Whelk Pot Trapping and its Implications for Inshore Fisheries Development in Coastal Georgia

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Abstract

Whelk (Mollusca: Family Melongenidae) harvest potential and pot efficiency of four different experimental traps (modified crab trap, plastic rectangular trap, plastic pyramid trap, and mesh pyramid trap) were compared for catch efficiency against a standard crab trap from May 10, 2006 to June 27, 2006 in coastal Georgia waters. Two sites, an open sound site off Dead Man Hammock, Wassaw Island and a salt-marsh tidal creek, Beard Creek, were compared. A total of 734 whelks [47.7% channeled (*Busycotypus canalicalatus*), 34.7% knobbed (*Busycon carica*), and 17.6% pearwhelk (B*usycotypus spiratus*)] were caught at both sites. Traps with smooth plastic surfaces caught more whelks than 3.8-cm vinyl-coated-wire mesh traps at each location. Traps with more sloped plastic sides out performed and caught more species than the plastic rectangular trap where whelks were required to crawl vertically up the sides to reach the hole at the top of the trap. The standard crab trap and modified crab trap averaged higher weight catches than the other traps for all species. Significantly ($p=0.0063$) more males were caught in the open sound location and more females in the tidal creek location. Significantly heavier ($p<0.0001$) channeled whelks were caught in the tidal creek and heavier ($p<0.0001$) knobbed whelks were caught in the open sound. No pearwhelks were caught in the tidal creek. Pot trapping rapidly depleted local stocks, indicating poor potential to expand from a crab by-catch to a direct pot fishery.

Introduction

Four species of whelks (Mollusca: Family Melongenidae) are found in Georgia coastal waters; the knobbed whelk, *Busycon carica* (Gmelin, 1791), the lightning whelk, *Busycon sinistrum* (Hollister, 1958), the channeled whelk, *Busycotypus canalicalatus* (Linnaeus, 1758), and the pearwhelk, *Busycotypus spiratus* (Lamarck, 1816) (Abbott 1974, Walker *et al.* 2008). *B. carica* and *B. sinistrum* prey on marine bivalves (Colton 1908, Warren 1916, Magalhaes 1948, Carriker 1951, Menzel and Nichy 1958, Paine 1962, Kent 1983, Walker 1988) such as intertidal stocks of oysters, *Crassostrea virginica* (Gmelin, 1791), and northern quahogs, *Mercenaria mercenaria* (Linnaeus, 1758), during the spring and fall in Georgia (Walker 1988, Walker *et al.* 2008). *B. canaliculatus* has a more scavenging feeding mode and can be readily caught in commercial blue crab (*Callinectes sapidus* Rathbun, 1896) traps that are baited with carrion (Shaw 1960, Logothetis and Beresoff 2004, Bruce *et al*. 2006, Walker *et al*. 2003). *B. spiratus* occurs infrequently in Georgia waters (Walker 1988) but can be occasionally caught in crab traps inshore near the mouth of sounds (Walker *et al*. 2003) or in offshore trawls (Walker *et al*. 2008). *B. carica*, *B. sinistrum* and *B. canaliculatus* may occur in the intertidal zone during daytime in spring and fall, but are generally absence in summer and winter (Walker 1988; Walker *et al*. 2008). *B. spiratum* inhabits subtidal areas in Georgia.

The Georgia Department of Natural Resources' (GADNR) Coastal Resources Division first authorized the commercial harvest of whelks in 1980 (Belcher *et al*. 2001). In the winter months after the penaeid shrimp fishery closes, some shrimp boats swap gear to fish for whelks in offshore areas using trawl nets with bigger 10.16 cm stretch mesh and heavier chains. The commercial offshore whelk-trawling season usually occurs January through March in Georgia (Belcher *et al*. 2001) with intertidal hand gathering occurring in spring and fall (Walker 1988, Walker *et al*. 2008) and crab trap harvesting of whelks as a by-product occurring throughout the year (Walker 1988). Annual landings of whelk meat peaked in 1990 at 462,196 kilograms, valued at $507,718 (GADNR unpublished fisheries landings data). However, in more recent years, landings have decreased significantly to 40,900 kg in 2003 and down to less than 2,200 kg per year for 2004 through 2008 (GADNR unpublished fisheries landings data). The offshore trawl fishery in Georgia accounts for the greatest number of whelks harvested, with the inshore blue crab fishers harvesting channeled whelks that entered crab traps as a by-product of that fishery (Walker 1988). In addition oyster and northern quahog fishers and growers gather whelks by hand during the spring and fall from the intertidal oyster reefs and clam farm plots. Whelks in the intertidal zone remain buried during daytime in summer and winter (Walker *et al*. 2004, Shalack 2007). Currently, there is not a limit on the size or quantity of whelks that can be harvested in Georgia waters. However, there generally is a limit to the size of whelks, usually less than 150 mm in length that a processor deems not economical to process. Processed meats are used in salads, chowders, fritters, as scungilli (pasta), and they are canned or frozen for national and international distribution (Power *et al*. 2009). Local seafood markets sell any size live whelk. With the apparent collapse of the offshore whelk trawl fishery, an increased interest in harvesting whelks from inshore areas where trawling is banned has developed.

Traditionally, Georgia has not had a pot fishery for channeled whelks. There have been concerns expressed about increased numbers of floats interfering with boat traffic and aesthetics. On the other hand, a local fisherman has indicated that he can fetch a greater price for channeled whelks than the offshore trawl fisher, and these stocks may represent an underutilized natural resource. Seasonal and cyclically successful pot fisheries exist throughout Europe, Asia and North America (Shaw 1960, Hancock 1976, MacIntosh 1980, Ito *et al*. 1981, Davis and Sisson 1988, Himmelman 1988, Fahy *et al*. 1994, MacKenzie *et al*. 1997, Power 2000, Logothetis and

Beresoff 2004, Bruce *et al*. 2006). Georgia crabbers currently use the standard crab trap, however typically wooden or plastic traps that provide easier surfaces for whelks to climb onto and into are utilized elsewhere. The Marine Extension Service previously examined a wooden Chesapeake Bay pot and found that it did not outperform crab traps but recommended that alternative pot designs be evaluated (Walker *et al*. 2003). Whelk harvested as a by-catch product are not currently subject to fisheries regulations, however a direct pot trap fishery would be pursued under an experimental permit for which certain stipulations could be enforced. The current study seeks to assist the industry by examining the efficiency of four different experimental trap designs and contributing information to determine the sustainability of a directed pot whelk fishery in Georgia.

Materials and Methods

Study Area

The study occurred in two locations 1) off Dead Man Hammock, Wassaw Island in Wassaw Sound, GA and 2) in Beard Creek on the south side of Wilmington Island, GA (Figure 1). The Wassaw Sound Site is approximately 300 meters from the shore of Dead Man Hammock in the Wassaw Island National Wildlife Refuge. An extensive oyster reef at the edge of the salt marsh runs the length of the Dead Man Hammock area. Water depth at low tide is approximately 3-4 meters. The substrate is mostly muddy sand. The Beard Creek site is a tidal creek running through an area of extensive salt marsh. The creek is approximately 30 meters wide at its entrance. Oyster reefs can be found in the intertidal zone, scattered along the length of the creek. Water depth is approximately 3-4 meters at low tide. The creek bottom substrate is mostly mud.

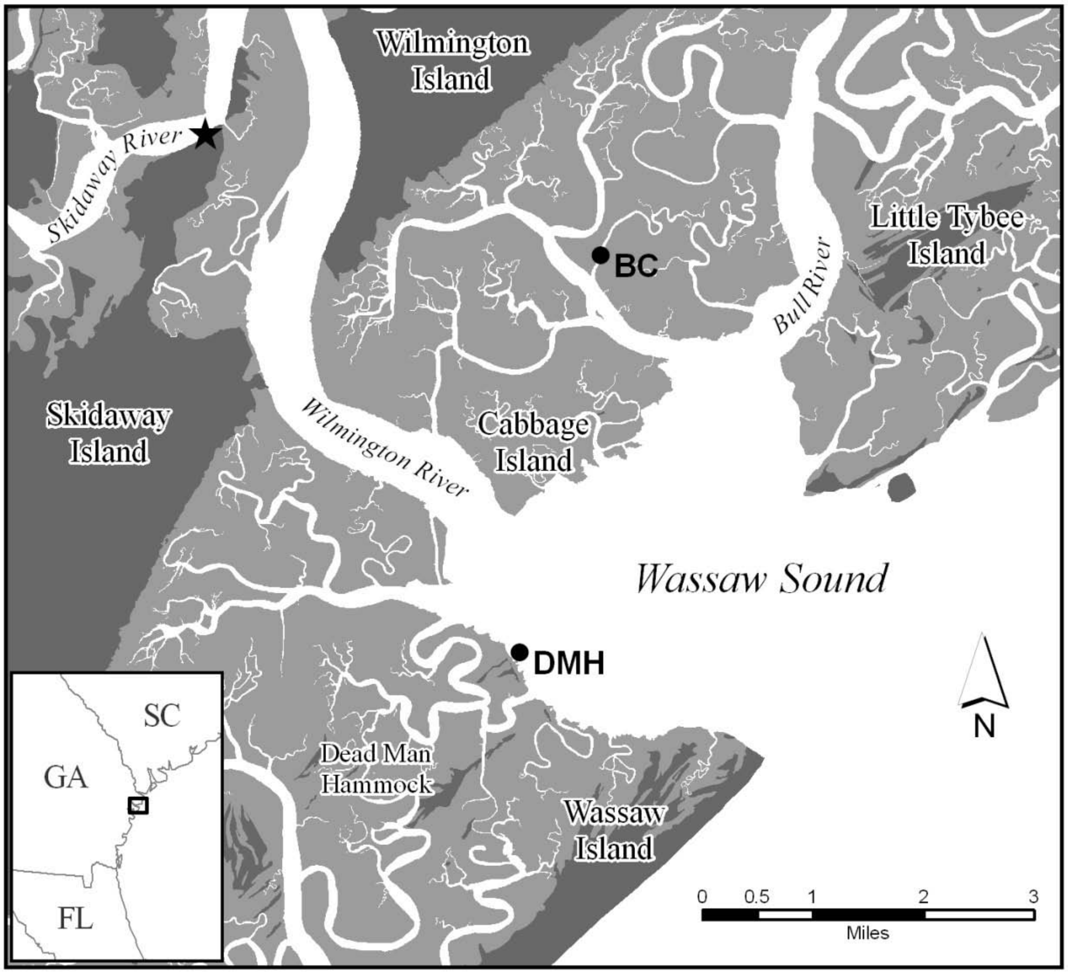

Figure 1. Dead Man Hammock (DMH) and Beard Creek (BC) study sites. The star is the location of the University of Georgia Marine Extension Service dock on the Skidaway River.

Study Design

Analysis of whelk harvest potential and pot efficiency occurred from May 10, 2006 to June 27, 2006. Four different experimental traps (modified crab trap, plastic rectangular trap, plastic pyramid trap, and mesh pyramid trap) were compared for catch efficiency against a standard crab trap (Figure 2). One of each type of trap, spaced 10 meters apart, was randomly assigned to a line (no plastic rectangular traps in Beard Creek lines). Crab floats were attached to each end of the long line to aid in retrieval. Four lines of traps were deployed at each of the two study sites. Traps were baited with Atlantic Menhaden (*Brevoortia tyrannus* Latrobe, 1802) and blue crab. Traps were checked and rebaited every two days (except for two 3 day soaks when checks were postponed due to weather conditions and boat problems). One of the lines of traps at the Dead Man Hammock site was lost after the 14th harvesting session (June 3, 2006). At each sampling, water temperature was determined by a hand held thermometer. Whelks from each trap were placed into individual pre-labeled buckets. Blue crabs and other by-catch were identified and released approximately 1 km from harvest areas to prevent recaptures. The collected whelks were transported to the University of Georgia Marine Extension Service Shellfish Research Laboratory at Skidaway Island, GA for further data collection and then placed in holding facilities until the end of the trapping experiment. For each sample, whelk species was identified, its shell length (apex to siphon canal) in mm, shell width (across shoulder) in mm, weight in grams, and sex was recorded. Whelks were placed in seawater containing 7% magnesium chloride to relax the organism and sex was determined by the presence or absence of a penis. At the end of the study, the captured whelks were released at the site of harvest.

Trap Design

Standard crab trap (Figure 2)

The trap was a 60 x 60 x 60 cm cube made of 3.8 cm vinyl-coated wire mesh. It had four 16.5 cm funnels, one on each of the sides for organisms to enter. A wire mesh bait box was attached to the bottom in the center of the trap. One centimeter diameter steel rebar (re-enforcement rods) was attached to the bottom of the trap to aid in sinking and provide resistance to movement in currents.

Modified crab trap (Figure 2)

Polypropylene (1.6 mm thickness) was cut to the shape of the funnel and attached to a standard crab trap. The plastic was attached to the bottom half of each funnel entrance and in front of the funnels to the bottom of the trap.

Plastic rectangular trap (Figure 2)

A 15-cm diameter hole was cut in the top of a plastic 18.9 liter ethanol container. One centimeter mesh netting was attached around the opening at the top to prevent whelks from crawling out. Two centimeter holes were drilled in the sides of the container to aid in dispersion of chemical cues from the bait. A 2.54 cm layer of concrete was poured in the bottom of the trap to aid in sinking and to provide resistance to movement in currents. A wire mesh bait box was attached to the inside bottom of the trap. This trap is representative of traps currently used in the waved whelk, *Buccinum undatum* Linnaeus, 1758, fishery in Ireland (Power *et al*. 2002b).

Plastic pyramid trap (Figure 2)

The trap was 60 x 60 cm at the base and 20 cm tall pyramid covered in 1.6 mm polypropylene. The bottom of the trap was covered with 1 cm plastic mesh. The frame was made of 1.27 cm pvc tubing. The opening at the top was 15 x 15 cm with 3 cm of plastic extending down into the hole to prevent whelks from crawling out. Two centimeter holes were drilled in the sides of the trap to aid in dispersion of chemical cues from the bait. Two wire mesh bait boxes were attached to the inside bottom of the trap on opposing sides. One centimeter diameter steel rebar was attached to the bottom of the trap to aid in sinking and provide resistance to movement in currents.

Mesh pyramid trap (Figure 2)

The trap was the same as plastic pyramid trap except 3.8 cm vinyl-coated wire mesh was used in place of the 1.6 mm polypropylene.

Data Analysis

Data was analyzed using SAS and R (SAS Institute, 1989). Chi-squared tests ($\alpha = 0.05$) were used to evaluate global significant differences in whelk catches between study sites and traps. Poisson models were built to evaluate significant differences in number caught by location and traps by individual species. A generalized linear model was built to evaluate whelk weights by location and trap type with the Beard Creek site and plastic pyramid serving as baseline values.

Figure 2. Standard crab trap (top left), Modified crab trap (top right), Plastic rectangular trap (middle left), Plastic pyramid trap (middle right), Mesh pyramid trap (bottom left).

Results

A grand total of 734 whelks [350 channeled (47.7%), 255 knobbed (34.7%), and 129 pearwhelk (17.6%)] were caught from May 10, 2006 to June 27, 2006 (total of 24 harvesting sessions) (Table 1). For channeled whelks, Chi-squared tests indicate that no significant difference occurred between locations ($p=0.1038$), but there was a significant difference in trap type ($p<0.0001$). For knobbed whelks, Chi-squared tests indicated no significant difference between locations ($p=0.3481$) or trap type ($p=0.0625$). There was a significant difference in trap type ($p<0.0001$) for pearwhelks. No pearwhelks were caught at the Beard Creek site.

In total the plastic pyramid trap caught more whelks (N=286; 39%) than any other trap (Table 1). The plastic rectangular trap caught the least (N=63; 8.5%) of any trap in total but was only deployed at the Dead Man Hammock site (Table 1). No knobbed whelks were caught in the plastic rectangular traps (Table 1). Traps with more sloped plastic sides out performed and caught more species than the plastic rectangular trap where whelks were required to crawl vertically up the sides to reach the hole in the top of the trap.

In general the traps with the plastic surfaces caught more whelks (N=537) than the traps having only the 3.8 cm vinyl-coated mesh (N=197) (Table 1). The traps having 3.8 cm vinyl-coated mesh generally had higher average catch weights than traps with plastic outside walls (Table 2). The performance of the traps by average weight caught and total number caught is listed in Table 2.

Table 1. Total numbers of whelks caught by the study traps (plastic rectangular trap = A, standard crab trap = CT, modified crab trap = MC, mesh pyramid trap = MP, and plastic pyramid trap = PP). N.A = not available: no alcohol traps were used at this site

	Trap					
	A	CT	MC	MP	PP	Total
Dead Man						
Channeled	33	29	27	10	57	156
Knobbed	0	24	49	12	21	106
Pear	30	10	12	12	65	129
Total	63	63	88	34	143	391
Beard Creek						
Channeled	N.A.	32	61	24	77	194
Knobbed	N.A.	15	39	29	66	149
Total	N.A.	47	100	53	143	343
Combined						
Channeled	33	61	88	34	134	350
Knobbed	0	39	88	41	87	255
Pear	30	10	12	12	65	129
Total	63	110	188	87	286	734
Plastic	63		188		286	537
Mesh		110		87		197

Table 2. Order of traps in terms of average weight and total number caught for each species (plastic rectangular trap = A, standard crab trap = CT, modified crab trap = MC, mesh pyramid trap = MP, and plastic pyramid trap = PP)

	Average Weight			Total Number		
	Channeled	Knobbed	Pear	Channeled	Knobbed	Pear
Highest	CT	MC	CT	PP	MC	PP
	(<0.001*)	(<0.0001*)	(<0.0001*)		(0.9719)	
	MC	CT	MC	MC	PP	A
	(<0.001*)	(<0.0059*)	(<0.0001*)	(0.0563)		(0.024*)
	MP	PP	MP	A	MP	MC
	(0.0302*)		(<0.0001*)	(0.098)	(0.0642)	(<0.0001*)
	PP	MP	A	CT	CT	MP
		(0.1472)	(0.042*)	(0.0003*)	(0.0523)	(0.0001*)
Lowest	A	A	PP	MP	A	CT
	(0.3584)	(N.A.)		(0.0001*)	(N.A.)	(<0.0001*)

*Significantly different from the plastic pyramid trap

Overall, there were 318 females, 325 males, and 91 of unknown sex whelks caught (Table 3). The Pearson's Chi-squared showed that there was no significant difference (p=0.1118) in sex among trap types or lines (p=0.0599). However, significantly more (p=0.0063) males occurred at Dead Man Hammock, whereas more females occurred in Beard Creek. For both sites, there was no significant difference (Chi-squared) in sexes for channeled and pearwhelk; however there were significantly more male knobbed whelks harvested at Dead Man Hammock (Table 3).

Table 3. Total number of male and female whelks caught at Dead Man Hammock and Beard Creek. Chi-square results, * indicates significantly different at p<0.05.

Species	Females	Males	Unknown	p-value
Dead Man				
Channeled	61	71	24	0.758
Knobbed	37	59	10	5.04*
Pear	42	47	40	0.281
Total	140	177	74	
Beard Creek				
Channeled	98	86	10	0.783
Knobbed	80	62	7	2.28
Total	178	148	17	
Grand Total	318	325	91	

Length, width, and weight were found to be closely correlated (Pearson). Lengths and weight data for the whelks caught are found in Table 4. The results of a generalized linear model for channeled whelk average weight showed that a significant difference ($p<0.0001$) occurred between locations with whelks from Beard Creek being significantly heavier. For knobbed whelks, there was a significant difference ($p<0.0001$) in average weight by location with whelks from Dead Man Hammock being heavier. No pearwhelks were caught in Beard Creek.

Table 4. Length and weight data for whelks caught.

Species	Total Number	Length (mm) Mean ± Std.	Length (mm) Range	Weight (g) Mean ± Std.	Weight (g) Range
Dead Man					
Channeled	156	84.7 ± 19.2	42-155	39.7 ± 29.22	6 - 273
Knobbed	106	91.7 ± 22.7	60 – 170	101.7 ± 92.24	28 - 586
Pear	129	76.9 ± 12.07	49- 122	28.5 ± 13.51	6 – 92
Beard Creek					
Channeled	194	94.98 ± 15.41	53 – 159	54.47 ± 29.8	10 - 228
Knobbed	149	75.66 ± 14.23	37 – 116	46.78 ± 24.62	12 – 130

In addition to the 734 whelks caught in traps, 1,407 other non-whelk organisms were captured as by-catch in these traps. A total of 176 blue crabs were caught at both locations (Table 5). More blue crabs (N=152) were caught at the Dead Man Hammock site than at the Beard Creek site (N=24). The standard crab trap and the modified crab trap (N= 150) caught more than the other traps (N= 26) (Table 5). Other by-catch (N=711 specimen) at the Dead Man Hammock and the (N= 520) Beard Creek sites are listed in Table 6. Seven species of decapods plus mud crabs (Xanthidae) and three species of hermit crabs (combined counts) were collected. One Mollusca, one Reptilia, and thirteen Pisces species were gathered.

Table 5. Total numbers of blue crabs (*Callinectes sapidus*) caught by study traps (plastic rectangular trap= A, standard crab trap= CT, modified crab trap=MC, mesh pyramid trap=MP, and plastic pyramid trap=PP). N.A = not available: no alcohol traps were used at this site

	Trap					
	A	CT	MC	MP	PP	Total
Dead Man	6	65	62	11	8	152
Beard Creek	N.A.	11	12	1	0	24
Total	6	76	74	12	8	176

Total whelk catches per harvesting session were quickly reduced during the study. At the Dead Man Hammock site, total catches of whelks per day dropped below 20 after only three weeks and never recovered (Figure 3). At the Beard Creek site, after an initial high within the first week of fishing, the numbers caught dropped to less than 15 per day for the rest of the study (Figure 3).

Table 6. By-catch of species caught in whelk traps at Dead Man Hammock (DM) and Beard Creek (BC) minus blue cabs. Mean ± S.E. over 24 day sample period

Species	Site	Total No.	Crab Trap	Plastic Pyramid	Mesh Pyramid	Plastic Rectangle	Modified Crab Trap
Decapoda							
Callinectes similis	DM	251	0.88 ± 0.207	4.29 ± 0.636	1.75 ± 0.364	2.04 ± 0.410	1.54 ± 0.306
	BC	146	1.08 ± 0.256	3.13 ± 0.379	1.00 ± 0.228		0.83 ± 0.183
Hepatus ephiliticus	DM	6		0.13 ± 0.089	0.08 ± 0.08	0.04 ± 0.04	
Hermit crabs*	DM	70	1.08 ± 0.249	0.63 ± 0.256	0.38 ± 0.145	0.08 ± 0.06	0.75 ± 0.296
	BC	111	2.54 ± 0.734	0.08 ± 0.056	0.88 ± 0.290		1.08 ± 0.391
Libia dubia	DM	25	0.67 ± 0.163		0.21 ± 0.102	0.08 ± 0.06	0.17 ± 0.76
	BC	15	0.33 ± 0.096		0.04 ± 0.04		0.33 ± 0.112
Libinia emarginata	DM	54	0.63 ± 0.211	0.50 ± 0.167	0.33 ± 0.130	0.21 ± 0.083	0.63 ± 0.194
	BC	4	0.04 ± 0.04		0.04 ± 0.04		0.08 ± 0.08
Lysmata wurdemanni	DM	1				0.04 ± 0.04	
	BC	1		0.04 ± 0.04			
Menippe mercenaria	DM	222	3.0 ± 0.449	1.00 ± 0.250	1.04 ± 0.239	1.21 ± 0.186	2.95 ± 0.440
	BC	100	1.50 ± 0.284	0.83 ± 0.183	0.29 ± 0.110		1.75 ± 0.319
Portunus spinimanus	DM	1		0.04 ± 0.04			
	BC	1			0.04 ± 0.04		
Family Xanthidae	DM	15		0.29 ± 0.125	0.04 ± 0.04	0.29 ± 0.14	
	BC	86	0.08 ± 0.08	2.29 ± 0.397	1.50 ± 0.577		0.42 ± 0.166
Mollusca							
Thais haemastoma floridana	DM	1		0.04 ± 0.04			
Pisces							
Centropristis philadelphica	DM	1					0.04 ± 0.04
Centroprsitis striata	DM	5	0.04 ± 0.04	0.08 ± 0.06	0.08 ± 0.06		
	BC	1					0.04 ± 0.04
Chaetodipterus faber	DM	9	0.43 ± 0.088				0.04 ± 0.04
	BC	26	0.92 ± 0.408				0.17 ± 0.096
Chilomycterus schoepfi	DM	6	0.16 ± 0.076				0.08 ± 0.06
Gymnachirus melas	DM	1	0.04 ± 0.04				
Gymnura altavela	BC	1					0.04 ± 0.04
Hypsoblennius hentzi	DM	1	0.04 ± 0.04				
Menticirrhus sp	DM	2	0.04 ± 0.04				0.04 ± 0.04
	BC	2	0.08 ± 0.08				
Micropogonias undulates	DM	2		0.08 ± 0.08			
Opsanus tau	DM	37	0.04 ± 0.04	0.58 ± 0.131	0.54 ± 0.257	0.04 ± 0.04	
Paralichthys lethostigma	BC	7	0.13 ± 0.068				0.17 ± 0.076
Stellifer lanceolatus	BC	1		0.04 ± 0.04			
Trinectes maculates	DM	1					0.04 ± 0.04
	BC	1	0.04 ± 0.04				
Reptilia							
Malaclemys terrapin	BC	1					0.04 ± 0.04

*Hermit crabs = *Clibanarius vittatus*, *Petrochirus diogenes*, and *Pagurus policaris*

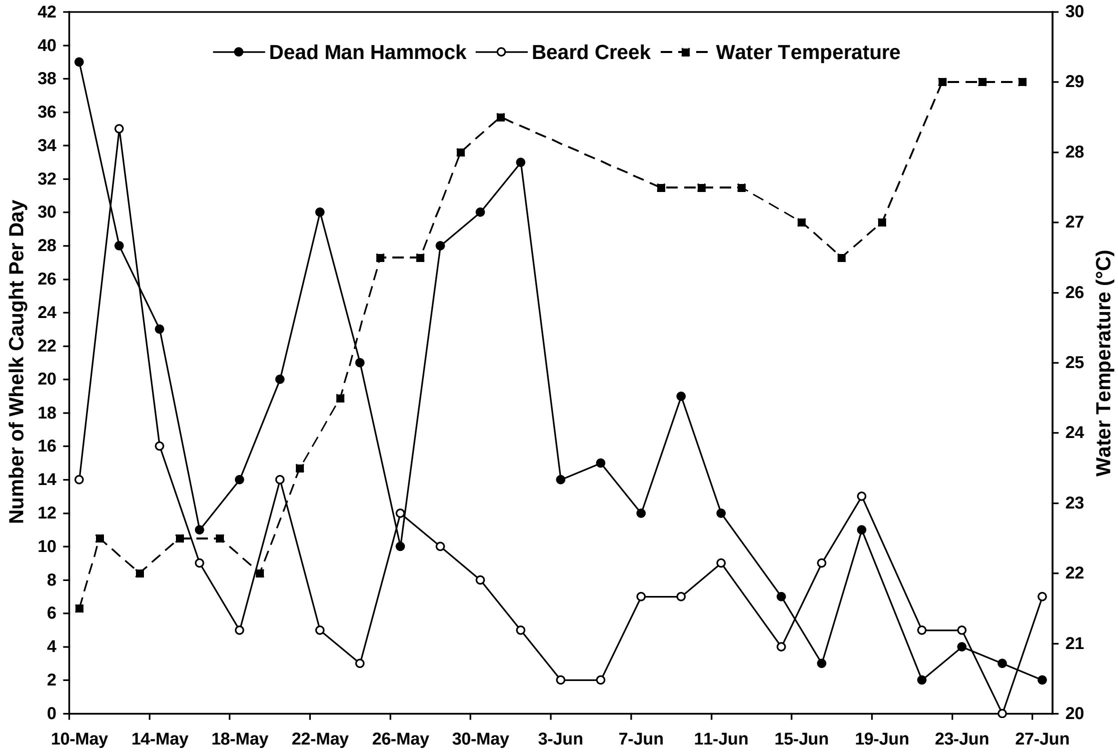

Figure 3. Total number of whelks caught during study at the Dead Man Hammock (●) and Beard Creek (o) study sites. Water temperatures (ºC) in Wassaw Sound during study.

Discussion

A greater number of channeled whelks were caught compared to other species of whelks. Channeled whelks are known to eat carrion (Magalhaes 1948, Walker *et al*. 2003) and make up the majority of the whelks caught in pot fisheries along the eastern coast of the United States (Shaw 1960, Davis and Sisson 1988, Logothetis and Beresoff 2004, Bruce *et al*. 2006). Walker *et al*. (2003) who worked in the same sound as this study using standard crab traps and wooden Chesapeake Bay conch pots caught 89% channeled whelks. Logothetis and Beresoff (2004) who worked in near shore waters in North Carolina also caught more channeled whelks (99%) than other species in pot trapping experiments. The proportion of channeled whelks caught in this study (47.7%) is considerably less.

The greater catches of knobbed whelks in this study may be related to behavior. March/April is the beginning of the spring reproductive season for knobbed whelks in Georgia (Power *et al*. 2002a). The Walker *et al*. (2003) study was conducted in March/April. During mating up to nine males may attempt to copulate with a single female (Walker *et al*. 2008). Whelks can spend days and weeks copulating and depositing egg strings during this period, and therefore feeding activities are minimal (Power *et al*. 2002a). Thus, the lower capture rate of knobbed whelks in Walker *et al*. (2003) study may have been controlled by reproductive events rather than a lower relative abundance inferred by the lower catch rates of baited traps for this particular species.

Water temperatures may have been a factor for the reduced percentage of channeled whelks caught. Walker *et al*. (2003) trapped whelks during late March to April and Logothetis and Beresoff (2004) worked from November to March. Water temperatures were significantly warmer during this study than the others, as it was performed from mid-May to late June (Figure 4). Whelk pot fisheries in cooler waters where channeled whelks dominate, in more northern states on the east coast such as Delaware (Bruce *et al*. 2006) and Massachusetts (Shaw 1960), consistently catch more channeled whelks than knobbed whelks in pot fisheries. The warmer temperatures may have resulted in greater activity of the knobbed and pearwhelks or a lessening of activity from the channeled whelks. Knobbed whelks can be found abundantly during daytime on intertidal areas during the spring and fall but are generally absent during daytime in summer and winter (Walker 1988, Walker *et al*. 2008). Knobbed whelks may have moved to deeper subtidal areas, where the traps were located, as air and water temperatures increased. However, a knobbed whelk tagging study at this site showed that whelks remained active within the intertidal regions during high tide in summer, but remained buried during daytime at low tide (Shalack 2007). Channeled whelks are known to feed in water temperatures ranging from 15.6 to 22.2ºC in Massachusetts (Shaw 1960). Polites and Mangum (1980) found that in Virginia, channeled whelks behave abnormally in water above 23ºC and become conspicuously sluggish at 24ºC. Water temperatures in Wassaw Sound during this study reached these temperatures around May 22 (Figure 3). It is likely that channeled whelks found in Georgia are slightly more adapted to higher water temperatures than channeled whelks found in more northern areas, but Georgia is near the southern end of the distributional range for channeled whelks (Abbott 1974). Therefore, it is likely that the summer month water temperatures in Georgia are approaching the physiological limit for channeled whelks.

At both sites, Dead Man Hammock and Beard Creek, the traps with smooth plastic surfaces caught more whelks than solely mesh wire traps (standard crab trap and mesh pyramid trap). The smooth surface may provide more surface area for a whelk's foot to securely attach to the trap as it crawls. The Georgia coast has a relatively high tidal range from 2-3 meters between low and high tide. Therefore, tidal currents can be rather swift along the Georgia coast. This may increase the importance of the available foot attachment surface area on the traps. Whelks may have greater trouble entering wire mesh traps than in the smooth plastic type traps. Knobbed whelks are successful at tracking prey odors even in fast turbulent flows in Georgia (Ferner and Weissburg 2005). Upon reaching the crab trap, they may be prevented from entering by becoming trapped in the mesh wire from the outside.

Most (80.8%) of the whelks caught were less than 100 mm in total length. The 38 mm wire mesh covering the standard crab trap and the mesh pyramid might have hindered the foot attachment of smaller whelks. This may have prevented some whelks from entering the wire mesh covered traps. The modified crab trap was also covered in the wire mesh, but the modifications to the funnel entrance with pieces of plastic provided a foot attachment site for the smaller whelks.

The mesh coverings may also explain the average catch weights. For channeled and pearwhelks, the standard crab trap had the highest average catch weights, followed by the other two traps with mostly large mesh coverings (modified crab trap and mesh pyramid). For knobbed whelks the overall order was similar with the modified crab trap standard crab trap having the highest average catch weights. The larger mesh size may have had a combination affect on the size of the whelks caught; 1) it prevented smaller sized whelks from effectively entering the trap and 2) allowed even smaller whelks that did manage to enter the trap, to fall out as the trap was being lifted into the boat.

Total numbers of whelks collected during each harvest at both sites quickly declined. The quick depletion of whelk stocks in an area is not unusual. Shaw (1960) reports catching more than 80 percent of total channeled whelk catch within the first two weeks in trapping experiments in Massachusetts. Walker *et al*. (2003) showed that catch rates for channeled whelks dropped from an initial mean of approximately 32 per crab trap to less than 5 per trap by week four of trapping. By week four, most potted whelks were ones that had been previously caught, tagged, released some 200 meters away and had re-entered the trapping site. The quick depletion combined with most (80.8%) of the trapped whelks being less than 100 mm in length makes the probability of a commercially viable whelk potting fishery in Georgia unlikely.

Although the plastic pyramid trap caught the greatest number of whelks (40% of total catch), most of the whelks were relatively small. The modified crab trap caught the second greatest number of whelks and had the highest average catch weight for knobbed whelks and the second highest for channeled and pearwhelks. Probably the most commercially effective way of potting whelks in Georgia is as a combined by-catch fishery with the current blue crab fishery. By adding plastic to the funnel entrance of current crab traps, crabbers can increase the number of marketable size whelks caught by the standard crab traps currently in use.

Logothetis and Beresoff (2004) reports on the by-catch of a whelk trap fishery in North Carolina. They captured 16,506 individual items comprising 59 species from 6 Phyla over the October to March period. Of these crustaceans accounted for 93.75%, echinoderms 2.5%, pisces 2.1%, mollusks 1.6% and other 0.05% of the catch. Blue crabs and spider crabs accounted for 53% and 30.5% of the by-catch, respectively. In addition to whelks and blue crabs in our study, 26 by-catch species were caught in whelk traps deployed inshore in this study (Table 6). Walker *et al*. (2003) captured no blue crabs or spider crabs (*Libinia* sp.) in Chesapeake Bay conch pots as compared to standard blue crab traps in Georgia. Power *et al.* (submitted) lists 32 by-catch species from 9 Phyla in an offshore Georgia knobbed whelk trawl study. Three of these were the channeled, lightning and pearwhelks and one was the blue crab. Of the remaining 28 species, only eight (*Centropristis striata*, *Chaetodipterus faber*, *Chilomycterus schoepfi*, *Clibanarius vittatus*, *Hepatus ephetiticus*, *Libinia dubia*, *Menippe mercenaria*, and *Paralichthys lethostigma*) were in common with by-catch caught inshore. Many of the species caught in the trawl net were immobile species (unknown sponge species; sea squirt, *Styela plicata*; sea pork, *Aplidium constellatum*; sea pansy, *Renilla renifomis*; sea cucumber, unknown species, sand dollar, *Mellita quinquiesperforata*; and Atlantic giant cockle, *Dinocardium robustrum*) which would not be expected to be caught in a trap fishery. However Logothetis and Beresoff (2004) found non-mobile species such as sea pansy, *Renilla renifomis*; hard clams, *Mercenaria mercenaria*; blood arks, *Anadara ovalis;* and an unknown colonial tunicate in crab traps in North Carolina. For the 26 by-catch species caught in inshore whelk traps and with proper care by the fisherman, they can easily be returned unharmed to the water with the exception of the terrapin, *Malaclemys terrapin* that could drown if it becomes entrapped within the standard crab and modified crab traps.

This study does not address several questions which must be addressed before establishing a commercial fishery. It does not address whether the whelk harvest would be viable for multiple years in the same locations. Pot trapping in this study and the Walker *et al*. (2003) study both clearly showed that localized stocks were rapidly depleted. Likewise, a hand harvesting study of whelks from the intertidal zone in Georgia revealed that stocks were depleted from an area of approximately 2.4 ha from February 27 to April 1 (Shalack *et al*. 2011). Furthermore, Walker *et al*. (2008) showed that the majority of 17,826 whelks tagged and released at various intertidal sites about Wassaw Sound, GA stayed in their area of release. While some whelks migrated great distances, the fact that the majority did not move that far would indicate that areas would be fished out and re-colonization would be slow. These studies indicate that an inshore trap fishery would not be sustainable at viable commercial levels. In Georgia, knobbed whelk males reach sexual maturity at 85 to 90 mm in 4 years and females at 100 mm in 6 years (Power *et al.* 2009). The majority of the knobbed whelks caught at both sites in this study were well below the sexual maturity size for females (mean of 91.7 mm at Dead Man Hammock and 75.6 mm at Beard Creek; Table 4). Since there were an equal number of male (N= 121) and female (N= 117) knobbed whelks potted trapped (Table 3), it would appear that some females were removed from the population prior to being allowed the opportunity to lay eggs at least once in their life. Removing females prior to being allowed to contribute to the next generation is an unsustainable practice. Power *et al*. (2002c) reported that channeled whelk can increase in shell length at a rate approximately three times that recorded for knobbed whelks (mean of 1.84 versus 0.61mm/mo.). It is also likely that this species matures faster than knobbed whelk, however, the size and time needed to attain sexual maturity is still unknown. Also, it is unclear how often a female whelk lays eggs in Georgia. Until these questions can be addressed, a sustainable as well as commercially viable harvest level cannot be set.

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