Shediac Bay Watershed Green Crab (C*arcinus maenas)* Survey in Coastal Waters of the Southeast Gulf of St. Lawrence: Shediac Bay

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Final Report

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ABSTRACT

During the 2013 summer - fall sampling season, a total of 10 Fukui crab traps were fished for 24 hours periods in Shediac Bay. Sampling of 10 sites on the inner bay was set twice a month for 2 ½ months for a total of seven outings. During the summer – fall sampling season in 2014 and 2015, 10 Fukui crab traps were set once a month from May to September. In 2013, eight transects of the same 10 traps were set around the entire bay over the same period. It was determined that this was not necessary in 2014 or 2015. The amount of marine area covered by the study was 20.16 square kilometres. Green crab was the target species as they have moved into the bay as they were first observed 3 years ago (2012). In 2014, their numbers were observed to have increased exponentially. In 2015, numbers were down significantly, but did show signs of rebounding in September (2015). The study purpose for all three seasons was to acquire an idea of their density and distribution in the bay. Every fished effort resulted in some crab being caught. The green crabs were prevalent in eel-grass habitat and were not found in sandy bottom locations. Males were more dominant than females especially later in the season.

1.0 INTRODUCTION

In 2011, the first of the invasive green crabs first appeared in Community Aquatic Monitoring Program (CAMP) survey beach seines. The local environmental NGO, Shediac Bay Watershed Association (SBWA) had predicted they would appear as they were known to be migrating up the Northumberland Strait. They had already become prolific in Nova Scotia and Prince Edward Island. In 2012, CAMP surveys saw an exponential increase in the numbers of crab collected in the Shediac bay area. It was after this significant increase that SBWA decided that a more extensive survey would be beneficial to understanding how extensive the green crab population has become. Phase I (2013) was to do an initial survey to determine what the population dynamics appeared to be. Phase II (2014) would be to repeat the sampling regime to determine any population structure changes. Funding was acquired from the NB Wildlife Trust Fund (NBWTF) in 2015 to continue this important monitoring study.

1.1 Background

The European green crab C*arcinus maenas* is considered an aggressively invasive alien species in most of the regions it inhabits. It has spread across the globe by hitching rides on the hulls of ships and possibly as larval stage in ballast water and is now found on every continent except for Antarctica.

A native of Europe and Northern Africa, the green crab has invaded the Atlantic and Pacific coasts of North America, South Africa, Australia, South America, and Asia. In North America, the distribution of green crabs now extends from Newfoundland to Virginia and from British Columbia to California.

This species originated in the northeastern parts of the Atlantic Ocean, particularly the Baltic Sea. However, with the help of global fishing and shipping industries, it has quickly broadened its range and is now found in parts of Canada.

Green crabs live up to 4-7 years and can reach a maximum size of 9-10 cm (carapace width). The life cycle alternates between benthic adults and planktonic larvae. Green crabs are efficient larval dispersers, but most invasions have been attributed to anthropogenic transport.

This species most distinctive feature is the greenish tinge on its shell. Although it can range anywhere from grey to red, the species is primarily green in most regions. The shell has no bumps on it and extends all the way to the eyes, giving it an almost saucer-like shape. On average, the crab is 60 millimeters long and 90 millimeters wide.

The green crab has successfully colonized sheltered coastal and estuarine habitats and semi-exposed rocky coasts. Fecundity was estimated at 140,000- 200,000 embryos per mass. It is commonly found from the high tide level to depths of 5 - 6m. It is eurythermic, being able to survive temperatures from 0 to over 35 ^{o}C and reproduce at temperatures between 18 and 26 ^{o}C. It is euryhaline, tolerating salinities from 4 to 52 $^{o}/_{oo}$. It is reasonably tolerant of low oxygen conditions.

Green crabs prey on a wide variety of marine organisms including commercially important bivalves, gastropods, decapods and fishes. Impacts on prey populations are greater in soft-bottom habitat and in environments sheltered from strong wave action.

The demise of the soft-shell clam fishery in northern New England and Nova Scotia in the mid-1950s was associated with green crab. The green crab is aggressively colonizing along Canada's east coast, putting Canada's clam, mussel, and oyster industries at risk. The landed value of Atlantic clams, mussels, and oysters was about $57 million in 2000. The landed value of Atlantic lobster, which scientists believe may also be threatened, was over $500 million in 2000. The values represented here are dated and their impact in the current decade may be even higher. Eel fishermen livelihood is also threatened as the crabs enter nets and by attacking eels bunched in the eel trap can significantly affect the quality of the eel catch.

The species potentially competes for food with many other predators and omnivores. The predominant predators of green crabs include fishes, birds, and larger decapods.
The effects of green crabs have been of particular concern to shellfish culture and fishing industries, as well as eel fisheries. Control efforts have included fencing, trapping and poisoning. Commercial fisheries for green crab have reduced its abundance in parts of its native range.
In all regions where green crabs have been found, they were more abundant in protected embayments. Green crabs have been successful invaders of warm, sheltered coastal and estuarine habitats throughout the world.

Green crabs are well-documented to suppress the abundance of bivalve prey, including several species that are commercially fished or grown in aquaculture in Canada: blue mussels *Mytilus edulis*, quahogs *Mercenaria mercenaria*, eastern oysters *Crassostrea virginica*, soft-shell clams *Mya arenaria*, and bay scallop *Argopecten irradians.*

"It must be concluded that the green crab is one of the worst, if not the worst, clam predators we know. Its ability to multiply rapidly, to feed on many varieties of shellfish other than commercial species, and its large appetite for commercially important shellfish, all suggest that it can do enormous damage."

In Atlantic Canada this species is a threat to vital eel-grass habitat that many migratory birds and fish species rely on. By chopping off the shoots of eel-grass right at its base, the crab can easily destroy an entire area. The crabs do not consume these roots, they are searching for food. In fact, this voracious critter is on the One Hundred of the World's Worst Invasive Alien Species List.

The green crab, otherwise known as the cockroach of the sea, invaded the coast of North America at Cape Cod more than a century ago. By the 1950s, it had colonized in the waters of New Brunswick in the Bay of Fundy. The green crab not only preys on native crabs, clams, oysters, and mussels and occupies their habitat but also eats the same food as crabs, lobster, and many seabirds. A single green crab can eat 40 clams in a day. It also carries a parasite that is harmful to the eider duck, whose downy feathers have been prized for generations as insulation and bedding material.

1.2 Purpose of the study

The invasive green crab has a history of being very destructive to local habitat and to populations of preferred prey. Once it was verified that they had moved into the Shediac Bay area, SBWA undertook to determine at what population levels we had and to monitor how they would change over the years. SBWA is the first to undertake such a survey. From past experience in eastern Canadian coastal waters, there have been explosive numbers verified for locations in Nova Scotia and PEI. Now that their northern coastal migration has reached us, we hope to determine rough population size and to be able to monitor change during subsequent years. Lacking the resources of government or university agencies allows us to do limited evaluation.

There are fishing industries that experience detrimental effects due to green crab introduction. Decimation of molluscan beds, especially clams, has been well documented. Green crabs that get into eel nets have been known to ruin fresh eel product and in some cases have caused the eel fishery to be non-viable. In the search for food, green crab have been documented to destroy eel grass beds. Destruction of this important habitat will have detrimental effects on the health of the Bay, as it has in other locations. The overall health of the eel grass habitat is vital to the health of any inshore marine ecosystem.

In order to initiate any control over the numbers, population data is needed. A possible limited sustainable fishery for green crab is a solution that will not be initiated until valid population data is available to warrant the introduction of such a control method. These decisions are out of our control or jurisdiction. The data we gather through this study may help influence a sooner rather than later need for control measures. This is a problem that will not go away as the green crab migrate up the coast of the Northumberland Strait.

2.0 MATERIALS and METHODS

2.1 Materials required to carry out the trapping survey

Ten Fukui traps (Polyethylene Fish Trap Nets Model FT-100) (Figure 1) were purchased and delivered in the early spring of 2013.

Figure 1. Top view of the Fukui trap used in this study

These are the exact same traps used by DFO for their green crab studies and we expect the same traps will be used in a possible upcoming study to be carried out by a university led NRC group possibly starting next year. Lines and buoys were borrowed from DFO. The lack of water velocity in the bay meant that no extra weight was needed to keep the traps in place. In channels close to the two rivers, the traps were placed just off channel to avoid drift caused by tidal flow and river flow currents.

A loan agreement was reached with DFO to borrow and maintain a boat and trailer to use for this survey in 2013 and 2014. The boat was a 19 foot Boston Whaler with a 90 HP Honda outboard. DFO paid for spring and fall servicing. O and N Sports in Grande Digue did all the service and the cost invoice was paid by DFO. SBWA paid for transport to and from the storage facility at the beginning and end of the season and for all the gas expense and daily maintenance. SBWA had hoped the boat would again be available for the 2015 season. However, it was not, so a similar sized boat was rented for the study in 2015.

Figure 2. Boston Whaler with traps loaded to set that day.

We experimented with different types of bait. In the end it was determined the most cost effective were cans of sardines. We used 10 of the soya oil based cans for each sampling. We used thick plastic bottles similar to our water sample bottles where several holes were drilled, 3 to 4 sardines put in each bottle and placed in the net bait bag in the trap.

Figure 3. Bottles with drilled holes ready to be baited with sardines from can.

The traps were all set for 24 hours. Weather, especially wind conditions, usually determined the exact date to fish in the middle and at the end of the month during the study in 2013. In 2014, limited funding allowed only monthly sampling. Additional funding from NBWTF allowed this important study to maintain continuity in 2015.

In 2013, the Shediac Bay Marina provide a berth free of charge to the SBWA where we could keep the boat all season which meant we did not have to drop and remove the boat each sampling. In 2014, we had free storage at the O and N boatyard, in-kind launch contribution from the Pt. Du Chene Harbour Authority and in-kind storage for 24 hours at the Pt. Du Chene marina. A similar

arrangement from the Harbour Authority was negotiated for 2015. Storage between trap sets was provided by First Choice Marine in 2015.

2.2 Study Area

A map of Shediac Bay shows the extent of the study area outlined in black and shaded light blue.

The total square kilometres is 22.3 minus 2.14 (Shediac Island) to give us 20.16 square kilometres or 20,160,000 square meters, a number to be used later to determine rough population estimates. The bay is basically shallow with mostly an eel-grass bottom. Shediac Island in the outer middle directs two outflows from the two rivers to the Northumberland Strait.

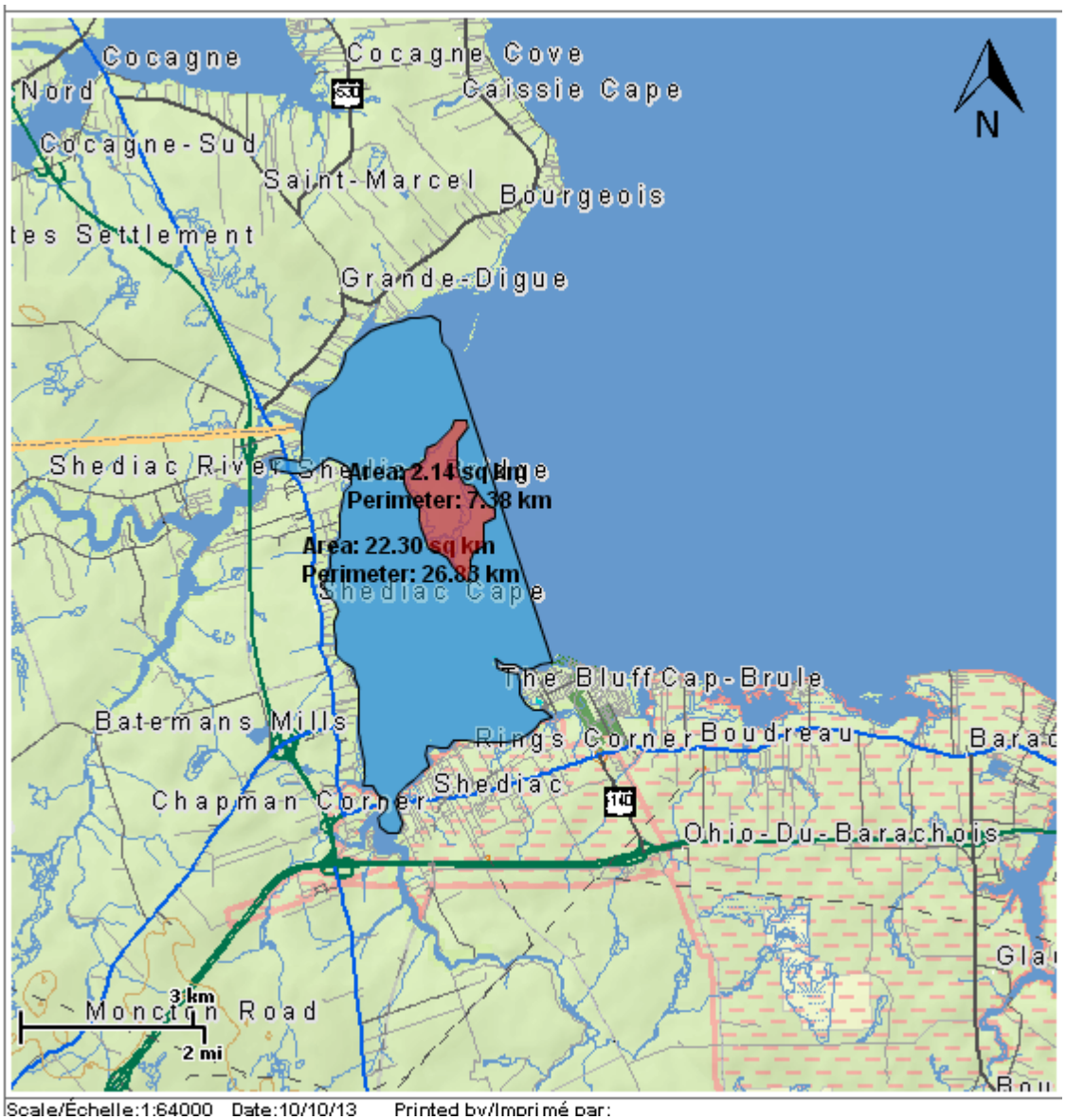


Figure 4. Total surface area of waters in Shediac Bay included in study area for baseline data collection (outlined in black)

2.3 How sites were chosen

Sites were chosen by the author to represent a valid cross-section of the inner bay. Sites were always in eel-grass beds. They were always above the low water mark and usually close to shore. This was always a challenge at low tide and the engine often needed to be lifted to drop and retrieve the traps. Coverage along the shore of the inner Bay was a priority as transects into deeper water were also carried out. The previous year CAMP sampling indicated there was green crab close to shore so some locations did overlap though our traps were usually set outside the CAMP locations.

2.4 Locations of the Green Crab sites 2013

After beach seine results in 2012 from the Community Aquatic Monitoring Program (CAMP) surveys, green crab were seen to be present and becoming abundant in Shediac Bay. Funding from SHELL Canada was secured to initiate a survey of waters to determine the extent of green crab population in Shediac Bay. **Figure 4** shows where sample sites were located. The only one off the shore on the inner bay was "D" and it was close to Shediac Island shore.

Table 1 The exact latitude-longitude location of collection sites repeated bi-monthly during the study 2013.

Site	Green Crabs - Site details (2013)		
A	Pass Under the Bridge Chez Leo (CAMP)	46° 16' 17.52"	64° 34' 32.44"
B	Bridge (CAMP) Chez Leo, left of boat launch point	46° 16' 19.18"	64° 34' 329.01"
C	In front of CAMP site (Oak Point)	46° 16' 22.52"	64° 33' 48.07"
D	Shediac Island (middle) off line of oyster lease buoys	46° 15' 53.72"	64° 33' 00.20"
E	Yellow House, shore before Friars	46° 15' 15.87"	64° 34' 02.86"
F	flag St Martins in Woods Rd	46° 14' 06.84"	64° 33' 38.09"
G	Before crossing bridge Scoudouc River Lobster from Marina	46° 13' 10.98"	64° 33' 16.69"
H	After crossing bridge opposite Shediac Lobster inside next to channel	46° 13' 04.65"	64° 33' 11.76"
I	Close to old SBWA Office, outer Shediac marina opposite crane	46° 13' 34.70"	64° 33' 43.45"
J	Pointe-du-Chêne inner South Cove (eelgrass site)	46° 14' 06.62"	64° 31' 26.75"

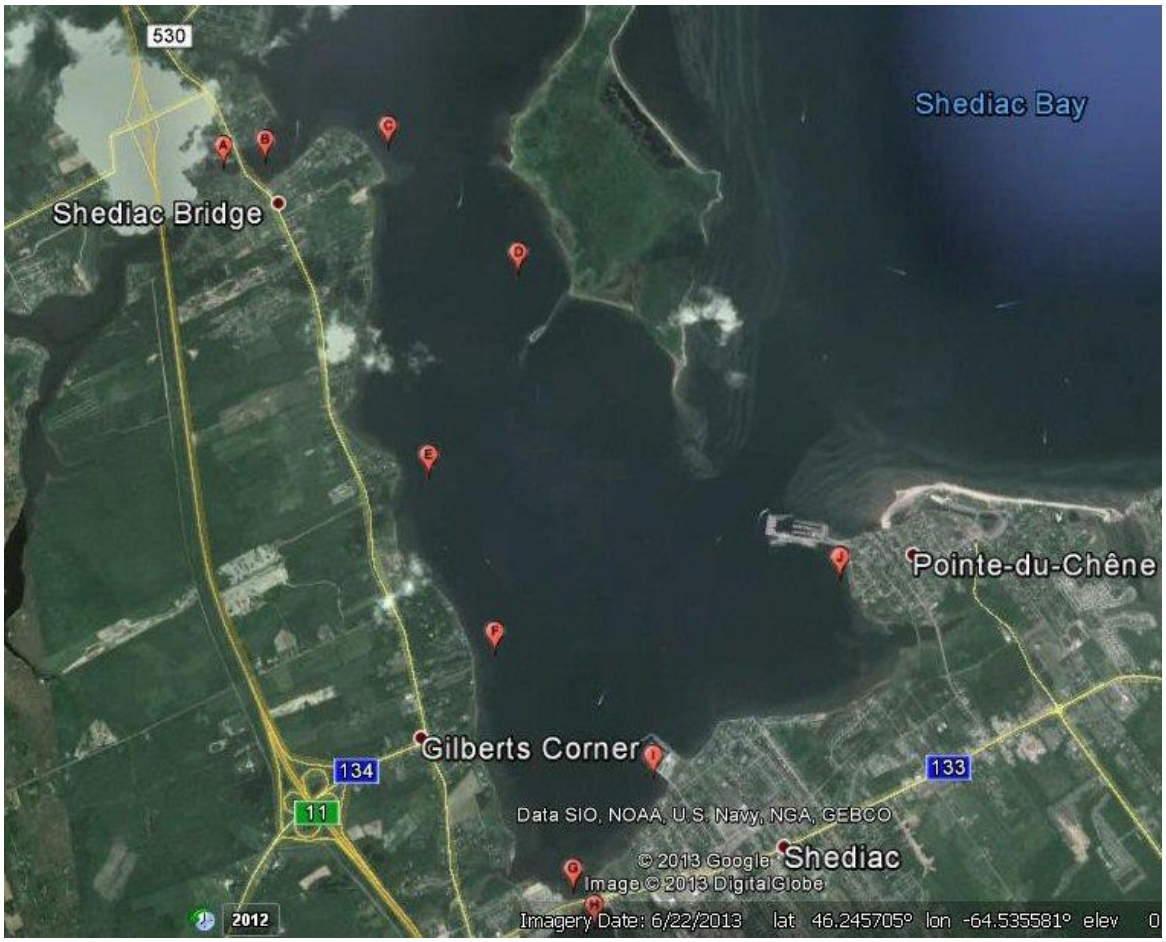


Figure 5. The chosen 10 sites for repeat trapping lettered A to J for the 2013 spring to fall season in Shediac Bay

The traps were positioned across the transect at estimated identical intervals. Care was taken not to put traps in channel areas where boaters may encounter a line. Also transects in locations frequented by boaters were avoided by sampling later in the season because of reduced potential boater interactions. One of our main concerns was possible trap removal by the curious boater. We put the word out to local fishers, especially the active quahog fishers, about what our survey involved. They were very co-operative and not an issue. What we were worried about most was a recreational boater pulling up our trap and taking it home for a souvenir.

The table shows the date sampled as abbreviations, “A” for August, “S” for September and “O” for October. Traps 2-9 are in-between and generally are in a straight line or as in the case of Shediac Island and along Parlee beach, follow the coast just out from the low water mark.

Table 2 The exact latitude-longitude location of start and finish locations for the 8 transects fished 2013.

Green crab transects site details	trap # 1 (start)	trap # 10 (end)
A22- left of office, around low water edge to channel	46° 13' 25.74"	46° 13' 24.58"
	64° 32' 52.18"	64° 33' 21.09"
A28- end Tippary St out to center bay channel	46° 13' 47.31"	46° 14' 17.27"
	64° 32' 08.59"	64° 32' 20.54"
S6- end of Shediac island around to tip close to point (inside)	46° 16' 44.85"	46° 15' 07.78"
	64° 32' 27.04"	64° 32' 16.62"
S11- end of Shediac Island around to tip close to point (outside)	46° 16' 39.72"	46° 15' 07.63"
	64° 32' 00.09"	64° 31' 05.39"
S20- Cape Bimet across front Parlee beach to just outside wharf	46° 14' 21.59"	46° 14' 29.57"
	64° 29' 37.53"	64° 31' 33.21"
S28- Friars across to Skull island	46° 15' 03.07"	46° 15' 21.39"
	64° 33' 53.84"	64° 33' 05.16"
O2- across Shediac River inside brook to Oak Point	46° 16' 44.11"	46° 16' 25.94"
	64° 34' 22.20"	64° 33' 46.83"
O11- outer Shediac River, inside small sandbar to tip of Shediac Island	46° 17' 43.44"	46° 16' 45.48"
	64° 32' 47.19"	64° 32' 24.69"

As mentioned, in addition to bi-monthly sampling, transects were established to determine spatial population structure. **Figure 6** shows these locations. First trap (number 1) is close to shore or at the beginning of the transect, number 10 is the last trap location. Dates on the transect line were the collection dates.

Figure 6. There were 8 transect lines chosen to represent a cross section of the Bay. These are dated to show when the traps were hauled and contents enumerated.

3.0. RESULTS AND DISCUSSION

3.1 Materials required to carry out the trapping survey

The survey was carried out for two seasons as this is stipulated in the SHELL funding agreement. Money had been ear-marked for a duplicate survey in 2014. Funding was secured (2015) from NBWTF to cover part of salary, rental, transportation, education and maintenance costs. Other parameters may be involved if a proposed NRC project gets underway. We are an in-kind contributor to their proposed study at this point, though we hope for a more money related role as logistic support. We requested and received a loan agreement for the boat from DFO for both 2013 and 2014. Another boat was rented in 2015 as the DFO boat was not available to us in 2015. We have the ropes and buoys in our storage space and can keep them until we no longer have a need, whereas we have to sign them back into the warehouse. We would have no need of traps. I did sign out an extra from DFO in the event one of ours was lost or removed. Sardines are easily purchased with best price being from Giant Tiger and No-Frills in Shediac. There was a short time to experiment with the most suitable bait. Canned clams worked well. The best bait was dead fresh fish be it mackerel or tomcod. This is harder to come by in early spring unless we wanted to outlay money to purchase. Fish that entered the trap were attacked by the crab and the feeding frenzy would attract even more green crabs. Our main cost after the trap purchase was gas for the project boat. For the 2013 season this was approximately 370 dollars. Gas for 2014 season totalled 219.45 dollars. Gas for the 2015 season was approximately 260 dollars.

3.2 Study Area

The actual bay is reasonably large and does provide a suitable location for 2 marinas and many boaters. On calm sunny days in the summer season, boat traffic can be quite busy. The health of this bay fed by two estuaries is important to the local economy. The majority of the local and temporary residents do not even know what a green crab looks like. Efforts of the SBWA to inform the public have been on-going and our efforts have resulted in an increase in numbers of people made aware of the issues related to green crabs. The health of the bay is one of the association's prime mandates and as such the possible threats to the health of the bay that can be the result of habitat destruction by green crab is a major concern. This initial survey will provide a necessary baseline for our monitoring efforts. Strategies for controlling or maintaining a sustainable healthy state of this marine ecosystem will be helped by studies such as this.

3.3 How Sites Were Chosen for 2015

After choosing the sites, they had to be revisited and fished on a set schedule. There was some consultation and discussion with DFO, but the final locations were determined by SBWA staff. The determined trap line could have been more extensive but our staff worked within the parameters of the resources available. Trap delivery was an issue as they were not in stock in Canada and had to be shipped from Japan. This delayed our trap set to mid-July, rather than

the first of July in 2013. As the study will be repeated each year various staff and volunteers, mainly Board members, did get experience with the locations.

3.4 Locations of the Green Crab Sites for 2015

Getting back to the same location was not a major issue. This was taken into account when sites were initially chosen as the first visit was at a low tide. It seemed every two weeks when we went back to sample it was always low tide again. This was the case in 2013. In 2014 and 2015, we set the traps at or near high tide. This was much more friendly to the propellers. These chosen sites had to have eel-grass as this is known to be a preferred feeding location. At each visit the sampler was always looking at the state of the eel-grass beds to determine if a major eel-grass removal might have occurred. This was a visual examination only as a more detailed transect diving regime would have to be put in place to determine if this was occurring. This was beyond the scope of this survey, so only anecdotal observations were made. Overall, there were no obvious patches of removed eel-grass bed material observed over the three years.

3.5 What Was in the Traps

After 24 hours the trap was brought in and all green crab were counted and sexed. Aging was not done in this survey. All other contents were also identified and counted. Green crabs were brought to shore and the uses are described in the discussion. All other species were returned to the water. Each crab was handled with a thick rubber glove as they can deliver a nasty squeeze with their large claws. The holding and walking claws have sharp ends and can also inflict a pinch. Other fish and starfish were easily removed. Some care was exercised to minimize stretching the opening as over time it can become larger and we speculate crabs can wiggle back out. The bait bottle was also removed to be baited again with the next sampling.

The area of influence of a baited trap of the type used in the southwestern Gulf of St. Lawrence snow crab fishery was studied by releasing tagged snow crabs at increasing distances from the bait and noting recaptures after fishing periods of 24 and 48 hr. For the shorter fishing period, the recapture rate decreased with increasing distance of released crabs from the trap. The radius of the prospected area was estimated to be in the range of 100-140 m, with the radius of the effective fished area being about 50-70 m. We cannot find any reference to distance that green crab will come to a baited trap.

3.5.1 Total crab catch over the repeated sample sites for the 2013 season

The table below summarizes the catch at each site and the totals for the bi-monthly sampling.

Table 3. Summary of total green crab catch for sites A to J for each bimonthly sample 2013.

Site	July 17	July 31	Aug 15	Aug 30	Sept 16	Sept 29	Oct 15
A	0	4	0	1	3	4	0
B	10	10	7	2	19	0	0
C	0	2	4	0	15	15	3
D	0	0	1	1	3	2	0
E	4	1	3	19	16	4	2
F	0	0	0	10	1	1	0
G	0	2	3	1	1	2	3
H	1	1	1	1	1	0	0
I	0	8	2	2	2	1	0
J	0	0	1	6	0	1	4
2013	**15**	**28**	**22**	**43**	**59**	**30**	**12**

In 2013, catches were fairly consistent over the sampling season with a slight rise in September. This September rise was probably due to an input of seasonal recruitment as the young hatched in the spring reached a size that would be able to get into the trap and remain. Also more live fish were in the traps later in the season and once inside could be easily attacked by the crab and this dead fish acted as additional bait thus probably attracting more prey, i.e. green crab. On August 30, the traps were in the water for 48 hours as stormy weather preventing lifting traps. This double catch time reflects a doubling of catch for this 2 day catch period. Lower numbers in July probably reflect less activity as this is the end of the mating season when crabs might have been less active. Colder water may have been a factor in the October sampling. These are just author speculations, further hypothesis that would require more detailed experimentation.

3.5.2 Total crab catch over the repeated sample sites for the 2014 season

The table below summarizes the catch at each site and the totals for the monthly sampling.

Table 4. Summary of total green crab catch for sites A to J for each monthly sample 2014.

Site	May 29	June 28	July 30	Aug 27	Sept 25
A	0	0	4	5	10
B	0	0	0	42	4
C	0	11	5	12	1
D	0	0	12	8	1
E	3	27	9	5	6
F	1	7	4	5	5
G	1	0	21	18	6
H	0	0	0	2	3
I	0	2	8	0	7
J	0	0	4	9	3
2014	**5**	**47**	**67**	**106**	**46**

In 2014, traps were only fished at the end of each month. Numbers were low in May which corresponds to spawning time when crabs appear less active. Numbers continued to rise all summer and dropped off again in the fall. Younger crabs were more dominant in the early spring, thus if any could escape the trap, the smaller ones would have this ability. With summer growth, and the obvious number increase, more were caught. Decreasing temperature of the water in the fall could explain the drop in numbers observed in September.

3.5.3 Total crab catch over the repeated sample sites for the 2015 season

The table below summarizes the catch at each site and the totals for the monthly sampling.

Table 5. Summary of total green crab catch for sites A to J for each monthly sample 2015

Site	May 26	Jun 30	July 30	Aug 27	Sept 29
A	0	0	2	0	3
B	0	0	0	2	8
C	1	1	3	2	1
D	1	0	0	0	0
E	0	0	0	2	4
F	0	0	0	0	0
G	0	0	0	2	10
H	0	0	0	0	27
I	0	o	0	0	6
J	1	0	0	1	0
2015	**3**	**1**	**5**	**9**	**59**

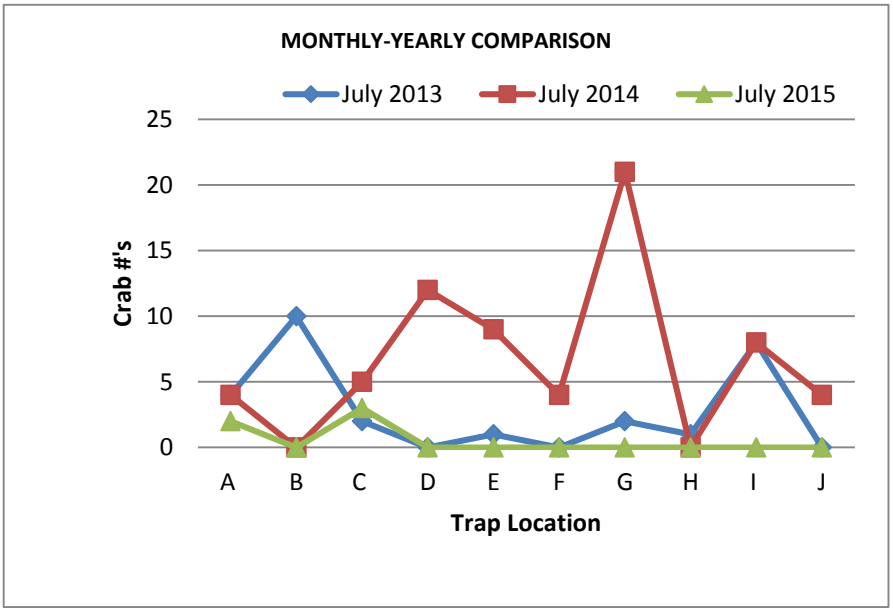
Again in 2015, traps were set near the end of the month. Compared to the previous two years, numbers had dropped off significantly. By September, numbers were back to levels close to what existed in 2013 and 2014. There was a significant drop in numbers over the season compared to previous years. The most probable explanation is that the harsher than normal winter created conditions that were detrimental to overwintering survival. Thicker ice in the bay, colder temperatures, longer winter that delayed spring temperature increase and the subsequent delay in available food are probable causes of this dramatic population decrease. Also the large number in 2014 could have reduced available food supplies for the spring crop in 2015. Additional studies could be initiated to help shed some insight on these and other possible causes of the observed population decline. Anecdotal conversations with fishermen did help determine that more shell remnants were present in the early spring that indicated winter mortality being higher in 2015. The population structure did show a big increase in numbers by September, when compared to still quite low numbers in August.

3.5.4 Comparison of 2013, 2014 and 2015 catch results for the same month.

The tables below summarize the catch at each site and the totals for the bi-monthly sampling for a monthly comparison. The results are also represented graphically.

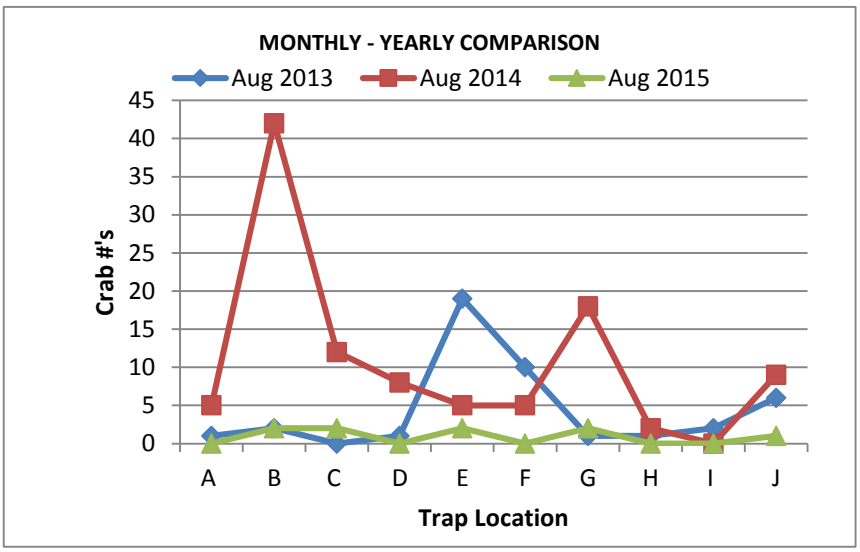
Figure 7. These figures numerically and graphically compare catch results for the month for all 10 sites for the three years of the study.

	2013	2014	2015
Site	July 31	July 30	July 30
A	4	4	2
B	10	0	0
C	2	5	3
D	0	12	0
E	1	9	0
F	0	4	0
G	2	21	0
H	1	0	0
I	8	8	0
J	0	4	0
	28	**67**	**5**



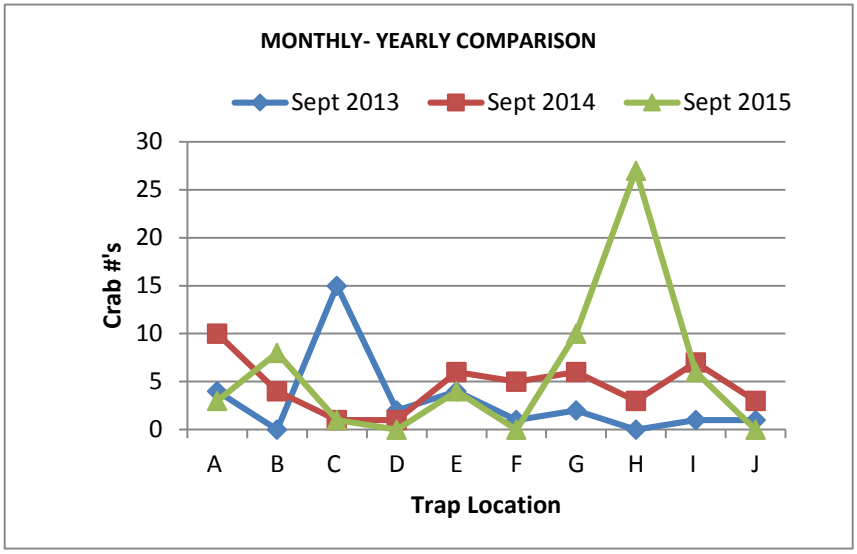
In July, number of green crabs caught was highest in 2014 for all sites except **B** (10 vs 0) and **H** (1 vs 0). Site **I** had 8 green crabs for both years 2013 and 2014. Numbers were considerably lower (only 5 crab total) for early summer in 2015 for possibilities previously outlined. Eight of 10 sites had no crab at all for the 24-hour trapping time frame. This is a very significant drop compared to previous years.

	2013	2014	2015
Site	Aug 30	Aug 27	Aug 27
A	1	5	0
B	2	42	2
C	0	12	2
D	1	8	0
E	19	5	2
F	10	5	0
G	1	18	2
H	1	2	0
I	2	0	0
J	6	9	1
	43	**106**	**9**



As in July, the same pattern of more crabs in 2014 was evident (106 vs 43 total), though locations **E** and **F** had more crabs in 2013 than 2014.Numbers remained low in August in 2015, though a slight increase from July is evident.

	2013	2014	2015
Site	Sept 30	Sept 25	Sept 29
A	4	10	3
B	0	4	8
C	15	1	1
D	2	1	0
E	4	6	4
F	1	5	0
G	2	6	10
H	0	3	27
I	1	7	6
J	1	3	0
	30	**46**	**59**



In September, numbers show decreasing trends for 2013 and 2014 compared to the previous month. But in 2015, the opposite is evident; numbers are up to their highest level compared to the whole sampling season.

Overall, most sites show that more green crabs were caught in 2014. This leads to an obvious pattern of crab population increasing in Shediac Bay compared to the previous year. But the significant drop in numbers in 2015 was surprising. We have speculated as to the reasons that influenced this drop (see 3.5.3), but it could just be a normal population fluctuation. Though hard to verify, we have had anecdotal reports that certain diving ducks have been seen consuming green crabs. Could the slower recovery than what was normal in the previous two years in the early spring-summer been influenced by these winged predators consuming the young and/or moulting crabs?

Table 6. Breakdown of male to female green crab catch for each site A to J for each bimonthly sample 2013.

Site	July 17		July 31		Aug 15		Aug 30		Sept 16		Sept 29		Oct 15	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
A	0	0	3	1	0	0	1	0	2	1	4	0	0	0
B	10	0	10	0	7	0	2	0	14	5	0	0	0	0
C	0	0	1	1	4	0	0	0	15	0	7	8	2	1
D	0	0	0	0	0	1	1	0	3	0	2	0	0	0
E	4	0	0	1	2	1	14	5	15	1	2	2	0	2
F	0	0	0	0	0	0	6	4	1	0	1	0	0	0
G	0	0	2	0	3	0	1	0	1	0	2	0	2	1
H	0	1	0	1	1	0	1	0	1	0	0	0	0	0
I	0	0	5	3	1	1	1	1	2	0	1	0	0	0
J	0	0	0	0	0	1	6	0	0	0	1	0	4	0
sub-total	14	1	21	7	18	4	33	10	52	7	20	10	8	4
		15		**28**		**22**		**43**		**59**		**30**		**12**

Overall numbers of male crab always exceeded those of female crab by a ratio of at least 2 to 1. This tells us that the male population far exceeds the female population. Early in the season, several females would be in the traps with eggs attached thus probably less active in searching out food. The fecundity of the females has been noted at a possible production rate of 160,000

eggs a season, often with more than one event if conditions are ideal. It is assumed the females are less active especially early in the season. We also note in aquarium observations that the males are more active and more aggressive, aggressiveness being a trait shared by the crabs in general. We have seen crabs catch swimming silversides in the aquarium, rare, but it has been observed.

Table 7. Breakdown of male to female green crab catch for each site A to J for each monthly sample 2014.

Site	May 29		June 28		July 30		Aug 27		Sept 25	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
A	0	0	0	0	4	0	4	1	10	0
B	0	0	0	0	0	0	40	2	3	1
C	0	0	7	4	5	0	12	0	1	0
D	0	0	0	0	10	2	8	0	1	0
E	3	0	7	10	6	3	4	1	6	0
F	1	0	5	2	3	1	5	0	5	0
G	1	0	0	0	8	13	18	0	6	0
H	0	0	0	0	0	0	2	0	3	0
I	0	0	1	1	7	1	0	0	7	0
J	0	0	0	0	2	2	9	0	2	1
sub-total	5	0	20	27	45	22	102	4	44	2
2014		**5**		**47**		**67**		**106**		**46**

In May, there were no female crabs probably caught because of egg laying. In June, they were more numerous than males as illustrated by their increased activity most likely related to their need for additional nourishment after egg laying processes were completed. Why the female numbers were so low in August and September is interesting and would be a valid question to explore.

Table 8. Breakdown of male to female green crab catch for each site A to J for each monthly sample 2015.

Site	May 26		June 30		July 30		Aug 27		Sept 29	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
A	0	0	0	0	0	2	0	0	3	0
B	0	0	0	0	0	0	2	0	8	0
C	0	1	0	1	3	0	2	0	1	0
D	0	1	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	1	1	3	1
F	0	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	2	0	8	2
H	0	0	0	0	0	0	0	0	23	4
I	0	0	0	0	0	0	0	0	4	2
J	0	1	0	0	0	0	1	0	0	0
sub-total		3		1	3	2	8	1	50	9
2015		**3**		**1**		**5**		**9**		**59**

This season was more than unusual. The extreme low numbers at the beginning of the season has been referenced. What few crabs caught early were females with no males captured until the end of July. Then in August and September, patterns similar to previous years was evident that being more males. But, compared to previous years, numbers did not drop in the fall, rather they were higher at the end of the season. This indicates a late start to the crab population recovery from the stressful winter.

3.5.5 Total crab catch over the transect sample sites for the 2013 season

The table below summarizes the catch at each transect location and the totals for the 10 sites in that transect.

Table 9. Summary of total green crab catch for sites 1 to 10 for each transect collection

SITE	Aug-22	Aug-28	Sep-06	Sep-11	Sep-20	Sep-28	Oct-02	Oct-11
1	6	2	0	0	0	0	2	2
2	1	0	4	0	0	7	13	0
3	0	1	0	0	0	2	2	1
4	0	0	89	0	0	0	2	0
5	0	0	0	0	0	1	1	0
6	0	0	0	0	0	5	6	2
7	16	0	0	0	0	0	0	0
8	0	0	1	0	0	0	0	7
9	0	0	0	0	0	0	1	7
10	2	0	0	0	0	0	0	1
	25	**3**	**94**	**0**	**0**	**15**	**27**	**20**

Each transects illustrated distinctly different results depending on location. The two sites close to the estuary mouth, August 22 and October 2 (Scoudouc River and Shediac River respectively) show the highest numbers suggesting the hypothesis that this is preferred habitat, probably related to food availability and denser eel-grass habitat. The one aberration in total catch numbers is September 6 sampling inside Shediac Island. One trap had a very high number. In this trap were 2 tomcod, one completely eaten, the other half-eaten and 3 flounder. This fresh fish bait attracted lots of green especially after the first tomcod was attacked and eaten. September 11 was outside Shediac island. Patches of eel-grass were present but not abundant, it was mostly a sand substrate, This was also the case in front of Parlee beach, all sand, very little eel-grass. In both locations a lot of rock crabs were caught. The middle transects in South cove produced very low numbers, Eel-grass beds here are not as thick as near the Scoudouc estuary mouth and inside Shediac Island. The eel-grass beds outside Shediac River are of medium density and the crab numbers are similar.

The transects were not repeated in 2014 or 2015 due to time and funding restrictions. Also the need to duplicate these transects was determined to be unnecessary as the trapping regime was providing the information we required.

Table 10. Breakdown of male to female green crab catch for each sites 1 to 10 for each transect sample

Site	Aug 22		Aug 28		Sept 6		Sept 12		Sept 16		Sept 28		Oct 2		Oct 11	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1	5	1	1	1	0	0	0	0	0	0	0	0	2	0	1	1
2	0	1	0	0	3	1	0	0	0	0	7	0	10	3	0	0
3	0	0	1	0	0	0	0	0	0	0	2	0	2	0	1	0
4	0	0	0	0	79	10	0	0	0	0	0	0	2	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
6	0	0	0	0	0	0	0	0	0	0	5	0	5	1	2	0
7	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0
9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	1
10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
sub-total	19	6	2	1	83	11	0	0	0	0	15	0	23	4	18	2
		25		**3**		**94**		**0**		**0**		**15**		**27**		**20**

As was noted for the repeated bimonthly sample sites, males always outnumber females. The September 28 in the middle of the inner bay sample had no females. Where the transect went from shallow to deeper water, August 8, September 28, October 2 and October 11, there is a slight indication of less crab in deeper water near the channel but this is not consistent enough to speculate a pattern. If there is eel-grass there will be crab.

3.5.6 Incidental catches for bi-monthly and transect sampling

The traps usually had other occupants besides green crabs. Species observed included the following: rock crabs, mud crabs, starfish, snails, mummichugs, tomcod, flounders, silversides, and cunners. As mentioned, the two sandy habitats, outside Shediac Island and along Parlee beach caught only rock crabs; 28 and 103 respectively. The fish that came into the trap looking for food was unexpected, but became the norm after the first samples were counted. Sometime the fish predators became the prey in a confined trap. A lot of snails got into the trap and starfish, slow moving as they are, could be quite numerous after only 24 hours. One trap had six starfish. Another interesting note was that rock crab and green crab would often be found in the same trap. Obviously they are competitors being attracted to the

same bait and occupying the same niche. However the numbers of green crabs far outnumber the rock crab. We do not know if rock crab numbers are the same or on a decrease or increase. We do know that, since their arrival in the Bay, green crab now far outnumber the indigenous rock crab.

3.6 Non statistical estimations of the green crab population in Shediac Bay

Applying statistical extrapolation to population dynamic structure is beyond the scope of this survey. However, a rough estimation of population size will be presented based on average catch per trap and chosen square metres that the crab might travel to get at the bait in the traps.

From the bimonthly catch data there were 209 crabs caught. There were 7 times 10 or 70 traps put in the water. The average number of crabs per trap 209 / 70 equals 2.9857 or let's say 3 per trap. The number of square metres was 20,160,000. But this number includes outside Shediac Island where no green crabs were caught. It also includes in front of Parlee beach where no crabs were caught. So we will use 20 million square metres for this rough estimate.

Now how far will a green crab travel to get to a bait source. Let's assume several radii distances. **Table 11** below provides such predictions.

Table 11. Non-statistical estimates of possible population size in Shediac Bay

Distance from trap	Number of square metres	water area 20,000,000 m^2	Divided by square metres	Number of units	Times 3 crabs per unit
1 metre	3.14	20,000,000	3.14	6,369,426	19,108,280
2 metre	12.56	20,000,000	12.56	1,592,356	47,77,070
3 metres	28.26	20,000,000	28.26	707,714	2,123,142
4 metres	50.24	20,000,000	50.24	398,089	1,194,267
5 metres	78.50	20,000,000	78.50	254,777	764,331

So, if all three crabs only came from a one metre distance away, there might be 19 million crabs in the bay. If they travel from 5 metres away in 24 hours, then only ¾ of a million are in the bay. Chances are they travel more than 5 metres away, but not knowing the distance from which they can sense the bait and make it to the trap, makes this only a best estimate.

3.7 Summary of Objectives Subsequent to NBWTF Requirements

Funding from NBWTF had two main components, one being the actual monitoring of the green crab population dynamics and the other was the educational aspect of the green crab program. As outlined in our proposal, we did duplicate the sampling protocols from the previous two years. As mentioned, the unusual decrease in population numbers was not expected. This would not have been determined if funding had not been awarded.

Our student staff gave presentations at the Homarus eco-centre all summer season. These included educational seminars, visitor discussions on crab life cycle, impact scenarios of green crabs on local populations of molluscs and the actual population study itself. Each Sunday, staff manned a booth in the Sunday in the Park market. Live green crabs at the booth was always a fun thing for residents and tourists.

Social media plays a more important role in getting information out to those who access our website or follow new stuff on Facebook. Also our newsletter describes all project in a briefer form that this report. We always get inquiries just loading and unloading the boat full of traps, a great opportunity to do the interpretation related to the project.

4.0 CONCLUSION

This survey was carried out because the population of green crabs in Shediac Bay had yet to be documented by any government agency. There has been no government sponsored scientific investigation since the green crab migrated into the bay. Ten locations were chosen and sampled twice a month for 3 ½ months in 2013. The same sites were fished exactly the same on a monthly basis in 2014 and 2015 from May to September. Eight transects covered cross-sections of the bay and around Shediac Island and across Parlee beach. Crabs were found in all locations that had an eel-grass substrate. Sandy substrates did not produce any crab catches. Winds are usually an issue in Shediac Bay so sampling was generally carried out in the mornings. In-kind support from DFO allowed SBWA to carry out this study within an acceptable budget for the first two years.

Male green crabs were more abundant in the traps. All age classes were trapped over the course of the study. The very young were less numerous or more likely, they could escape back out of the trap, or be eaten by adult crabs when confined in the trap. Females with eggs were not present in any catches. The only change in methodology from 2013 was that traps were only set monthly in 2014 and 2015. This 3-year study did allow the determination of notable changes in population structure as the 3-year comparison did illustrate. Overall, there seemed to be a higher population density in 2014. It was the 2015 year that yielded unexpected results. Seeing numbers drop rather stay the same or increase would not have been picked up if NBWTF had not granted funding to continue this study in 2015. Funding will be sought for a continuation of this study in subsequent years.

Using processed sardines may not be the best bait but it works, especially those processed in oil. Testing other baits such as fresh fish, clams and dead mackerel was done outside the study, but these sources are not always reliably available.

There is a large population of green crabs in Shediac Bay. The need for a removal program to keep the population at an acceptable yet sustainable level will reduce the threat to the health of the local littoral ecosystem in the bay. There is a thriving quahog and eel fishery in the bay and if green crab populations are not controlled in some manner, they are the most likely to suffer.

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