HARD CLAM (*Mercenaria mercenaria*) POPULATION DENSITY AND DISTRIBUTION IN REHOBOTH BAY AND INDIAN RIVER BAY, DELAWARE

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Introduction

Delaware's hard clam (*Mercenaria mercenaria*) population is an important resource, both commercially and recreationally, in the State's primary inland bays, Rehoboth Bay and Indian River Bay. Currently these two bays support fifty-five commercial clammers and a popular recreational clam fishery for Delaware's residents and visitors.

Hard clams are the only commercially important bi-valve molluscan shellfish species harvested from the Rehoboth and Indian River Bays, although small populations of Eastern Oysters, surf clams, razor clams and mussels are found in these waters. Currently the population of oysters and surf clams are well below commercial densities and harvest gear restrictions (prohibited use of mechanical and hydraulic dredges in Delaware's Inland Bays) prevent the harvest of the various razor clam species. During the first half of the twentieth century, there was a viable oyster industry supported by relaying shellstock from the Delaware Bay to private leases in the Inland Bays for grow out and depuration. During the 1950's, the disease MSX killed almost all oysters in the Inland Bays, which resulted in the termination of private owned leased beds in the Rehoboth and Indian River Bays (Cole, et al. 1976).

Hard clam surveys were conducted in the Indian River Bay and Rehoboth Bay in 1967, by Humphries and Daiber (1968) and in 1975-1976 by Cole and Spence (1976). These two surveys provide the historical data used to monitor changes in density in Delaware's hard clam population and distribution. For the purpose of this study, the 1967 survey data was not analyzed because sampling methods (manual harvest) did not produce adequate collection efficiency and only clams 1.5" or larger were collected. Delaware's other Inland Bay, the Little Assawoman Bay, was found to support very low numbers of hard clams and is currently classified as a non-productive resource area by the State Shellfish and Recreational Water Programs. A bull rake survey was conducted of ten sample locations in the summer of 2012, with a total of nine *M. mercenaria* collected.

Under federal law, all waters used for commercial shellfish harvest must be classified and surveyed for actual or potential pollution sources by the state's shellfish program. In Delaware, The Department of Natural Resources and Environmental Control, Division of Watershed Stewardship, Shellfish and Recreational Water Programs, is responsible for all water quality sampling and pollution survey work conducted to meet the U.S. Food and Drug Administration's (FDA) standards under the National Shellfish Sanitation Program (NSSP) Model Ordinance. Reviews of classified waters are conducted annually by the Shellfish and Recreational Water Programs, and areas approved for shellfish harvesting are adjusted based on these findings.

Due to the significance of this resource, a hard clam density study of the Indian River Bay and Rehoboth Bay was conducted in 2010 and 2011 (hereby referred to as the '2011 survey') to identify significant changes in clam populations since previous surveys in the late 1970's and to identify areas of productive clam habitat.

Methods

The Venturi Suction Dredge survey method used duplicated the method used during the Spence and Cole Survey (1976) to increase the accuracy and precision between these two data sets. The dredge was fabricated from aluminum with a mesh net attached capable of capturing clams greater than 8mm. The dredge was powered by a 4" water pump with a 4" reinforced intake hose and 3" effluent hose attached to the Venturi dredge. The sample quadrat was a

$1m^2$ frame constructed from 1" PVC piping with holes drilled into the material to allow the pipe to fill with water and stay weighted on the sediment.

The sample stations duplicated the survey points used during the Humphries and Daiber survey (1967). Sample stations which were located near the Indian River Inlet or in navigational channels were either eliminated or moved to adjacent locations due to safety hazards. In the event a sample location was to near to a shore line to allow operation of the dredge, the quadrat was located as near to the original point as possible and the new coordinates were recorded.

Sample stations were located using a hand held global positioning system (GPS) to get within 3m of the location, and a weighted buoy was thrown randomly to mark the specific site. Two divers would place the quadrat on the northern side of the buoy weight and remove and record any macro-algae present. One diver would operate the Venturi dredge, excavating all substrate to a minimum depth of 12". The second diver stabilized the quadrat to prevent movement and verified the station was completely sampled before surfacing. If the substrate could not be excavated to a depth of 12", the actual depth and limiting factors were recorded. Any clams which were partly located within the inside portion of the quadrat were included in the sample. Clams were included if the diver could run a finger along the inside edge of the PVC pipe and feel the shell within the quadrat. To avoid sampling additional substrate which caved into the sample area, the diver did not re-dredge any portions which were already sampled.

Once samples were brought to the surface, all live bi-valve molluscan shellfish were sorted from the material, and measurements of the shell width and length, along with species were recorded. Qualitative sediment type was also recorded for each site, along with water depth. All calipers used were frequently calibrated on a known standard following procedures outlined in the Quality Assurance Project Plan.

Significant differences in clam densities were tested for: 1) between the 1976 and 2011 surveys; and 2) between bays within a given survey. Differences in the distribution of clam densities (i.e. 'shapes' of the catch distributions) were also investigated: 1) between the 1976 and 2011 surveys; and 2) between bays within a given survey.

Results

There were a total of 194 sites sampled in the Rehoboth Bay (Table 1) and 83 sites sampled from the Indian River Bay (Table 2; Figures 1, 2). Catch distributions from the 1976 and 2011 surveys are depicted in Figure 1. Clam densities for the 2011 Rehoboth and Indian River Bays are shown in Figure 3. Density Maps were created using ARC GIS, to extrapolate site specific catch data using spline interpolation with a 25m x 25m grid to bay wide densities (Wilson 2012).

Current clam densities were compared to the 1976 survey densities using the Wilcoxon two-sample test. The non-parametric Wilcoxon two-sample test was chosen given the: 1) lack of improvement from transformations of the non-normally distributed datasets, and 2) the non-normal residual diagnostics from a generalized linear model.

There was no significant difference in clam density in Rehoboth Bay between 1976 and 2011 ($P=0.45$) (Table 3). Similarly, clam densities were not significantly different in Indian River Bay between 1976 and 2011 ($P=0.36$). There were significant differences in clam density between bays in 1976 ($P<0.001$) and in 2011 ($P=0.049$) (Table 3).

Differences in the distributions of clam densities (i.e. shapes of the catch distributions) were examined using the Komolgorov-Smirnov two-sample test. Whereas the Wilcoxon test describes differences in location (i.e. median) between surveys or bays, the K-S test detects differences that might also be related to range, dispersion, or skewness between surveys or bays (statistics observable in the catch distribution 'shape'). There were no significant differences in the shape of the catch distributions between years in either bay: Rehoboth Bay (P=0.31), Indian R. Bay, (P=0.34). Catch distributions were significantly different between bays in 1976 (P<0.0001), but not in 2011 (P=0.296) (Table 4; Figure 2).

Discussion

Analysis of catch distributions showed a significant difference between bays in 1976, but no significant difference between bays in 2010. This is a result of greater zero catch frequencies in the Rehoboth Bay in 2010 as compared to 1976. Both 1976 and 2010 had similar zero catch frequencies in the Indian River Bay. Clam densities also remained higher in Rehoboth Bay as compared to the Indian River Bay for both surveys. The Rehoboth Bay has similar environmental conditions bay wide, including sediment, salinity and depth, which may be more conducive to clam settlement and survival. The Indian River Bay has a wider range of environmental conditions, including higher salinity ocean water near the Indian River Inlet (Inlet) and lower salinities near the Indian River. Sediments in the Indian River Bay also vary more than the Rehoboth Bay, with more sandy and shell based sediments near the Inlet and mud based sediments in the upper bay.

Clam densities in the Rehoboth and Indian River Bays appear to be stable based on the most recent survey data. In Delaware's Inland Bays, substrate type appears to be the greatest variable in clam densities. Based on previous surveys, substrates that are composed of shell or sandy mud have a significantly higher clam density than those composed of mud or gravel (Cole, et al. 1976). Although no analysis was conducted to confirm the significance of substrate in the 2011 survey, observations tend to support this theory. The highest clam density occurred in the Rehoboth Bay in a substrate composed primarily of oyster shell. The shell layer was approximately 2-3" deep and covered by approximately 1-2" of mud. At this location, a total of 33 clams per m^2 were collected, the highest of any previous survey of these Bays. Most locations which had no clams found during dredging were located in areas that were dominated by mud or very soft mud. These locations also tended to be located in areas that were closer to rivers and creeks and were also further from the Indian River Inlet than substrates composed of sand or mud/sand mixes. Although it is believed to be the substrate that limited clam densities, factors such as salinity, tidal flushing and dominant phytoplankton species may also contribute to observed differences in clam densities.

Substrate is also believed to affect survival and predation rates of young clams, particularly from crabs, gastropods, fish and birds (Kraeuter, et al 2009). Predation based on substrate may be a primary factor driving clam densities In the Inland Bays. During diving, Cow Nosed Rays (*Rhinoptera bonasus)* were often observed in areas with substrates composed of sand or sand mud mixes, and the shallow depression made while feeding were noted in these areas. Human predation through harvest was also observed in areas that had sediment types favorable to high clam densities, particularly recreational clam harvest in shallow waters. The difference in human harvest and natural predation is that substrates which limit natural predation may concentrate human effort harvesting in these more productive areas. Although the use of the Inland Bays for recreational uses has increased dramatically since the 1970's, this does not appear to have had an impact on clam densities since there was no significant difference in catch between surveys. The greatest impact from human growth and development in the Bays on clam habitat has been the closure of clam harvesting areas due to actual or potential pollution sources as required by the National Shellfish Sanitation Program. These changes in growing area classification have mostly resulted in seasonal harvest closures which limit harvest to winter months and reduce pressure from recreational harvesters.

The commercial harvest of clams does not appear to have a negative impact on clam populations. This is due to good management practices which limits daily quotas and enforce gear restrictions to reduce long term impacts to the species and habitat. Commercial harvest gear types are primarily bull and hand rakes or overboard harvesting with the use of no gear. The use of mechanical dredging, for any commercial harvest, is prohibited in all of the Inland Bays.

Due to the amount of time between comprehensive *M. mercenaria* surveys in the Inland Bays, only significant changes in density between the two surveys and Bays can be calculated. To determine the long term trends for this species, more frequent surveys would need to be conducted to collect sufficient data.

Literature Cited

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Appendix

Table 1. Density and distribution of *M. mercenaria* in Rehoboth Bay, DE June 2010- July2011

Station_Number	Latitude	Longitude	NumbClams	water_depth	sediment_type
218	38.6341667	-75.1097222	5	3	sandy clay
220	38.6341667	-75.0944444	15	5	shell/sandy clay mix
211	38.6302778	-75.0944444	3	4	sand gravel mix
212	38.6302778	-75.0888889	6	5	sand shell mix
207	38.6263889	-75.0888889	5	6	shell/sandy clay mix
208	38.6263889	-75.0833333	1	4	soft sand
209	38.6263889	-75.0788889	9	5	sand shell mix
312	38.6625000	-75.0788889	4	4	very fine sand
313	38.6625000	-75.0733333	4	2	very fine sand
326	38.6666667	-75.0733333	3	2	very fine sand
203	38.6222222	-75.0888889	0	3	soft sand
204	38.6222222	-75.0833333	3	3	sand/mud mix
385	38.6916667	-75.1458333	0	3	mud
386	38.6916667	-75.1402778	0	2	sand/mud mix
387	38.6916667	-75.1352778	0	1	mud/organic detritus mix
237	38.6422222	-75.1300000	7	2	sand/gravel
238	38.6422222	-75.1250000	13	5	sand
249	38.6463889	-75.1250000	9	7	mud silt
250	38.6463889	-75.1200000	3	10	mud and oyster shell mix
197	38.6180556	-75.0888889	0	5	soft sand
233	38.6380556	-75.0888889	6	3	soft sand
221	38.6341667	-75.0888889	4	3	mud/sand
214	38.6302778	-75.0788889	6	2	muddy silt/sand/shell
215	38.6302778	-75.0733333	1	2	sand/mud mix
295	38.6586111	-75.0991667	1	12	mud
296	38.6586111	-75.0944444	10	9	mud/shell mix
297	38.6586111	-75.0888889	8	8	mud/sand/shell mix
298	38.6586111	-75.0833333	5	7	mud/sand mix
299	38.6586111	-75.0788889	0	3	sand
300	38.6586111	-75.0733333	3	2	sand
309	38.6625000	-75.0944444	2	10	mud
310	38.6625000	-75.0888889	4	9	mud/shell mix
311	38.6625000	-75.0833333	6	7	mud/ shell mix
322	38.6666667	-75.0944444	0	7	mud
323	38.6666667	-75.0888889	2	7	mud
324	38.6666667	-75.0833333	2	9	mud
325	38.6666667	-75.0788889	17	6	sand/mud/shell mix

334	38.6708333	-75.0944444	5	8	mud/shell mix
335	38.6708333	-75.0888889	3	7	mud
336	38.6708333	-75.0833333	33	8	shell/mud mix
337	38.6708333	-75.0788889	6	4	sand
338	38.6708333	-75.0733333	1	2	sand
347	38.6750000	-75.0944444	0	7	mud
348	38.6750000	-75.0888889	0	7	mud
349	38.6750000	-75.0833333	0	6	mud
350	38.6750000	-75.0788889	0	7	mud/sand mix
205	38.6222222	-75.0788889	7	2	sand
202	38.6222222	-75.0944444	18	5	sand/gravel
210	38.6302778	-75.1041667	0	4	mud
219	38.6341667	-75.0991667	12	5	sand
230	38.6380556	-75.1041667	1	2	sand
231	38.6380556	-75.0991667	3	5	sand
232	38.6380556	-75.0944444	7	6	sand/shell mix
234	38.6380556	-75.0833333	1	2	sand
246	38.6463889	-75.0833333	4	3	sand/shell mix
358	38.6791667	-75.0991667	0	8	mud/shell mix
359	38.6791667	-75.0944444	3	7	mud
360	38.6791667	-75.0888889	0	7	mud
361	38.6791667	-75.0833333	4	8	mud/sand/shell mix
362	38.6791667	-75.0788889	3	3	sand
381	38.6875000	-75.0944444	2	3	sand/shell mix
382	38.6875000	-75.0888889	4	2	sand/mud mix
389	38.6916667	-75.0888889	2	5	mud
390	38.6916667	-75.0833333	5	5	mud/sand
391	38.6916667	-75.0788889	1	2	sand/gravel
259	38.6505556	-75.1300000	1	3	mud
260	38.6505556	-75.0916667	4	4	mud/sand
222	38.6341667	-75.0833333	2	3	mud/sand mix
213	38.6302778	-75.0833333	6	2	sand
223	38.6341667	-75.0788889	2	2	sand/shell mix
229	38.6380556	-75.1097222	7	7	sand/gravel
269	38.6505556	-75.0788889	1	4	sand
268	38.6505556	-75.0833333	8	5	sand
267	38.6505556	-75.0888889	4	4	sand
266	38.6505556	-75.0944444	19	6	sand/mud mix
265	38.6505556	-75.0991667	8	7	sand/mud mix
264	38.6505556	-75.1041667	8	7	sand/mud mix
263	38.6505556	-75.1097222	3	8	mud

262	38.6505556	-75.1147222	1	8	mud
261	38.6505556	-75.1200000	8	4	sand
279	38.6547222	-75.1250000	0	4	sand
289	38.6586111	-75.1300000	2	5	sand/gravel
216	38.6341667	-75.1352778	0	3	sand gravel/ organic biomass
270	38.6666667	-75.1825000	0	4	peat organic mud
314	38.6666667	-75.1352778	0	3	mud/ organic debris
339	38.6750000	-75.1352778	1	3	sand/mud
301	38.6625000	-75.1300000	11	5	sand/shell mix
244	38.6422222	-75.0944444	17	5	sand/mud
255	38.6463889	-75.0944444	8	5	sand/shell mix
256	38.6463889	-75.0888889	13	4	sand/shell mix
257	38.6463889	-75.0833333	12	4	sand/shell mix
245	38.6422222	-75.0888889	7	5	sand/mud/shell mix
198	38.6180556	-75.0833333	2	3	mud
200	38.6180556	-75.0733333	10	4	sand/mud mix
201	38.6180556	-75.0680556	1	1	sand/mud mix
340	38.6750000	-75.1300000	3	n/a	mud/shell mix
327	38.6708333	-75.1300000	1	n/a	mud/sand mix
315	38.6666667	-75.1300000	2	n/a	mud
271	38.6625000	-75.1772222	0	2	mud/gravel
275	38.6586111	-75.1716667	0	3	mud
276	38.6586111	-75.1666667	0	3	mud
272	38.6586111	-75.1872222	0	2	mud
273	38.6586111	-75.1825000	0	4	mud
274	38.6547222	-75.1772222	0	1	mud/sand
277	38.6547222	-75.1558333	0	5	mud
278	38.6547222	-75.1508333	0	4	mud
258	38.6505556	-75.1458333	0	4	mud
248	38.6463889	-75.1402778	0	2	mud
247	38.6463889	-75.1458333	0	2	mud
235	38.6422222	-75.1402778	1	2	mud
375	38.6875000	-75.1402778	0	5	mud
376	38.6875000	-75.1352778	1	5	mud
366	38.6833333	-75.1200000	4	5	sand
388	38.6916667	-75.1200000	0	2	mud
378	38.6875000	-75.1097222	9	5	sand/shell/gravel mix
351	38.6791667	-75.1352778	0	3	sand/gravel
241	38.6422222	-75.1097222	8	6	sand/mud
242	38.6422222	-75.1041667	8	7	sand/shell mix
243	38.6422222	-75.0991667	10	5	sand/shell mix

253	38.6463889	-75.1041667	7	6	sand/mud mix
288	38.6547222	-75.0788889	0	3	sand
251	38.6463889	-75.1147222	6	8	hard sand mud mix
252	38.6463889	-75.1097222	1	8	hard sand mud mix
254	38.6463889	-75.0991667	6	7	sand mud mix
199	38.6180556	-75.0788889	3	5	mud
206	38.6547222	-75.1558333	0	1	sand/mud mix
239	38.6422222	-75.1200000	2	7	mud
240	38.6422222	-75.1147222	16	6	sand/mud mix
225	38.6380556	-75.1300000	4	6	mud
226	38.6380556	-75.1250000	2	6	mud
227	38.6380556	-75.1200000	8	8	sand
217	38.6341667	-75.1200000	0	8	mud
228	38.6380556	-75.1147222	14	6	sand/shell
236	38.6422222	-75.1352778	0	3	mud
280	38.6547222	-75.1200000	7	5	sand
281	38.6547222	-75.1147222	1	8	mud
282	38.6547222	-75.1097222	4	9	mud
283	38.6547222	-75.1041667	0	7	mud
284	38.6547222	-75.0991667	6	7	mud/sand mix
285	38.6547222	-75.0944444	4	8	mud
286	38.6547222	-75.0888889	1	6	mud/sand mix
287	38.6547222	-75.0833333	2	3	sand
379	38.6875000	-75.1041667	3	5	mud
380	38.6875000	-75.0991667	2	5	mud
383	38.6875000	-75.0833333	2	7	mud
384	38.6875000	-75.0788889	4	7	mud/sand mix
374	38.6833333	-75.0788889	2	4	sand/shell mix
290	38.6586111	-75.1250000	1	7	mud
291	38.6586111	-75.1200000	13	5	sand/gravel
292	38.6586111	-75.1147222	5	7	mud/shell mix
293	38.6586111	-75.1097222	7	8	mud
224	38.6341667	-75.0733333	0	3	mud
377	38.6875000	-75.1147222	2	6	mud
363	38.6833333	-75.1352778	1	4	mud
364	38.6833333	-75.1300000	1	5	mud
365	38.6833333	-75.1250000	0	6	mud
367	38.6833333	-75.1147222	6	6	sand
368	38.6833333	-75.1097222	6	7	mud/sand mix
369	38.6833333	-75.1041667	6	6	sand/shell mix
370	38.6833333	-75.0991667	0	7	mud

371	38.6833333	-75.0944444	3	6	mud
372	38.6833333	-75.0888889	3	6	mud
373	38.6833333	-75.0833333	10	4	sand
352	38.6791667	-75.1300000	0	7	mud
353	38.6791667	-75.1250000	0	7	mud
354	38.6791667	-75.1200000	1	7	mud
355	38.6791667	-75.1147222	1	7	mud
356	38.6791667	-75.1097222	1	7	mud
357	38.6791667	-75.1041667	2	6	mud/sand mix
346	38.6750000	-75.0991667	0	8	mud
345	38.6750000	-75.1041667	1	8	mud
344	38.6750000	-75.1097222	2	7	mud/shell mix
343	38.6750000	-75.1147222	0	7	mud/shell mix
342	38.6750000	-75.1200000	0	7	mud/shell mix
341	38.6750000	-75.1250000	1	7	mud/shell mix
328	38.6708333	-75.1250000	11	5	sand
333	38.6708333	-75.0991667	3	7	mud
332	38.6708333	-75.1041667	1	7	mud
331	38.6708333	-75.1097222	2	7	mud
330	38.6708333	-75.1147222	4	7	mud/shell mix
329	38.6708333	-75.1200000	0	8	mud
321	38.6666667	-75.0991667	0	8	mud
320	38.6666667	-75.1041667	0	7	mud
319	38.6666667	-75.1097222	0	7	mud
318	38.6666667	-75.1147222	0	7	mud
317	38.6666667	-75.1200000	7	5	sand/mud mix
316	38.6666667	-75.1250000	7	6	sand/mud mix
294	38.6586111	-75.1041667	1	7	sand/mud mix
308	38.6625000	-75.0991667	3	8	mud
307	38.6625000	-75.1041667	7	8	mud
306	38.6625000	-75.1097222	0	9	mud
304	38.6625000	-75.1147222	0	8	mud/gravel
303	38.6625000	-75.1200000	3	4	sand/gravel
302	38.6625000	-75.1200000	2	7	sand/mud mix

Table 2. Density and distribution of *M. mercenaria* in Indian River Bay, DE July 2011- August 2011.

Station_Number	Latitude	Longitude	NumbClams	water_depth	sediment_type
192	38.5977778	-75.0680556	0	1.5	Sand/mud mix
194	38.5894444	-75.0683056	14	6.5	Sand/mud mix
196	38.5816667	-75.0680556	0	4.5	mud
187	38.5894444	-75.0733333	2	1.5	Sand/mud mix
155	38.5894444	-75.0944444	19	5	sand
159	38.5691667	-75.0944444	0	4	mud
161	38.5564722	-75.0939722	0	2	mud
168	38.5852778	-75.0888889	6	4.5	sand
175	38.5816667	-75.0833333	5	4.5	sand
151	38.6061111	-75.0944444	0	7	sand
149	38.6138889	-75.0944444	0	7	Sand/mud mix
157	38.5816667	-75.0944444	6	7	Sand/mud mix
173	38.5894444	-75.0833333	7	4	sand
171	38.5977778	-75.0833333	7	3.5	sand
184	38.6016667	-75.0733333	1	2	Sand/mud mix
146	38.5771667	-75.0987778	5	1.5	gravel/Sand/mud mix
144	38.5852778	-75.0991667	16	5.5	Sand/mud mix
142	38.5936111	-75.0991667	16	4	Sand/mud mix
140	38.6016667	-75.0991667	7	5.5	sand
138	38.6100000	-75.0991667	0	6	sand
136	38.6180556	-75.0991667	2	12	gravel/sand mix
127	38.6138889	-75.1041667	4	4.5	sand
129	38.6061111	-75.1041667	5	6	sand
131	38.5977778	-75.1041667	7	6	sand
133	38.5894444	-75.1041667	18	5.5	gravel/sand
135	38.5816667	-75.1041667	0	5	Sand/mud mix
125	38.5816667	-75.1097222	0	2.5	mud
123	38.5936111	-75.1097222	1	8	mud
121	38.6016667	-75.1097222	1	8.5	Sand/mud mix
119	38.6100000	-75.1097222	6	8	Sand/mud mix
117	38.6180556	-75.1097222	7	4.5	sand
111	38.6138889	-75.1147222	14	6.5	Sand/mud mix
113	38.6061111	-75.1147222	0	9	mud
189	38.5775000	-75.0733333	0	3.5	mud
115	38.5977778	-75.1147222	2	9	mud
110	38.5936111	-75.1200000	10	5	sand
108	38.6016667	-75.1200000	1	9	mud
99	38.6138889	-75.1250000	2	8	mud

106	38.6100000	-75.1200000	2	9.5	mud
101	38.6061111	-75.1250000	0	9	mud
103	38.5977778	-75.1250000	1	8	mud
98	38.5936111	-75.1300000	3	4	sand
96	38.6016667	-75.1300000	0	8	mud
94	38.6100000	-75.1300000	1	6.5	mud
89	38.6061111	-75.1352778	0	7	mud
91	38.5977778	-75.1352778	3	8	mud
69	38.6100000	-75.1508333	10	2.5	sand/shell mix
75	38.5860000	-75.1495833	3	2	sand/mud/gravel mix
63	38.6058611	-75.1555833	5	1.5	Sand/mud mix
61	38.6138889	-75.1613889	0	1	mud
84	38.6016667	-75.1402778	0	8.5	mud
82	38.6100000	-75.1402778	1	6.5	mud
86	38.5936111	-75.1402778	3	6	Sand/mud mix
81	38.5894444	-75.1458333	2	6	mud
79	38.5977778	-75.1458333	0	6	mud
77	38.6061111	-75.1458333	3	6	mud
7	38.5937500	-75.2083333	1	4.5	mud
5	38.5894444	-75.2183333	0	2.5	mud
31	38.5611111	-75.1972222	0	2	mud
34	38.5617778	-75.2075000	0	2.5	Sand/mud mix
32	38.5655556	-75.2027778	0	4.5	mud
65	38.5977778	-75.1558333	2	7	mud
67	38.5894444	-75.1558333	0	9	mud
60	38.5775000	-75.1608611	0	3	sand/shell mix
58	38.5852778	-75.1613889	0	7	mud
56	38.5936111	-75.1613889	3	7	mud
49	38.5977778	-75.1666667	6	4	Sand/mud mix
37	38.5936111	-75.1772222	0	4.5	mud
18	38.5936111	-75.1922222	0	1.5	mud
13	38.5936111	-75.2027778	0	2	mud
15	38.5852778	-75.2027778	0	2.5	mud
17	38.5852778	-75.1972222	0	3.5	mud
21	38.5931667	-75.1826389	2	1	sand/shell mix
23	38.5852778	-75.1825000	1	4.5	sand
73	38.5936111	-75.1508333	0	9	mud
71	38.6016667	-75.1508333	1	9	mud
44	38.5936111	-75.1716667	1	7	mud
51	38.5894444	-75.1666667	0	8	mud
38	38.5894444	-75.1772222	0	6.5	mud

46	38.5852778	-75.1716667	0	7.5	mud
53	38.5816667	-75.1666667	1	7	mud
48	38.5775000	-75.1716667	9	5.5	Sand/mud mix
40	38.5816667	-75.1772222	2	7	Mud

Table 3. Comparison of clam densities between years and between bays (Wilcoxon two-sample test).

Statistical Test	Result	P-value
Rehoboth Bay clam density: 1976 versus 2011	Not Significant	P=0.45
Indian River Bay clam density: 1976 versus 2011	Not Significant	P=0.36
Rehoboth Bay versus Indian River Bay clam density: 1976	Significant	P<0.001
Rehoboth Bay versus Indian River Bay clam density: 2011	Significant	P=0.049

Table 4. Comparison of the distributions of clam densities between years and between bays (Kolmogorov-Smirnov two-sample test).

Statistical Test	Result	P-value
Rehoboth Bay clam density: 1976 versus 2011	Not Significant	P=0.31
Indian River Bay clam density: 1976 versus 2011	Not Significant	P=0.34
Rehoboth Bay versus Indian River Bay clam density: 1976	Significant	P<0.0001
Rehoboth Bay versus Indian River Bay clam density: 2011	Not Significant	P=0. 296

Figures

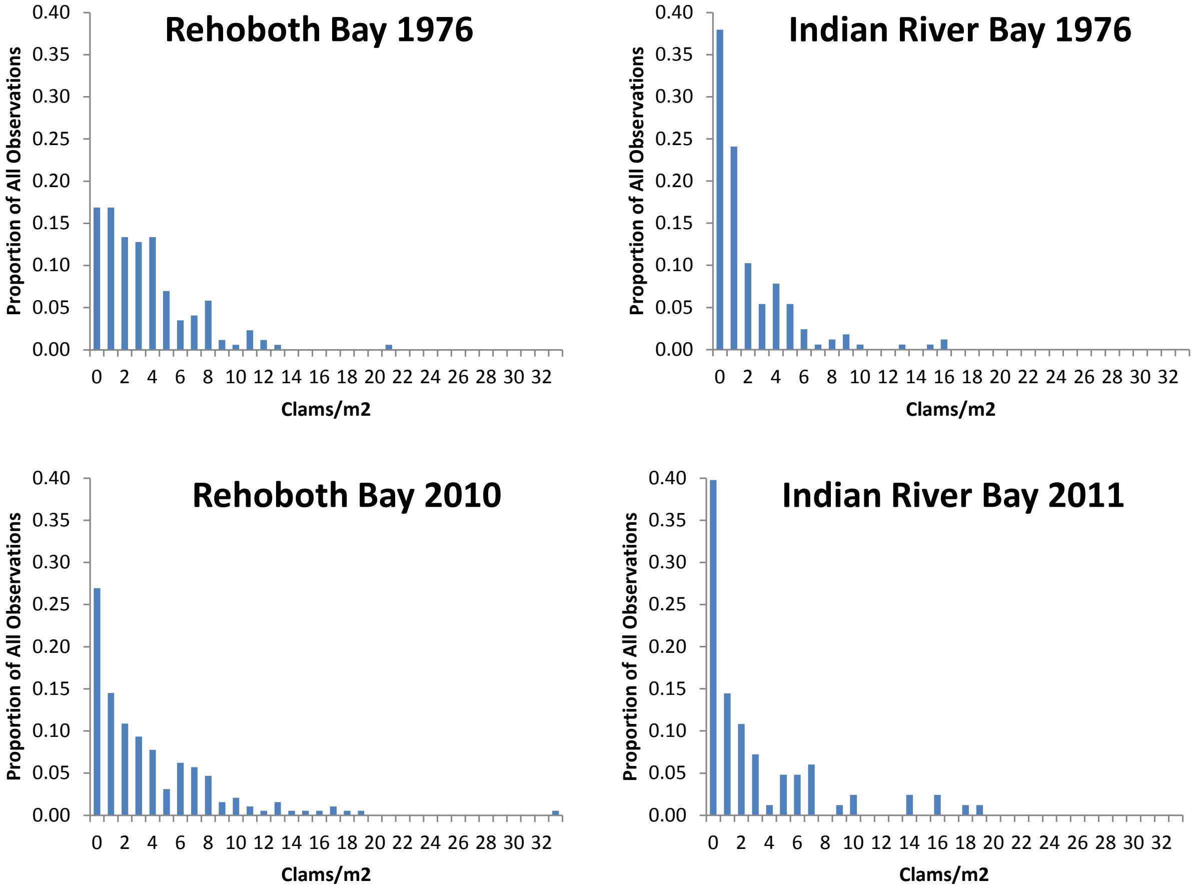

Figure 1. Distribution of clam catches in the 1976 and 2011 surveys.

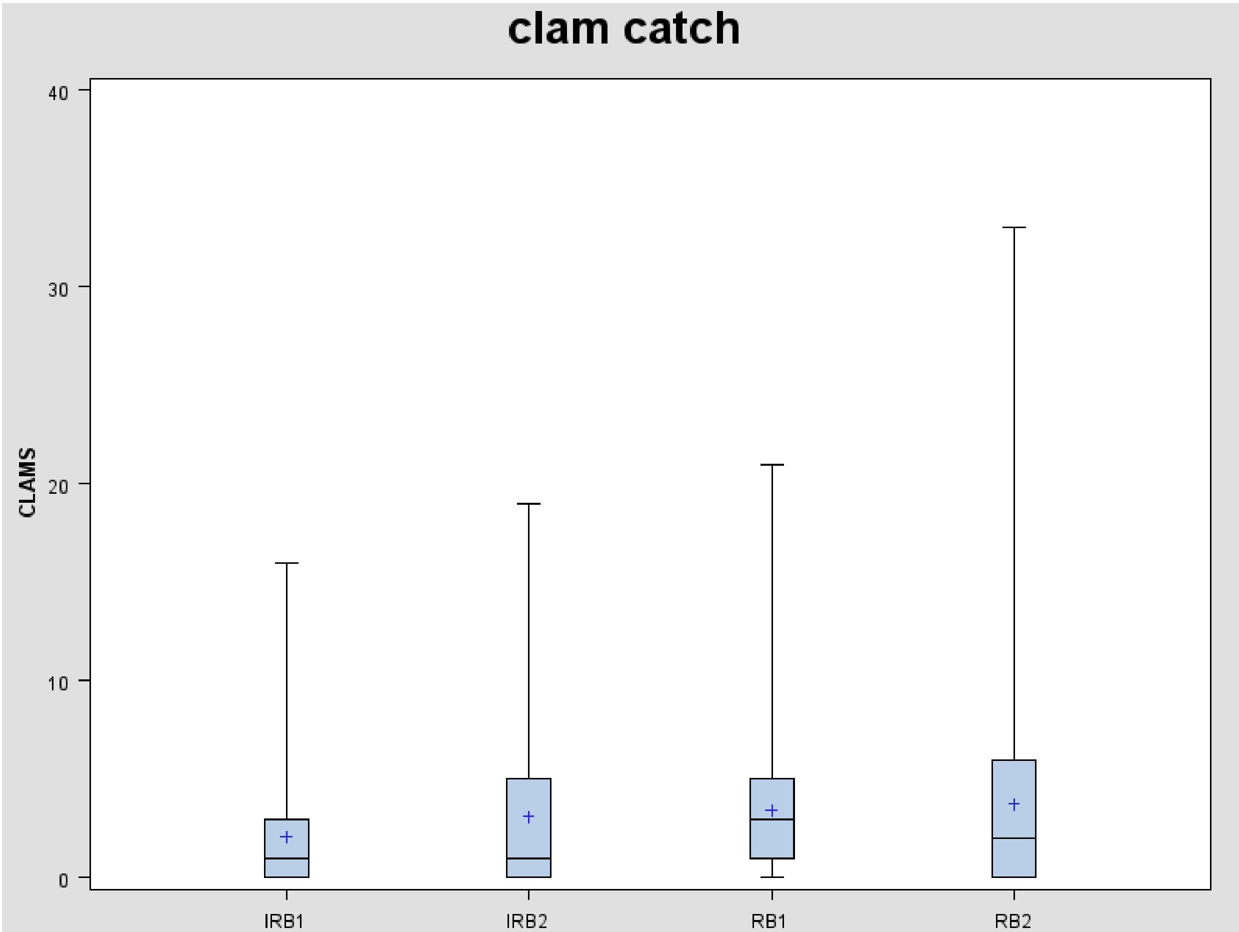

Figure 2. Box and whisker plot showing the mean (+), median, 25th and 75th percentiles, and full range of clam catch data for Rehoboth and Indian River Bay.

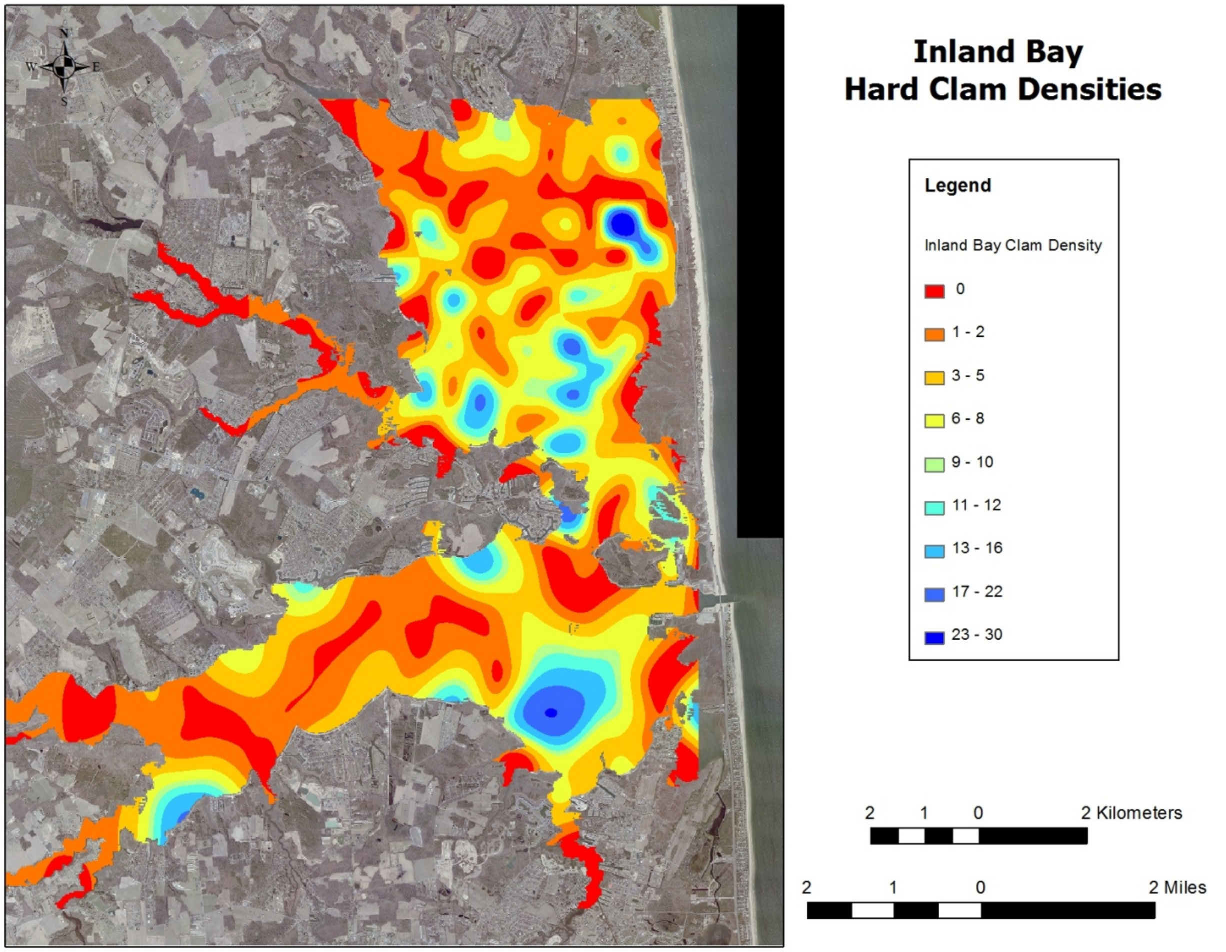

Figure 3. Hard clam densities of 2011 survey using spline interpolation with a 25m x 25m grid.