A dredge for collection of juvenile (pre-recruit sized) ocean quahogs (*Arctica islandica*) and surfclams (*Spisula solidissima*): design considerations.

A final report to Industry Advisory Board (IAB) of the
Science Center for Marine Fisheries (SCeMFiS)
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Summary

We describe the development of a hydraulic clam dredge designed to capture pre recruit to fishery size individual ocean quahog (*Arctica islandica*) and surf clam (*Spisula solidissima*) when operated as part of the annual NEFSC-NMFS survey from an industry vessel, the ESS Pursuit. Testing and performance of the dredge as part of the 2014 survey effort is described in an accompanying report by Hennen and Mann.

Introduction and project objective.

Management of long-lived species in support of sustainable fisheries presents unique problems, especially so when the period between spawning and recruitment from the larval stage, and recruitment to the fishery is long. The ocean quahog, *Arctica islandica*, is prime example of such a species. A very large ocean quahog resource is present in the Middle Atlantic and Georges Bank region of the US continental shelf where it supports a major fishery. First exploited as a regional fishery in southern New England after the Second World War, the fishery grew in the 1960's to what is now, in combination with the surf clam fishery, the largest offshore clam fishery in the world. The fishery is managed under the guidelines of the Magnusson Stevens Act and the subject of regular stock assessment surveys by the NEFSC of NMFS. The resource is not overfished (currently at 171% BRP for B*msy*, see MAFMC 2014) and overfishing is not occurring. Nonetheless management council discussions regularly return to the subject of frequency and intensity of recruitment into the ocean quahog population that supports the fishery, given that the current fishery is targeting year classes that recruited to the benthos over 50 years ago, and the intervening period has been one of documented climate change. The surf clam (*Spisula solidissima*) fishery similarly supports a major fishery in the Mid Atlantic. The resource is not overfished and overfishing is not occurring (MAFMC 2014). The longevity of surf clams is less than that of ocean quahogs, with maximum age at 20-35 years, with growth to a maximum size in excess of 150 mm shell length. Pre-recruit growth rate is high, with juveniles reaching 80-100 mm shell length in 5 years (Picariello, 2006). Information describing recruitment periodicity and intensity in surf clams is desirable in fishery management, although the time frames of data paucity (5 years versus 50 years for ocean quahogs) prior to recruitment to the fishery are less.

Prior investigations of pre recruitment size ocean quahogs and surf clams have employed lined commercial dredges to target collection of juveniles (here defined as individuals smaller than that targeted by commercial dredges). Most recently liners have been fabricated from chicken wire and have focused on selectivity of survey gear with respect to size of the target species. While wire provides appropriate "mesh" size, in field operation these lined dredges rapidly fail to pass sediment and become horizontal box cores filling with sediment. Thus swept area sampled is limited and retrieval of a filled dredge both challenges winch operation and creates unsafe shipboard conditions. Sorting of the retrieved material to collect the desired specimens is tedious, very time consuming (and therefore expensive) and specimens are typically damaged. The limited swept area per tow prevents adequate description of recruitment on a population wide basis. It has long been recognized that a better collection device is needed to address quantitative and representative collection of juvenile ocean quahogs and surf clams to address the aforementioned recruitment periodicity question. This report describes design and construction of a new dredge dedicated to this challenge in summer 2014 with IAB support. The dredge is identified as the Dameron-Kubiak dredge after its (respectively) designer and builder.

Design considerations.

The design challenge is to sample a large swept area while retaining juvenile clams. The design focused primarily on ocean quahogs given the magnitude of the time period pre recruit in this species. Closing the bar spacing and/or sorting structure increases the probability of sediment retention. Thus design is, at the outset, a trade off between desired minimum size of retention versus area sampled in survey mode. The initial question posed in the design process is "what is the relationship between age of the targeted juvenile ocean quahog and bar spacing required for retention?" This question was addressed through a consideration of the length (L, maximum dimension parallel to the hinge) versus height (H, maximum dimension from the hinge to the growing edge) versus width or thickness (W, maximum dimension perpendicular to the plane formed by the junction of the two valves) relationship in ocean quahogs. The width is the smallest of these measurements and sets the discussion on the space between adjacent bars (this is not the on center bar spacing which includes the thickness of the bars), but all management discussions are based on age and length measurements, so the L:H:W ratios are important.

Source material for the L:W:H measurements is that described in Powell and Mann (2005) and Harding et al (2008): clams collected with the F/V Christie in September 14-19, 2002 on a survey that extended from the eastern end of Long Island to the Virginia Capes. A dredge lined with chicken wire (2.54 cm = 1 inch) was used on the survey. The shaker was bypassed and all small clams directed to the belt for hand sorting. The clams were collected and measured. Powell and Mann (2005) described the size frequency distribution. Harding et al (2008) sectioned a selection of shells to cover the size range collected and counted the growth lines, thus developing an age versus length descriptor. For the current study archived material was sampled in random order and the first 10 shells retained from each of the size ranges 30-40 mm L, 40-50 mm L, 50-60 mm L, 60-70 mm L, and 70-80 mm L. A limited number of individuals < 30 mm L and > 80 mm L were also included as they were encountered in the sampling sequence. For each shell L, H and W were measured with calipers to the nearest 0.1 mm. A total of 61 sets of valves were recorded. In some instances one of the valves had been embedded in epoxy for the sectioning and age determination process of Harding, but measurements of both H and half of the W value were easily obtained for these in that the cut and polished section was intentionally cut along the hinge to growing edge axis at the maximum value of H. L had been previously recorded for all valves, was checked again for each shell examined, and included with the archive (each set of valves was and is stored and labeled individually). It was possible to measure W in a single step when both valves were intact and free. If one valve was broken then the remaining valve was measured to give a half W value and the x2 correction applied. This was the case with 26 sets of valves, all at the small end of the size range. The data set is summarized in Appendix 1 (*Arctica islandica* "shape" description). Also included in the file are the Area and Station numbers of collection where available from Powell and Mann (2005). These records are provided so that the individual specimens in the archive can be revisited if needed. The "half width" values are also included to note where the measurement was made on a single valve as described above. All measurements are in mm, recall that 25.4 mm = 1 inch.

The age plot developed by Harding et al (2008) for pre-recruit ocean quahogs is given in Figure 1. The relationship between age (years) and shell length (mm) for 311 ocean quahogs <80 mm is described with a power equation:

$$\text{Shell length (L, mm)} = 10.132 * \text{Age (y)}^{0.498},\ R^2 = 0{:}73,\ n=311$$

The included length range approximates to an age range of 0-70 years. For the current study the relationship of H and W (both on y axis) versus L (x axis) is given in Figure 2 (data from Appendix 1). Using the simplest linear fit through the origin gives the following relationships:

$$\text{Shell height (H, mm)} = 0.886 * \text{Shell length (L, mm)},\ R^2 = 0.99$$

$$\text{Shell width (W, mm)} = 0.498 * \text{Shell length (L, mm)},\ R^2 = 0.98$$

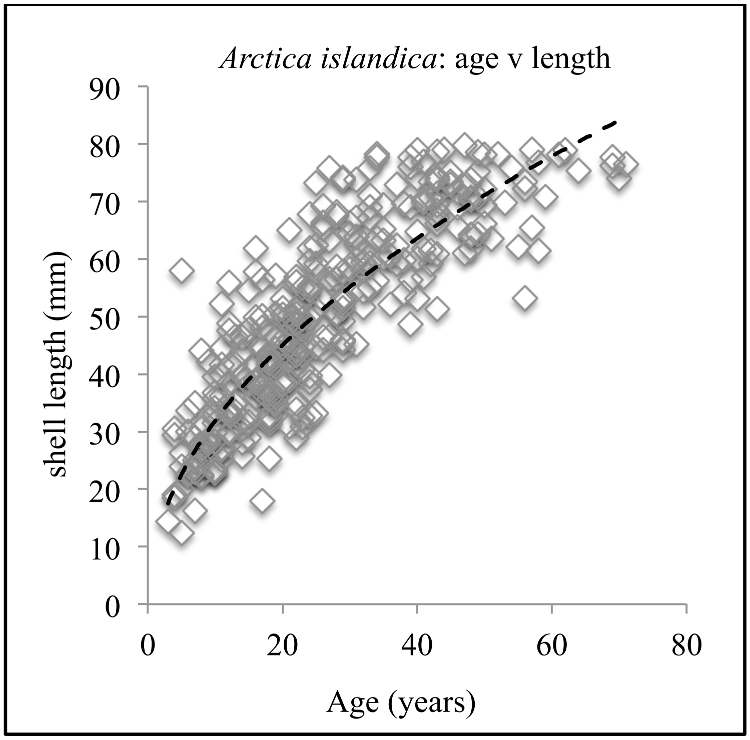

Figure 1: Length at age, ocean quahogs <80 mm shell length (Harding et al, 2008)

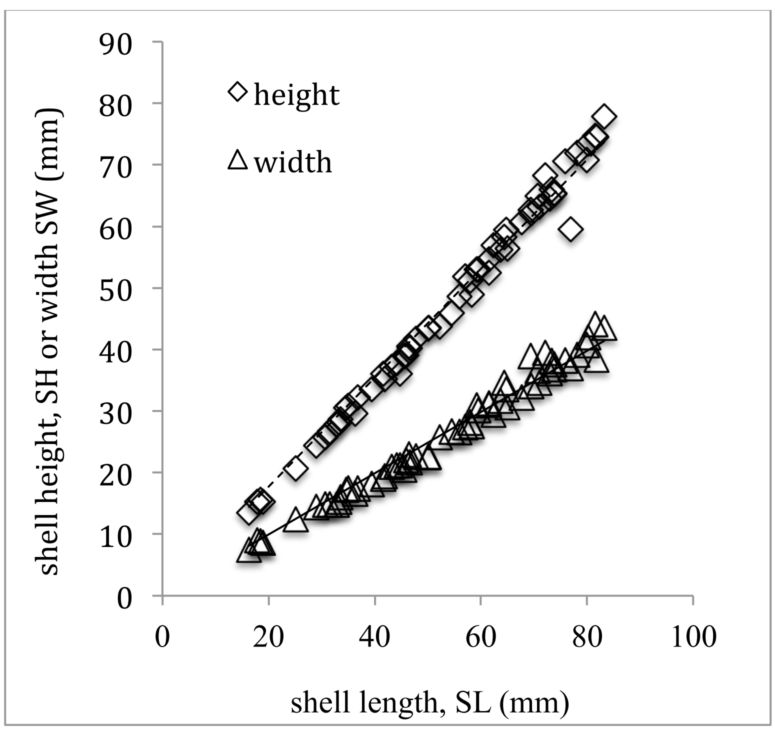

Figure 2: Shell height (SH, mm) and Width (SW, mm) versus shell length (SL, mm).

The R^2 values indicate that the simple fits are acceptable. Quahogs grow with a consistent L:H:W ratio, that is their shape is constant with size and age. To assist the choice of bar spacing interval the relationship of L, H and W with age, developed from the relationships given above, is illustrated in Figure 3 (below). The plots relate L, H and W (in mm on left axis) to age; approximate comparable values in inches are given on the right hand axis (approximate because the origin of the right hand axis measures -0.1 inches). If the intent is to capture all clams with an age of 30 y or older the minimum space between the bars is the calculated Width value of 27.4 mm or 1.08 inches, it can be seen on the graph at approximately 28 mm or 1.1 inches. If the intent is to capture 40 y and older clams the calculated values are 31.7 mm or 1.25 inches. The 30 and 40 y corresponding shell lengths are 54.2 and 62.8 mm, or 1.18 and 1.57 inches.

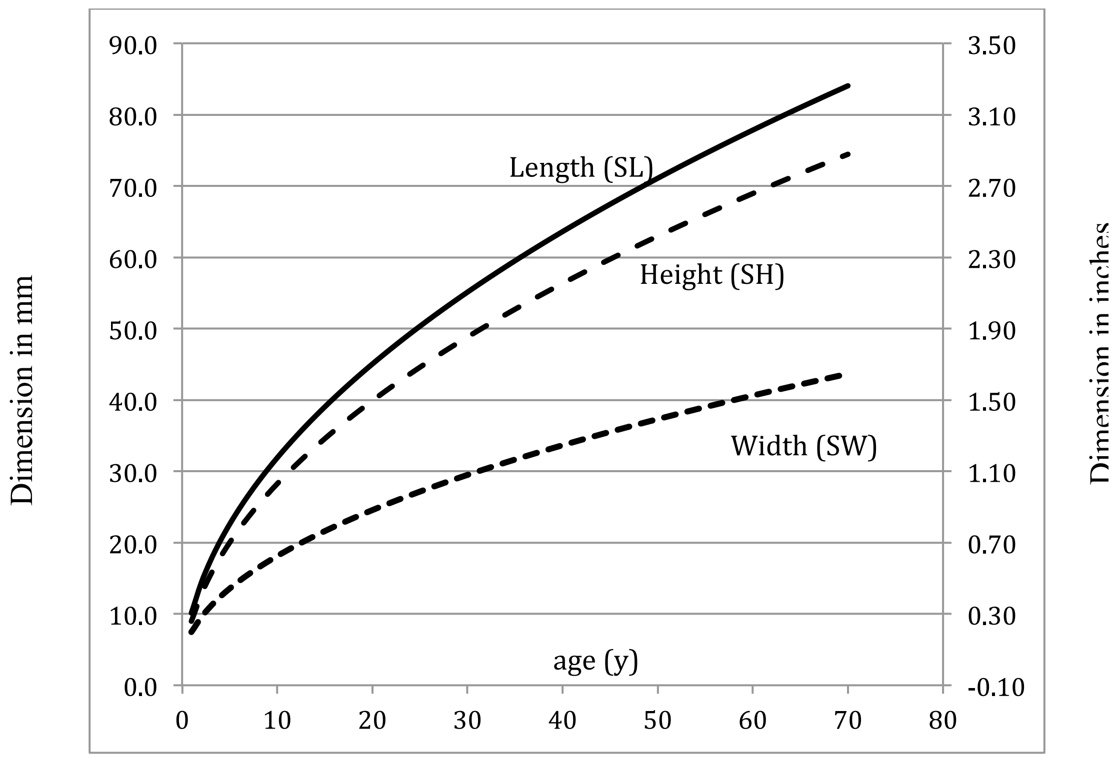

Figure 3: Shell length, height and width relationships to age in ocean quahogs

The final choice of bar spacing is not simply a matter of width dimension, but also the practicality of insuring that the unwanted dredged material will wash through the dredge in operation. Any accumulation of material in the dredge will serve to reduce the bar spacing through blockage. Figure 3 provides a basis for discussion of what age classes (and therefore years of animals smaller than recruit to fishery size) can be sampled with a dredge of specified bar spacing.

A meeting of industry members at Rutgers University Haskin Shellfish Research Laboratory in March 2014 discussed (a) the need to build such a dredge for examination of recruitment processes in ocean quahogs and, to a lesser extent, surf clams; and (b) design options for a dredge with reduced bar spacing to meet the retention limits described earlier. A productive discussion supported dredge development and encouraged development of a proposal to be presented to the SCeMFiS IAB at the April 2014 meeting. The proposal was supported for funding at the $70,000 level with Roger Mann (VIMS) as the lead science PI, and Tom Dameron (Surfside Foods) as the industry liaison. Final dredge specifications are included as an Appendix to the Hennen and Mann document. The title to the dredge resides at College of William and Mary– VIMS is the School of Marine Science of the College of William and Mary. The dredge is stored and maintained at the industry dock on Maryland Ave, Atlantic City, NJ. Construction of the dredge began in June 2014 with disassembly of a donor dredge from Mr. Jimmy Meyers of Ocean View Inc. Construction was completed by talented company fabricators lead by Mr. Tony Kubiak. The dredge was completed in late July prior to the August 2014 NEFSC assessment survey based on the industry vessel F/V Pursuit.

Dredge deployment and testing - August 2014

The completed dredge was installed on the port gantry of the F/V Pursuit prior to the NEFSC clam stock assessment surveys in August 2014 (NOAA Cruise EP201401). The focus for leg 1 of the survey in 2014 was the southeast corner of Gorges Bank and Southern New England and completion of the strata to be surveyed as part of the three-year total area coverage required by NEFSC. A limited number of tows were available at the end of leg 1 for dredge evaluation. Leg 1 activity with the dredge is notable for two station tows. At Station 713 (date 8/9/14, 5 minute tow duration at 3 knots a blade depth of 3.5 inches and with 2:1 scope) a catch of 115 bushels was obtained with effectively no sediment retention. The subsequent tow at Station 714 used a 20mm bar space setting, and a 2 minute tow duration with the blow backs off to catch 95 bushels of clams, again with no evidence of sediment accumulation. Both stations were very encouraging as the F/V Pursuit then returned to New Bedford at the end of Leg 1.

Leg 2 was devoted to comparison of the Dameron-Kubiak dredge with a commercial dredge lined with chicken wire, as used in prior selectivity studies. Leg 2 was limited in duration as the Hurricane Cristobal moved past to the south and delayed deployment for a 24-hour period. Leg 2 activity is reported in the accompanying document by Daniel Hennen (NEFSC) and Roger Mann (VIMS) entitled "Testing the performance of a hydraulic dredge modified to capture small animals."

The test sites for Leg 2 dredge comparisons were chosen by Captain Mike Mohr of the F/V Pursuit. The quahog site details were as follows: Lat 40 48 431, Long 072 11 236, depth 125 feet, scope at 2:1, and blade depth at 3.5 inches. These are stations 715-737 in the report by Hennen and Mann. In addition to the selectivity studies a size selection of clams was retained for investigation of both age v length (frozen on board, n = 100 plus extras for practice cutting) and minimum size at maturation (dissect, fix tissue in neutral buffered formalin for >24 hr, then transfer to alcohol for transport to the VIMS histology lab, samples individually numbered and shells individually numbered for measurement of both length and age). These collections will be described to the IAB in the final report on a separate award focused on recruitment studies. The surf clam site details were as follows: Lat 40 33 954, Long 073 05 090, depth 81-83 feet, scope 2:1, and blade depth at 4.5 inches. These are stations 740-759 in the report by Hennen and Mann. This site is south of Fire Island inlet and adjacent to a location that had been used in 2011 for a surf clam depletion study. There were a few large quahogs (up to 118mm SL) in most tows but very few small ones. Sand dollars (*Echinarachnius parma)* were in abundance as was the attendant green covering of benthic diatoms. These observations suggestion is that this is a former quahog site that is being colonized by surf clams as the waters warm in the summer.

Acknowledgements.

The efforts of Mr. Tony Kubiak in dredge fabrication, Captain Mike Mohr and crew of the F/V Pursuit, and the staff of the NEFSC field survey crew during the August 2014 survey are appreciated.

Literature cited

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Appendix 1: Arctica islandica "shape" description
length, height and width of selected individuals from Powell and Mann(2005) and Harding et al (2008) as maintained in VIMS archive
original collection on F/V Christie 2002, area and station data refer to cruise data
some material has only one valve intact or one valve embedded for age sectioning - these have (width*0.5) values recorded.

LENGTH	area	station	length	height	width*0.5	width
<30	1	16	16.3	13.5	3.7	7.4
	1	4	17.9	15.2	4.5	9
	4	82	18.5	15.6	4.4	8.8
	1	4	19	15.2	4.3	8.6
	1	8	25.1	20.7	6.2	12.4
	5	86	29	24.4	7.2	14.4
30-40	5	87	30.6	25.8	7.4	14.8
	1	4	31.5	26.7	7.4	14.8
	1	26	32.8	27.8	7.4	14.8
	5	86	33.3	28.1	7.6	15.2
	1	17	33.5	28.7	8	16
	1	18	34.6	30.5	8.6	17.2
	1	4	35	30.8	8.7	17.4
	5	86	36.3	29.6	8.3	16.6
	1	23	36.8	32.2	8.7	17.4
	5	87	39.5	33.6	9.1	18.2
40-50	1	16	41.6	36	9.5	19
	5	92	41.8	35.2	9.7	19.4
	1	38	43.2	37.2	10.5	21
	1	28	44.1	37.8	10.6	21.2
	1	14	44.8	36	10.6	21.2
	1	25	45.6	39	10.2	20.4
	1	8	46	39.1	11	22
	5	94	46.4	40.5		22.9
	5	94	46.5	40.2		21.7
	1	8	47.8	41.8	11.3	22.6
50-60	5	91	50.1	43.4		22.5
	1	31	50.2	43.5	11.3	22.6
	5	87	52.2	43.7		25.7
	5	91	54.5	45.9		26.7
	5	88	56	48.6		26.6

LENGTH	area	station	length	height	width*0.5	width
	5	87	57.1	51.9		27.4
	5	89	58	51.2		28.1
		27	58.2	48.9		27.5
	5	86	59.2	53		30.9
	4	82	59.4	53		30.1
60-70	5	91	61.5	54.7		31.1
		58	61.5	52.5		31.3
	4	95	62.4	56.9	14.7	29.4
	5	89	63.7	56.2		31.7
	5	97	64.4	58.3		34.6
	4	82	64.8	59.4		33.6
	5	88	65	56.4		30.6
	5	88	67.6	60.7		32.2
	5	92	69.4	62.7		39
	4	82	69.5	62.1		34.1
70-80	5	95	70.7	65		36.6
		56	71	63.2		34.6
	5	87	72.1	68.3		39.5
		38	72.9	64.5		36.2
	5	86	73.3	66		38.1
	4	82	73.8	65.3		36.8
		71	73.8	65.4		37.6
	5	89	75.8	70.6		38.2
	1	17	76.9	59.5		37
	5	91	78.2	71.9		39.2
80-90		6	80	70.8		40.7
		80	80.2	73.5		42
		3	81.5	74.7		44.2
	5	88	81.7	74.5		38.3
		3	83.2	77.8		43.5