Spatial and Temporal Distribution of Invasive Rusty Crayfish (*Orconectes rusticus*) on Crucial Nearshore Spawning Reefs in Northern Lake Michigan

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Chapter 1 → Now the brief introduction/background section

What do we have so far for this? Put into an outline.

Chapter 1

Introduction

Objectives:

The objective of this study was to determine temporal patterns of Rusty Crayfish on native fish spawning reefs and adjacent substrates in Grand Traverse Bay (GTB) and Little Traverse Bay (LTB), northern Lake Michigan. Assess Rusty Crayfish movement, survivability, and population size on a native fish spawning reef in GTB, Lake Michigan.

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Methods:

Quadrat Sampling

Rusty Crayfish on and near native fish spawning reefs in northern Lake Michigan were monitored monthly from May to December 2013. Three sampling sites in Grand Traverse Bay (GTB) and Little Traverse Bay (LTB) (GTB Central, LTB Bay Harbor, and LTB Crib) were previously determined by the Michigan Department of Natural Resources (MDNR) to be spawning sites for native fish (Figure 1; Jonas et al. 2005; Barton et al. 2011). Within each site, 3 - 4 subsites were sampled. The subsites included the spawning reef and adjacent habitats (Figure 1, Table 1).

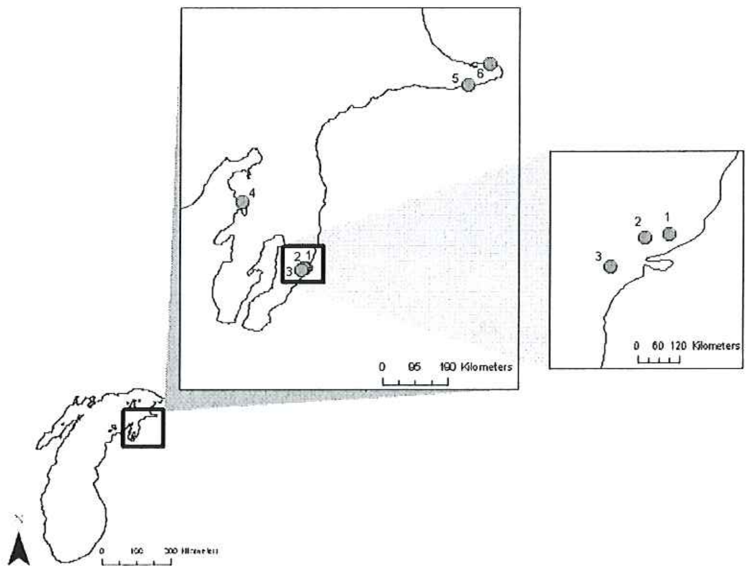
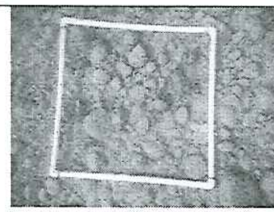
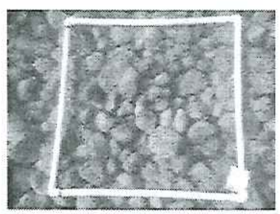


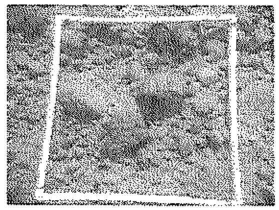
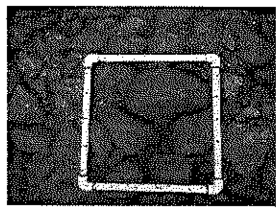
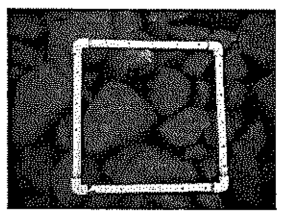
Figure. 1. Map indicating study site locations in Grand Traverse Bay (GTB) and Little Traverse Bay (LTB), northern Lake Michigan: 1. GTB North, 2. GTB Central, 3. GTB South, 4. LTB Bay Harbor, and 5. LTB Crib.

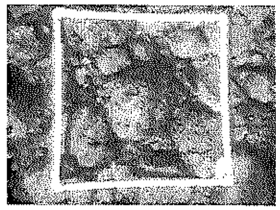
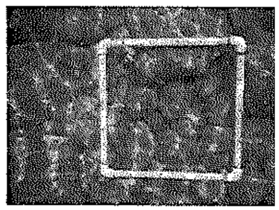
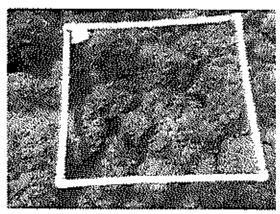
Habitat Classification

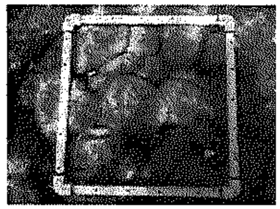
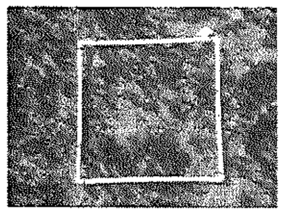
Two SCUBA divers sampled each subsite ten times with a randomly placed $1m^2$ quadrat. The substrate within the quadrat was photographed with an underwater camera (Panasonic Lumix). In shallow subsites (<1m), the $1m^2$ quadrat was too large to fit into the frame of the photograph; in this case, a $0.25m^2$ quadrat was used. The images were then analyzed in the laboratory with Image-Pro software, and the diameter (mm) and density ($\#/m^2$) of individual rocks within each quadrat were calculated (Table 1). Rock diameter was used to classify the substrate with the revised Udden (1898) and Wentworth (1922) scale proposed in Blott and Pye (2012). To determine if the subsites were

Table 1. Summary and photographs of subsite characteristics at sampling sites in Little Traverse Bay (LTB) and Grand Traverse Bay (GTB), northern Lake Michigan. Substrates are classified using scale developed by Blott and Pye (2012). Native fish spawning reef habitats are indicated by (*). Depth (m), mean rock density (#/m^2) (SE), and mean rock diameter (mm) (SE) data were gathered by analyzing ten quadrat (1m^2 – see photographs below) photographs of each habitat used in the quadrat sampling survey with Image-Pro software. See Figure 1 for site locations.

Site	Subsite	Substrate Classification	Photograph	Depth (m)	Rock Density (#/m²) (SE)	Rock Diameter (mm) (SE)	Rusty Crayfish (#/m²) (SE)
GTB Central	1	Very coarse gravel		~1	245.30 (27.70)	38.35 (2.78)	1.02 (0.14)
GTB Central	2*	Very small boulder		~2	72.70 (7.66)	88.87 (5.15)	2.70 (0.59)

GTB Central	3	Very coarse gravel		~5	99.20 (10.59)	61.12 (5.08)	3.18 (0.58)
LTB Bay Harbor	1	Very coarse gravel		~1	169.02(83.50)	56.52 (5.40)	1.95 (0.62)
LTB Bay Harbor	2*	Very small boulder		~2	77.60 (18.59)	124.90 (3.30)	0.38 (0.12)

LTB Bay Harbor	3	Small boulder		~3	22.80 (1.36)	180.72 (10.88)	1.5 (0.18)
LTB Bay Harbor	4	Small boulder		~5	16.70 (1.34)	167.48 (10.30)	1.00 (0.27)
LTB Crib	1	Very small boulder		~1	91.20 (8.36)	110.88 (6.14)	2.02 (0.56)

LTB Crib	2*	Small boulder		~2	62.80 (6.05)	143.51 (7.78)	0.12 (0.06)
LTB Crib	3	Sand		~5	<1 (0)	<1 (0)	0 (0)

different among the subsites, rock diameter and density were analyzed using analysis of variance (ANOVA). A Tukey's honest significant difference (HSD) test was used to compare variables when the ANOVA indicated significant differences among subsites (Figure 2). Relationships between depth and rock diameter and depth and rock density were examined with Pearson's product-moment correlation.

Rusty Crayfish Quadrat Sampling

Rusty Crayfish were sampled monthly from May to December 2013; samples were not collected in November due to weather-related logistical issues. During sampling events, the bottom temperature (°C) was recorded at each subsite with a hand held temperature probe (Onset HOBO Water Temp Pro v2). SCUBA divers randomly sampled each subsite ten times with a 1 m^2 quadrat. Within the quadrat, SCUBA divers removed the first layer of substrate by hand, recording the number of Rusty Crayfish in the quadrat. After sampling the quadrat, the disturbed substrate was returned to its original position. The SCUBA divers followed a randomly generated code, which dictated the location of the next quadrat within the subsite; the process was repeated until all ten quadrats were sampled.

The influence of subsite characteristics and water temperature on Rusty Crayfish densities over time in Grand Traverse and Little Traverse Bay were examined with a generalized linear mixed effects model (GLMM) with a Poisson distribution using the statistic program R (R Core Team, 2014) lme4 package (Bates et al. 2014). Depth, rock diameter, rock density, temperature, and time (month) were fixed effects; site (GTB Central, LTB Bay Harbor, LTB Crib) set as a random effect. A likelihood ratio test was conducted to determine the significance of each fixed effect.

Mark and Recapture

Rusty Crayfish were sampled and tagged at the GTB Central site (Figure 1). SCUBA divers delineated four mark and recapture zones, of varying depths, with lead line (Table 4). The zones were 15m x 15m and were further divided into nine equal sections (5m x 5m) (Figure 2).

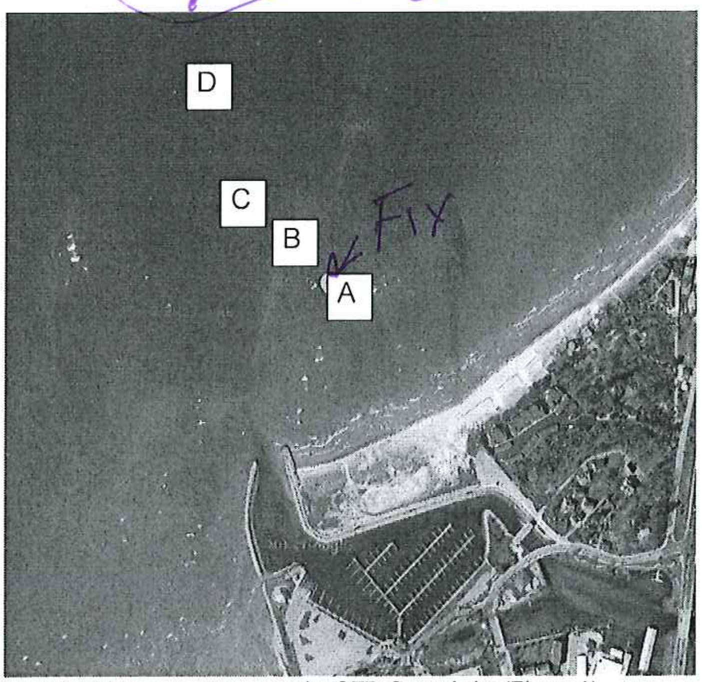


Figure 2. Mark and recapture zones at the GTB Central site (Figure 1).

Table 4. Description of mark and recapture zones located at the GTB Central site (Figure 2) including mean depth (m), distance from shore (m), and visual observations of substrate type.

Zone	Depth (m)	Distance from Shore(m)	Substrate type
A	1	200	Very coarse gravel
B	2	310	Very small boulder
C	3	400	Very coarse gravel
D	5	580	Very coarse gravel

Sampling was conducted 8 August - 11 September, 2013. Each zone was sampled biweekly over eight weeks for a total of four sampling events. In each zone, a team of 2-4 SCUBA divers randomly searched the first layer of substrate in each section and captured Rusty Crayfish by hand or with a hand net, placing any captured Rusty Crayfish into a mesh bag. Once a section was thoroughly searched, the Rusty Crayfish were taken to the support boat to be sexed and measured (carapace length, CL, nearest mm). The first 1000 Rusty Crayfish with a carapace length greater than 18mm were marked with a uniquely numbered Floy Tag (Model FTSL-73), inserted dorsally through the abdominal musculature of the tail underneath the first tail segment. The tags did not interfere with leg or tail movement and were designed to last through molting. The Rusty Crayfish were secondarily marked with a uropod clip. Rusty Crayfish not given a Floy Tag were marked with a uropod clip to prevent overestimation of the population. Rusty Crayfish were then returned to the same section in which they were captured. SCUBA divers placed returned Rusty Crayfish underneath rocks and cover to prevent the crayfish from swimming out of the section.

Statistical Analyses

Need to add

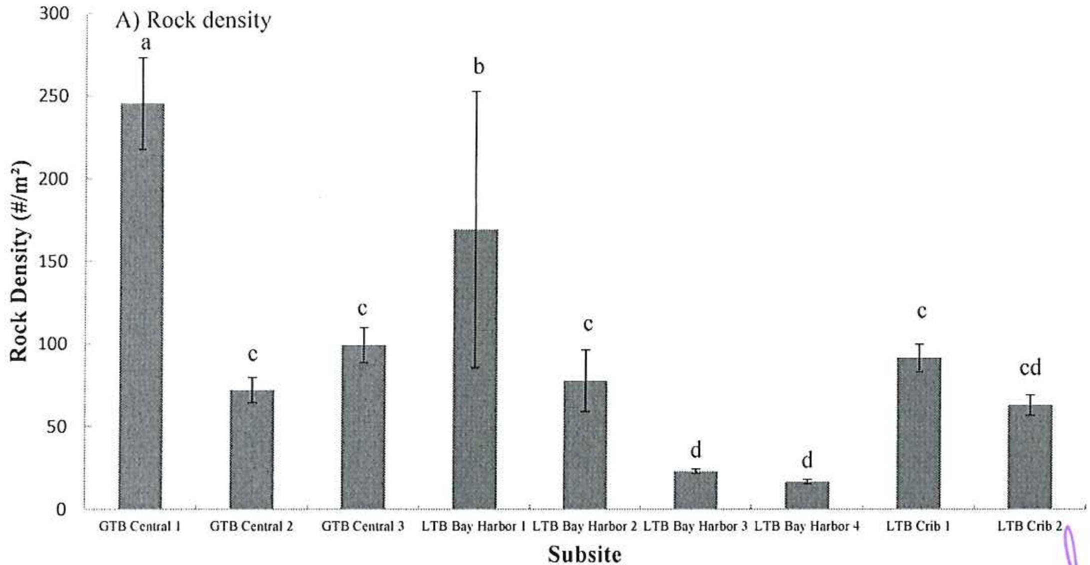
Results:

Quadrat Subsite Habitat Classification

All ten subsites were classified into four sediment classes; sand (<1mm), very course gravel (32mm - 64mm), very small boulder (64mm – 128mm), and small boulder (128mm – 256mm) (Blott and Pye 2012). The GTB Central site aveaged the smallest class sizes, very course gravel and very small boulder substrate (Table 1). LTB Bay Harbor 1 subsite is also very coarse gravel, but the deeper subsites contain very small boulders and small boulders. The LTB Crib 1 and 2 substrates were classified as very small boulder and small boulder, which are the largest classifications of the shallow and spawning reef substrates. LTB Crib 3 was classified as sand which is the smallest classification out of all of the subsites (Table 1).

Rock diameter was significantly different between subsites ranging from <1mm (SE = 0) at LTB Crib 3 to the largest substrate 180.72 mm (SE = 10.88) at subsite LTB Bay Harbor 3 (df, 9, 90, F = 81.33, $P = < 2.0\text{x}10^{-16}$) (Figure 2a). Pearson's product-moment correlation showed that there was no relationship between diameter and depth (df = 98, r = -0.021, P = 0.837). However, if the deep sandy habitat from LTB Crib 3 is removed from the analysis, Pearson's product-moment correlation indicates a significant positive correlation between rock diameter and depth (df = 88, r = 0.326, P = 0.0017). The habitat at each site is rocky near shore and becomes sandy as you continue offshore. LTB Crib site becomes a sand habitat shallower and closer to shore than the other sites. Therefore, across the majority of the sites, as depth increases the diameter of the rocks increase until the sandy habitat is reached offshore.

There was a significant difference in rock density (#/m^2) between subsites (df = 9, 90, F = 31.57, P = < $2x10^{-16}$) (Figure 2b). Rock density ranged from no rocks at LTB Crib 3 to 245.30 rocks/m^2 (SE = 27.7) at GTB Central 1. There was a negative correlation between rock density and water depth (df = 98, r = -0.545, P = $4.403x10^{-9}$). As water depth increases rock density decreases as rocks diameter increases and start to dissipate into sandy habitat.



Need all the subsites on here

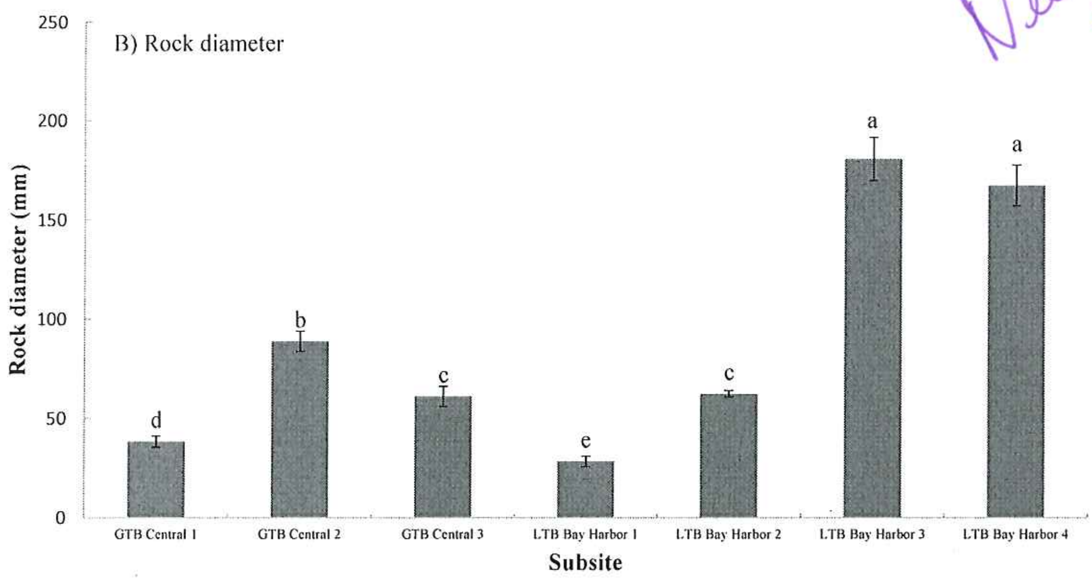


Figure 2

Figure 2. A) mean rock diameter (±SE) and B) mean rock density (±SE) of each subsite used in monthly quadrat sampling that were determined with Image-Pro analysis. The letters above the bars indicate a significant difference between the subsites (one-way ANOVA, Tukey-HSD post hoc test; *P* = 0.05). See Figure 1 for sampling locations.

Rusty Crayfish Quadrat Densities

The generalized linear mixed effect model indicated that water depth and rock density were not significant predictors of Rusty Crayfish density across the subsites (Table 2). Rock diameter was not a significant factor, but may still play a role in Rusty Crayfish densities with a *P* = 0.058 (Table 2). Both time and temperature were significant predictors of Rusty Crayfish density (Table 2). Rusty Crayfish density varied across subsites, but peaked in one or more subsite at each site during the month of September as water temperature peaked ~20°C (Figure 2).

The mean Rusty Crayfish density increased with depth at GTB Central site (Table 1). GTB Central 1 and 3 were classified as very course gravel; however the mean rock diameter at GTB Central 3 was almost twice the size of GTB Central 1(Table 1). GTB Central 3 had a mean crayfish density three times higher than GTB Central 1 (Table 1). There were equal peaks at GTB Central 2, the spawning reef with the largest rock diameter, and GTB Central 3 during September (~6 crayfish/m^2) (Figure 2). Rusty Crayfish densities decrease after September to ~1.5 crayfish/m^2 and ~3 crayfish/m^2 at GTB Central 2 and 3 respectively.

Unlike GTB Central, the majority of the Rusty Crayfish at LTB Bay Harbor were found in the shallowest subsite, LTB Bay Harbor 1 (Table 1). LTB Bay Harbor 1 was classified with the smallest substrate, very course gravel, at the LTB Bay Harbor site.

Rusty Crayfish densities were lowest at LTB Bay Harbor 2, the spawning reef classified as very small boulder, and increased slightly in the deeper subsites (Table 1). LTB Bay Harbor 3 and 4 had the largest rock diameter and were classified as small boulder (Table 1). Rusty Crayfish density peaked in September at 5 crayfish/m^2 (SE = 0.63) LTB Bay Harbor 1. During September there were also above average reading at LTB Bay Harbor 3 and 4 (Figure 2). Rusty Crayfish density decreased in October at all sites as temperature dropped from its peak, ~20°C to ~15°C, except in LTB Bay Harbor 4 where density increased slightly, 1.9 crayfish/m^2 (SE = 0.48) to 2.2 crayfish/m^2 (SE = 0.40). In December Rusty Crayfish density decreased to less than 1 crayfish/m^2 at all subsites, with the highest densities in subsite 3 and 4, 0.9 crayfish/m^2 (SE = 0.28) and 0.8 crayfish/m^2 (SE = 0.29) respectively.

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LTB Crib 1 had the highest mean Rusty Crayfish density, 2.02 crayfish/m^2 (SE = 0.56), at the LTB Crib site (Table 1). There was a peak in September at both LTB Crib 1 and 2 subsites, 4.7 crayfish/m^2 (SE = 1.05) and 0.5 crayfish/m^2 (SE = 0.17) respectively. Rusty Crayfish density decreased in October and December in LTB Crib 1 and 2 as temperatures dropped from their peak in September ~20°C to their low ~4°C in December (Figure 2). Given the sandy habitat and lack of shelter, no Rusty Crayfish were detected in LTB Crib 3 during the study.

↓ Important

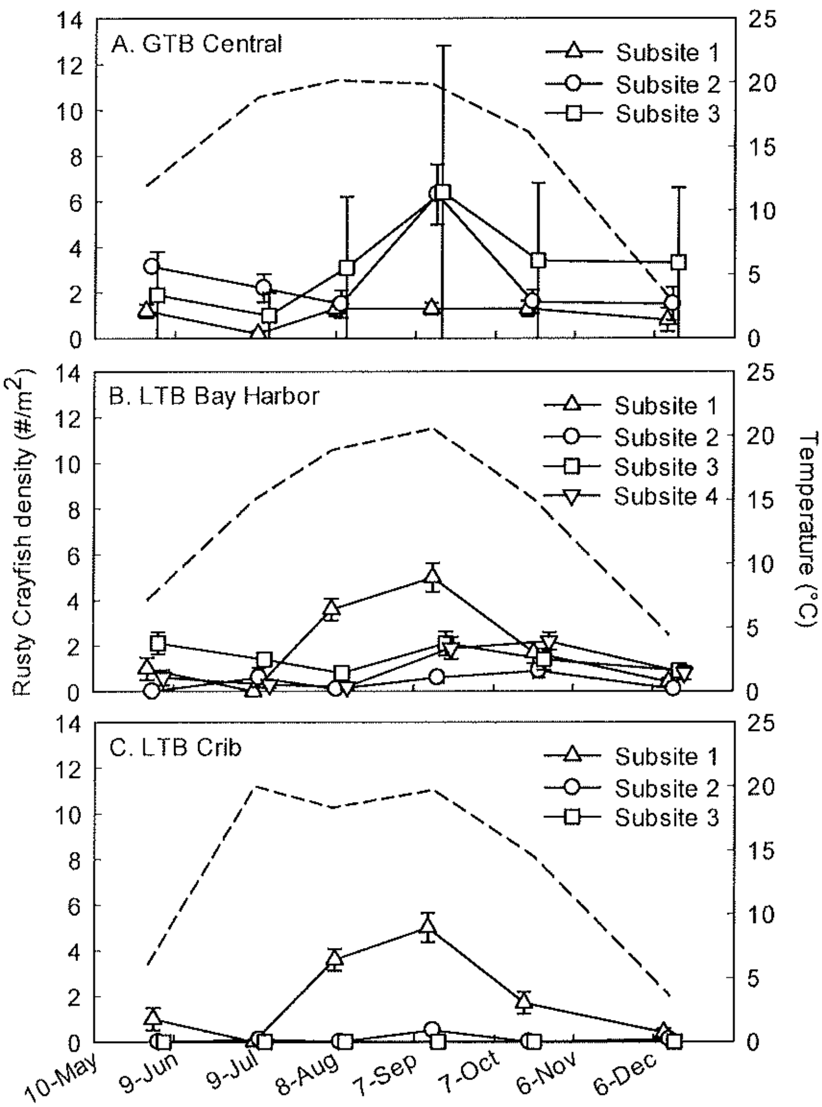

Figure 3. Mean Rusty Crayfish density (# Rusty Crayfish/m²) from quadrat sampling at LTB Bay Harbor (A), LTB Crib (B), and GTB Central (C) from May-December 2013. Error bars indicate ± SE. Checkered line represents the water temperature (°C), averaged across each subsite, of each site.

Table 2. Rusty Crayfish densities collected by monthly quadrat sampling, May – December 2013, in Grand Traverse Bay (GTB) and Little Traverse Bay (LTB), northern Lake Michigan, were analyzed with a Generalized Linear Mixed Effect Model (GLMM) to determine ecological influences on the Rusty Crayfish population. Model 1 represents the full model: Rusty Crayfish density ~ depth + rock diameter + rock density + time + temperature + (1| site). Model 2 represents the full model minus a given fixed effect. The degrees of freedom (Df), log likelihood (LogLik), Chi-Square (χ^2), *P*-value (P ($>\chi^2$)) for each fixed effect were determined by conducting a likelihood ratio test.

Fixed Effect		Df	LogLik	Df	X^2	$P(>X^2)$
Depth	Model 1	7	-1042.5			
	Model 2	6	-1043.1	1	1.22	0.268
Rock Diameter	Model 1	7	-1042.5			
	Model 2	6	-1044.3	1	3.59	0.058
Rock Density	Model 1	7	-1042.5			
	Model 2	6	-1042.7	1	0.435	0.509
Temperature	Model 1	7	-1042.5			
	Model 2	6	-1086.7	1	88.40	$<2.20 \times 10^{-16}$
Time	Model 1	7	-1042.5			
	Model 2	6	-1068.0	1	50.84	8.72×10^{-13}

Mark and Recapture:

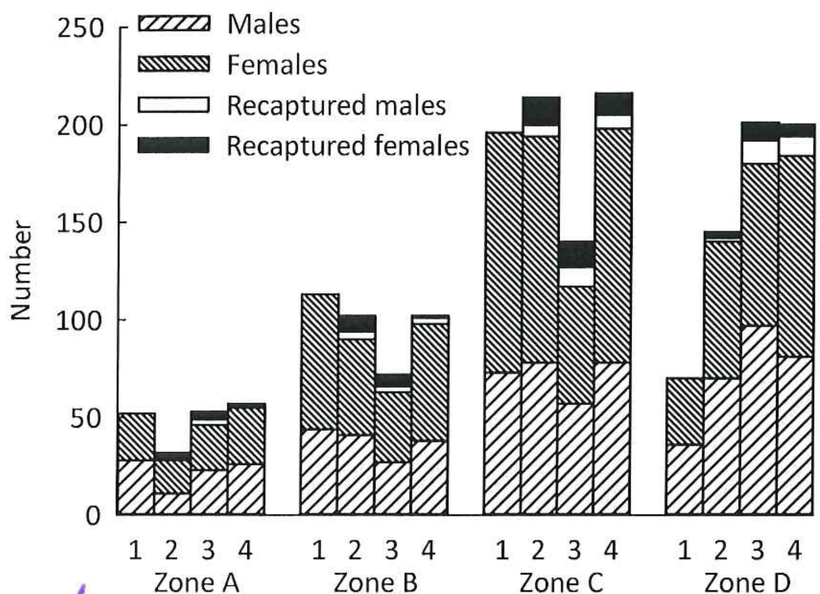

Figure 3. Number of male and female Rusty Crayfish captured (hatched bars) and recaptured (solid) during the mark and recapture period, August - September 2013, at the GTB Central site. See Figure 1 for site locations.

Results?

Chapter 3

Objective:

Conduct invasive Rusty Crayfish removal using a variety of gear types.

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Methods:

Removal

Rusty Crayfish removal was conducted at the GTB South, GTB Central, GTB North, and LTB Crib sites, Lake Michigan (Figure 1). Methods used for removal included minnow traps, tangle nets, and hand removal via SCUBA diving (Table 5). Captured Rusty Crayfish were measured (carapace length, CL, nearest mm), sexed, and euthanized.

Minnow traps were set two meters apart on a line secured by anchors and marked with floating buoys. Minnow traps were baited with chunks of fresh Lake Trout gathered from gill netting surveys and cleaning stations. Any native species of fish or crayfish captured in the minnow traps were identified, measured (total length, TL, mm), and released immediately. How often were minnow traps checked?

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Tangle nets were created by baiting monofilament gill nets with Lake Trout carcasses and placing them on the substrate. Lake Trout were placed every two meters along the tangle net. The tangle nets were anchored to the lake bottom with additional weights placed every 5m on top of the net to prevent the net from floating. Nets were checked by SCUBA divers during removal events that occurred during the time period that the nets were deployed. All Rusty Crayfish ensnared in the tangle nets were counted and sacrificed.

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SCUBA divers removed Rusty Crayfish at several of the sites. SCUBA divers searched the first layer of substrate along transect lines and captured Rusty Crayfish by hand or with a hand net, placing any captured Rusty Crayfish into a mesh bag. Captured Rusty Crayfish were taken to the support boat to be sexed, measured (carapace length, CL, nearest mm), and euthanized. Effort varied among the sites. The Little Traverse Bay Crib and the Elk Rapids North reef received the greatest amount of effort, while the Elk Rapids Central and South sites received less removal effort respectively (Table 5).

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Statistical Analysis

Catch per unit effort (CPUE) was calculated differently for each gear type. Minnow trap CPUE was calculated by Rusty Crayfish/trap/day. Tangle net CPUE was calculated as Rusty Crayfish/ m of net/day. Hand removal CPUE was calculated as Rusty Crayfish/m of transect/day. Differences in carapace length among the removal types? by site? were examined with a one-way analysis of variance (ANOVA) ateach site. Male:female ratio was analyzed with a regression over time to see patterns across sampling events at each site. Rusty Crayfish captured by minnow traps were not analyzed due to their limited use. Tangle nets were not analyzed because entangled Rusty Crayfish sex and carapace length were not measured.

Commented [GTL7]: Put this first since the focus is on the number of removed

Commented [GTL8]: Time is the dependent variable? Just checking

Commented [GTL9]: Just for the scuba diving? Not clear with next two sentences.

Commented [GTL10]: Are you just referring to carapace lengths? Not clear

.

Results:

A total of 2,693 Rusty Crayfish were removed from across all sites. The fewest number of Rusty Crayfish, 0.07%, were removed from GTB South. The Rusty Crayfish removed from GTB Central and GTB North contributed 10.66% and 15.22% to the total

Commented [GTL11]: This is good.

amount of Rusty Crayfish removed respectively. The Rusty Crayfish removed from the LTB Crib made up 74.04% of the total Rusty Crayfish removed.

Minnow traps were used at GTB North, GTB Central, and GTB South (Table 5). Thirteen Rusty Crayfish (0.48% of total Rusty Crayfish removed) were removed with minnow traps across all three sites (Table 7). Due to weather conditions and logistical issues, minnow traps were the least used removal method (Table 5). Mean carapace length of the Rusty Crayfish captured by minnow traps across sampling dates was 32.91(SE = 1.79) mm for males and 32.67 (SE = 3.33) mm ± 3.33 for females. The mean male:female ratio of Rusty Crayfish captured by minnow traps across all sites and dates was 76.9%. What was the CPUE?

Tangle nets removed 17.45% of the total Rusty Crayfish. Tangle nets were used at GTB North, GTB Central, and LTB Crib (Table 5). What else can you say about the tangle nets? What was the CPUE?

Hand removal via SCUBA diving captured the majority (82.1%) of Rusty Crayfish at the GTB North, GTB Central, and LTB Crib sites (Table 7). The mean CL ± SE of Rusty Crayfish at GTB North was different among removal events ($P = 0.03$) (Table 8). The male:female ratio at the GTB North site did not differ over time ($R^2 = -0.11$, $P = 0.49$,). Carapace length decreased over time at the GTB Central site ($P = 0.003$) (Table 8). Given that only two hand removal events were conducted at the GTB Central site (Table 5), a regression could not be used to analyze the male:female ratio over time. TTEST The male:female ratio was 46% during the first removal and 36% after the second removal (Table 8). Mean CL was significantly different between removal

Commented [GTL12]: Can you just give the numbers rather than the percentages?

Commented [GTL13]: What is the pattern?

Commented [GTL14]: Breakdown by sex like you did for the minnow traps

Commented [JB15]: When I asked around Randy and Andrew said that I could use a regression. Also the data is not balanced so I don't think I can run a repeated ANOVA on this.

Commented [GTL16]: Why regression and not repeated measures

Commented [GTL17]: For males and females?

Commented [GTL18]: So how did you analyze the carapace length?

Commented [GTL19]: How?

events at LTB Crib (P = <0.001). The male:female ratio did not differ over time (R^2 = 0.33, P = 0.079).

The catch per unit effort varied between gear types and site (Table 6). At GTB North, minnow trap CPUE ranged from 0.27-2.38 units. Tangle nets had a CPUE of 0.02 unit. Hand removal CPUE was unable to be calculated for the GTB North site due to insufficient data (dive time or transect length) needed to calculate CPUE. Minnow traps at the GTB Central site CPUE was 5.56, tangle nets were 0.014, and hand removal was unable to be calculated due to insufficient data. Minnow trap CPUE ranged from 0 - 1.63 at GTB South site. Tangle net CPUE ranged from 0.006 to 0.14 at the LTB Crib site. Hand removal conducted at LTB Crib had the highest CPUE across all sites and methods ranging from 2.93 - 31.38 (Table 6).

Commented [GTL20]: Give the units

Commented [GTL21]: ?

Commented [GTL22]: What does this mean? Was it not recorded?

Commented [GTL23]: I think the CPUE data needs to be moved up

Commented [GTL24]: Reorganize so that comparisons can be more easily made

Table 5. Summary of Rusty Crayfish removal methods (minnow traps, tangle nets, and hand removal via scuba diving) in 2013 at GTB North, GTB Central, GTB South, and LTB Crib. For each site and date, the number of minnow traps and the set times (hrs) are provided for the minnow trap removal method. The total length of nets (m) and total hours deployed are provided for the tangle net method. The total length of surveyed transects and total hours of diver removal are given for the hand removal methods. Dashes (-) indicate unspecified value (e.g., transect length not recorded). See Figure 1 for site locations.

Site	Date	Minnow Traps		Hand removal		Tangle nets	
		# traps	hrs	Total transect length (m)	Hrs	Total net length (m)	Hrs
GTB North	19-Sep			-	-		
	30-Sep			-	4.8		
	11-Oct			-	-	200	26
	28-Oct					200	40
	29-Oct	30	1				
	3-Nov			-	2.6		
	20-Nov	30	3				
GTB Central	18-Sep			-	2.5		
	11-Oct			-	-		
	28-Oct					230	96
	29-Oct	30	1				
GTB South	29-Oct	30	1				
	20-Nov	61	3				
LTB Crib	13-Aug			-	-		
	19-Aug			32	-		
	23-Sep			80	2.8		
	24-Sep			150	6.9		
	25-Sep			100	8.4		
	26-Sep			250	11.		
	4-Oct			60	2.9	550	38
	10-Oct			-	-		
	15-Oct			90	2.8	550	26
	17-Oct			70	3.3		
	28-Oct					550	31

Table 6. Total number of Rusty Crayfish removed and mean catch-per-unit-effort (CPUE; #/24hr) of Rusty Crayfish by date removed via minnow traps, tangle nets, and hand removal via SCUBA diving in 2013 at GTB North, GTB Central, GTB South, and LTB Crib sites. See Figure 1 for site locations.

Site	Gear	Date	# removed	CPUE Mean
GTB North	Minnow trap	29-Oct	3	2.38
		20-Nov	1	0.27
	Hand removal	19-Sep	127	-
		30-Sep	92	-
		11-Oct	8	-
		3-Nov	48	-
	Tangle net	11-Oct	54	0.02
		28-Oct	75	0.02
GTB Central	Minnow trap	29-Oct	7	5.56
	Hand Removal	18-Sep	117	-
		11-Oct	36	-
	Tangle net	28-Oct	127	0.014
GTB South	Minnow trap	29-Oct	2	1.63
		20-Nov	0	0
LTB Crib	Hand removal	13-Aug	250	-
		19-Aug	115	-
		23-Sep	86	8.96
		24-Sep	224	5.15
		25-Sep	286	8.17
		26-Sep	352	2.93
		4-Oct	202	31.38
		10-Oct	18	-
		15-Oct	98	9.17
		17-Oct	123	12.55
	Tangle net	4-Oct	56	0.006
		15-Oct	83	0.014
		28-Oct	75	0.010

Table 7. Total number of Rusty Crayfish removed via minnow traps, tangle nets, and hand removal via scuba diving in 2013 at GTB North, GTB Central, GTB South, and LTB Crib. Dashes (-) represent that a gear type was not used at that site. See Figure 1 for site locations.

Gear	GTB North	GTB Central	GTB South	LTB Crib	Total removed
Traps	4	7	2	-	13
Tangle nets	129	127	-	214	470
Hand removal	277	153	-	1780	2210
Total removed	410	287	2	1994	2693

Table 8. Mean carapace length (SE; mm) and male:female ratio during each removal event at GTB North, GTB Central, and LTB Crib sites, 2013. See Figure 1 for site locations.

Site	Gear	Date	Carapace Length (mm) (SE)	Male:Female ratio
GTB North	Minnow trap	29-Oct	33.33 (1.45)	0.67
		20-Nov	36 (0)	0
	Hand removal	19-Sep	25.57 (0.57)	0.58
		30-Sep	29.64 (0.64)	0.64
		11-Oct	27.13 (2.15)	0.38
		3-Nov	27.79 (0.99)	0.52
GTB Central	Minnow trap	29-Oct	29.29 (1.29)	0.86
	Hand Removal	18-Sep	24.15 (0.47)	0.46
		11-Oct	21.28 (0.83)	0.36
GTB South	Minnow trap	29-Oct	41.5 (3.5)	1
		20-Nov	0	0
LTB Crib	Hand removal	13-Aug	24.85 (0.31)	0.48
		19-Aug	22.23 (0.45)	0.47
		25-Sep	25.17 (0.31)	0.5
		26-Sep	26.45 (0.27)	0.52
		4-Oct	23.74 (0.30)	0.46
		10-Oct	22.89 (1.21)	0.5
		15-Oct	23.27 (0.39)	0.43
		17-Oct	25.42 (0.45)	0.38

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