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ECOLOGICAL IMPACT OF WATER-LEVEL DRAWDOWN ON LAKE CHUBSUCKER (*ERIMYZON SUCETTA*) IN THE ST. CLAIR NATIONAL WILDLIFE AREA

Context

The St. Clair National Wildlife Area (NWA) is a 352 ha wetland complex located on the east shore of Lake St. Clair in the municipality of Chatham-Kent, Ontario. Between 1940 and 1980, a series of dykes, pumps, and other water control structures were installed within the St. Clair Unit to maintain water levels in the East and West wetland cells. Dyking was necessary to maintain wetted area and other habitat functions in the face of drainage modifications to the surrounding landscape and due to ongoing water-level fluctuations of Lake St. Clair (ECCC 2018).

Management of the St. Clair NWA is the responsibility of the Canadian Wildlife Service of Environment and Climate Change Canada (ECCC). Currently, thirty five species (birds, reptiles, insects, fishes, vascular plants) listed under the *Species at Risk Act* (SARA) occur within the NWA. The area is also internationally recognized as an important migratory stopover for numerous waterfowl and other migratory bird species. The management plan for the St. Clair NWA (ECCC 2018) identifies periodic water-level drawdown through the dyke and pump system as a necessary activity to maintain a diverse, native aquatic vegetation community, similar to the water-level fluctuations experienced in an undyked coastal wetland. Periodic drying of soils is aimed at rejuvenating the seed bank of native aquatic plants and achieving hemi-marsh conditions (described as an equal ratio of vegetated and open water), but may also allow for targeted removal of exposed plants, such as American White Water-lily (*Nymphaea odorata*) and the invasive European Common Reed (*Phragmites australis subsp. australis)*.

Water-level drawdown was proposed for 2020, which was intended to achieve a 95% reduction of water volume over a five month period in the East cell of the St. Clair Unit. Although the long-term maintenance of native aquatic vegetation imposed by such a drawdown may benefit fishes within the cell, concern exists that drawdown will impose substantial mortality or other negative effects on Lake Chubsucker (*Erimyzon succetta)*, SARA listed as Endangered, owing to stranding or other effects (e.g., increased predation by waterbirds; Bouvier and Mandrak 2011). DFO's Species at Risk and Fish and Fish Habitat Protection programs have requested that DFO Science provide advice on the potential impact of water-level drawdown on Lake Chubsucker; namely, to identify: 1) the relationship between drawdown increment and available refuge habitat for Lake Chubsucker in the East cell; 2) the relationship between habitat availability and Lake Chubsucker abundance; and, 3) the potential for deep water habitat creation in advance of drawdown to increase available refuge.

This Science Response Report results from the Science Response Process of May 14, 2020 and February 9, 2021 on the Ecological Impact of Water-Level Drawdown on Lake Chubsucker (*Erimyzon Sucetta*) in the St. Clair National Wildlife Area.

Analysis and Response

Background

The St. Clair Unit of the St. Clair NWA is composed of the East and West cells, which are small (East: 60.9 ha wetted area) impounded wetlands whose water levels are controlled by a dyke and pump system. Both cells are shallow (< 2 m depth) and contain numerous native and non-native emergent and submerged aquatic vegetation species, though cattail (*Typha* spp.) predominates (ECCC 2018). ECCC (2018) provides a brief history of the installation of dykes that resulted in the creation of the East and West cells, as well as the intended role of water-level drawdown for achieving hemi-marsh conditions and the natural hydrologic cycles (flooding, drying) common within coastal wetlands.

The primary rationale for drawdown in the St. Clair NWA is the management of aquatic plant species. Periodic drying and re-flooding of soils can rejuvenate marsh soil, maintain native seed banks, and ensure the proliferation of diverse aquatic plant communities (ECCC 2018). In the absence of drawdown, aquatic plant monocultures can occur because certain species are less reliant on drawdown and flooding. Soil exposure during drawdown can also facilitate the targeted removal of undesirable and (or) invasive plant species. European Common Reed, an invasive emergent species, has increased in stand size in the East cell from 1.51 ha to 8.13 ha between 2010 and 2015 (Melanie Shapiera, pers. comm., ECCC). Additionally, White Water Lily, a native floating-leaf plant species, has increased within previously open water areas. The increase of White Water Lily has decreased available habitat for areal foraging bird species such as Forster’s and Black Terns (ECCC 2018). Concerns also exist that the proliferation of White Water Lily may impede water circulation within the East cell (ECCC 2018).

Drawdown of the East cell

To inform the proposed drawdown for 2020, ECCC conducted bathymetric measurements in the East cell to understand the relationship between drawdown increment and wetted area. These data were used by ECCC to understand the expected degree of soil exposure for a given drawdown increment. Based on these data and an assumed normal operating level (NOL) of 176.0 m, ECCC proposed a 0.60 m drawdown increment, which would lead to a 95% reduction in water volume and reduction of 80% of the wetted area in the East cell for a five month period; the NOL was revised to 176.1 m based on 2019 data. The drawdown would begin April 15, and full drawdown conditions would occur May 15 through September 15, 2020.

The 0.60 m increment and five month period was chosen to maximize seedbank exposure and the eventual regeneration of native macrophyte species, and to allow targeted control efforts of exposed White Water Lily and European Common Reed. Consideration was also given to the availability of deep water refuge for fishes and other aquatic species. However, because the proposed drawdown increment is likely to lead to substantial reductions in available habitat for Lake Chubsucker during the drawdown period, science advice has been requested on the relationship between drawdown increment and refuge habitat for the species. The salvage of Lake Chubsucker from the East cell prior to drawdown is unlikely to be an effective mitigation strategy due to the size of salvage area and potential for fish stranding in areas that would be inaccessible by field crews, so modifications to the proposed drawdown increment, including the creation of deep water habitat, may be considered as a mechanism to reduce or avoid the ecological impact to Lake Chubsucker.

This science response evaluates refuge habitat availability for Lake Chubsucker; additional SARA-listed species in the East cell (such as turtles or birds) are not considered.

Life History and Habitat Requirements of Lake Chubsucker

An extensive review of the life cycle and habitat requirements of Lake Chubsucker is provided in Bouvier and Mandrak (2011). In brief, spawning occurs in the late spring (late April to June), when water temperatures reach approximately 20 °C. Young hatch shortly thereafter at temperatures between 22 and 29 °C. Spawning habitat consists of shallow waters containing beds of aquatic vegetation, dead grasses, or filamentous algae. Young of year (YOY) habitat is described as shallow (> 0 to 2 m) habitats containing heavy aquatic vegetation. Young of year have been collected in Ontario in as little as 0.1 m water depth (Bouvier and Mandrak 2011). Young of year are typically captured in Ontario in areas with aquatic vegetation cover > 70%, and have been collected in proximity to numerous submerged, emergent, and floating plant species, including European Common Reed and White Water Lily. Juvenile habitat is presumed to be similar to young of year habitat. Based on the known collection records of Lake Chubsucker in Ontario until 2011, adults have been known to occupy water depths from 0.38 m to 2 m, though the upper bound reflects sampling restrictions (Bouvier and Mandrak 2011). Although Lake Chubsucker is tolerant of low levels of dissolved oxygen (Cooper 1983), the species is susceptible to hypoxia during the overwinter period, seen in a large hypoxia-induced mortality event in the Old Ausable Channel (Bouvier and Mandrak 2011). Most populations in Ontario have access to deep water habitats (e.g., areas > 2 m depth; DFO, unpublished data), and it is presumed that deep water refugia is used during periods of drought or hypoxia.

Population Modelling of Lake Chubsucker

Population modelling of Lake Chubsucker was conducted as part of DFO’s Recovery Potential Assessment of the species (Young and Koops 2011). Elasticity analysis, which identifies the sensitivity of population growth rate to chronic changes in stage-specific vital rates, indicated that population growth rate was most sensitive to changes in early life survival (ages 1 and 2; Young and Koops 2011). Lake Chubsucker populations were also sensitive to changes in survival and fecundity of newly mature adults, while changes in older adult rates of survival and fecundity were less important (Young and Koops 2011).

The minimum viable population (MVP) of Lake Chubsucker was evaluated (Young and Koops 2011). Based on an extinction threshold of two individuals and assuming a catastrophic decline (50% reduction in abundance) that occurred at a probability of 0.10 per generation, MVP was 800 adults, aged 2–8 (range: 600–1,000 adults). However, when catastrophes occurred at 15% per generation (~4% annually), MVP was estimated as 2,730 adults (range: 1,936–3,764). If a Lake Chubsucker population experienced significant winterkill or other widespread mortality more frequently than 4% annually, MVP would be much higher. For example, the frequent winterkill scenario (15% annually or 44% per generation) resulted in an MVP of over 10 million adults. MVP also increased when the extinction threshold was increased. Increasing the extinction threshold from two to 20 adults, and assuming a 15% chance of catastrophe per generation, increased MVP from 2,730 to 16,800 adults. Taken together, these results indicate that 1) MVP increases when large mortality events occur; and, 2) increasing the extinction threshold sharply increases MVP. It should be noted that a drawdown event would be best represented by a model that assumes a transient (e.g., one to three year) increase to mortality, rather than the chronic perturbations outlined in Young and Koops (2011).

The minimum area for population viability (MAPV), which represents the habitat area necessary to support MVP, was calculated by combining the required stage-specific habitat area per individual with MVP estimates (see Minns 1995 and Randall et al. 1995, summarized in Young and Koops 2011). Based on a stable stage distribution of 99.2% young of year, 0.05% age-1, and 0.03% adults (ages 2–8) and a MVP of 2,730 adults (extinction threshold of two individuals and 0.15 probability of catastrophe per generation), a Lake Chubsucker population would require 100 ha of suitable habitat (Table 1). However, if the extinction threshold is increased to 50 individuals, MAPV increases sharply to 1,600 ha of habitat. This approach assumes that available habitat is perfectly suited to the species, and does not account for the potential overlap of individual habitats among life stages. Under the MAPV of 100 ha, the required habitat area is greatest for young of year (94 ha), followed by age-1 (2 ha), and ages 2–8 (4 ha). Under the MAPV of 1,600 ha scenario, Lake Chubsucker would require 1,549 ha (young of year), 35 ha (age-1), and 60 ha (ages 2-8). If habitat sharing among life stages occurs, the young of year estimates represent MAPV of the population as a whole (94 ha and 1,549 ha; Table 1).

Table 1. Age, stable stage distribution (percentage of the population in each stage), area per individual (API), number of individuals for each age class to support a minimum viable population (MVP), and the resulting estimate of required habitat area for each stage and for the entire population (MAPV). A 15% per generation probability of catastrophe was assumed. MVP^1 and MAPV^1 were based on an extinction threshold of two individuals, while MVP^2 and MAPV^2 were based on an extinction threshold of 50 individuals. Adopted from Young and Koops 2011.

Age	Distribution (%)	API (m^2)	MVP^1	MAPV^1 (km^2)	MAPV^1 (ha)	MVP^2	MAPV^2 (km^2)	MAPV^2 (ha)
0	99.92	0.1	9.08×10^6	0.94	94	150×10^6	15.49	1,549
1	0.05	4.7	4,556	0.02	2	75,047	0.35	35
2-8	0.03	8.5–45.9	2,730	0.04	4	44,976	0.60	60
All	-	-	-	1.0	100	-	16.44	1,644

Lake Chubsucker in the St. Clair NWA

Lake Chubsucker has been detected in both the East and West cells of the St. Clair Unit. Detections of Lake Chubsucker in the West cell occurred in 2004 (six individuals; Bouvier 2006), 2016 (19 individuals; DFO, unpublished data), and 2019 (five individuals; Barnucz et al. 2021), while detections in the East cell occurred in 2016 (22 individuals; Biotactic 2016), 2018 (six individuals; Barnucz et al. 2021), and 2019 (9 individuals; Barnucz et al. 2021). Multiple year classes have been detected in both cells, indicating that reproduction is likely occurring. Detections in the East cell in 2016 were presumed to be young of year (mean total length 47.1 mm, 55.3 mm, and 77.6 mm total length (TL) in July, August, and September, respectively; Biotactic 2016), and were captured in shallow water (0.25 to 0.45 m depth) with organic substrate and *Chara* sp. nearby (Biotactic 2016). Detections by DFO in 2018 occurred in September, with specimens ranging from 75 to 200 mm TL. These individuals were captured at sites with mean depth of between 0.57 and 1.13 m and submerged aquatic vegetation coverage between 50 and 60%, emergent vegetation between 5 and 20%, floating vegetation between 20 and 40%, and open water coverage (i.e., un-vegetated area) of 0%. Lake Chubsucker captured by DFO during September 2019 ranged from 74 to 215 mm TL. These individuals were captured at sites with mean depth of between 0.64 and 1.73 m and submerged aquatic vegetation coverage between 40 and 80%, emergent vegetation between 5 and 10%, floating vegetation between 10 and 50%, and open water coverage (i.e., un-vegetated area) between 0 and 5%. Further details of DFO sampling in September 2018 and 2019 can be found in Barnucz et al. (2021).

Both cells contain warmwater fish communities, with the East cell supporting a predominance of Centrarchid species. Sampling by DFO in the East cell in 2018 (May and September) documented 1,386 fishes representing 16 species, including Lake Chubsucker. Based on pooled catch data across surveyed sites, the most abundant species in the East cell were Pumpkinseed (68.5% of total fishes captured), Black Crappie (9.7%), Largemouth Bass (7.4%), Bowfin (6.1%), and Brown Bullhead (1.9%). Lake Chubsucker (n = 6) was detected at four netting locations and represented 0.4% of total abundance (Barnucz et al. 2021). Similar trends were observed in the East cell during 2019 sampling (September only), with the collection of 768 fishes representing 13 species. Based on pooled catch data across surveyed sites, the most abundant species in the East cell were Pumpkinseed (61.7% of total abundance), Golden Shiner (9.2%), Black Crappie (7.0%), Largemouth Bass (6.8%), and Bowfin (4.6%). Lake Chubsucker (n = 9) was detected at six netting locations and represented 1.2% of total abundance (Barnucz et al. 2021). Movement of fishes including Lake Chubsucker between the cells via the pump system is presumed to be infrequent. Further description of the fish community and aquatic habitat features of both cells can be found in Marson et al. (2010), F. Montgomery (University of Toronto Scarborough; 2019 unpublished data), ECCC (2018), and Barnucz et al. (2021).

Ecological Impact of Water-level Drawdown

The relationship between water-level drawdown, changes in aquatic habitat during the drawdown period, and ecological impact on Lake Chubsucker is dependent on the magnitude and duration of the drawdown. Greater drawdown increments and longer duration will impose greater changes in aquatic habitat availability, which will impose greater changes to Lake Chubsucker growth, mortality, or reproduction. The relationships between drawdown and aquatic habitat change, and aquatic habitat change and the response of Lake Chubsucker, may be non-linear, as fishes have some adaptive capacity to withstand changes in habitat, after which a response in productivity, growth, and (or) reproduction may occur (DFO 2013).

In brief, water-level drawdown imposes an immediate loss of wetted area and water volume, with the severity dependent on the increment. The reduction in wetted area and volume will increase the density of Lake Chubsucker and co-occurring species in the remaining habitat area, which can increase density-dependent impacts. Density-dependent impacts include increased predation risk owing to a higher probability of encounter with fish or bird predators; reduced food supply and the potential for growth effects owing to higher density of competitors; increased potential for disease transfer due to crowding; and, reduced dissolved oxygen due to heightened fish density. These density-dependent effects could be exacerbated as the timing of the drawdown overlaps the spawning and nursery windows when Lake Chubsucker is likely to concentrate in shallower areas. The drawdown is proposed to begin at the start of spawning season, leaving adults susceptible to stranding if they do not complete spawning and recede to deeper waters in time. Spawning could be foregone altogether if habitat has been compressed prior to commencement of spawning (i.e., in cooler springs). Eggs and young of year are also at risk of being stranded in shallow pools that may dry completely or will not be of sufficient size to support them. Additionally, a reduction in wetted area and water volume can also cause density-independent effects, such as increased water temperature owing to poor thermal buffering capacity of remaining shallow water; decreased dissolved oxygen due to increased water temperature; and, loss of structure and cover when certain habitat patches become inaccessible.

Density-dependent and density-independent effects can independently or collectively lead to changes in the productivity of Lake Chubsucker through changes in reproductive success, decreased growth, and increased mortality. DFO (2013) reviewed the relationships between changes in wetted area, dissolved oxygen, food supply, temperature, decreasing structure/cover (including vegetation), and access to habitat on the productivity of fish populations. These relationships are generally negative, with some support for non-linear responses of productivity.

Relationship Between Drawdown Increment and Total Refuge Habitat

High resolution bathymetric measurements obtained by ECCC for the East cell were provided to DFO for analysis of the relationship between drawdown increment and refuge habitat (Figure 1). The depth raster was converted to a discrete matrix of depth measurements with a spatial resolution of 1 m^2. A baseline NOL of 176.1 m was assumed, based on correspondence from ECCC (Melanie Shapiera, pers. comm., ECCC) about NOL during 2019. The availability of refuge habitat for Lake Chubsucker considers only water availability under different drawdown increments; analysis was not conducted to determine the availability of particular habitat features (e.g., macrophyte composition; substrate type). Analysis was also not conducted on the short vs. long-term effects of drawdown on Lake Chubsucker; this science response only considers the change in ecological conditions experienced during the drawdown period.

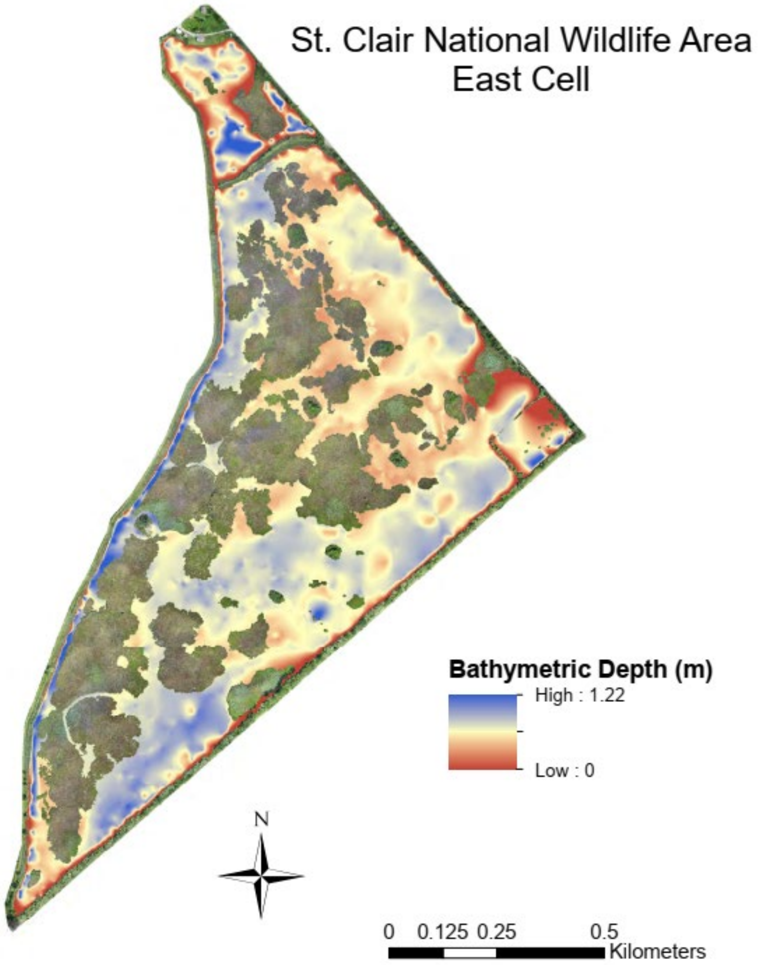

Figure 1. Bathymetric data for the East cell, with depth measurements based on NOL 176.0 m; subsequent analysis by ECCC indicates NOL 176.1 m as of 2019. Figure provided by Environment and Climate Change Canada.

To understand the relationship between drawdown increment and refuge habitat, the wetted area (ha), water volume (m^3), mean depth (m), median depth (m), 75th percentile of depth (m), 90th percentile of depth (m), and water area (ha) above three depth thresholds (0.5, 0.75, 1.0 m) was calculated for 0.05 m drawdown increments between 0 m and 0.75 m below NOL = 176.1 m. Wetted area and the area above each depth threshold (0.5, 0.75, 1.0 m) were considered the primary determinants of total refuge habitat availability. Although young of year have been collected in as little as 0.24 m depth and adults in water as shallow as 0.57 m in the East cell, the species' preferred depth is up to at least 2 m. Therefore, a reduction in wetted area will decrease habitat availability for both young of year and adults, which will impose density-dependent effects on those life stages. The area above each depth threshold (hereafter, 'deep water habitat') was incorporated to account for density-dependent effects where depth is a determinant of growth or mortality. Deep water habitat also provides the greatest protection against density-independent effects due to increased thermal buffering capacity and greater volume of undisturbed habitat during the drawdown period. In general, as the area of wetted and deep water refuge habitat declines, the ecological impact to Lake Chubsucker will increase, whether due to density-dependent effects (e.g., increased predation by waterbirds and fishes; food limitation and growth reductions; disease transfer) or density-independent effects (e.g., changes in temperature and dissolved oxygen).

In the absence of water-level drawdown, the East cell has 60.9 ha of wetted area and contains 355,307 m^3 of water (Table 2). The cell is relatively shallow; maximum depth is 1.31 m, mean depth is 0.58 m, and median depth is 0.60 m (Table 2, Figure 2). The distribution of water area vs. depth is shown in Figure 2; Figure 3 provides the cumulative distribution of depth vs. area. Bathymetric data indicate poor availability of deep water habitat in the East cell under baseline conditions (0.23 ha > 1 m in depth, 4.77 ha > 0.75 m in depth, and 47.5 ha > 0.5 m in depth; Table 2, Figures 2, 3). Moreover, the wetted area of the East cell in the absence of water-level drawdown (NOL of 176.1 m: 60.9 ha) is less than the smallest estimate of MAPV for Lake Chubsucker (100 ha) (Table 1). If only a subset of the wetted portion of the East cell is functioning as Lake Chubsucker habitat, then the habitat deficit relative to MAPV is even greater.

Table 2. Relationship between drawdown increment (shown as metres below normal operating levels (NOL) of 176.1 m), water volume, mean depth, maximum depth, median depth, 75th percentile of depth, 90th percentile of depth, wetted area, and refuge area > 1m, > 0.75, and > 0.5 m in depth. The drawdown increment of 0 represents baseline conditions in the absence of water-level drawdown.

Drawdown Increment (m below NOL 176.1 m)	Volume (m^3)	Mean Depth (m)	Max Depth (m)	Median Depth (m)	75th Percentile of depth (m)	90th Percentile of depth (m)	Wetted Area (ha)	Refuge Area > 1m depth (ha)	Refuge Area > 0.75 m depth (ha)	Refuge Area > 0.5 m depth (ha)
0 (baseline)	355308	0.58	1.31	0.60	0.67	0.73	60.93	0.23	4.77	47.50
0.05	324844	0.53	1.26	0.55	0.62	0.68	60.93	0.07	0.58	39.58
0.1	294388	0.48	1.21	0.50	0.57	0.63	60.64	0.02	0.44	30.02
0.15	264291	0.43	1.16	0.45	0.52	0.58	59.82	0.01	0.31	19.28
0.2	234555	0.38	1.11	0.40	0.47	0.53	59.13	0.0013	0.21	10.10
0.25	205164	0.34	1.06	0.35	0.42	0.48	58.43	0.0005	0.13	4.77
0.3	176125	0.29	1.01	0.30	0.37	0.43	57.72	0.0001	0.07	2.50
0.35	147457	0.24	0.96	0.25	0.32	0.38	56.95	0	0.02	1.40
0.4	119194	0.20	0.91	0.20	0.27	0.33	56.07	0	0.0058	0.86
0.45	91632	0.15	0.86	0.15	0.22	0.28	53.69	0	0.0013	0.46
0.5	66211	0.11	0.81	0.10	0.17	0.23	47.50	0	0.0005	0.23
0.55	44368	0.07	0.76	0.05	0.12	0.18	39.58	0	0.0001	0.096
0.6	26899	0.04	0.71	0.00	0.07	0.13	30.02	0	0	0.0239
0.65	14613	0.02	0.66	0.00	0.02	0.08	19.28	0	0	0.0063
0.7	7373	0.01	0.61	0.00	0.00	0.03	10.10	0	0	0.0014
0.75	3856	0.01	0.56	0.00	0.00	0.00	4.77	0	0	0.0005

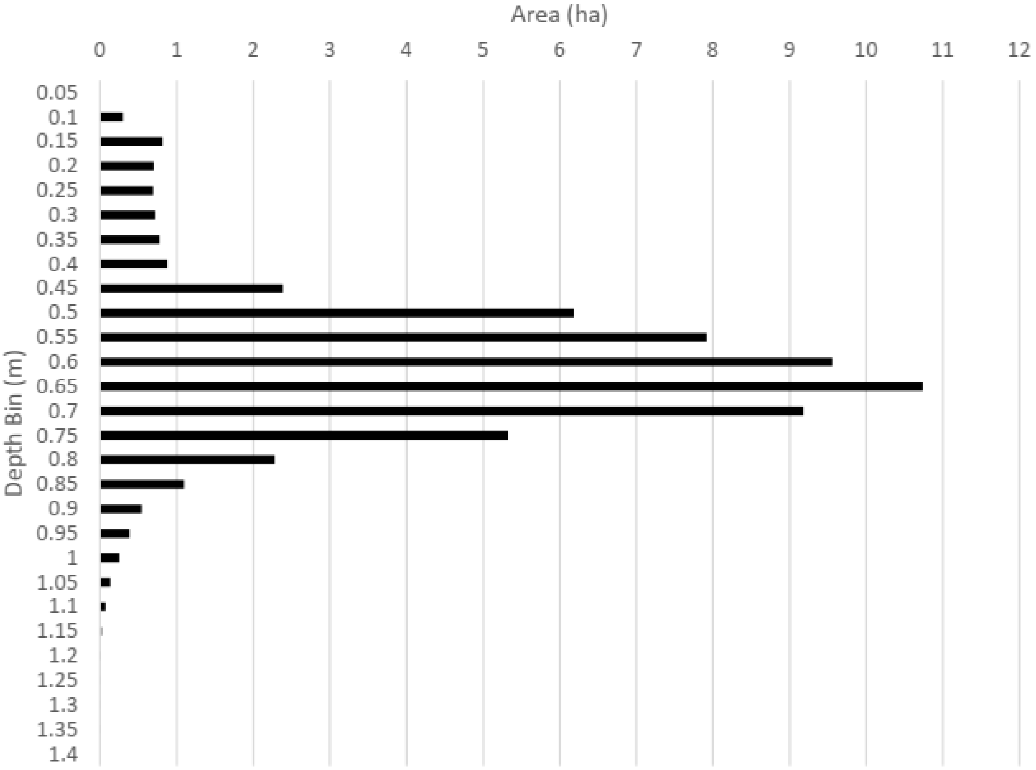

Figure 2. Area per depth bin (0.05 interval) in the East cell under baseline conditions (NOL = 176.1).

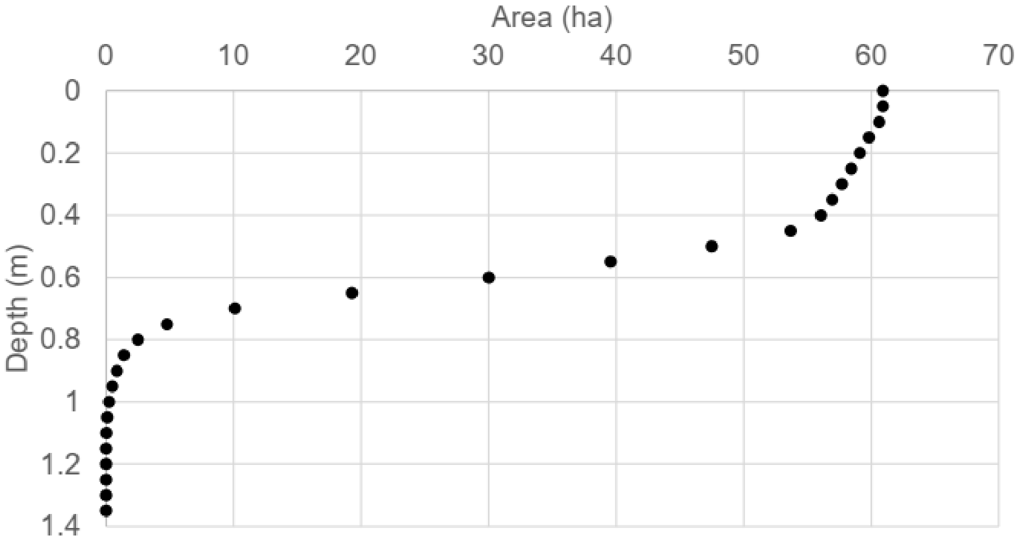

Figure 3. Cumulative area by depth in the East cell under baseline conditions (NOL = 176.1). Each data point represents the cumulative habitat area (x-axis value) greater than a given depth (y-axis value). For example, the habitat area greater than 0.6 m in depth is 30 hectares.

The relationship between drawdown increment and wetted area was non-linear (Figure 4). Small changes in wetted area occurred with drawdown increments of 0.45 m or less; much larger changes in wetted area occurred with drawdown increments greater than 0.45 m. Linear relationships were observed between drawdown increment and mean depth, and between drawdown increment and 75th percentile of depth, from 0 m until about 0.5 m drawdown increment, and were non-linear thereafter (Figure 5). A linear relationship was observed between drawdown increment and maximum depth (Figure 5). Non-linear relationships were observed between drawdown increment and the remaining area of deep water habitat across each depth threshold (Figure 6).

Because of the very limited deep water habitat in the East cell under baseline conditions (e.g., 0.23 ha > 1 m in depth; Table 2), small drawdown increments led to substantial losses of available deep water habitat. For example, a drawdown of 0.35 m led to the complete loss of deep water refuge > 1.0 m in depth, with 0.02 ha habitat remaining > 0.75 m in depth (reduction of 99.58%), and 1.4 ha habitat remaining > 0.5 m in depth (reduction of 97.05%; Figure 6, Table 2). Greater drawdown increments led to even greater reductions in deep water habitat. For example, a 0.6 m drawdown increment would lead to no available refuge habitat > 0.75 m, and only 0.2 ha > 0.5 m (reduction of 99.58%; Figure 6, Table 2). The cumulative distribution of refuge habitat availability for each drawdown increment is provided in Figure 7 and Table 3.

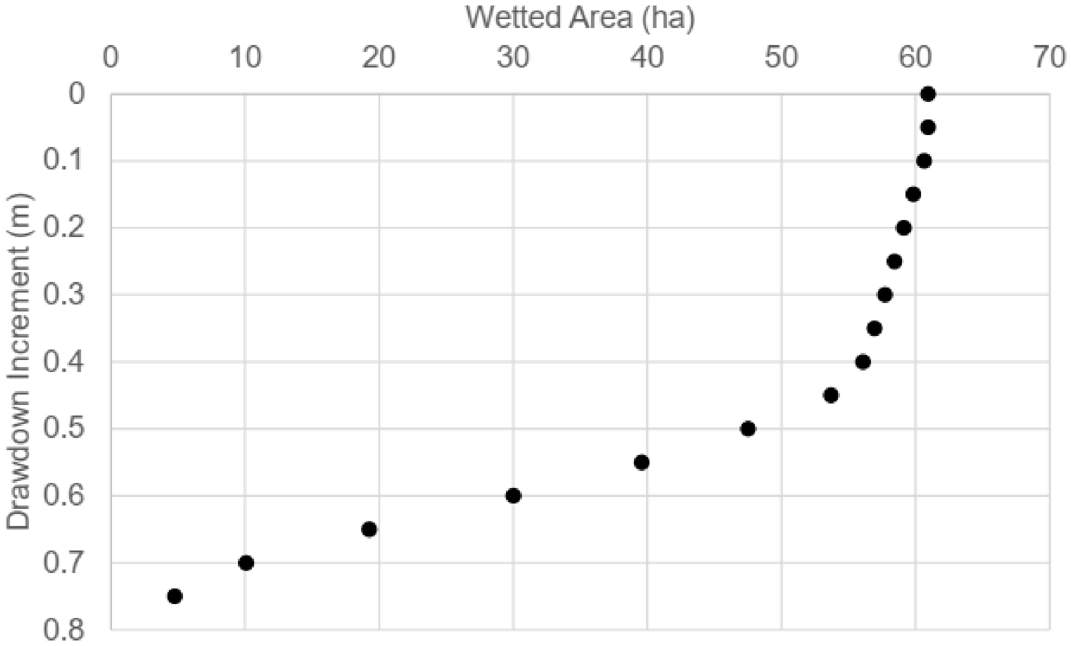

Figure 4. Relationship between drawdown increment (m; metres below NOL = 176.1) and wetted area (ha).

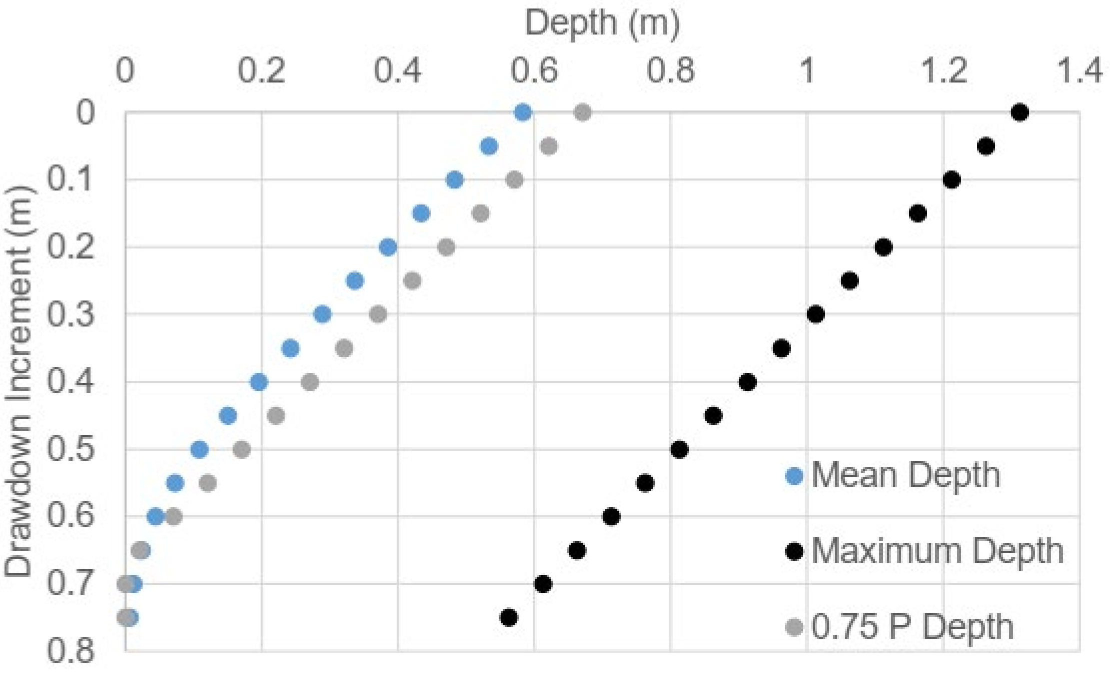

Figure 5. Relationship between drawdown increment (m; metres below NOL = 176.1) and three depth statistics (mean, maximum, and 75th percentile of depth (m)).

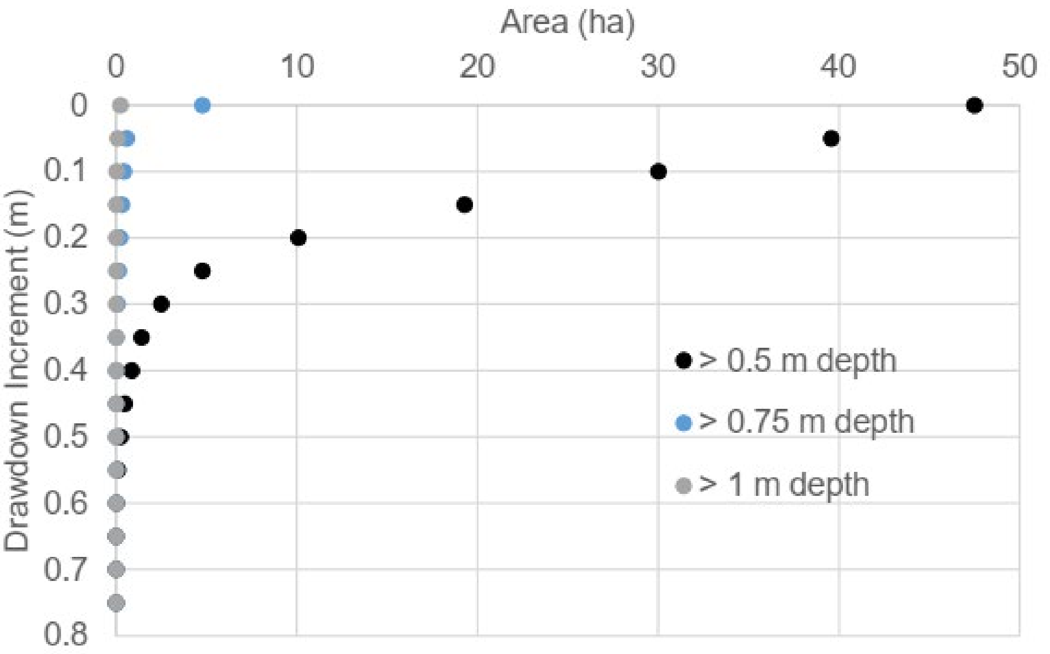

Figure 6. Relationship between drawdown increment (m; metres below NOL = 176.1) and remaining habitat area greater than 0.5 m, 0.75 m, and 1.0 m in depth.

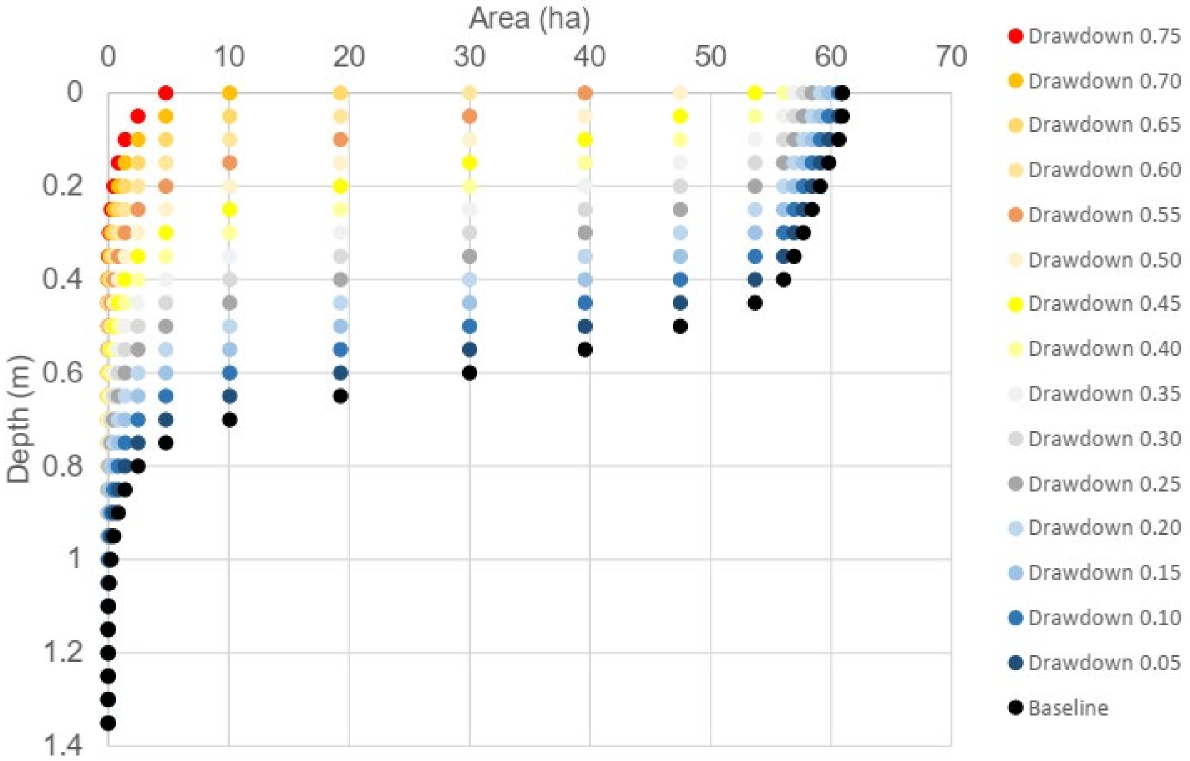

Figure 7. Cumulative relationship between area-by-depth and drawdown increment (m; metres below NOL = 176.1). Cooler colours (blue, grey) represent smaller drawdown increments; warmer colours (yellow, orange, red) represent greater drawdown increments. Each data point represents the cumulative habitat area (x-axis value) greater than a given depth (y-axis value) under each drawdown increment (legend colours).

Table 3. Cumulative area-by-depth and drawdown increment (m; metres below NOL = 176.1). The data in each cell represent the cumulative habitat area (ha) greater than a given depth increment (y-axis) for a given drawdown increment (x-axis). Data in this table are presented in Figure 7.

		Drawdown Increment (m)															
		0	**0.05**	**0.1**	**0.15**	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**	**0.45**	**0.5**	**0.55**	**0.6**	**0.65**	**0.7**	**0.75**
Depth (m)	**0**	60.93	60.93	60.64	59.82	59.12	58.43	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77
	0.05	60.93	60.64	59.82	59.12	58.43	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5
	0.1	60.64	59.82	59.12	58.43	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4
	0.15	59.82	59.12	58.43	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86
	0.2	59.12	58.43	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48
	0.25	58.43	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23
	0.3	57.72	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1
	0.35	56.95	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02
	0.4	56.07	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01
	0.45	53.69	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0
	0.5	47.5	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0
	0.55	39.58	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0
	0.6	30.02	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0
	0.65	19.28	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0
	0.7	10.1	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0	0
	0.75	4.77	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0	0	0
	0.8	2.5	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0	0	0	0
	0.85	1.4	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0	0	0	0	0
	0.9	0.86	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0	0	0	0	0	0
	0.95	0.48	0.23	0.1	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0
	1	0.23	0.1	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	1.05	0.1	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.1	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.15	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Relationship Between Drawdown Increment and Patches of Refuge Habitat

Another consideration for refuge habitat availability is the uneven bathymetry of the cell, in that drawdown will not leave one continuous habitat area that progressively shrinks in size with each drawdown increment. Rather, drawdown will likely create patches of disconnected habitat. Although some of the patches may have suitable depth to allow the survival of Lake Chubsucker, it is likely they will not be of sufficient size to provide suitable refuge habitat without substantial density-dependent effects. Additionally, young of year typically occupy shallower depths than adults and may be more prone to being stranded upon drawdown; therefore, connectivity to deeper habitats is likely essential for young of year survival.

An additional bathymetric analysis was conducted using ArcGIS 10.6.1 to determine quantity and size of patches remaining at each drawdown increment. To understand the creation and distribution of patches, wetted area at each drawdown increment was identified by first excluding 1 m^2 grid cells on the depth raster matrix that had a depth ≤ 0 m. Then, the depth raster was converted to integers so that a region grouping tool could be applied to group remaining wetted adjoining grid cells that create a patch ≥ 5 m^2. This patch size was chosen as it could reasonably be considered fish habitat; however, this size is unlikely to allow Lake Chubsucker to carry out all life history processes, and may not provide refuge habitat if depth is insufficient. A four neighbour setting was applied to the grouping of grid cells, meaning that a patch was created when at least five 1 m^2 grid cells were adjacent, forming any shape, without including diagonal grid cells. This ensures the smallest patch is created for a conservative estimate of patch size. Only including adjacent cells increases the likelihood that fish can move freely about a patch and are not limited by small corridors within it. The ‘patch’ layer (output of the region grouping) was then used to select depth points from the original depth raster matrix. This allowed for depth and wetted area of each patch to be calculated and then summarized across all patches at each drawdown increment (Table 4).

Table 4. Relationship between drawdown increment (m; metres below NOL = 176.1), number of habitat patches ≥ 5 m^2 in wetted area, mean patch depth, maximum patch depth, median patch depth, standard deviation of patch depth, mean patch wetted area, maximum patch wetted area, median patch wetted area, and standard deviation of patch wetted area. The drawdown increment of 0.00 represents baseline conditions in the absence of water-level drawdown.

Drawdown Increment (m below 176.1 m NOL)	Number of Patches (≥5 m^2)	Mean Patch Depth (m)	Max Patch Depth (m)	Median Patch Depth (m)	SD Patch Depth (m)	Mean Patch Wetted Area (ha)	Max Patch Wetted Area (ha)	Median Patch Wetted Area (ha)	SD Patch Wetted Area (ha)
0.00 (baseline)	18	0.51	1.31	0.55	0.15	3.3848	60.8195	0.0018	13.9300
0.05	18	0.46	1.26	0.50	0.15	3.3848	60.8195	0.0018	13.9300
0.10	21	0.38	1.21	0.44	0.18	2.8871	55.6973	0.0021	11.8528
0.15	25	0.30	1.16	0.39	0.18	2.3927	55.0959	0.0021	10.7874
0.20	21	0.31	1.11	0.35	0.13	2.8152	54.6103	0.0018	11.6112
0.25	18	0.32	1.06	0.32	0.05	3.2461	54.1306	0.0024	12.3703
0.30	18	0.27	1.01	0.27	0.06	3.2062	53.6214	0.0024	12.2541
0.35	20	0.21	0.96	0.21	0.07	2.8471	53.0721	0.0024	11.5450
0.40	20	0.17	0.91	0.16	0.06	2.8033	52.4349	0.0026	11.4064
0.45	33	0.09	0.86	0.06	0.08	1.6267	50.1812	0.0044	8.5973
0.50	68	0.05	0.81	0.03	0.06	0.6985	33.4557	0.0030	4.1785
0.55	86	0.04	0.76	0.02	0.05	0.4601	23.3713	0.0068	2.6483
0.60	69	0.05	0.71	0.02	0.05	0.4350	17.5652	0.0066	2.1842
0.65	79	0.04	0.66	0.02	0.05	0.2439	5.0147	0.0109	0.7703
0.70	79	0.04	0.61	0.02	0.05	0.1277	3.4140	0.0083	0.4263
0.75	65	0.05	0.56	0.03	0.04	0.0733	1.8622	0.0059	0.2567

At baseline, the habitat is divided into 18 patches (Figure 8). The number of patches is variable, but relatively low (i.e., ≤33), at drawdown increments of 0.45 m or less (Table 4; Figure 8). The number of patches more than doubles at 0.50 m of drawdown and reaches a maximum of 86 patches at the 0.55 m drawdown increment. With further drawdown, the number of patches fluctuates as some patches become too small to meet the 5 m^2 minimum size requirement. The relationship between drawdown increment and mean patch depth was non-linear (Figure 9). Mean patch depth decreases nearly linearly to a drawdown increment of 0.15 m then stays approximately the same (i.e., ~0.03 m) to a drawdown increment of 0.25 m; another approximately linear decrease in mean patch depth is observed up to 0.50 m of drawdown, after which there is no further change in mean depth of patches (i.e., mean depth of patches ≤ 0.05 m). At drawdown increments greater than 0.3 m, both the mean and median patch depths are less than the minimum depth at which young of year Lake Chubsucker have been captured in the East cell. The relationship between drawdown increment and mean patch wetted area was also non-linear (Figure 10). Mean patch wetted area was highly variable across drawdown increments, but ranged from 2.4–3.4 ha at drawdown of 0.40 m or less. At 0.45 m of drawdown, mean patch wetted area was 1.6 ha, and at further drawdown, mean patch wetted area declines somewhat linearly from 0.69–0.07 ha.

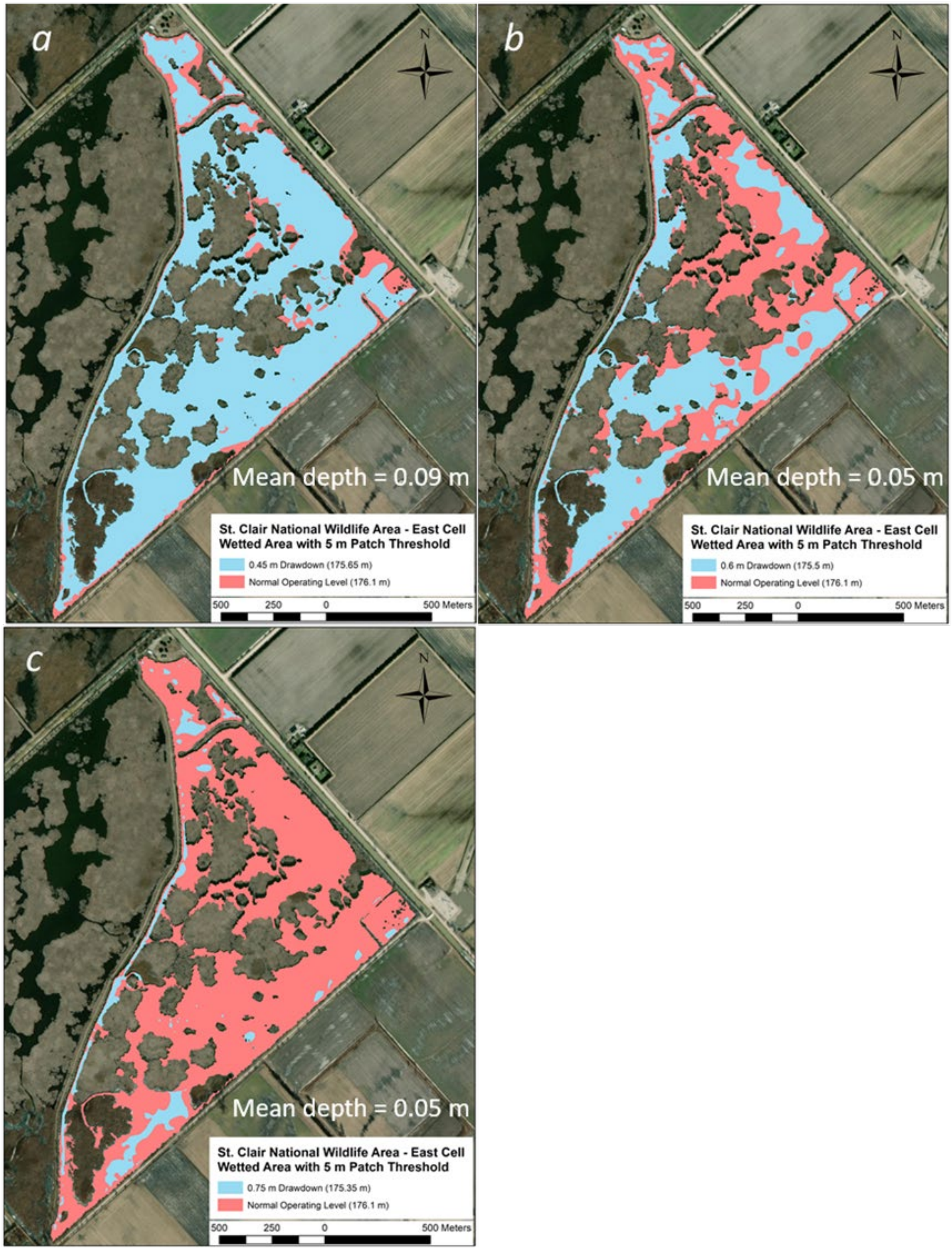

Figure 8. Patches of wetted area (≥ 5 m^2) created at drawdown increments of (a) 0.45 m (n = 18 patches), (b) 0.6 m (n = 69 patches) and (c) 0.75 m (n = 65 patches).

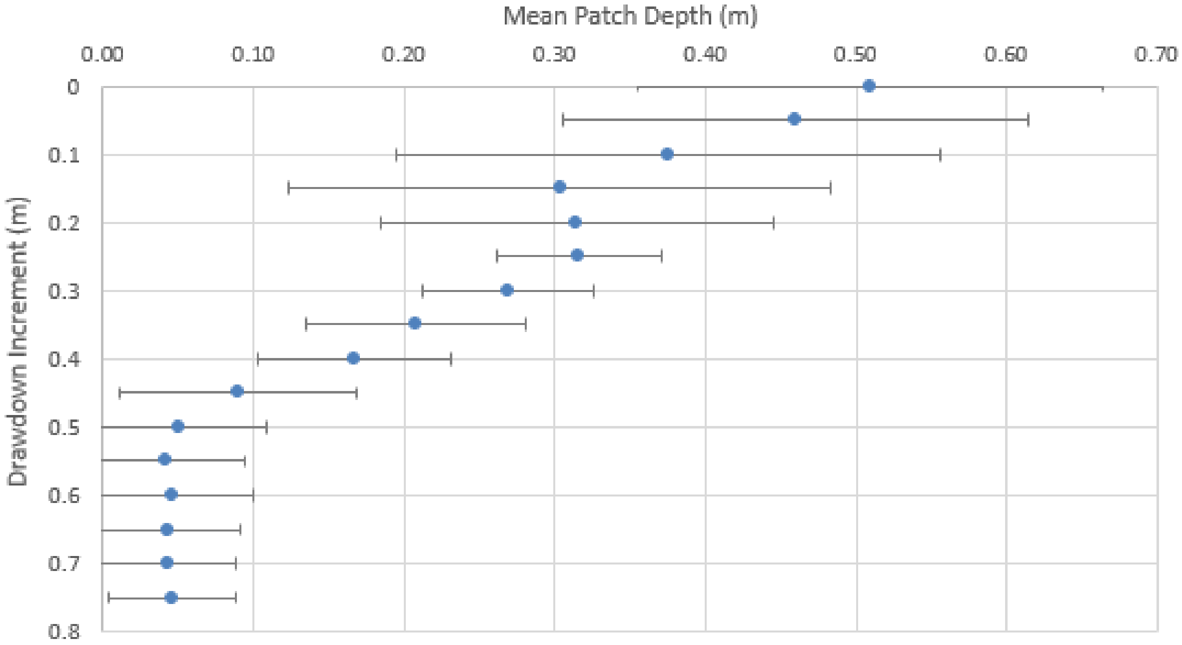

Figure 9. Relationship between drawdown increment (m; metres below NOL = 176.1) and mean patch depth (m). Error bars represent standard deviation.

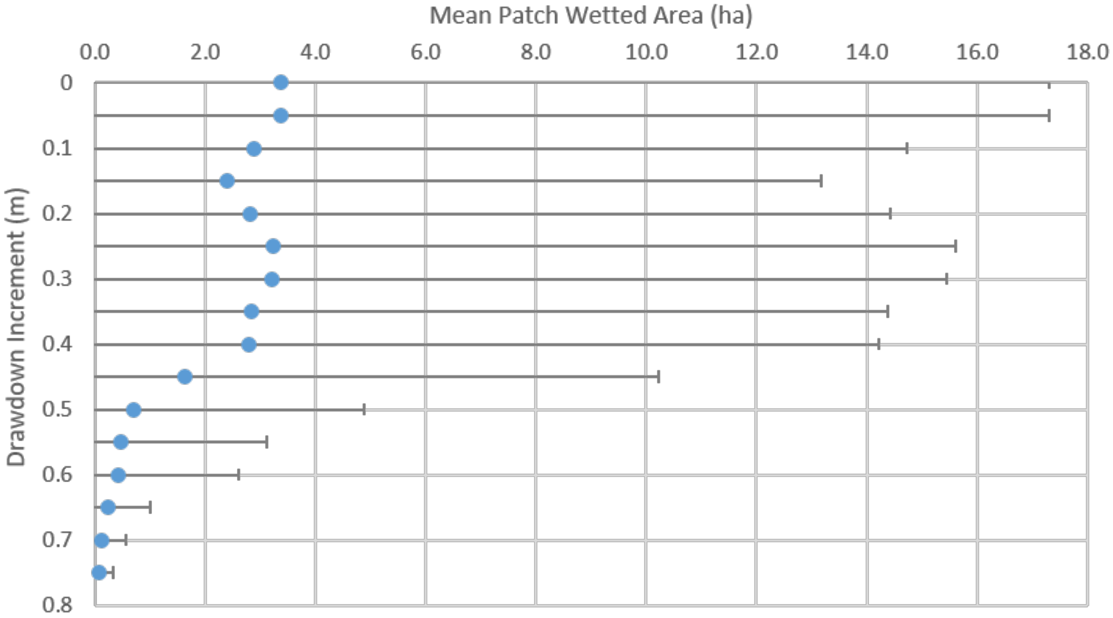

Figure 10. Relationship between drawdown increment (m; metres below NOL = 176.1) and mean patch wetted area (ha). Error bars represent standard deviation.

Relationship Between Habitat Availability and Lake Chubsucker Abundance

The relationship between habitat availability and Lake Chubsucker abundance was estimated under baseline and drawdown conditions. The relationship was estimated using methods from Randall et al. (1995), where the density of fishes in the community is determined based on their mean weight. Capture data from DFO sampling in the East cell in September 2019 (Barnucz et al. 2021) were assumed to provide a representative sample of the fish community. The geometric mean total length (mm) of each captured species was calculated based on species-specific minimum and maximum total lengths obtained during field sampling. Geometric mean length was converted to mean weight (g) based on length-weight relationships from Coker et al. (2001) (Table 5), which allowed a weighted mean weight of the fish community sample to be calculated (15.24 g). The relationship between mean fish weight (g) and fish density (fish/ha) was estimated from the lake-based equation in Randall et al. (1995) as:

$$Log10\ D = 4.48 - 1.01 \times Log10\ W$$

where *D* is fish per hectare and *W* is mean community weight in grams. The estimate of *D* was 1,925.18 fish/ha.

The fish density estimate was multiplied by habitat availability under baseline and drawdown conditions (0.05 increments below NOL 176.1) to determine the total abundance of fishes in the community. Two estimates of habitat availability were incorporated. The first estimate assumed that all wetted habitat contributed to fish community production. The second estimate assumed that only habitats greater than 0.3 m depth contributed to fish community production. In both cases, the abundance of Lake Chubsucker was calculated by multiplying the total abundance of fishes by the relative abundance of Lake Chubsucker in the East cell (1.17% of total catch during September 2019; Barnucz et al. 2021). The number of adult Lake Chubsucker was estimated by modifying the stable stage distribution in Young and Koops (2011) in which adult abundance was assumed to be 0.03% of total Lake Chubsucker abundance. Because the stable stage distribution in Young and Koops (2011) includes eggs and larvae (i.e., stage distribution immediately following reproduction), it was adjusted to determine the number of adults in September by assuming that 95% of mortality of young of year and 50% of mortality of age-1 individuals occurred between April and September. The resulting modified stable stage distribution was 59% young of year, 23% age-1, and 18% adults (ages 2–8). The probability of extinction of Lake Chubsucker over 100 years, assuming a 15% probability of catastrophe per generation, was estimated from Young and Koops (2011) as:

$$Pext\ = 41 \times N^{-1.047}$$

where *N* = the initial abundance of Lake Chubsucker adults.

A worked example is as follows. Under the assumption that all wetted habitat contributes to fish community production in the East cell, baseline habitat availability was 60.93 ha under NOL = 176.1. Given a community density of 1,925.2 fish/ha, total abundance was 117,302 fishes in the East cell. Assuming that 1.17% of the fish community was composed of Lake Chubsucker, the total abundance of Lake Chubsucker was 1,375 individuals of which 18% (247) were adults. Given an initial abundance of 247 adults, the baseline probability of extinction was 0.128 over 100 years. During drawdown, the availability of wetted habitat decreases, which reduced the total abundance of fishes that can be supported at a given density. At a drawdown increment of 0.60 m below NOL 176.1, wetted habitat was reduced to 30 ha. The community density (1,925.2 fish/ha) resulted in 57,792 total fishes, a total abundance of 677 Lake Chubsucker, an estimated 122 adult Lake Chubsucker, and a probability of extinction of Lake Chubsucker of 0.269 over 100 years.

The assumptions of this approach are: 1) habitat is functioning similarly to the natural systems used to generate the community density relationships in Randall et al. (1995); 2) catch data are representative of the fish community (both in species composition and size); 3) drawdown does not shift the mean size of fishes in the community or the proportional representation of species composition; and, 4) density-dependent process act on the fish community based on the constraints of available habitat. The degree to which density-dependent processes act to reduce total fish abundance will depend on habitat availability constraints as well as the duration of the drawdown period. At shorter drawdown durations, it is possible that the severity of density-dependent processes (e.g., competition for food and space; predation) is reduced, in which case the abundance of fishes (including Lake Chubsucker) may be higher than predicted for a given drawdown increment. Alternatively, the approach does not incorporate changes in species-specific habitat suitability as drawdown progresses (e.g., the effect of warming water temperature, reduced dissolved oxygen, or increased predation from waterbirds), indicating that total declines in fishes and Lake Chubsucker in particular may be more severe than predicted if refuge habitat becomes unsuitable. The approach also does not incorporate the partitioning of fishes into isolated habitat patches, which may lead to declines in abundance that are greater than predicted owing to large crowding effects, but would depend on how fish are distributed among remnant patches.

Results indicated that Lake Chubsucker abundance in the East cell is low in the absence of drawdown (1,375 individuals and 247 adults under the wetted habitat scenario, and 1,302 individuals and 234 adults under the > 0.3 m habitat scenario), with both estimates of adult abundance below the most optimistic estimate of MVP (600–1,000 adults) from Young and Koops (2011). In the absence of drawdown, extinction risk for Lake Chubsucker under both scenarios was > 0.12 over 100 years (Tables 6,7). Drawdown reduced total and adult Lake Chubsucker abundance and increased the probability of Lake Chubsucker extinction, with severity dependent on the drawdown increment (Tables 6,7; Figure 11). Under the assumption of wetted habitat contributing to fish community production, greatest increases in the probability of extinction occurred at drawdown levels below the 0.5 m increment, with the probability of extinction reaching 1.0 at the 0.75 m increment. Under the assumption of habitats > 0.3 m depth contributing to fish community production, greatest increases in the probability of extinction occurred below the 0.2 m increment, with the probability of extinction reaching 1.0 at the 0.45 m increment.

Table 5. Species, total length (geometric mean [min, max] TL; mm), length-weight regression coefficients (a,b from Coker et al. (2001)); mean weight (g), and relative abundance of fishes in the East cell based on Barnucz et al. 2021 (September 2019 sampling; % of total catch). Length-weight regression coefficients were measured in Log10 units and mm (TL) and g (W). The Brown Bullhead equation was assumed for Ameiurus sp.; the Largemouth Bass equation was assumed for Lake Chubsucker; the Pumpkinseed equation was assumed for Lepomis sp., and the Banded Killifish equation was assumed for Central Mudminnow.

Common Name	Scientific Name	Mean Total Length (min, max); mm	Length-Weight Regression Coefficient (a)	Length-Weight Regression Coefficient (b)	Weight (g)	Relative Abundance (%)
Black Bullhead	*Ameiurus melas*	277.99 (230, 336)	-4.9743	3.085	367.74	0.65
Yellow Bullhead	*Ameiurus natalis*	205.66 (141, 300)	-5.374	3.232	126.52	2.08
Brown Bullhead	*Ameiurus nebulosus*	273.71 (221, 339)	-5.076	3.105	310.32	1.30
	Ameiurus sp.	60 (60, 60)	-5.076	3.105	2.79	0.13
Bowfin	*Amia calva*	413.64 (295, 580)	-4.961	2.992	737.81	4.56
Goldfish	*Carassis auratus*	106.48 (54, 210)	-4.53	2.9	22.35	0.26
Lake Chubsucker	*Erimyzon sucetta*	126.13 (74, 215)	-5.316	3.191	24.42	1.17
Northern Pike	*Esox lucius*	441.24 (295, 660)	-5.437	3.096	563.56	0.78
Pumpkinseed	*Lepomis gibbosus*	81.42 (34, 195)	-5.17	3.237	10.35	61.72
Bluegill	*Lepomis macrochirus*	83.79 (36, 195)	-5.374	3.316	10.07	1.69
	Lepomis sp.	64.81 (35, 120)	-5.17	3.096	2.75	2.08
Largemouth Bass	*Micropterus salmoides*	153.95 (60, 395)	-5.316	3.191	46.12	6.77
Golden Shiner	*Notemigonus crysoleucas*	73.61 (42, 129)	-5.593	3.302	3.73	9.24
Black Crappie	*Pomoxis nigromaculatus*	126.33 (56, 285)	-5.618	3.345	25.79	7.03
Central Mudminnow	*Umbra limi*	53.03 (37, 76)	-5.09	3.0412	1.427489	0.52

Table 6. Relationship between drawdown increment (m below NOL = 176.1), available habitat contributing to community production (ha; assumes all wetted habitat), total fish community abundance, Lake Chubsucker abundance (total, adult), percent decline Lake Chubsucker abundance (total, adult), and the probability of extinction of Lake Chubsucker over 100 years.

Drawdown Increment (m below NOL 176.1)	Available Habitat (ha)	Fish Community Abundance	Lake Chubsucker Total Abundance	% Decline Total Lake Chubsucker	Lake Chubsucker Adult Abundance	% Decline Adult Lake Chubsucker	Prob. Extinction
0.00 (baseline)	60.9	117,302	1375	0.0	247	0.00	0.128
0.05	60.9	117,302	1375	0.0	247	0.00	0.128
0.10	60.6	116,734	1368	0.5	246	0.48	0.129
0.15	59.8	115,170	1350	1.8	242	1.82	0.131
0.20	59.1	113,826	1334	3.0	240	2.96	0.132
0.25	58.4	112,496	1318	4.1	237	4.10	0.134
0.30	57.7	111,112	1302	5.3	234	5.28	0.136
0.35	56.9	109,630	1285	6.5	231	6.54	0.138
0.40	56.1	107,944	1265	8.0	227	7.98	0.140
0.45	53.7	103,356	1211	11.9	217	11.89	0.146
0.50	47.5	91,449	1072	22.0	192	22.04	0.166
0.55	39.6	76,196	893	35.0	160	35.04	0.201
0.60	30.0	57,792	677	50.7	122	50.73	0.269
0.65	19.3	37,108	435	68.4	78	68.37	0.428
0.70	10.1	19,437	228	83.4	41	83.43	0.842
0.75	4.8	9,183	108	92.2	19	92.17	1.000

Table 7. Relationship between drawdown increment (m; below NOL = 176.1), available habitat contributing to community production (ha; assumes all habitat > 0.3 m depth), fish community abundance, Lake Chubsucker abundance (total, adult), percent decline Lake Chubsucker abundance (total, adult), and the probability of extinction of Lake Chubsucker over 100 years.

Drawdown Increment (m below NOL 176.1)	Available Habitat (30 cm or greater)	Fish Community Abundance	Lake Chubsucker Total Abundance	% Decline Total Lake Chubsucker	Lake Chubsucker Adult Abundance	% Decline Adult Lake Chubsucker	Prob. Extinction
0.00 (baseline)	57.7	111122	1302	0.0	234	0.0	0.136
0.05	57.0	109639	1285	1.3	231	1.3	0.138
0.10	56.1	107945	1265	2.9	227	2.9	0.140
0.15	53.7	103363	1211	7.0	218	7.0	0.146
0.20	47.5	91446	1072	17.7	192	17.7	0.166
0.25	39.6	76199	893	31.4	160	31.4	0.201
0.30	30.0	57794	677	48.0	122	48.0	0.269
0.35	19.3	37118	435	66.6	78	66.6	0.428
0.40	10.1	19444	228	82.5	41	82.5	0.842
0.45	4.8	9183	108	91.7	19	91.7	1.000
0.50	2.5	4813	56	95.7	10	95.7	1.000
0.55	1.4	2695	32	97.6	6	97.6	1.000
0.60	0.9	1656	19	98.5	3	98.5	1.000
0.65	0.5	924	11	99.2	2	99.2	1.000
0.70	0.2	443	5	99.6	1	99.6	1.000
0.75	0.1	193	2	99.8	0	99.8	1.000

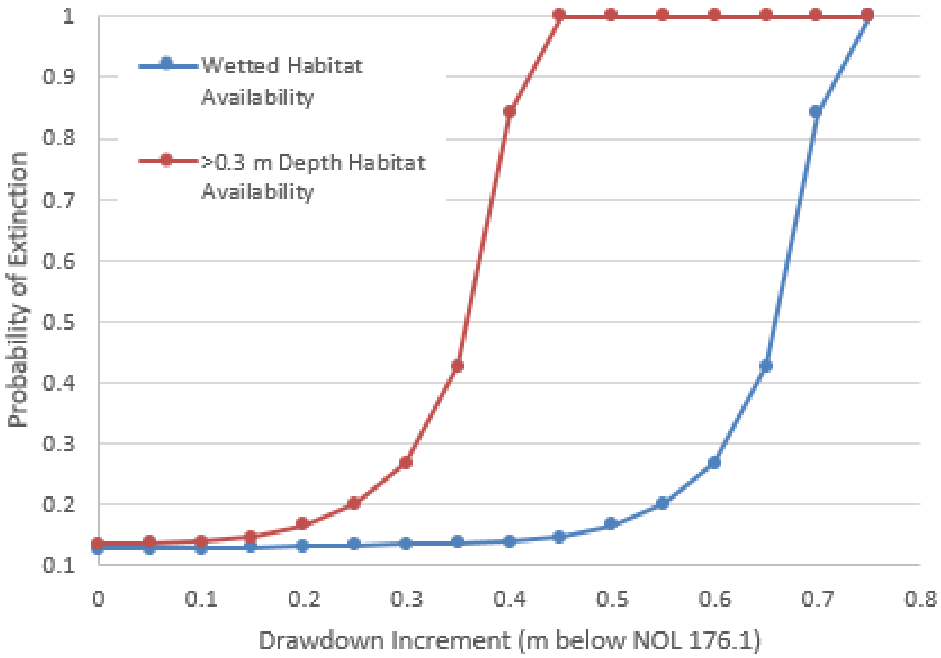

Figure 11. Relationship between drawdown increment (metres below NOL = 176.1) and the probability of extinction of Lake Chubsucker under two scenarios: a) all wetted habitat contributes to fish community production; and, b) only habitat > 0.3 m depth contributes to fish community production.

Deepwater Habitat Creation and Patch Connectivity

Given the loss of deep water habitat under different drawdown increments, the creation of deep water habitat in advance of the drawdown period, and the connection of isolated habitat patches, have been proposed as potential mitigation measures. If the creation of deep water habitat and connecting channels is logistically feasible and can be done to minimize the effect of dredging on Lake Chubsucker, such activities would reduce the density-dependent and density-independent effects associated with the loss of deep water habitat. The degree to which habitat creation and connectivity could ameliorate drawdown effects depends on the proposed drawdown increment, resulting loss of deep water habitat, and ability to increase depth through habitat creation.

To counteract the loss of deep water habitat during drawdown, deep water habitat could be created such that there is no loss (or net gain) of deep water habitat during the drawdown period. For example, under baseline conditions, the East cell contains 47.5 ha > 0.5 m in depth. A 0.6 m drawdown would reduce the availability of these deep water habitats by 99.96% to 0.23 ha. To prevent such a reduction, habitats > 0.5 m in depth under baseline conditions could be increased in depth by 0.6 m prior to the drawdown. In this situation, Lake Chubsucker would experience a net gain in deep water habitat following the re-flooding of the East cell (all habitats > 0.5 m would increase in depth by 0.6 m), and would not experience a reduction of deep water habitat from baseline during the drawdown itself. Such actions would likely benefit Lake Chubsucker over the long term given the depth-limited composition of the cell. If a greater depth threshold is chosen (e.g., all habitats > 0.75 m increased by 0.6 m), the resulting area of deep water habitat creation would be smaller. For a given area, greater depth will decrease thermal effects and dissolved oxygen depletion, and reduce the probability of encounter with waterbirds.

For a given depth, greater habitat area will decrease predation from fishes, competitive effects, and disease transfer. However, depth and area are not equivalent; a very small area of very deep habitat is unlikely to provide sufficient refuge for the species. Rather, maximizing the area of deep water habitat creation would reduce density-dependent effects for this benthic species. One way this could be achieved is through strategically dredging “channels” to connect isolated deep water habitat patches. These connections would allow fish to access a larger amount of the habitat in the cell and thus, reduce density-dependent and independent effects. Optimal placement of the channels would depend on the drawdown increment, but could be done to maximize access to deep water habitat and minimize risk of stranding. If this is done in combination with increasing depth of deep water habitat in advance of drawdown, both total wetted area and area of deep water habitat would be maximized, likely offering the greatest benefit to Lake Chubsucker.

In all situations, density-dependent and density-independent effects are still likely to occur if the drawdown imposes a reduction of wetted area and other changes in habitat attributes (e.g., temperature, dissolved oxygen), indicating that protecting against the sum total of drawdown effects would require additional mitigation or offset measures.

Conclusions

The Lake Chubsucker population in the East cell of the St. Clair Unit is estimated to be below the minimum viable population size of 600–1,000 adults (East cell estimate of 234–247 adults and 1,302–1,375 total individuals), with the probability of extinction greater than Pr = 0.12 in the absence of water level drawdown. Drawdown of the East cell will increase the likelihood of harm to the population, with greatest initial increases in the probability of extinction beginning at drawdown increments of 0.2 to 0.45 m below NOL 176.1, and the probability of extinction reaching 1.0 at drawdown increments of 0.45–0.75 m below NOL 176.1.

Because the East cell is depth limited, small drawdown increments will cause substantial changes in wetted area and deep water habitat, which are anticipated to impose density-dependent and density-independent impacts to Lake Chubsucker. Additionally, drawdown will create disconnected patches of habitat where Lake Chubsucker may become stranded.

Under the proposed drawdown duration (full extent from May 15th to September 15th), year-class failure may occur due to forgone spawning activity or other ecological impacts acting on young of year. Impacts to other life stages are also expected. As Lake Chubsucker populations are most sensitive to changes in young of year, efforts to reduce these impacts will reduce changes in population productivity. The creation of deep water habitat in advance of drawdown and connection of deep water habitats through dredging may reduce density-dependent and density-independent impacts. Greater spatial extent of deep water habitat creation would provide greater protection from predation and competition. However, protecting against the sum total of drawdown effects would likely require additional mitigation or offset measures.

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