Monitoring and Assessment of Maine's Sea Urchin Resource

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Photo by Rachel Feeney, Northeast Consortium

SEA URCHINS

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Executive Summary:

During 2009 – 2014, information about the Maine green sea urchin was collected through a commercial fishery monitoring (port sampling) program, and an annual fisheries-independent dive survey.

Job #1: Biological Monitoring of the Sea Urchin Resource and Fishery

Background:

The green sea urchin, *Strongylocentrotus droebachiensis* (Müller), has been harvested for human consumption since prehistoric times. A small commercial fishery for sea urchins has existed in Maine since at least the 1940's, to ethnic markets in Boston and New York, and, in the 1970s, to Europe. The fishery expanded rapidly in 1987 when a market developed in Japan. Sea urchin "roe" is a delicacy in Japan, Europe, and ethnic markets in the USA, and, more recently, other high-end domestic markets (Pols, 2014).

The fishery occurs primarily in shallow waters during the winter, with landings currently occurring between September and March. Urchins are harvested by divers using SCUBA (with an occasional snorkeler) and by draggers, plus a few rakers who stand in the shallows and rake during low tide. In the 2013–14 season, 60% of the landings were made by about 115 active divers and 3 rakers, and the remaining 40% by about 86 draggers, according to preliminary dealer reports (Maine DMR, unpublished data).

The Maine coastline is divided into two management zones. Landings by zone (from dealer reports) are shown in Table 1 and Figure 2, and exhibit a classic boom-bust cycle.

Purpose: The project has two objectives.

1. Determine spatial/temporal patterns in catch, effort, catch per unit effort, gonad condition, size composition, percent roe, and test (shell) condition of dive and drag harvested urchins – fishery dependent data which are useful for resource monitoring, assessment, and management.
2. Conduct a fishery-independent survey of Maine's sea urchin resource using SCUBA diving techniques, to develop a time series of abundance and biomass indices for the state by region.

Approach, Objective 1:

This report covers the period from the beginning of the 2009–10 fishing season through the 2013–14 season, or September 2009 through March 2014, and also the spring 2014 dive survey. Because there is no sea urchin fishing in Maine during the late spring and summer months (April – August), harvest data are collected and compiled for each fishing season, rather than by calendar year.

A commercial sea urchin port sampling program was initiated during the 1994–95 fishing season. A description of the program and methods can be found in Hunter *et al*. 2010. Divers, rakers, and dragger captains are interviewed at landing sites for landings and effort data, and biological samples are collected. We attempted to sample in each of the two management zones (Figure 1a) during the open season at randomly selected buying locations, during weather conditions when harvesters were active. Sampling activities were usually confined to locations where at least five harvesters were expected to unload their catches. The sampling schedule was confounded by a complicated season of different fixed open days for the two zones, different days for the two gear types (dive/rake and drag), and the harvesters' choice of either an early or late open season for each zone and gear. This resulted in up to eight different open seasons, which sometimes overlapped. The first season began in September, when management Zone 1 opened for early divers for ten or fifteen days, usually spread over about three–four weeks, and continued as the early Zone 1 season closed and the Zone 2 early season opened, usually in October with about three open days per week; then the Zone 1 and Zone 2 late seasons opened in

December, and the Zone 2 late diver and dragger seasons continued for about three days per week through March. Because landings, participation in the fishery, and the number of open days in Zone 2 have declined (Tables 1 and 2), our sampling schedule was reduced from roughly once a week to about once every two weeks, except when both zones were open at the same time.

We tried to proportionally allocate the sampling trips to each coastal county where fishing occurred (Lincoln and Knox in Zone 1, and Hancock and Washington in Zone 2 - see Figure 1a) by the importance of the county to overall landings. More interviews and samples were obtained in counties with more buying locations and more landings. The sampling of urchin landings by proportional allocation was complicated by a constant change in the numbers and locations of buying stations during the course of the season. Achieving representative sampling has been a challenge, and random sampling approaches have not worked because of the shifting and mobile nature of the buying stations (which varied from long-established buyers with their own shops to buyers in a truck parked on the side of the road), a limited market which shut some buyers down on some days, the complicated season structure described above, and because of severe weather conditions during what is predominantly a winter fishery.

During a sampling trip, as many divers and draggers as possible arriving at the buying station to sell their catch were asked about their fishing experience (age and years fishing), effort for the day (bottom hours and away hours for divers; drag hours and away hours for draggers), boat length, location of fishing (10-minute square), depths fished, total catch (lbs), price, and estimated urchin roe content (%). A random sample of 20 urchins was collected from each catch when possible, and each of these was weighed, measured (test diameter), evaluated for shell/spine condition, and returned to the buyer.

Findings, Objective 1:

The numbers of interviews conducted, sea urchins measured, and calculations of sampling intensity are listed, by season, in Table 3. Over the past five seasons, program staff interviewed

harvesters representing an average of 4.2% of the fishery (by landed weight) and measured an average of 0.025% of the landed sea urchins.

Daily catches, diver ages, boat lengths, and hours fishing — Information recorded from diver and dragger interviews during the 2009-2010 through 2013-14 seasons is shown in Tables 4-7.

The median daily catches for Zone 1 divers in the past five seasons have been higher than the previous five seasons, while the reverse is true for Zone 2 divers and draggers. The new daily trip limit (7 trays, about 616 lbs or 0.28 mt) in Zone 2 in 2013-14 did not seem to cause a reduction in daily catches compared with the previous year (Table 4).

Interviewed divers in Zone 1 are generally older than in Zone 2, about 52 years old in Zone 1 and 43 years old in Zone 2 (Table 5).

Dive boats in Zone 1 are generally smaller than in Zone 2 (Table 6). This is probably because most sampling in Zone 1 is conducted in September, when divers can fish from open skiffs. Dive boats in Zone 2 were smaller than draggers, about 30 feet (9.1 m) long vs 38 feet (11.6 m).

There were no obvious trends in diver bottom time or dragger drag time over the past five seasons (Table 7).

Catch Rates — Landings per unit effort (LPUE) is presented as a proxy for catch per unit effort (CPUE) here. However, using LPUE as a proxy for catch rates is problematic, if catch methods and/or discard rates have not been stable. The implementation of culling on bottom rules for Zone 1 divers in 2003 and Zone 2 divers in 2012 may have reduced discard rates. If culling on bottom required more time on bottom for the same amount of landings, their landings rates would decline. Divers who culled on bottom voluntarily before the regulations were implemented told us that divers would soon learn the technique and landings rates would not be significantly affected.

LPUE for both divers and draggers is presented in Table 8 and Figure 3. Median pounds per bottom hour was chosen as a robust estimator of LPUE (Perry *et al.* 2002). A comparison of the median pounds per bottom hour summarized from diver interviews conducted during twenty consecutive harvesting seasons (Figure 3a), shows that Zone 2 diver LPUE dropped steadily over the first eight years of the series, to what was probably an economic threshold, about 125 to 150 lbs/hr. Zone 1 LPUE had probably declined nearly to that threshold before the project began, and continued to decline during the next four seasons. It improved during the next three seasons and then dropped again, remaining near 125 lbs/hr until 2008–09. Zone 1 LPUE rose to about 160 lbs/hr during the 2009–10 to 2013–14 seasons. LPUE increased similarly in Zone 2 between 2003 and 2006, but was lower during 2010–11 to 2012–13, at about 125 lbs/hr, then jumped to 164 lbs/hr in 2013–14, probably due to the new daily trip limit. LPUE was usually higher in Zone 2 than in Zone 1 until 2008–09.

Dragger LPUE (Figure 3–b) for Zone 2 shows trends similar to the divers, except that the decline for the first 8 years of the series is not as evident, and there was not a significant increase in 2013–14. Only eight dragger interviews were conducted in Zone 1 during the 2002–03 to 2013–14 seasons, because few fished.

Rising or stable LPUE does not necessarily indicate increasing or stable stock abundance, according to our survey results (see next sections) and our analytical analyses (Chen and Hunter, 2003). It is likely that LPUE is not a good index of stock abundance for this fishery, and there is extensive literature on the problems resulting from assuming that commercial catch rates are in proportion to abundance (e.g. Hilborn and Walters 1992, Keesing and Baker 1998, Prince and Hilborn, 1998, Chen and Hunter 2003, Erisman *et al.* 2011). In this case, there are a number of factors that can keep overall catch rates stable (hyperstability) or even increasing when stock abundance is declining, such as serial depletion, economic thresholds, attrition of the least successful harvesters (see discussion in Hunter *et al.* 2005), aggregating behavior of the stock, and changes in fishing strategy and efficiency.

There is evidence that all of these factors have influenced Maine sea urchin catch (landings) rates. For example, the higher rates for Zone 1 divers during 2009–14 (Figure 3a) have been

accompanied by a decline in roe content (DMR, unpublished data from dealer reports). Although changes in roe content could be attributed to climate change, a series of bad weather years, or other environmental factors, Zone 2 roe did not exhibit a similar decline during the same time periods, suggesting that Zone 1 harvesters may have changed their fishing strategy, from targeting high quality urchins to targeting higher volume, poorer quality urchins.

Fishing Depths — Divers and draggers were asked for their estimates of the minimum depth (ft) and the maximum depth they fished. The median values of their responses are shown in Table 9 and Figure 4. Fishing deeper may indicate difficulty in finding urchins in shallow depths, which might be of concern to managers, or it may just indicate the depth of the kelp-urchin feed line (Miller and Nolan, 2008). There do not seem to be any worrying trends in recent depths fished.

Deeper depths fished in the 1995–96 season (Figure 4) by both divers and draggers in both zones are probably due to bias introduced when the port sampling program began late (Dec. 18) and missed the first 3 months of that season. There is some indication that fishing is generally shallower in September and deeper in March–April. Harvesters tell us they can find urchins in the spring that are not yet spawning if they fish deeper.

Pounds per Tray — Landed sea urchins are usually stored and transported in standard plastic trays, or totes, which are easily stacked. During port sampling, samplers counted the total number of trays for each landed catch. Partially filled trays were counted as whole ones, and the average weight per tray for each catch was estimated as the weight of the total catch (from dealer landed weights, after taring) divided by the number of trays. The median average weight per tray for the past ten seasons is listed in Table 10, by zone and gear type. Note that Zone 1 divers usually had the lightest trays (about 83 lbs, or 38 kg), and Zone 2 draggers usually had the heaviest (about 96 lbs, or 44 kg). These estimates have been useful when evaluating the impact of proposed daily tray limits (trip limits). For the 2013–14 season, a seven-tray daily limit (about 640 lbs or 290 kg) was implemented for all Zone 2 harvesters, and for 2014–15, a twelve-tray limit (about 1,000 lbs, or 454 kg) was enacted for Zone 1.

Size Distributions — Expanded size (test diameter) frequency information summarized from commercial samples, and expressed as a relative percentage, is shown for the 2009–10 to 2013–14 sampling seasons for each zone in Figure 5. Size-frequencies were expanded from each sample to the sample's catch, summed for all the samples in the zone, and converted to a relative percentage for each millimeter increment. There was no further expansion to landings or stratification by gear or month.

In Table 11 and Figure 6, median urchin diameter, as well as the first and third quartile diameters, is presented over time for each zone. After the increase in the minimum size in 2001, from 2 inches to $2^{1}/_{16}$ inches (50.8 to 52.4 mm), the median sea urchin diameter in commercial catches has consistently been about 60 mm (2.36 inches) in both zones, until 2009–10, when the size in Zone 1 increased, to a median value of 63 mm (2.48 inches) in 2012–14. This increase coincides with increasing catch rates and declining roe content (discussed above). Note that there is generally a wider range of sizes caught in Zone 2 than in Zone 1, possibly because of wider geographic range of active fishing grounds in Zone 2 and the prevalence of small urchins in Cobscook Bay and large ones in the Jonesport to the Cutler shore area. Also note that the use of a manual measuring board marked in millimeters for measuring urchin diameter, where users are required to round the diameter they read to the nearest millimeter, sometimes created artificial modes at 55, 60, 65, and 70 mm. This user bias for round numbers (also evident in previous years) was eliminated during the 2013–14 season by switching to electronic calipers.

Diameter-Weight Relationships — which have been used in our modeling efforts (Chen and Hunter, 2003) are presented for the 2013-14 season samples, by zone, in Figure 7. Parameters were estimated for each zone for the relationship: Weight = $a \cdot \text{Diameter}^{b}$ where x=diameter and y=weight..

Evaluation, Objective 1:

The project goals and objectives were attained, by obtaining catch, effort, and biological data over the temporal and spatial range of the dive and drag sea urchin fisheries each season.

Approach, Objective 2:

This section covers the period from 2010 through 2014. An annual spring dive survey of the Maine coastline was begun in 2001. The same methods have been used every year since, with minor changes and additions. A video camera survey conducted in deeper sites during 2001-2004 was discontinued in 2005 because of problems with the camera cable, and the lack of sea urchins found at the deeper sites in the six westernmost regions.

The state's coastline was divided into nine survey regions in 2001 (Figure 1b), each of roughly equal economic importance, that is, with roughly equal sea urchin landings in 2000. Each year, at least ten random dive sites were evaluated in each of the nine regions. These sites were chosen randomly from areas with hard bottom (Barnhardt et al, 1996) and a complete depth profile from 0-15m (0-49 ft.). There were five additional fixed sites in each of the nine survey regions. These sites were part of the random pick in 2001, and then were selected to be revisited each year, with input from harvesters, as sites that historically supported urchin populations (fixed sites, Figure 1b).

At each site, 60 quadrats were evaluated. Two divers began their dives at about 15m depth and swam a compass course toward shore. They each carried a 1-m^2 frame made of ¾-inch diameter PVC pipe. They each dropped this frame haphazardly ten times in the 10-15m (33-49 ft) depth range (stratum), again in the 5-10m (16-33 ft) depth range, and again in the 0-5m (0-16 ft) depth range. Occasionally a site would have no hard substrate in the 10-15m depth range, and the survey would begin in the 5-10m range for that site.

All urchins at least 20mm in diameter within the frame (quadrat) were counted, and the algal cover was evaluated. Algae were classified as encrusting, turfing (understory), or canopy (Steneck and Dethier, 1994), and the percent cover of each of these three classifications was determined for each quadrat. Each diver collected all the urchins from one randomly selected quadrat from each depth stratum, brought them to the surface, measured test diameter to the nearest mm, and released them.

In 2002 we began counting and measuring (carapace width) sub-samples of the crabs *Cancer borealis* and *Cancer irroratus*, which have been reported as increasingly important predators of Maine's sea urchins (Leland, 2002; Steneck et al, 2004). Beginning in 2004, crabs were also sexed. Because of underwater sampling logistics, crabs, if present, were collected in each of the three depths into one sample for the site, instead of maintaining the samples separately by depth stratum as was done for urchins.

In 2003, lobsters (*Homarus americanus*) were counted, and sea stars (*Asterias vulgaris)* were counted and measured (longest arm length in mm), and this has been continued.

In 2007, the invasive white colonial tunicate *Didemnum* sp. was evaluated as either Absent, Present at less or equal to 50% of cover, or Common at more than 50% of cover, in each quadrat. *Didemnum* sp. continues to be evaluated in this way each year.

The survey and its protocols are described further by Grabowski *et al.* (2005), Jones (2005), and Hunter *et al.* (2010).

Findings, Objective 2:

Data elements include stratified arithmetic mean urchin abundance (number of individuals per square meter, or $N \cdot m^{-2}$) and estimates of stratified arithmetic mean biomass (grams per square meter, or $g \cdot m^{-2}$, calculated by multiplying the abundance of each diameter size category (1 mm) by weight from a diameter-weight relationship from Scheibling *et al.* (1999) and summing over size categories), for each of three depth strata (0–5, 5–10, and 10–15 m), then weighted by stratum area (rock and gravel substrates only, Table 13) for the region (Jones 2005; Grabowski *et al.* 2005).

The numbers of sites visited each year, quadrats evaluated, total counts of urchins, crabs, lobsters, starfish, and cucumbers, and the numbers measured, are presented in Table 12. Note that Region 1, in Zone 1, was not surveyed in 2012 and 2013. To estimate the Zone 1 means in those years, the 2011 values for Region 1 were used again for 2012 and 2013.

Sea Urchin Biomass — Biomass indices ($g \cdot m^{-2}$) were generally lowest in regions 1–7 and highest in regions 8–9 (Table 14 and Figure 9), and highest in the shallowest depth stratum and lowest in the deepest (Table 15). Note that biomass is consistently lower in Zone 1 (regions 1–3) than Zone 2 (regions 4–9). Biomass in Zone 2 fell steadily from its high of 315 $g \cdot m^{-2}$ in 2001 until 2007, rose to about 196 $g \cdot m^{-2}$ in 2009–2010, reached a time series low of 105 $g \cdot m^{-2}$ in 2013 and rose in 2014. In Zone 1, biomass was highest with a value of 106 $g \cdot m^{-2}$ in 2002, then fell to below 30 $g \cdot m^{-2}$ in ten out of eleven years between 2004 and 2014. Its time series low was in 2013. In Zone 1, Region 3 has consistently had the highest biomass and Region 1 the lowest. In Zone 2, Region 9 has consistently had the highest biomass and Region 5 the lowest (Table 14). Biomass in all regions has declined since the survey began in 2001. The rate of decline was greatest between 2001 and 2004, and has slowed after the fishing seasons were drastically shortened in 2004 (Table 2).

Sea Urchin Abundance — Abundance indices ($number \cdot m^{-2}$) (Figure 8) generally followed the same trends as biomass. The lowest abundance was observed in Zone 1 in 2012 and in Zone 2 in 2013. Abundance in all regions has declined since the survey began in 2001.

Sea Urchin Size Distributions — Size (test diameter) distribution plots (Figure 10) from the spring survey often exhibit the bimodality discussed by other researchers (Botsford *et al.* 1994, Vadas *et al.* 2002, reviewed by Scheibling, 1996).

Figure 10 perhaps best illustrates the trends noted in the abundance and biomass indices above. Declines between 2001 and 2013 seem to have occurred for all sizes of urchins. Median diameters dropped in Zone 1 between 2001 and 2008, but have since risen (Figure 11).

Algal Cover — Algal cover data from the spring survey are displayed in Figure 12. Because the evaluation of percent algal cover is the most subjective observation made during the survey, only data from the one diver who participated in all survey years were used here. Note that adding the percent understory and the percent canopy cover together sometimes results in a total percent algal cover greater than 100%. The total cover of fleshy algae (understory plus canopy, darkest

shades in figures) increased in both zones to a peak in 2004 (Figure 12), as sea urchin biomass fell (Figure 9), and then declined until 2007, then rose and fell again. There does not seem to be any continued negative correlation with urchin biomass, or other long term trend, after 2004. Generally, Zone 2 has had more canopy and encrusting algae, and less understory algae, than Zone 1. Zone 1 tends to have more of the understory red alga *Chondrus crispus* (Irish moss) than Zone 2 (Robert Russell, DMR, pers. obs.). Region 9 has consistently had the lowest values of all types of algae. This may be due in part to the high frequency of dragging activity there, as well as the relatively high abundance of sea urchins.

Crab Abundance — *Cancer* crabs (*C. borealis*, the Jonah crab, and *C. irroratus*, the rock crab) have been implicated as major predators of green sea urchins in Maine, preying upon both newly settled juvenile urchins, and adult urchins. See Steneck *et al.* (2013) and Scheibling and Hatcher (2013) for reviews. We began counting crabs during the 2002 spring sea urchin survey, although these crabs become more active and more visible later in the summer. The results (abundance in stratified mean numbers per square meter) are displayed in Figure 13. The survey data support anecdotal accounts of a "wave" of crabs that moved from west to east along the Maine coastline, peaking in Zone 1 in 2003 and in Zone 2 in 2005. Time series lows for both species occurred in Zone 1 in 2011 and in Zone 2 in 2013. Zone means for Jonah crabs were always higher than rock crabs, except in Zone 2 in 2002, 2012, and 2013. Region 9 consistently had the lowest abundance of both species.

Lobster abundances — were also averaged and stratified in the same manner and are shown in Figure 14a. Highest abundances have generally been in Regions 1-6 and lowest in Region 9. The lowest abundance by zone since counting began in 2003 was observed in both zones in 2007; the highest in 2010 in Zone 1 and 2011 in Zone 2. Abundances were higher in Zone 1 than in Zone 2 in all years except 2014.

Sea star abundances — were also averaged and stratified in the same manner and are shown in Figure 14b. Abundances have generally declined in both zones since they were first evaluated in 2003. Survey divers noted that high abundances of sea stars coincided with high abundances of small blue mussels (*Mytilis edulis*).

Sea cucumber abundances — first evaluated in 2010 (Figure 14c), have been higher in Zone 2 than Zone 1, and reached time series lows in both zones in 2014.

Evaluation, Objective 2:

The project goals and objectives were attained, by conducting annual dive surveys of Maine's sea urchin (and related biota) resources, and developing a time series of abundance indices and biomass estimates for the state by region.

Dissemination:

Annual reports are compiled and published on the DMR web site at http://www.maine.gov/dmr/rm/seaurchin/research.htm. The latest landings, annual LPUE data, and survey abundance and biomass indices are routinely provided to DMR managers and the Maine Sea Urchin Zone Council (SUZC), which provides management advice to the Maine DMR. The pounds per tray data were presented to the SUZC during recent daily tray-limit discussions. Fishery landings, sample size distributions, historical LPUE data, and survey biomass indices and size distributions are also used in a formal stock assessment (Chen & Hunter, 2003) which was last conducted in 2004 (Kanaiwa et al, 2005) and is updated annually and presented informally to managers and at SUZC meetings (e.g. SUZC March 2013 meeting minutes PDF 1 MB). Survey results have also been provided to the Monterey Bay Aquarium Seafood Watch. The *Didemnum* data have been provided to Maine Sea Grant and the USGS Nonindigenous Aquatic Species Program. All survey data have also been provided to several University of Maine graduate students and faculty over the years, most recently to Caitlin Cleaver (MS thesis, 2014) and Dr. James Wilson and other scientists and their students for an effort modelling competition, cooperation, conservation, and social structures in the lobster, sea urchin, and groundfish fisheries (Wilson *et. al* 2013).

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Table 1. Maine sea urchin landings by fishing season and zone, from NMFS port agent reports through 1995–96, and then from DMR dealer reports. 2013-14 data are preliminary.

	Pounds			Metric Tons			Value	Price
Season	Zone 1	Zone 2	Total	Zone 1	Zone 2	Total	$	$/lb
1987-88			4,074,614			1,848.2	840,104	0.21
1988-89			7,479,854			3,392.8	2,512,549	0.34
1989-90			10,507,781			4,766.3	4,238,658	0.40
1990-91			17,500,228			7,938.1	8,291,892	0.47
1991-92			19,705,059			8,938.2	11,063,187	0.56
1992-93			39,288,946			17,821.3	23,478,555	0.60
1993-94			37,829,393			17,159.3	26,968,165	0.71
1994-95	17,430,440	19,706,850	37,137,290	7,906.4	8,939.0	16,845.4	35,536,073	0.96
1995-96	15,479,639	14,782,860	30,262,499	7,021.5	6,705.5	13,727.0	33,183,441	1.10
1996-97	10,389,420	13,465,189	23,854,609	4,712.6	6,107.8	10,820.4	26,580,434	1.11
1997-98	6,609,750	10,338,950	16,948,700	2,998.2	4,689.7	7,687.9	18,339,532	1.08
1998-99	5,772,995	10,929,943	16,702,938	2,618.6	4,957.8	7,576.4	20,102,119	1.20
1999-00	5,072,148	8,982,967	14,055,115	2,300.7	4,074.6	6,375.4	18,858,460	1.34
2000-01	4,426,427	7,391,533	11,817,960	2,007.8	3,352.8	5,360.6	16,119,624	1.36
2001-02	3,202,928	4,647,644	7,850,572	1,452.8	2,108.2	3,561.0	9,717,479	1.24
2002-03	1,952,361	4,748,271	6,700,632	885.6	2,153.8	3,039.4	8,758,199	1.31
2003-04	1,293,602	5,040,920	6,334,522	586.8	2,286.5	2,873.3	8,860,609	1.40
2004-05	156,803	3,630,293	3,787,096	71.1	1,646.7	1,717.8	5,802,979	1.53
2005-06	112,192	3,740,713	3,852,905	50.9	1,696.8	1,747.7	5,371,416	1.39
2006-07	154,991	2,874,500	3,029,491	70.3	1,303.9	1,374.2	4,581,572	1.51
2007-08	178,550	2,975,853	3,154,403	81.0	1,349.8	1,430.8	5,043,356	1.60
2008-09	138,683	2,960,823	3,099,506	62.9	1,343.0	1,405.9	5,089,928	1.64
2009-10	121,710	2,991,471	3,113,181	55.2	1,356.9	1,412.1	5,902,851	1.90
2010-11	148,767	2,152,991	2,301,758	67.5	976.6	1,044.1	5,143,746	2.23
2011-12	181,226	2,149,873	2,331,099	82.2	975.2	1,057.4	5,081,370	2.18
2012-13	273,371	1,564,810	1,838,181	124.0	709.8	833.8	5,721,560	3.11
*2013-14	384,143	1,539,565	1,923,708	174.2	698.3	872.6	5,067,105	2.63

* preliminary

Table 2. The annual (top) or seasonal by zone (bottom) number of open fishing days in the Maine sea urchin fishery.

Year or Season	Total Days	(No Zones until 1994)
1986	365	
1987	365	
1988	366	
1989	365	
1990	365	
1991	365	
1992	366	
1993	335	(closed Jul. 9 – Aug. 7)

	Zone 1 Days	Zone 2 Days
1994–1995	228, Aug. 16 – Mar. 31	272, Aug. 16 – May 14
1995–1996	229, Aug. 16 – Mar. 31	212, Oct. 2 – Apr. 30
1996–1997	150, Aug –Mar	170, Aug – Apr
1997–1998	120, Sep – Feb	120, Oct – Apr
1998–1999	120, Sep – Feb	120, Oct – Apr
1999–2000	120, Sep – Feb	120, choice of early (Oct–Mar) or late (Nov–Apr)
2000–2001	110, Sep – Feb	110, choice of early (Oct–Mar) or late (Nov–Apr)
2001–2002	94, Sep – Mar	94, choice of early (Oct–Mar) or late (Nov–Apr)
2002–2003	94, Sep – Mar	94, choice of early (Oct–Mar) or late (Nov–Apr)
2003–2004	94 dive, 84 drag, Sep – Mar.	94, choice of early (Oct–Mar) or late (Nov–Apr)
2004–2005	10, Sep dive, Dec drag	45, choice of early (Sep–Jan) or late (Dec–Mar)
2005–2006	10, choice of Sep or Dec.	45, choice of early (Sep–Jan) or late (Dec–Mar)
2006–2007	10, choice of Sep or Dec.	45, choice of early (Sep–Jan) or late (Dec–Mar)
2007–2008	10, choice of Sep or Dec.	45, choice of early (Oct–Jan) or late (Dec–Mar)
2008–2009	10, choice of Sep or Dec.	45, choice of early (Oct–Jan) or late (Dec–Mar)
2009–2010	10, choice of Sep or Dec–Jan.	45, choice of early (Sep–Jan) or late (Dec–Mar)
2010–2011	10, choice of Sep or Dec–Jan.	45, choice of early (Sep–Jan) or late (Dec–Mar)
2011–2012	10, choice of Sep or Dec–Jan.	45, choice of early (Sep–Jan) or late (Dec–Mar)
2012–2013	15, choice of Sep or Dec–Jan.	36, choice of early (Oct–Jan) or late (Dec–Mar)
2013–2014	15, choice of Sep or Dec–Jan.	38, choice of early (Oct–Jan) or late (Dec–Mar)

Table 3. Maine sea urchin port sampling summary statistics and sampling intensity. 1000 pounds (lbs) = 453.6 kg.

Season	Total Landings (lbs)	Number of harvester interviews	Total weight of interviewed catches (lbs)	Sampling rate for harvester interviews by catch weight	Mean weight of a sampled urchin (g)	Estimated number of urchins landed	Total number of urchins measured	Sampling rate for measured urchins	Number of urchins per lb
1994-95	37,137,290	404	249,705	0.67%			0	0%	
1995-96	30,262,499	180	115,613	0.38%	99.78	137,575,329	5,585	0.0041%	4.5
1996-97	23,854,609	537	330,568	1.39%	95.91	112,820,251	10,674	0.0095%	4.7
1997-98	16,948,700	464	280,111	1.65%	98.25	78,247,551	9,274	0.0119%	4.6
1998-99	16,702,938	499	308,119	1.84%	101.09	74,942,759	9,839	0.0131%	4.5
1999-00	14,055,115	416	243,592	1.73%	98.86	64,491,089	8,320	0.0129%	4.6
2000-01	11,817,960	343	198,336	1.68%	90.70	59,099,886	5,919	0.0100%	5.0
2001-02	7,850,572	314	167,638	2.14%	91.53	38,906,817	4,560	0.0117%	5.0
2002-03	6,700,632	219	126,003	1.88%	89.82	33,837,499	2,940	0.0087%	5.0
2003-04	6,334,522	166	97,767	1.54%	93.56	30,710,274	1,960	0.0064%	4.8
2004-05	3,787,096	111	70,936	1.87%	89.46	19,201,854	1,420	0.0074%	5.1
2005-06	3,852,905	116	90,881	2.36%	95.11	18,375,906	1,660	0.0090%	4.8
2006-07	3,029,491	117	87,047	2.87%	101.86	13,490,057	1,415	0.0105%	4.5
2007-08	2,949,228	107	74,506	2.53%	105.42	12,689,185	1,260	0.0099%	4.3
2008-09	3,099,506	60	39,902	1.29%	103.44	13,591,481	978	0.0072%	4.4
2009-10	3,113,181	124	86,969	2.79%	100.52	14,048,395	2,112	0.0150%	4.5
2010-11	2,301,633	205	125,185	5.44%	94.68	11,026,962	3,740	0.0339%	4.8
2011-12	2,331,099	130	70,318	3.02%	95.25	11,100,476	2,300	0.0207%	4.8
2012-13	1,838,181	188	106,130	5.77%	100.31	8,312,439	2,780	0.0334%	4.5
***2013-14**	1,923,708	129	76,410	3.97%	96.04	9,085,641	1,900	0.0209%	4.7

* Landings are preliminary

Table 4. Maine sea urchin median daily landings (pounds, lbs) per harvester by management zone and season, for divers (left) and draggers (right), from harvester interviews. One pound = 0.454 kg.

Season	Diver Median Daily Landings (lbs)			
	Zone 1		Zone 2	
	median	std err	median	std err
2004-05	417	49.4	650	50.7
2005-06	618	51.5	683	62.2
2006-07	426	55.0	709	45.0
2007-08	571	106.6	680	41.9
2008-09	603	49.8	600	58.8
2009-10	663	102.7	647	44.2
2010-11	738	58.9	527	38.7
2011-12	667	76.3	570	40.8
2012-13	853	54.1	550	30.4
2013-14	666	103.4	604	16.0

Season	Dragger Median Daily Landings (lbs)			
	Zone 1		Zone 2	
	median	std err	median	std err
2004-05	*Fewer than 3 dragger interviews per season in Zone 1 since 2000-01.*		570	88.3
2005-06			1005	86.3
2006-07			882	96.8
2007-08			548	99.6
2008-09			638	113.8
2009-10			656	57.2
2010-11			563	52.1
2011-12			502	38.0
2012-13			573	52.1
2013-14			573	34.2

Table 5. Maine sea urchin diver median age (left) and years of experience (right), by management zone and season, from harvester interviews.

Season	Diver Median Age (yrs)			
	Zone 1		Zone 2	
	median	std err	median	std err
2009-10	50.0	1.14	42.5	52
2010-11	53.0	1.81	44.0	0.67
2011-12	52.0	2.39	42.0	0.90
2012-13	53.0	1.38	43.0	0.68
2013-14	52.5	2.06	44.0	0.83

Season	Diver Median Experience (yrs)			
	Zone 1		Zone 2	
	median	std err	median	std err
2009-10	17.0	0.99	19.0	4.02
2010-11	22.0	1.70	20.0	0.42
2011-12	25.0	1.77	20.0	0.66
2012-13	24.0	1.41	21.0	0.29
2013-14	21.0	1.05	21.5	0.37

Table 6. Maine sea urchin fishery median boat length (feet) by management zone and season, for divers (left) and draggers (right), from harvester interviews. One foot = 0.305 meter.

Season	Diver Median Boat Length (ft)			
	Zone 1		Zone 2	
	median	std err	median	std err
2009-10	24	1.84	26.0	1.15
2010-11	20	1.39	31.0	0.81
2011-12	20	1.63	31.0	1.08
2012-13	20	1.47	35.0	0.94
2013-14	20	1.44	28.0	1.10

Season	Dragger Median Boat Length (ft)			
	Zone 1		Zone 2	
	median	std err	median	std err
2009-10	*Fewer than 3 dragger interviews per season in Zone 1 since 2000-01.*		39	0.70
2010-11			38	0.70
2011-12			37	0.76
2012-13			38	0.90
2013-14			38	1.06

Table 7. Maine sea urchin median daily bottom hours fished per diver (left) and daily median towing hours per dragger, by management zone and season, from harvester interviews.

Season	Diver Median Daily Bottom Hours			
	Zone 1		Zone 2	
	median	std err	median	std err
2009-10	4.0	0.33	4.0	0.23
2010-11	4.0	0.32	4.5	0.16
2011-12	3.3	0.46	4.0	0.19
2012-13	5.0	0.23	4.0	0.14
2013-14	4.0	0.30	3.5	0.15

Season	Dragger Median Daily Tow Hours			
	Zone 1		Zone 2	
	median	std err	median	std err
2009-10	*Fewer than 3 dragger interviews per season in Zone 1 since 2000-01.*		4.6	0.25
2010-11			5.0	0.31
2011-12			4.6	0.24
2012-13			4.8	0.28
2013-14			4.1	0.36

Table 8. Maine sea urchin landings per unit effort (lbs/hr) medians by management zone and season, for divers (left) and draggers (right), from harvester interviews. One pound = 0.454 kg. One foot = 0.305 meter.

Diver pounds per bottom hour				
	Zone 1		Zone 2	
Season	median	std err	median	std err
1994-95	150	8.1	220	11.6
1995-96	126	9.4	208	13.5
1996-97	132	6.4	201	6.7
1997-98	117	6.8	189	7.8
1998-99	154	6.1	185	7.3
1999-00	146	6.0	176	8.3
2000-01	161	10.4	152	7.6
2001-02	136	5.3	130	7.4
2002-03	135	7.5	145	8.7
2003-04	128	10.0	164	14.1
2004-05	120	12.8	150	10.5
2005-06	137	15.3	189	10.8
2006-07	122	11.1	177	10.0
2007-08	122	17.6	152	9.9
2008-09	147	13.7	154	13.3
2009-10	166	18.4	145	9.3
2010-11	158	16.3	124	12.3
2011-12	162	20.4	122	8.0
2012-13	170	13.2	126	5.8
2013-14	153	23.2	164	11.8

Dragger pounds per ft width tow hour				
	Zone 1		Zone 2	
Season	median	std err	median	std err
1994-95	24.6	5.1	31.3	8.1
1995-96	17.9	7.6	28.4	7.7
1996-97	23.1	5.8	24.8	3.4
1997-98	28.1	5.3	28.5	4.2
1998-99	27.2	3.2	33.6	3.5
1999-00	19.4	11.4	28.3	3.3
2000-01	20.6	2.0	29.1	3.9
2001-02			22.5	2.8
2002-03	*Fewer than 3 interviews per season in Zone 1 since 2000-01.*		25.9	3.2
2003-04			26.4	3.2
2004-05			23.4	3.9
2005-06			35.0	3.8
2006-07			35.2	4.9
2007-08			29.3	11.1
2008-09			28.6	5.6
2009-10			23.5	4.4
2010-11			19.0	3.4
2011-12			20.9	3.4
2012-13			22.6	3.1
2013-14			22.8	4.2

Table 9. Maine sea urchin harvester fishing depths from harvester interviews by season, gear, and zone. Data are the median minimum depth fished (feet) response, the median maximum depth fished (feet) response, and the number of interviews (N). 2012–14 data for draggers are not available yet. One foot = 0.305 meter.

	Diver Median Depths					
	Zone 1			Zone 2		
Season	Min.	Max.	N	Min.	Max.	N
1994-95	10	20	209	9	20	132
1995-96	15	35	97	10	30	113
1996-97	5	20	176	6	20	249
1997-98	6	25	183	8	25	194
1998-99	6	22	229	6	20	193
1999-00	5	25	168	6	20	159
2000-01	10	25	165	10	25	105
2001-02	10	20	146	12	25	120
2002-03	15	20	79	15	25	101
2003-04	20	20	68	20	30	60
2004-05	15	20	30	20	20	51
2005-06	10	20	24	20	22.5	64
2006-07	10	20	26	15	20	55
2007-08	10	20	27	20	20	51
2008-09	5	20	7	20	20	31
2009-10	13.5	20	12	12	20	57
2010-11	10	20	22	10	20	114
2011-12	0	15	18	10	18	53
2012-13	0	15	30	10	20	88
2013-14	0	15	26	10	20	70

	Dragger Median Depths					
	Zone 1			Zone 2		
Season	Min.	Max.	N	Min.	Max.	N
1994-95	30	42	13	10	30	49
1995-96	10	35	11	10	40	47
1996-97	11	39	10	12	50	81
1997-98	10	40	11	13	60	63
1998-99	12	60	7	16	50	67
1999-00	22	44	3	10	40	75
2000-01	13.5	22	6	11	40	60
2001-02				20	30	47
2002-03				30	39	39
2003-04				20	40	38
2004-05				35	45	28
2005-06				27.5	40	26
2006-07				30	40	30
2007-08				40	40	29
2008-09				22.5	40	22
2009-10				25	50	47
2010-11				20	40	67
2011-12				20	30	53
2012-13						
2013-14						

Fewer than 3 dragger interviews per season in Zone 1 since 2000-01.

Table 10. Maine sea urchin harvester median pounds per tray from harvester interviews by season, gear (divers left, draggers right), and zone. One pound = 0.454 kg.

Season	Diver Median Pounds per Tray			
	Zone 1		Zone 2	
	median	std err	median	std err
2004-05	83.9	3.91	86.3	2.55
2005-06	86.4	2.66	85.7	1.52
2006-07	80.2	2.81	90.0	2.08
2007-08	81.3	3.18	85.0	2.84
2008-09	83.7	2.88	86.1	2.88
2009-10	85.0	3.31	92.3	1.71
2010-11	81.0	3.25	85.7	1.25
2011-12	82.6	2.16	88.6	2.61
2012-13	81.4	1.48	91.9	1.22
2013-14	88.0	2.70	89.6	0.95

Season	Dragger Median Pounds per Tray			
	Zone 1		Zone 2	
	median	std err	median	std err
2004-05			91.5	3.27
2005-06			95.5	2.83
2006-07			99.4	2.77
2007-08			98.5	3.97
2008-09			91.8	2.69
2009-10			99.4	2.73
2010-11			94.0	2.03
2011-12			98.3	1.76
2012-13			95.7	1.72
2013-14			87.2	2.40

Fewer than 3 dragger interviews per season in Zone 1 since 2000-01.

Table 11. Maine sea urchin diameters (mm) by management zone and season, from samples of the landed catch. Note that the minimum legal size changed from 2 inches (50.8 mm) to $2^{1}/_{16}$ inches (52.4 mm) beginning with the 2001–02 season.

Zone 1									
Season	**No. of samples**	**Total urchins**	**Mean**	**StDev**	**Min**	**1st quartile**	**Median**	**3rd quartile**	**Max**
1995-96	111	2,220	60.6	7.1	41	55	60	65	101
1996-97	194	3,880	58.8	6.5	39	54	58	63	90
1997-98	199	3,980	61.2	6.5	44	56	60	65	89
1998-99	230	4,600	60.9	6.5	42	56	60	65	91
1999-00	177	3,540	60.1	6.5	40	55	59	64	88
2000-01	134	2,680	58.8	6.1	43	55	58	62	86
2001-02	96	1,920	60.5	6.4	47	55	60	65	88
2002-03	43	860	61.4	5.5	45	58	61	64	86
2003-04	31	620	59.4	4.3	47	56	59	62	86
2004-05	27	540	60.9	5.0	50	57	60	64	82
2005-06	15	300	61.6	5.0	50	58	60	64	78
2006-07	16	320	61.5	5.3	50	57	60	65	77
2007-08	14	280	61.6	6.4	48	57	60	65	81
2008-09	6	120	61.0	4.9	52	58	60	64	74
2009-10	11	220	63.9	7.0	50	59	62	66	85
2010-11	21	420	67.1	6.9	38	61	66	71	87
2011-12	19	380	63.1	5.6	50	59	63	67	80
2012-13	22	440	63.2	6.5	50	59	63	67	93
2013-14	18	360	63.2	6.0	48	59	63	67	80

Zone 2									
Season	**No. of samples**	**Total urchins**	**Mean**	**StDev**	**Min**	**1st quartile**	**Median**	**3rd quartile**	**Max**
1995-96	169	3,365	60.6	8.9	40	54	59	66	95
1996-97	340	6,794	60.9	8.5	39	55	59	66	94
1997-98	265	5,294	62.4	7.9	41	57	61	67	97
1998-99	262	5,239	62.2	8.1	44	56	61	67	110
1999-00	239	4,780	62.0	8.2	44	55	61	68	99
2000-01	162	3,239	58.7	6.7	44	54	57	63	90
2001-02	132	2,640	59.3	6.1	45	55	58	63	85
2002-03	104	2,080	61.0	6.0	37	56	60	65	81
2003-04	67	1,340	60.3	6.3	45	55	60	65	81
2004-05	44	880	61.6	5.4	51	58	61	65	83
2005-06	68	1,360	61.4	5.9	45	56	60	64	86
2006-07	55	1,095	62.4	6.2	47	57	60	65	85
2007-08	49	980	62.5	6.1	47	57	60	63	80
2008-09	43	858	63.1	6.6	47	58	63	67	83
2009-10	95	1,892	61.6	7.0	43	55	60	65	84
2010-11	166	3,320	61.4	6.5	45	56	60	65	86
2011-12	96	1,920	61.0	6.8	47	55	59	64	87
2012-13	117	2,340	61.8	6.8	47	55	60	65	89
2013-14	77	1,540	62.6	6.2	45	58	61	66	89

Table 12. Maine spring sea urchin survey — number of survey sites and quadrats evaluated, urchins counted and measured, Jonah crabs counted and measured, rock crabs counted and measured, lobsters counted, starfish counted and measured, and sea cucumbers counted, by survey year.

Year	Number of Sites	Number of Quadrats	Urchins counted	Urchins measured	Jonah crabs counted	Jonah crabs measured	Rock crabs counted	Rock crabs measured	Lobsters counted	Sea stars counted	Sea stars measured	Cucumbers counted
2001	292	14,072	123,945	14,623	-	-	-	-	-	-	-	-
2002	226	8,510	81,702	10,140	534	467	708	674	-	-	-	-
2003	225	8,793	54,728	8,850	974	863	495	454	313	16,900	881	-
2004	195	8,310	42,274	7,003	1,000	982	286	283	246	7,027	653	-
2005	144	8,080	41,973	6,293	1,093	1,100	284	284	319	7,162	277	-
2006	144	7,570	35,827	4,305	713	696	280	292	292	3,684	239	-
2007	144	7,640	29,056	3,516	424	416	103	91	184	3,588	157	-
2008	144	7,799	41,089	4,867	562	541	189	203	382	3,206	149	-
2009	144	7,711	41,472	5,411	275	271	112	115	435	3,273	234	-
2010	144	7,348	43,370	4,921	212	207	93	96	372	1,828	122	813
2011	144	7,460	25,205	3,095	129	126	83	85	399	1,290	95	923
2012	150	7,380	27,123	3,700	125	112	103	99	342	499	41	632
2013	155	7,814	29,524	3,533	109	104	85	87	235	642	71	589
2014	144	7,007	33,000	3,225	174	174	135	133	267	1,021	83	328

Table 13. List of sea urchin survey regions with estimated area (m^2) of rock and gravel substrates in depths 0–15 m.

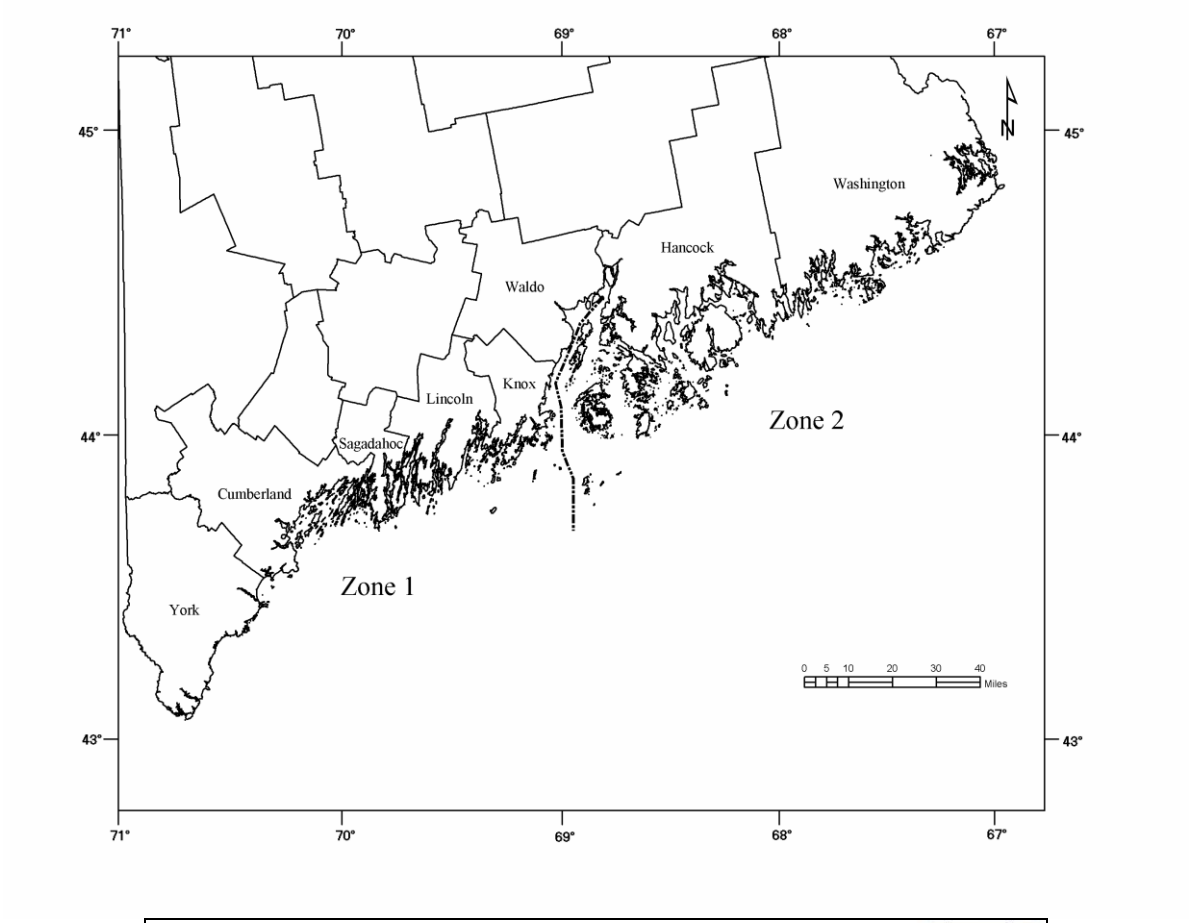
Region	Zone	Area (m^2)	Region name
1	1	164,511,949	Kittery to Phippsburg
2	1	73,524,490	Phippsburg-Boothbay-Bristol-Bremen
3	1	128,001,597	Friendship-Port Clyde-Tenants Hbr-Rockland
4	2	273,888,174	Isleboro-Vinalhaven-Stonington
5	2	148,299,821	Bluehill-Swans Is-Mount Desert Is
6	2	61,985,887	Frenchman Bay-Winter Hbr-Corea-Steuben
7	2	179,631,845	Milbridge-Addison-Jonesport
8	2	97,938,299	Roque Is-Machiasport-Cutler-W. Quoddy Head
9	2	52,045,499	Cobscook Bay-Passamaquoddy Bay

Table 14. Maine spring dive survey stratified mean sea urchin biomass (grams per square meter), with standard errors (SE), by region (1–9) and zone (1–2), depths 0–15m, all survey years, not including industry sites. Note that Region 1 in Zone 1 was not surveyed in 2012 and 2013. To estimate the overall Zone 1 means in those years, the 2011 values for Region 1 were used again for 2012 and 2013.

Zone	1								2											
Region	1		2		3		1-3 (Zone 1)		4		5		6		7		8		9		4-9 (Zone 2)	
Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
2001	5.3	2.6	143.1	49.4	206.6	64.5	103.4	24.7	197.4	72.1	100.7	21.6	417.5	80.7	408.3	99.2	585.6	76.6	587.4	81.6	314.8	35.1
2002	6.3	4.4	237.4	71.7	158.4	34.9	105.9	19.0	139.8	51.5	84.0	32.8	456.7	64.4	262.2	68.5	568.4	89.2	565.7	104.2	259.6	27.4
2003	4.5	2.1	60.1	29.9	155.6	40.4	68.5	15.4	89.6	38.5	123.7	45.0	376.2	87.4	225.3	44.2	381.4	58.1	699.7	132.4	221.7	22.2
2004	5.6	4.2	32.2	13.0	24.0	8.0	17.4	4.3	55.7	25.2	63.4	27.3	225.7	71.0	125.1	28.2	336.8	57.0	617.0	108.2	155.1	16.1
2005	1.7	1.1	12.0	4.0	62.9	24.5	25.2	8.6	12.2	8.2	48.4	19.1	227.5	70.9	146.4	41.3	473.6	85.1	435.4	57.6	147.4	15.8
2006	10.9	4.0	24.1	13.0	51.2	28.0	27.6	10.3	90.2	45.5	41.4	19.6	86.9	33.3	76.1	28.9	461.7	83.6	509.6	83.9	149.4	20.6
2007	6.2	2.5	18.5	10.1	14.6	8.1	11.6	3.7	145.9	50.7	68.8	39.4	50.9	20.5	22.4	7.0	323.4	64.8	336.3	59.2	130.9	20.5
2008	5.2	3.2	38.5	25.8	20.6	14.7	17.3	7.4	130.7	59.6	31.2	12.1	164.6	84.8	106.3	30.0	428.1	82.9	376.9	52.9	161.3	24.6
2009	2.2	0.8	14.8	7.1	18.7	5.5	10.5	2.4	87.6	28.3	58.8	17.4	144.5	49.6	265.3	62.1	527.2	124.9	358.8	50.9	196.2	23.2
2010	5.4	1.7	9.9	3.1	81.5	30.9	32.9	10.8	200.0	72.0	77.4	19.2	270.5	114.7	83.8	38.4	329.1	107.4	388.4	45.8	185.0	30.4
2011	0.9	0.3	24.1	10.1	46.7	21.4	21.6	7.8	170.1	56.3	75.3	26.3	86.1	29.6	49.6	26.8	221.7	71.1	306.7	43.3	134.8	22.4
2012			1.5	1.1	44.8	16.3	16.4	5.7	145.3	52.3	47.7	11.4	162.8	47.2	25.5	8.6	213.1	64.0	340.2	49.0	123.0	20.0
2013			2.9	1.3	26.1	11.9	10.1	4.2	55.2	18.2	45.4	18.1	86.9	46.1	75.0	29.8	276.6	71.0	338.3	36.6	104.9	13.5
2014	1.6	1.0	4.9	2.7	76.5	30.5	28.5	10.7	187.4	65.7	35.8	12.9	19.3	6.8	25.0	12.3	337.7	138.3	663.0	220.8	159.6	31.3

Table 15. 2013 Maine spring dive survey stratified mean sea urchin biomass (grams per square meter) by depth stratum and region. Heavy gray shading indicates the depth of highest biomass for each region; no shading indicates the depth of lowest biomass.

	Depth Strata		
Region	**1**	**2**	**3**
2	6.5	1.3	1.8
3	57.6	5.8	1.2
4	95.7	4.6	0.2
5	74.4	51.4	6.3
6	129.1	21.4	17.6
7	86.3	75.7	6.1
8	233.3	355.7	289.9
9	397.1	275.9	171.8



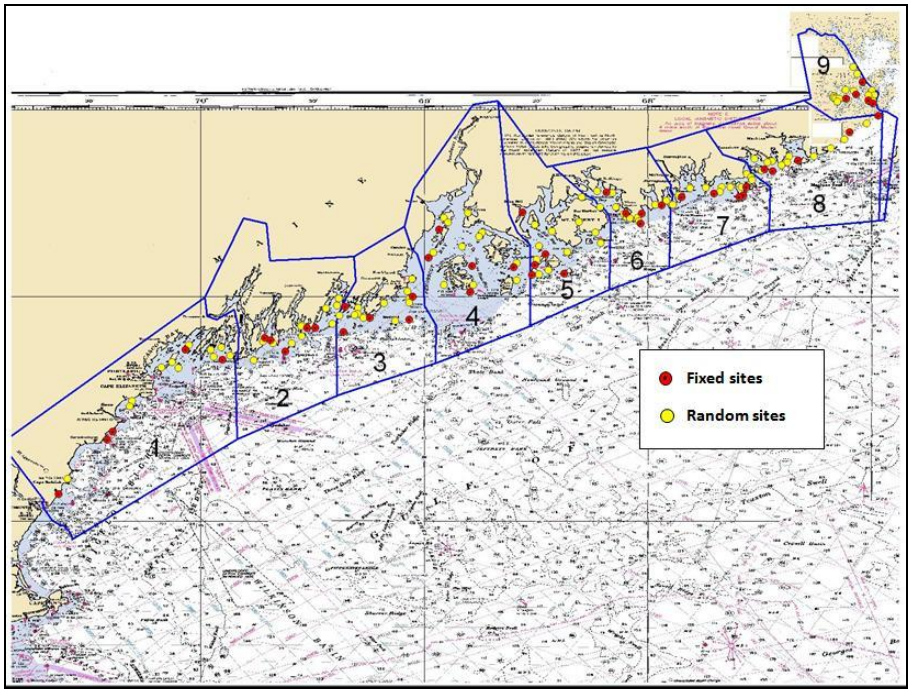


Figure 1a-b. Maine coastal counties and the two sea urchin management zones (above), and the nine survey regions with 2014 survey sites (below).

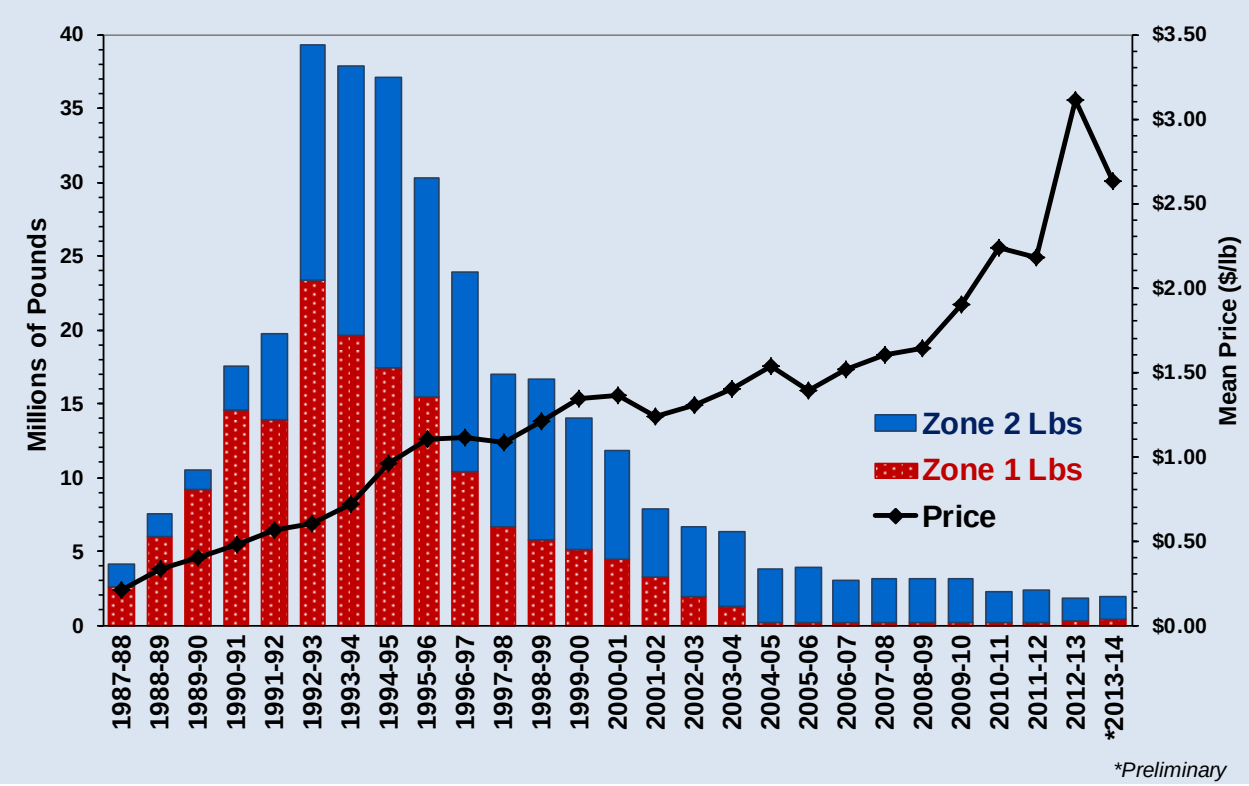
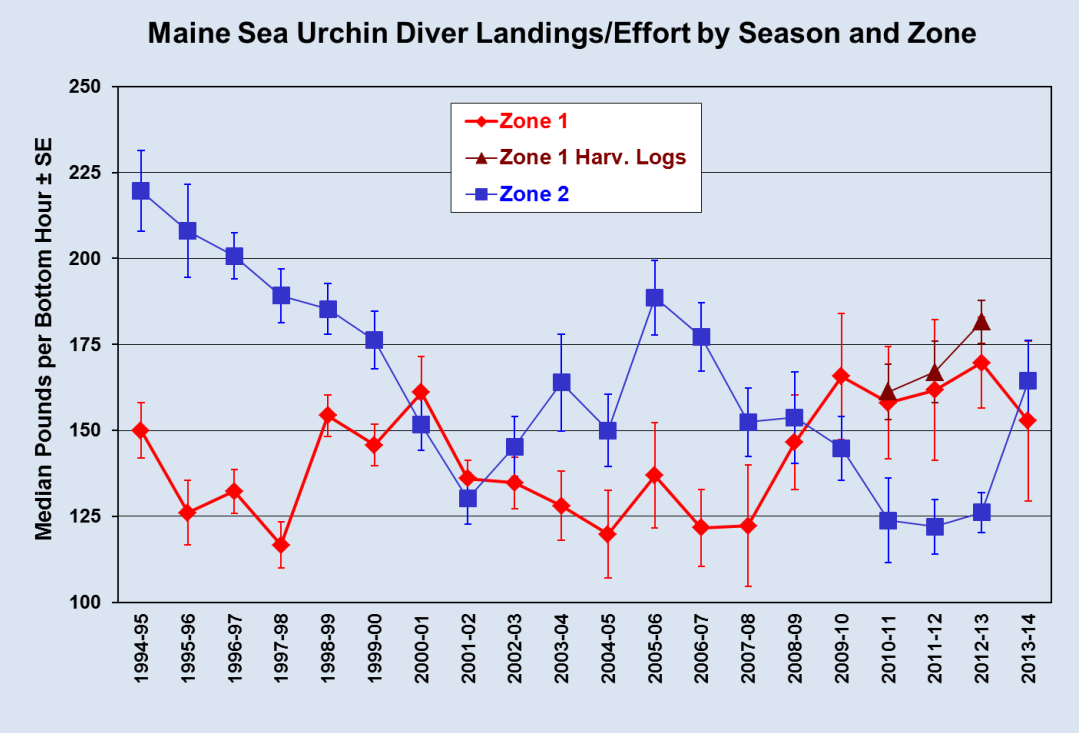


Figure 2. Maine sea urchin landings (millions of pounds) by fishing season and zone, from dealer reports. * 2013-14 data are preliminary. One million pounds = 454 mt.



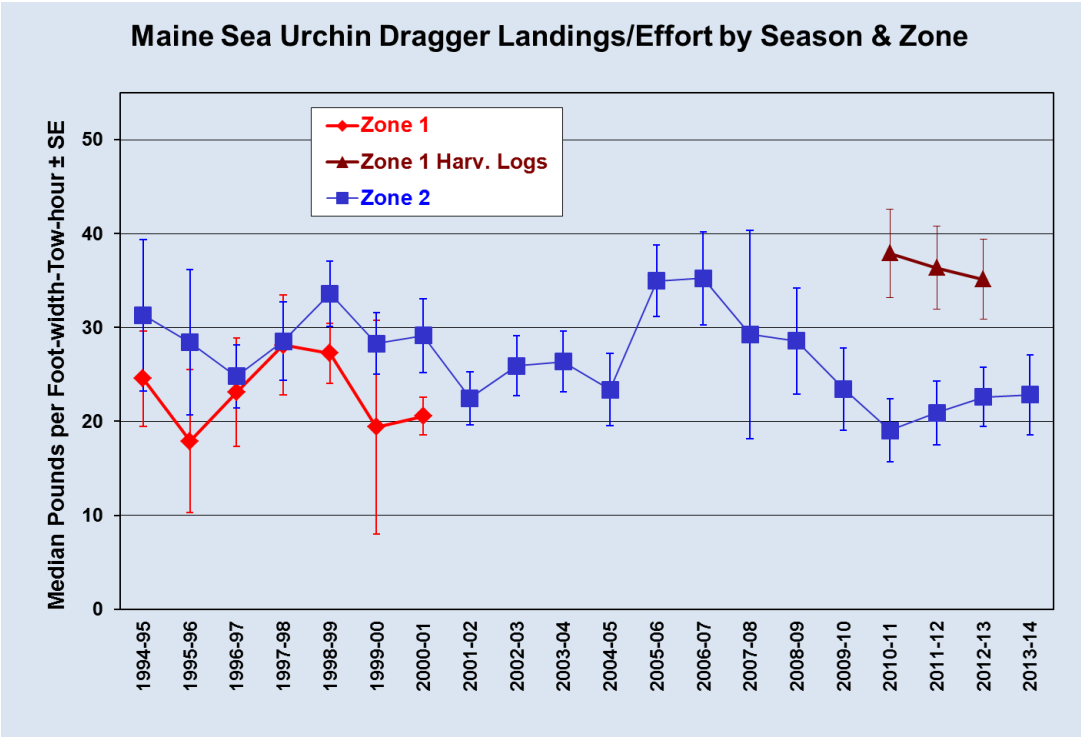


Figure 3a–b. Maine sea urchin diver (above) and dragger (below) median landings per effort by season and zone, from port interviews, and from harvester logs where noted. Zone 1 dragger interview data for 2001–02 through 2013–14 are not displayed because there were fewer than three interviews each season.

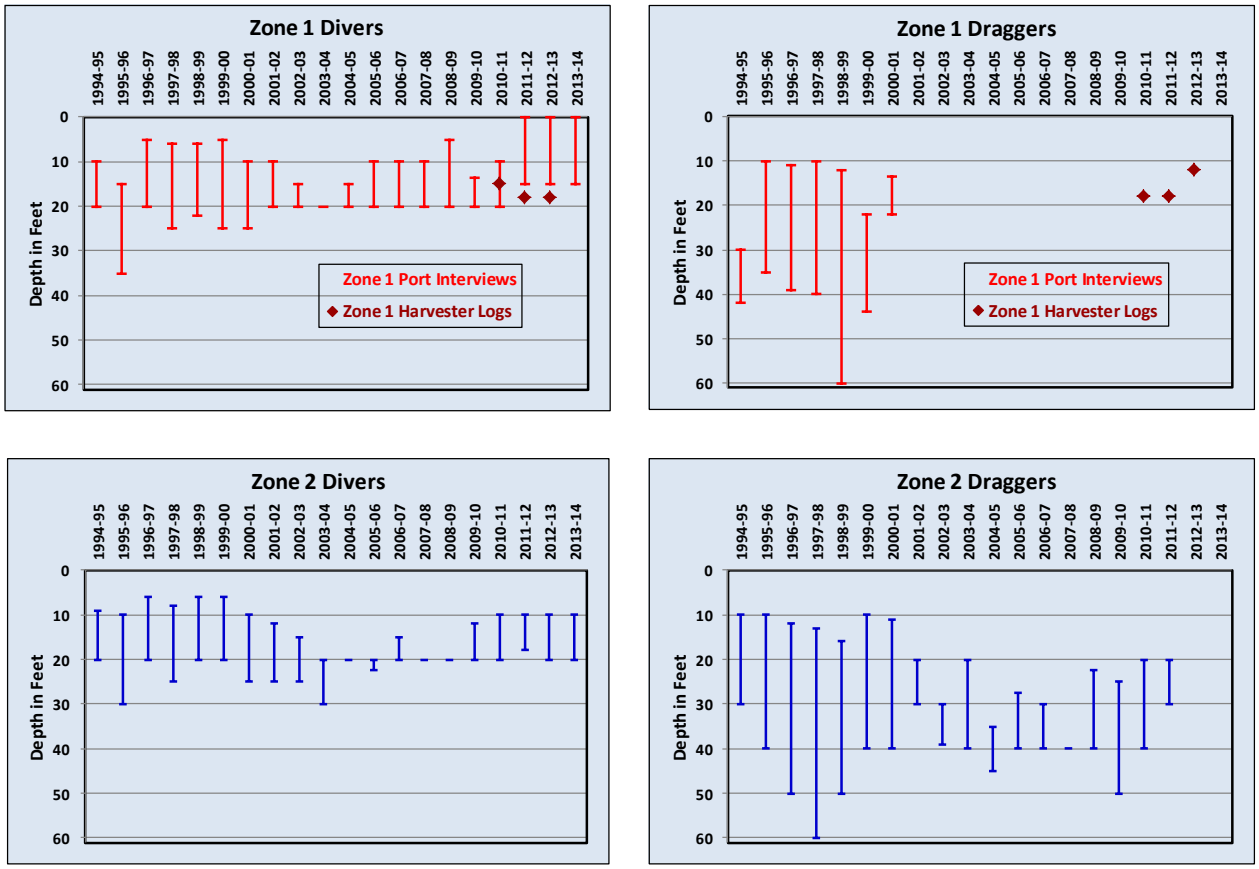


Figure 4a–d. Maine sea urchin harvester fishing depths from port interviews by season, gear, and zone. Bars indicate the median minimum depth fished (ft) response, and the median maximum depth fished (ft) response. Zone 1 graphs also indicate the median depth fished from harvester log books. Dragger interview data for Zone 1 for 2001–02 through 2013–14 are not displayed because there were fewer than three interviews each season. 2012–14 interview data for Zone 2 dragger depths are not yet available.

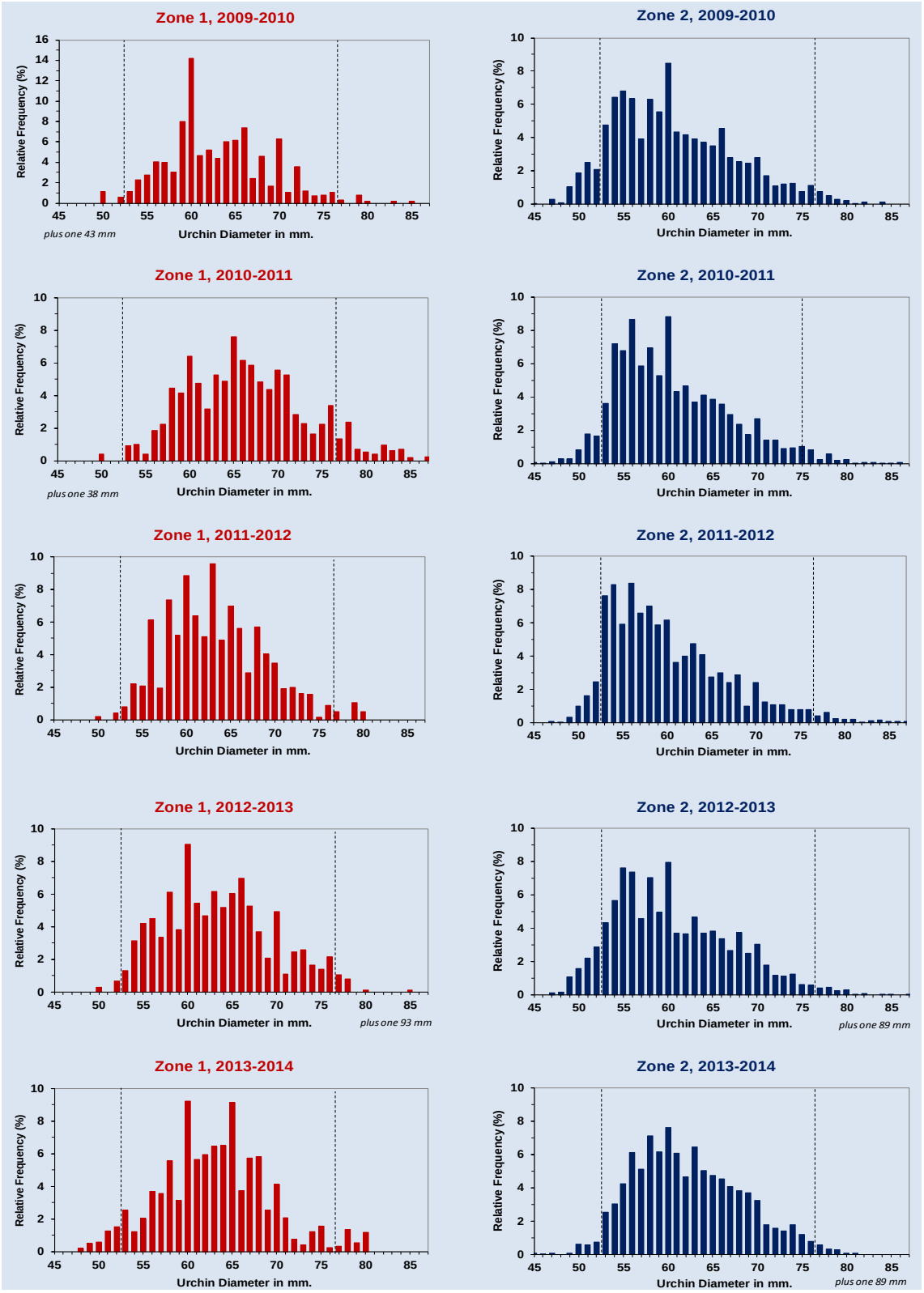
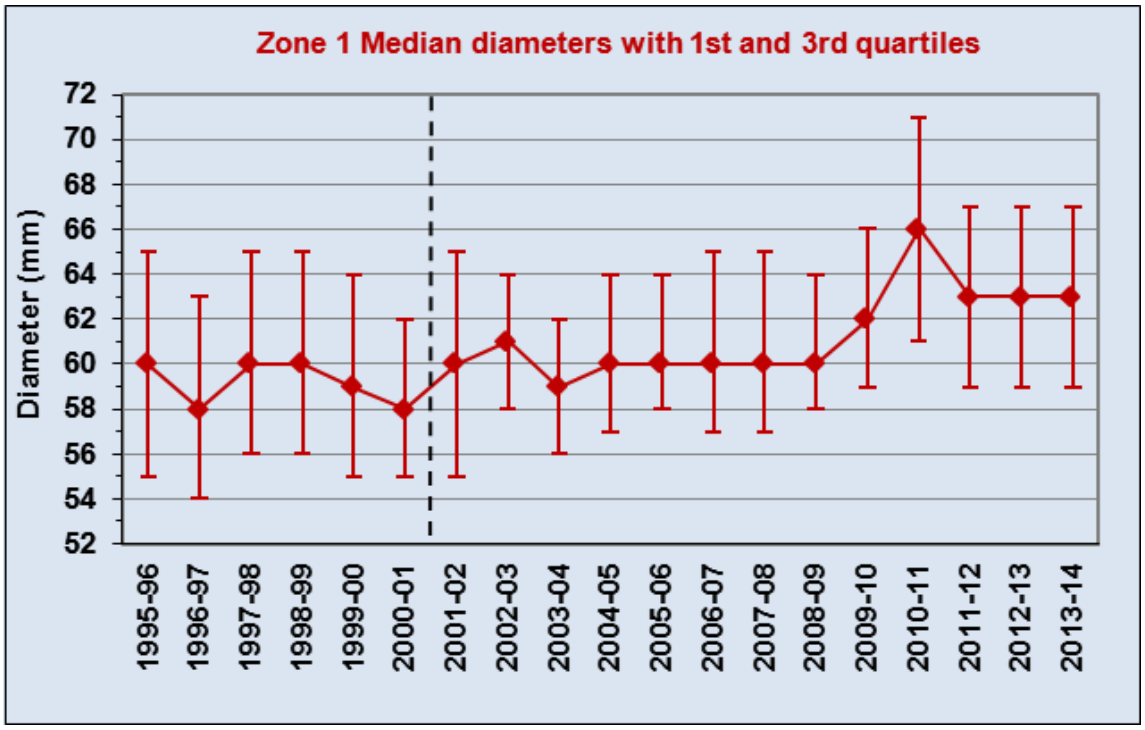


Figure 5a–e. Relative expanded size (test diameter) frequency for Zone 1 (left) and Zone 2 (right) from sea urchin port samples for 2009–10 to 2013–14. Dotted lines indicate the minimum (52.4 mm) and maximum (76.2 mm) legal size limits.



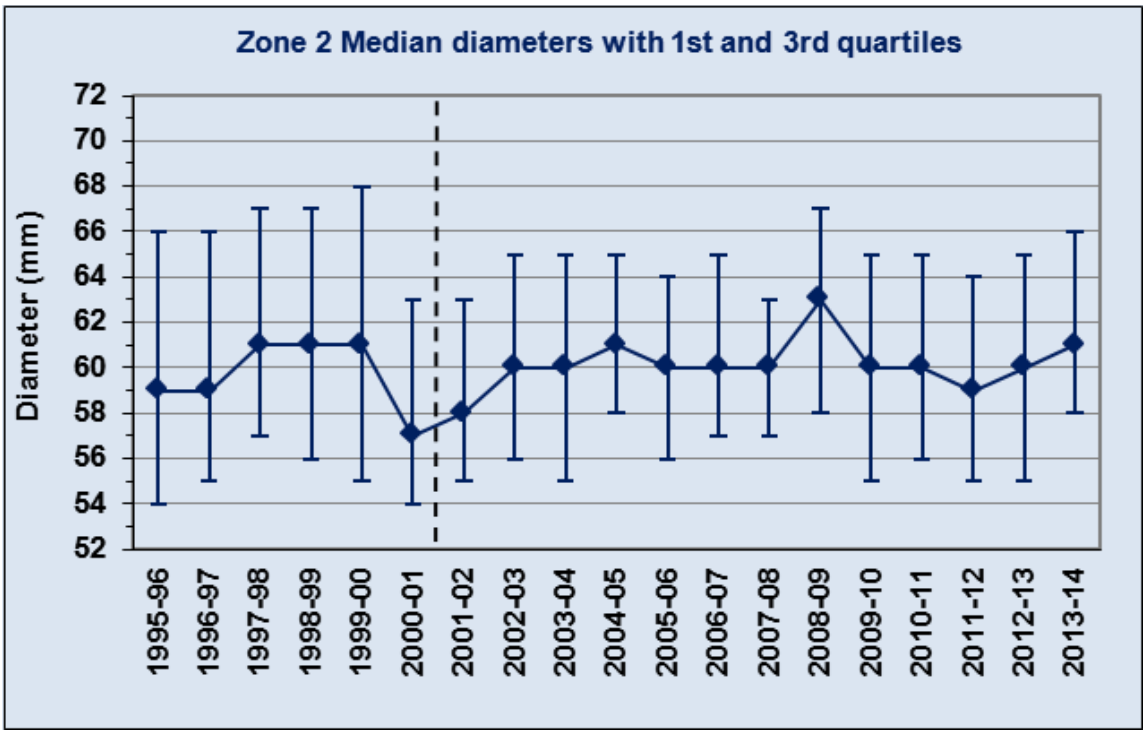
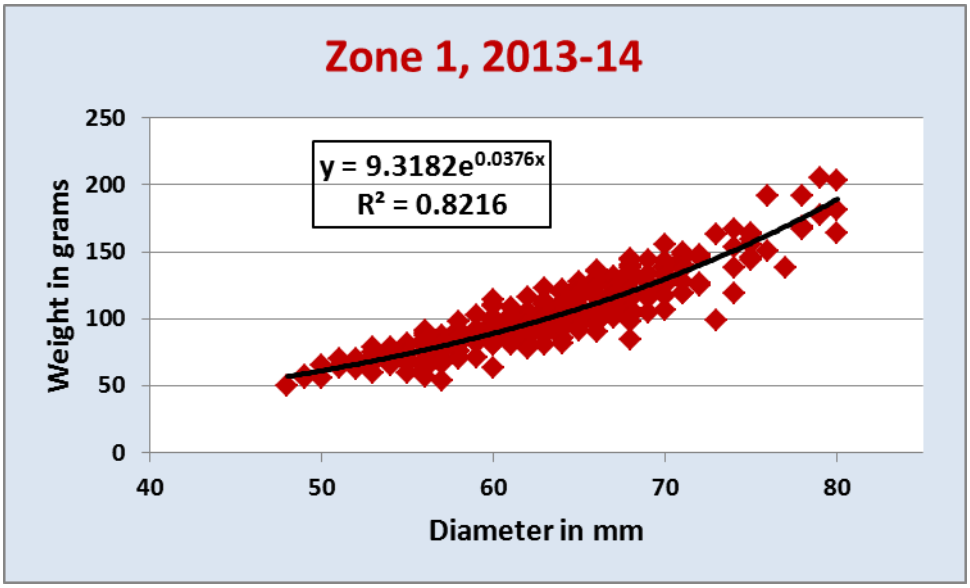


Figure 6a–b. Median sea urchin diameters from port samples, for Zone 1 (above) and Zone 2 (below), by season, with 1st and 3rd quartiles (brackets). Minimum legal size was 2 inches (50.8 mm) until 2001–02 (dotted line), when it increased to $2^{1}/_{16}$ inches (52.4mm).



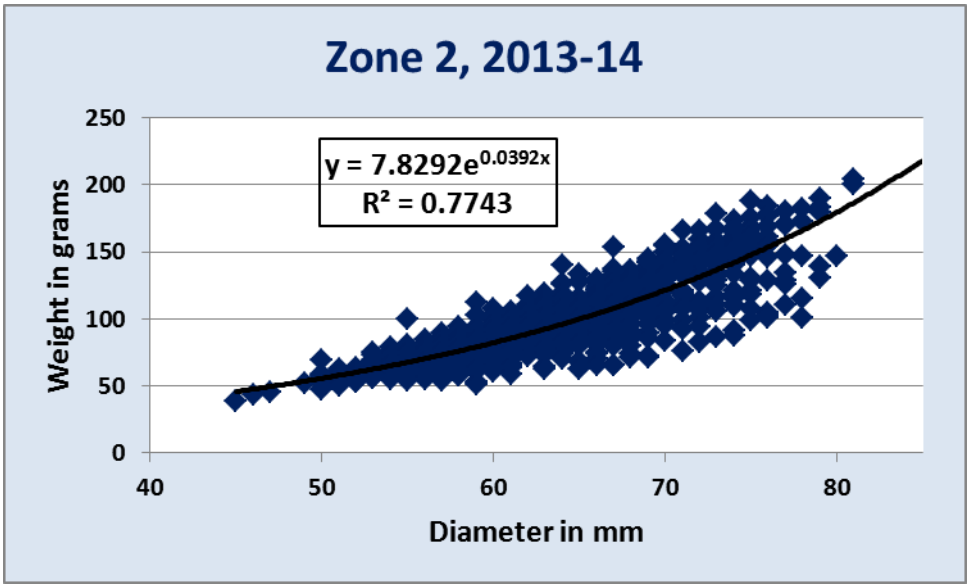
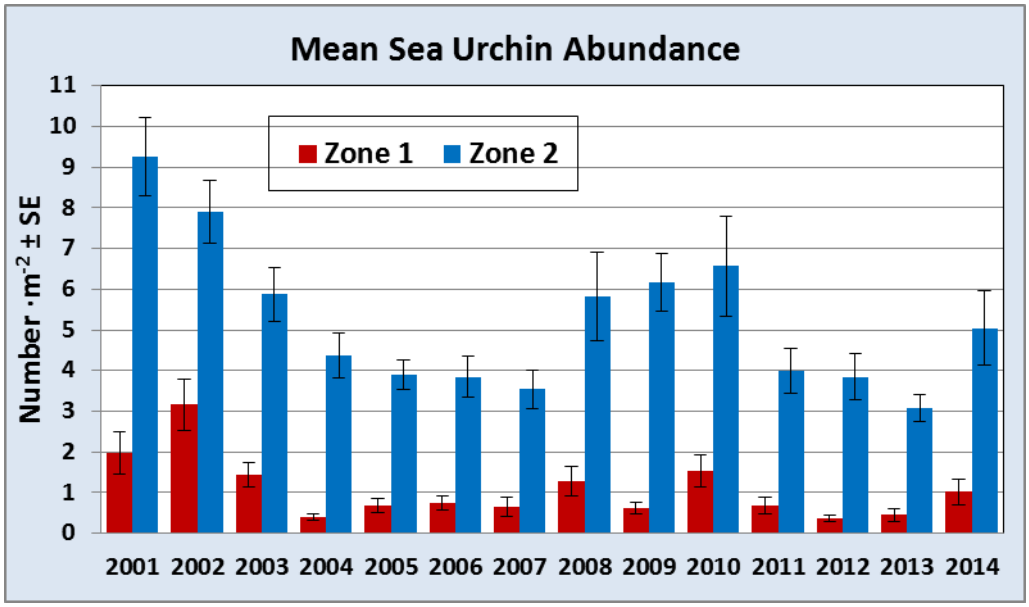


Figure 7a–b. Sea urchin whole wet weights (g) vs. diameter (mm) from 2013-14 season port samples for Zone 1 (above) and Zone 2 (below). Parameters were estimated for each zone for the relationship: Weight = a·Diameter^{b} where x=diameter and y=weight.



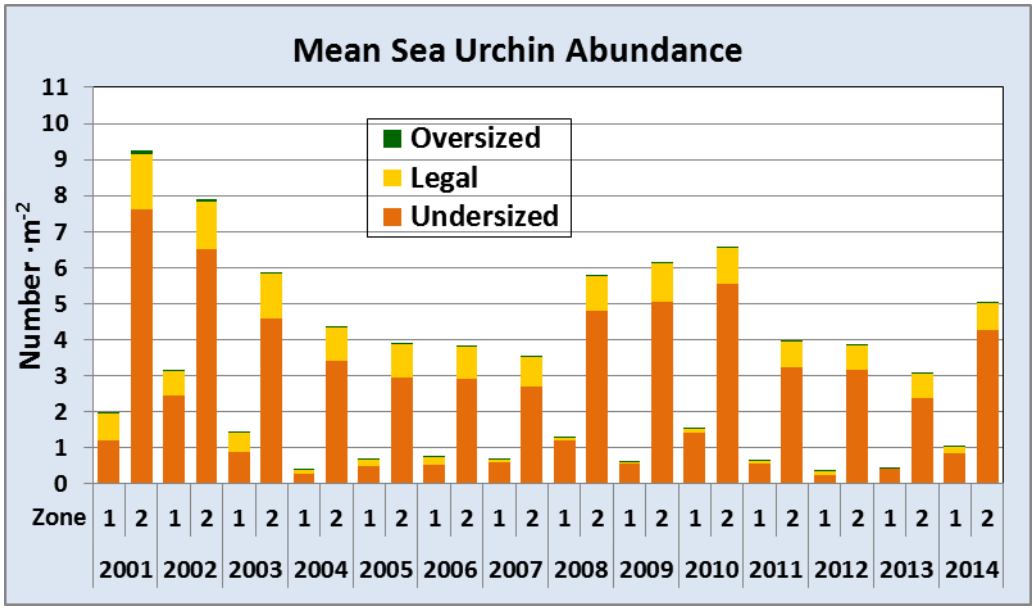
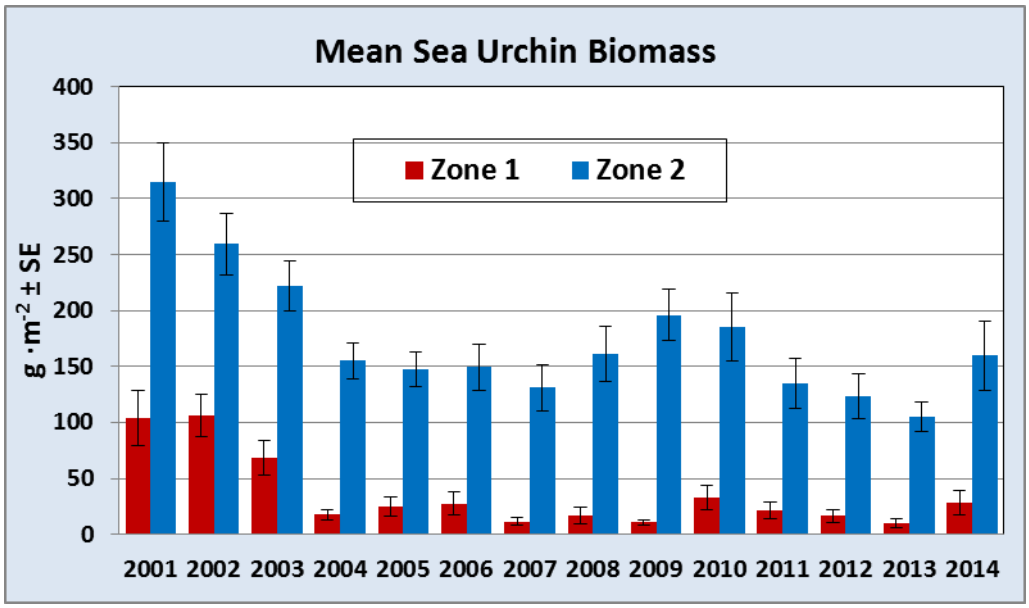


Figure 8a-b. **Stratified mean sea urchin abundance (number per square meter) from the spring dive survey by zone and year with standard errors above, and by zone, year, and size category (sub-legal or undersized, legal, and oversized) below.**



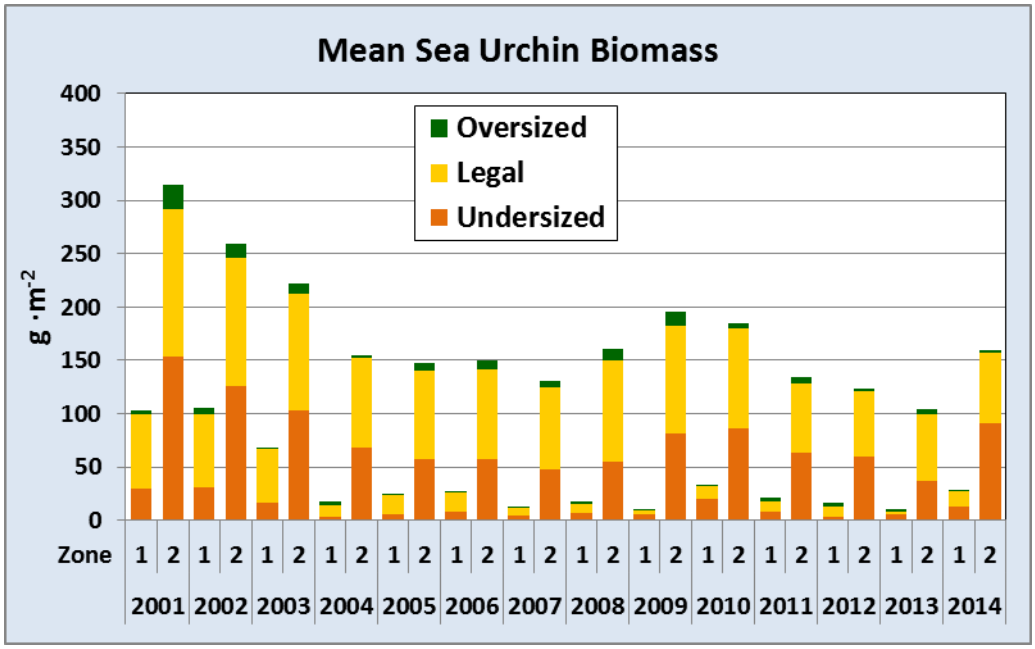


Figure 9a–b. Mean sea urchin biomass (grams per square meter) from the spring dive survey by zone and year with standard errors above and by zone, year, and size category (sub-legal or undersized, legal, and oversized) below.

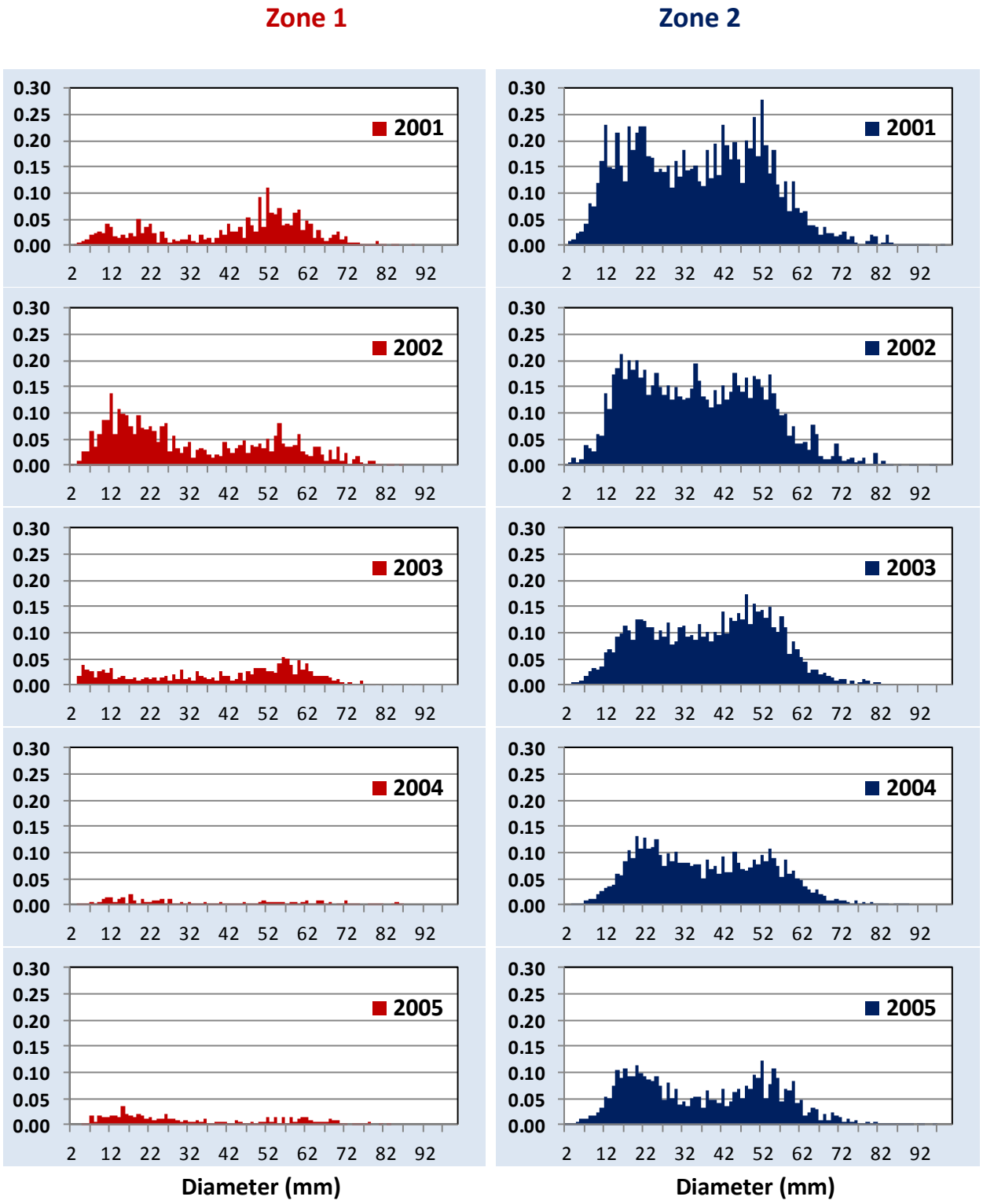


Figure 10. Stratified mean sea urchin abundance (number per square meter) from the spring survey, by zone (Zone 1 left, Zone 2 right), year, and diameter in mm.

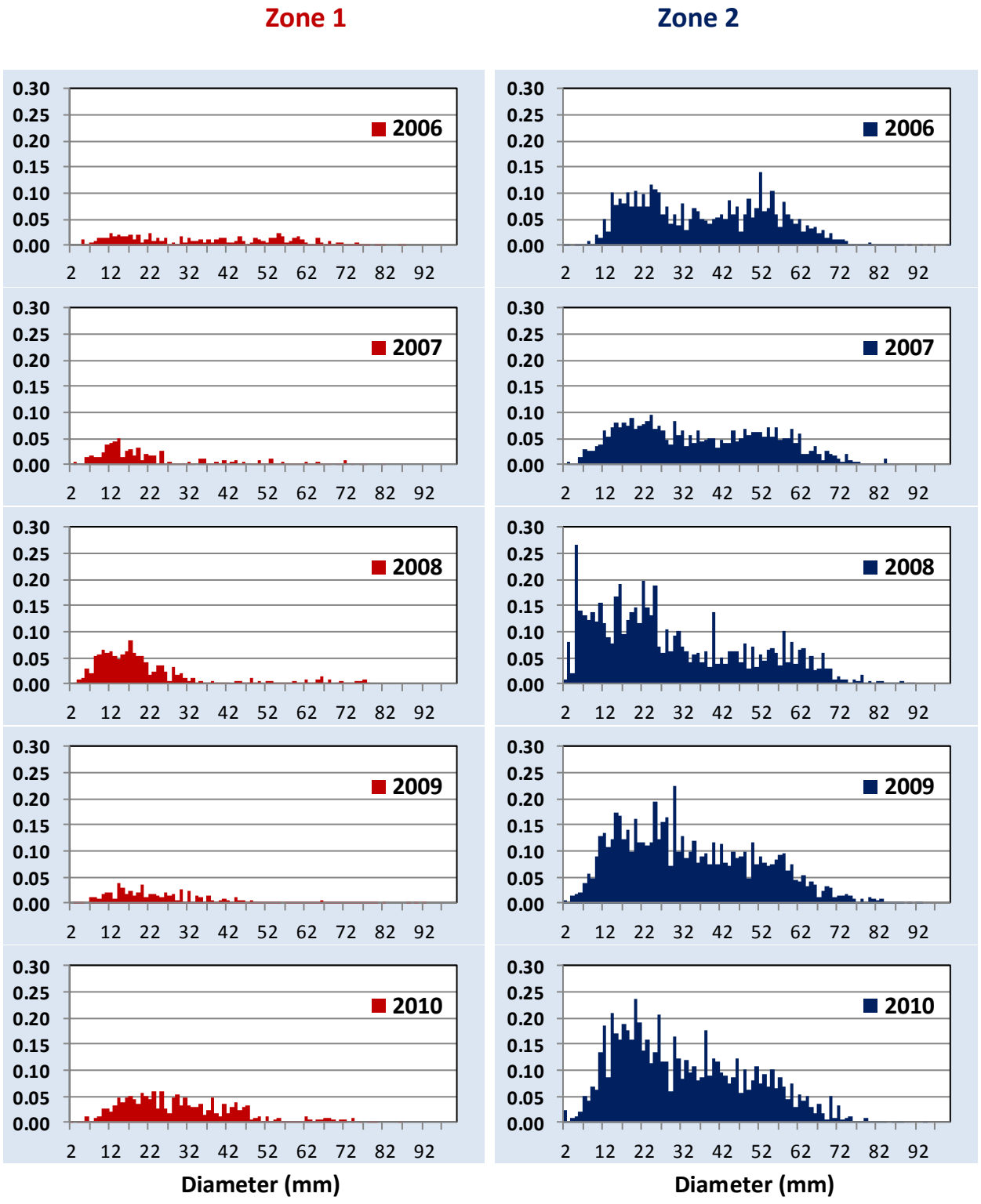


Figure 10. continued.

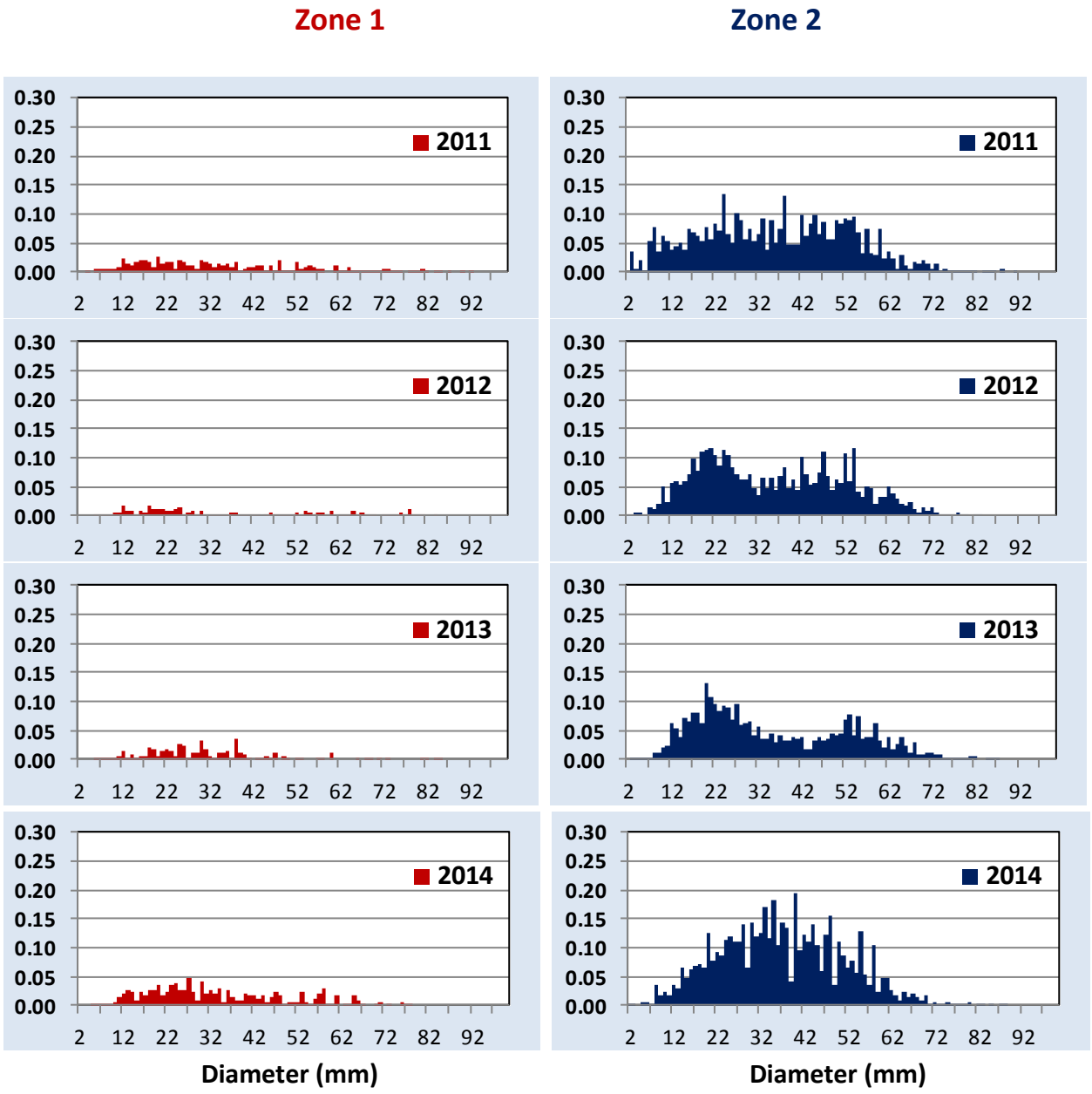
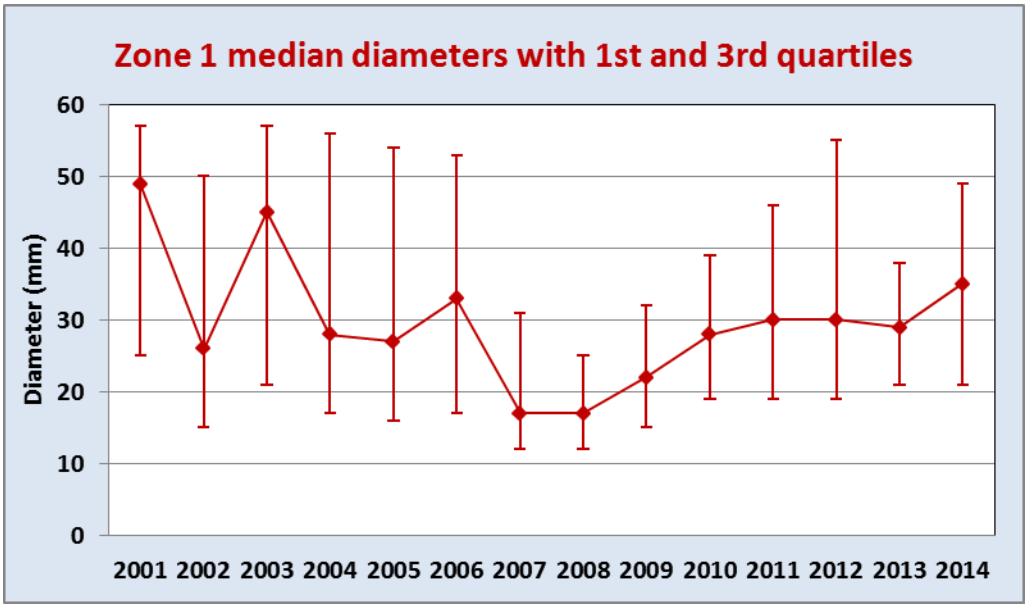


Figure 10. continued.



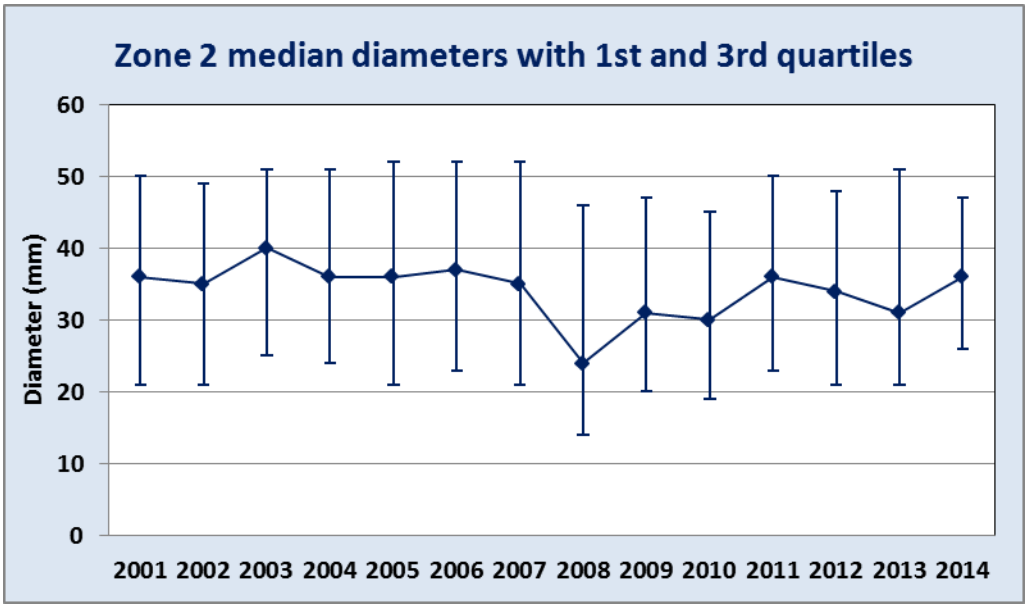


Figure 11. Median sea urchin test diameters (mm) from the spring survey by year, for Zone 1 (above) and Zone 2 (below), with 1st and 3rd quartiles (brackets).

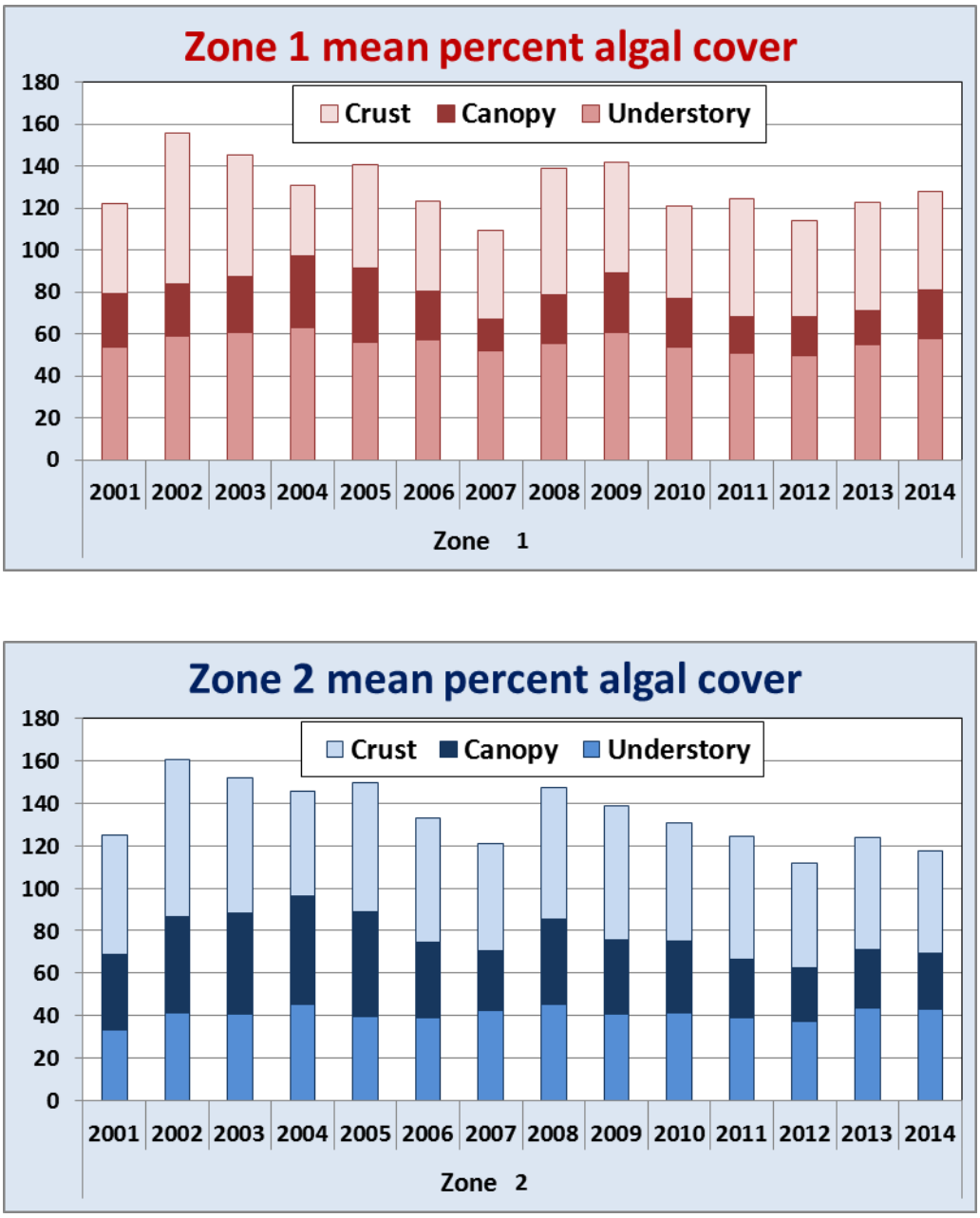


Figure 12. Stratified mean algal cover (%) from the spring survey by algal type, year, and zone, Zone 1 above and Zone 2 below. Note that the total cover can be more than 100%.

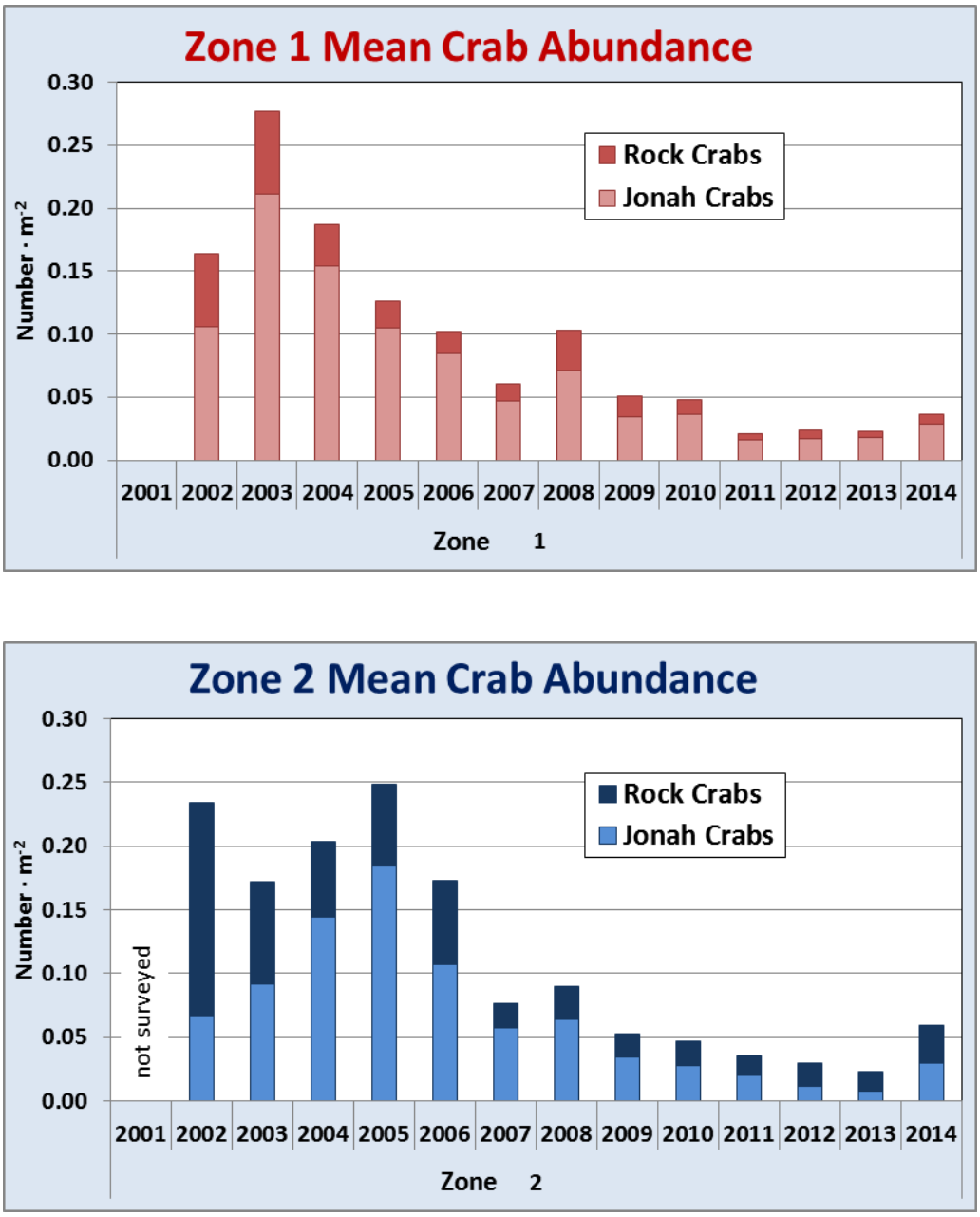


Figure 13. Stratified mean Jonah crab (*C. borealis*) and rock crab (*C. irroratus*) abundance (numbers per square meter) from the spring survey by species, year and zone, Zone 1 above and Zone 2 below.

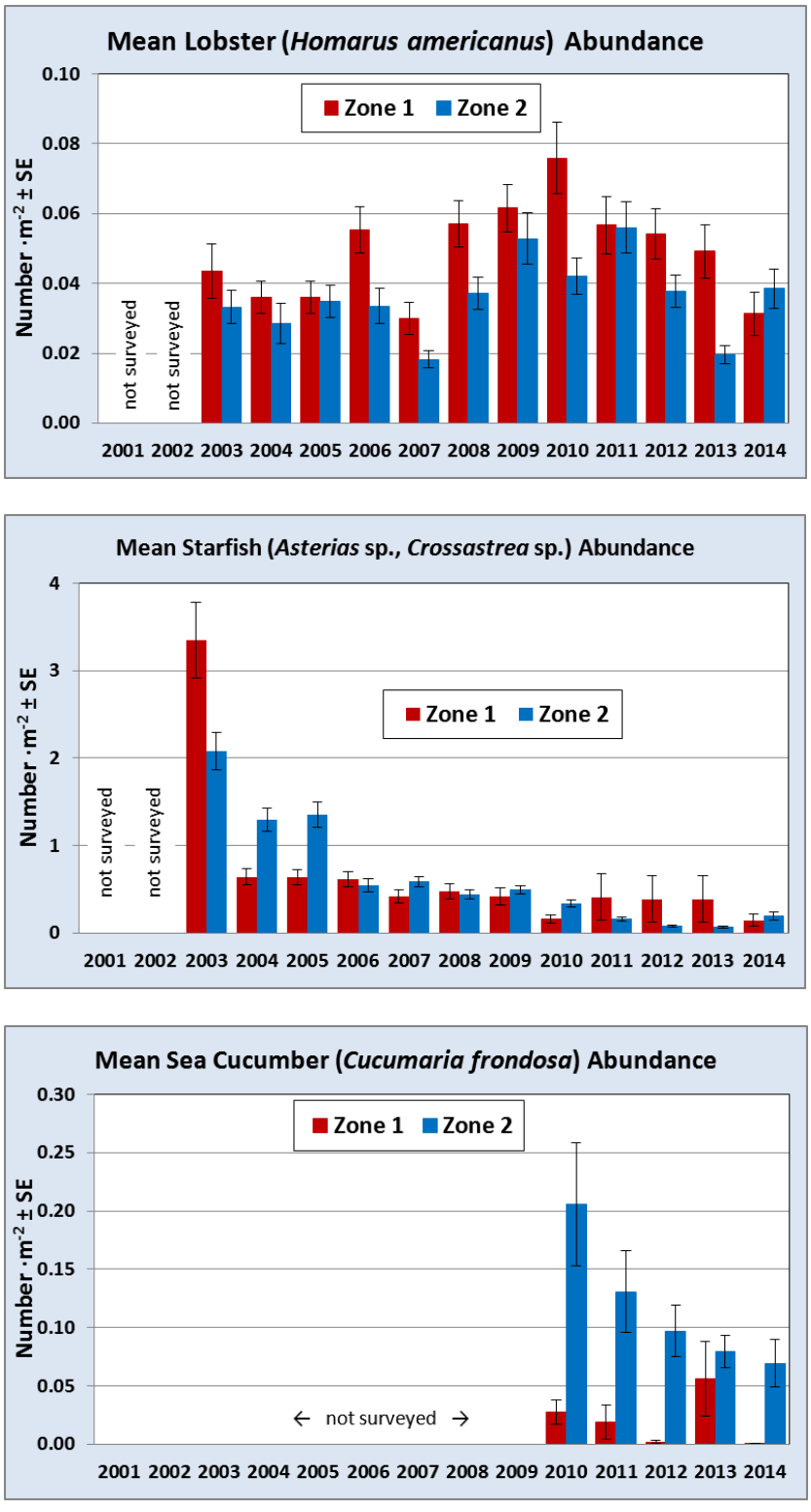


Figure 14a-c. Stratified mean lobster (*Homarus americanus*), sea star (*Asterias sp.*and *Crossastrea sp.*), and sea cucumber (*Cucumaria frondosa*) abundance (numbers per square meter), from the spring dive survey by zone and year with standard errors.