	Brown Bullhead	0.19	0.01	0.19	0.18	0.39	0.47
LKW	Lake Whitefish	8.34	0.42	2.09	0.90	1.58	2.80
LMB	Largemouth Bass	0.18	0.01	0.18	N/A	1.43	N/A
NOP	Northern Pike	65.60	3.28	5.47	2.79	3.52	4.29
PMK	Pumpkinseed	0.19	0.01	0.19	N/A	N/A	N/A
RKB	Rock Bass	7.57	0.38	0.33	0.21	0.27	0.35
SMB	Smallmouth Bass	14.03	0.70	1.17	0.67	0.83	1.17
TLC	Tullibee (Cisco)	242.04	12.10	0.70	0.31	0.66	0.93
WAE	Walleye	440.62	22.03	1.08	0.83	1.00	1.28
WTS	White Sucker	90.04	4.50	1.80	1.66	1.92	2.20
YEP	Yellow Perch	116.89	5.84	0.17	0.13	0.16	0.22
		Total Pounds Fish/Set:	49.75		* Quartiles for Mean Weight		

Electrofishing Catch Summary for EF

Standard electrofishing

Total run-time for all stations: 03:00:00
Total on-time for all stations: 03:00:00
First Sampling Date: 06/03/2020
Last Sampling Date: 06/05/2020
Daylight Sampling: No
Target Species: All ages largemouth bass, All ages smallmouth bass

		Summary By Numbers			Summary By Weight (pounds)			
		Total	Number per Hour		Total	Lbs per Hour		Mean
Abbr	Species	Number	Run-Time	On-Time	Weight	Run-Time	On-Time	Weight
LMB	Largemouth Bass	2	0.67	0.67	2.40	0.80	0.80	1.20
SMB	Smallmouth Bass	181	60.33	60.33	104.72	34.91	34.91	0.58

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Natural Reproduction Catch Summary for EW

Fall electrofishing for walleye

Total run-time for all stations: 03:00:00
Total on-time for all stations: 03:00:00
First Sampling Date: 09/22/2020
Last Sampling Date: 09/24/2020
Daylight Sampling: No
Target Species: Young of the year walleye

Abbr	Species	Age	Total Number	Number Measured	Mean Length (inches)	Length Range (inches) Min	Length Range (inches) Max	Catch Rates (number per hour) Run-Time	Catch Rates (number per hour) On-Time
WAE	Walleye	YOY	216	216	6.34	4.84	7.52	72.00	72.00
WAE	Walleye	≥ 1	5	5	8.19	7.68	8.46	1.67	1.67

Length Frequency Distribution for GN (for fish < 36.00 inches)

Standard gill net sets

(Field work conducted between 08/31/2020 and 09/15/2020)

	BLC	BLG	BRB	LKW	LMB	NOP	PMK	RKB	SMB	TLC	WAE	YWAE	WTS	YEP
< 3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.00 - 3.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.50 - 3.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.00 - 4.49	1	1	-	-	-	-	-	-	-	-	-	-	-	-
4.50 - 4.99	-	1	-	-	-	-	-	-	-	-	-	-	-	-
5.00 - 5.49	2	3	-	-	-	-	-	2	-	-	-	-	-	29
5.50 - 5.99	-	3	-	-	-	-	-	3	-	-	-	1	-	240
6.00 - 6.49	-	4	-	-	-	-	1	5	-	-	-	-	-	149
6.50 - 6.99	-	8	-	-	1	-	-	1	-	-	-	1	-	70
7.00 - 7.49	-	2	-	-	-	-	-	2	-	2	-	-	-	52
7.50 - 7.99	2	1	1	-	-	-	-	3	-	8	-	-	1	33
8.00 - 8.49	1	-	-	-	-	-	-	3	-	36	2	-	1	31
8.50 - 8.99	1	1	-	-	-	-	-	1	1	78	10	-	3	31
9.00 - 9.49	-	-	-	-	-	-	-	2	-	25	19	-	-	19
9.50 - 9.99	1	-	-	-	-	-	-	1	1	5	25	-	-	13
10.00 - 10.49	1	-	-	-	-	-	-	-	1	-	12	-	-	13
10.50 - 10.99	1	-	-	-	-	-	-	-	-	-	18	-	3	3
11.00 - 11.49	-	-	-	-	-	-	-	-	-	4	28	-	3	4
11.50 - 11.99	1	-	-	-	-	-	-	-	1	12	32	-	-	6
12.00 - 12.99	-	-	-	-	-	-	-	-	1	38	55	-	2	3
13.00 - 13.99	-	-	-	1	-	-	-	-	4	68	56	-	4	1
14.00 - 14.99	-	-	-	-	-	-	-	-	2	59	50	-	1	-
15.00 - 15.99	-	-	-	-	-	-	-	-	1	11	18	-	2	-
16.00 - 16.99	-	-	-	1	-	-	-	-	-	-	11	-	6	-
17.00 - 17.99	-	-	-	1	-	-	-	-	-	-	10	-	12	-
18.00 - 18.99	-	-	-	1	-	-	-	-	-	-	16	-	6	-
19.00 - 19.99	-	-	-	-	-	-	-	-	-	-	4	-	3	-
20.00 - 20.99	-	-	-	-	-	-	-	-	-	-	10	-	2	-
21.00 - 21.99	-	-	-	-	-	-	-	-	-	-	6	-	-	-
22.00 - 22.99	-	-	-	-	-	2	-	-	-	-	6	-	-	-
23.00 - 23.99	-	-	-	-	-	1	-	-	-	-	5	-	-	-
24.00 - 24.99	-	-	-	-	-	1	-	-	-	-	3	-	-	-
25.00 - 25.99	-	-	-	-	-	-	-	-	-	-	6	-	-	-
26.00 - 26.99	-	-	-	-	-	-	-	-	-	-	2	-	-	-
27.00 - 27.99	-	-	-	-	-	-	-	-	-	-	1	-	-	-
28.00 - 28.99	-	-	-	-	-	1	-	-	-	-	-	-	-	-
29.00 - 29.99	-	-	-	-	-	2	-	-	-	-	1	-	-	-
30.00 - 30.99	-	-	-	-	-	3	-	-	-	-	-	-	-	-
31.00 - 31.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32.00 - 32.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33.00 - 33.99	-	-	-	-	-	1	-	-	-	-	-	-	-	-
34.00 - 34.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35.00 - 35.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
= > 36.00	-	-	-	-	-	1	-	-	-	-	-	-	-	-

	BLC	BLG	BRB	LKW	LMB	NOP	PMK	RKB	SMB	TLC	WAE	YWAE	WTS	YEP
Total	11	24	1	4	1	12	1	23	12	346	406	2	49	697
Min. Length	4.25	4.06	7.56	13.98	6.89	22.24	6.10	5.24	8.74	7.28	8.15	5.63	7.91	5.12
Max. Length	11.93	8.58	7.56	18.94	6.89	38.39	6.10	9.88	15.55	15.94	29.65	6.93	20.12	13.27
Mean Length	8.15	6.31	7.56	16.69	6.89	28.71	6.10	7.23	12.57	11.39	13.85	6.28	15.37	7.16
# Measured	11	24	1	4	1	12	1	23	12	346	406	2	49	449
No Lengths for	0	0	0	0	0	0	0	0	0	1	0	0	1	248

Note: Unless all fish were measured in the catch, totals shown for some length-frequency distributions may differ from the total number of fish in the catch, due to rounding of fractions used in the estimation of length frequency from a subsample of measured fish

DRAFT

Length Frequency Distribution for GN (for fish ≥ 36.00 inches)

Standard gill net sets

(Field work conducted between 08/31/2020 and 09/15/2020)

	BLC	BLG	BRB	LKW	LMB	NOP	PMK	RKB	SMB	TLC	WAE	YWAE	WTS	YEP
< 36.00	11	24	1	4	1	11	1	23	12	347	406	2	50	697
36.00 - 36.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.00 - 37.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38.00 - 38.99	-	-	-	-	-	1	-	-	-	-	-	-	-	-
39.00 - 39.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40.00 - 40.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41.00 - 41.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42.00 - 42.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.00 - 43.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.00 - 44.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45.00 - 45.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46.00 - 46.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47.00 - 47.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48.00 - 48.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49.00 - 49.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.00 - 50.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51.00 - 51.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52.00 - 52.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53.00 - 53.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54.00 - 54.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55.00 - 55.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56.00 - 56.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57.00 - 57.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58.00 - 58.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59.00 - 59.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60.00 - 60.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61.00 - 61.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62.00 - 62.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63.00 - 63.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64.00 - 64.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65.00 - 65.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66.00 - 66.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67.00 - 67.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68.00 - 68.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69.00 - 69.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70.00 - 70.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71.00 - 71.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72.00 - 72.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73.00 - 73.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74.00 - 74.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.00 - 75.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76.00 - 76.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77.00 - 77.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
= > 78.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	BLC	BLG	BRB	LKW	LMB	NOP	PMK	RKB	SMB	TLC	WAE	YWAE	WTS	YEP
Total	11	24	1	4	1	12	1	23	12	347	406	2	50	697
Min. Length	4.25	4.06	7.56	13.98	6.89	22.24	6.10	5.24	8.74	7.28	8.15	5.63	7.91	5.12
Max. Length	11.93	8.58	7.56	18.94	6.89	38.39	6.10	9.88	15.55	15.94	29.65	6.93	20.12	13.27
Mean Length	8.15	6.31	7.56	16.69	6.89	28.71	6.10	7.23	12.57	11.39	13.85	6.28	15.37	7.16
# Measured	11	24	1	4	1	12	1	23	12	346	406	2	49	449
No Lengths for	0	0	0	0	0	0	0	0	0	1	0	0	1	248

Note: Unless all fish were measured in the catch, totals shown for some length-frequency distributions may differ from the total number of fish in the catch, due to rounding of fractions used in the estimation of length frequency from a subsample of measured fish.

Length Frequency Distribution for EF

Standard electrofishing

(Field work conducted between 06/03/2020 and 06/05/2020)

	LMB	SMB
< 3.00	-	1
3.00 - 3.49	-	1
3.50 - 3.99	-	1
4.00 - 4.49	-	2
4.50 - 4.99	-	9
5.00 - 5.49	-	10
5.50 - 5.99	-	17
6.00 - 6.49	-	7
6.50 - 6.99	-	14
7.00 - 7.49	-	7
7.50 - 7.99	-	8
8.00 - 8.49	-	7
8.50 - 8.99	-	8
9.00 - 9.49	-	13
9.50 - 9.99	-	9
10.00 - 10.49	-	12
10.50 - 10.99	-	5
11.00 - 11.49	-	3
11.50 - 11.99	-	9
12.00 - 12.99	1	17
13.00 - 13.99	1	7
14.00 - 14.99	-	5
15.00 - 15.99	-	3
16.00 - 16.99	-	3
17.00 - 17.99	-	3
18.00 - 18.99	-	-
19.00 - 19.99	-	-
20.00 - 20.99	-	-
21.00 - 21.99	-	-
22.00 - 22.99	-	-
23.00 - 23.99	-	-
24.00 - 24.99	-	-
25.00 - 25.99	-	-
26.00 - 26.99	-	-
27.00 - 27.99	-	-
28.00 - 28.99	-	-
29.00 - 29.99	-	-
30.00 - 30.99	-	-
31.00 - 31.99	-	-
32.00 - 32.99	-	-
33.00 - 33.99	-	-
34.00 - 34.99	-	-
35.00 - 35.99	-	-
= > 36.00	-	-

	LMB	SMB
Total	2	181
Min. Length	12.72	2.52
Max. Length	13.39	17.72
Mean Length	13.05	9.04
# Measured	2	181
No Lengths for	0	0

Note: Unless all fish were measured in the catch, totals shown for some length-frequency distributions may differ from the total number of fish in the catch, due to rounding of fractions used in the estimation of length frequency from a subsample of measured fish

Length Frequency Distribution for EW

Fall electrofishing for walleye

(Field work conducted between 09/22/2020 and 09/24/2020)

	WAE	YWAE
< 0.50	-	-
0.50 - 0.99	-	-
1.00 - 1.49	-	-
1.50 - 1.99	-	-
2.00 - 2.49	-	-
2.50 - 2.99	-	-
3.00 - 3.49	-	-
3.50 - 3.99	-	-
4.00 - 4.49	-	-
4.50 - 4.99	-	2
5.00 - 5.49	-	8
5.50 - 5.99	-	46
6.00 - 6.49	-	68
6.50 - 6.99	-	72
7.00 - 7.49	-	19
7.50 - 7.99	1	1
8.00 - 8.49	4	-
8.50 - 8.99	-	-
9.00 - 9.49	-	-
9.50 - 9.99	-	-
10.00 - 10.49	-	-
10.50 - 10.99	-	-
11.00 - 11.49	-	-
11.50 - 11.99	-	-
12.00 - 12.49	-	-
12.50 - 12.99	-	-
13.00 - 13.49	-	-
13.50 - 13.99	-	-
14.00 - 14.49	-	-
14.50 - 14.99	-	-
15.00 - 15.49	-	-
15.50 - 15.99	-	-
= > 16.00	-	-

	WAE	YWAE
Total	5	216
Min. Length	7.68	4.84
Max. Length	8.46	7.52
Mean Length	8.19	6.34
# Measured	5	216
No Lengths for	0	0

Note: Unless all fish were measured in the catch, totals shown for some length-frequency distributions may differ from the total number of fish in the catch, due to rounding of fractions used in the estimation of length frequency from a subsample of measured fish.

Age Class Frequency Distribution

Species & SS Type (1)	Number of Fish (2)			Number of Fish in Year Class ('yy) and Age Class														
				'20	'19	'18	'17	'16	'15	'14	'13	'12	'11	'10	'09	'08	'07	'06	<'06
	Aged	Keyed	Unaged	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Lake Whitefish																			
GN	3	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Largemouth Bass																			
EF	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
GN	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals:	3	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass																			
EF	181	0	0	0	2	49	12	35	45	9	5	15	3	4	0	1	0	0	1
Walleye																			
EW	19	154	48	167	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GN	408	0	0	2	66	155	34	70	39	7	7	7	9	2	2	1	3	2	2
Totals:	427	154	48	169	72	155	34	70	39	7	7	7	9	2	2	1	3	2	2
Yellow Perch																			
GN	204	494	0	0	83	156	241	165	38	2	1	8	1	2	1	0	0	0	0

(1) Key to Sampling Station (SS) Type abbreviations:

GN = Standard gill net sets
EF = Standard electrofishing
EW = Fall electrofishing for walleye

(2) Notes:

Number of Fish Aged: Fish that were aged from bony parts.
Number of Fish Keyed: Fish assigned an age with an age-length key or by expansion of mesh or station age distributions.
Number of Fish Unaged: Fish that were not aged and were not assigned an age.

Other Species

Gear Type (1)	Other Species (Gender) (2)	Total Num	Number Measured	Length (inches) Min - Mean - Max	Number Weighed	Weight (pounds) Min - Mean - Max
GN	Rusty Crayfish	2,227	0	N/A	0	N/A

(1) Key to sampling gear abbreviations:

GN = Standard gill net sets

(2) Gender: If identified and reported.

Field Notes - General Field

Other assessments and monitoring activities were conducted in 2020 that are not included in the standard Large Lake Survey Report. Bimonthly (June) and monthly (July-October) zooplankton sampling with associated temperature and dissolved oxygen profiles were completed. Zooplankton sampling was not done in May due to the COVID-19 pandemic. Continuous water temperature monitoring occurred via a temperature logger in SW Big Bay. The previous logger was retrieved on 06/19/2020 and a new logger was deployed on 06/23/2020 with various new components. Finally, floating leaf and emergent vegetation mapping began in July in Pike Bay. Potato Island was not surveyed for double-crested cormorant or gull nesting activity in 2020 due to the COVID-19 pandemic. Additionally, seining was not completed in 2020 for multiple reasons.

The spring electrofishing survey targeting bass did not follow the timing outlined in the current management plan (i.e., 1 out of 3 years), but was conducted due to potential spring time constraints in future years and stakeholder concerns. Also, an opportunity existed to complete the survey while following COVID-19 safety protocols. All smallmouth bass and largemouth bass captured during spring electrofishing were bagged by sampling station and frozen prior to lab workup where biological information was collected. During otolith aging, an additional year was added to the number of visible annuli due to the sample timing.

Moderate to very strong west winds (southwest to northwest) occurred during the entire first week of gill netting (GN's 1-6, 8 and 9). It may have slightly influenced catches. A cold front moved in before the start of week 2 and lasted during the early part of the week. As usual, some fish were heavily damaged by crayfish. In those cases, lengths were estimated and other biological information was not be collected. Scales were taken for archiving DNA material. Otoliths were taken as aging structures for all walleyes captured in gill nets. Subsamples of twenty-five yellow perch lengths were taken from individual meshes of gill-nets with high catches and the rest were bulk counted. Also, a subsample of otoliths were taken from 10 yellow perch per 10-mm length group for each basin. The increased yellow perch sample size followed guidelines set out by a recent DNR research project. Yellow perch were only subsampled if all pertinent biological information could be collected. Cisco were not examined in 2020 for sex, maturity, or triaenophorus due to time constraints. Otoliths were taken and read separately by Jeff Mueller from three lake whitefish captured during the fall gill-net assessment. Serial numbers were assigned after the fact for these samples and they were not retained with the rest. Limited examination for diseases and parasites occurred for all species captured in the 2020 gill-net survey. For the fifth consecutive year, two additional gill nets were set in Head of the Lakes Bay (see Targeted Survey for details). Several fish from the gill-net survey were donated to Veterans on the Lake Resort and to animal rehabber Heather Flikke of Cripple Critter Ranch. Lots of angling and boating activity was noted during the gill-net survey throughout the lake. This followed the trend that was observed throughout the summer.

During fall electrofishing, only walleyes captured that were questionable to be young-of-the-year (generally >180 mm in East Vermilion and >200 mm in West Vermilion) were retained for lab analysis and aging. A minimum of 50 YOY walleye were subsampled from each station for length, if available. The rest were bulk counted. Again, noticeable increased angling and boating activity was observed throughout the lake during the survey.

Discussion

Introduction

Lake Vermilion is part of the Minnesota Department of Natural Resources (DNR) Large Lake Monitoring Program which includes annual fisheries population assessments, water quality monitoring, and regularly scheduled creel surveys on the 10 largest lakes in Minnesota. Since 1984, standardized assessments including gill netting, shoreline seining, and water quality sampling have occurred following protocols defined for the Large Lake Monitoring Program (Wingate and Schupp 1984). Trap-netting and electrofishing have been added to the initial fisheries assessment design in addition to monitoring water temperature and zooplankton.

The current management plan for Lake Vermilion was designed to guide fisheries management for a six year period, 2017 to 2022, following input from the Lake Vermilion Fisheries Input Group and the general public (MNDNR 2018). The plan increased the use of defined fisheries goals, objectives, and management activities for individual fish species. While taking into account historical trends, the objectives set forth in the plan are based on 20 years (1996 to 2015) of fisheries assessment data.

Discussion (*Continued*)

Lake Vermilion (Appendix A; Figure 1) is comprised of two major basins, East Vermilion (east of Oak Narrows) and West Vermilion (west of Oak Narrows), that are significantly different in terms of habitat and fish communities; therefore, basin specific objectives were defined for Walleye in the management plan in addition to lakewide objectives (MNDNR 2018).

Since 2017, the special Walleye regulation has been a 20 to 26 inch protected slot limit, with one fish over 26 inches allowed in a four fish possession limit. Walleyes have been managed with protective slot limit regulations since 2006 when the possession limit was also reduced from six to four fish. All other fish species are managed under current statewide regulations.

Walleye

The 2020 annual fall gill-net survey produced the highest lakewide Walleye catch rate in the 37 years of standardized sampling in Lake Vermilion at 20.4 fish/net (Appendix A; Figure 2). High catch rates were observed throughout the lake even after substantial fishing pressure had occurred during the spring and summer based on anecdotal observations. The significant increase in catch rates, relative to the two previous years, was driven by recent strong recruitment. The Lake Vermilion Walleye abundance objective was met for the first time since 2017 (MNDNR 2018). The 3-year moving average (2018 to 2020) of 14.7 fish/net exceeded the objective of 14 fish/net set in the management plan.

The 2020 East Vermilion Walleye catch rate of 23.3 fish/net ranked as the third highest catch rate historically in that basin (Appendix A; Figure 2). It was a substantial increase from the previous two years, and the 2020 catch rate brought the 3-year moving average to 16.4 fish/net. This was the first time that the management plan objective of 16 fish/net was met since 2017 (MNDNR 2018). The 2020 West Vermilion catch rate of 16.0 fish/net ranked as the second highest catch rate historically in that basin (Appendix A; Figure 2). It was a significant increase from the previous four years and maintained the 3-year moving average (12.2 fish/net) above the management plan objective (10 fish/net) for the sixth consecutive year.

The mean length of Walleyes captured during the 2020 gill-net survey was 13.9 inches (n = 406), excluding young-of-the-year fish. This was the smallest average size since 2008 which can be attributed to the recent strong year classes that produced above average catches of fish under 15 inches. An increasing trend in the mean length of sampled Walleyes was initially observed following the implementation of protected slot limits beginning in 2006. This trend has levelled off over the last several years, but larger mean lengths continue to be observed when compared to the pre-regulation period. The stabilization of mean lengths may be partially attributed to the levelling off of mature female Walleye abundance that are mostly in the protected slot. Growth differences occur when comparing the basins, as fish in West Vermilion on average grow faster at younger ages. For example, age-2 fish captured in West Vermilion in 2020 ranged in length from 10.7 to 15.9 inches (mean = 12.9 inches) compared to a range of 10.0 to 13.1 inches (mean = 11.4 inches) for age-2 fish in East Vermilion.

Due in part to the high catch rates observed in 2020, the number of Walleyes captured in 1-inch length groups were near or above lakewide historical medians for nearly every category (Appendix A; Figure 3). Notably high numbers of fish were observed in the 9 to 14-inch length groups. In fact, this was the highest catch rate of fish under 13 inches ever observed in Lake Vermilion. These fish should provide substantial catch and harvest opportunities over the next several years. Additionally, high catch rates of fish 20 inches and larger will continue to provide memorable catch opportunities throughout the lake.

In East Vermilion, catches of fish in the 8 to 16-inch length groups were near or above historical medians (Appendix A; Figure 3). Fish in the 9 to 11-inch length groups and the 14-inch length group greatly exceeded median catches. The catch rate of fish under 13 inches was the third highest ever recorded in the basin. Additionally, fish in the 18-inch length group and fish over 20 inches were caught in above average numbers. In particular, the catch rate of fish 20 inches and larger was the highest ever observed in East Vermilion. These fish should provide notable catch and harvest opportunities in East Vermilion in 2021 and beyond along with the chance to catch a memorable sized fish.

Discussion (*Continued*)

In West Vermilion, catches of fish in the 11 to 14-inch length groups notably exceeded historical medians (Appendix A; Figure 3). The catch rate of fish under 13 inches was the third highest observed historically. Combined with the above average numbers of fish in the 17 and 18-inch length groups, West Vermilion should provide exceptional catch and harvest opportunities in the near future. Above-average numbers of fish 20 inches and larger will continue to provide memorable catch opportunities. Low numbers of fish in the 15 and 16-inch length groups may partially be attributed to angler harvest, as that is within the preferred harvest length for most anglers.

Walleyes captured in gill nets in 2020 ranged in age from 0 to 23 years old (n = 408) based on otolith aging. Lakewide catch rates of age-0 (2020 year-class), age-1 (2019 year-class), age-2 (2018 year-class), age-4 (2016 year-class), age-5 (2015 year-class), age-7 (2013 year-class), and ages-8 and older fish were at or above historical medians (Appendix A; Figure 4). The catch rate of age-2 fish was the highest ever observed for an age-2 cohort. This follows an above-average catch rate of that year-class as an age-1 cohort in 2019, suggesting strong recruitment. For the third consecutive year, catch rates from the 2017 year-class were below the 25th percentile indicating poor recruitment from that cohort. The catch rate of fish ages-8 and older exceeded the 75th percentile for the second consecutive year and for the 10th time in 11 years. Following implementation of size protective walleye regulations in 2006, the catch rate of these older fish has drastically increased.

In East Vermilion, catch rates of age-0, age-1, age-2, age-4, age-5, age-7 and ages-8 and older Walleyes were above historical medians (Appendix A; Figure 4). The catch rate of age-1 fish was above the historical 75th percentile for catch rates of age-1 cohorts and the catch rate of age-2 fish was just below the historical 75th percentile of age-2 cohorts indicating recent strong recruitment. Catch rates from the 2017 year-class were below the 25th percentile for the third consecutive year indicating poor recruitment from that cohort. Catch rates of fish ages-8 and older were the highest ever observed in East Vermilion continuing an increasing trend.

In West Vermilion, catch rates of age-2, age-4, age-5, and ages-8 and older fish were above historical medians (Appendix A; Figure 4). The catch rate of age-2 fish was the highest ever observed for any cohort in that basin. This followed a catch rate above the 75th percentile for the same cohort in 2019, signaling strong recruitment from the 2018 year-class. Age-3 fish were captured below the historical 25th percentile for age-3 cohorts following 2 years with below median catch rates for the 2017 year-class. Walleyes from this year-class were mostly within the preferred harvest size range and had not yet reached the protected size suggesting harvest could have reduced numbers. The catch rate of fish ages-8 and older declined dramatically in West Vermilion compared to 2019. However, the 2020 catch rate still exceeded the historical median. Over the past 11 years, the catch rate of older fish has been above the 75th percentile eight times. However, recent trends suggest that the number of older fish in the basin are declining.

A linear mixed model was used to estimate year-class strength based on gill-net catches of age-1 to age-3 Walleyes (D. Staples, DNR, unpublished data). This model factors in annual variation in catchability thus year-class strength estimates for individual cohorts change slightly as additional data are input into the model. The annual differences are mostly negligible, except for more recent cohorts that are still being captured in gill nets. Year-class strength index values assigned to the first two cohorts (i.e., 1981 and 1982) and the two most recent year-classes sampled are not complete and have greater uncertainty associated with them because those cohorts were not sampled at age-1, age-2, and age-3. Generally, the 25th percentile is a threshold below which year-class strength is considered weak. Recruitment concerns occur when weak year-classes are produced in consecutive years. A strong year-class is defined by meeting or exceeding the 75th percentile of historic estimates.

Lakewide year-class strength values ranged from 0 to 4.5 from 1983 to 2017 (Appendix A; Figure 5). The Lake Vermilion management plan Walleye recruitment objective was met in the 2020 survey (MNDNR 2018). The most recent strong year-class was produced in 2016 and preliminary estimates indicate 2018 and 2019 could also be strong year-classes. The most recent weak year-class occurred in 2017. Lakewide year-class strength estimates are heavily influenced by catches in East Vermilion since the basin is larger, receives more gill nets, and has a higher Walleye abundance.

In East Vermilion, year-class strength estimates ranged from 0 to 3.3 from 1983 to 2017 (Appendix A; Figure 5). The

Discussion (***Continued***)

management plan recruitment objective for that basin was met in 2020 (MNDNR 2018). The most recent strong year-class was produced in 2016 and preliminary estimates indicate 2019 could be strong. The last weak year-class was produced in 2017.

In West Vermilion, year-class strength values ranged from 0 to 4.7 from 1983 to 2017 (Appendix A; Figure 5). The current 3-year moving average met the recruitment objective and estimates over the last 6 years indicate consistent moderate to strong recruitment following a weak 2013 year-class (MNDNR 2018). It appears that after multiple years of sampling, the 2018 cohort will be the first strong year-class in West Vermilion since 2014 and a potential banner year-class overall. However, the majority of those fish will likely be within the preferred harvest size range at some point during 2021, and angler harvest could be significant enough to reduce gill-net catch rates in the fall which could be reflected in reduced year-class strength estimates overall.

Year-classes produced annually within each basin have displayed a weak positive correlation. However, during some years this relationship has become decoupled. For example, in 2014 a weak year-class was produced in East Vermilion while a strong year-class was produced in West Vermilion. The mechanisms of why this occurs is not fully understood, but it is assumed that fish can move freely between the basins and compensate as habitat and food webs allow.

Fall electrofishing provides useful information on abundance and growth of young-of-the-year (YOY) Walleyes near the end of their first growing season (MNDNR 2017). In Lake Vermilion, both the catch rate of YOY Walleyes and the mean length of fish captured display a moderately positive correlation with future lakewide year-class strength estimates for individual cohorts. When comparing individual basins, East Vermilion displays a strong positive correlation between the mean length of YOY Walleyes and future year-class strength while there is no relationship in West Vermilion. On the other hand, both basins display a moderately positive relationship with YOY catch rates and future year-class strength.

In 2020, the lakewide catch rate of YOY Walleyes of 72.0 fish/hour fell below the 25th percentile of previous surveys (Appendix A; Figure 6). The mean length of fish captured was 6.3 inches (n = 216) which was the highest average size ever recorded. The catch rate in East Vermilion was 104.5 fish/hour, slightly above the 25th percentile for that basin (Appendix A; Figure 6). The 6.3 inch (n = 209) average length of YOY Walleyes captured in that basin was the largest average size ever observed. The catch rate in West Vermilion of 7.0 fish/hour fell below the 25th percentile for the second consecutive year (Appendix A; Figure 6). The average length of YOY Walleyes captured was 7.1 inches (n = 7) and the small sample size produced the second highest average size recorded.

Electrofishing catch rates in West Vermilion have been on a declining trend from highs observed in the mid to late 1990s and early 2000s. However, variability in year-class strength appears to be fluctuating normally, moderate to strong year-classes are still being produced, and gill-net catch rates have been relatively stable. On the other hand, catch rates in East Vermilion display a slightly increasing trend dating back to 1988, although that trend has leveled off more recently. Nonetheless, variability in year-class strength appears to be fluctuating normally and weak year-classes still occur. Based on East Vermilion YOY catch rates and average length of fish observed, preliminary data suggests the 2020 year-class is likely to be moderate. In West Vermilion, the 2020 year-class is likely to be moderate to weak which would result in an overall moderate year-class lakewide.

The density of mature female Walleyes, or spawning stock biomass (SSB), is expressed as pounds per surface acre and is estimated from gill-net catches using a gill-net catchability model (qabg model) (Anderson 1998). Since initial estimates of SSB were made in 1988, lakewide density has ranged from 0.4 to 2.7 pounds/acre with a steadily increasing trend (Appendix A; Figure 7). The management plan defined an objective range for SSB from 1.3 to 2.1 pounds/acre (MNDNR 2018).

In 2020, the highest ever lakewide SSB was observed at an estimated 3.0 pounds/acre. This was due in part to the historically high gill-net catch rates that occurred. The 3-year moving average was above the objective range for the 8th consecutive year. However, the most recent trend indicates SSB is leveling off. In East Vermilion, SSB has ranged from 0.3 to 2.7 pounds/acre since 1988 (Appendix A; Figure 7). The SSB objective range for East Vermilion was set from 1.1 to 1.8 pounds/acre (MNDNR 2018). The 2020 estimate of 3.5 pounds/acre was by far the highest

Discussion (*Continued*)

ever observed in that basin, and the 3-year moving average remained above the objective for the 8th consecutive year. In West Vermilion, SSB has ranged from 0.4 to 3.2 pounds/acre since 1988 (Appendix A; Figure 7). The 2020 estimate of 2.3 pounds/acre was the lowest since 2014 and continues a slightly declining trend over the last 6 years. The 3-year moving average was within the objective range of 1.6 to 2.5 pounds/acre for the second consecutive year.

Despite being above the lakewide objective range, the current SSB levels do not appear to be negatively impacting the Walleye population. Our understanding of the dynamics between spawning stock densities, natural reproduction, and ultimately recruitment is somewhat limited, in part due to Walleye fry stocking activities that occur. In a dynamic lake ecosystem, it is difficult to define the "optimal" level of SSB because of the complexity of the system. Both strong and weak year-classes have been produced at both low and high levels of SSB illustrating the complexity of the issue. The protected slot limit regulations, in effect since 2006 for Lake Vermilion, have played a role in the increasing density of mature female Walleyes in the lake. The regulation adjustment made in 2017 was primarily done to increase harvest opportunity with the understanding that SSB would likely be reduced over time. Overall, SSB estimates may have plateaued or even displayed slight declines, specifically in West Vermilion, following steady increases initially observed after the size protective Walleye regulations were implemented.

Yellow Perch

Yellow Perch are a primary forage species in Lake Vermilion that also provide some incidental angler harvest. The 2020 lakewide gill-net catch rate of 34.9 fish/net was the highest catch rate observed since 2013 and also surpassed the historic 75th percentile (Appendix A; Figure 8). The 3-year moving average exceeded the management plan objective of 19 fish/net for the second consecutive year. However, there continues to be a notable difference in the variation of catch rates when comparing the basins.

Historically, East Vermilion catch rates have varied greatly from 9.7 to 56.9 fish/net. The 2020 catch rate of 15.6 fish/net was an improvement from 2019 (10.7 fish/net) and slightly above the 25th percentile (Appendix A; Figure 8). However, this marks the fifth time in the last 6 years and the 11th time in the last 14 years that the catch rate has been below the basin median. Overall, East Vermilion Yellow Perch catch rates have displayed a decreasing trend since the early 1990s which is likely due to a combination of factors including habitat loss and increased predation. In contrast, the West Vermilion catch rate of 63.8 fish/net was the second highest ever observed in that basin (Appendix A; Figure 8). This was also the second consecutive year that catch rates greatly exceeded the 75th percentile and the seventh year in the previous 11 years that they were above the basin median. Overall, West Vermilion Yellow Perch catch rates have displayed an increasing trend and have also continued to fluctuate cyclically as typical of perch populations.

On average, West Vermilion catch rates have historically been higher than East Vermilion, and the basins have displayed a weak positive correlation in catch rates. Large variations in year to year catch rates are not uncommon, but catch rates over the last 14 years in East Vermilion have remained relatively low with little fluctuation outside of 2013. This likely signals significant changes in the Yellow Perch population in East Vermilion. On a positive note, the high Yellow Perch catches observed recently in West Vermilion along with above average Cisco catches in East Vermilion over the last several years are potentially limiting any negative impacts to the food web.

The mean length of Yellow Perch captured in 2020 was relatively small at 7.2 inches (n = 449) compared to historic averages. This was driven by very high numbers of 5 and 6-inch fish captured primarily in West Vermilion. Overall, 5 and 6-inch fish accounted for about 57% of the total measured catch lakewide and approximately 85% of the measured catch in West Vermilion. Numbers of 7 and 8-inch fish were near historical medians. The catch rate of fish 9 inches and larger, which are typically the size anglers prefer to harvest, was below median for the 12th time in the last 13 years.

Yellow Perch captured in gill nets ranged from 1 to 11 years old (n = 204) based on otolith aging. Fish from the 2016 (age-4), 2017 (age-3), and 2018 (age-2) year-classes made up 21%, 29%, and 25% of the aged sample. It was the third consecutive year that fish from the 2016 year-class made up over 20% of the sample indicating moderate to strong recruitment of that cohort. Age-5 fish (2015 year-class) made up 12% of the sample continuing the trend of high representation observed in the previous three surveys suggesting a strong year-class was produced that year.

Discussion (*Continued*)

Very few fish from the 2014 (age-6) and 2013 (age-7) year-classes were captured for the 4th consecutive year indicating weak recruitment during those years.

Smallmouth Bass

Smallmouth Bass are found throughout Lake Vermilion and they provide an important fishery. Spring night electrofishing targeting Smallmouth Bass habitat in Lake Vermilion began in 1989, but the nine standardized locations were not established until 1994. From 1994 to 2011, standardized surveys were conducted almost annually with a single-boom anode electrofishing boat configuration. During this period, Smallmouth Bass catch rates displayed an increasing trend throughout the lake indicating increasing abundance. In 2013, Tower Area Fisheries obtained a new electrofishing boat with a dual-boom anode configuration. Due to higher catchability of fishes with the dual-boom configuration compared to the single-boom configuration (MNDNR 2017), future analysis of Lake Vermilion data will be focused on the period after 2013. Abundance and size structure have been vastly different when comparing the two basins, as West Vermilion tends to have greater abundance with much smaller fish on average when compared to East Vermilion. The trend in catch rates of recent surveys suggest increasing abundance specifically in West Vermilion. During the management planning process, it was decided that bass assessment frequency could be reduced to once every three years and still adequately monitor the population (MNDNR 2018). However, due in part to recent stakeholder concerns and potential time constraints in future years, sampling was conducted in 2020 for the second time in 3 years.

The lakewide catch rate of Smallmouth Bass during spring electrofishing in 2020 was 60.3 fish/hour (Appendix A; Figure 9). This was a slight decline from 2018, but near the median for catch rates in the five surveys since 2014. The East Vermilion catch rate of 44.0 fish/hour was similar to the 2018 survey and near the median of surveys since 2014.The West Vermilion catch rate of 93.0 fish/hour was down from 2018 (145.0 fish/hour), but was at the median of the past five surveys.

The number of Smallmouth Bass captured in 1-inch length categories were mostly near recent median catches dating back to 2014 (Appendix A; Figure 10). The number of small fish (<6 inches) and 12-inch fish notably exceeded recent median catches. On the other hand, the number of 7, 11, and 13-inch fish were notably below median. The basins continue to display dramatically different length frequency distributions (Appendix A; Figure 11). The average length of fish captured in West Vermilion was 7.4 inches and no fish over 13 inches were sampled. In contrast, the average length of fish sampled in East Vermilion was 10.8 inches and about one-fourth were over 13 inches.

Smallmouth Bass captured during electrofishing ranged in age from 1 to 15 years old (n = 181) based on otolith aging. This was the second consecutive survey that fish were aged using otoliths rather than scales. Each year-class from age-1 (2019 year-class) to age-10 (2010 year-class) was represented in the sample indicating consistent recruitment, but their representation in the catch varied. Age-2 (2018 year-class), age-4 (2016 year-class), and age-5 (2015 year-class) fish comprised 27%, 19%, and 25% of the aged sample indicating moderate to strong recruitment in those years. Age-8 fish (2012 year-class) made up the next highest proportion of the sample (8%) indicating good recruitment that year as well, particularly given their age. The 2012 and 2015 year-classes combined to make up over 57% of the sample in the 2018 survey further indicating strong recruitment during those years. Age-3 (2017 year-class), age-6 (2014 year-class), and age-7 (2013 year-class) fish each made up less than 7% of the total sample indicating moderate to weak recruitment during those years. The 2013 year-class was also not well-represented in the 2018 survey further indicating weak recruitment that year.

Overall, the Smallmouth Bass population in Lake Vermilion displayed a stable to increasing trend in abundance based on electrofishing, gill net, seine, and creel data. Length and age distributions of fish indicated that recruitment to the fishery should continue to bolster the population in the near future. Abundance continued to remain higher in West Vermilion, but fish were smaller on average due to slower growth compared to East Vermilion. Also, the maximum length of sampled fish continued to be relatively small in West Vermilion especially compared to East Vermilion.

Largemouth Bass

Discussion (*Continued*)

Largemouth Bass are a minor component of the Lake Vermilion fishery and are predominantly found in West Vermilion. Spring night electrofishing is the standard assessment technique to assess Largemouth Bass populations in Minnesota, however Lake Vermilion surveys have historically targeted primarily Smallmouth Bass habitat. Therefore, Largemouth Bass were rarely encountered. In fact, they had not been captured during spring electrofishing surveys that were conducted almost annually from 1994 to 2012. In 2013, one fish was captured in West Vermilion, but subsequent annual surveys from 2014 to 2016 did not capture any additional fish. The West Vermilion Largemouth Bass catch rate during the previous spring electrofishing survey conducted in 2018 was 2.0 fish/hour.

In 2020, the West Vermilion catch rate was 2.0 fish/hour for the second consecutive survey. The fish measured 12.7 and 13.4 inches. They were both mature females and age-5 fish. The Largemouth Bass population is likely small and limited to specific areas of preferred habitat in the lake. However, DNR electrofishing, gill net, and creel data suggests a stable or increasing population in West Vermilion along with greater recruitment based on increasing catches of young-of-the-year fish observed during summer seining surveys.

Muskellunge

Muskellunge provide an important catch-and-release sport fishery on Lake Vermilion. The population was established via a stocking program that began in late 1980s with the goal of providing a low density, high quality fishery. The spring of 2020 was intended to be the second year (i.e., recapture phase) in a two-year effort to get a population estimate of adult Muskellunge in Lake Vermilion utilizing mark and recapture techniques (MNDNR 2017). Due to the COVID-19 pandemic, that assessment was not completed. In order to obtain an accurate and precise two-sample population estimate (i.e., Petersen method), mark and recapture phases must occur within the same year or in consecutive years to meet the assumptions of a closed population model. Therefore, options for obtaining population estimates in the future are being evaluated.

The Leech Lake strain Muskellunge fingerling stocking program began in 1987 with the goal of establishing a viable population. The most recent management plan calls for a base stocking quota of 3,000 fingerlings annually with up to 2,000 surplus fingerlings per two-year period as available (MNDNR 2018). DNR's Muskellunge egg take operations did not occur in 2020 due to the COVID-19 pandemic. Consequently, no Muskellunge fingerlings were stocked into Lake Vermilion in 2020 due to a lack of availability statewide.

Northern Pike

Northern Pike have historically been present in relatively low abundance in Lake Vermilion but are an important gamefish for some anglers. Ice-out trap-net assessments are completed periodically to obtain size structure information on adult pike and additional data is collected during annual fall gill-net assessments. Ice-out trap netting was not conducted in 2020, however twelve Northern Pike (0.6 fish/net) ranging in length from 22.2 to 38.4 inches were captured in gill nets. The gill-net catch rate was at the historical 25th percentile. Overall, a declining trend in Northern Pike catch rates has been observed lakewide. At the same time, the size structure has shifted towards larger fish which can partially be attributed to protected slot limit regulations that have been in place since 2003. Another factor likely contributing to these results is competition with stocked Muskellunge which has shown to increase mean weight and stabilize or reduce catch rates of Northern Pike in several lakes across Minnesota (Knapp, Mero and Staples 2020). 2020 was the second year that the Northern Pike population was managed under the northeast zone regulations.

Black Crappie

Black Crappies are generally a minor component of the Lake Vermilion fishery but on occasion produce notable angling opportunities. Summer trap-net catch rates have historically been relatively low and stable with generally higher catch rates in West Vermilion as compared to East Vermilion. Summer trap-netting targeting panfish, including Black Crappie, did not occur in 2020 for various reasons. Alternative sampling methods are being evaluated to provide useful data on the relative abundance and size structure of the Black Crappie population (MNDNR 2017).

Bluegill

Discussion (***Continued***)

Bluegills provide significant catch and harvest opportunity in Lake Vermilion. Summer trap-net catches indicate greater abundance of fish in West Vermilion compared to East Vermilion. Summer trap-netting targeting panfish, including Bluegill, did not occur in 2020 for various reasons. Alternative sampling methods are being evaluated to provide useful data on the relative abundance and size structure of the Bluegill population (MNDNR 2017).

Cisco

Ciscoes (tullibee) are classified as a coldwater fish species that require cold, well-oxygenated water. Due to their specific habitat requirements and sensitivity to changing climatic conditions, they are considered indicator species and are subject to occasional late summer die-offs. In Lake Vermilion, they serve primarily as an important prey species. The 2020 lakewide Cisco gill-net catch rate of 17.4 fish/net was a dramatic increase from 2019 (6.7 fish/net) and the highest catch rate since 2002 (Appendix A; Figure 12). The 2020 catch rate was the 4th highest all-time and exceeded the historical 75th percentile. Cisco abundance has been variable over the years ranging from 1.9 to 19.5 fish/net. However, there has been a slightly declining trend especially since the highs observed in the late 1990s and early 2000s.

The lakewide declining trend is due to reduced catches in West Vermilion over the last 15 years (Appendix A; Figure 12). The 2020 West Vermilion catch rate of 15.6 fish/net exceeded the historic median for the first time since 2008. Historically, Cisco gill-net catch rates were nearly double in West Vermilion compared to East Vermilion on average, but over the last 5 years East Vermilion catches have annually exceeded West Vermilion. The 2020 East Vermilion catch rate of 18.5 fish/net was the 2nd highest ever observed and above the 75th percentile for all previous surveys. The length distribution of Ciscoes captured in 2020 displayed well above average numbers of 7-9 inch fish indicating recent strong recruitment. Additionally, numbers of 13-15 inch fish exceeded historic medians.

Fish Diseases and Parasites

Fish collected during surveys are inspected for external and internal diseases and parasites. Additionally, fish samples from targeted surveys and ovarian fluid from female Walleyes collected at the Pike River Hatchery are sent in annually to the DNR Pathology Lab for viral hemorrhagic septicemia (VHS) monitoring. VHS has never been detected in Lake Vermilion. Historically, several diseases and parasites have been observed in fishes captured in Lake Vermilion including Neascus (black spot disease), bass tapeworm, yellow grub, Triaenophorus, Heterosporis, and lymphocystis. See the 2020 Fish Health narrative for details.

Water Quality

Water quality samples were taken at the five standard sites spread across the lake on 08/03/2020 and submitted to the Minnesota Department of Agriculture for laboratory analysis. Various water quality parameters were analyzed including alkalinity, calcium, chlorophyll-a, conductivity, magnesium, pH, phosphorus, sulfate, and total dissolved solids. Historical trends for most water quality parameters have been relatively stable throughout the lake dating back to 1984. Although, total alkalinity and conductivity, which are closely related, continue to show an increasing trend. This can be attributed to decreasing acidic deposition resulting from large-scale emissions control programs which have improved surface water chemistry throughout the Northern Hemisphere (Skjelkvale, et al. 2005). Water clarity measurements taken with a Secchi disk have not displayed any significant trends across the lake. Water temperature and dissolved oxygen profiles were taken at standard sites periodically throughout the open-water period and analysis of historic profiles indicate that no significant trends have occurred. Water temperature loggers have been collecting data in the southwest part of Big Bay since 2009. The logger was retrieved on 06/19/2020 and a new logger was deployed on 06/23/2020. Data from 2020 indicate that mean daily water temperatures were mostly below average from the beginning of April to mid-May and generally above average from mid-May to mid-June.

Zooplankton

Since 2012, zooplankton samples have been collected at three to five sites across Lake Vermilion from May to November and sent to DNR Ecological and Water Resources (EWR) staff for analysis. This sampling was initiated

Discussion (*Continued*)

primarily to provide early detection of aquatic invasive species (AIS) and to collect baseline data prior to AIS infestations. Initially samples were taken at the five established water quality stations (WQ1-WQ5). From 2013 to 2017, the sampling was reduced to three stations that cover East (WQ1), East Central (WQ3), and West Vermilion (WQ5). In 2018, WQ4 (Niles Bay, West Vermilion) was added back to the sampling design in order to evaluate the spread of spiny waterfleas (SWF), an invasive zooplankter first discovered in East Vermilion in 2015. SWF were subsequently sampled in West Vermilion for the first time in 2018 at the Niles Bay site and in 2019 at the Wakemup Bay site (WQ5) indicating lakewide distribution.

Zooplankton sampling was delayed in 2020 due to the COVID-19 pandemic. Samples were ultimately taken at the four standard water quality sites from June through October. Early ice development prevented a sample in November. Staff changes in EWR delayed analysis and results were not available at the time of reporting.

Aquatic Invasive Species

Aquatic invasive species are nonnative animals and plants that do not naturally occur in Minnesota waters and cause varying levels of ecological and economic harm. Several invasive species are present in Lake Vermilion including Chinese mystery snails, curly-leaf pondweed, Heterosporis sutherlandae, purple loosestrife, rusty crayfish, and spiny waterfleas.

Rusty crayfish, native to the Ohio River basin, are invasive crustaceans that were first captured in survey gear and identified in Lake Vermilion in 1986. The population increased rapidly and they were abundant in a significant portion of East Vermilion by 1993 when they were first counted in the gill-net catch. They have significantly reduced aquatic plant beds in certain areas and have displaced native crayfish. Rusty crayfish continue to be more abundant in East Vermilion, but have continued to expand further into West Vermilion at low abundances.

Catches of rusty crayfish in the annual gill-net survey tend to fluctuate and display a slightly increasing trend since the early 1990s. They tend to be found predominately in East Vermilion with the highest numbers typically occurring in Big Bay. In 2020, the rusty crayfish catch was near the historical median. Contrarily, native crayfish have displayed a steady decline in abundance based on gill-net catches and 2020 was the first year that no native crayfish were captured.

Double-crested Cormorants

Double-crested cormorant (DCCO) nest counts could not be conducted in 2020 due to the COVID-19 pandemic. Nest counts from 2013 to 2019 stabilized around 330 nests following the peak of 434 in 2012. No new nesting colonies have been established outside of Potato Island. Population control was conducted from 2013 to 2015; however cormorant control efforts were suspended in 2016. In the absence of control, no significant changes in the number of nests has occurred, but DCCO foraging has undoubtedly increased compared to control years. In 2021, DNR will not conduct DCCO control on Lake Vermilion. However, the cormorant colony will continue to be monitored and the data collected will be reported.

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Discussion (***Continued***)

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Status Of The Fishery

2021 Angling Prospects

Lake Vermilion continues to be a solid multispecies fishery that provides both catch and harvest opportunities for several species. The annual DNR survey in 2020 indicated that walleye abundance is near record highs throughout the lake despite the seemingly higher than normal fishing pressure that occurred. The high walleye abundance is due to recent strong year-classes that were mostly under 15 inches in the fall of 2020. These fish should provide ample catch and harvest opportunities in 2021 and beyond. Also, an abundance of walleyes over 20 inches will continue to provide memorable catch opportunities throughout the lake while also ensuring plenty of broodstock.

Anglers seeking muskellunge (muskies) will find opportunities for fish with trophy potential as a significant portion of the population are 50 inches or larger. Anglers targeting smallmouth bass should find them throughout the lake. East Vermilion has fewer but on average larger fish than West Vermilion, which has higher numbers of smaller fish. Additionally, largemouth bass can be found in low numbers overall, but certain areas of West Vermilion provide the best catch opportunities. Although low in abundance overall, northern pike can be found in specific areas providing catch and harvest opportunities with the possibility to catch fish up to 40 inches. Additionally, black crappie and bluegill will continue to provide angling opportunities. Whitefish and cisco (tullibee) offer harvest opportunities primarily during the fall sport gill-netting season.

Anglers are reminded that a special regulation exists for walleyes where all fish from 20 to 26 inches must be immediately released. There is a four walleye possession limit with only one fish over 26 inches allowed. Anglers are also reminded that since 2019, northern pike are managed under the northeast zone regulation requiring release of all fish between 30 and 40 inches, only one allowed over 40 inches, and a two fish possession limit. For darkhouse spearing, you are allowed two pike but only one may be over 26 inches. All other fish species are managed under current statewide fishing regulations.

Fisheries Management

Lake Vermilion is comprised of two major basins, East Vermilion (east of Oak Narrows) and West Vermilion (west of Oak Narrows), that are significantly different in terms of habitat and fish communities. The lake is part of the Minnesota Department of Natural Resources (DNR) Large Lake Monitoring Program which includes annual fisheries population assessments, water quality monitoring, zooplankton monitoring, aquatic invasive species surveillance, and regularly scheduled creel surveys on the 10 largest lakes in Minnesota. Since 1984, standardized fish population assessments have included a variety of sampling gears to collect various fish species at different life stages. The gears include gill nets, trap nets, shoreline seines, and electrofishing boats. Fisheries assessments are standardized so that the same sampling gear is used at the same locations during the same time of year to best track population trends over time. Length, weight, age, and other data are collected for fish of management concern.

The current management plan for Lake Vermilion was designed to guide fisheries management for a six-year period from 2017 to 2022. Since 1971, DNR has annually operated the walleye spawn take and hatchery at the Pike River, a major tributary to Lake Vermilion. A small portion of the walleye fry produced annually at the Pike River Hatchery are put back into Lake Vermilion. In the previous 10 years, between 5 and 15 million fry have been stocked annually. DNR's walleye spawn take operations were suspended in 2020 due to COVID-19 safety concerns, resulting in no walleye fry being stocked. However, natural reproduction of wild walleye fry is high in Lake Vermilion and one year without "put back" stocking will likely be unnoticeable to anglers.

A muskellunge stocking program began in 1987 with the goal of establishing a low density, high quality muskie population in Lake Vermilion. The most recent management plan calls for a base stocking quota of 3,000 fingerlings annually with up to 2,000 surplus fingerlings per two-year period, as available. DNR's muskellunge spawn take operations were also suspended in 2020 due to COVID-19 safety concerns. Therefore, no muskellunge fingerlings were stocked into Lake Vermilion in 2020 due to a lack of availability statewide. Recent surplus stocking along with natural reproduction should help offset any negative impacts from the missed stocking event.

Walleye

Status Of The Fishery (*Continued*)

In 2020, the DNR's annual fall gill-net survey produced the highest lakewide walleye catch rate in the 37 years of standardized sampling in Lake Vermilion at 20.4 fish/net. High catch rates were observed throughout the lake even after substantial fishing pressure had occurred during the spring and summer of 2020 based on anecdotal observations. The significant increase in catch rates from the previous two years was driven by recent strong recruitment. The 2020 East Vermilion walleye catch rate of 23.3 fish/net ranked as the third highest catch rate historically in that basin. The West Vermilion catch rate of 16.0 fish/net ranked as the second highest catch rate historically in that basin.

The average length of walleyes captured in the fall 2020 gill-net survey was about 14 inches. It was the smallest average size since 2008, which can be attributed to the recent strong year classes that produced exceptionally high catches of fish under 15 inches throughout the lake. These fish should provide substantial catch and harvest opportunities over the next several years. Additionally, high catch rates of fish 20 inches and larger will continue to provide memorable catch opportunities throughout the lake while also ensuring plenty of broodstock.

Walleyes captured in gill nets in 2020 ranged from 0 to 23 years old. Lakewide catch rates of age-0 (2020 year-class), age-1 (2019 year-class), age-2 (2018 year-class), age-4 (2016 year-class), age-5 (2015 year-class), age-7 (2013 year-class), and ages-8 and older fish were at or above historical averages. The catch rate of age-2 fish was the highest ever observed for an age-2 cohort. This follows an above-average catch rate of that year-class as an age-1 cohort in 2019, suggesting strong recruitment. The catch rate of fish ages-8 and older exceeded the 75th percentile for the second consecutive year and for the 10th time in 11 years. Following implementation of size protective walleye regulations in 2006, the catch rate of these older fish has drastically increased.

The most recent strong walleye year-class was produced lakewide in 2016 and preliminary estimates indicate 2018 and 2019 could also be strong year-classes. The most recent weak year-class occurred lakewide in 2017. In East Vermilion, the most recent strong year-class was produced in 2016 and preliminary estimates indicate 2019 could be strong. The last weak year-class was produced in 2017. In West Vermilion, consistent moderate to strong recruitment has occurred annually since the last weak year-class in 2013. The 2018 cohort will likely be the first strong year-class in West Vermilion since 2014 and a potential banner year-class overall.

Fall electrofishing provides useful information on abundance and growth of young-of-the-year (YOY) walleyes near the end of their first growing season. In Lake Vermilion, both the catch rate of YOY walleyes and average length of fish captured help predict future year-class strength. In 2020, the lakewide catch rate of YOY walleyes of 72.0 fish/hour fell below the 25th percentile of previous surveys. Below average catches of YOY fish occurred in East Vermilion while catches below the 25th percentile were recorded in West Vermilion. The average length of fish captured lakewide was 6.3 inches, which was the highest average size ever recorded.

Muskellunge

Muskies provide an important catch-and-release sport fishery on Lake Vermilion. The muskie population was established via a stocking program that began in the late 1980s with the goal of providing a low density, high quality fishery. In 2020, DNR had planned to conduct the second year of a two-year effort to get a population estimate of adult muskies in Lake Vermilion. Due to safety concerns with the COVID-19 pandemic, that assessment was not completed. Options for obtaining population estimates in the future are being evaluated. During the most recent assessment conducted in 2019, muskies averaged 44.7 inches in length and over 10% of the fish sampled were 50 inches or larger.

Smallmouth Bass

Smallmouth bass are found throughout Lake Vermilion and they provide an important fishery. Spring electrofishing targeting primarily smallmouth bass habitat has been conducted almost annually since 1989 as the primary assessment of the population. Based on survey results, smallmouth bass abundance has generally increased over the last three decades. Recent surveys indicate that the trend in increasing numbers continues in West Vermilion, but abundance has stabilized in East Vermilion. Abundance and size structure are very different between the two basins, as West Vermilion tends to have higher numbers with much smaller fish on average when compared to East

Status Of The Fishery (*Continued*)

Vermilion. During the most recent management planning process, it was decided that bass assessment frequency could be reduced to once every three years and still adequately monitor the population. However, due in part to recent stakeholder concerns, sampling was conducted in 2020 for the second time in 3 years.

The lakewide catch rate of smallmouth bass during spring electrofishing in 2020 was 60.3 fish/hour. This was a slight decline from 2018, but near the average for catch rates in the five surveys since 2014. The East Vermilion catch rate of 44.0 fish/hour was similar to the 2018 survey and near the average of surveys since 2014.The West Vermilion catch rate of 93.0 fish/hour was down from the record high in 2018 (145.0 fish/hour), but was average over the past five surveys. The average length of fish captured in West Vermilion was 7.4 inches and no fish over 13 inches were sampled. In contrast, the average length of fish sampled in East Vermilion was 10.8 inches and about one-fourth were over 13 inches. The fish ranged from 1 to 15 years old and each year class from age-1 (2019 year-class) to age-10 (2010 year-class) was represented in the sample indicating consistent recruitment.

Overall, the smallmouth bass population in Lake Vermilion displays a stable to increasing trend in abundance based on electrofishing, gill net, seine, and creel data. Length and age distributions of fish indicate that recruitment to the fishery should continue to bolster the population in the near future. Abundance continues to remain higher in West Vermilion, but fish are smaller on average due to slower growth compared to East Vermilion.

Largemouth Bass

Largemouth bass are a minor component of the Lake Vermilion fishery and are primarily found in West Vermilion. They do provide fishing opportunities and typically have low harvest rates. Spring electrofishing is the standard assessment technique to assess largemouth bass populations in Minnesota. However, Lake Vermilion surveys have historically targeted smallmouth bass habitat because it is much more abundant in the lake. Largemouth bass were first captured during the standard electrofishing survey in West Vermilion in 2013 and have continued to be rarely encountered. However, in 2020, the West Vermilion catch rate was 2.0 fish/hour for the second consecutive survey. Largemouth bass are not abundant and are limited to specific areas of preferred habitat in the lake. However, DNR electrofishing, gill net, and creel data suggests a stable or increasing population primarily in West Vermilion.

Northern Pike

Northern pike are generally found in relatively low numbers in Lake Vermilion but are an important gamefish for some anglers. Ice-out trap-net surveys have been done periodically to obtain size structure information on the northern pike population and additional data is collected during annual fall gill-net assessments. Ice-out trap netting was not conducted in 2020, however 12 northern pike (0.6 fish/net) ranging in length from 22.2 to 38.4 inches were captured in gill nets. The gill-net catch rate was at the 25th percentile of previous catches in Lake Vermilion. Overall, a declining trend in northern pike abundance has been observed lakewide over the past three decades. At the same time, the size structure has shifted towards larger fish which can partially be attributed to protected slot limit regulations that have been in place since 2003.

Yellow Perch

Yellow perch are a primary forage species in Lake Vermilion that also provide some incidental angler harvest. The 2020 lakewide gill-net catch rate of 34.9 fish/net was the highest catch rate observed since 2013 and also surpassed the historic 75th percentile. However, there continues to be a notable difference in catch rates when comparing the basins. The 2020 East Vermilion catch rate of 15.6 fish/net was an improvement from 2019 (10.7 fish/net) and slightly above the 25th percentile for that basin. In contrast, the West Vermilion catch rate of 63.8 fish/net was the second highest ever observed in that basin. Overall, East Vermilion yellow perch catch rates have displayed a decreasing trend since the early 1990s which is likely due to a combination of factors including habitat loss and increased predation. On the other hand, West Vermilion catch rates have displayed an increasing trend and have also continued to fluctuate cyclically typical of perch populations.

The average length of yellow perch captured in 2020 was relatively small at 7.2 inches compared to historic averages. This was driven by very high numbers of 5 and 6-inch fish captured primarily in West Vermilion. The catch rate of fish

Status Of The Fishery (*Continued*)

9 inches and larger, which are typically the size anglers prefer to harvest, was below average. Fish captured in gill nets ranged from 1 to 11 years old. A high proportion of fish from age-2 to age-4 in the sample indicate consistent recruitment in recent years which may continue to bolster gill-net catch rates in the future.

Bluegill and Black Crappie

Bluegills provide significant catch and harvest opportunities in Lake Vermilion, while black crappies are generally a minor component of the fishery that can on occasion produce very good fishing. Trap-net catches and creel data indicate greater abundance of both species in West Vermilion compared to East Vermilion. Summer trap-netting targeting panfish did not occur in 2020 because sampling frequency was reduced in the current management plan. Alternative sampling methods are being evaluated to provide useful data on relative abundance and size structure of panfish populations.

Aquatic Invasive Species

Aquatic invasive species are nonnative animals and plants that do not naturally occur in Minnesota waters and cause varying levels of ecological and economic harm. Lake users should follow Minnesota's aquatic invasive species laws to prevent introduction and minimize the spread of nonnative species. Several invasive species are present at varying levels in Lake Vermilion including Chinese mystery snails, curly-leaf pondweed, Heterosporis sutherlandae, purple loosestrife, rusty crayfish, and spiny waterflea.

Survey Attachments

Note: The following attachment is excluded from this report:

(1) 2020 Discussion Appendix A.docx

Approval Dates And Notices

Date Approved By Tower Area Fisheries Supervisor: _____

Date Approved By Northeast Region Fisheries Manager: _____

This DRAFT VERSION of the Lake Survey Report contains preliminary data (as of 04/15/2021), and is therefore subject to change at any time.

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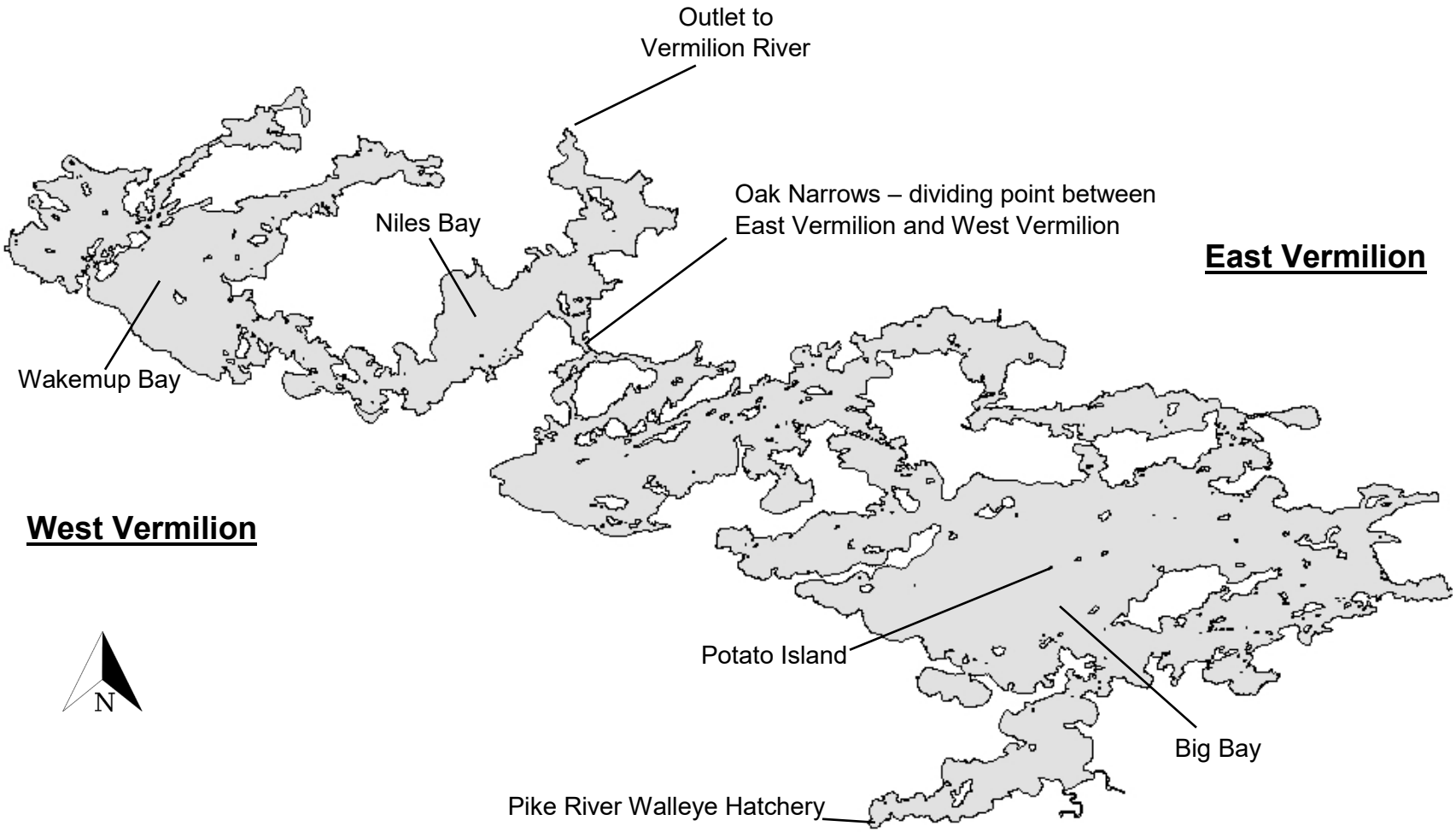

***Figure 1**. Map of Lake Vermilion with major features.*

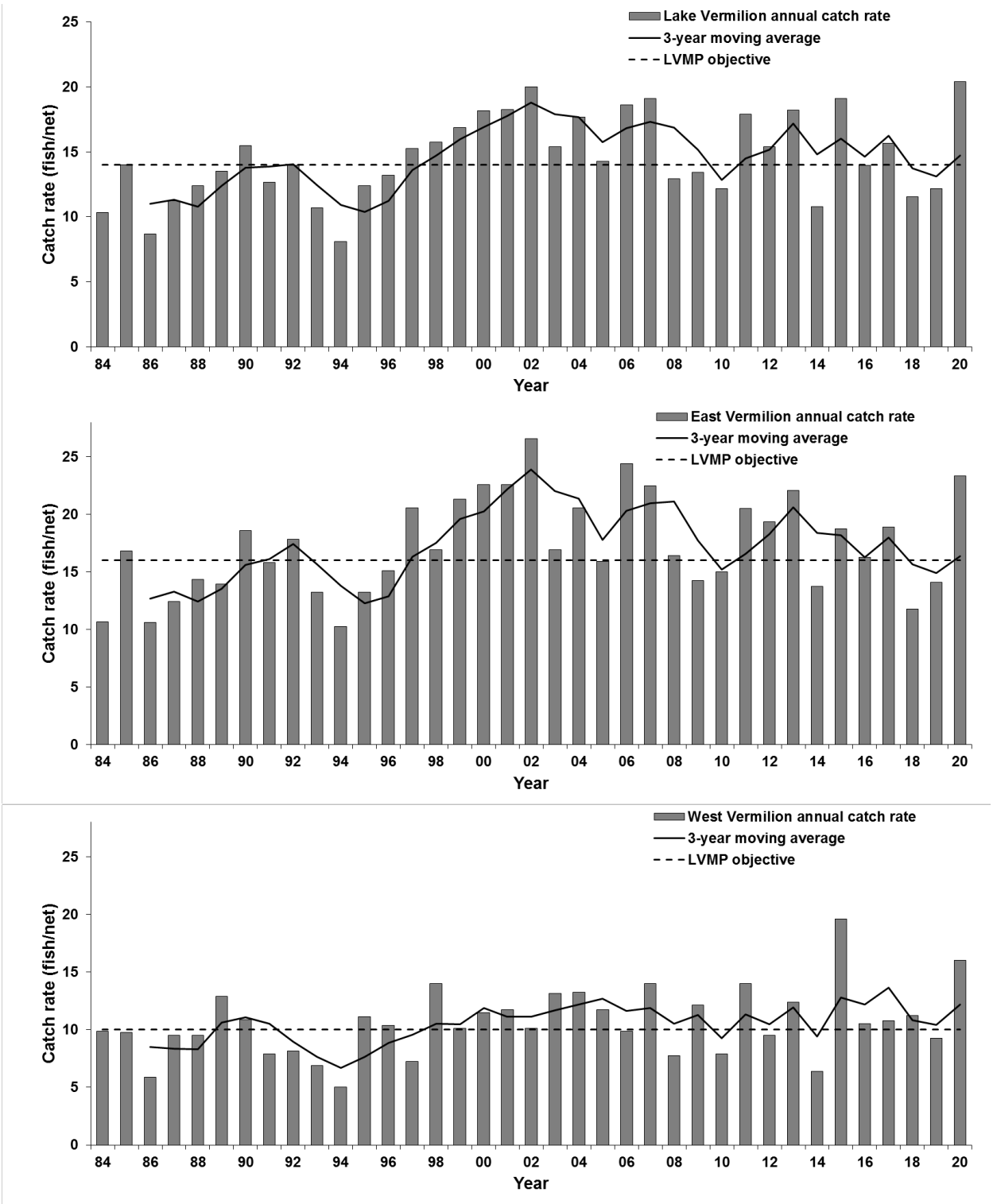

***Figure 2**. Gill-net catch rates (fish/net) of Walleye in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 1984-2020. Horizontal dashed lines represent the management plan objectives. Solid lines represent the 3-year moving averages.*

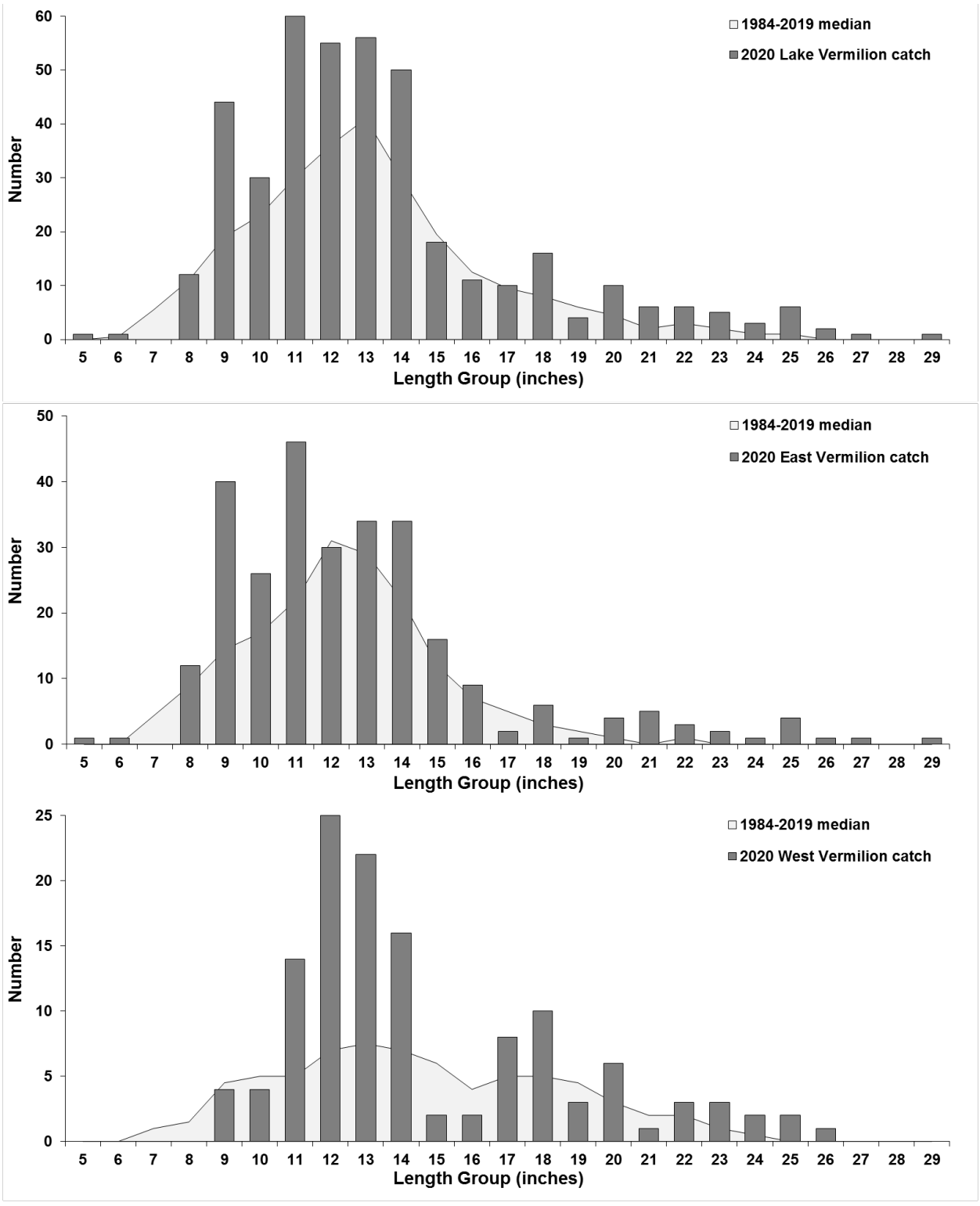

***Figure 3**. Length frequency distributions of gill-net captured Walleye (dark bars) in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom) in 2020 in relation to historic median length frequency distributions from 1984 to 2019 (light gray).*

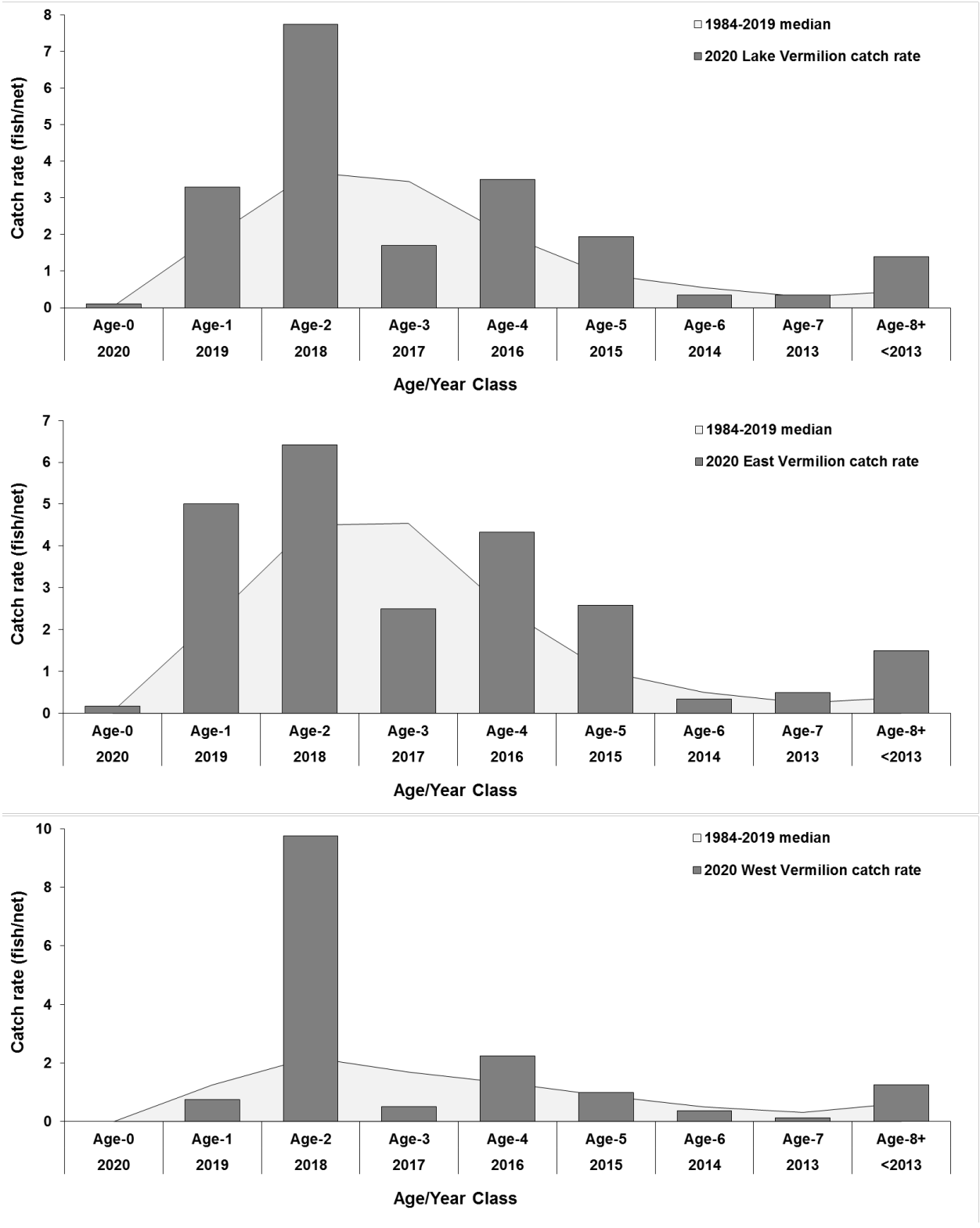

Figure 4*. Gill-net catch rates (fish/net; dark bars) of Walleye by age in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom) in 2020 in relation to historic median catch rates from 1984 to 2019 (light gray).*

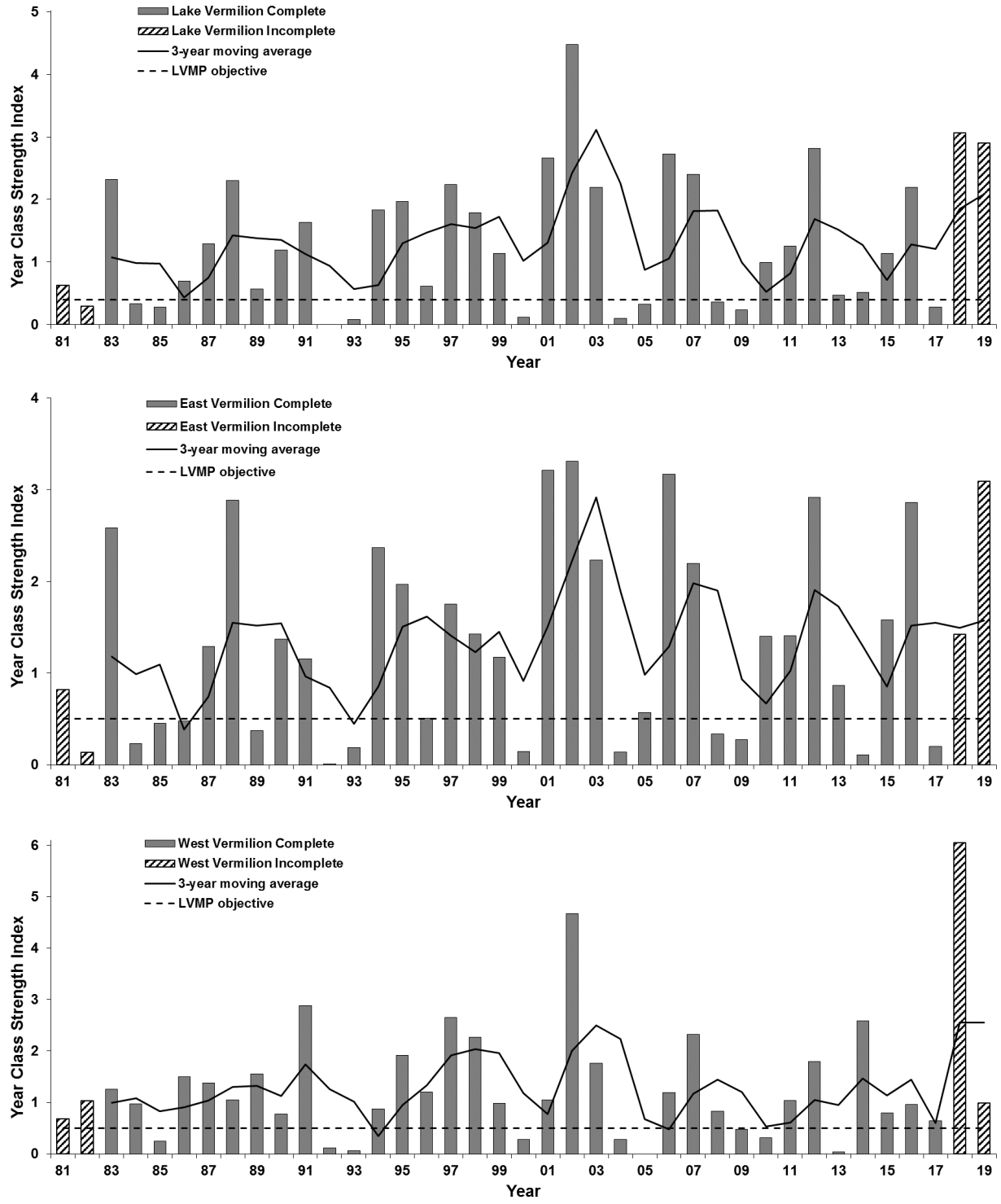

Figure 5*. Walleye year class strength index in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 1981-2018. Both complete and incomplete estimates are indicated. Horizontal dashed lines represent the management plan objectives. Solid lines represent the 3-year moving averages.*

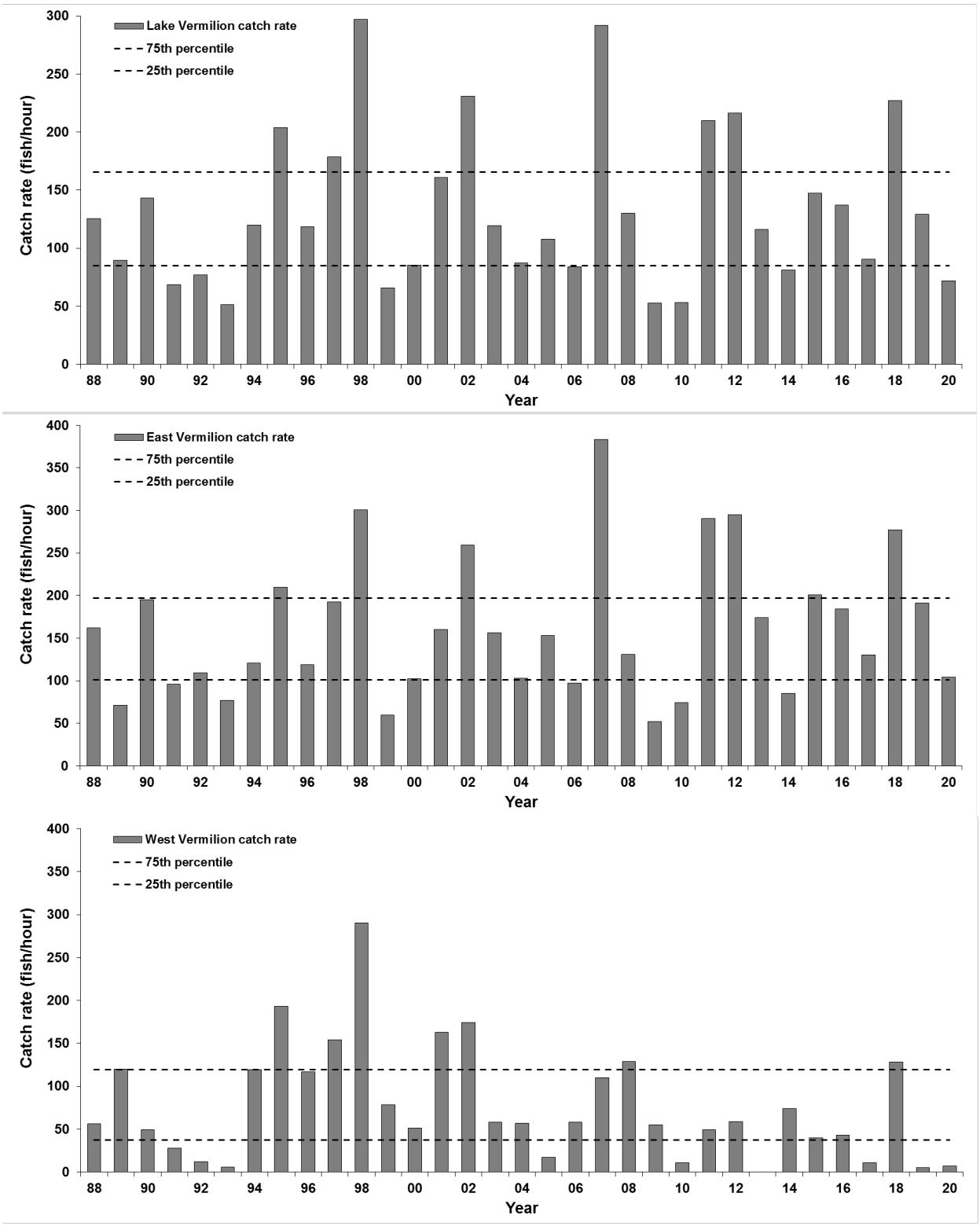

***Figure 6**. Fall electrofishing catch rates (fish/hour) of young-of-the-year Walleye in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 1988-2020. Horizontal dashed lines represent the 25th and 75th percentiles from 1988-2019.*

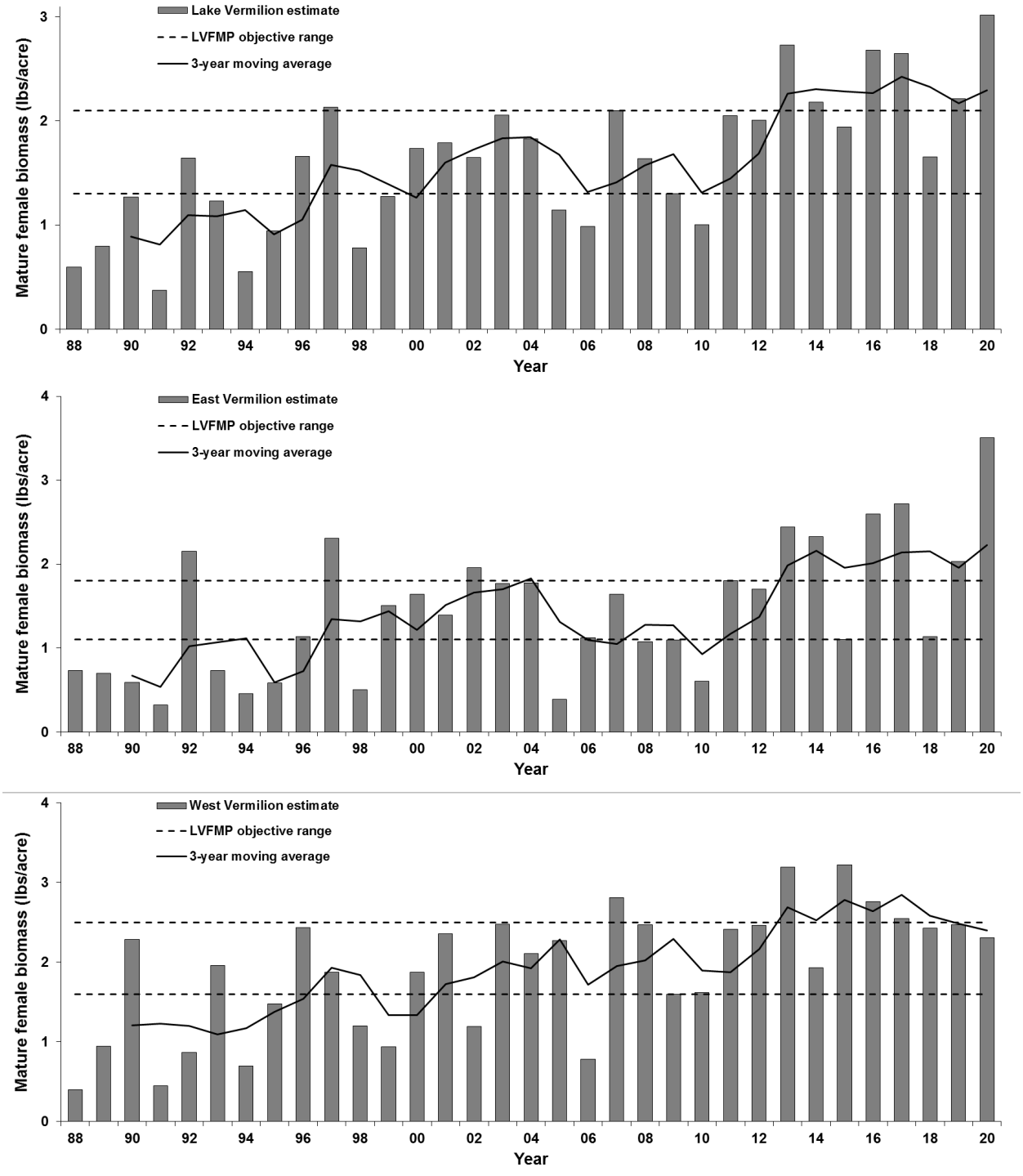

***Figure 7**. Estimated biomass (pounds/acre) of mature female Walleye in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 1988-2020. Horizontal dashed lines represent the management plan objective ranges. Solid lines represent the 3-year moving averages.*

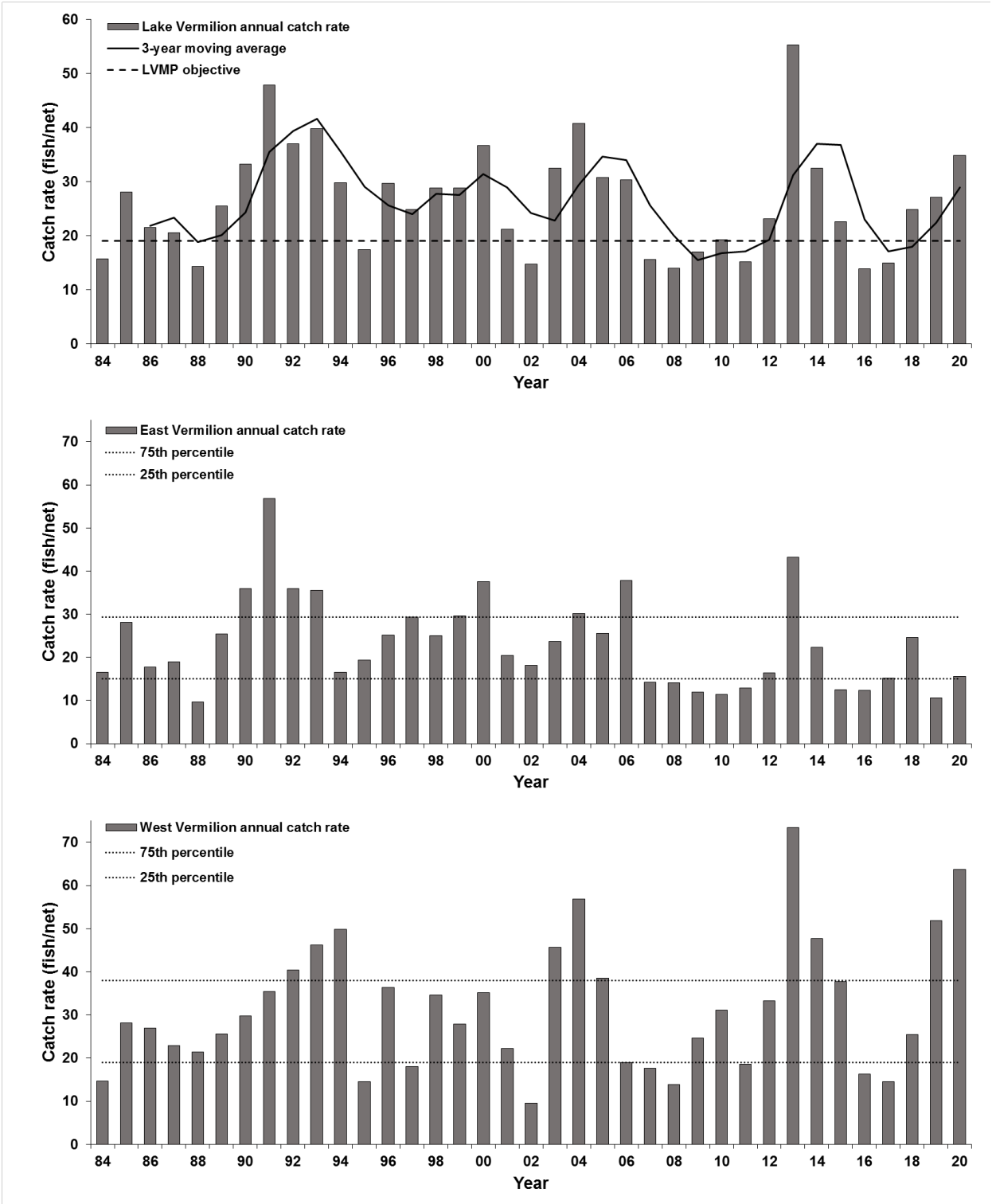

***Figure 8**. Gill-net catch rates (fish/net) of Yellow Perch in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 1984-2020. The horizontal dashed line represents the management plan objective. The solid line represents the 3-year moving average. The horizontal dotted lines represent the 25th and 75th percentiles.*

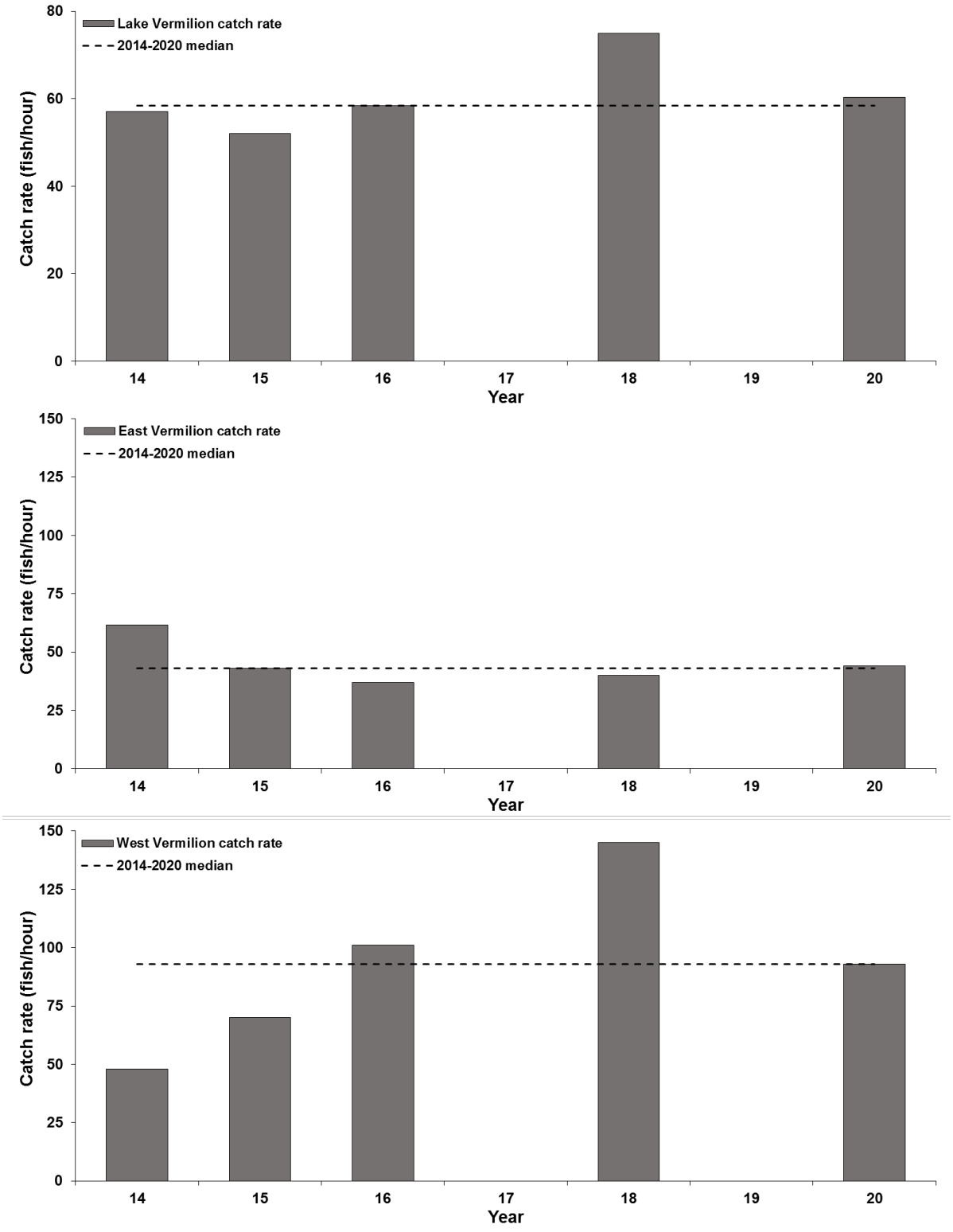

***Figure 9**. Spring electrofishing catch rates (fish/hour) of Smallmouth Bass in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 2014-2020. Gaps indicate sampling did not occur during those years. Horizontal dashed lines represent the 2014-2020 medians.*

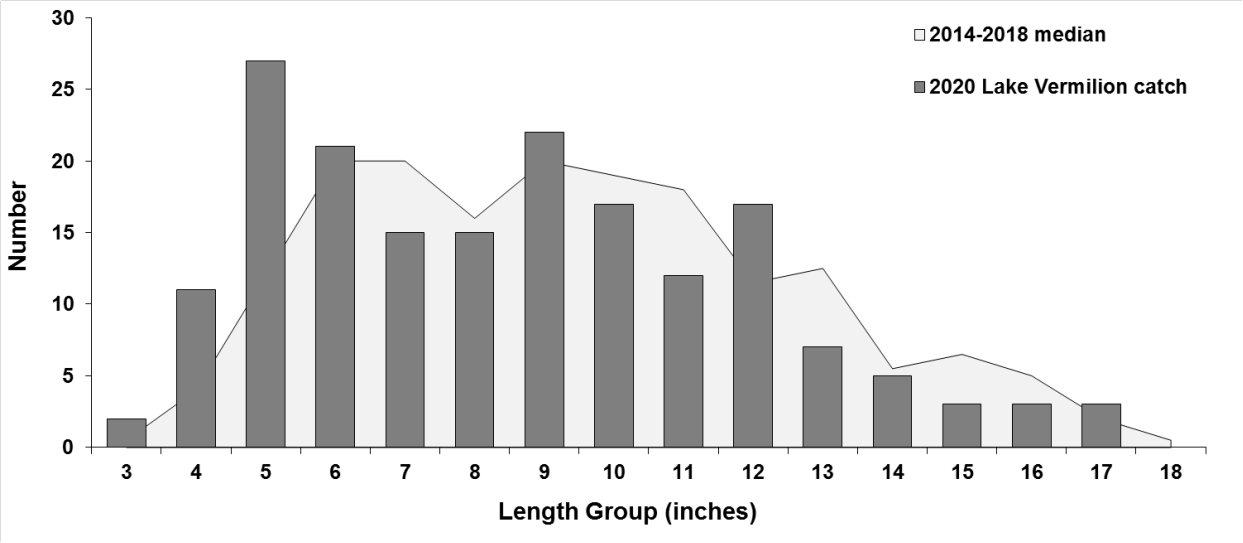

***Figure 10**. Length frequency distribution of Smallmouth Bass (dark bars) captured in Lake Vermilion during spring electrofishing in 2020 in relation to median length frequency distributions from 2014 to 2018 (light gray).*

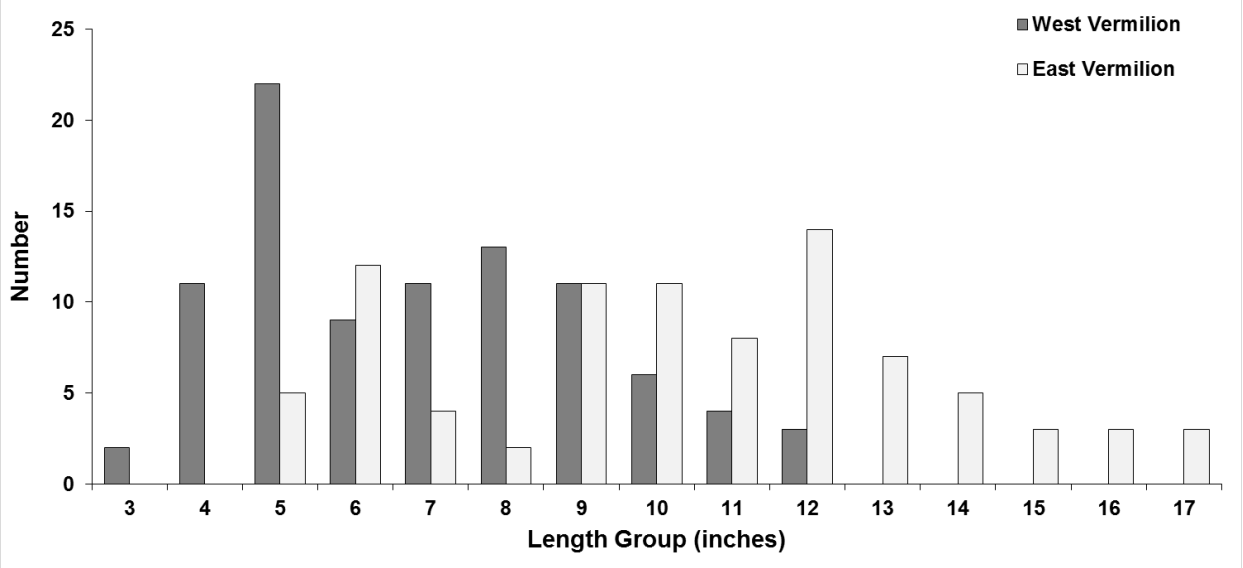

***Figure 11**. Length frequency distribution of Smallmouth Bass captured during spring electrofishing in East Vermilion (light gray bars) and West Vermilion (dark gray bars) in 2020.*

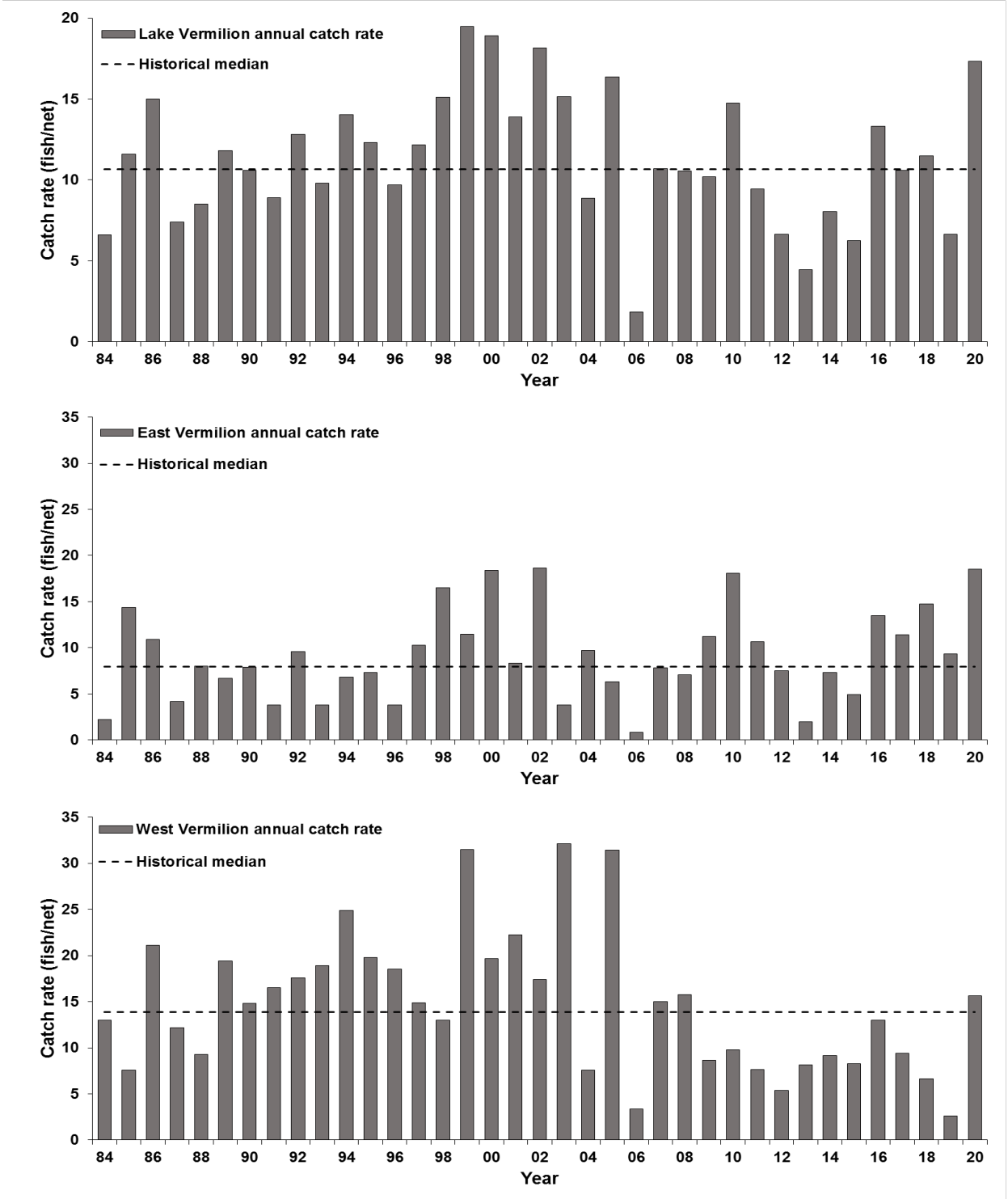

***Figure 12**. Gill-net catch rates (fish/net) of Cisco in Lake Vermilion (top), East Vermilion (middle), and West Vermilion (bottom), 1984-2020. The horizontal dashed lines represent the historical median catch rate.*