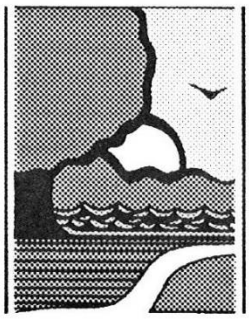

Illinois Department of Natural Resources
Division of Fisheries

Salmonid Community of Lake Michigan: 2016 Fall Harbor Assessment

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EXECUTIVE SUMMARY

Four salmonid species have been stocked in the Illinois waters of Lake Michigan at rates of approximately 304,000 Chinook Salmon, 300,000 Coho Salmon, 100,000 Rainbow Trout, and 100,000 Brown Trout annually. In 2006, the number of Chinook Salmon stocked in Illinois waters was reduced to approximately 250,500 in a lake-wide effort to reduce the prey demand placed on the forage base by the number of Chinook Salmon in the lake. Continued declines in prey-fish biomass (Madenjian *et al.*, 2012; Warner *et al.*, 2012) prompted further Chinook stocking reductions to approximately 230,000 in 2013-2016. In fall 2016, we sampled mature salmonids in four Illinois harbors to assess their relative abundance, age and growth, and the tendency of marked fish to return to the location at which they were stocked.

Chinook Salmon and Coho Salmon comprised 90.6% of the salmonids sampled. Compared to 2015, catch-per-unit-effort (CPUE) of all salmonids increased at Waukegan Harbor, Diversey Harbor, and North Point Marina while total CPUE decreased slightly at Jackson Harbor. In 2016, total numbers of Chinook Salmon, Coho Salmon, Rainbow Trout, and Brown Trout increased, but fewer Brown Trout were sampled from Diversey and Jackson harbors, and fewer Coho Salmon were sampled from Jackson Harbor. The total number of sampled Chinook Salmon and Rainbow Trout increased at every sampling location in 2016 compared to 2015.

The highest proportion (56.5%) of Chinook Salmon (N = 174) in 2016 were age-1. The second most abundant age class was age-3 (23.7%), followed by age-2 (16%), age-0 (3.5%) and age-4 (< 1%). Similar to past years, most of the coded-wire tagged Chinook Salmon captured in Waukegan Harbor (N = 190) were stocked at that harbor (74%; 140 of 190). Although numbers of sampled Chinook Salmon were lower in the other two stocked harbors, a majority of CWT fish captured at those locations were originally stocked there (47/57 Diversey Harbor; 16/25 Jackson Harbor).

INTRODUCTION

The origin of the salmon fishery in Lake Michigan dates back to 1966 when Coho Salmon were first stocked as a means to utilize and ultimately control the over-abundant Alewife population (Keller *et al*., 1990). Over 10 million salmonids are stocked annually into Lake Michigan in an attempt to control Alewife population growth and also support the world class fishery that has developed. Salmonids were first stocked in Illinois waters in 1976 and Illinois currently stocks approximately 230,000 Chinook Salmon, 300,000 Coho Salmon, 100,000 Rainbow Trout, and 100,000 Brown Trout annually comprising approximately 6% of the lake-wide stockings (Table 1).

Since the Illinois shoreline of Lake Michigan lacks permanent flowing tributaries, salmon and trout are stocked in harbors. Adult fish that return to these harbors in the fall are sampled by Lake Michigan Program staff using a DC electrofishing boat. This technique has proven both convenient and effective for collecting information on mature salmon and trout in harbors with relatively low water conductivity (approx. 150 μm/cm).

The objectives of annual fall salmonid harbor sampling are to: 1) collect data on returning fin-clipped and coded-wire tagged fish and assess movements and fidelity to stocking sites; 2) collect information on the condition and abundance of returning fish to address questions regarding health of the fish and the effects on the forage base; and 3) collect fish flesh samples to update the Illinois Fish Consumption Advisory.

METHODS

Fish were sampled using a GPP 5.0 (Smith-Root, Inc.) boat electrofishing pulsed-DC control box capable of delivering 5.0kw from the generator to the electrodes. Prior to beginning an electrofishing run, the control box was used to adjust amperage to 10-12 amps and pulse frequency was set to 60 Hz. Total sampling time was based on harbor size, weather conditions, and the amount and type of fish collected.

Most sites were sampled for approximately one hour. In some cases, however, the entire site was sampled in less than 60 minutes due to weather conditions or an abundance of shoreline anglers preventing sampling in much of the harbor. Selection of sampling sites (Figure 1) was based on harbor configurations that were conducive to electrofishing (e.g., areas < 3 m in depth) and harbors in which salmonids were stocked. In 2016, both basins of North Point Marina, the south harbor at Waukegan (referred to as Waukegan Harbor throughout), Diversey Harbor and adjacent Lincoln Park Lagoon (jointly referred to as Diversey Harbor throughout), and the inner harbor at Jackson Park (referred to as Jackson Harbor throughout) were sampled weekly between mid-September and mid-November (Table 2).

Three of the four sampling sites are stocked with a full complement of the four species; however, North Point Marina is only stocked with Brown Trout (Table 1). Salmonid species were the target of sampling efforts. Abundance of non-target species (e.g., Alewife, Gizzard Shad, and Common Carp) was usually only noted. Sampled fish were dip-netted and held onboard until biological data were obtained. Fish were measured to the nearest 5 mm (maximum total length) and weighed to the nearest 10 grams. In addition, clipped fins, lamprey wounds, sex and maturity, and snag hook wounds were recorded. Otoliths were collected from Chinook Salmon and processed as per Robillard and Marsden (1996). Chinook Salmon with an adipose fin clip, indicating a coded-wire tagged fish, also had the head removed for tag extraction. Fish tags were removed in the lab and tag numbers were used to pair stocking site and location information with specific fish. Fall harbor assessment catch-per-unit-effort (CPUE) was calculated as the number of fish sampled per one hour electrofishing effort.

RESULTS AND DISCUSSION

A total of 682 salmonids were sampled in four Illinois harbors during fall of 2016. Coho Salmon (N=310) represented the highest proportion of fish sampled, 45.5%, followed by Chinook Salmon (N=308, 45.2%),

then Brown (N=34) and Rainbow Trout (N=30) contributing 5.4 and 4.4% of the total catch in 2016 (Table 3).

Fall assessment CPUE for all salmonids combined was highest in Waukegan Harbor (38.7 fish/hour). CPUE was 26.0 fish/hour at Diversey Harbor and 15.2 fish/hour at Jackson Harbor. North Point Marina CPUE remained the lowest out of all harbors sampled, with 5.2 fish/hour (Figure 2). With the exception of anomalously high CPUEs at Jackson Harbor in 2011 and Diversey Harbor in 2009, CPUEs have exhibited a general decline since 2006, reaching decadal lows at Jackson Harbor in 2012, Waukegan Harbor in 2014, and Diversey Harbor and North Point Marina in 2015. In 2016, though, CPUE for all salmonids combined increased compared to 2015 with the exception of Jackson Harbor, where CPUE decreased slightly from 2015.

CPUEs vary from year to year at each of the sampling sites depending on the success of capturing particular species during their peak spawning run, water temperatures, growth, survival, and variability in sport angler harvest. For purposes of this assessment, it is generally assumed that CPUEs represent actual returns regardless of variability in electrofishing effort and environmental conditions among harbors.

Chinook Salmon

Chinook Salmon CPUE in 2016 was highest in Waukegan Harbor (21.3 fish/hour), followed by Jackson Harbor (9.2 fish/hour), Diversey Harbor (7.5 fish/hour), and North Point Marina (1.5 fish/hour). Chinook Salmon CPUEs at all sampling locations were below the fifteen-year (2002-2016) averages of 48.5, 31.9, 18.4, and 14.8 fish/hour at Waukegan Harbor, Diversey Harbor, Jackson Harbor, and North Point Marina, respectively.

Sampled Chinook Salmon averaged 685 mm in length and ranged from 290 to 1005 mm (Figure 3), 55 mm longer than the average length of Chinook Salmon sampled in 2015 but 36 mm shorter than the 15-year average. The most commonly sampled age group in 2016 was age-1, compared to age-2 in 2015 and age-3 in 2014. Age-1 fish averaged 614 mm in length in 2016. The observed bi-modal length distribution of Chinook Salmon in 2016 is typical for the species, however the proportion of age-1 fish (56%) is higher than in past years (15 year average proportion of age-1 fish = 24%). In fall 2016, we sampled 11 age-0 (stocked in 2016), 174 age-1, 49 age-2, 73 age-3, and one 1 age-4 Chinook Salmon (Figure 3).

Since 2011, all hatchery-reared Chinook Salmon stocked in Lake Michigan have been implanted with coded-wire tags as part of a lake-wide mass-marking program coordinated through the U.S. Fish and Wildlife Service (USFWS)[1]. An adipose fin clip, indicating the presence of a coded-wire tag (CWT), was present on 306 Chinook Salmon sampled in 2016; although CWTs from 21 individuals were either not recovered, lost, or damaged so that stocking information for these fish could not be determined. Two Chinook Salmon were collected that did not have any fin clips and origin could not be determined with certainty for this fish. Potentially, these unclipped fish could be from natural recruitment.

Information from the CWTs confirms "homing" to harbors for Illinois fish. Fish with CWTs were recaptured at the location where they were originally stocked 71.2% of the time (203 of 285; Table 4), similar to the 76% return rate measured in 2015. This information suggests that homing to harbors is not absolute; in 2016 CWTs indicated that 21 (7.4%) of the Chinook Salmon sampled in Illinois harbors were stocked in Wisconsin, and 61 (21.4%) Illinois-stocked Chinook Salmon were sampled in harbors different from their stocking location.

[1] Indiana released 52,969 unclipped Chinook salmon into Salt Creek, a tributary to Lake Michigan, in 2011.

Coho Salmon

Coho Salmon CPUE was highest at Diversey Harbor (16.8 fish/hour) and lowest at North Point Marina where 1.4 Coho were sampled per hour. With the exception of CPUEs around 25 fish/hour at Waukegan Harbor between 1998-2002, catch rate for Coho Salmon has been variable among harbors and has remained low since 2011 (i.e., < 2 fish/hour) at North Point Marina, where no salmon are stocked. Coho Salmon CPUE increased to 14.7 fish/hour at Waukegan Harbor and 16.8 fish/hour at Diversey Harbor, for a 292% and 162% increase in CPUE from 2015, respectively. Coho Salmon CPUE at Jackson Harbor decreased by 162% from 2015 to 5.09 fish/hour.

Sampled Coho Salmon ranged in length from 345 to 730 mm (Figure 4). The mean length of Coho Salmon in 2016 was 560 mm, and was above the 15-year sampling average (2002-2016, 537 mm). In past years, length distributions tended to be skewed toward smaller sizes as was seen in 2015, yet favored median size classes in 2016 (Figure 4).

In 2015, Illinois initiated the first alternating fin-clip schedule for Coho Salmon since 1998. The left pectoral clip (LP) was used for Coho Salmon stocked into Diversey harbor in 2015 and a right pectoral clip (RP) applied to Coho Salmon stocked into Waukegan Harbor in 2016. Information on returns of fin-clipped Coho Salmon has indicated that Coho Salmon generally return to Illinois harbors to spawn following two summers in the lake. In 2016, 106 Coho Salmon with LP fin-clips (i.e., stocked into Diversey Harbor in 2015) were sampled, of which 93% were collected from Diversey Harbor. The remaining LP-marked Coho Salmon sampled in 2016 were from Waukegan Harbor (n = 6) and Jackson Harbor (n = 1). Average length of LP-marked Coho Salmon was 545.5 mm (range 350-630), and no RP-marked Coho Salmon were sampled.

Rainbow Trout

Approximately 50,000 Arlee-strain and 50,000 Skamania-strain Rainbow Trout have been stocked each year since 2002. In general, relatively few Rainbow Trout are sampled during the fall in comparison to Coho and Chinook Salmon. Thirty Rainbow Trout were collected in 2016, averaging 702 mm and ranging from 400 to 785 mm (Figure 5). The time-series of relatively low Rainbow Trout CPUEs (15 year average = 0.73 fish/hour) provides little meaningful information on whether a trend in the data exists or not. Almost all (24 of 30) Rainbow Trout sampled were marked with an adipose right-pectoral (AdRP) fin clip indicating Illinois origin (Skamania-strain), and three fish were marked with an adipose only (AD) fin clip. The snouts of the AD clipped Rainbow Trout were collected but no CWTs were detected in the laboratory. Three Rainbow Trout sampled also contained no signs of a fin-clip, thus their origin (i.e., stocked or of wild recruitment) could not be determined.

An attempt to mark all Rainbow Trout stocked in Lake Michigan with fin clips has been less than successful, meaning site fidelity and growth rates have not been determined. A USFWS coordinated lake-wide mass-marking program to clip and implant Rainbow Trout with CWTs will begin in 2017.

Brown Trout

The number of Brown Trout sampled in any particular year has been highly variable and most strongly influenced by the number sampled at North Point Marina, although the recent trend has been declining CPUEs. The total number of Brown Trout captured in 2016 (N = 34) was higher than in 2015 (N = 25), but the total CPUE (0.99 fish/hour) in 2016 is lower than the 15-year average (1.69 fish/hour). Given that the number of Brown Trout stocked into Illinois waters has been consistent, it is likely that the variability in sport angler harvest and fall returns of Brown Trout is driven by stocking in other states (e.g., 700,000-900,000 stocked in Wisconsin waters annually) and weather patterns.

Fins typically are not clipped on Brown Trout stocked into Illinois waters because significant regeneration of the fins and the naturally-occurring curving of the fins by this species make identification difficult, and no Brown Trout were sampled in 2016 with fin clips indicating a stocking source outside of Illinois waters. Brown Trout averaged 560 mm in length and ranged from 390 to 750 mm (Figure 6).

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

The number of Chinook Salmon stocked in Lake Michigan was reduced in 1999 in an effort to minimize stress on the limited forage base and lessen the possibility of another epizootic outbreak which resulted in mass die-offs of Chinook Salmon in the late-1980s. Chinook Salmon numbers were reduced again in 2006 (25% lake-wide) and then again in 2013 (50% lake-wide) due to the continued decline of forage fish (primarily Alewife) and measured increases in Chinook Salmon natural recruitment. A new index of predator-prey balance has been developed by the Salmonid Work Group of the Lake Michigan Technical Committee to provide guidance to fishery management agencies, and current indications suggest that a continued decline in Alewife abundance in Lake Michigan requires further reduction in Salmonine predator stocking (Madenjian et al., 2016). In 2017, Illinois will reduce the number of stocked Chinook Salmon to 150,000 (35% reduction from 2016) to contribute to a coordinated lake-wide reduction in predators.

Recommendation: Work with Salmonid Work Group of the Lake Michigan Technical Committee to continue adapting Chinook Salmon stocking strategies and monitoring the effects of reduced Chinook Salmon stocking on a lake-wide basis; provide data to assess predator-prey dynamics.

A high return rate of stocked salmon to Illinois harbors is not likely to be realized since Illinois lacks tributary streams where fish may imprint and return to at maturity, and because relatively few fish are

stocked compared to other jurisdictions. In an attempt to identify stocking site fidelity and track mortality rates, all Chinook Salmon stocked in Illinois waters have been implanted with coded-wire tags since 2011. In the first sampling year after the project was initiated, 80% of the CWT Chinook Salmon captured were caught in the same harbor they were stocked into. This return rate had decreased below 65% in 2013 and 2014, but has returned closer to original return rates over 2015 and 2016 (75% and 71%, respectively). Beginning in 2017, the USFWS-coordinated lake-wide mass-marking program will begin marking Chinook Salmon with an adipose-only clip (i.e., no CWT), and CWT tagging efforts will instead be focused on identifying growth, movements, and site fidelity of Rainbow Trout stocked in Lake Michigan.

A Coho Salmon marking program was initiated in Illinois in 2015, with stocked Coho Salmon receiving an RP or LP fin clip, alternating by year and stocking location. Clip returns during 2016 suggest high site fidelity (96%) by LP-clipped Coho Salmon stocked into Diversey Harbor in 2015. No RP-clipped Coho Salmon (stocked into Waukegan Harbor in 2016) were sampled. Coho Salmon stocked into Diversey Harbor in 2017 will receive LP-clips.

Recommendation: Begin participation in lake-wide marking (i.e., CWT) of Rainbow Trout in 2017 to evaluate site fidelity to stocking locations. Continue fin clipping Coho Salmon and examination of site fidelity to stocking locations.

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Table 1. The 2016 salmonid stocking numbers for the Illinois waters of Lake Michigan and the sites where fall harbor assessments were conducted.

		Number of fish stocked				
Location	Fall harbor assessment site	Coho Salmon	Chinook Salmon	Rainbow Trout (Arlee)	Rainbow Trout (Skamania)	Brown Trout
North Point Marina	X					10,004
Waukegan Harbor	X	106,606	79,788		27,287	10,004
Highland Park				10,002		10,089
Dawes Park				10,001		10,090
Montrose Harbor				10,017		10,175
Belmont Harbor						10,059
Diversey Harbor	X	90,908	73,958		27,145	10,059
Burnham Harbor				10,018		10,175
31st Street Harbor				10,018		10,060
Jackson Harbor	X	101,882	77,632	10,012		10,038
Calumet Harbor						10,038
TOTALS		**299,396**	**231,378**	**60,068**	**54,432**	**110,791**

Table 2. Amount of electrofishing effort (min) and water temperature in four Illinois harbors sampled in 2016. Dates are separated over nine 1-week periods.

	Location			
Dates	North Point Marina	Waukegan Harbor	Diversey Harbor	Jackson Harbor
20, 21 September	60 / 60F	55 / 62F	47 / 68F	30 / 71F
26, 27 September	52 / 61F	67 / 62F	72 / 64F	25 / 70F
3, 5 October	53 / 62F	77 / 59F	52 / 64F	32 / 67F
13, 14 October	55 / 61F	77 / 60F	53 / 60F	25 / 63F
20, 21 October	55 / 59F	65 / 58F	60 / 61F	25 / 63F
26, 27 October	64 / 52F	60 / 52F	60 / 56F	22 / 56F
31 October, 4 November	63 / 56F	56 / 57F	72 / 56F	30 / 58F
7, 10 November	58 / 53F	60 / 53F	31 / 58F	N/A
15, 16 November	64 / 50F	55 / 50F	60 / 51F	N/A

Table 3. Total electrofishing effort (hrs) and numbers of salmonids sampled in four Illinois harbors in 2016.

Harbor	Effort (hrs)	Coho Salmon	Chinook Salmon	Rainbow Trout	Brown Trout	All salmonids
North Point Marina	8.73	12	13	2	18	45
Waukegan Harbor	9.53	140	203	12	14	369
Diversey Harbor	8.45	142	63	14	1	220
Jackson Harbor	3.15	16	203	2	1	48
All Harbors	**29.86**	**310**	**308**	**30**	**34**	**682**

Table 4. Origin and count of Chinook Salmon with coded-wire tags sampled in four Illinois harbors in 2016.

Stocking year	Stocking location	Sampling Location			
		North Point Marina	Waukegan Harbor	Diversey Harbor	Jackson Harbor
2012	IL-Waukegan Harbor	0	1	0	0
2013	IL-Diversey Harbor	1	9	0	2
	IL-Jackson Harbor	0	2	1	2
	IL-Waukegan Harbor	0	42	1	0
	WI-Kenosha/Racine	2	5	0	1
	WI-Multiple sites	0	1	0	0
2014	IL-Diversey Harbor	0	4	2	1
	IL-Jackson Harbor	0	0	1	3
	IL-Waukegan Harbor	0	27	2	1
	WI-Kenosha/Racine	0	2	1	0
2015	IL-Diversey Harbor	2	15	43	2
	IL-Jackson Harbor	0	3	1	7
	IL-Waukegan Harbor	6	70	3	0
	WI-Kenosha/Racine	2	6	0	1
2016	IL-Diversey Harbor	0	1	2	1
	IL-Jackson Harbor	0	2	0	4

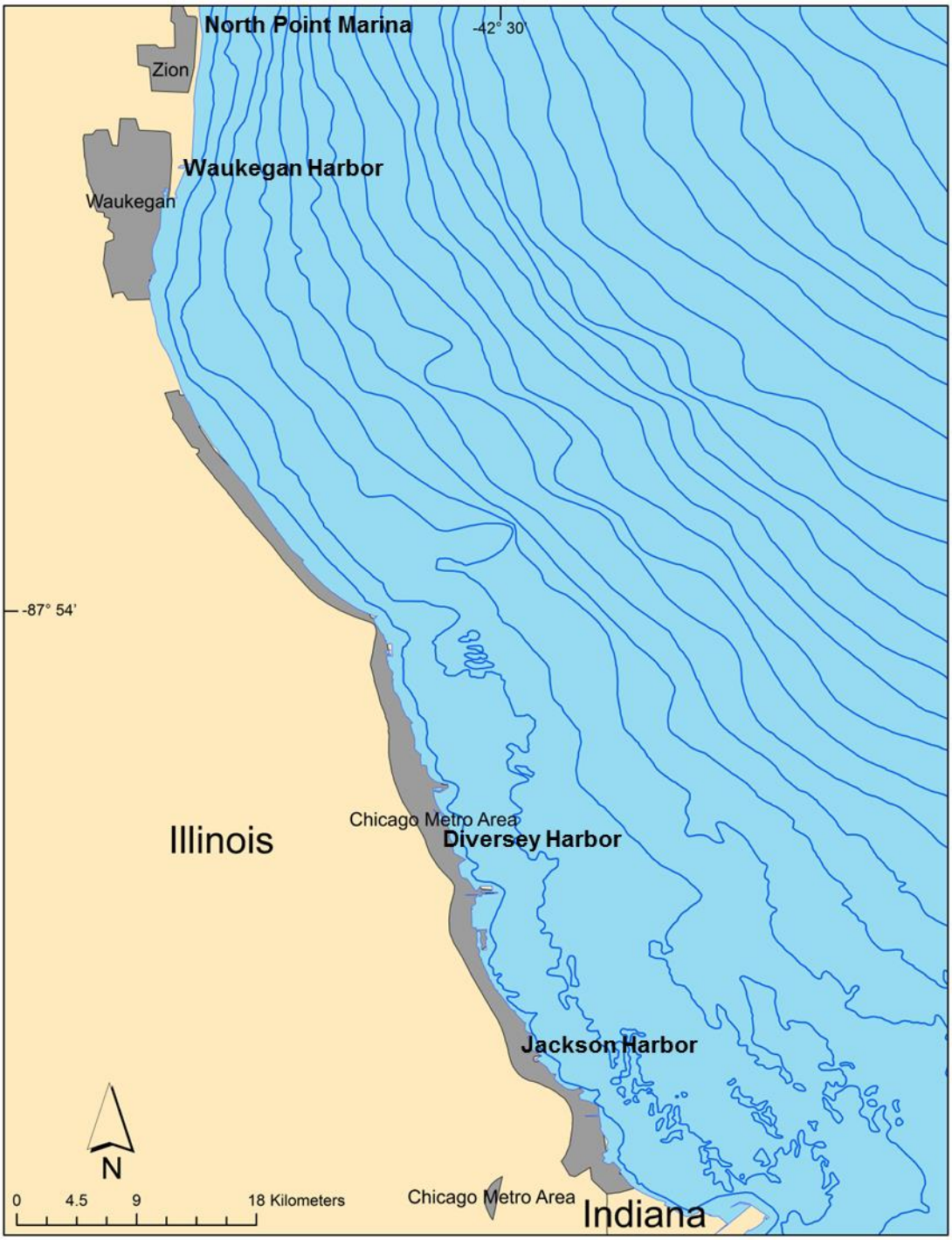

Figure 1. Sites of fall harbor salmonid assessments in 2016.

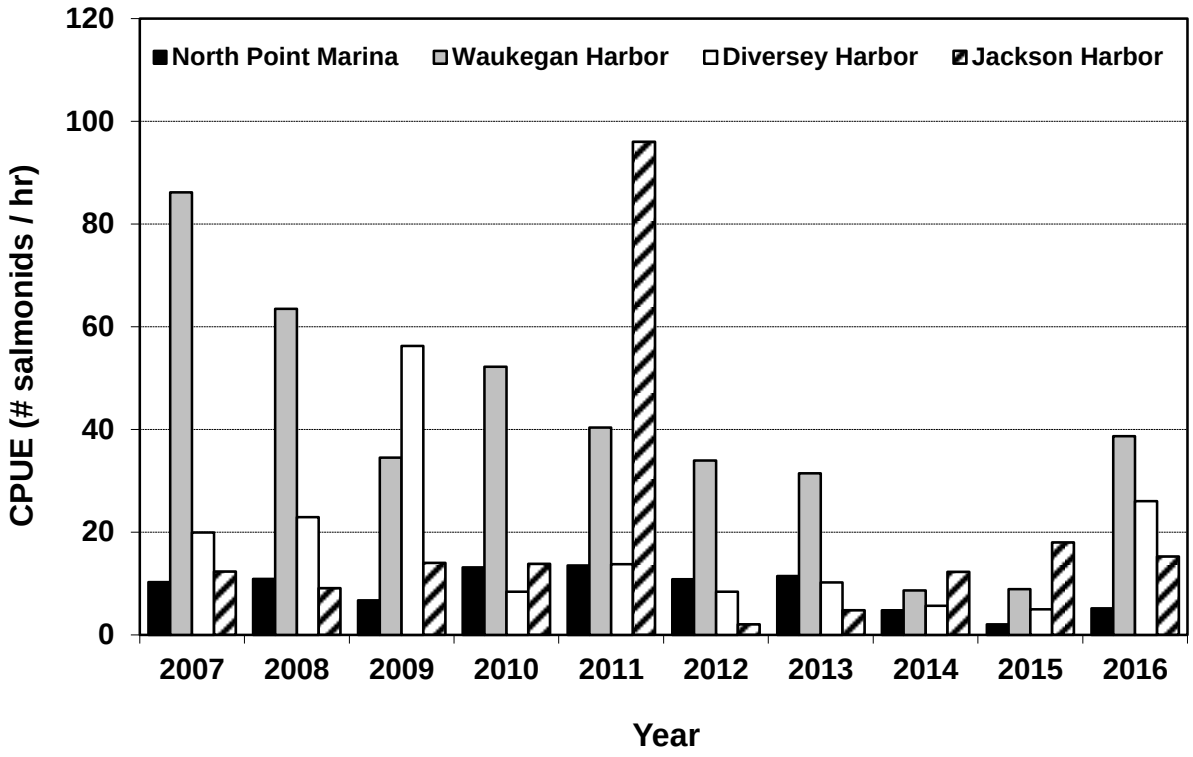

Figure 2. Catch-per-unit-effort (CPUE) of all salmonid species captured at four sampling sites from 2007 to 2016.

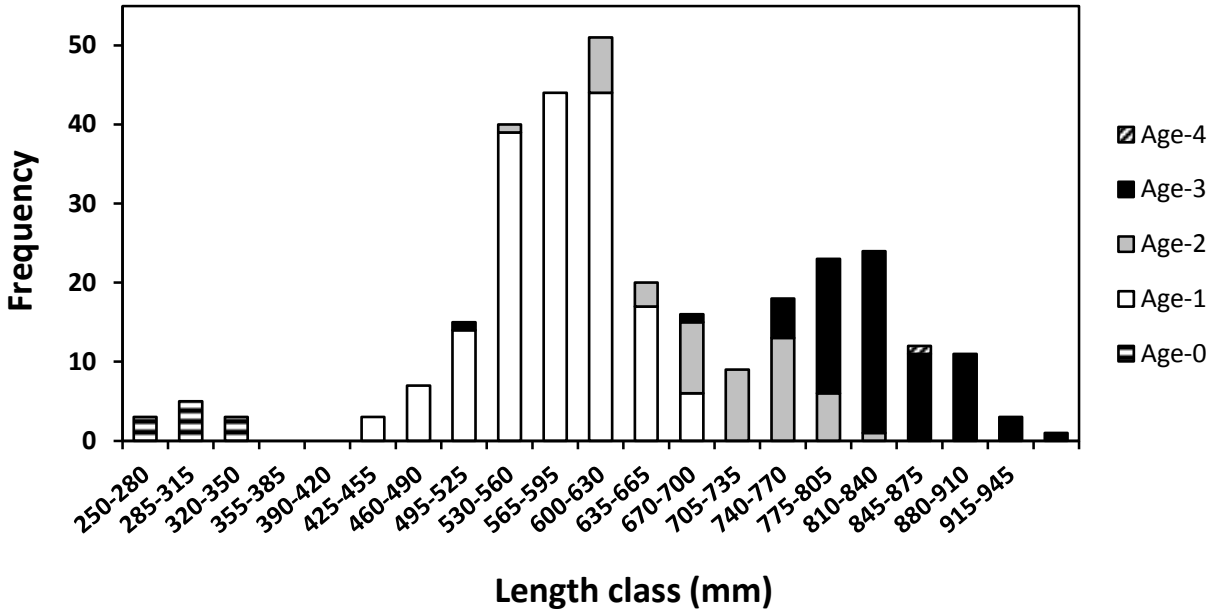

Figure 3. Length distribution of age-0 through age-4 Chinook Salmon sampled in four Illinois harbors in 2016.

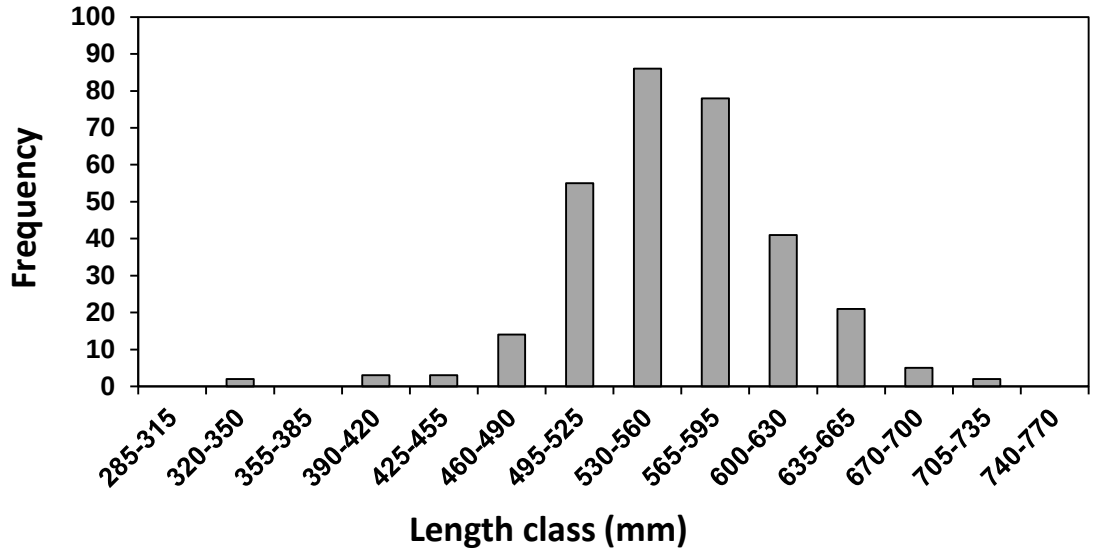

Figure 4. Length distributions of Coho Salmon sampled from four Illinois harbors in 2016.

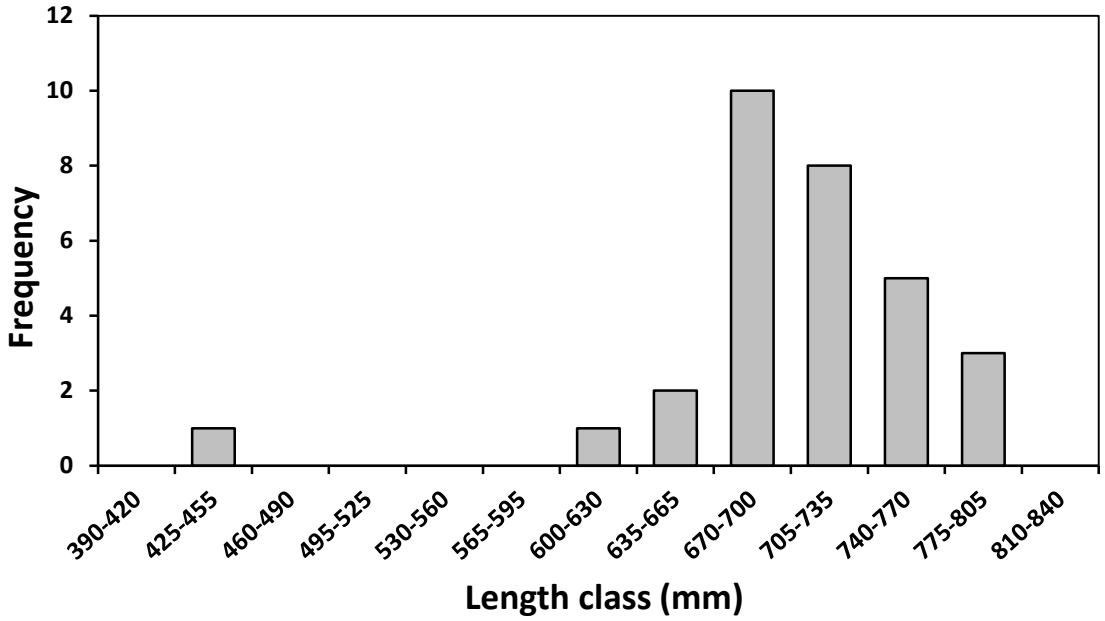

Figure 5. Length distribution of Rainbow Trout captured at four Illinois harbors in 2016.

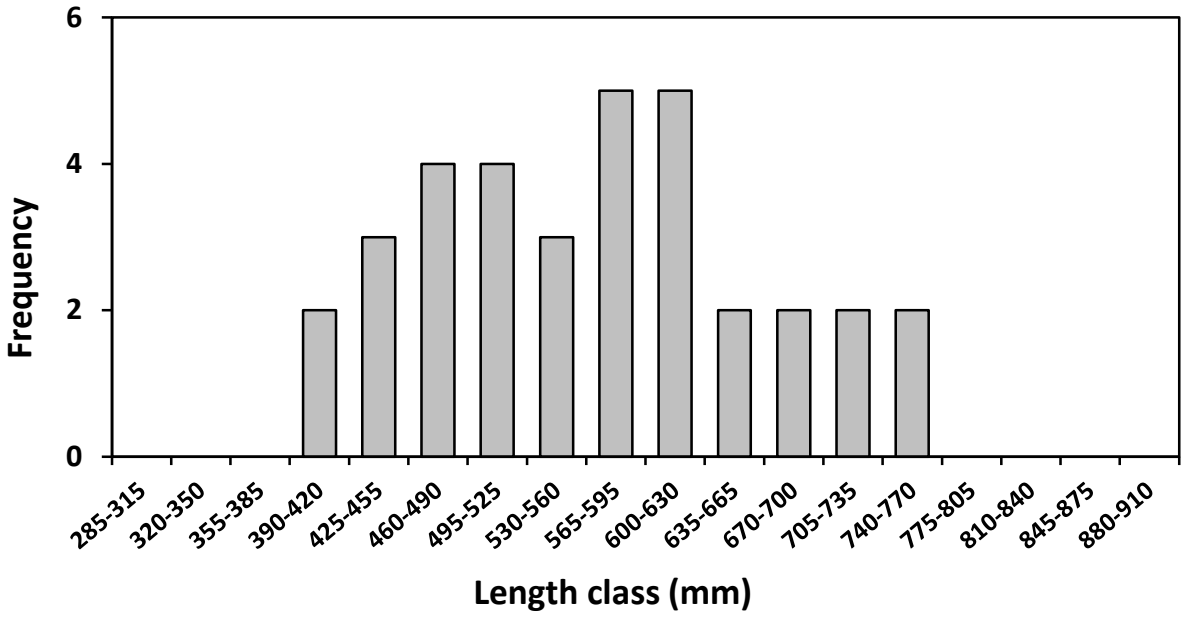

Figure 6. Length distribution of Brown Trout sampled from four Illinois harbors in 2016.