NORTHEAST CONSORTIUM

Project Title: ***A Collaborative Effort to Examine New Strategies for Managing Closed Bottom Habitats for Sea Scallops***

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Budget Request: $143,625 over two years ($114,875 in Year I and $28,750 in Year II)
Percentage of direct costs: Commercial Fishing Industry (87%)

Brief project description (1 paragraph):

Fishermen in eastern Maine wish to evaluate the efficacy of closed areas with respect to enhancement of wild sea scallops. Beginning in Spring 2007, two 1 km^2 zones that were once, but are no longer, productive scallop grounds will be created in the Beals-Jonesport area. To determine the best methods to collect, handle, transport, and deploy wild sea scallops (5-70 mm SL), we will initiate and complete experimental bottom trials in each zone over a period of 30 days beginning in late April or early May. In addition, we will attempt to collect wild scallop spat (5-10 mm SL) using collection methods transferred from successful field trials in the Canadian Maritimes.

Project objectives

The objectives of the work are to: 1) determine method(s) of handling commercial quantities of sea scallops (both legal and sublegal sizes) to minimize mortality prior to deploying on bottom; 2) determine the most effective method(s) of deploying commercial quantities of sea scallops to bottom plots; 3) follow the fate of scallops deployed into bottom plots over a month after deployment; 4) determine sites that maximize numbers of wild scallop spat per spat collector; and 5) provide fishermen and resource managers with information that will enable them to decide whether the use of closed and enhanced bottom areas is a viable management tool.

Project scientific hypotheses

Handling experiments

Hypothesis 1: There is no difference in the fate of legal and sublegal sizes of sea scallops that are transported from collection sites damp/moist vs. wet/aerated.

Hypothesis 2: There is no difference in the fate of legal and sublegal sizes of sea scallops that are seeded in bottom plots from the surface of the water from a vessel vs. hand-seeded by divers into bottom plots.

The purpose of this experiment is to determine the best handling and transportation methods to minimize handling mortality prior to enhancement. We are unfamiliar with previous attempts to relocate commercial quantities of legal and sublegal size sea scallops. Scallops will be harvested (dragged) from several locations near Jonesport, Maine in April and May 2007 when seawater and air temperatures are usually below 10^{o}C. One-half of the animals will be placed carefully into dry, plastic fish totes filled to one-half capacity (20-22 kg) and then covered with a 3-4 inch layer of moist, nylon spat bags. The other half will be placed into specially designed, flow-through, aerated holding tanks (700-liter Xactic box -- double wall polyethylene box with polyurethane foam insulation) retrofitted with shelves to hold scallops. We will estimate mean shell length and height of scallops from both handling treatments prior to deployment by measuring 50 individuals to the nearest 0.1 mm using Vernier calipers.

Because of fast currents, winds, and extreme tides, we had to abandon hypothesis #2 and have divers place transported sea scallops in bottom plots. That is, we decided not to deploy scallops into bottom plots via a broadcasting method from boats at the surface. We could not ensure that scallops would fall into the delineated bottom plots, and, since we repeatedly returned to these plots over a 30-day period to assess the fate and growth of the animals, we did not think that the method of broadcasting scallops from the surface would yield valuable information about how scallop density changed over time in the marked plots.

Wild spat collection

Hypothesis 1: There is no difference in number of sea scallop spat per bag between shallow (< 20 m) and deep (> 30 m) locations (bottom types similar).

Hypothesis 2: There is no spatial or temporal difference in number of sea scallop spat per bag.

The purpose of this field trial is to determine whether collecting wild sea scallop spat is a viable management option to use in conjunction with closed areas.

Work completed to date

The 2007 Northeast Consortium project enabled us to engage in two activities. The first was to determine the best methods to collect, handle, transport, and deploy wild sea scallops into bottom plots in two closed areas. Those results are presented here. We eliminated one level of the factors in the first activity (deployment methods). We had proposed to seed scallops using divers who would distribute scallops into the bottom plots, and to drop scallops from a boat into the plots that we marked both at the surface and the bottom. However, because of high winds, stormy weather, and fast currents, we decided to abandon that idea because it became clear that any attempt to seed from the surface would not accomplish our goals of being able to quantify scallop survival in marked bottom plots. Because many of the scallops seeded from the surface would have fallen outside the marked bottom plots, this method of distributing scallops would have led us to conclude that scallop migration from the plots was higher than it actually was (see below). The second activity was an attempt to collect wild spat using collection methods transferred from successful field trials in the Canadian Maritimes. Those results are pending (as of 7 Decmber 2007).

On 4 May 2007, we initiated a short-term (30-day) field experiment to examine how handling and transporting wild sea scallops collected using commercial drags affected their fate and growth. The study site was located near Sheep Island in Eastern Bay between Great Wass Island, town of Beals, and Kelley Point, town of Jonesport (44^{o} 31.10'N; 67^{o} 33.91'W). A similar study was initiated on 9 May 2007 between Perio Point, town of Beals, and the Coast Guard Station in town of Jonesport (Moosabec Reach – 44^{o} 31.52'N; 67^{o} 36.95'W). Both sites were approximately 1-km^2. The bottom type at Sheep Island was sparse boulders and cobble with scattered individuals of *Agarum clathratum* and *Laminaria longicruris*. Few decapods were observed (rock crabs, *Cancer irroratus*, Jonah crabs, *C. borealis*, green crabs, *Carcinus maenas*, and American lobsters, *Homarus americanus*) during any of our visits to the site; however, this area is heavily fished for lobsters from June through November of each year. In addition, the site had been fished commercially by scallopers and urchin draggers/divers during the winter months (M. Alley, pers. obs.), which may explain the sparse macroalgae. On 3 May 2007, divers sampled 80 random 1-m^2 quadrats within the site, finding a density of 0.088 individuals m^{-2} ranging in size from 85-120 mm SH. Water depths at Sheep Island ranged from 3 to 6 meters at low tide. At the Moosabec Reach site, the bottom type was similarly mixed with some boulders, but was mostly flat ledge with juvenile mussels occupying the shallowest areas. Macroalgae was even more sparse at this site than at Sheep Island. Only green and rock crabs were observed during our visits to the site. Because the Beals-Jonesport bridge bisected the enhancement sites, current velocities at any particular bottom location were always significantly faster than those occurring at the Sheep Island site. On 8 May 2007, divers found 0.063 scallops m^{-2} ranging in size from 80-140 mm SH. The Moosabec Reach site also is heavily fished for scallops, urchins, and periwinkles, *Littorina littorea* (E. Kelley, Jr., pers. obs.). These sites were chosen based on three factors: 1) proximity to the fishing villages of Jonesport and Beals Island; 2) each was a traditional scalloping ground with a history of high scallop abundance, but with low abundances in recent years; and 3) both are easily enforced in terms of poaching and other violations of the closed management area rules.

Within each site, eight bottom plots (15 m x 15 m) were created approximately 3-5 days before collecting, transporting, and deploying seed. Plots were marked at each corner with cement filled cinder blocks. Polypropylene sink rope (15 m lengths) was used to connect each block so that divers could delineate the periphery and area within each plot. Two permanent transect lines (sink rope, 15 m in length with white, numbered, plastic paper markers tied into each at 1-m intervals) were affixed to two opposite bottom lines approximately 5 m from each cement block.

Wild scallops were collected using commercial scallop drags at an area in Englishman's Bay in Jonesport (44^o 36.17'N; 67^o 32.03'W). Scallops were held and transported on each of two draggers on 4 and 9 May 2007. One-half of the scallops were placed in a flow-through Exactic box ("Wet Storage") while the other half were kept in plastic fish totes with several holes in the bottom of each tote to allow seawater to drain out ("Dry Storage"). Totes were covered with a piece of blue plastic tarpaulin, and placed under the stern of each boat, out of direct sunlight. Seawater temperatures on these dates was 8^o C measured at the nearby Downeast Institute on Great Wass Island (44^o 28.83'N; 67^o 35.92'W). Air temperatures on these dates ranged from 7 to 12^o C. From time-to-time throughout the day, sea scallops in the totes were watered by pouring a 5-gallon bucket of seawater over them. Boats worked the collection site for approximately 6 hours on both days. At the end of the day, the scallops were transported directly to the enhancement site where divers distributed the scallops evenly throughout each of the eight bottom plots. Scallops from each handling treatment were randomly assigned to the bottom plots. Initial enhancement density at both sites was established at 2.5 m^{-2}, or approximately 30-40 times ambient densities. This density was chosen based on practical measures (the length of time needed to collect enough animals for the trials, but also based on results from Canadian efforts to enhance bottoms with smaller animals (see Hatcher et al. [1996], Wong et al., [2005]). Mean (± 95% CI) shell height (SH) of scallops transplanted into bottom plots at Sheep Island was 86.4 ± 1.97 mm (n = 189), and 85.9 ± 1.54 mm (n = 309) at Moosabec Reach (Fig. 2). On each collection date, 30 sea scallops from each handling treatment and representing the frequency of sizes transplanted to bottom plots were taken to the Downeast Institute and held in flowing ambient seawater for 30 days to assess their survival. This gave us a measure of predator-independent handling mortality.

We returned to each site on **Days 1, 2, 3, 5, 10, 20, and 30** after deployment. On each visit, divers collected data on sea scallop density in five 1-m^2 randomly selected quadrats along each transect line within each plot (5 quadrats per transect line x 2 transect lines per plot x 4 plots per handling treatment x 2 handling treatments = 80 samples per site per sampling date). On the last sampling date, all scallops within each quadrat were taken to the surface where the shell height of each was measured to the nearest 0.1 mm using Vernier calipers.

Results from the Sheep Island enhancement site were unambiguous (Fig. 3, Table 3). First, there was no effect due handling treatment and there was no effect to due sampling date. In fact, the mean density in the 80 quadrats on 2 June 2007 was 2.5 ± 0.63 individuals m^{-2}. In addition, none of the sixty sea scallops that were taken from the group that was placed in bottom plots at Sheep Island and held at the Downeast Institute in ambient seawater for the 30-day period died. The results provide strikingly clear evidence that 1) in low-flow areas, adult sea scallops generally tend to stay where they are transplanted for at least 30 days, and 2) moving scallops from wild beds to enhancement sites can be done easily using plastic fish totes in which the animals are stored dry, but moistened with seawater from time-to-time.

Figure 2. Size-frequency distribution and mean size of sea scallops used in the field experiment at Sheep Island (n = 189), and Moosabec Reach (n = 309).

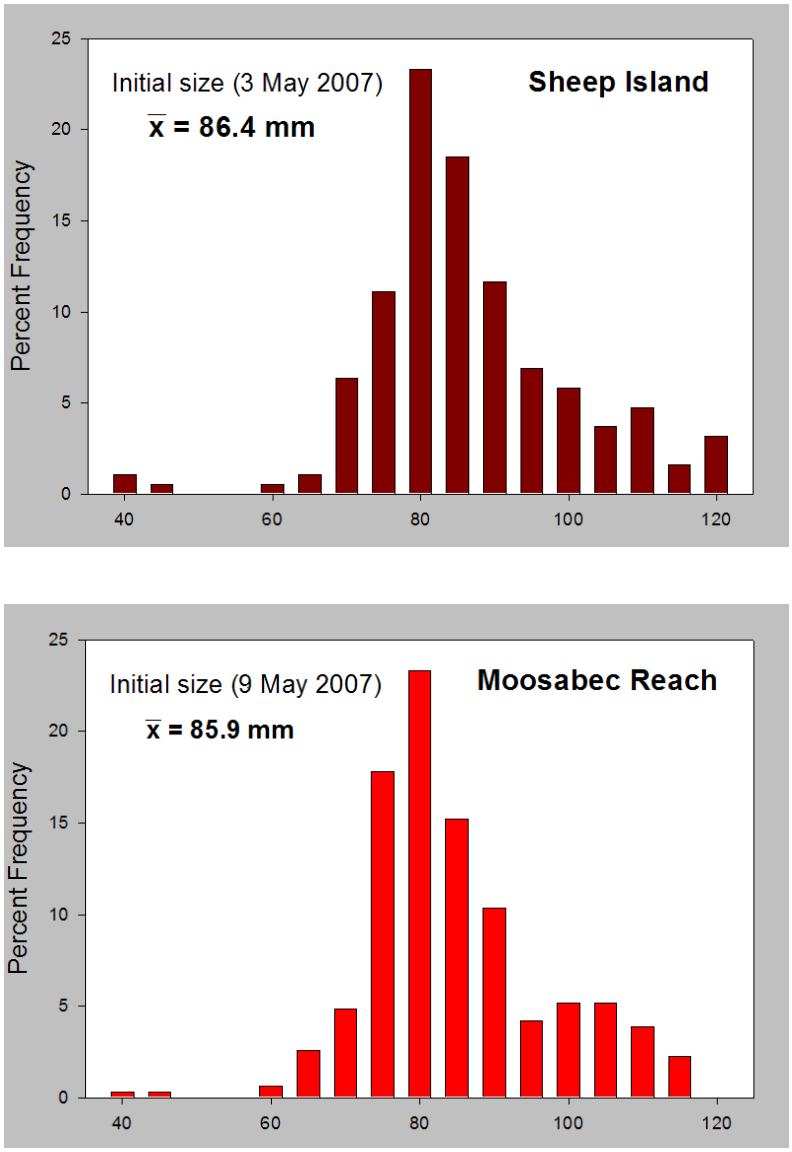

Figure 3. Fate of sea scallops, *Placopecten magellanicus*, seeded at a density of 2.5 m^{-2} in bottom plots at the Sheep Island enhancement site from 4 May to 2 June 2007.

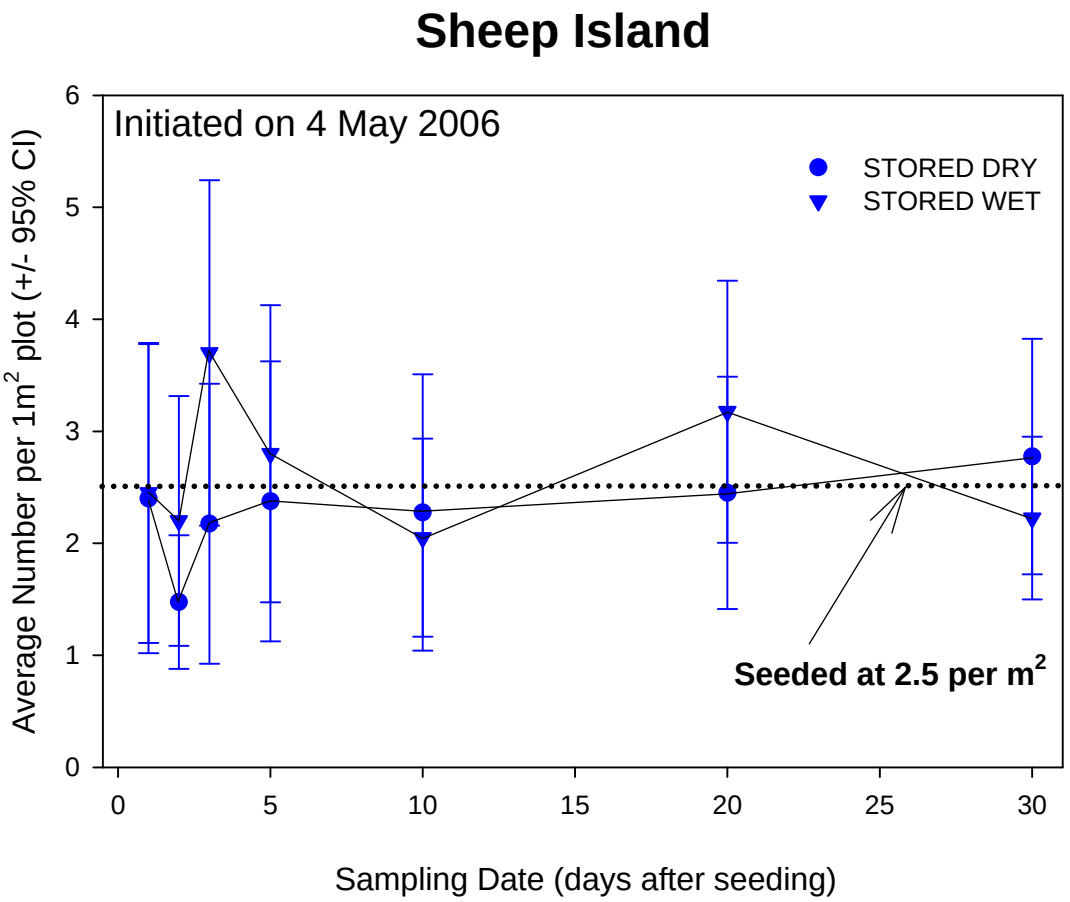

Table 3. Analysis of variance on the mean number of sea scallops per 1-m^2 quadrat on 7 dates from 4 May to 2 June 2007 at the Sheep Island enhancement site. (n = 5)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Handling Treatment	1	20.44464286	20.44464286	0.59	0.4707
Sampling date	6	67.76785714	11.29464286	1.17	0.3429
Treatment x Date	6	57.81785714	9.63630952	1.00	0.4405
Transect	1	78.00178571	78.00178571	1.26	0.3053
Treatment x Transect	1	44.01607143	44.01607143	0.71	0.4321
Date x Transect	6	56.76071429	9.46011905	0.85	0.5398
Treatment x Date x Transect	6	38.39642857	6.39940476	0.58	0.7471
Plot(Treatment)	6	207.0392857	34.5065476	2.72	0.0131
Date x Plot(Treatment)	36	346.9857143	9.6384921	0.76	0.8414
Transect x Plot(Treatment)	6	372.6535714	62.1089286	4.90	<.0001
Date x Trans x Plot(Treat)	36	400.2714286	11.1186508	0.88	0.6738
Error	448	5673.200000	12.663393		
Corrected Total	559	7363.355357			

Only two of the eleven sources of variation were statistically significant, and these were not important in the overall scope of the project. The first source of variation that was statistically significant was Plot nested within Treatment ($P = 0.013$). This suggests that for at least one of the handling treatments that not all plots behaved similarly. Further decomposition of this source of variation indicated that plot-to-plot variation within both wet ($P = 0.0389$) and dry ($P = 0.0492$) treatments was statistically significant ($\alpha = 0.05$). The other significant source of variation occurred between some of the transect lines in some plots, but this variability is to be expected.

Results from the Moosabec Reach enhancement site were similar to those at Sheep Island with respect to overall effect of the handling treatments ($P = 0.413$), but require diver observations to help interpret results from Day 20 to Day 30 (Fig. 4, Table 4). Divers reported that on the final sampling date (8 June 2007), they saw live scallops near the periphery of some plots and outside the sink rope that delineated the plots. Scallops seemed to be responding to increasing rates of flow associated with astronomically high tides during the period before and after the full moon (31 May 2007). Nonetheless, divers reported that scallops were alive and indicated few deaths due to apparent mortality by decapods or other large predators. In addition, only one of the sixty scallops died (from the wet storage containers) that had been held at the Downeast Institute from among those seeded into bottom plots in Moosabec Reach. This independent estimate of handling mortality suggests, again, that future attempts to move sea scallops should use the easiest and least expensive method – dry storage in plastic fish totes.

Scallop growth was negligible over the 30-day trial at both sites (final mean SH at Sheep Island was 87.5 ± 2.01 mm [$n = 199$] compared to the initial mean SH of 86.4 ± 1.97 mm [$n = 189$]; final mean SH at Moosabec Reach was 90.0 ± 3.15 mm [$n = 102$] compared to the initial mean SH of 85.9 ± 1.54 mm [$n = 309$]). In addition, there was no significant handling effect on final mean length at either site ($P > 0.50$).

We plan to present the results given here at the March 2008 Fishermen's Forum. We presented this information to the Maine Department of Marine Resource's Scallop Advisory Council on 14 June 2007.

Results of our spat collection study, initiated in September 2007, will be available sometime during May 2008.

In summary, we have carried out each facet of our Northeast Consortium-funded project carefully and diligently, and it has guided us in the new directions we are currently proposing. The interaction between fishermen and scientists has been enlightening, and both groups have come to appreciate each other's perspectives, goals, and insights into what each feels necessary, important, and meaningful. We look forward to continuing the partnership we have forged.

Figure 4. Fate of sea scallops, *Placopecten magellanicus*, seeded at a density of 2.5 m^{-2} in bottom plots at the Moosabec Reach enhancement site from 9 May to 8 June 2007. One plot (wet storage) were lost during the 30-day trial.

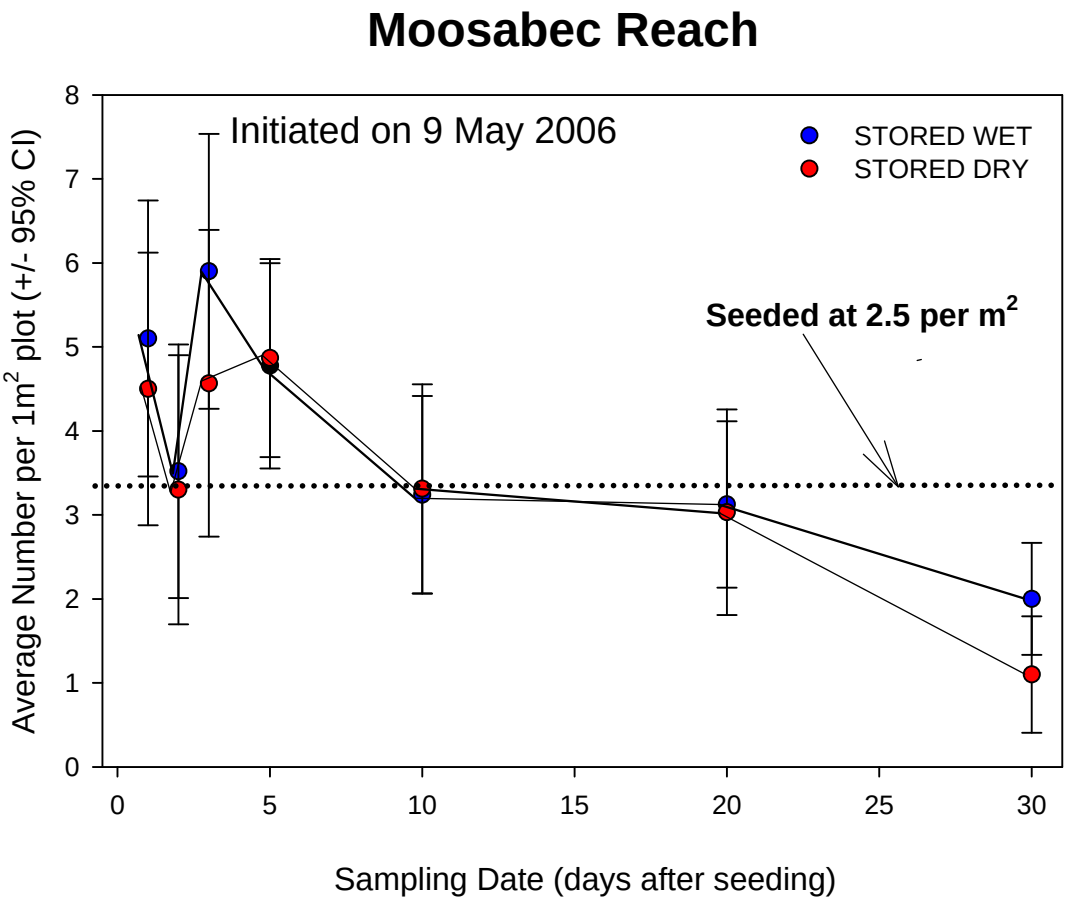

Table 4. Analysis of variance on the mean number of sea scallops per 1-m^2 quadrat on 7 dates from 9 May to 8 June 2007 at the Sheep Island enhancement site. (n = 4 or 5)

Dependent Variable: scallop

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Handling Treatment	1	18.30476190	18.30476190	0.80	0.4125
Sampling Date	3	132.7386691	44.2462230	3.85	0.0317
Sampling Date x Treatment	3	19.3547619	6.4515873	0.56	0.6488
Transect	1	16.73111511	16.73111511	0.12	0.7403
Treatment x Transect	1	29.34404762	29.34404762	0.22	0.6621
Sampling Date x Transect	3	44.97464029	14.99154676	0.47	0.7100
Date x Treatment x Transect	3	65.52023810	21.84007937	0.68	0.5781
Plot(Treatment)	5	114.6166667	22.9233333	1.30	0.2669
Date x Plot (Treatment)	15	172.4666667	11.4977778	0.65	0.8313
Transect x Plot (Treatment)	5	681.0916667	136.2183333	7.70	<.0001
Date x Transec x Plot(Treat)	15	482.1583333	32.1438889	1.82	0.0336
Error	224	3964.400000	17.698214		
Corrected Total	279	5746.996429			

Data

The data we have collected to date have been analyzed using SAS software. The format that we have used to determine growth and survival at both sites has been placed into SAS files. These files will be submitted to the NEC Fisheries and Ocean Database after consultation with Dicky Allison at Woods Hole, but all data are contained in files on this CD.

Impacts and Applications

To date, the project has had a great impact on the project participants and the fishermen that these individuals fish within the Beals-Jonesport region. They are encouraged by the results of the closed area work, and wish to expand the effort to include new sites. Hence, they worked on a 2008 NEC consortium proposal that was submitted in December 2007.

Partnerships

To date, all the fishermen listed in the participant list, plus two others have been directly involved in the project. There have been three scientists involved directly. Fishermen have been involved with using their boats as research platforms for data collection, and they have communicated the findings to others in the local community.

Presentations

A presentation was made by the PI to the Maine Sea Scallop Advisory Committee on 14 June 2007. The title of the presentation was the same as the title of the project. It occurred at the third floor meeting room at the office complex of the Maine Department of Marine Resources in Halowell, Maine. Another presentation is scheduled for Saturday, March 1, 2008 at the Fishermen's Forum in Rockport, Maine.

Student participation

Eight undergraduate students from the University of Maine at Machias have been involved in the project to date.

Images

All images that have been taken using a digital camera are contained on the CD.