APPENDIX B2: Report on the ocean quahog resource in Maine waters.

2009 Maine Ocean Quahog Assessment

Introduction

The Maine fishery for Ocean quahogs, although harvesting the same species (*Artica islandica*), is persecuted in a different way and fills a different sector of the shellfish market than the rest of the EEZ fishery. The Maine "mahogany" quahog is harvested at a smaller size (38-64 mm or 1.5-2.5 in shell length, SL) than elsewhere in the EEZ fishery where ocean quahogs are harvested at 89-140 mm (3.5-5.5 in) SL.

Ocean quahog from Maine waters are marketed as a less expensive alternative for *Mercenaria mercenaria* (Maine DMR 2003). Harvesting takes place year round with the highest market demand during the summer holidays (Memorial Day through Labor Day). During this peak harvest period 20-30 out of a total of 57 license holders may land some volume of product.

The majority of the vessels in the Maine fleet is between 10.7-13.7 m (35-45 ft) and classified as "under-tonnage" or "small" in issuing permits. All of the vessels use a "dry" dredge (with no hydraulic jets to loosen the sediments) with a cutter bar set by regulation at no more than 0.91 m (36 in). There are no restrictions on any other dimension of the dredge.

Quahog Fishing in Maine takes place in relatively few locations along the coast north of 43 degree 50 minute latitude. Historically the bulk of fishing activity has taken place between Mt. Desert Rock and Cross Island with two significant quahog beds south of Addison and Great Wass Island covering an area of approximately 60 square nautical miles.

The Maine fishery began to expand into Federal waters in the 1980's due in part to PSP closures within state waters. In 1990 it was determined that this fishing activity conflicted with the Magnuson-Stevens Fishery Management Conservation Act which calls for a stock to be managed as a unit throughout its range. The Maine fishery was granted "experimental" status from 1990-1997.

In 1998, the Maine fishery was fully incorporated under Amendment 10 of the FMP and given an initial annual quota of 100,000 bushels based on historical landings data. There was no independent assessment of the resource available at that time. The State of Maine is responsible under Amendment 10 to certify harvest areas free of PSP and to conduct stock assessments.

In 2002 the State of Maine conducted a pilot survey to assess the distribution and abundance of quahogs along the Maine coast. This survey was a critical first step in establishing distribution, size composition and relative abundance information for the Maine fishery and for directing the design of the current survey work. While this initial survey provided valuable information it did not have the resources to estimate dredge efficiency and therefore was not able to estimate total biomass or biological reference points. The survey conducted in 2005 was focused on estimating dredge efficiency and to map quahog density on the commercial fishing grounds.

Estimates of biomass and mortality presented in this report are only for the commercial beds south of Addison and Jonesport/Great Wass Maine. This approach was chosen due to available resources and because it was conservative. Other quahog beds are known to exist along many parts of the Maine coast. If mortality targets could be met using the estimates from the primary fishing grounds then biomass outside the survey area can act as a *de facto* preserve.

Fishery Data

Data through out this report is presented in metric units. In some cases there are specialized terms and conversion factors which are listed below.

"Mid Atlantic" bushels of Ocean Quahogs x 10	=	lbs meat.
"Mid Atlantic" bushels of ocean quahogs x 4.5359	=	kg meat
1 "Mid Atlantic" (= "industry") bushel	=	1.88cubic feet
1 "Maine" (= "US Standard") bushel	=	1.2448 cubic feet
"Under-tonnage" vessel	=	1-4.9 GRT
"Small" vessel	=	5-49.9 GRT
1 "Maine" bushel	=	0.00303 metric tons meat weight

There are 57 ocean quahog licenses in the state of Maine. Since 2004 the number of licenses reporting landings has declined from 36 to 24.

Landings have trended downwards since 2002 (Table 1). The exception to this trend is in 2006 when landings increased to 124,839 bushels. This increase is most likely due to the reopening of a highly productive portion of the fishing grounds that had been closed in previous years from PSP. After the initial boost to landings from additional fishing ground, landings again began to decline. By the end of 2008 only 67,698 bushels out of a 100,000 bushel quota had been landed. LPUE has tracked landings closely over recent years. For 2008 LPUE was at a level 6.21 bushels/hour (Figure 1).

Incidental mortality in the ocean quahog stock off Maine is an important topic for future research. Maine has a very high level of fishing activity relative to the size of the fleet. Approximately 10,776 hours of fishing took place during 2008 representing over 64,000 tows at 10 min per tow. Using standard industry dredge dimensions and tow speeds this level of fishing activity represents 31.42 nautical miles^2 of bottom swept by commercial dredges.

Research Surveys

With the limited funds dedicated for survey work on quahogs, it was decided to focus all of the survey efforts in 2005, 2006 and 2008 on the primary commercial fishing grounds south of Addison and Great Wass Is. This decision is important in the interpretation of all following data as results because estimates pertain only to these two beds and not to the coast of Maine as a whole. Vessel logbooks and the 2002 independent survey abundance indices show that the majority of fishing activity and a sizable portion of the resource was in this region (Figure 2).

The first step in designing the 2005 survey was to establish a 1 km^2 grid overlay using Arcveiw 3.2 over the known commercial beds. Based on number of days at sea, 260 sites (tows) could be completed. The centers of the 260 1 km^2 grids covering the commercial beds were selected as start points for survey tows. These points were transferred to The Cap'n Voyager Software for use on board the survey vessel.

As of 2005 the quahog bed south of Addison, (referred to as "western") had been the only open fishing grounds for 3 years due to PSP issues in other beds. The quahog bed south of Great Wass Island, (referred to as "eastern") had been unfished for 3 years but had previously been one of the most productive fishing grounds. The 2006 survey took place 9 months after the "eastern" bed had been reopened. All areas were open during the 2008 survey.

Survey gear and procedures

The original survey in 2005 was conducted using the commercial vessel F/V Promise Land. It was a 12.8 m (42 ft) Novi Style dragger piloted by Capt. Michael Danforth and was contracted to perform all the survey drag operations in 2005 and 2006. All survey tows during these two years were conducted using the same dredge with dimensions: cutter bar 0.91 m (36 in), 2.44 m (8 ft) long x 1.83 m (6 ft) wide x 1.22 m (4 ft) high, overall weight 1,361 kg (3,000 lbs), bar spacing all grills 19.05 mm (¾ in). The survey dredge was the same dredge used by the F/V Promise Land during normal fishing activity. Prior to the 2008 survey The F/V Promise Land was sold and the captain left the fishery. To conduct the survey we had to contract a new vessel and captain which also meant the drag used was different than the two previous surveys. The new vessel, The F/V Allyson J4, had nearly identical specifications to the F/V Promise Land. Captain of the F/V Allyson J4, Bruce Porter, has been a quahog fisherman for 24 years. The dredge used for the 2008 survey had been built to nearly the same specifications as the original with the difference that the catch box on the original had extensions added to allow it to hold more sediment during longer commercial tows (Figure 3). These extensions meant the original dredge was roughly 400lbs heavier than the current dredge. During tow operations it was noted that the teeth on the cutter bar of the new dredge shined to depth of 3 inches just as they had in the original dredge. From this we assumed that the new dredge was cutting to the same depth as the original. It was also felt that since the survey tows were short (2 min) in order to avoid any overfilling and subsequent material loss that the additional catch box capacity of the original dredge would not give it any advantage over the current dredge.

For the initial survey in 2005 as the vessel approached the center of one of the 260 selected tow grids, bottom type and the feasibility of conducting a tow were assessed. If suitable bottom was not immediately present at the predetermined start point, the vessel would start crossing runs within the grid. If after 5 to 6 crosses no towable bottom or a tow path free of fixed lobster gear could not be found, then the grid location was deemed untowable, a note was made, and the captain continued on to the next site. When a suitable tow path was found within a grid the dredge was lowered to the bottom by free-spooling until the ratio of cable length to depth was 3:1. Once the desired cable length was reached the drum was locked, a two minute timer was started and a GPS point was taken.

Tows were made into the current at approximately 6.48 km/hr (3.5 knots) speed over ground (average tow 188 m). After two minutes elapsed, a second GPS point was taken and the dredge was brought to the surface.

Tow distances calculated using the start and stop GPS points are good estimates of the distance actually traveled by the dredge. The manner in which the dredge is set and retrieved does not create a situation in which the dredge continues to fish as it is retrieved or before the drum is locked. In particular, the weight of the dredge keeps it in place on the bottom when the drum is unlocked at the end of the tow. In addition, the practice of backing the vessel toward the stopping point at the end of each tow means that the dredge was unlikely to travel very far at the end of the tow as it is lifted into the water column.

After the dredge was retrieved and before it was brought onboard the vessel, excess mud was cleaned from the dredge by steaming in tight circles with the dredge in the vessel's prop wash (Figure 4). Once on board, the dredge was emptied and photographed with a digital camera (Figure 5). The contents were placed on a shaker table (Figure 6), bycatch was noted and then all live quahogs were sorted out from the catch. From each tow a 5 L subsample of quahogs was taken at random (the entire catch was taken if catch was less than 5 L). The subsample was used to estimate tow counts, volume, and size frequency of the catch. The remainder of the catch was placed in calibrated buckets to determine total catch volume.

All data collected on board during operations were entered into a Juniper Systems handheld Allegro field computer running Data Plus Professional Software. All GPS data were collected using a pair of Garmin Etrex handheld units and transmitted in real time to the Allegro and a laptop running Cap'n Voyager Software. Data entry screens on the Allegro for the abundance survey consisted of: 1) trip information (date, time out, weather, sea state, time in, and comments); 2) site information (depth, bottom type, start tow GPS position, speed, end tow GPS position, and comments); 3) catch information (sample portion 5 L or all, volume, weight, count, photo id, size frequency 5 L or all, and comments); and 4) bycatch information (species, abundance).

The lengths (longest dimension) of all subsampled quahogs were measured to the nearest 0.01 mm and entered into the Allegro handheld using a Fowler Ultra-Cal IV digital caliper with an RS232 port. Estimated counts of quahogs were made by counting the number of clams in the 5 L sample and then expanding that value using the total volume of the catch. All data were analyzed using Excel with variances calculated using a bootstrap program (10,000 iterations) written by Dr. Yong Chen at the University of Maine, Orono.

Tow distances were determined by The Cap'n Software and were checked using ESRI ArcInfo software. All data from the tows were standardized to a 200 m tow prior to further analysis. For the 2006 and 2008 surveys only the 183 stations deemed towable during the initial survey were revisited. Due to vessel availability the 2006 survey needed to be conducted in the fall when there is a large amount of fixed lobster gear in the tow area. As a consequence only 130 tows could be completed.

Dredge efficiency

The Maine dry dredge is much less efficient (2-17%, ME DMR 2003) than hydraulic dredges used in the rest of the EEZ which can be up to 95% efficient (Medcolf and Caddy, 1971). A reliable estimate of dredge efficiency is needed to convert survey densities to a biomass estimate (NEFSC 2004).

One method of estimating dredge efficiency is through depletion experiments which are used to measure survey dredge efficiency for NEFSC clam surveys in Federal waters. Depletion studies for ocean quahog involve sensor and data processing equipment that were not readily available in

2005. The dry dredge used in the Maine survey is also relatively small compared to the depth of fishing. We hypothesized that it would be difficult to control the dredge precisely given the depth, size of dredge and strong currents in this region off Maine.

For the conditions off Maine is was determined that the best approach to estimating dredge efficiency would be through the use of box core samples (to directly estimate quahog density) followed by survey tows in the same area. Considering only ocean quahogs available to the fishery, the ratio of density measured by "follow on" dredge tows divided by boxcore density is an estimate of survey dredge efficiency (Thorarinsdottir and Jacobson 2005).

The *F/V Promise Land* with its large A frame and winches was able to deploy the 544 kg (1,200 lb) Ocean Instruments 610 box core with a core capacity of 0.062 m^2 and maximum penetration up to 60 cm (Figure 7). Follow on tows were conducted using the same gear used during all previous portions of the survey.

Box core work was conducted at three locations during three separate trips, one in August of 2005, one in January of 2006 and the last in April 2006. In all three experiments, follow on survey tows were made the day after the cores had been taken. The locations sampled were in the eastern quahog bed in an area of relatively high abundance. This area was also selected because it was a closed fishing ground during the August 2005 trip which would eliminate the possibility of the box core sites being commercially towed before follow on tows could be made. In January and April 2006 the region had been reopened to commercial fishing. However, VHF radio announcements describing the type of work underway were broadcast to local fisherman who were very cooperative and stayed well away from the experimental areas until all follow on tows could be completed the next day. Data entered into the Juniper Systems Allegro field computer included information about: 1) the trip (date, start tow, end tow), core (core #, core length, count, volume, weight, count of newly settled).

Each experiment began by establishing a single long towpath. To do this, the vessel was slowed to the standard tow speed of 3.5 kts and a GPS point was taken and plotted. After 2 min steaming along a fixed heading, a second GPS point was taken and plotted. These waypoints determined the endpoints for the follow on commercial tows and the path for boxcore sampling. Cores were then taken haphazardly along the tow path (60 for the August 2005 trip, 34 on the January 2006 trip and 30 on the April 2006 trip).

Once a core was brought on board it was measured for overall length and sieved through a large screen (1cm^2 mesh size). All quahogs were counted and their total volume and weight were measured.

During coring operations, it was noted that the upper 1-2 cm of very soft sediment contained recently settled quahogs (< 5mm length). The number of quahogs in this size range were recorded separately for all further cores and newly settled quahogs were retained to be preserved. During the January and April 2006 trips the top 5 cm of each core was removed and washed separately through a 300 μ sieve and all quahogs <5mm SL were preserved.

It was noted during boxcore sampling during the August 2005 boxcore trip that there was a change in sediment type beginning around 12-15 cm from the surface of each core. At this transition the sediment turned to a matrix of solid clay and old quahog shell. None of the live quahogs found in the cores in 2005 were below this transition. To assess this, the maximum depth within the core of live quahogs was measured during the 2006 trips.

After the maximum number of cores had been completed for a given trip the commercial dredge was deployed at one of the endpoints of the established tow path. Standard commercial towing was conducted for 2 min along the same path as the cores had been taken allowing the dredge to tow from one endpoint to the next. After each round of coring, 6 tows were made along the same path, three in one direction and 3 opposing to help mitigate any effect from tide.

Dredge survey results

The original 2005 survey visited 259 potential tow grids. Out of the 259 there were 183 (121 in the western bed and 62 in the eastern bed) or 70.7% that were towable. Only two stations were untowable due to fixed lobster gear or other known obstructions. The remainder of the untowable sites were due to inappropriate substrate.

Tow distance, catch volume and counts were all standardized to a 200m tow. For the 2006 and 2008 surveys only the 183 towable grids were revisited. In 2006 130 of the 183 tows were completed. In 2008 181 of the 183 tows were completed.

For all surveys the highest concentration of biomass was in the eastern bed. The eastern section has had the most variable open and close status due to PSP. Substrate data (Figure 8) from Kelly et al. (1998) show the complexity of the substrate in the eastern section with highest quahog densities found near the boundary of hard rocky substrate with gravels, sands or mud. Substrate data collected independently using sidescan imaging showed that Kelly et al.'s (1998) substrate information was relatively accurate. However, in some cases substrate labeled as "sand" or "gravel-sand mix" near our most productive tows may have been shell hash from old quahog beds that was seen in box cores from the same area.

Size frequencies for all subsampled quahogs (n=20,737 in 2005, n=2,014 in 2006 and n=4,055 in 2008) Show a difference in size structure between the western and eastern beds. The quahogs in the eastern bed were larger (mean SL of 56mm $\pm$ 5for 2008) than the western bed (mean SL 52mm $\pm$ 4.9 for 2008). Cumulative size frequency distributions and a Kolmogorov-Smirnov test were used to test the null hypothesis that the size frequency distributions in the eastern and western areas were the same (Zar 1999). The null hypothesis was rejected (p=0.001). It should also be noted that in the 3 years since the initial survey the mean size for both western and eastern beds has increased by 5.03mm and 4.45mm respectively(Figure 9). Given the growth data available for this stock these size increases should take between 8 and 14 years. This may suggest that harvesting in Maine which targets smaller sizes may be altering the stock towards a larger and older quahog.

Because the two beds have differing size compositions and abundance levels, it was decided to calculate abundance for the two beds separately before estimating combined abundance for the entire survey area. Abundance estimates (see below) include a dredge efficiency that was estimated by applying 10,000 bootstrapped efficiency estimates from the three boxcore trips to 10,000 average abundance estimates from the surveys.

To estimate the total biomass in each year for the commercial fishing grounds the size frequency distributions were converted to proportion of the population in each 1 mm size bin. Shell length (*L*) was converted to meat wet weight (*W*) using W=4.97x10-6 x $L^{3.5696}$ (Maine DMR 2003).

year	bed	Median Abundance Estimate	Median mt Meat Weight	CV
2005	west	1.729E+09	8,653	39%
	east	2.404E+09	17,208	40%
	combined	4.134E+09	25,862	39%

2006	west	1.996E+09	10,166	41%
	east	1.225E+09	8,846	41%
	combined	3.221E+09	19,012	41%
2008	west	7.111E+08	5,471	40%
	east	1.094E+09	11,103	41%
	combined	1.805E+09	16,574	40%

Box core results

Efficiency estimates from box core experiments are presented based on sizes taken in the commercial fishery (35mm SL and greater). The estimated dredge efficiency was 17.91% with a 95% bootstrap confidence interval of 8.0%-34.4%.

Another important result from the boxcore work was that the average depth of live quahogs in the region sampled was no deeper than 9.55 cm (CV 20%). The standard commercial dry dredge has cutting teeth that are set to a depth of 7.62cm. We did not see evidence of anaerobic quahogs located deep in the sediments as has been reported elsewhere (Chenowith and Dennison,1993; Taylor 1976). Based on these results, it would seem that the majority of quahogs in this region would be impacted after one pass of a dredge.

Per recruit modeling

Biological and fishery parameters from a variety of sources were used to carry out a per recruit analysis for ocean quahog in Maine waters. Age at length and growth information was taken from Kraus et al. (1992). Von Bertalanffy growth parameters estimated from a sample of 663 quahogs from Machias Bay were: $L_{inf} = 59.470 \pm 2.089$, $K = 0.055 \pm 0.006$, and $t_o = -0.235 \pm 0.483$. The growth curve from Maine shows relatively fast growth the first few years of life in comparison to curves for other areas (Figure 19). Length-weight parameters were from the 2002 Maine Quahog survey: $W = 4.97 \times 10^{-6} * L^{3.5696}$. Length-weight curves for the Maine ocean quahogs and the rest of the EEZ stock were similar (Figure 10). Size at maturity data estimates were based on Rowell et al. (1990) who found that females became fully mature at an average size of 49.2mm for a quahog stock in Nova Scotia, Canada.

Fishery selectivity was modeled as a linear ramp function that was zero at 37 mm SL and one at 47mm. Following surveys, quahog of various sizes were pushed through the grates on the commercial dredge (19.05 mm, 3/4 in. bar spacing) to see what sizes might be retained. Clams from 34mm to 38mm generally passed through the grate with some getting caught. After 41mm almost all clams were thick enough to be retained. The regression model for shell depth and shell length in Feindel (2003) shows that a 19.05 mm (¾ in) bar spacing is the thickness of an ocean quahog with 38.7 mm SL.

The per recruit model used in this analysis was a length based approach which can be downloaded from the Northeast Fisheries Science Center as part of the NMFS Stock Assessment Toolbox.[7] The length based per recruit model was also used by Thorarinsdottir and Jacobson (2005). The biological reference points estimated in per recruit modeling for ocean quahog were F_{max} =0.0561, $F_{0.1}$=0.0247 and $F_{50\%}$ =0.013 y^{-1} (Figure 11).

Sensitivity analysis shows biological reference points from the per recruit model for ocean quahog are most sensitive to fishery selectivity parameters and, in particular, the length at which

7 Contact Alan.Seaver@noaa.gov for information about the NMFS Stock Assessment Toolbox.

ocean quahog in Maine waters become fully recruited to the fishery. Commercial port sampling conducted in 2009 confirms the size selectivity estimates used in the modeling (Figure 12).

Fishing mortality rate

For this report fishing mortality is estimated as the catch in biomass/average biomass. The surveys each take place over a period of 1 month, but mortality rates are relatively low so that survey biomass is a good proxy for average biomass. Following NEFSC (2004), the catch for each year used in fishing mortality estimation was landings plus a 5% allowance for incidental mortality to account for clams that are killed during fishing activity but not harvested. Catches for 2005, 2006 and 2008 including the 5% for incidental mortality were 528mt , 642mt and 348 mt of meat weight respectively. Biomass estimates for the same years were 25,862mt, 19,012mt and 16,574mt of meat weight respectively(Table 2). F=0.020 y^{-1} for 2005, F=0.033 y^{-1} for 2006 and F=0.021 y^{-1} for 2008. Thus for 2005 and 2008 F is roughly equal to $F_{0.1}$ but higher than $F_{50\%}$.

Stock Status

It is not necessary to evaluate stock status of ocean quahog in Maine waters because the stock component off Maine is a relatively small part of the EEZ stock as a whole. Ocean quahog biomass in Maine waters represented less than 1% of the biomass for the EEZ stock as a whole during 2005. Overfishing definitions apply to the EEZ stock as a whole.

It was not possible to compare or evaluate current biomass levels relative to biological reference points associated with maximum productivity, depleted stock or historical levels because no appropriate biological reference points or historical biomass estimates are available.

The fishing mortality rates during all three surveys has been almost equal to $F_{0.1}$=0.0247 and the assumed natural mortality rate M=0.02 y^{-1} but almost double $F_{50\%}$ =0.013 y^{-1}. $F_{0.1}$ might be a reasonable reference point for managers if the goal is to maximize yield per recruit while preserving some spawning stock. Simulation analysis (Clark 2002) indicates that $F_{50\%}$ (1.3% per year) might be a reasonable reference point for managers if the goal was to preserve enough spawning potential to maintain the resource in the long term. However, preservation of spawning potential may not be necessary if recruitment originates mostly outside of Maine waters.

There is evidence or recent recruitment (newly settled ocean quahog < 5 mm SL) in one of the beds that were surveyed. However, although growth is relatively rapid in Maine waters, it may be 3 decades or longer before these recruits become large enough to enter the fishery.

Stock assessment advice concerning ocean quahog in Maine waters would be easier to provide if management goals were formulated and if biological reference points for biomass and fishing mortality were defined.

Research Recommendations

1. Impact on habitat and substrate should be investigated for the Maine Dredge along with good estimates of area swept by fishing activity,
2. More work needs to be done to determine age, growth rates and size/age at maturity for Maine ocean quahogs. New digitized methods may help in this process.

Acknowledgements

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Table 1. Landings from vessel logbooks.

year	Landings (Maine bushels) all vessel classes combined	Landings (only records with both effort and catch>0)	Effort (hrs fished)	Nominal LPUE (ME bushel/hr)
1990	1018	1018	286	3.56
1991	36679	34360	17163	2.00
1992	24839	24519	13469	1.82
1993	17144	17144	5748	2.98
1994	21672	21672	5106	4.24
1995	37912	37912	5747	6.60
1996	47025	47025	8483	5.54
1997	72706	72706	11829	6.15
1998	72466	72152	11745	6.14
1999	93015	92285	11151	8.28
2000	121274	119103	12739	9.35
2001	110272	110272	13511	8.16
2002	147191	147191	19681	7.48
2003	119675	119675	17853	6.70
2004	102187	102187	19022	5.37
2005	100115	100115	17063	5.87
2006	121373	121373	14902	8.14
2007	102006	102006	14018	7.28
2008	66926	66926	10776	6.21

Table 2. Commercial landings from Dealer Logbooks converted to mt meat weight for estimates of *F*.

year	landings from dealer logs (bushels)	metric tons meat landed w/ 5% incidental mortality	*F*
2005	102,671	528	0.020
2006	124,839	642	0.033
2008	67,698	348	0.021

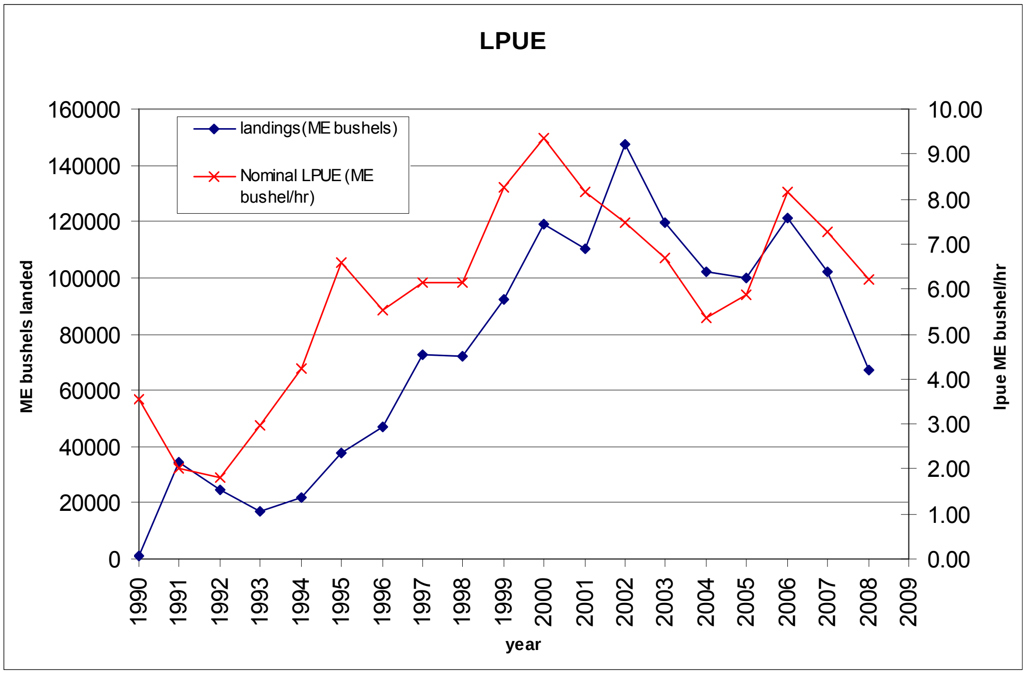

Fig 1. Commercial LPUE and Landings from vessel trip reports.

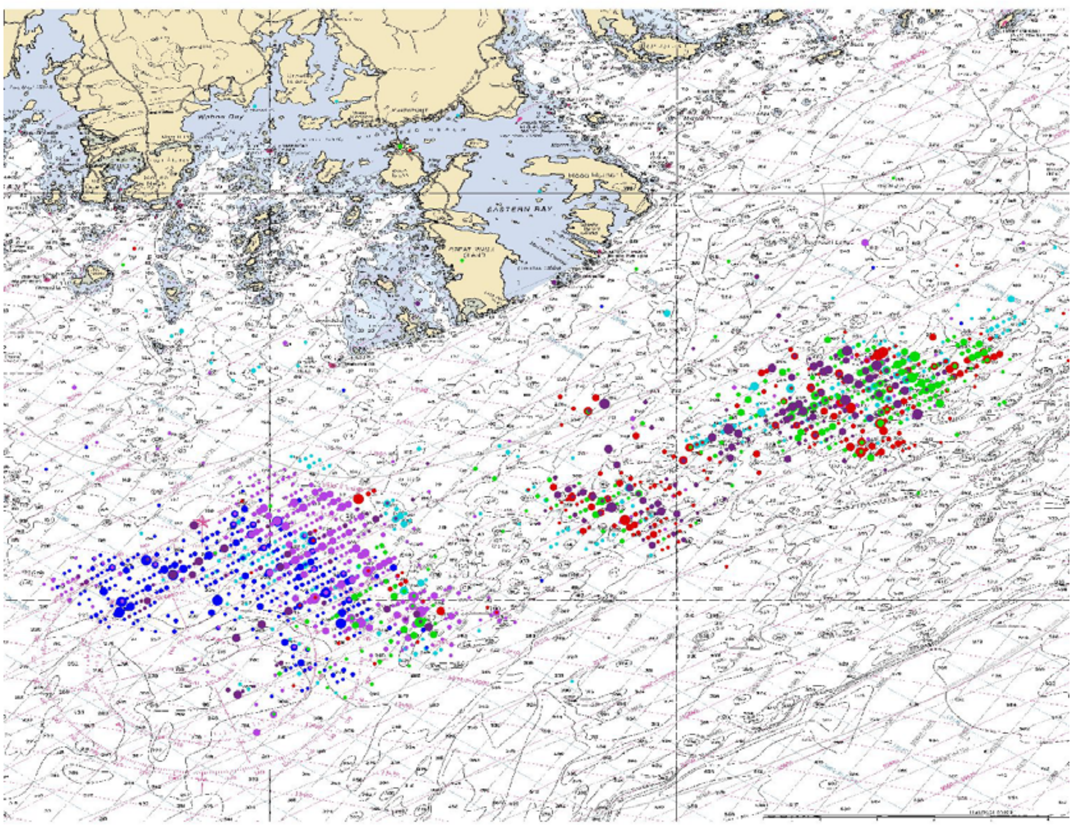

Figure 2. Combined locations of all reported commercial landings 2003-2008.

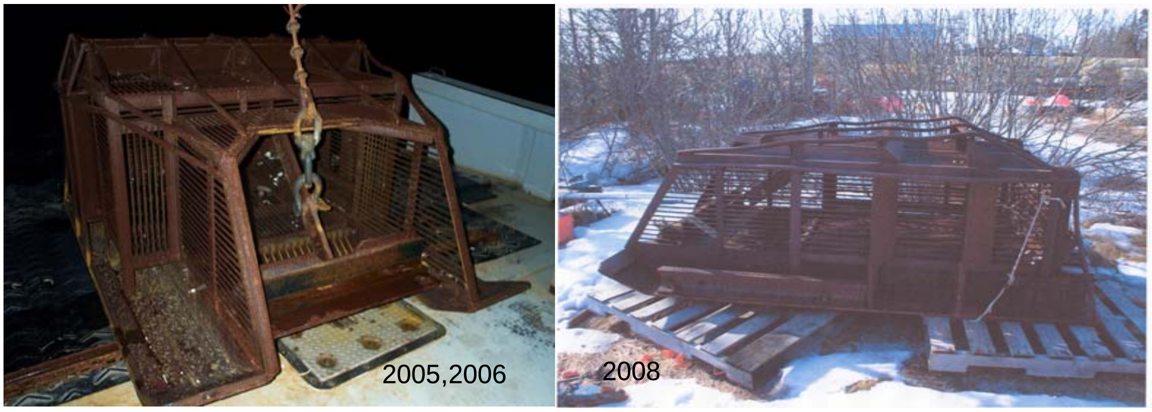

Figure 3. On left, Commercial dredge used in 2005, 2006 operations roughly 3,000lbs. On right commercial dredge used in 2008 roughly 2,600lbs.

Figure 4. Washing the catch in vessel prop wash.

Figure 5. Typical 2 min tow. Note very low bycatch and uniform size of clams.

Figure 6. Processing the catch on shaker table, used to remove shell fragments and mud. This step is performed in commercial operations as well.

Figure 7. Ocean Instruments box corer used during survey.

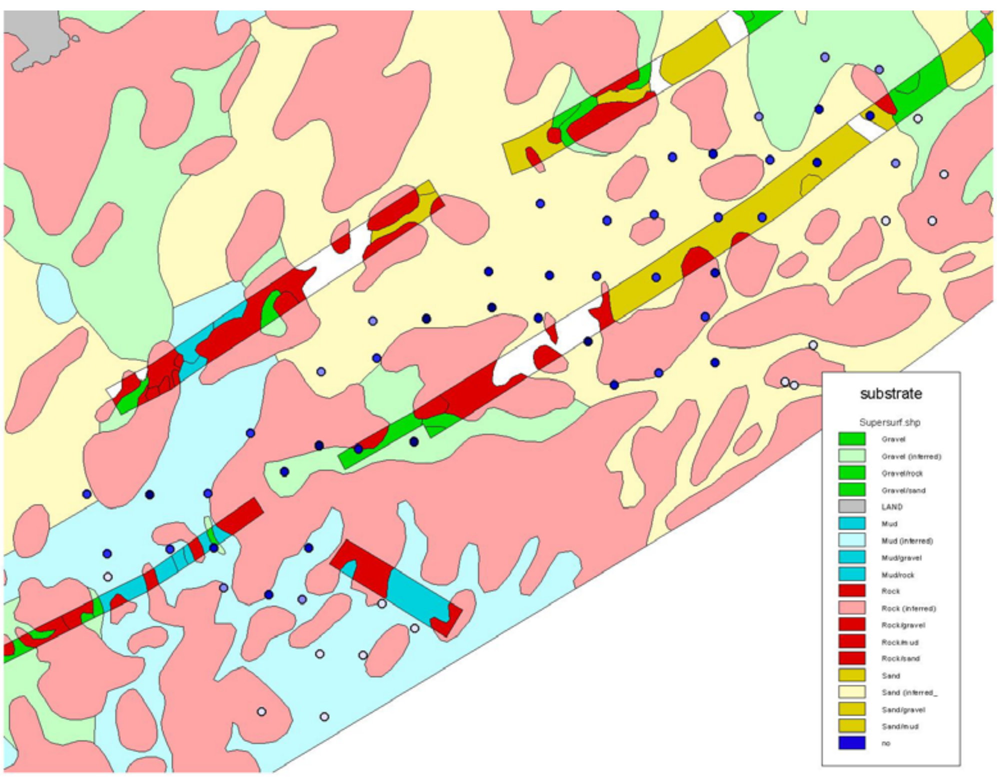

Figure 8. Substrate information from Kelly et al. Showing coincidence of hard bottom edges with high density quahog tows from eastern bed.

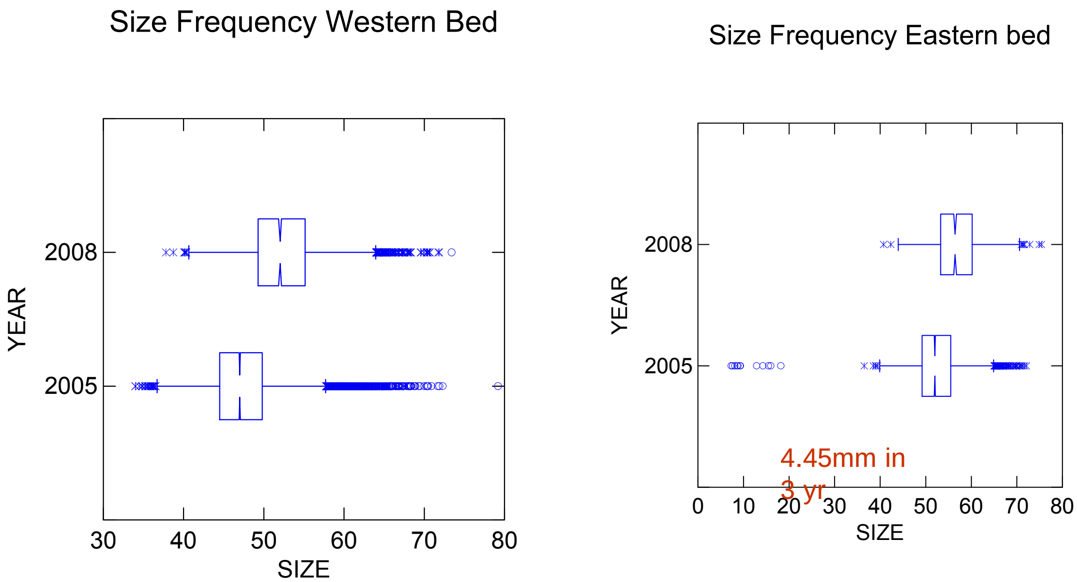

Figure 9. Growth in quahogs between 2005 and 2008 surveys. Based on Maine growth data an increase of 5mm in the western bed should have taken 8 years and the 4.45mm increase in the eastern bed should have taken 14 years.

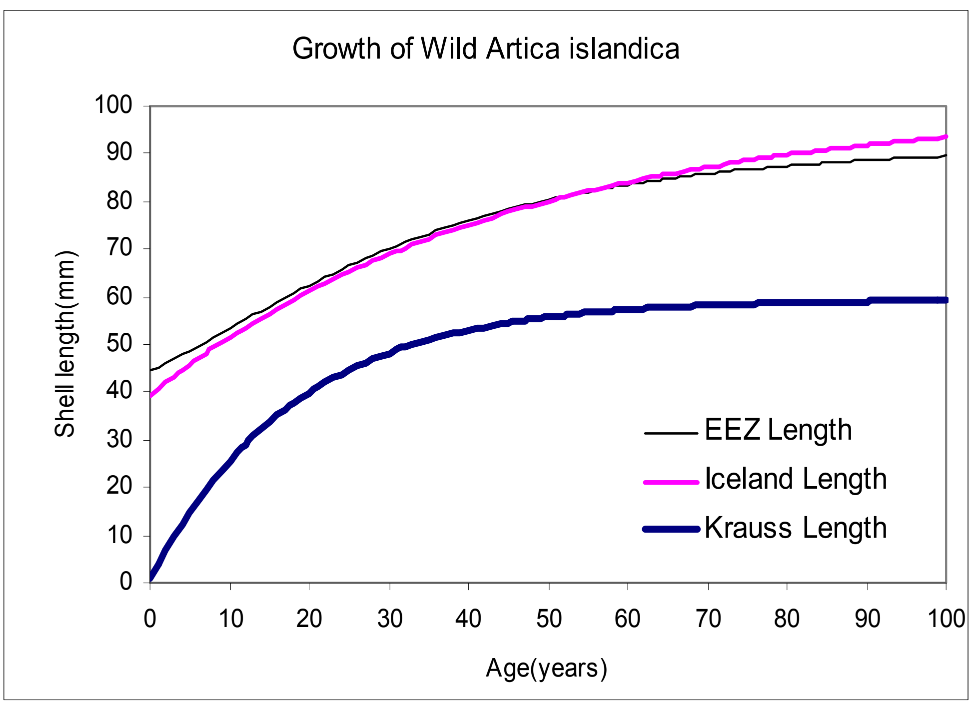

Figure 10. Growth curves for various quahog stocks. Maine (Krauss) shows rapid initial growth with much lower maximum size.

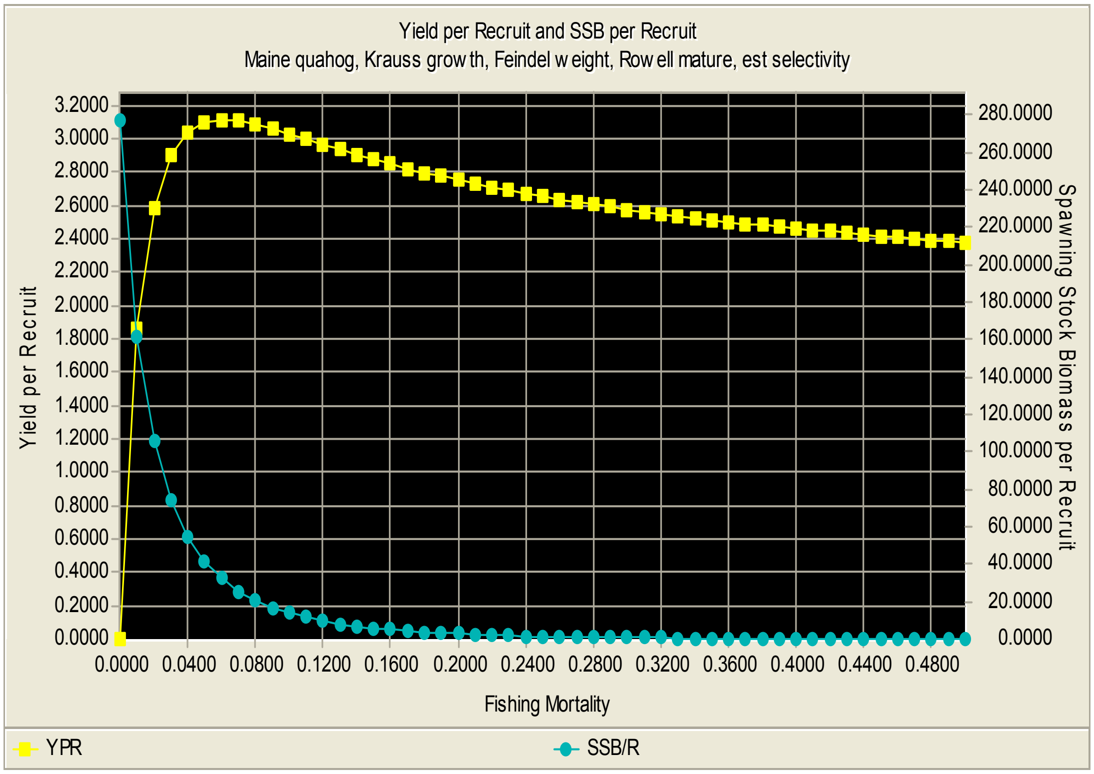

Figure 11. YPR analysis run in 2005. No new information was available to modify these results.

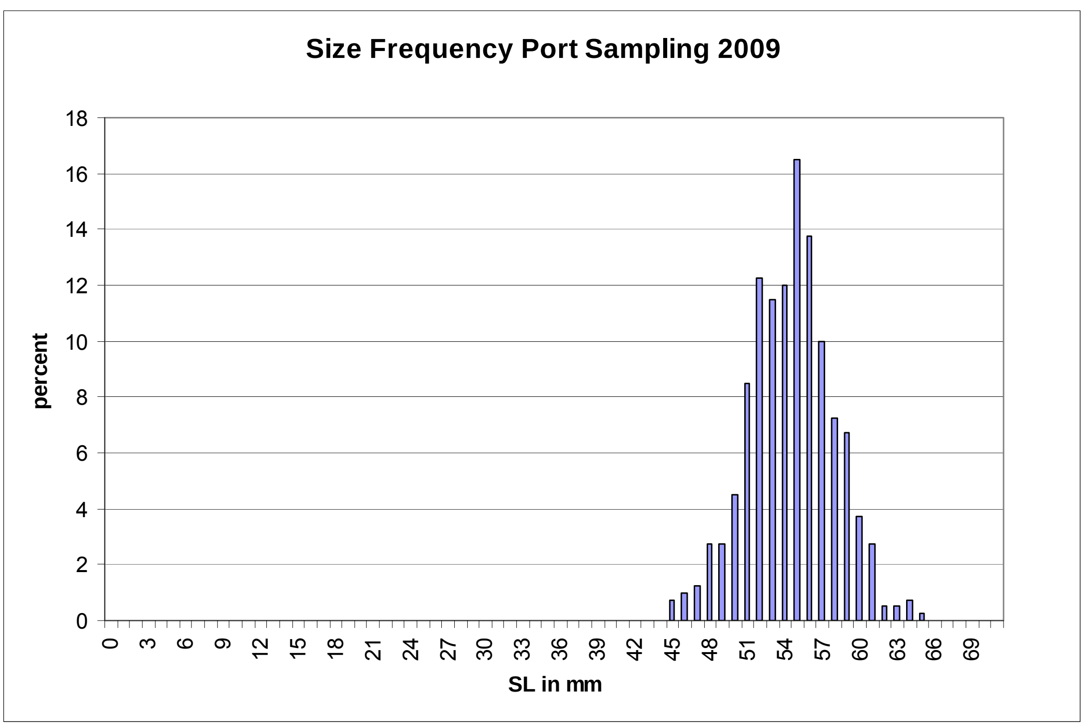

Figure 12. Size frequency for port samples collected in Jan- March 2009 from 6 different vessels. These sizes concur with ramp function used in YPR analysis