Distribution and abundance of Jonah crabs, *Cancer borealis*, in the near shore Gulf of Maine.

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1. Abstract:

Jonah crab (*Cancer borealis*) has been a traditional and unregulated by-catch of the Maine lobster industry. Little is known about adult *C. borealis* biology and ecology, making the development of assessment and management approaches difficult. Much of the information available on the distribution and abundance of this species was gathered from bottom trawl surveys. Unknown gear selectivity of these survey programs with respect to crabs, and associated gear limitations in complex habitats make interpretation of these results problematic. In the spring of 2004, the Maine Department of Marine Resources (DMR) collaborated with fishermen to complete an experimental video survey in the nearshore Gulf of Maine. We identified that complex bottom habitat, shallow water, eastern survey locations and season contributed to the patterns of distribution observed. Estimates of abundance from the video survey are confounded by the relatively small area sampled at each location.

Two other DMR surveys presently collect data on *Cancer* crabs - the Maine Inshore Trawl Survey and the Maine Green Sea Urchin Dive and Video Survey. The relative abundance and spatial distribution pattern did not agree among any survey as each survey has strengths and weaknesses when sampling crabs. There remains a need to accurately document the patterns of distribution and abundance of crabs within the Gulf of Maine. Continued development of a video survey remains a likely candidate as this methodology allows surveying of complex bottoms at any depth. However; problems with area surveyed and levels of detection in complex bottom should be resolved first.

2. Introduction:

The Jonah crab, *C. borealis*, has been a traditional bycatch for the Maine lobster industry for over 50 years. Jonah crabs are found from Newfoundland to Florida and in the Bermudas, but are most abundant in the northern latitudes (Haefner, 1977; Stehlik et al., 1991). Recent increases in perceived abundance and value have led to an increased interest in and landings of crabs in Maine. The landings and value of the fishery peaked in 2002 at 9.5 million pounds and $4.1 million dollars (Figure 1).

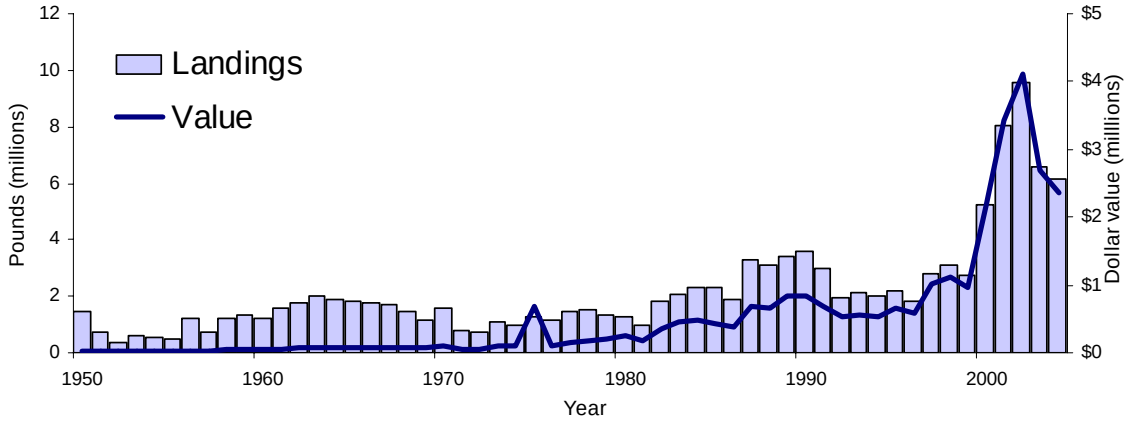

Figure 1. Annual landings and value of crab landed in Maine from 1950-2004. Current reporting is voluntary and is not reported by species.

Despite the large volume of crab being landed, neither state nor federal management agencies regulate the harvest of crab. The only management requirement in the State of Maine is the possession of a Maine Lobster and Crab license. In 2005, the State of Maine recommended the adoption of biological limits for *Cancer* crabs including a prohibition of harvest of female crabs and a minimum size for male crabs that is matched with functional maturity (Moraysu et al. 2002).

Minimal data exist to assess the population status of Jonah crabs. Historically, fishery independent monitoring of Jonah crabs was limited to trawl surveys. While the broad distribution and relative abundance of Jonah crabs have been mapped using trawl surveys, the surveys indicated Jonah crabs were absent from large portions of the coast. The presence of an active bycatch fishery for crabs along the entire coast suggest that Jonah crabs may (1) be below the level of detection of individual trawl stations or (2) not susceptible to trawl gear.

The fishery independent surveys in the Gulf of Maine collecting Jonah crab information include the NMFS Groundfish Bottom trawl survey, the Maine DMR Inshore Trawl Survey, and the Maine Sea Urchin Survey. The NMFS bottom trawl survey has the longest time series dating back to the 1960's. It is completed in the Fall, Winter, and Spring and is limited to sampling featureless bottom throughout the Gulf of Maine. The Maine Inshore Trawl Survey has been completed since 2000 and is limited to simple substrate by the sampling method, but it targets the inshore waters. The Sea Urchin Survey is primarily a SCUBA dive survey on complex bottom in shallow water (<20 m).

A specific research goal of the Northeast Consortium is to cooperatively develop alternative approaches to analysis of species' distribution and abundance. This project sought to design video survey that could be operated from inshore lobster vessels and collect quantitative information on the distribution and abundance of Jonah crabs to insure well-informed recommendations on the sustainability of a targeted Jonah crab trap and/or fishery.

3. Project objectives and scientific hypotheses:

Objectives

1. To develop and evaluate the effectiveness of a video survey for monitoring and assessment of Jonah crabs, *C. borealis*, in near-shore waters (<200m).
2. To develop and test survey methodology and sampling design.
3. To quantify the relative abundance of Jonah crabs and associated species of commercial value by region and depth along the Coast of Maine.
4. To collaborate with fishermen from communities along the coast in order to obtain local knowledge on bottom characteristics.

Hypotheses

1. Patterns of distribution and abundance of Jonah crabs vary by region, depth, and habitat.
2. Patterns of distribution and abundance of Jonah crabs do not match those derived from trawl surveys.

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5. Methods:

5.1 Video survey equipment

The camera used for the video survey was selected from Subsea Video Systems, Inc (TUFFCAM Model # S630/29). The camera had an 82º field of view and 29 mm focal length. The video system provided a live video feed to the vessel through a non-load bearing cable and hydraulic winch system. Halogen lights provided illumination.

The video footage was recorded using a High-8 video recorder. SEATRAX video overlay hardware using a GPS unit added text to the video footage indicating position, date/time, course-over-ground, and speed-over-ground in real time. A Hobo StowAway TidbiT Logger (-5C to +37C) was attached to the frame and took a temperature reading every 5 minutes.

5.1.1 Towed Video Sled

A sled was designed (Image 1), but after 2 days of at-sea trials, it soon became apparent that, though the sled could traverse rough bottom, it could not protect the electronics and cable well enough for a three week long survey (Image 2). In discussion about the options with industry participants, it was decided that a drop camera quadrat design could work well to quantify crabs distribution and abundance in all habitats and depths.

5.1.2 Drop Camera System

The new quadrat frame was built and tested (Image 6). The camera was mounted to a bar across the top of the frame positioned perpendicular to the quadrat plane. The camera was 1.04 m from the sea floor. The camera view of the quadrat was 1.2 m^2 in water. A scale bar with 10 cm increments was fastened to the frame. The 4 halogen lights were secured inside each of the four lower corner posts.

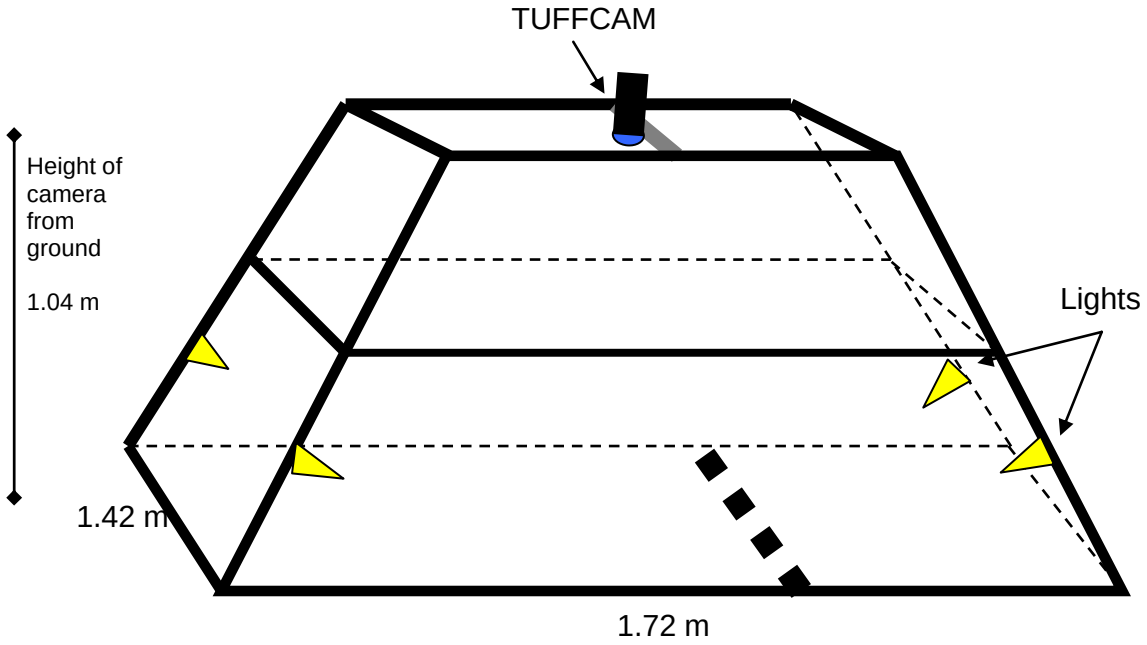

Figure 2. Drop camera system frame used for the video survey.

5.2 Experimental design and sampling protocol

The sites were randomly chosen using a stratified random design by depth within the Maine portion of Lobster Management Area 1. A one nautical mile grid was overlaid over the study area and each square was assigned a depth strata. Using 4 equal depth strata from 0-183 meters (0-100 fathoms), we chose random sites proportionally to the area of each strata (Table 1, Figure 3). Each grid was then assigned a number from which we randomly selected 100 locations. The center of each grid was the location selected for sampling. If the location was incorrectly labeled for depth, captains selected the closest location within the appropriate strata. The 40 fixed stations from the Inshore Trawl Survey were sampled for direct comparison between the video and trawl. At each site, we recorded the start and end depth, latitude, longitude, and time.

Table 1. Depth strata ranges and number of sampled sites in each strata.

Depth Strata	Depth Range (meters)	Trawl Survey Points	Random Draw Points
1	0 - 45.7	10	20
2	45.8 - 91.4	15	23
3	91.5 - 137.1	11	26
4	137.1 - 182.8	3	22
Total		39	91

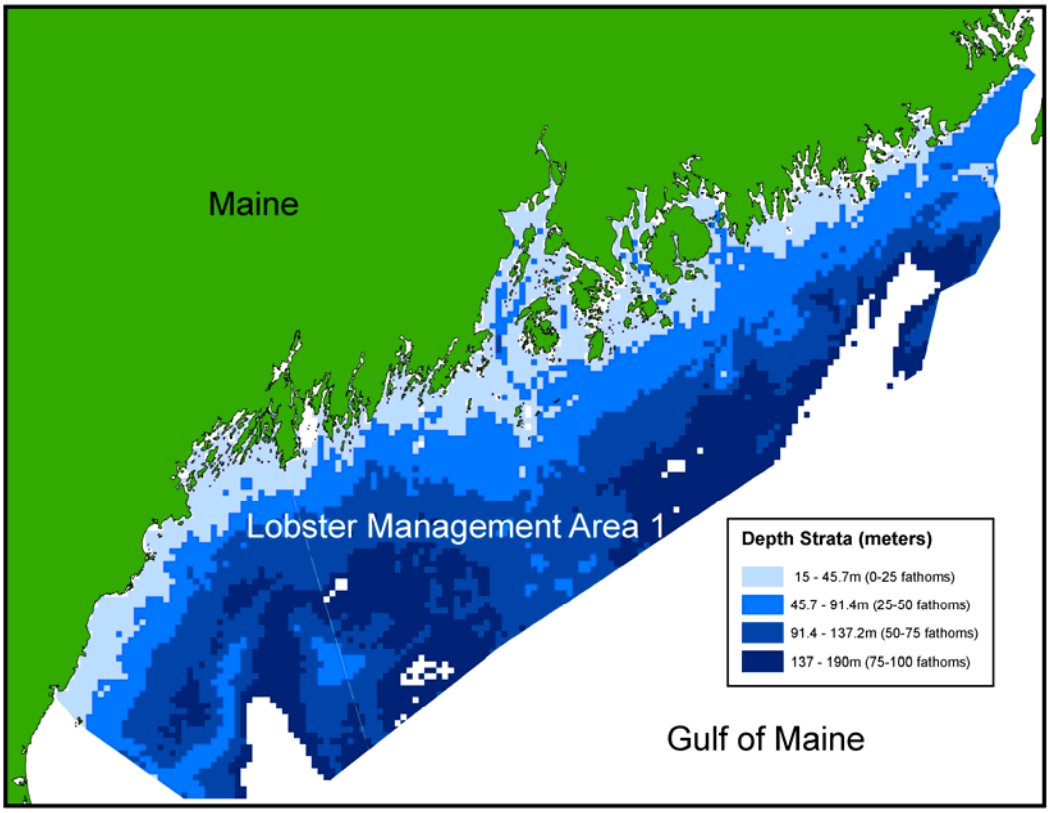

Figure 3. Depth strata distribution in Lobster Management Area 1.

Each site comprised of a single transect of 50 independent camera drops. In total, 60m^2 was sampled at each site. Using a pot hauler, with a crewman tending the video cable (Image 12), the captain dropped the frame to the sea floor, then hauled it up a few meters until clear of the previous drop, then released it again. The boat idle speed, current, or wind moved the boat and frame clear of the previous drop. The captain of each boat was able to monitor the progress of the transect with an extra television screen with live feed from the camera making it possible for the captain to know when the frame had reached the bottom, was clear of the previous drop (not in a mud cloud in the water column), and to observe events. The scientist on board monitored the video

recording equipment, counted the number of quadrats per transect, and recorded site information. One clear frame or a short period of video was used for each camera drop. Often movement could be detected and used to quantify what and how many animals were in the quadrat.

5.3 Project Timeline

The design of the original sled was completed in the winter of 2003. The construction of the winch for the video cable was supposed to be completed by March 2003, but delays required a postponement of the scheduled spring survey because the equipment was not ready and the industry participants were gearing up for the busiest part of their fishing season. In the December of 2003, during at-sea trials, it became apparent that the video sled system would not withstand the abuse of an entire survey. By March 2004, the new video quadrat frame was built and tested. The survey began on March 21st, 2004. The harsh spring weather and continued electronic (cable) problems stretched the survey until May 13th, 2004, with 20 logged sea days. Because of the time and transportation needed to transfer the video quadrat system to each boat, we tried to go from west to east, though after doing the most western sites with Larry Knapp, we jumped to Brent Oliver's boat that covered the many midcoast sites, then jumped back to the southern midcoast area with Brian McLain because of scheduling conflicts.

5.4 Post Analysis

The video was reviewed at slow speeds to ascertain that no animals were missed. The number and size (if possible) of all crabs and lobsters were noted as well as other identifiable species. Sometimes it was not possible to identify the species of crab due to lack of movement or visibility so these animals and were noted as *Cancer sp*. (*C. borealis* and *C. irroratus*) For most analyses, all crab counts were combined.

Each quadrat was assigned a bottom type of mud, featureless ledge, gravel, and cobble/boulder as a measure of bottom complexity.

The raw temperature data from the Hobo temperature logger was downloaded and the average temperature for each site was calculated using the start and end time information. Temperature readings from the descent or ascent of the frame were not included in the average. These data were entered into an Access database for later data analysis.

5.5 Data Analysis

5.5.1 Presence/Absence of crabs and Habitat Variables

Due to a low abundance of crab or low level of detection from the survey methodology, many of the analyses were completed with a presence/absence score of crab rather than a density. For the analyses of the habitat variables including temperature, depth, and day of year the presence or absence of crabs was by site. For the substrate type analysis, the crabs present by quadrat was used.

To determine the significant habitat variables, we performed a principal component analysis (PCA) to develop habitat indicators using temperature, depth, bottom type, and day of year in relation to the presence of crab in the sites. The purpose of a PCA is to take multiple variables that likely interact with each other and condense them into a new set of fewer variables (principle components – PCs). Once the PC's were developed, we quantified the relationship between the initial habitat variables and the presence/ absence of crab. The original variables were then evaluated in terms of the proportion of sites with crab to extract trends to help interpret the biological meaning of the PCs.

5.5.2 Survey Comparison

Using the fixed sites from the Maine Inshore Trawl Survey, we compared the presence or absence of crab in the sites that both surveys sampled in the Spring of 2004.

We also compared the spatial trends determined by the video survey to the Maine Inshore Trawl Survey (ITS) and the Maine Green Sea Urchin Dive survey (SUS). The ITS is a trawl survey using a modified shrimp trawl with 2in mesh, 57ft head rope, and 70ft foot rope. The ITS sites are chosen using a stratified random design by region and depth. The depth range of the ITS is 10-183 m, and it samples mud, sand, and gravel substrate. The SUS primarily a dive survey with a video quadrat component in the deepest strata. The SUS sites are chosen using a stratified random design by depth and substrate. The depth range of the SUS is in water depths <35 m and it samples gravel, ledge, boulder, and cobble. (Table 2)

For analysis, the relative densities per m^2 were calculated for each survey. For spatial analysis, we calculated the average density for each square area in a ten minute square grid (TMS). To compare spatial trends between surveys, we used three approaches:

(1) We created linear regressions of the crab densities from each TMS to determine trends.
(2) Using ArcGIS, we created three interpolation grids of the crab density from the sample points with the Inverse Distance Weighted method and
(3) The CVS density values were ranked 100-500, SUS was ranked 10-50, and ITS was ranked 1-5 with the lowest rank for each equal to zero crabs. The ranks were added together so each TMS had a value showing if the relative survey ranks were similar.

Table 2. Characteristics of the three surveys sampling the nearshore Gulf of Maine region in spring 2004.

	Dates	Depths (m)	Method	# of sites	Positive ID of CI and CB	Random stratified design	Substrate sampled	Area sampled/swept at each site
Crab Video Survey	3/21/04 - 5/13/04	15 - 183	drop quadrat video	130	not always	by depth	mud, sand, gravel, ledge, cobble, boulder	$60m^2$
Urchin Survey	5/10/04 - 7/8/04	1 - 35	dive/drop quadrat video**	195	yes	by substrate and depth	gravel, ledge, cobble, boulder	$60m^2/10m^2$**
Inshore Trawl Survey	5/3/04 - 6/8/04	10- 198	modified shrimp trawl*	103	yes	by region and depth	mud, sand, gravel	$14818m^2$

*2in. mesh with 1 in. liner in the cod end. 57ft head rope and 70ft foot rope.

**method was depth dependent - diver quadrats 0-15m ($60m^2$ per site) and camera quadrats 15-35m ($5m^2$ per site)

6. Data:

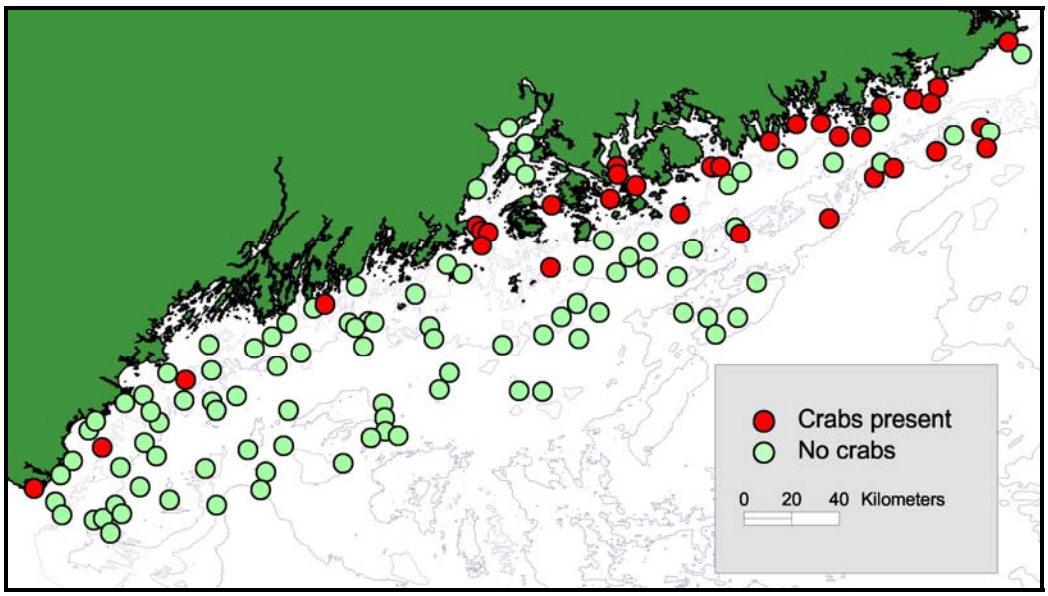

Figure 4. Map of site locations with red dots representing sites with crabs present.

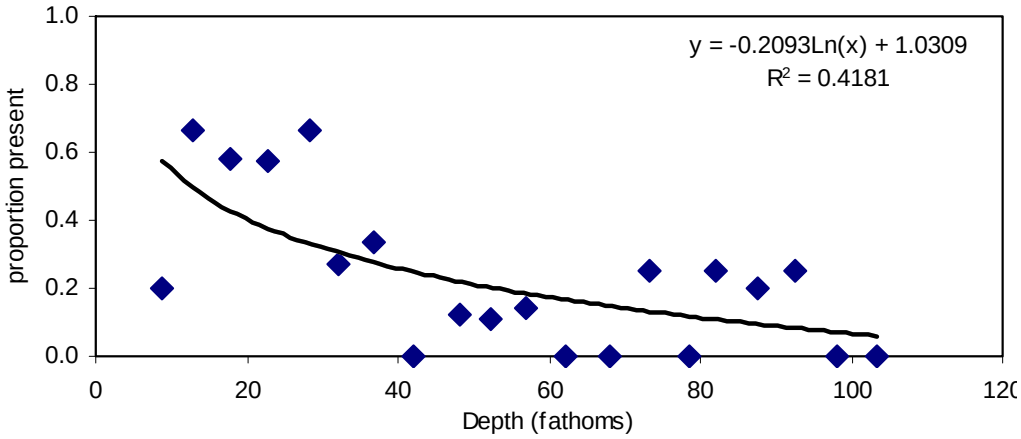

Figure 5. Proportion of crabs present with depth in 5 fathom bins.

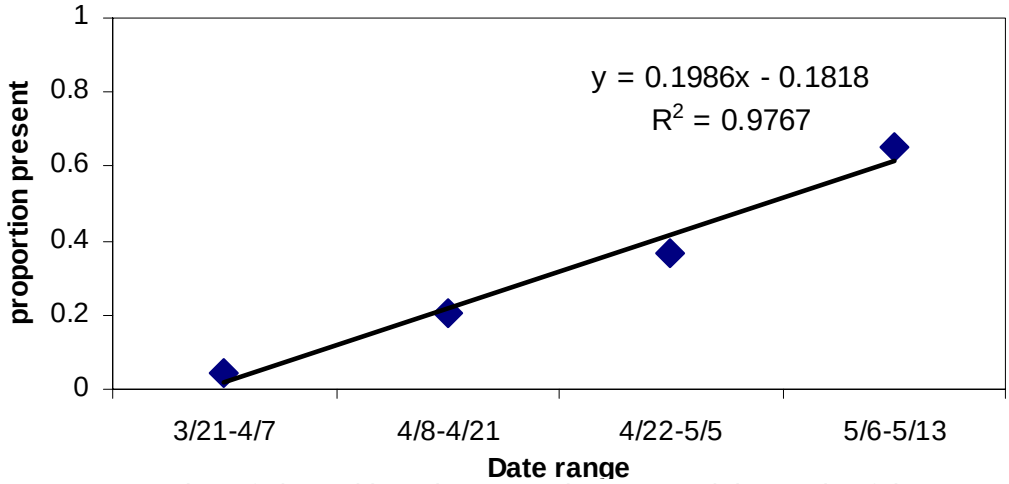

Figure 6 Proportion of sites with crab present by two week intervals of the survey.

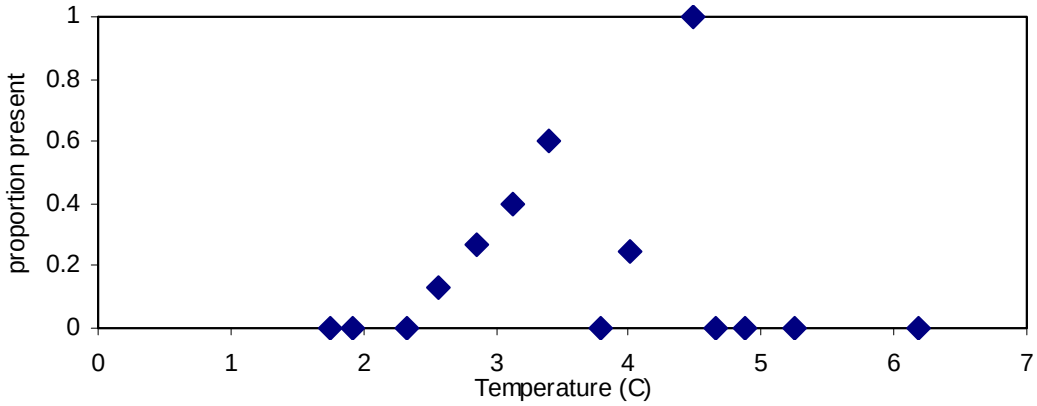

Figure 7. Proportion of sites with crab present by observed bottom temperature.

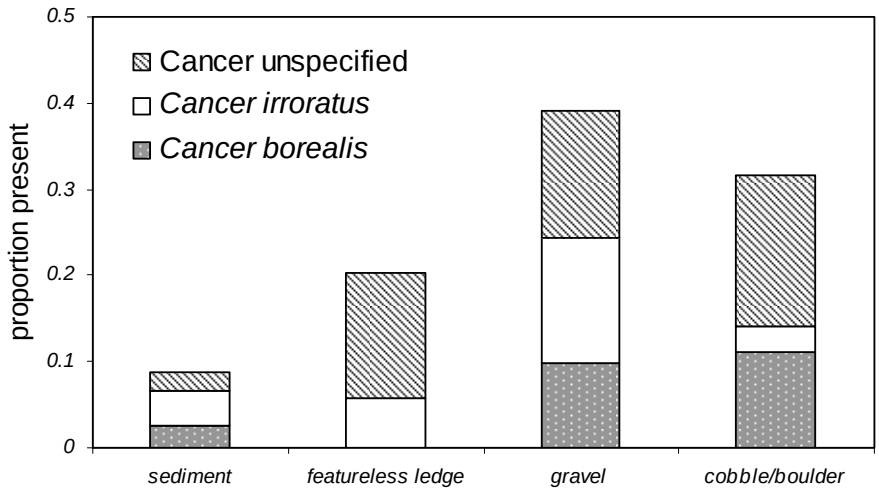

Figure 8. Proportion of quadrats with crab present by substrate type.

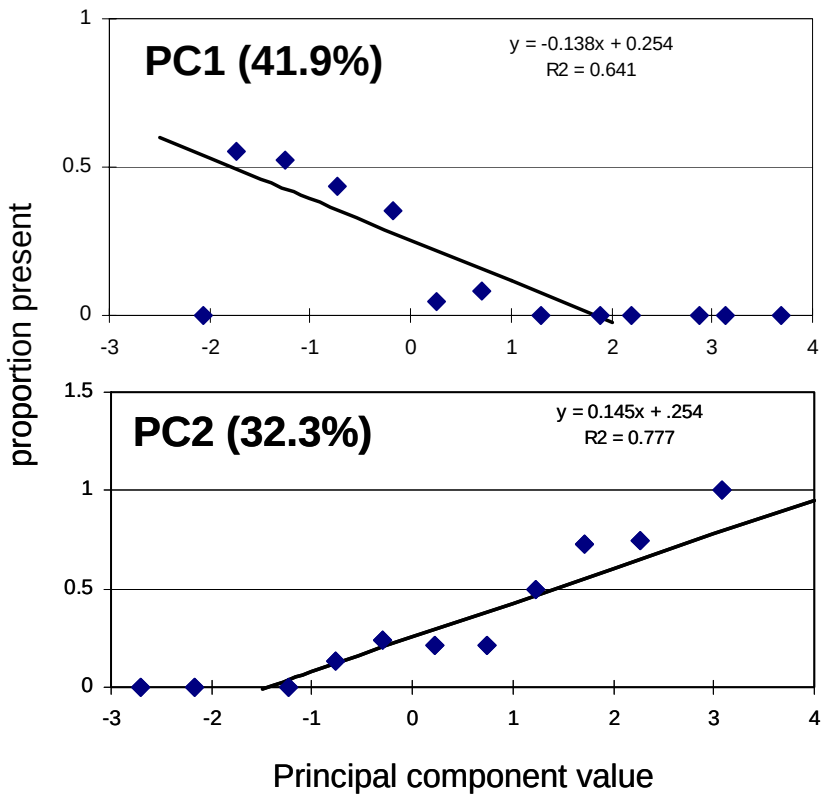

Figure 9. The of proportion of sites with crabs present using the new descriptive variables, PC1 and PC2. PC1 Eigenvectors Depth (.70) and temperature (0.47); PC2 Eigenvectots day of year (0.71), temperature (0.56) and habitat (0.42).

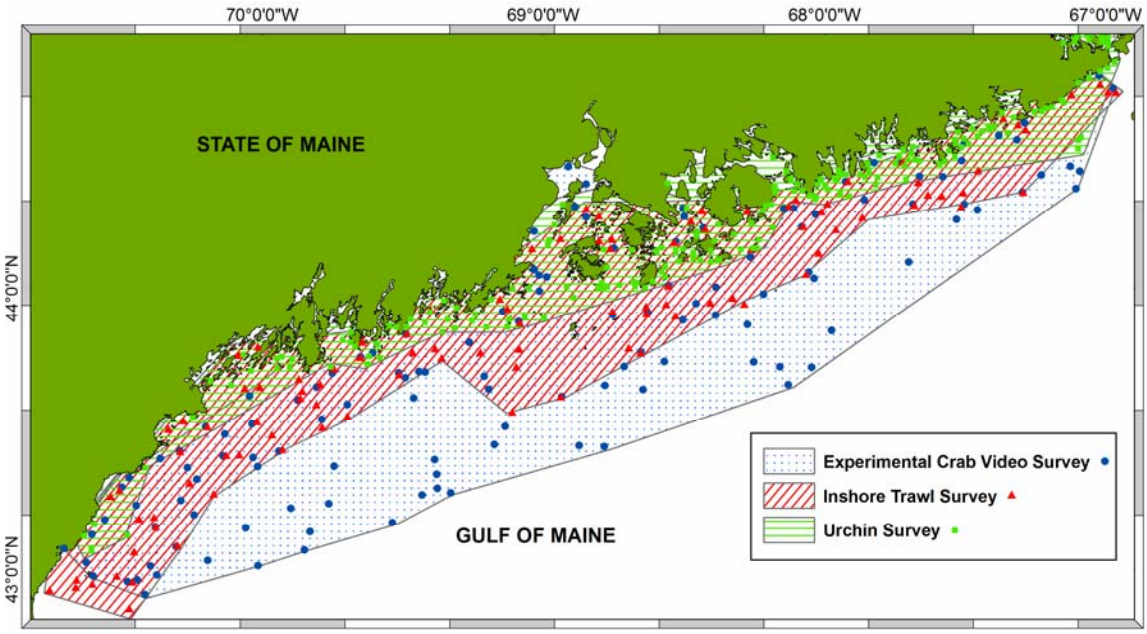

Figure 10. Map of survey locations and area coverage for the Experimental Crab Video Survey, the Inshore Trawl Survey and the Urchin Survey in the nearshore Gulf of Maine.

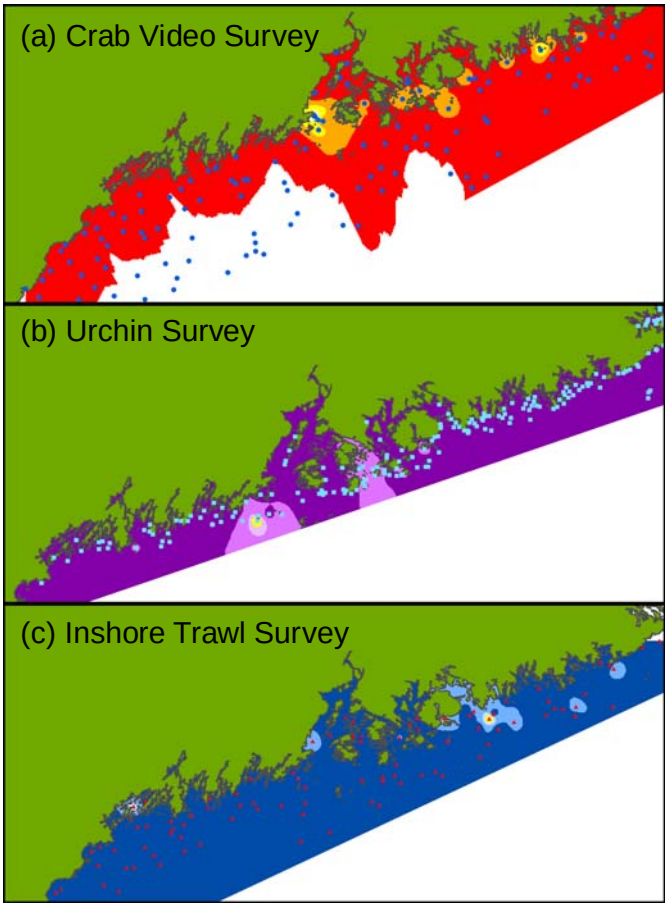

Figure 11. Inverse distance weighted interpolation of the *Cancer* crab density from the three surveys. (a) Crab Video Survey 0.026 - 0.233 crabs/m^2. (b) Urchin Survey 0.1 – 1.3 crabs/m^2. (c) Inshore Trawl Survey 0.0001 - 0.0087 crabs/m^2. Dark colors have lowest density and light colors have highest density (white areas had no data or, for the CVS only, represent zero density).

Table 3. Number of ten minute squares (TMS) covered by each survey with the proportion of ten minute square with crabs observed.

	#TMS sampled	proportion of TMS with crab
Crab Video Survey	80	0.21
Urchin Survey	44	0.52
Inshore Trawl Survey	54	0.69

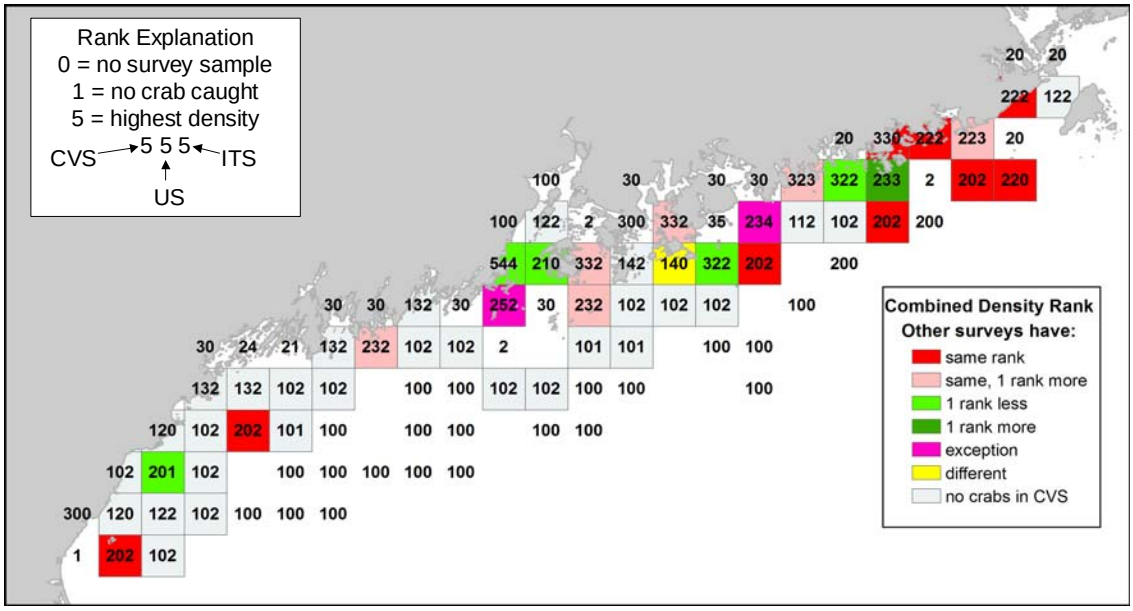

Figure 12. Ten minute square grid with colors designating squares with similarities (same rank or within 1 rank), differences, or no comparison between the crab densities observed by the CVS and the two other surveys. Numbers represent a combined density rank. Only squares that were sampled by the CVS and at least one other survey were considered.

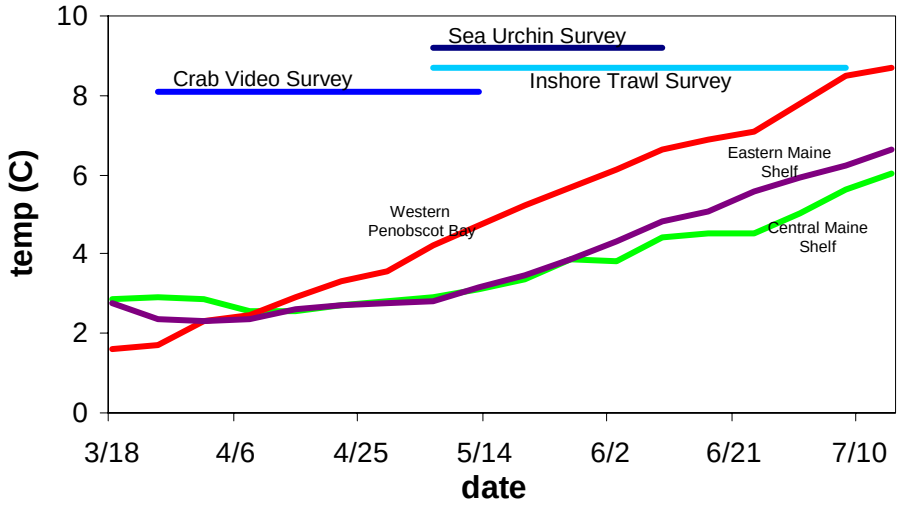

Figure 13. Weekly averaged water temperatures at 50m for three Gulf of Maine Ocean Observing System buoys (GoMOOS) over time of the experimental Crab Video Survey, Maine Urchin Survey, and the Maine Inshore Trawl Survey (survey length designated by straight blue lines at top of figure).

7. Results and Conclusions:

7.1 Video Survey Advantages and Disadvantages

The drop camera system has the advantage of being unlimited by habitat, depth, gear conflicts, and is easily deployed from a standard inshore lobster boat. It could sample in habitats where trawls could not be used and below diving depths. Crabs have been difficult to sample with trawls because of avoidance behavior. Unlike lobsters who have been observed to tail flip into trawls to avoid the foot rope, crabs are more likely to hide or burrow into the sediment than end up in the net (Richards et al., 1986, Estrella, 1989). With a video array, we can see the movement of crabs as the frame is descending and in contact with the bottom.

There were also limitations to the video survey. We could not observe crabs hiding under rocks or that are already buried in soft sediment. Only divers, or possibly ROVs could more thoroughly sample, but these two approaches are limited by depth and cost.

The survey was conducted in early spring because the fishermen had the time to participate and fishermen often report their highest catches of crab in late spring. Unfortunately, spring of 2004 was especially cold and the crab catch was down. The extended sampling period ranged over a rapidly changing time of year in terms of water temperature (1.5-6.3° C), and even so, we did not observe any sites with temperatures as high as the published temperatures with high crab abundance (10-12°) (Haefner, 1977, Palma et al 1998) (Figure 13).

Using a stratified survey by depth makes the assumption that depth is the most important variable for the presence of crab. It is possible that if we had been able to stratify by habitat, we would have been able to determine more significant trends of distribution, but the Gulf of Maine region does not have the highly resolved digital maps needed to create such a survey. We may have disproportionately sampled one type of habitat (simple mud or sand).

Sample size at each site directly impacted the level of detection of the survey. The sample size of 50 drops per site was based on the expectation to observe at least one crab at low reported density (Palma et al., 1998) and to balance the constraints or vessel time and the distribution of the coast-wide survey. Additionally, the effective quadrat size of 1.2m^2 was limited because of the visibility in coastal waters. Better visibility and a larger quadrat size would have increased the effective area sampled and would not have impacted the logistical constraints of the survey.

Electronic gear failure consumed time and effort. The problems with cable entanglements in the sea trials of the original sled design likely compromised the cable early in the survey.

7.2 Presence/Absence of crabs

7.1.1 Distribution and abundance

The experimental video survey sampled 130 sites in the nearshore Gulf of Maine (Figure 3). The survey observed a total of 104 Cancer crabs (30 *C. borealis*, 29 *C. irroratus*, and 45 *Cancer spp*. Most sites west of Penobscot Bay or in deep strata did not have any crabs present. Eastern sites, sampled at the end of the survey had a high proportion of present crabs (Figure 3).

7.1.2 Habitat Variables and Principal Component Analysis

The shallower sites were more likely to have crab (Figure 5). Most sites with crabs were shallower than 40 fathoms. A significant seasonal (two week interval) increase in the presence of crabs was observed throughout the survey (Figure 6).

The role of temperature for the likelihood of observing crab is unclear (Figure 7). In previous studies, the Jonah crabs were not found below 3° C (Stehlik et al., 1991). The timing and length of this survey introduced a seasonal change in temperature so we expect temperature to be related to day of year, but also, temperature may be related to depth. From 2.5° to around 3.5° C, there were an increasing proportion of sites with crab, but above this range, the trend is unclear (Figure 7). The average depth of the sites below 3.5° C was less than 55 fathoms. All sites at or above 4° C degrees were more than 75 fathoms and the previous analysis of depth showed that fewer crabs were seen at deeper sites explaining the lack of significance for sites above 4° C (Figure 5, Figure 7).

Previous studies based on trawl surveys found most Jonah crabs were captured on silty sand (Stehlik et al., 1991). The trawl surveys were limited by relatively featureless bottom, while this video survey was not limited by bottom complexity. For this survey, the presence of crab increased with increased complexity of habitat (Figure 8). The video survey confounds this trend because, as habitat becomes more complex, the survey may become biased because the downward looking view camera cannot look between or under rocks. With more places to hide, the crabs may be more abundant, but the survey could not sample them. From divers' experience in the Urchin Survey, we would expect that if the crabs are in cobble/boulder habitat, a large proportion may be hidden from above.

The PCA produced two new variables, PC1 and PC2, which explain depth, temperature, and day of year effects (Figure 9). PC1 explains 41.9% of the variation in the original data while PC2 explains 32.3% so that together these two unrelated variables explain more than 70% of the original patterns observed. The first principal component is primarily correlated with the depth variable with correlation to temperature (Figure 9 eigenvectors). The second PC is primarily correlated with the day of year, and limited correlation with both temperature and habitat (Figure 9 Eigenvectors). The two new PC variables are related to the proportion of sites with crabs present (Figure 9). The trend lines are weighted by the sample number for each point. For PC1, there is a decreasing trend where the proportion of sites with crab decreases with the increase in PC1 or the

sites with lower PC1 values are more likely to have crab. For PC2, the sites with higher values are more likely to have crab.

In conclusion from this habitat variable analysis, we determined that depth and season are very important variables influencing the presence or absence of crab in the study area. Also, substrate type is likely to be an important variable, but the survey design and potential bias makes it difficult to quantify the importance. Temperature probably influences the presence or absence, but the timing of the survey sampled sites only at the colder extreme of the range and is hard to compare to previous surveys.

7.3 Comparison with other surveys

7.3.1 Comparing fixed sites of the Inshore Trawl Survey

The video survey sampled 39 of the planned 40 fixed sites from the Inshore Trawl Survey. In the spring of 2004, the Inshore Trawl Survey sampled 34 of those 39 sites. Of those 34 sites sampled in common, the video survey observed crab in 24% (8) while the Inshore Trawl Survey captured crab in 76% (26) of the sites. The surveys were completed in different time periods and at different temperatures which may have impacted availability to each survey (Figure 13).

7.3.2 Comparing coast wide spatial trends of three surveys.

The Crab Video Survey covered the largest area and types of habitat, but actually sampled the smallest proportion of that area (Table 2, Table 3, Figure 10). The video survey stretched over a long period of time and was started earlier than either of the other surveys. The water temperature at 50m increased approximately 4 degrees from the beginning of the crab video survey to the end of the Inshore Trawl Survey (Figure 13). The Inshore Trawl Survey sampled only the least complex substrate but swept the largest area at each site (Table 2). The Urchin Survey covered the smallest area, but intensively sampled the shallow coastal areas targeting only hard substrate (Table 2, Table 3, Figure 10). When grouped by ten minute square (TMS), the Inshore Trawl Survey had the highest proportion of sampled area with crabs present (0.69) (Table 3).

Using linear regression of the average density of crabs for each ten minute square, we found no significant spatial similarities between the three fishery independent surveys. Using the inverse distance weighted method of spatial interpolation, we found the three surveys did not have similar spatial trends for density of crabs (Figure 11). The Crab Video Survey observed 0.026 - 0.233 crabs/m^2 for sites with crab; the Urchin Survey observed 0.1 – 1.3 crabs/m^2; and the Inshore Trawl Survey observed 0.0001 - 0.0087 crabs/m^2. Although the Urchin Survey and Inshore Trawl Survey were completed over similar time frames, the spatial trends were not similar (Table 2 and Figure 13). This dissimilarity is probably because of the two surveys sample different habitats and depths and have different levels of detection (Table 3).

The density of crabs was ranked for each survey in each ten minute square. Some areas do have similar trends when the average density by ten minute square is ranked and compared. For most ten minute square that were sampled by at least two surveys (CVS plus US or ITS), the density ranks for each survey were either the same or within

one rank (Figure 12). Nine ten minute squares had the same density rank between 2 or more surveys. Eleven ten minute squares had similar ranks (within 1) while only one ten minute square had two different ranks (more than 1) and two had one similar survey and one different rank from the crab video survey (Figure 12).

Comparing the three surveys can only be a rough analysis of spatial trends. The three surveys have very different objectives. The Crab Video Survey was an experimental survey trying to cover all habitats and was stratified by depth over the largest area. The Urchin Survey targeted urchins (and collected data on associated species, like *Cancer* crabs) and only sampled hard substrate in shallower coastal waters. The Inshore Trawl Survey is a generalized survey targeting groundfish over a large area that samples relatively uncomplex substrate.

There is also a range of catchability and level of detection between the surveys. The Crab Video Survey, though able to sample all habitats, can only sample a small area in one frame ($1.2m^2$) and is unable to see beneath rocks and obstacles or unbury animals. The catchability is high, except in the most complex habitat, but the sample size limits the level of detection when the crab density is low. The Urchin Survey also samples a very small area, but using SCUBA divers at all depth strata except 1 makes it possible to search for the animals on, under, and around the substrate. The Inshore Trawl Survey has an unknown catchability over a very large swept area. The timing of the three surveys also makes it difficult to compare because the Crab Video Survey was commenced about a month and a half before the other two surveys.

7.4 Conclusions

In this project, we met our objectives by designing, developing, and implementing a crab video survey. We designed a functional drop camera system. We demonstrated that the video quadrat frame can sample more habitats than previous approaches.

The Experimental Crab Video probably was completed too early in the season to observe crabs due to cold water temperatures. The system was an efficient way to sample all types of substrates, but the area sampled per site was too small to effectively observe spatial distribution because the level of detection was too low to sample low crab density. Future surveys should increase the area sampled, possibly by conducting drift video transects, to maximize the power of detection.

8. Partnerships:

This NEC funded project was conducted in strong partnership between industry and scientists. This survey developed new techniques to video crabs in complex habitats inaccessible by trawls. Industry participants designed the video drop camera system and contributed their specific knowledge of their fishing area to help facilitate this project.

9. Collaboration with other projects:

The rationale for and industry participants in this project originated from the Jonah crab trap project funded by NEC in 2002 (development award). The methods developed and equipment acquired during this project were directly used in the Monhegan Trapping projects funded by NEC in both 2003 (Development grant) and 2004 (full project). The comparison with other fishery independent surveys could not have been completed without the collaboration with Sally Sherman of the DMR Inshore Trawl Survey and Margaret Hunter of the DMR Green Sea Urchin Survey.

10. Presentations:

Specific presentations to scientific audiences were as follows:

Development, assessment, and management of a potential targeted Jonah crab (*Cancer borealis*) fishery in Maine. presented by Kathleen Reardon. School of Marine Science, University of Maine Graduate Mini-Symposium. 5/14/05.

Identifying key habitats of Cancer crabs in the Gulf of Maine using an experimental video survey. Reardon, K., C. Wilson, R. Russell, and Y. Chen. Presented by Kathleen Reardon. Annual Marine Benthic Ecology Meeting. Williamsburg, Virginia. 4/9/05.

Spatial Analysis of an experimental video survey for Cancer crabs in the Gulf of Maine. Reardon, K., C. Wilson, and Y. Chen. Poster presentation by Kathleen Reardon. American Fisheries Society Annual Meeting. Anchorage, AK. 9/12-13/05.

11. Student participation:

There has been one student directly involved with this project. Under the supervision of Dr. Yong Chen, University of Maine, Kathleen Reardon has worked toward a dual-masters degree in Marine Policy and Biology. Kathleen is scheduled to graduate in May 2006.

12. Published report and papers:

All portions of this report in addition to further analyses will be included in K. Reardon's thesis paper.

13. <u>Images</u>:

Image 1. Original video survey sled design.

Image 2. A three person job using the boom to lift the sled.

Image 3. Cable twisted around hauling line and sled after getting stuck on the bottom.

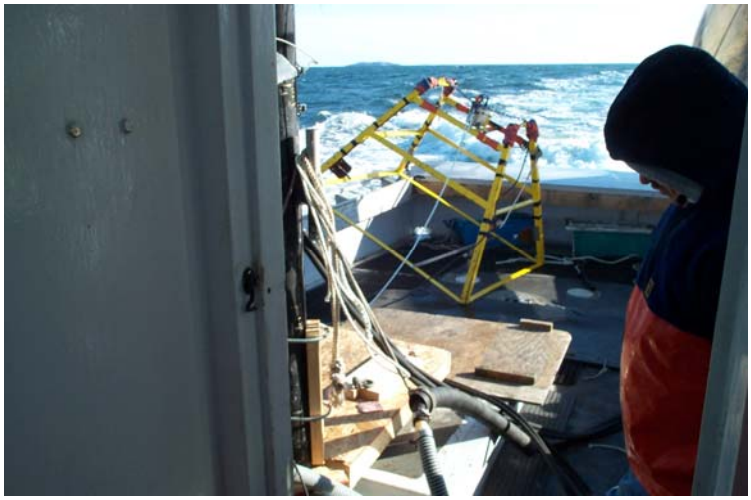

Image 4. Sea trails of new video quadrat frame design on Larry Knapp's boat.

Image 5. Winch setup on Larry Knapp's boat – on platform.

Image 6. Larry Knapp on a cold day in March.

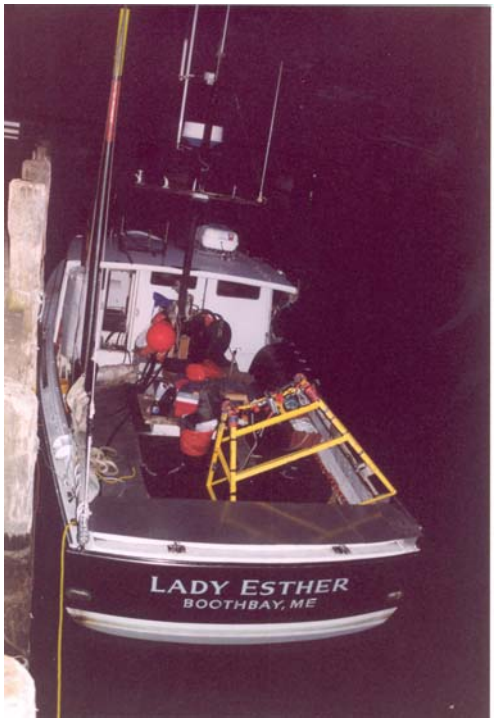

Image 7. Larry Knapp's boat Lady Esther in Cape Porpoise Harbor early morning.

Image 8. Larry Knapp on a warmer day working the hauler.

Image 9. Larry Knapp steaming home at sunset.

Image 10. Larry Knapp and crew tending the cable and hauler.

Image 11. About to release the quadrat frame on Brain McLain's boat.

Image 12. Releasing the quadrat frame on Brian McLain's boat.

Image 13.Retreieving the frame on Brian McLain's boat.

Image 14. The frame could be moved and handled with two people.

Image 15. Rigging Brian McLain's boat, Silver Bullet, in New Harbor.

Image 16. Brian McLain on F/V Silver Bullet.

Image 17. Brent Oliver and crew, Mike Yurchick, retrieving the frame.

Image 18. Brent Oliver and Mike Yurchick bringing the frame on board.

Image 19. Brent Oliver and Mike Yurchick tending the line, cable, and winch.

Image 20. Bill Look working the hauler with dual blocks.

Image 21. The video set-up on Bill Look's boat.

Image 22. Bill Look and crew, Shane, retrieving the quad frame.

Image 23. Shane leading the cable into the winch.

Image 24. Sunset steam back to shore.

Image 25. Image capture from video from extra day out of Stonington when frame was placed on top of a ghost trap.

Image 26. Capture from video with crab in complex substrate.

Image 27. Capture from video with *C. irroratus* in simple habitat.

Image 28. *C. irroratus* in mud cloud on simple substrate.

Image 29. *C. borealis* on simple substrate.

Image 30. *C. borealis* in complex habitat.

Image 31. Jonah crab in crevice between two boulders.

Image 32. Jonah crab with sea stars on top of boulder.

14. Future Research:

This project has highlighted the need for collecting more information on the status of the Jonah crab population in the Gulf of Maine. Regional differences in growth, maturity and movement are needed to better understand stock identification. The largest obstacle to management of crabs is the largely unregulated bycatch fishery for crabs by the existing lobster fishery.

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