Great Lakes Fish and Wildlife Restoration Act
FINAL Project Report Template
*Indicates required content

***Project Title:** Evaluation of Habitat Remediation in Thunder Bay, Lake Huron, on Lake Trout Spawning Success

***Project Sponsor:** Michigan Department of Environmental Quality, Remediation Division

***FWS Agreement Number:** F09AP00030

***Principal Investigator(s):** Janice Adams, J. Ellen Marsden, James Johnson & Natalie Dingledine

***Report Author(s):** J. Ellen Marsden, Natalie Dingledine, James Johnson & Janice Adams

***Date Submitted:** September 2012

Study Objectives: 1. Compare conditions of an impacted reef with a natural reef and determine the status of lake trout spawning and fry survival, prior to habitat remediation and 2. Determine whether lake trout spawning and fry survival increase in impacted areas after addition of clean cobble substrate (habitat remediation).

Description of Tasks:
Study site assessments: This work was planned to focus on three reef areas: (1) the cement kiln dust (CKD) impacted reef named CKD Pile Reef (see Figure 1), (2) the Cement Plant reef to the southwest of the CKD Pile reef, which appears to be similar in configuration, depth, and substrate to the CKD Pile reef, and (3) Mischley Reef, located approximately 8 km SE of the CKD Pile reef. During early surveys we determined that Mischley Reef was too far from the impacted site to be comparable with the constructed reefs, and too exposed to wind and waves to allow work in fall weather conditions. In addition, the prior side-scan sonar maps and video from this site that were collected in the early 1990s by U.S. Geological Survey could not be located. However, during survey work in 2009 we located a pile of substrate southeast of CKD and Cement Plant Reefs that looked highly attractive as lake trout spawning substrate; we named this East Reef. The substrate has deep interstices and, although the profile of the reef is no more than 1.5 m from the bottom substrate, the area of the reef is large (an irregularly-shaped mound about 650 ft in diameter). Previous data from gillnetting on the reef in November 2008 indicated that there is a large aggregation of spawning lake trout on this site, with 49% wild spawners. We suspect the reef is anthropogenic in origin, perhaps an accumulation of ballast material or a logging crib from the early or mid 1800s.

Mapping of nearshore areas: Initial mapping of the CKD Pile reef – both the impacted area and area of the potential new reef site - was conducted in July, 2008, using sidescan sonar and video to document geometry and to quantify current spawning substrate. In July, 2009 we surveyed

Cement Plant Reef and CKD Pile Reef using scuba. Both reefs had shallow gradients and cobble substrate that is deeply embedded; interstitial spaces were, at best, one cobble deep. These sites seem unlikely to attract spawning lake trout or retain spawned eggs; protection of eggs from predation by round gobies, or even dermersal fishes such as basses, seems minimal. In July 2010, potential new reef sites were once again mapped using side scan sonar since the potential site location and reef layout configuration had changed from earlier assessments. Thunder Bay National Marine Sanctuary (TBNMS) divers performed visual surveys of the potential sites to verify the absence of historic artifacts.

Reef construction: Nearly 1.5 acres of reef habitat was constructed at the project site in Thunder Bay, Lake Huron, Michigan. Reefs are located adjacent to the Cement Plant reef and CKD Pile reef; East Reef serves as an unaltered reference site (see Figure 1). In 2010, eight small 'pilot' artificial reefs were constructed to allow preliminary work to begin on evaluation of spawning activity. Each reef was approximately 7 m (30 ft) in diameter and 3 m (9 ft) tall. Four of these 'pilot' reefs were incorporated into a new reef; this was done because monitoring wells were placed in the 'pilot' reefs that the project team needed to use. In 2011, construction of 24 functional prototype reefs was completed; twelve reefs constructed at each site (named CEM 1 through 12 and CKD 1 through 12). In addition, a 5' high by 300' long reef was also constructed at the south-east toe of the CKD Pile array; this reef was named LaFarge Reef.

The prototype reefs are designed to allow comparison of the effect of reef orientation and height on density of lake trout spawning. Each of the 24 reefs is 23 m long x 2.4 m wide at the top (75 ft x 8 ft), to maximize the edge: area ratio, and is constructed of large rubble (up to 1 m diameter). At each site, half of the reefs are 1.5 m (5 ft) high, and 3 m (10 ft) high, to determine the importance of reef height. Half of the reefs are oriented in a NW-SE direction, the same orientation of the naturally occurring reefs and half are oriented in a NE-SW direction. Construction includes a full replicate design of four reefs, a pair of 5 ft and 10 ft reefs oriented NW-SE, and a second pair oriented NE-SW. This results in three replicates of the full design at each site.

Spawner assessments: Abundance of spawning lake trout is monitored annually in fall by the MDNR using assessment gillnets. Standardized index surveys have been conducted in Thunder Bay since 1975 including sites immediately adjacent to the CKD pile (Johnson and Van Amberg 1995, J. Johnson, MDNR, personal communication). Data are collected on fish abundance, age distribution, and fin clips (indicating whether they are hatchery or naturally-produced fish).
In 2011, trap nets were set on 4 of the newly constructed reefs (4 reefs were built incorporating a ramp so gear could be set easily). In addition one trapnet each was set on East, the Cement Plant, and the Cement Kiln Dust natural reefs. These nets were lifted and the catch measured and released every 2-3 days between October 6 and November 1. One standard lake trout fall-assessment gillnet (400 ft of 4.5-inch to 6-inch mesh) was set on Lafarge Reef. The trapnets produced a total catch of 377 lake trout, all but one caught by the net on East Reef. A total of 153 of these (59%) lacked fin clips and were probably wild. Other species caught included 101 mature whitefish, 92 of which were caught on East Reef, 7 on CEM 1, and 2 on the CKD Pile natural reef. Smallmouth bass, rock bass, and walleye composed a large percentage of the catch, including that on the constructed reefs. Trapnet fishing effectiveness was probably severely hampered by the small size of the constructed reefs; they could be fished with only 50 feet of

lead. The October trapnet catch is summarized in Table 1. The Lafarge Reef was long enough to accommodate most of the length of a standard fall assessment gillnet, therefore on November 3, 2012, one such net was fished on Lafarge for a single night, which produce a substantial catch of lake trout. The Lafarge Reef catch totaled 37 mature lake trout (92 per 1,000 ft) of which 22% were unclipped and presumably wild. Most (37 fish or 92%) were ripe or spent, suggesting egg deposition was occurring or had occurred on Lafarge Reef.

Egg, fry, and young-of-year assessments:
Egg collections: Egg density data were collected using a combination of egg bags buried by divers into the substrate (Perkins and Krueger 1995) and surface-deployed egg traps designed for this purpose (Riley 2008). Bags were typically buried in early fall and retrieved in late fall after most spawning was finished. Numbers of lake trout and lake whitefish eggs were quantified, and percent viable was recorded (dead eggs turn opaque and are therefore readily identifiable). Any potential egg predators (crayfish *Orconectes* spp., round goby *Neogobius melanostomus* and sculpins *Cottus* spp.) captured in the bags was recorded.

In 2009, 20 egg bags were set on Cement Plant Reef and CKD Reef in July, and retrieved on Nov. 12; 2 bags were lost from Cement Plant Reef and 6 from CKD Reef. Ten surface traps were set on Cement Plant Reef, CKD Reef, and East Reef and retrieved on Nov. 11; a single bag was lost from Cement Plant Reef. Forty-two lake trout eggs were collected on East Reef, at a density of 23.4/m^2; lake whitefish eggs were collected on all reefs, at a density of 1.7 to 35.8/m^2 on each reef. Eggs bags consistently collected more eggs than egg traps (Table 2).

In 2010, 10 egg traps were set on Cement Plant, CKD, and East Reef, and on six of the newly-constructed mini-reefs (A, B, C, D, E, F, and G). Traps were retrieved Nov. 8. Among all traps, a single lake trout egg was collected on a mini-reef (0.56 eggs/m^2); whitefish eggs were collected on CKD Reef, East Reef, and mini-reef G.

In 2011, ten egg bags were set on CKD Reef and East Reef, and five egg bags were set on CEM-1, 2, 3, 4, CKD-1, 2, 3, 4, and mini reefs B and E. Egg traps, set from the surface, were set on CEM-2, 9, 10, 11, and CDK-3, 4, 8, and 10. Ten egg bags were set on East Reef and CKD Reef. Lake trout eggs were collected only on East Reef (110, 61.2 eggs/m^2) and Cement Plant Reef (3, 2.1 eggs/m^2). Lake whitefish eggs were collected at all sites except CKD-3, where the line of egg traps was lost, at densities ranging from 48.7 to 1,052.4 eggs/m^2.

Fry collections: Lake trout fry were collected using surface-deployed passive fry traps (Marsden et al. 1988), set in early spring and checked weekly until fry were no longer seen (usually by mid-May). Fry collections commenced in 2010 to evaluate fry density prior to construction; 10 traps were set on East Reef, CKD Reef, and Cement Plant Reef. Fourteen fry were caught on East Reef (0.04 fry/trap-day).

In 2011, 10 fry traps were set on CKD Reef and East Reef, and 5 fry traps were set on seven of the mini-reefs (all except reef H). Two fry were caught on East Reef (0.004 fry/trap-day) and one on mini-reef A (0.004 fry/trap-day).

In 2012, a new, more durable design of fry traps made of stainless steel was set on Cement Plant

Reef, East Reef, LaFarge Reef, CKD-1, 3, 8, 10 and CEM-1, 4, 7, 10, and mini-reefs D and E; 10 traps were set at each site. A single fry was collected on CKD-1, CEM-1, and CEM-7 (0.003 fry/trap-day), two fry were collected on LaFarge Reef (0.005 fry/trap-day), and 20 were collected on East Reef (0.5 fry/trap-day).

Young-of-year collections: Lake trout young-of-year have been sampled during July and August by MDNR using standardized 33-foot headrope bottom trawling assessments since 1986 (Johnson and VanAmberg 1995, J. Johnson, MDNR, personal communication); these collections will continue and will indicate whether the new reef is associated with a rise in age-0 post-fry-stage lake trout or lake whitefish. In 2012, additional effort was composed of 28 beach seining tows, 14 tows using a 16-foot headrope bottom trawl, and 41 lifts of 0.5, 0.63, and 0.75 inch (bar mesh measure) "micromesh" gillnets designed to sample young of year and prey fish.

The data series from the larger 33-foot headrope bottom trawl is given in Table 3. Catches of age-0 lake whitefish have been in decline since 1995 and remained very low in 2012, in spite of the relatively high egg deposition as measured in the egg traps in 2011 and the catch of 145 fry in emergence traps and 77 fry in larval fish tows in spring 2012. Young-of-year whitefish can typically be indexed by beach seining in May and early June. During 1993, 41 beach seining tows yielded a catch rate of 33 age-0 whitefish per tow, but juvenile whitefish failed to appear in the beach seining catch and the 16 ft bottom trawl in 2012. A single young-of-year whitefish was sampled in the micromesh gillnets.

Two young-of-year lake trout were caught in the fourteen 33-foot headrope trawl tows. This catch rate was near the average recorded since 1990. No age-0 lake trout were caught in the other gear deployed.

Major findings and accomplishments:
As we expected, lake trout adults, eggs, and fry were found consistently and in the highest numbers at the un-degraded natural site, East Reef. Egg densities were lower than those at Parry Sound in Lake Huron (186-1,027 eggs/m2 in egg bags), where a self-sustaining population of lake trout is present, but higher than at natural sites in northern Lake Michigan (0.78 to 6.1 eggs/m2) where successful recruitment has not yet been observed (Marsden et al. 2005). Fry densities on East Reef ranged from 0.004 to 0.05 fry/trap-day, compared to 0.01 to 0.06 in Parry Sound, and zero in Lake Michigan (Marsden et al. 2005). In three years of egg collecting on the degraded reef (CKD Pile Reef) and poor-quality natural reef (Cement Plant Reef), eggs were only found in one year; 3 eggs were collected on Cement Plant Reef in 2011. No fry have been collected on these reefs. Substantial spawning was not observed on the constructed reefs with the exception of Lafarge Reef, where gillnetting produced a catch rate of 91 per 1,000 ft, which is within the range shown by Selgeby et al. (1995) to be adequate for natural reproduction. No egg deposition measurements were made on Lafarge reef because this reef was not part of the original study design, but 2 fry were caught in emergence traps set there 2012. A single egg was collected on a mini-reef in 2010, the year of construction. However, one fry was collected on a mini-reef in the subsequent year, and fry were collected on LaFarge Reef and three of the 75-foot constructed reefs in 2012, at densities of 0.003 to 0.005. Clearly lake trout have 'found' the new reefs, and within a year of construction; we anticipate that egg deposition, and consequently fry production, will increase as spawners become more familiar with these new sites over time.

Unlike lake trout, lake whitefish spawned both the natural reefs and all of the constructed reefs. Egg collections in 2010, when only egg traps were used, were very low, and eggs of either species were found on only four reefs; we suspect this may be an artifact of severe weather that produced 7m waves in the bay during the period of trap deployment. However, in 2011 weather was less severe, and whitefish eggs were found in both the egg bags and egg traps, at densities of 11.5 to 1,052 eggs/m^2. Lake whitefish fry collected in fry traps were recorded but that data has not been analyzed. The low capture of age-0 whitefish in trawls and micromesh gillnets and their absence in the beach zone is consistent with the hypothesis that there is a food bottleneck for whitefish fry in Thunder Bay. The improvement of spawning habitat and measurements of egg deposition and fry emergence afforded by this study constitute an opportunity to isolate the causes of whitefish recruitment declines.

There was no change in age-0 lake trout catch rates in the 33-foot bottom trawl; this result is consistent with egg deposition and fry emergence results that together suggest that any increase in lake trout fry production caused by the constructed reefs was small in 2012. Because of their larger mouth gape than lake whitefish fry, there is less likelihood of a food bottleneck for lake trout fry. A wider mouth gape at hatch means a wider variety of prey sizes can be consumed by lake trout than lake whitefish at the onset of exogenous feeding.

Management implications of your work:
This project has created new spawning habitat that is being used by both lake trout and lake whitefish for spawning; given the high quality of the substrate (i.e., clean of infilling, and sufficiently deep to protect eggs from interstitial predators such as round gobies), this new substrate will increase natural recruitment of lake trout, at least, and thereby enhance progress towards completely self-sustaining populations of lake trout. The reef project, by manipulating the availability of physical spawning habitat, has proved an important opportunity for isolating potential causes of recent declines in whitefish reproduction.

Attraction of spawners and use by spawning lake trout was lower than we anticipated based on prior work on artificial reefs. In part this may be due to the high proportion of wild spawners present in the bay, and availability of high quality (though spatially very limited), semi-natural substrates nearby that are familiar to these ‘experienced’ spawners. Stocked lake trout may be attracted to spawning aggregations of wild fish, instead of searching for spawning sites, and thus are less likely to find new areas; this is in contrast to prior work with artificial reefs in Lakes Michigan and Ontario, where wild spawners were not present (Marsden et al. 1995, Marsden and Chotkowski 2001).

Additional restoration work needed and/or areas for future research:
The reefs constructed during this project continue to offer significant opportunities to conduct research on factors that attract lake trout to spawning sites and lead to successful production of fry. In 2012 we will be conducting the first such funded project, taking advantage of the fact that there are two distinct reef arrays (CKD and Cement Plant) and replication of reefs within the arrays, to test whether lake trout are attracted only to substrate, or whether attraction is enhanced by the presence of other spawners or pheromones produced by prior spawning events. We anticipate further projects will develop that utilize these reefs.

As lake trout begin to use the constructed reefs and fry production rises, we will continue to measure age-0 lake trout abundance in summer using bottom trawling and micromesh gillnetting. Adult lake trout stock assessments will document the degree to which these reefs contribute to future recovery of local lake trout spawning stocks. Further work is needed in identifying the cause of the early recruitment bottleneck for lake whitefish. The reef mitigation work should help to eliminate spawning habitat as a cause, but the exact nature of the post-emergence bottleneck has yet to be described. Comparisons with Saginaw Bay, where prey for emergent fry appears to be adequate, could help to elucidate the problem in Thunder Bay.

List of presentations delivered and outreach activities:
A project poster and project brochure have been designed and are available for distribution.

A kiosk exhibiting the reef restoration project is in the planning stages and is to be housed at the Great Lakes Maritime Heritage Center, Alpena, Michigan

A web site describing the project, with a map and coordinates of all of the reefs, was created to inform the public about the project and also ensure that anglers were aware of the presence of sampling equipment in the bay in spring and fall. The web site can be accessed at www.uvm.edu/rsenr/thunderbay

Presentations by project investigators are listed at the end of this report.

***Include relevant pictures or images associated with the project:** *Please submit pictures* **as separate electronic image files**. *These can be emailed, mailed on a disc, etc. The images will be used to assist in describing the GLFWRA accomplishments and outcomes and may appear in any number of factsheets or reports (when images are used, appropriate photo credit will be noted). If no pictures are available, please let us know why.*

Geographic region project occurred in or affects:
Thunder Bay, Lake Huron, Michigan

Cement Reef Array – POB -83.3966, 45.0604; POE -83.3963, 45.0602
CKD Pile Reef Array – POB -83.3882, 45.0617; POE -83.3879, 45.0619

***List of reports and peer-reviewed papers completed or in-progress:** *Please attach copies of all completed reports and papers related to this work. Also, please remember to acknowledge funding support from the U.S. Fish and Wildlife Service through the Great Lakes Fish and Wildlife Restoration Act in publications, reports, presentations etc. that result from this work.*

None have been written to date. Project team will submit copies of any future papers or reports.

Literature Cited

Johnson and Van Amberg 1995. Evidence of natural reproduction of lake trout in western Lake Huron. J. Great Lakes Res. 21 (Suppl. 1):253-259.

Marsden, J.E., C.C. Krueger and C.P. Schneider. 1988. Evidence of natural reproduction by stocked lake trout in Lake Ontario. *J. Great Lakes Res.* 14:3-8.

Marsden, J. E., D. L. Perkins, and C. C. Krueger. 1995. Recognition of spawning areas by lake trout: deposition and survival of eggs on small, man-made rock piles. *J. Great Lakes Res.* 21 (suppl. 1):330-336.

Marsden, J. E., and M. A. Chotkowski. 2001. Lake trout spawning on artificial reefs fouled by zebra mussels: fatal attraction? *J. Great Lakes Res*. 27:33-43.

Marsden, J. E., B. J. Ellrott, J. Jonas, R. Claramunt, and J. Fitzsimons. 2005. A comparison of lake trout spawning, emergence, and habitat use in lakes Michigan, Huron, and Champlain. *J. Great Lakes Res.* 31:492-508

Perkins and Krueger. 1995. Dynamics of reproduction by hatchery-origin lake trout (Salvelinus namaycush) at Stony Island reef, Lake Ontario. J. Great Lakes Res. 21 (Suppl. 1):400-417.

Riley, J.W. 2008. Predation pressure on emergent lake trout fry in Lake Champlain and techniques for assessing lake trout reproduction in deep-water habitats. Master of Science thesis, University of Vermont, Burlington, VT.

Selgeby, J. H., C. R. Bronte, E. H. Brown, Jr.,M. J. Hansen, M. E. Holey, J. P. VanAmberg, K. M. Muth, D. B. Makauskas, P. McKee, D. M. Anderson, C. P. Ferreri, and S. T. Schram. 1995. Lake trout restoration ain the Great Lakes: stock-size criteria for natural reproduction. Journal of Great Lakes Research 21 (Supplement 1):498-504.

Table 1. Catch summary for seven trapnets set on four mitigation reefs and three natural reefs and monitored through the month of October, 2011.

	Reef type and name							
	Engineered reefs				*Native reefs*			
Species	CEM1	CEM5	CKD2	CKD9	East Reef	Cement	CKD	Combined Total Catch
Rock bass	19	73	25	241		24	17	399
Lake trout					**377**		**1**	**378**
Smallmouth bass	43	64	24	63	18	62	62	336
W. Sucker	3	57	2	10	23	72	32	199
Lake whitefish		**7**			**92**	**1**	**2**	**102**
Walleye	3	24	1		2	47	12	89
Burbot	4	14	3	9	12	1	7	50
Brown bullhead	2	2		2		1	2	9
Carp					3	2	2	7
Brown trout					1	2	2	5
Other		2		1	2	6	7	18

Table 2. Lake trout egg and fry collections and lake whitefish egg collections in Thunder Bay, Lake Huron, 2009 through 2012.

				Lake trout				*Whitefish*	
Year	Site	Gear	# lifted	eggs	per m^2	fry	CPUE	eggs	per m^2
2009	Cement	egg bag	18	0				45	35.8
	Cement	egg trap	9	0				7	4.3
	CKD	egg bag	14	0				35	35.8
	CKD	egg trap	10	0				3	1.7
	East	egg trap	10	42	23.4			17	9.5
2010	Cement	fry traps	10			0			
	CKD	fry traps	10			0			
	East	fry traps	10			14	0.041		
	Cement	egg trap	6	0				0	
	CKD	egg trap	10	0				12	6.7
	East	egg trap	10	0				1	0.6
	A	egg trap	10	0				0	
	B	egg trap	10	1	0.6			0	
	D	egg trap	10	0				0	
	E	egg trap	10	0				0	
	F	egg trap	10	0				0	
	G	egg trap	10	0				6	3.3
2011	CKD	fry traps	10			0			
	East	fry traps	10			2	0.004		
	A	fry traps	5			1	0.004		
	B	fry traps	5			0			
	C	fry traps	5			0			
	D	fry traps	5			0			
	E	fry traps	5			0			
	F	fry traps	5			0			
	G	fry traps	5			0			
	Cement	egg trap	8	3	2.1			70	48.7
	CKD	egg bag	5	0				4	11.5
	East	egg trap	8	0				201	139.8
	East	egg bag	10	110	61.2			248	355.6
	CEM -1	egg bag	5	0				367	1052.4
	CEM-2	egg bag	2	0				93	666.7
	CEM-3	egg bag	4	0				156	559.2
	CEM-4	egg bag	5	0				236	676.7

	CKD-1	egg bag	4	0			60	215.1
	CKD-2	egg bag	5	0			144	412.9
	CKD-3	egg bag	4	0			152	544.8
	CKD-4	egg bag	5	0			284	814.4
	CEM-2	egg trap	8	0			248	172.5
	CEM -9	egg trap	8	0			77	53.6
	CEM-10	egg trap	8	0			112	77.9
	CEM-11	egg trap	8	0			40	27.8
	CKD-3	egg trap	0	0				
	CKD-4	egg trap	8	0			214	148.9
	CKD-8	egg trap	8	0			290	201.7
	CKD-10	egg trap	8	0			82	57.0
	B	egg bag	5	0			53	152.0
	B	egg trap	4	0			246	342.2
	E	egg bag	5	0			99	283.9
	D	egg trap	4	0			189	262.9
2012	Cement	fry traps	10		0			
	East	fry traps	10		20	0.05		
	LaFarge	fry traps	10		2	0.005		
	CKD-1	fry traps	10		1	0.0025		
	CKD-3	fry traps	10		0			
	CKD-8	fry traps	10		0			
	CKD-10	fry traps	10		0			
	CEM-1	fry traps	10		1	0.0025		
	CEM-4	fry traps	10		0			
	CEM-7	fry traps	10		1	0.0025		
	CEM-10	fry traps	10		0			
	D	fry traps	10		0			
	E	fry traps	10		0			

Table 3. Catch and catch per tow in 33-foot headrope bottom trawl of age-0 lake trout and lake whitefish, 1986-2012, Thunder Bay.

Year	Number tows	Age-0 whitefish	Age-0 lake trout	Catch per tow, whitefish	Catch per tow, lake trout
1986	29	1,698	64	58.56	2.21
1987	68	659	22	9.70	0.32
1988	71	2,097	37	29.53	0.52
1989	119	13,583	54	114.15	0.45
1990	79	7,482	42	94.71	0.53
1991	44	4,518	5	102.69	0.11
1992	41	1,212	7	29.56	0.17
1993	46	1,937	15	42.11	0.33
1994	41	6,389	22	155.82	0.54
1995	36	1,967	4	54.65	0.11
1996	34	828	3	24.37	0.09
1997	47	931	5	19.81	0.11
1998	40	216	3	5.40	0.08
1999	38	364	2	9.58	0.05
2000	36	1,155	1	32.08	0.03
2001	36	1,317	0	36.60	0.00
2002	36	553	0	15.35	0.00
2003	29	795	0	27.43	0.00
2004	31	554	11	17.88	0.35
2005	46	80	15	1.74	0.33
2006	40	38	0	0.95	0.00
2007	75	237	26	3.16	0.35
2008	58	270	5	4.65	0.09
2009	37	354	13	9.57	0.35
2010	31	335	7	10.81	0.23
2011	33	32	1	0.97	0.03
2012	17	14	2	0.82	0.12

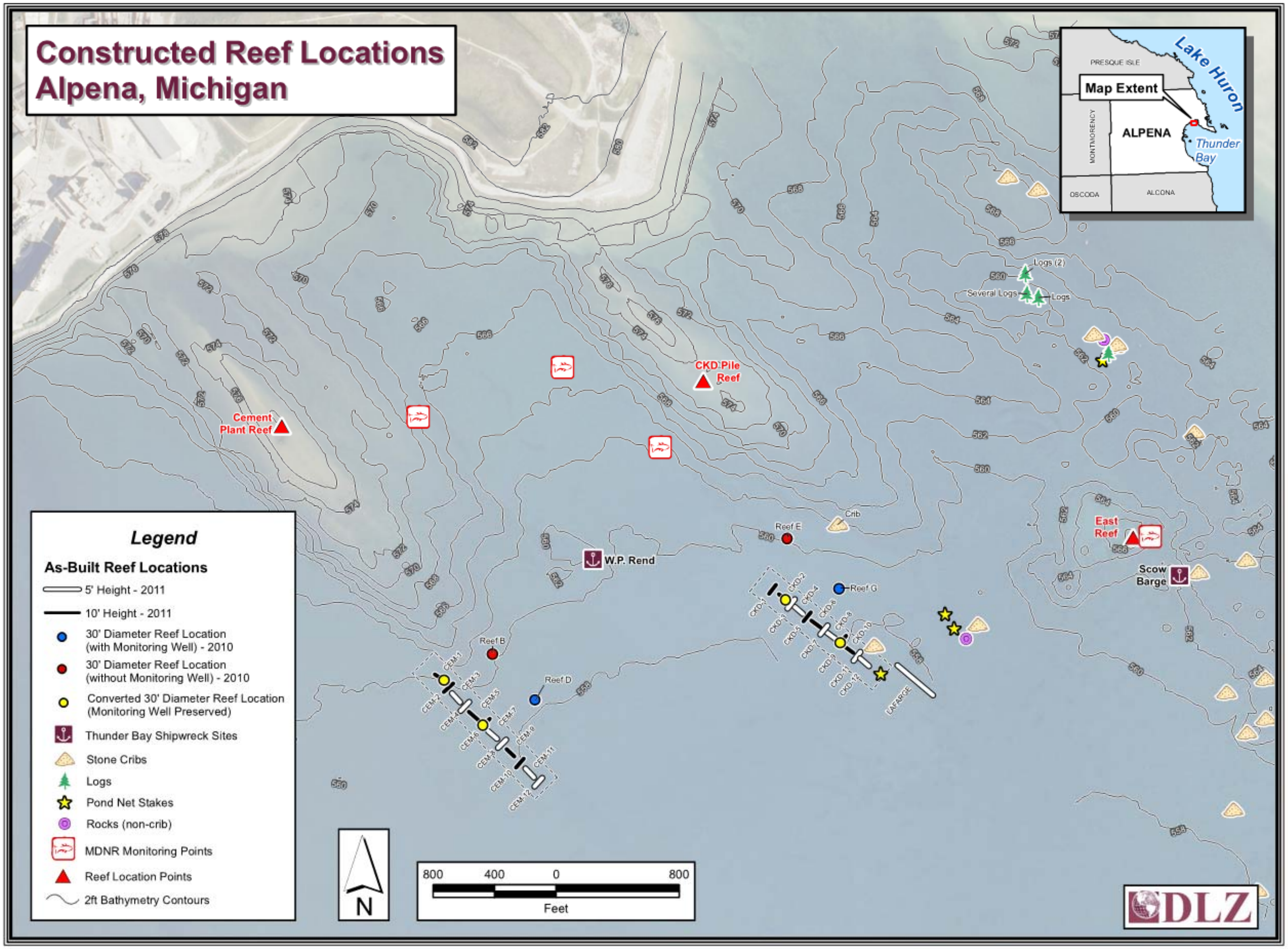

Figure 1. Locations of habitat remediation in Thunder Bay, Lake Huron.

List of Presentations

Dingledine, N. A. Thunder Bay Reef Habitat Restoration Project. Intergovernmental Air and Water Quality Committee Meeting, Alpena, Michigan. February 2010.

Johnson, J. Reef Restoration Progress Report, Spring Fishery Workshop, Alpena, Michigan. April 2011.

Johnson, J. Reef Restoration Progress Report, Thunder Bay Walleye Club. July 2011.

Adams, J.A. Thunder Bay Reef Habitat Restoration, Outreach Day, Alpena, Michigan. August 19, 2011.

Marsden, J. E. and J. Johnson. Reef Restoration in Thunder Bay, Lake Huron – Outreach Day, Alpena, MI, Aug. 19, 2011.

Adams, J.A. Reef Restoration Progress Report, DEQ Cadillac District Supervisors Meeting, Gaylord, Michigan, and Cadillac, Michigan. October 17, 2011.

Adams, J.A. Thunder Bay Reef Habitat Restoration Project. Intergovernmental Air and Water Quality Committee Meeting, Alpena, Michigan. October 20, 2011

Johnson, J. Reef Restoration Project Overview, Lake Huron Technical Committee. January 2012.

Johnson, J. Michigan Sea Grant/DNR Fishery Workshop, Alpena, Michigan. May, 2012.

Johnson, J. "Marine Technology and Great Lakes Issues" class, Alpena Community College. July 2012.

Johnson, J. Reef Restoration Presentation, North East Michigan Council of Governments in coordination with U.S. 23 Heritage Route Management Council, Alpena, Michigan. July 2012.

Adams, J. A. Reef Restoration Presentation, 23rd Northern Michigan Waterways Hazardous Material Spill Planning Committee (NO-SPILLS) Conference, Traverse City, Michigan. To be presented January 2013.

Marsden, J. E. Reef Restoration Presentation, 56th International Association for Great Lakes Research Conference, West Lafayette, Indiana. To be presented June 2013.

Media events

Marsden, J. E. Interview with Channel 11 news Alpena, MI in conjunction with outreach day on Reef Restoration project in Thunder Bay, Lake Huron, August 19, 2011

Alpena Now Radio – September 30, 2010

Alpena News (newspaper) August 19, 2011

Alpena News (newspaper) September 15, 2011