Table 9.1. Lee Counties logged artificial reef additions by year, with reef relief totals (height from depth). Information about spread, or length of additions was not available.

Year	Added Reef Relief Totals (ft)
2008	16
2007	135
2006	73
2005	29
2004	34
2003	8
2002	39
2001	74
2000	109
1999	64
1998	32
1997	80
1996	no Data
1995	12
1994	46
1993	166
1992	8
1991	8
1989	26
1988	14
1987	no data
1986	no data
1985	no data
1984	no data

Table 9.2. Species list for trawls completed in October of 2009 and April of 2010. The relative occurrence of each species is also listed, from abundant, common to uncommon, or rare.

Genus species	Common Name	Relative Occurrence Oct-2009	Relative Occurrence Apr-2010
**Lagodon rhomboides*	Pinfish (diet size shift)	abundant	abundant
***Nicholsina usta*	Emerald parrotfish	uncommon	uncommon
Echinaster sentus	Spiny seastar	common	common
Paralichthys lethostigma	Gulf flounder	common	common
Orthopristis chrysoptera	Pigfish	abundant	abundant
Serranus subligarius	Belted sandfish	uncommon	common
Chaetodipterus faber	Spade fish	uncommon	common
Sphoeroides nephelus	Southern pufferfish	common	common
Syngnathinae spp.	Pipefish	common	common
Parablennius marmoreus	Seaweed blenny	common	common
Scartella cristata	Molly miller blenny	uncommon	common
Panopeus sp.	Mudcrab	abundant	abundant
Haemulon favolineatum	Grunt	common	abundant
Acanthostracion sp.	Cowfish	common	common
Hippocampus sp.	Seahorse	uncommon	uncommon
Opsanus tau	Oyster toadfish	uncommon	uncommon
Diplodus argenteus	Porgie	common	common
Lactophrys sp.	Trunkfish	common	common
Monacanthus ciliatus	Filefish	abundant	uncommon
Eucinostomus argenteus	Spotfin mojara	common	common
Prionotus scitulus	Sea robin	uncommon	uncommon
Amaroucium stellatum (?)	Sea pork probably	common	common
Penaid spp.	commercial shrimp	abundant	abundant
Bairdiella chrysoura	Silver perch	uncommon	uncommon
Diopatra cuprea	Onuphid worm	uncommon	uncommon
Libinia spp.	Spider crabs	common	common
Tozeuma carolinense	Arrow shrimp	uncommon	common
***Lytechinus variegatus*	Varigated sea urchin	uncommon	uncommon
Ogcocephalus nasutus	Shortnose batfish	rare	uncommon
Metaporhaphis calcarata	Long leg crab	rare	rare
Scorpaena brasilensis	Scorpion fish	uncommon	uncommon
Lutjanus synagris	Lane snapper	abundant	common
Chilomycterus atinga	Striped burrfish	common	common
Lutjanus griseus	Mangrove snapper	abundant	uncommon
Epinephelus itajara	Goliath grouper	common	rare
Petrolisthes spp.	Porcelain crabs	abundant	abundant
Mycteroptera microlepis	Gag grouper	uncommon	rare
Archosargus probatocephalus	Sheepshead	uncommon	common
Callinectes sapidus	Blue Crab	uncommon	uncommon

* Indicates potential macroalgae grazer species.

Table 9.3. Palatability designated based on the literature. Column 1, the % of each individual species contributes to overall study combined biomass. Column 2 from Steneck and Watling (1985) with palatability based on the algal morphology. Colum 3 from Duffy and Hay (1990), based on algal "tolerance" to herbivory from low (unable to withstand heavy grazing) to high (turfy, will not affect entire plant). Column 4 from Littler and Littler (1980), scale using successional stage of algae with early colonizers susceptible to grazers, late successional species or less susceptible stages. Column 5 from Cobb and Lawrence (2005), diet preferences of two urchin species, *Lytechinus variegatus* ("L") and *Arbacia punctulata* ("A"). Scale also includes preferrred "+" or "-" avoided. Column 6 from Klinger (1982) uses feeding apparatus (Aristotle's lantern) ease of algal manipulation (not flat or blade-like). This scale is the effectiveness of urchin feeding on algae, easy for urchins to ingest vs. hard to ingest.

2010	% of Total Biomass	Steneck and Watling, 1985	Duffy and Hay 1990	Littler and Littler, 1980	Cobb and Lawrence, 2005	Klinger 1982
**Spyridia filamentosa*	9.2	1	2	1		easy
Chondria collinsiana	5.9	2	3	2		mod
Polysiphonia flaccidissima	5.7	1	2	1		easy
₮ *Gracilaria tikvahiae*	5.6	2	3	2		mod
**Gracilaria blodgettii*	4.8	2	3	2		mod
2009						
**Hypnea spinella*	9.6	2	3	2		mod
**Acanthophora spicifera*	6.3	2	3	2		mod
* ₮ *Solieria filiformis*	5.8	2	3	2		mod
₮ *Gracilaria tikvahiae*	5.6	2	3	2		mod
* ₮ *Botryocladia occidentalis*	5.4	2	3	2	L+,A+	mod
2008						
* ₮ *Solieria filiformis*	12.8	2	3	2		mod
* ₮ *Botryocladia occidentalis*	12.4	2	3	2	L+,A+	mod
**Gracilaria blodgettii*	10.7	2	3	2		mod
**Hypnea spinella*	9.4	2	3	2		mod
₮ *Gracilaria mammillaris*	6.4	3	4	2		hard

*****Indicates species used single species feeding trials; ₮, indicates species used in multiple choice experiments.

Table 9.4. Field notes and dates of deployment and assessment of exclusion cages. Note: three-1 m quadrats were placed at each site at random locations, field notes are as follows: L = *Lytechinus variegatus*, A = *Arbacia punctulata*, P = Pen shells.

Site	Date deployed	Check date	Check date	Check date	Check date	Check date	Check date
Redfish Pass RECON	June 9 2010	July 8, 2010	July 13, 2010	Aug. 9, 2010	Aug. 17, 2010	Sept.14, 2010	Note: Cages pulled
Notes		Some algae outside of cages on shells, light fouling, no algae inside cages, 1 cage pulled because of missing rebar	Redeployed cage #166, algae growing inside cages at 5% cover, 1 m^2 quadrats: (1) 15, (2) 10 and (3) 10 % cover, observed same species inside and outside (*G. mammillaris*)	No visibility, cages could not be seen	No urchins, no algae inside or outside. 1 cage is completely blocked by encrusting bryozoans and hard things, no light getting in.	All cages severely fouled, pulled for cleaning.	
Blind Pass RECON	June 9, 2010	July 8, 2010			Aug 17, 2010	Sept ember 14, 2010	
Notes		Light fouling, no algae inside			No visibility, cages could not be seen	Very bad visibility, seemed to be intact, no algae	No algae found in any cages, but algae found in 1 m^2 quadrats outside cage; (1) 15 % Cover, no urchins, (2) 25 % cover, no urchins, (3) 25 % cover, no urchins. Algae identified as *Gracilaria tikvahiae* and *Spyridia filamentosa*
GOM10	June 7, 2010	July 7, 2010	July 28, 2010		August 19, 2010	September 17, 2010	
Notes		1 cage missing, other one up above the sediment from possible scouring. Cage fixed, 2 cages remained	1 cage re-deployed, hitting hard bottom with rebar. 2 cages above the sediment level.		2 cages left, both above the sediment line. Rebar could not be pounded in.	Cages still above the sediment, concluded experiment at this site in September.	

Table 9.4 cont. Field notes and dates for deployment and checking of exclusion cages. Note, three-1 m^2 quadrats were placed at each site at random locations, field notes are as follows: L=*Lytechinus variegatus*, A=*Arbacia punctulata*, P=Pen shells.

Site	**Date deployed**	**Check date**	**Check date**	**Check date**	**Check date**	**Check date**	**Check date**
GOMRECON	April 29, 2010	May 12 and May 27, 2010	July 14, 2010		August 15, 2010	September 17, 2010	October 19, 2010
Notes		Light fouling, no algae inside. May 27- No algae inside, numerous small urchins	2 of 4 cages were above sediment level, no algae outside or inside cages. Light fouling, no urchins of any size.		Very poor visibility, cages intact, no algae or urchins observed	2 of 4 cages above sediment line, 1 stone crab inside, no algae however; one cage pulled as it could not be inserted into sediment. Outside 1 m^2 quadrats: (#1) 2L; (#2) 3L; (#3) 1L	No algae found in any of the cages, 1 m^2 quadrats.:(1) 5L, 6A (2) 14L (3) 3L, urchins found inside cages also; (1) 8 L inside, (2) 7 A, 10 L inside (3) 7L inside. All cages removed.
GOM04	July 7, 2010			July 28, 2010	August 19, 2010	September 17, 2010	October 13, 2010
Notes				No urchins, 1% algae in cage #160 (drifting *Halymenia* sp.) quadrats: (1) 1% algae cover (*Halymenia* sp.), no urchins,(2) nothing,(3) nothing	No algae inside or out, quadrats: (1) 2P, 2L; (#2) 2P 1A; (#3) 3P	Not many urchins outside of cages, those observed on cage itself outside. Quadrats: (#1) 3P, 1L; (#2) 2P; (#3) 3P, 1L, a school of spadefish observed surrounding cages; no urchins inside of cages, all cages intact. Very small individual *G. mammillaris* found in 1 cage, (<1%). Jellyfish abundant.	Small urchins found in cages. Also algae found inside of cages: % cover per cage (#1) 100% cover, with 8 small urchins inside; (#2) 25% with 1 small urchin inside; (#3) 40% cover, with 5 small urchins inside. Quadrats outside cages (#1) 10% algal cover, 3 *Arbacia;* (#2) 5 % algal cover with 1 *Arbacia*; (#3) 25% algae with 5 *Arbacia* outside. Algal species both and outside the cages identified as *Agardhiella subulata*, and *Botryocladia occidentalis*.

Table 9.4 Cont. Field notes and dates for deployment and checking of exclusion cages (see above).

Site	Date deployed	Check date	Check date	Check date	Check date	Check date	Check date
GOM03	July 7, 2010			July 28 2010	August 19 2010	September 17, 2010	October 13, 2010
Notes				Quadrats: (#1)1L 1P; (#2) 2L; (#3) 3L 1P, no algae in cages. Cage #1, 8 *Lytechinus* inside, sand was scoured around cage edge.	Cage: (#1) urchins inside; (#2) 10 urchins inside; (#3) 12 urchins inside, 1 flounder and also a red drum inside. Quadrats: (#1) 12L; (#2) 1P, 13L; (#3) 2P, 4L,; lots of very small *Lytechinus* outside	Quadrats: (#1) 5L; (#2) 5L; (#3) 10L; no algae inside or outside, very poor visibility. Small *Lytechinus*, about 2 inches, some small enough to fit through cage mesh, within 3 cages 8, 5 and 2 urchins inside cages, respectively.	No algae found, Quadrats: (#1) 1L; (#2) 3L; (#3) 1A, 1L. One of three cages were securely attached, others were laying on their sides, with several legs detached and still in the sediment. One had a stone crab. A number of juvenile fish in area, including Atlantic spadefish and snapper individuals.
GOM01	July 7, 2010			July 28, 2010	August 19, 2010	September 17, 2010	October 13, 2010
Notes				No algae, lots of *Arbacia*. Quadrats: (1) 2L 1A,(2) (3)1A 1P, 1P 1 seastar.	1 cage missing, lots of small *Lytechinus*, replaced cage. Quads: (#1) 2L; (#2) 6L; (#3) 1P, 2L.	Cages not found, too poor visibility.	No algae found, cages intact. Inside cages: (#1) 3L; (#2) 5L; (#3) 8L. Quadrats: (#1) 1P, 5L; (#2) 1A 6L; (#3) 10L.
Light 1	July 7, 2010			July 28, 2010	August 19, 2010	September 17, 2010	October 13, 2010
Notes				Cage #1 partly open on top, more cableties used. Light fouling, all cages in sediment. Quadrats outside: (#1) 1 L, 1 A; (#2) 1L 1P; (#3) 1A 1L. No algae outside.	No algae, light fouling, small *Lytechinus*, 1 cage missing. Did not replace. Other cages intact.	Replaced 1 cage, 2L, 3A urchins in one cage; flounder inside also. Quadrats: (#1) 5L; (#2) 3L; (#3) 1L;	No algae found, all three cages were intact, with small urchins inside. Cage: (#1) 3L; (#2) 3L; (#3) 1A. Quadrats : (#1) 4L; (#2) 1A, 1L; (#3) 1P, 1A

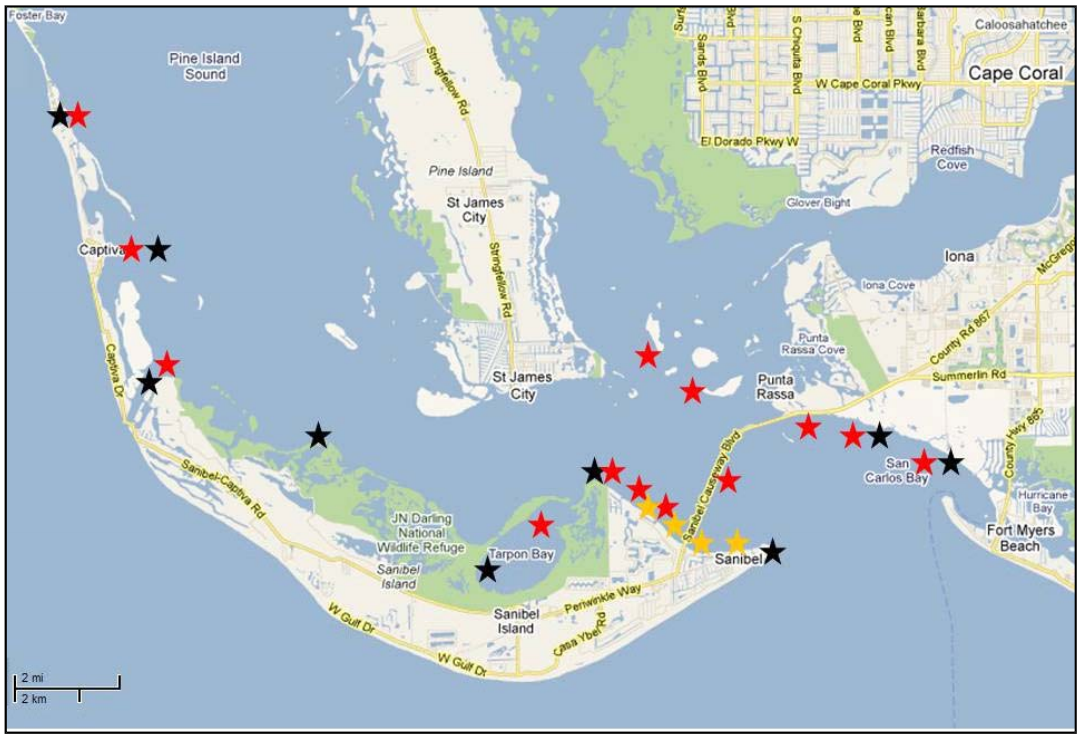

Fig. 9.1. Trawls made in October 2009 (black) and April 2010 (red). A survey made on September 10, 2010 by L. Coen and M. Thompson (orange), indicated that areas just east and west of the causeway have urchins 1-2 per m^2 also.

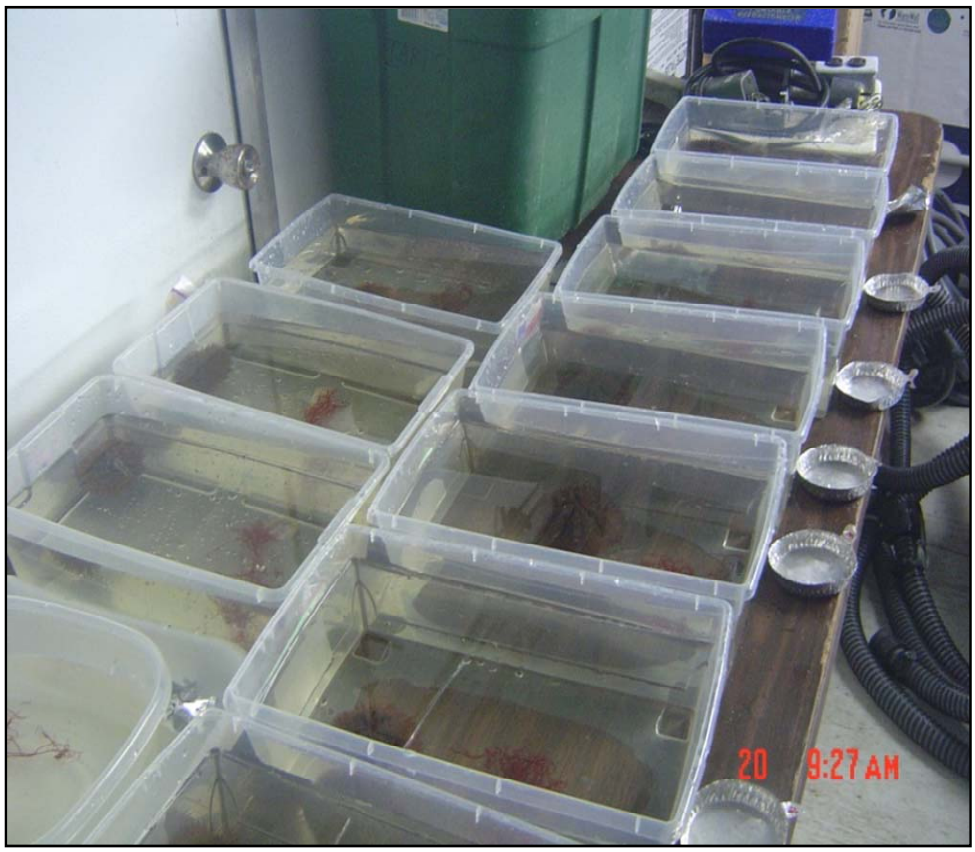

Fig. 9.2. Lab feeding trials utilized 1g (± 0.3g) of single species of algae, and also 1g (± 0.3g) multiple species of algae for the multiple choice experiment.

Fig. 9.3. SCCF Marine Lab mesocosm facility, three-300 gallon insulated holding tanks refitted with new circulating pumps/filters for holding urchins and macroalgae.

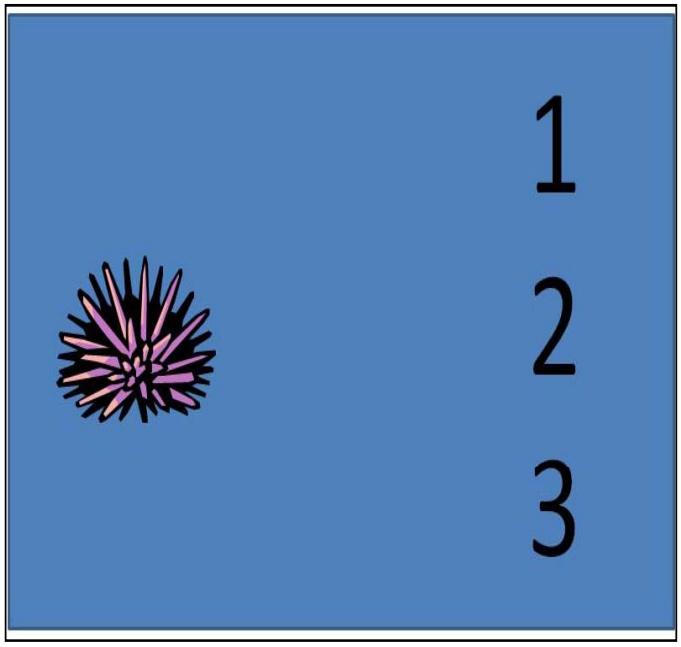

Fig. 9.4. Multiple choice experiments. Urchins were placed in 1 liter containers with the three species placed in random order on one side of the container. Urchins were observed every 15 minutes for 2 hours, and then every 30 minutes for 2 hours, for a total of 4 hours feeding time. Wet weight of algae left was measured following completion.

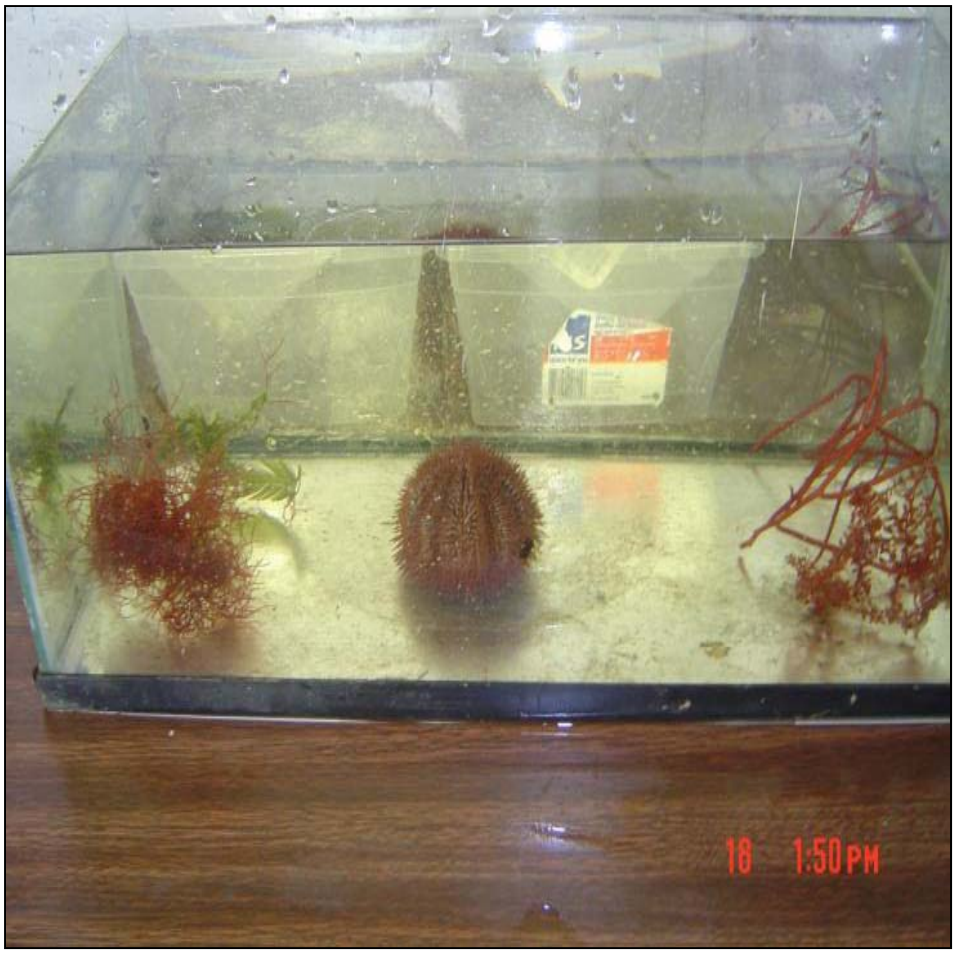

Fig. 9.5. Extended multiple choice feeding trial (n = 4 replicates). Urchins were allowed to feed overnight, (16 hours). Urchins (*Lytechinus* shown here) were placed in the center of a ten gallon tanks, with algae placed in each corner, thus urchins had an equal change of arriving at each species. Urchins were observed every 15 minutes or until they started to feed. Wet weight of algae remaining was taken the following morning (16 hours).

Fig. 9.6. Cage design, each cage had PVC frame, including legs, with rebar supports that were pounded into the sediment for deployment. Cages were numbered, and checked every 2-3 weeks for analysis. The same cage design was employed for both exclusion and inclusion experiments. Urchins were stocked at 3 per inclusion cage for the survival experiments, and 0 per exclusion cage. They were deployed so that the mesh bottom was embedded in sediment as deep as possible (14 cm generally).

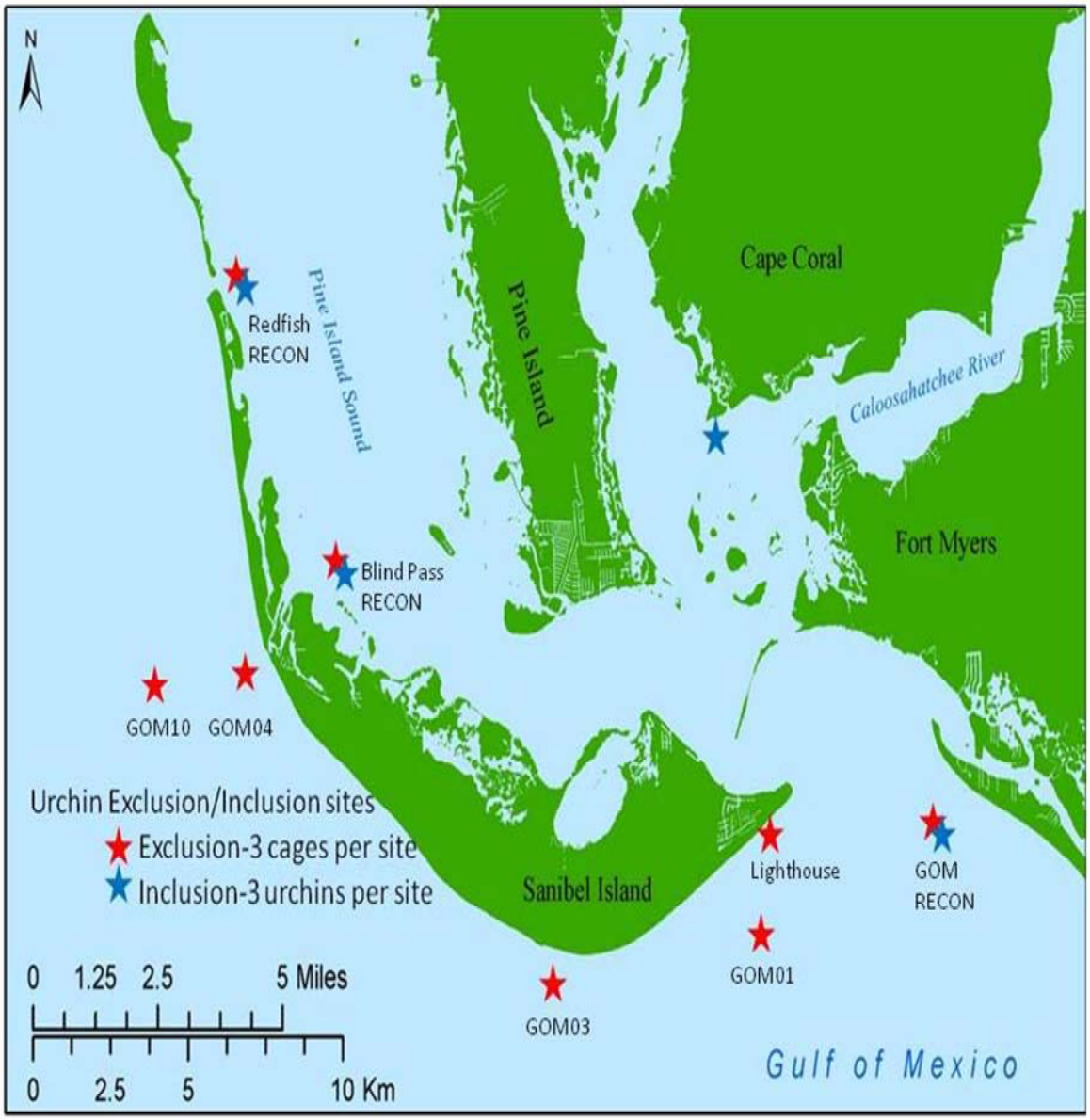

Fig. 9.7. Urchin exclusion/inclusion caging experiment placement. Cages were left for at least 3 months in the exclusion experiments, and 1 month (April 29, 2101 to end of May 2010) for the survivability experiment. Inclusion cages were located at the base of several of SCCF's real-time monitoring stations (RECON). These RECON sites were also used for the exclusion cages, deployed after the inclusion cage experiments were pulled.

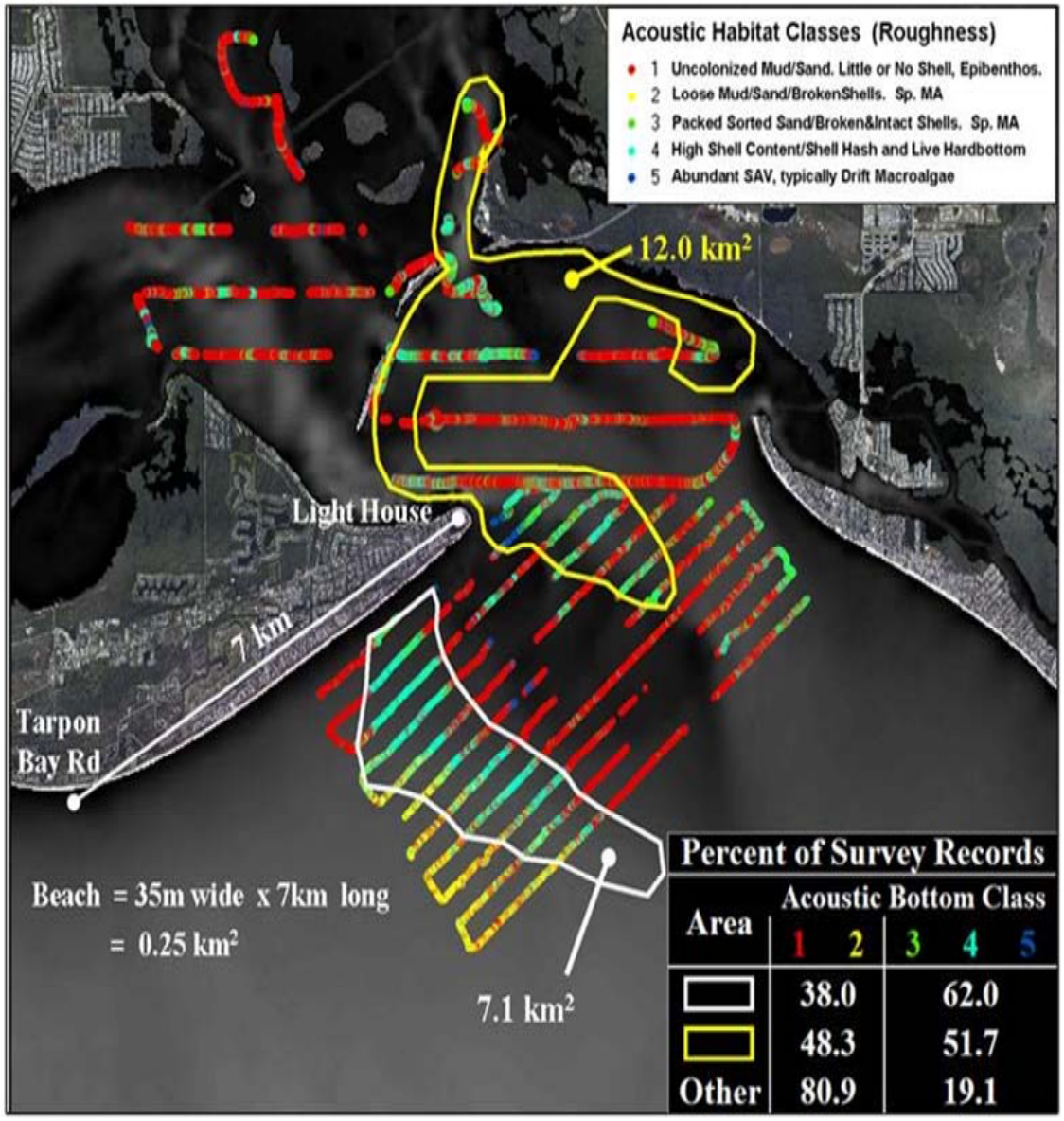

Fig. 9.8. Suitable or available habitat for algae attachment, taken from Hydroacoustic Video surveys conducted in 2010 by NOVA and UNH. Outlined area indicates areas of potential algae attachment sites. The Lighthouse Beach, Light 1 station was chosen within the outlined area, or high shell hash, live or hard-bottom sites close to Sanibel and Captiva and Ft. Myers Beach where urchins (*Lytechinus variegatus, Arbacia punctulata*) are often very abundant.

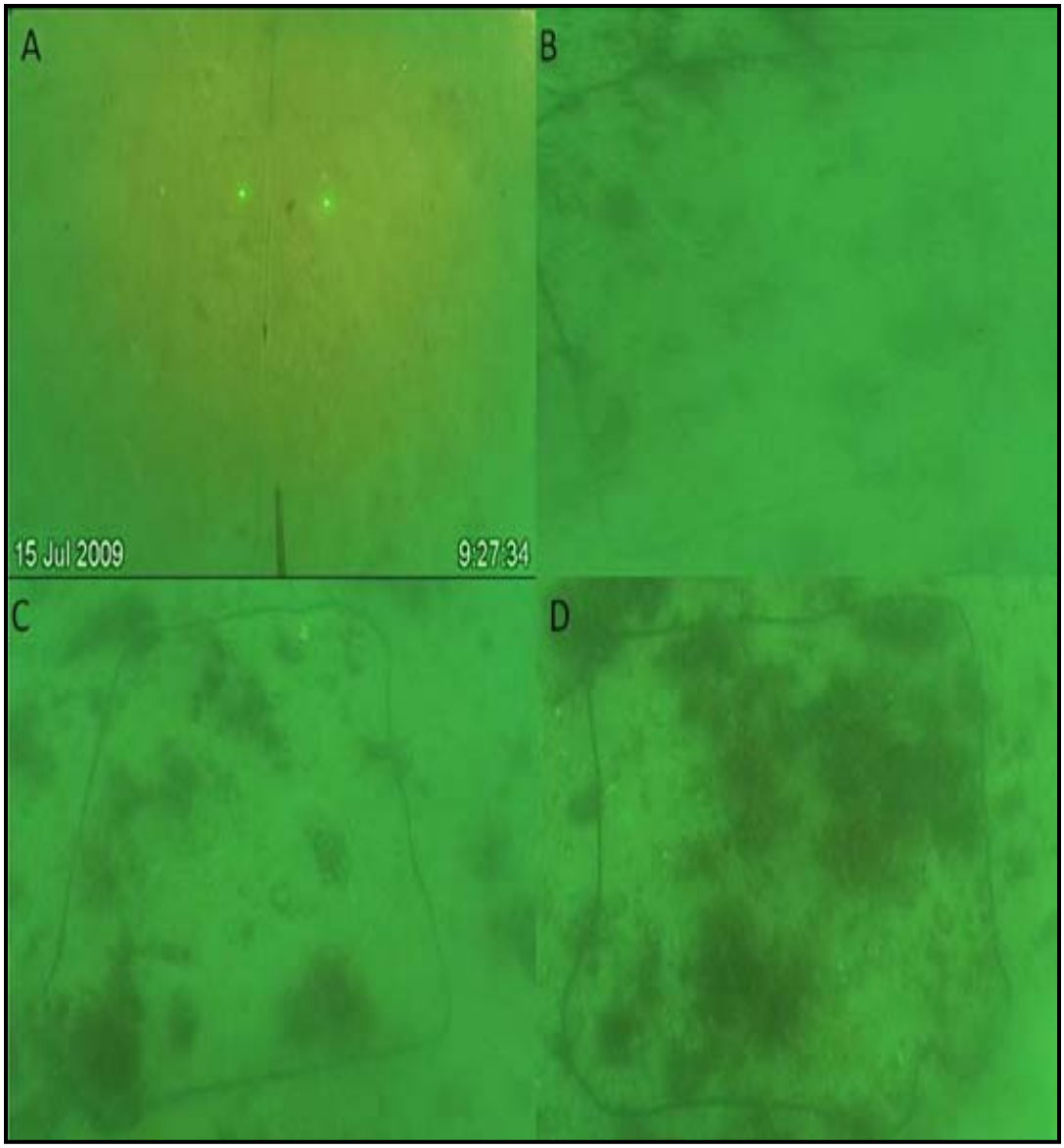

Fig. 9.9. Percent cover examples taken from GOM12 site. Visualization by divers was a 10 x 10 square grid, and divers estimated algal cover in each quadrat. (A) 0% cover, (B) 15% cover, (C) 30% cover; (D) 80% cover.

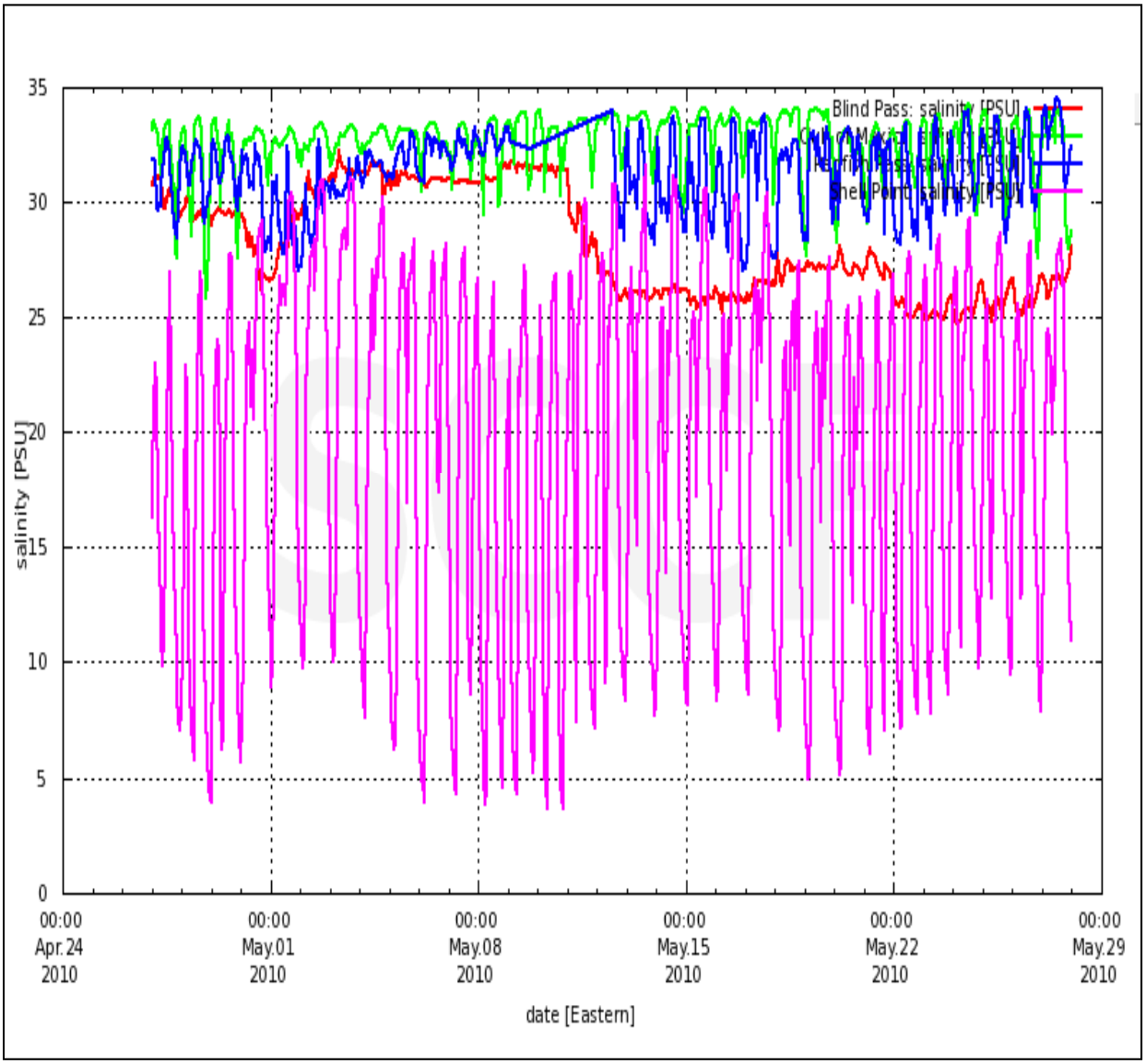

Fig. 9.10. Salinity data for the four *Lytechinus* urchin cage inclusion experiment. Cages were deployed at RECON stations on April 27, 2010, and were left for one month to assess urchin survival. Plot colors: pink is Shell Point RECON, blue is Redfish Pass RECON, green is Gulf of Mexico RECON, and red is Blind Pass RECON. Note that Shell Point (pink) varies over each tidal cycle often from near 5 over 30 ppt.

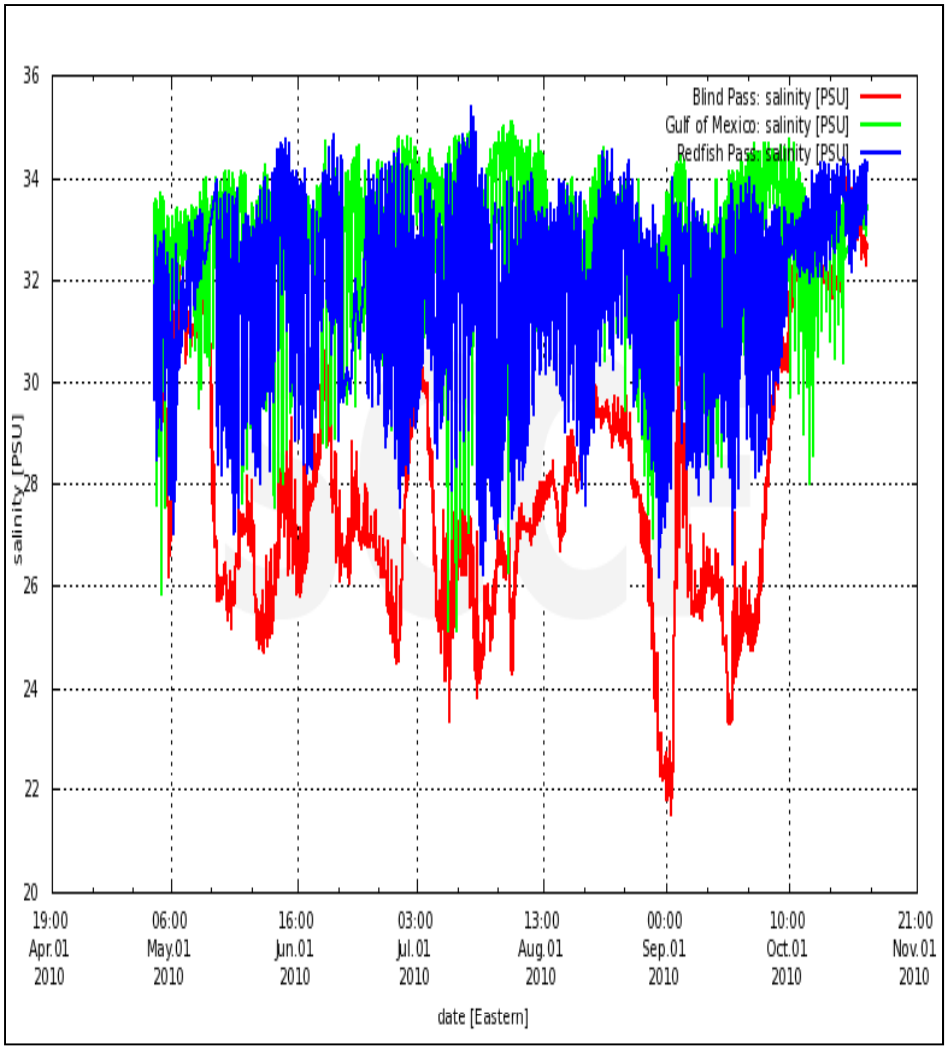

Fig. 9.11. Salinities at associated RECON sites for cages exclosure during the experiments. Cages were deployed starting in late May 2010, and left until October 2010.

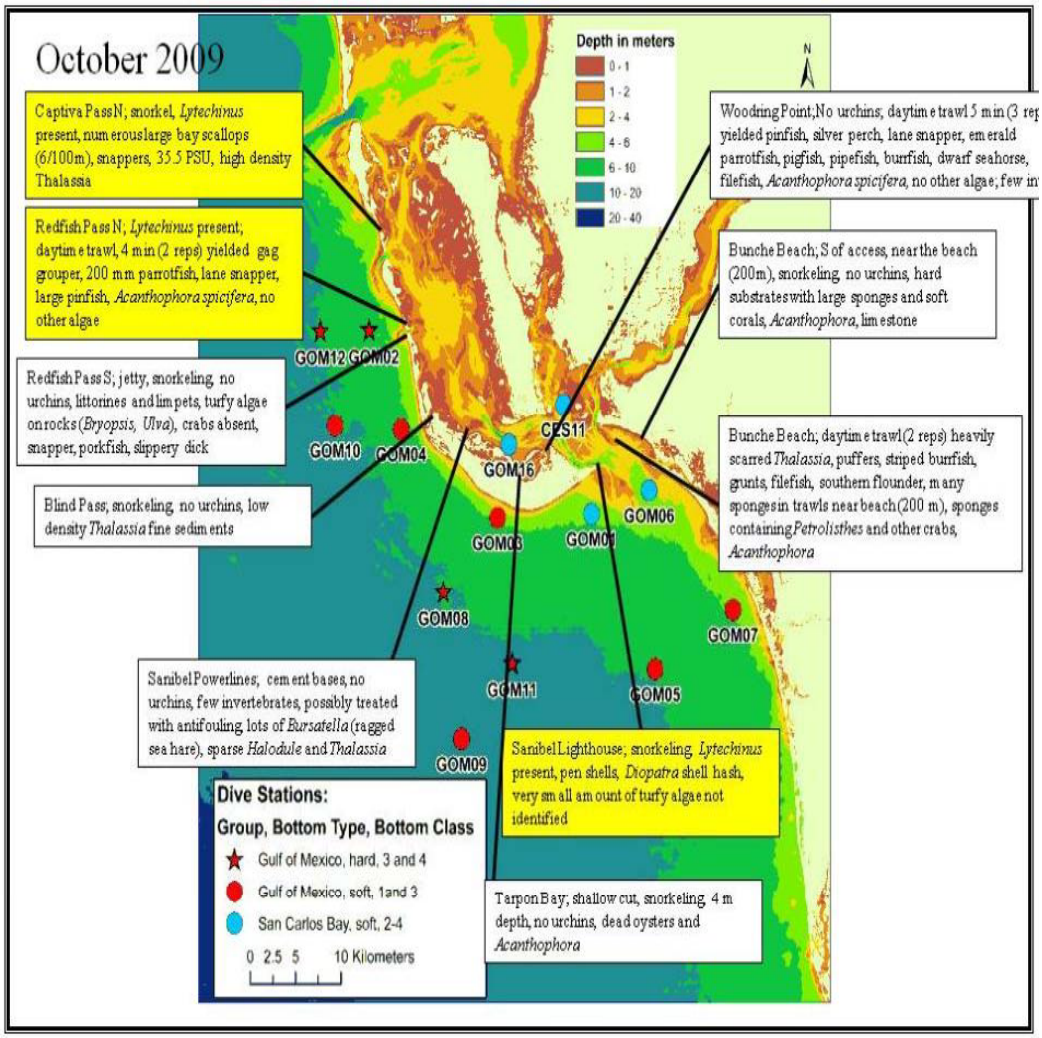

Fig. 9.12. Bathymetric map, dive stations, and locations of snorkeling and trawl surveys for October 2009. Highlighted boxes indicate areas where urchins were found based on information from focused sampling.

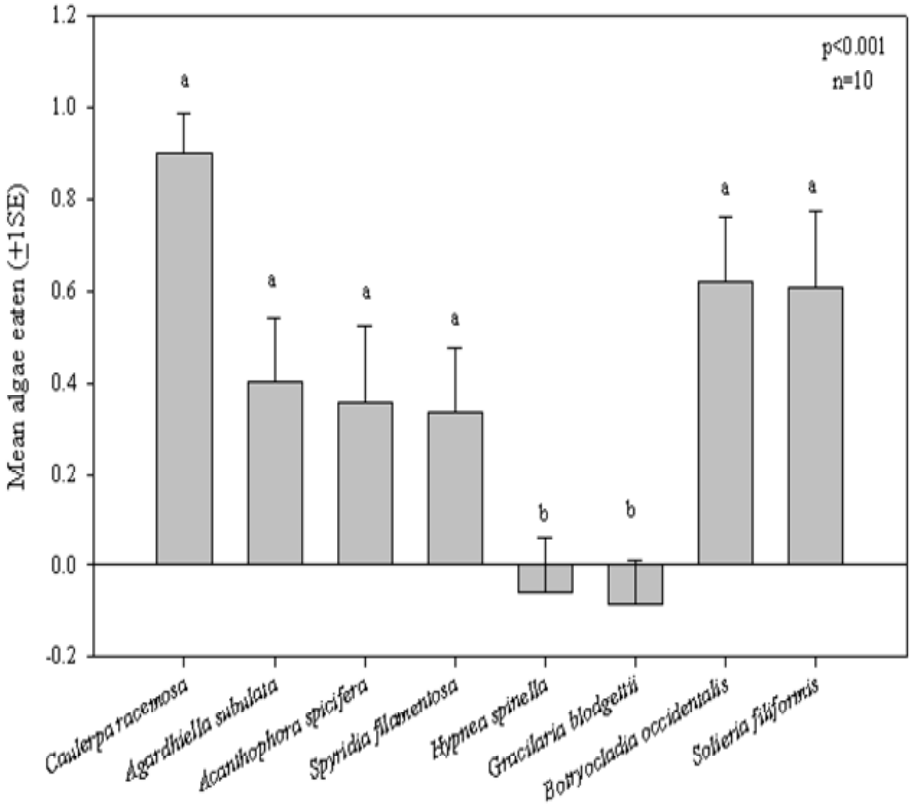

Fig. 9.13. Mean algae eaten per standardized urchin wet weight (+1SE) after four hours of single species feeding trials, a One-Way ANOVA (Sigma Stat) indicated a significant difference between means for group a vs. the rest of the trials ($P < 0.001$; $n = 10$ replicates per species). Note, *Gracilaria blodgettii, Agardhiella subulata,* and *Caulerpa racemosa, Botryocladia occidentalis* are species common to offshore and nearshore sites, while *Acanthophora spicifera, Spyridia filamentosa* and *Hypnea spinella* are more common at inshore sites. *Solieria filiformis* has been found in both areas that commonly have algae present.

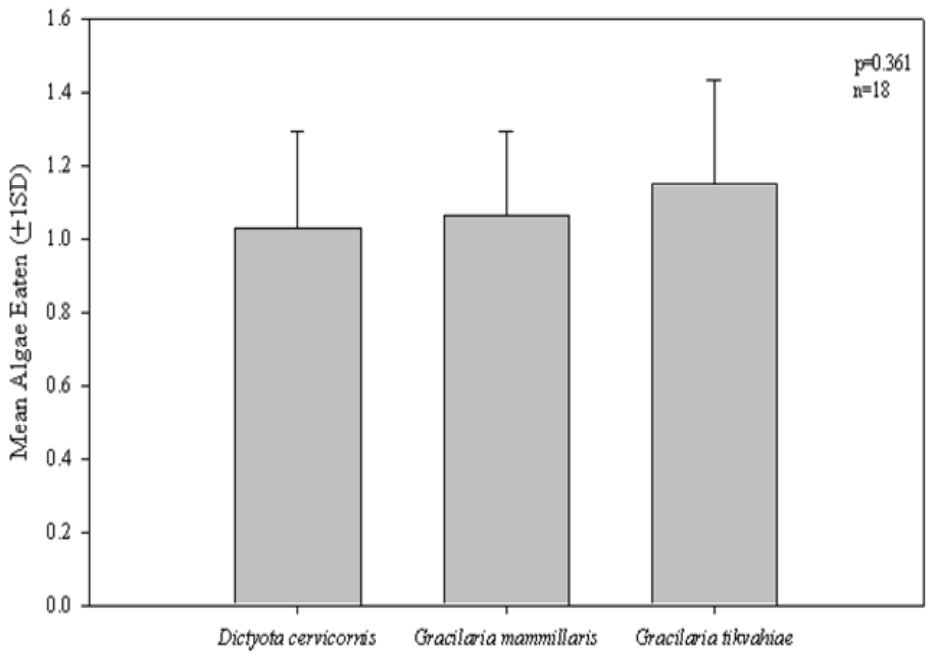

Fig. 9.14. Multiple choice feeding experiments. Mean algae eaten per standardized urchin wet weight (+1SE). Urchins were offered 1 g of each species of algae above, in random order. There was no statistical difference between algae eaten. This multiple choice experiment was run three separate times, with 18 replicates total (n = 18). Urchins arrived at *Dictyota cervicornis* first in 5 of the 18 (28%) trials; at *Gracilaria mammilllaris* 1 out of 18 (5.5%); for *Gracilaria tikvahiae* 6 out of 18 (33%), or did not move, 6 out of 18 (33%) runs. *Gracilaria tikvahiae* consumption was highest, with urchins arrived at this algae first more times than others (1.147 g eaten vs. 1.02 and 1.06 for *Dictyota cervicornis* and *Gracilaria mammillaris,* respectively).

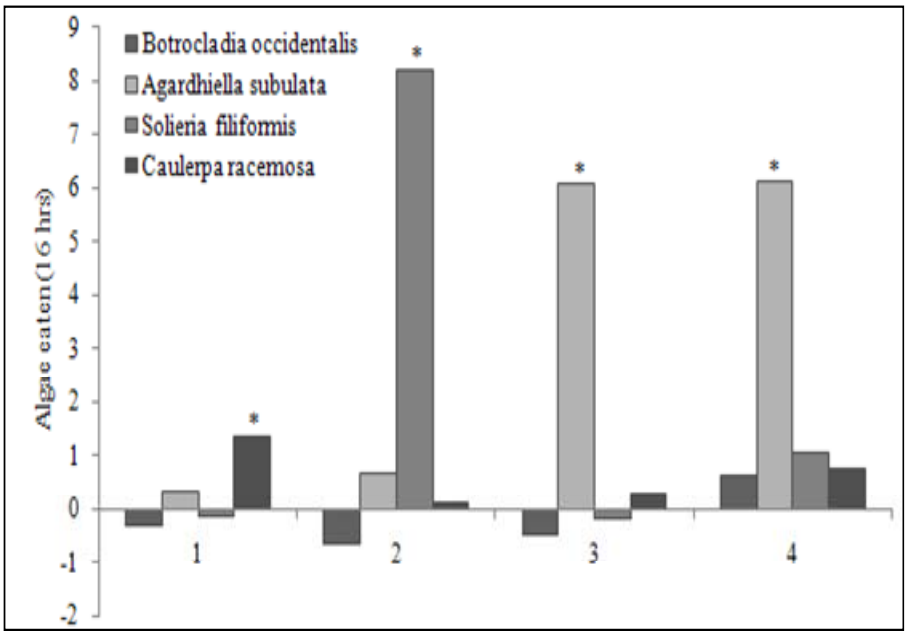

Fig. 9.15. Extended multiple-choice feeding experiment. Bars are algae eaten after 16 hours per mean *Lytechinus* urchin wet weight (109.73 g) for four trials. * indicates algal species that urchins went to first.

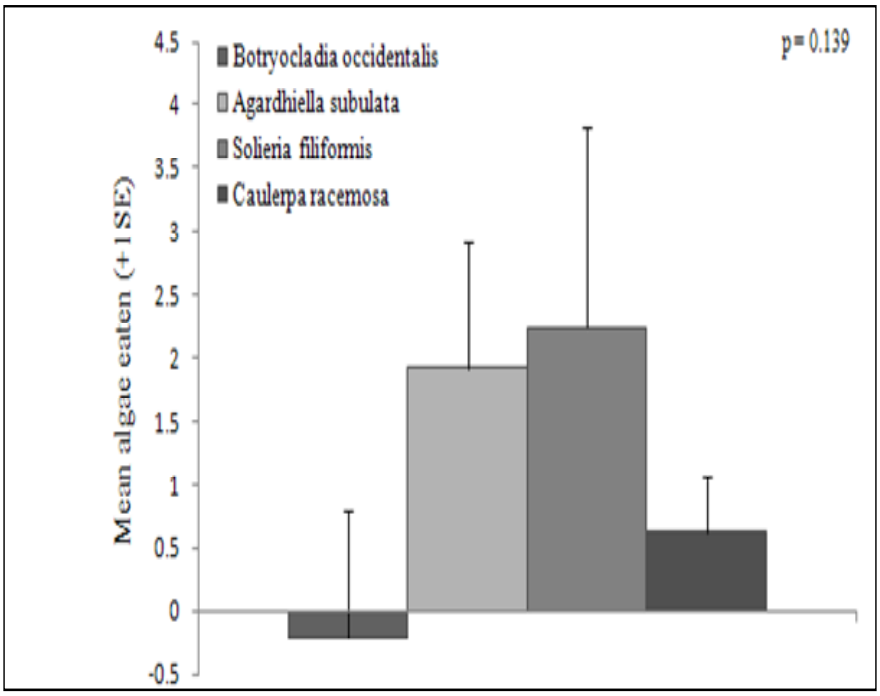

Fig. 9.16. Extended multiple choice feeding experiments. Bars are mean algae eaten after 16 hours per mean *Lytechinus* urchin wet weight (109.73 g). Mean of four replicates. *Lytechinus* arrived at *Agardhiella subulata* two out of four trials, *Solieria filiformis* one out of four trials, and *Caulerpa racemosa* one out of four trials.

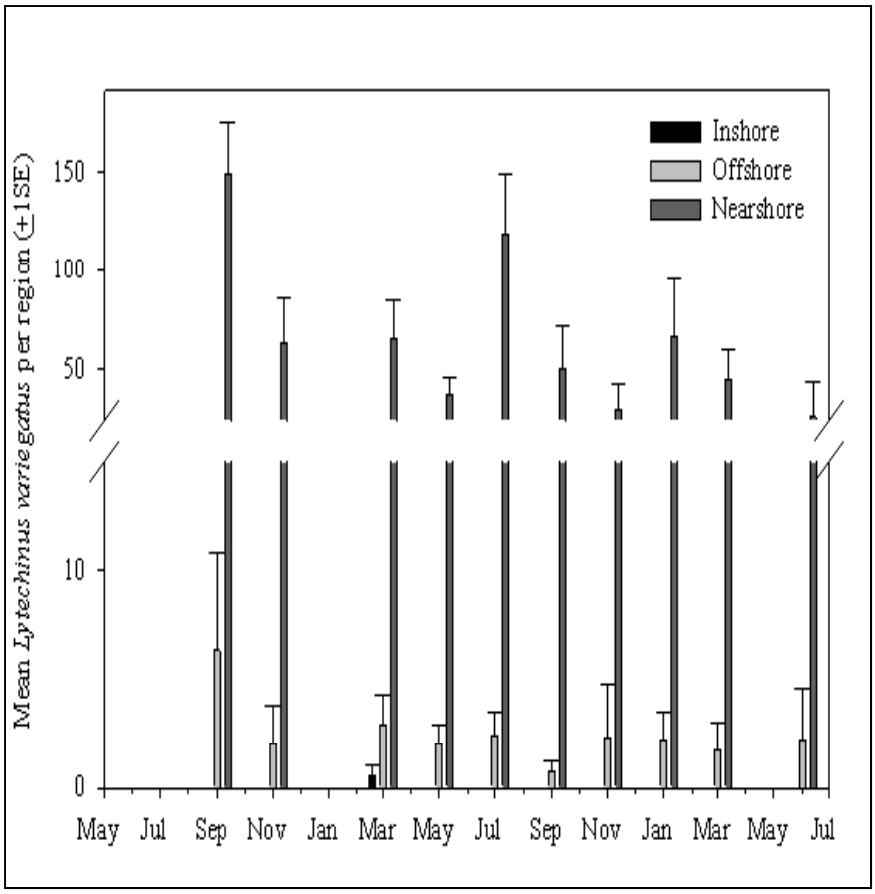

Fig. 9.17. Mean *Lytechinus variegatus* per 100 m^2 at study sites for the macroalgae biomass (Objective 5) section. Data were taken from video transect analysis. Note: scale break from 13 to 45. Nearshore regions had more urchins per 100 meters than other regions. Note, Table 9.4. is used to produce these estimates, for total m surveyed by video associated with each section.

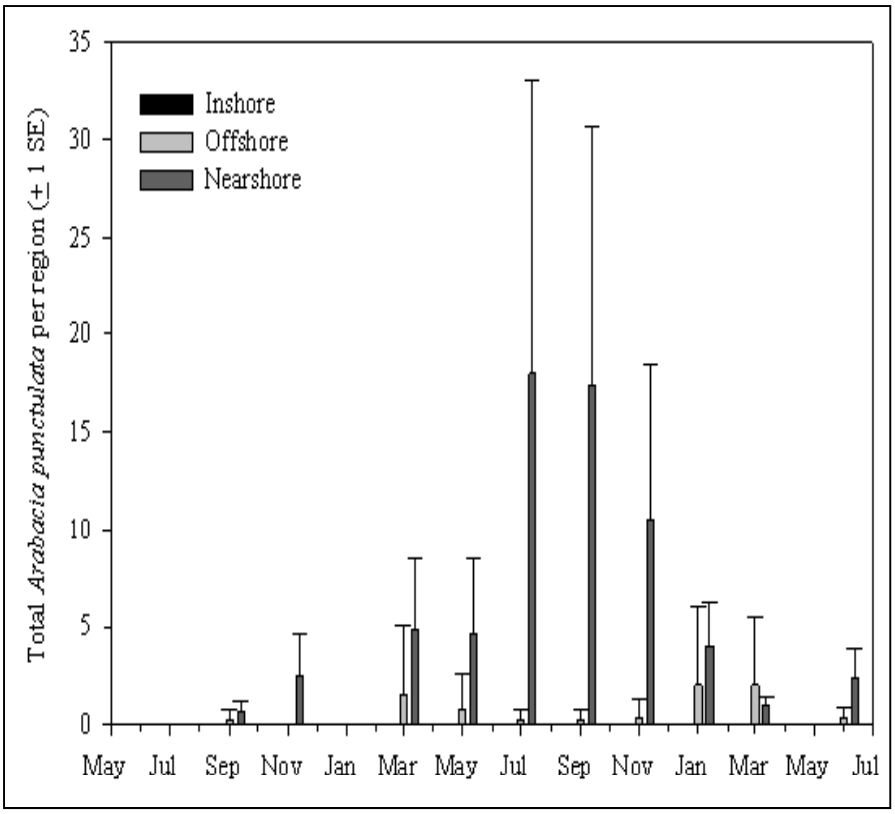

Fig. 9.18. Total *Arbacia punctulata* per 100 m^2 at study sites for the macroalgae biomass (Objective 5) section. Data taken from video transect analysis. Note scale break from 13 to 45. Nearshore regions had more urchins per 100 m than other regions. Note: Table 9.4 was also used to produce these estimates, and for finding total meters surveyed by video for each date.

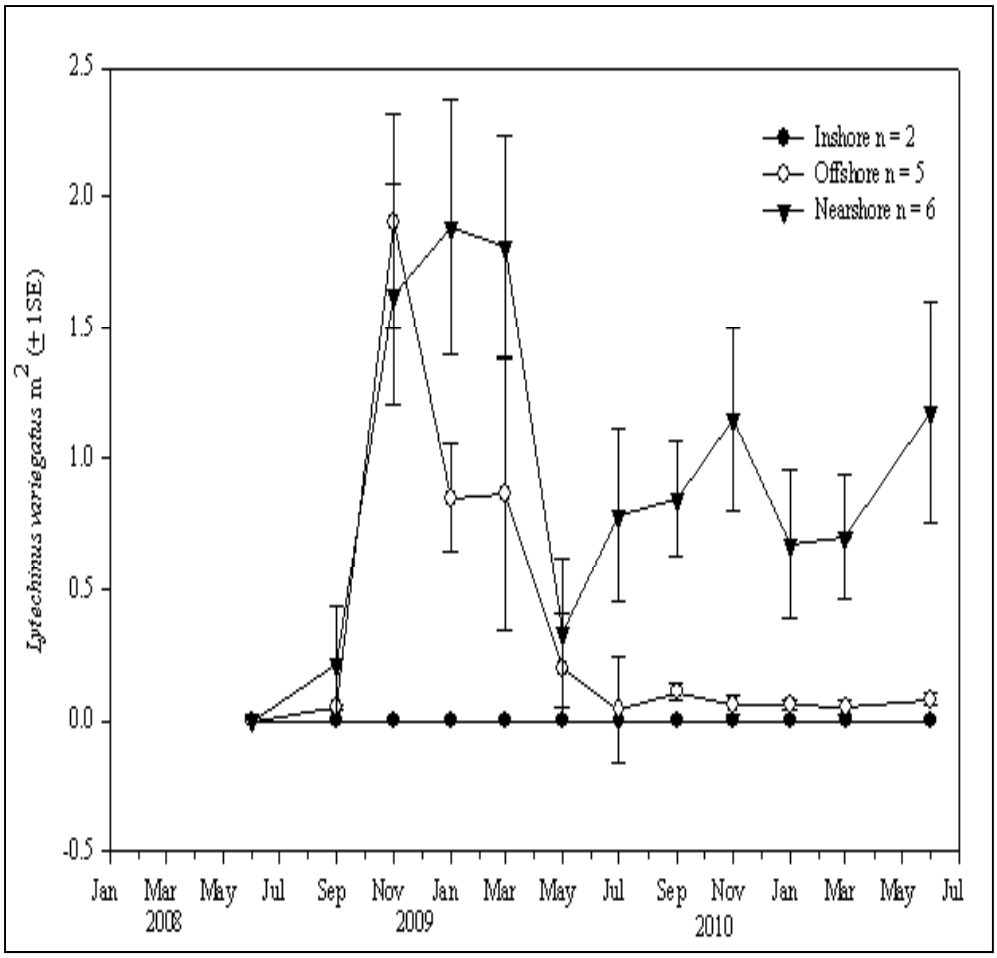

Fig. 9.19. Mean *Lytechinus variegatus* per m^2 ±1SE, from scheduled sampling sites associated with Objective 5. Data taken from diver analyses. Inshore group includes two stations, CES11 and GOM16; nearshore includes six stations GOM01, GOM02, GOM03, GOM04, GOM06 and GOM07; offshore includes five stations GOM05, GOM08, GOM09, GOM10, GOM11 and GOM12. Note: consistently 0 or low numbers of urchins for either inshore site.

Fig. 9.20. Cages were pulled in September 2010 due to extreme fouling. Sponges and encrusting bryozoans had to be removed with stiff brushes and chiseled off and often could not be cleaned sufficiently in the field.

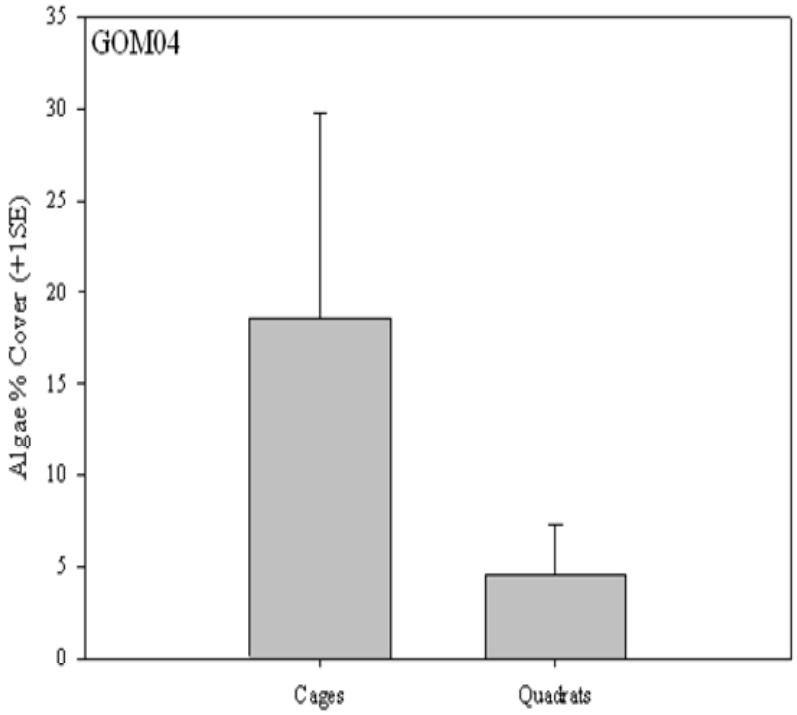

Fig. 9.21. Mean algae percent cover +1SE for station GOM04 for all dates checked (n = 12 cages, n = 12 quadrats; 3 cages and quadrats per visit, 4 visits), inside exclusion cages and surrounding quadrats outside of exclusion cages. Cages were checked every month for 4 months, three cages per site, and three quadrats per site per visit.

Fig. 9.22. Cage located at the Light 1 site. This station often had very poor visibility. Urchins (note with shells held at arrow) and pen shells were common at this site.

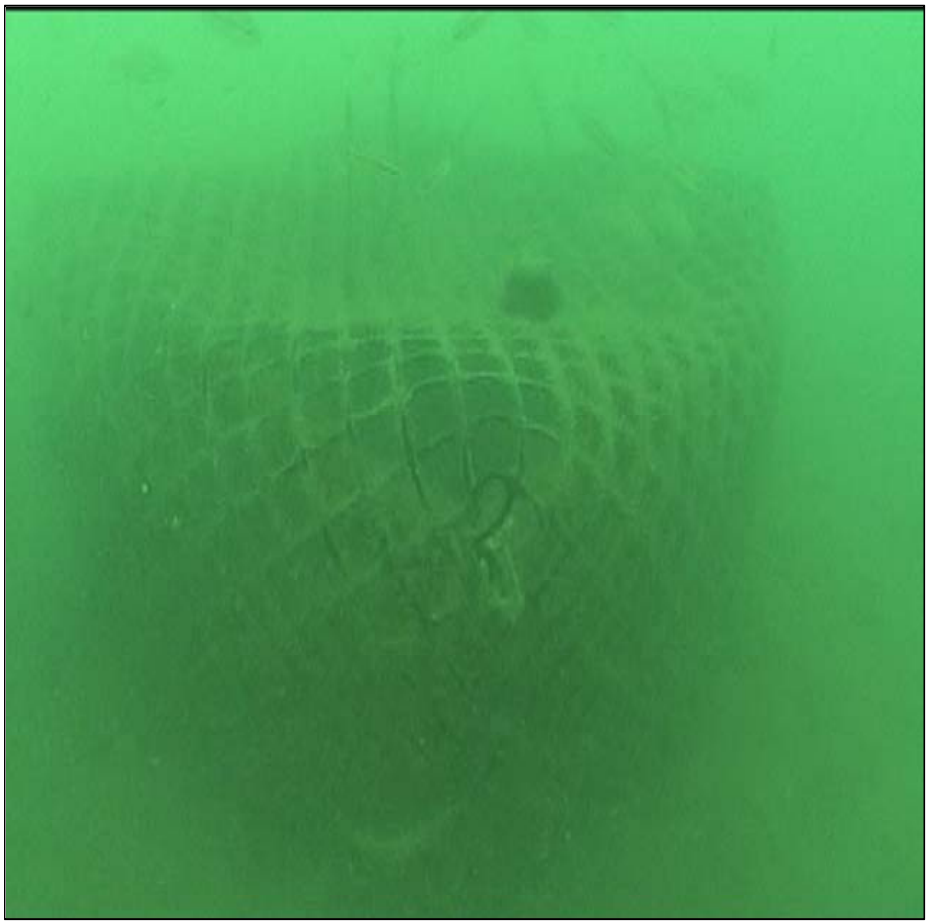

Fig. 9.23. Cages at GOM01. Fouling was minimal at this site; however, visibility was typically poor for assessing cages and outside community. Note *Lytechinus variegatus* on top of cage, and fish school behind it.

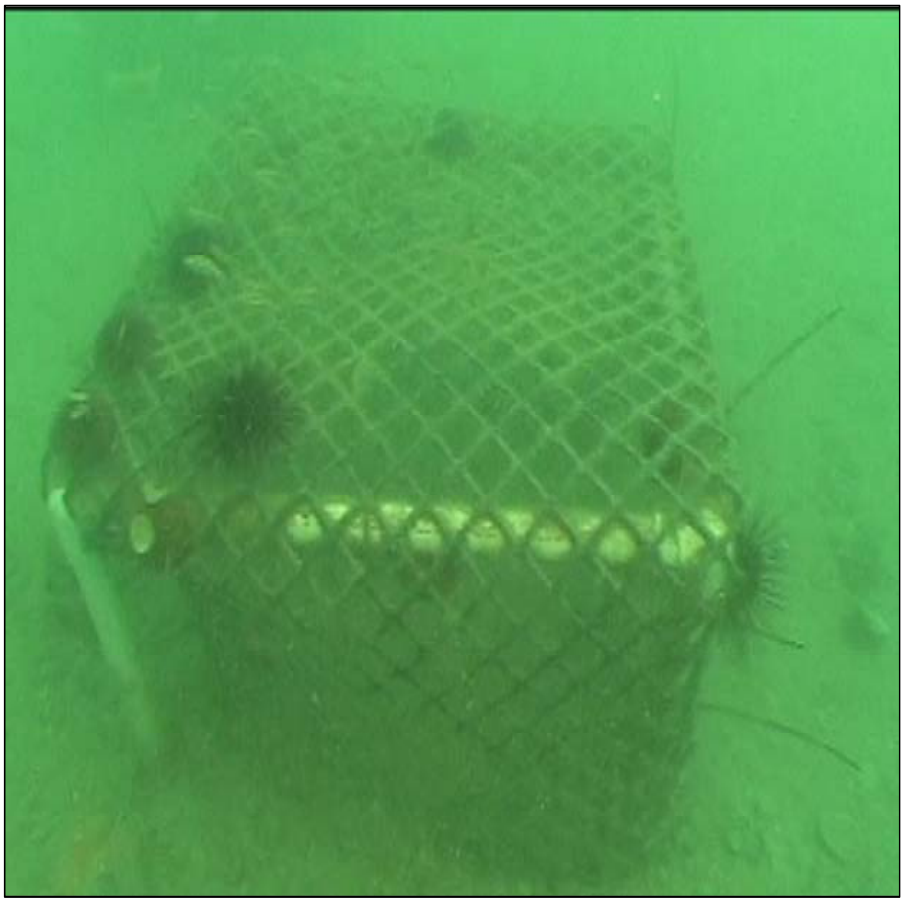

Fig. 9.24. Cages at GOM03. Note two species of urchins (*Lytechinus variegatus* and *Arbacia punctulata* with long spines) on the outside of cage. Fouling was moderate at this site, and visibility was sometime good enough to see or photograph the cages.

Fig. 9.25. Cage located at GOM04. Note algae inside the lower right corner, small *Halymenia psuedofloresia* individual found in July 29, 2010. Note sediment texture in photo with coarse shell material.