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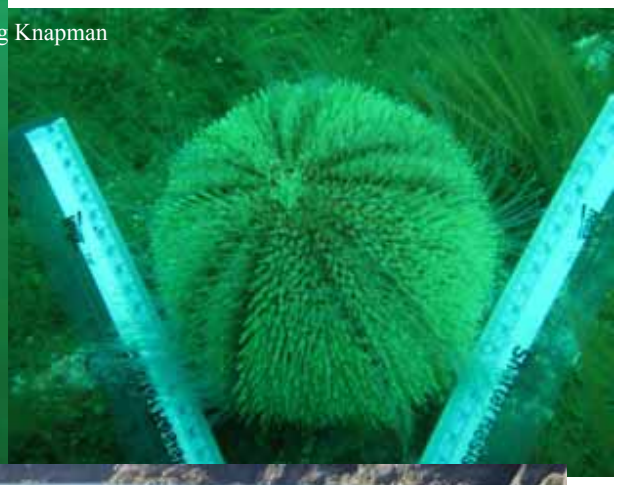
SKOMER MARINE NATURE RESERVE DISTRIBUTION AND ABUNDANCE OF *ECHINUS ESCULENTUS* AND SELECTED STARFISH SPECIES 2011

CCW Regional Report CCW/WW/11/04

K. Lock, M. Burton, P. Newman & J. Jones
2012

Greg Knapman



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SYNOPSIS

Echinus esculentus plays a key role in the structure of subtidal communities. Large numbers were removed from Skomer MNR during the 1970s when divers targeted the population for the curio trade and a population survey were completed in 1979 and 1982. No repeat surveys were completed until 2003 when data was collected to establish the status of both the *E. esculentus* population and conspicuous starfish species. In 2007 a survey was completed following the same methods as in 2003 and also established fixed surveys sites that can be used in future surveys. This survey was completed at the 2007 sites.

The survey was completed over 4 days by a team of 20 volunteer divers. *E. esculentus*, were counted and the diameter of *E. esculentus* were measured along 30m transects completed at different depth zones. *Marthasterias glacialis*, *Crossaster papposus* and *Luidia ciliaris* were also counted along these transects. The study sites were selected from the north and south coasts of the island and the north coast of the mainland. The mean densities of E. *esculentus* and *M. glacialis* were 9.1 and 3 per $100m^2$ respectively for the whole MNR, but density varied between sites. A normal size frequency distribution for *E. esculentus* was found and little variation in size range or mean density was found at different depths.

Plankton samples collected from March to November identified Echinoplutei in samples with abundance peaking in August. The Echinoplutei could not be identified to species level, therefore presence of *E. esculentus* larvae could not be confirmed. Late stage *Luidia spp* larvae were identified in September.

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Title of report: K. Lock, Burton, P. Newman & J. Jones (2012) Skomer Marine Nature Reserve Distribution and Abundance of Echinus esculentus and selected starfish species 2011. CCW Regional Report CCW/WW/08/2.

CRYNODEB

Mae *Echinus esculentus* yn rhan bwysig o strwythur cymunedau islanwol. Cafodd nifer fawr ohonynt eu cymryd o Warchodfa Natur Forol Ynys Sgomer yn ystod y 1970au pan aeth deifars ati i'w targedu er budd y fasnach mewn creiriau, a chwblhawyd arolwg o'r boblogaeth yn 1979 ac 1982. Ni chynhaliwyd arolygon wedyn tan 2003, pan aethpwyd ati i gasglu data i ddarganfod beth oedd statws poblogaeth *E. esculentus* a statws rhywogaethau amlwg o sêr môr. Yn 2007 cwblhawyd arolwg trwy ddilyn yr un dulliau ag a ddefnyddiwyd yn 2003, a hefyd cafodd safleoedd arolygu sefydlog eu creu – rhai y gellid eu defnyddio mewn arolygon yn y dyfodol. Cafodd yr arolwg hwn ei gynnal ar safleoedd 2007.

Cynhaliwyd yr arolwg dros bedwar diwrnod gan dîm o 20 o ddeifars gwirfoddol. Aethpwyd ati i gyfrif *E. esculentus* a mesurwyd diamedr *E. esculentus* ar hyd trawsluniau 30m ar barthau dyfnder gwahanol. Hefyd cafodd *Marthasterias glacialis*, *Crossaster papposus* a *Luidia ciliaris* eu cyfrif ar hyd y trawsluniau hyn. Cafodd safleoedd yr astudiaeth eu dewis ar arfordiroedd gogleddol a deheuol yr ynys ac ar arfordir gogleddol y tir mawr. 9.1 a 3 fesul 100m^2 oedd dwysedd cymedrig *E. esculentus* a *M. glacialis* (yn ôl eu trefn) ar gyfer yr holl Warchodfa Natur Forol, ond roedd y dwysedd yn amrywio o safle i safle. Daethpwyd o hyd i ddosbarthiad maint-amlder arferol ar gyfer *E. esculentus*, ac ychydig o amrywio a welwyd mewn maint a dwysedd cymedrig ar y gwahanol ddyfnderoedd.

Mewn samplau o blancton a gasglwyd rhwng mis Mawrth a mis Tachwedd daethpwyd o hyd i ddigonedd o *Echinoplutei*. Roedd y rhain ar eu mwyaf niferus yn ystod mis Awst. Nid oedd modd pennu union rywogaeth yr *Echinoplutei*, felly ni ellid cadarnhau presenoldeb larfa *E. esculentus*. Daethpwyd o hyd i larfa hwyr rhywogaeth *Luidia* ym mis Medi.

CONTENTS

1 INTRODUCTION

Since the designation of the Skomer Marine Nature Reserve in 1990 the work of the MNR team has focused on developing a range of projects to monitor the health of the Reserve and investigate the relevant aspects of species life histories for background information. The monitoring programme includes four volunteer diver projects that operate one a year on a four year rolling programme. One of these projects is the Edible urchin, *Echinus esculentus,* and selected starfish species population study, which allows a time series of comparable data to develop and allow changes in population structure to be identified.

1.1 *ECHINUS ESCULENTUS SURVEYS* IN SKOMER MNR

Echinus esculentus Linnaeus (1758) is an omnivorous grazer and a key biological structuring factor in subtidal communities. The grazing clears space making it available for colonisation by other species. In low numbers this grazing effect is beneficial; in high numbers it can be highly destructive even destroying whole kelp forests (Hagan, 1983).

During the 1970s divers targeted the Skomer population for the curio trade and large numbers were removed. The Underwater Conservation Programme carried out the first survey of the *Echinus esculentus* population in Skomer waters in 1978 (Earl, 1979). The results of the 1978 survey prompted a similar survey in 1981 by the Underwater Conservation Society (Bishop, 1982). Bishop (1982) reported that mean densities of *E. esculentus* of 5.5 per 100m^2 for Skomer in 1981 were not significantly different from densities in a commercially exploited population in Lamorna Cove, Devon. Densities were also significantly lower than those of other non exploited localities around the UK.

In 2003 the first *E esculentus* survey since the designation of the Skomer MNR Reserve was completed. The aim was to establish the current status of the population, including distribution, abundance, density and size frequency. Visual census conducted using standard SCUBA equipment and belt transects were selected as the most appropriate method. The method was designed for use with volunteer divers and is fully described in Luddington *et al* (2004). Study sites were selected from general areas along the north and south coasts of the island and the north coast of the mainland. The range of sites allowed all habitats and depths that *E. esculentus* are found in the Reserve to be surveyed.

In 2007 the survey was completed following the 2003 methods and established fixed survey sites using Geographic Positioning System (GPS) that can be used in future surveys. The 2003 method was reviewed and changes to allow improved size measuring techniques, habitat recording of sites and comparison between surveys. The survey method is fully described in Lock *et al* (2008).

The mean density of *E. esculentus* for the whole MNR was similar in the 2003 (6.1 per 100m$^{2)}$) and 2007 (7.2 per100m^2) but in both years the density varied between sites and depth. A normal size frequency distribution for *E. esculentus* was found and little variation in size range was observed no matter what the depth (Lock *et al* 2008).

1.2 STARFISH SURVEY IN SKOMER MNR

In 2003 and 2007 selected starfish species were recorded during the *E. esculentus* survey. The survey method suited the additional counting of easily identifiable species. Three starfish species were chosen: *Marthasterias glacialis* Spiny starfish, *Luidia ciliaris* Seven armed starfish and *Crossaster papposus* Common sunstar. *M. glacialis* and *L. ciliaris* show a southerly distribution whilst *C. papposus* shows a more northerly distribution occurring from the Arctic to the English Channel (Hayward & Ryland, 1995).

The aim was to establish the distribution and abundance of these starfish in the Skomer MNR. However the surveys were limited as the sites were selected for habitats suiting *E. esculentus* rather than habitats where the different starfish could be expected to occur. Although *M. glacialis* is found in the same rocky reef habitats as *E. esculentus*, C. *papposus* is found at sheltered sites with current swept sediment and *L. ciliaris* prefer sandy or sand scoured rock, gravel and mixed sediments (Picton, 1993).

The mean density of *M. glacialis* for the whole MNR was recorded at 4.98 per $100m^2$ in 2003 and 3.47 per $100m^2$ in 2007 the density varied between sites and depth. *Crossaster papposus* was not recorded in 2007 compared to 21 individuals being found in 2003. Two juvenile *Luidia ciliaris* were recorded in 2007 whilst none were seen in the 2003 survey suggesting low densities or that the surveyed habitat was unsuitable (Lock *et al*, 2008).

1.3 SURVEY OBJECTIVES

The survey aims to establish the current status of the *Echinus esculentus* population in Skomer MNR and record selected starfish species. The objectives are:

1. To determine the distribution and abundance of *E. esculentus* and describe their key habitats;

2. To determine the size frequency distribution of *E. esculentus*;

3. To record sunstar, *C. papposus*, spiny starfish *M. glacialis* and seven armed starfish *L. ciliaris*;

4. To allow a time series of comparable data to develop with the 2003 and 2007 survey results;

5. To record ‘bald’ *E. esculentus*.

6. To identify Echinoid larvae in plankton samples.

2 METHOD

2.1 SITE SELECTION

During the 2007 survey GPS positions for 6 permanent sites were established. These sites were selected to allow for coverage on the north and south coasts of the island and the north coast of the Marloes Peninsula. Site habitat descriptions recorded in the 2007 survey showed that 5 of these sites had suitable rock and boulder habitat for *E. esculentus*. These 5 sites are used again for the 2011 survey; each site position marked with buoyed sinkers for the duration of the survey. The Castle Bay site showed unsuitable (pebble) habitat so a new position following reconnaissance dives to assess suitability was established and used in the 2011 survey. The site positions are shown in Figure 3.2.

Figure 2.1. *Echinus esculentus* survey sites Skomer MNR 2011.

2.2 DIVING FIELD METHOD

2.2.1 Training

Time constraints limited pre-survey training. Teams of volunteers were therefore selected allowing for at least one experienced diver per diver pair. Experience was based on previous involvement of volunteer diving surveys. Each group of divers was briefed on the aims and methods of the survey prior to each dive session.

2.2.2 Field equipment

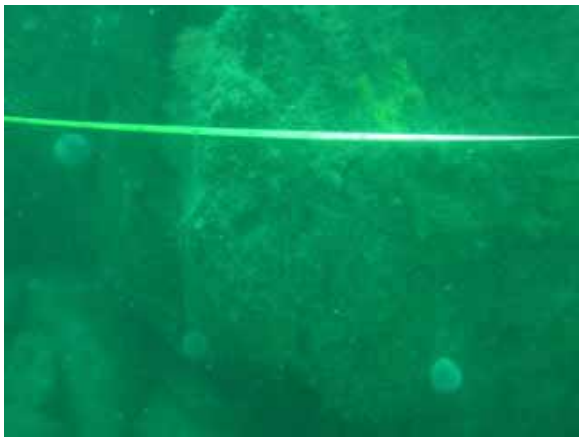
1 underwater writing slate, 1 *Gibbs urchin divider*, 1 transect tape (30m tape measure) and 1 weight (large shackle) attached to end of tape per diver pair.

2.2.3 Field method

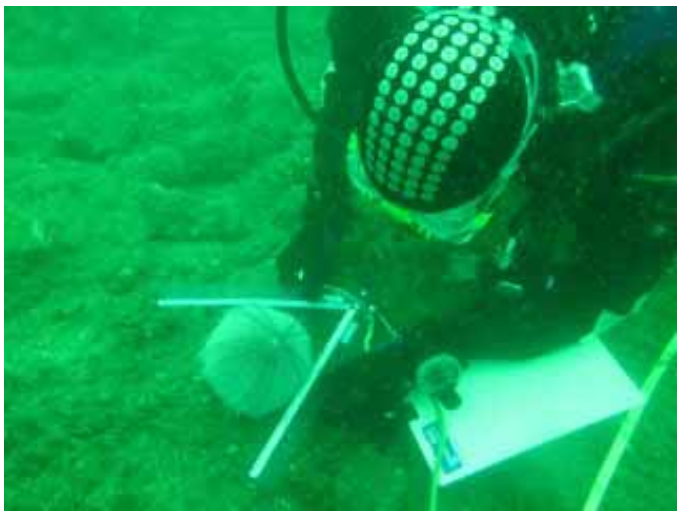
2.2.3.1 Transects

Transects were completed at 20m, 15m, 10m and 5m below chart datum (bcd) for each marked site. Site markers were positioned at 15m bcd and this was used as a reference for completing the transects at the different depths as follows: 15m bcd weight secured to site marker, 20m bcd weight secured (in a crevice or around a boulder) 5m deeper than the marker, 10m bcd weight secured 5m shallower than the marker and 5m bcd weight secured 10m shallower than the marker. Each dive pair was allocated which transects to complete before the dive with the aim to complete 2 transects per dive. The divers completed the method as follows:

1. Dive pair secure weight at the allocated transect depth and swims together on a depth contour laying out the tape.

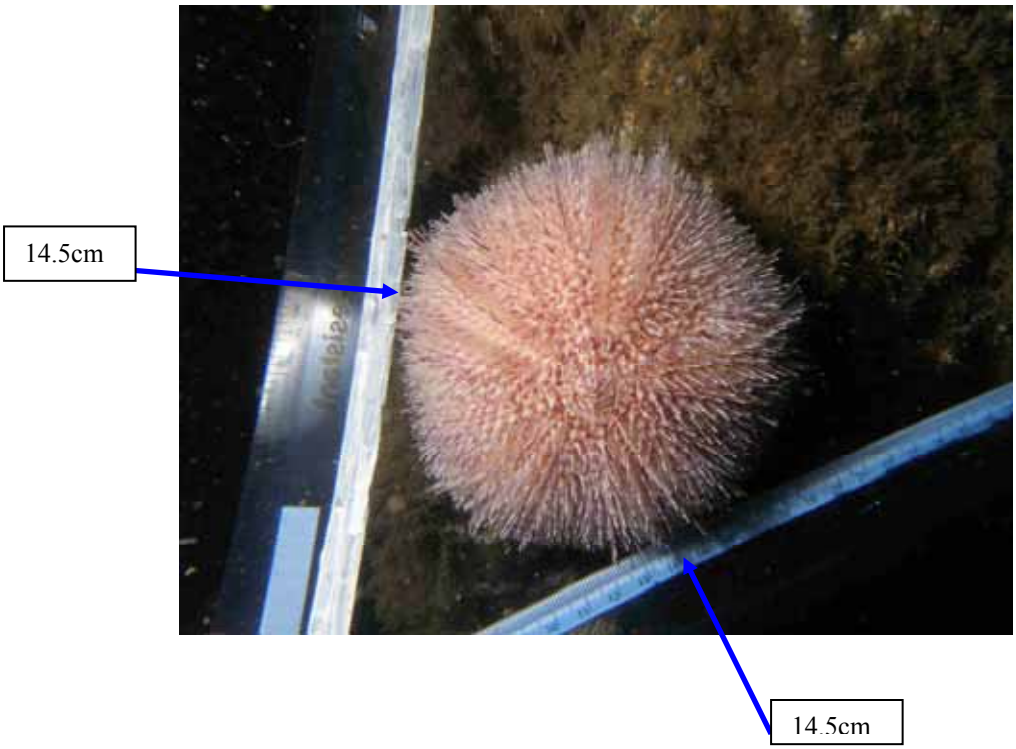


2. Dive pair swims back along the tape counting and measuring *E esculentus* and counting starfish in a 2m corridor, 1m either side of the tape.



(Photos: Greg Knapman)

***E .esculentus* recording:** Within the 2m corridor record the distance each urchin is found along the tape and measure each *E. esculentus* using the *Gibbs urchin divider* where the ruler touches the urchin at right angles to each other (tangent of the circle) as shown below:



3. Record any ‘bald’ Urchin 

4. Within the 2m corridor, record the total number of each of the following types of starfish:

   Spiny starfish (*Marthasterias glacialis*), common sunstar (*Crossaster papposus*) and seven armed starfish (*Luidia ciliaris)*



5. On completion of the 30m transect rewind the tape

6. Repeat the survey at shallower depth.

7. On the surface combine data from each member of the dive pair to obtain a complementary record of sightings for each transects.

2.2.3.3 Habitat description

Divers record seabed substrate, habitat and conspicuous species following Seasearch methods. On the surface completed a Seasearch surveyor form (Appendix 1).

2.2.3.2 Plankton sampling

Zooplankton sampling is completed following methods used by Plymouth Marine Laboratory (PML).

- 200um mesh pulled on a vertical haul from 35- 40m depth at 0.2m / sec (3.5 minute haul). The sample is collected in the 'cod-end' bottle and this is preserved in 4% formalin. Two samples are taken at each sampling event.

Samples analysis to be completed by PML.

3. RESULTS

The 2011 survey was carried out by a team of 20 volunteer divers on each of two weekends 4th and 5th June and 2nd and 3rd July 2011. Transects were completed at the 6 marked sites, 5 sites: Thorn Rock, North Wall, Rye Rocks, Martins Haven Point and High/Low Point were located at positions established in the 2007 and a new site position was established in the Castle Bay area. The densities of *E. esculentus* and starfish species for each site are shown in Appendix 2.

3.1 SURVEY SITE HABITATS

A summary of the seabed substrate, habitats and species for sites: Thorn Rock, North Wall, Rye Rocks, Martins Haven Point and High/Low Point were described in Lock *et al* 2007. . It was not necessary to complete this recording again for these sites.

A description of the newly positioned Castle Bay site is detailed below and a detailed species list is shown in Appendix 3.

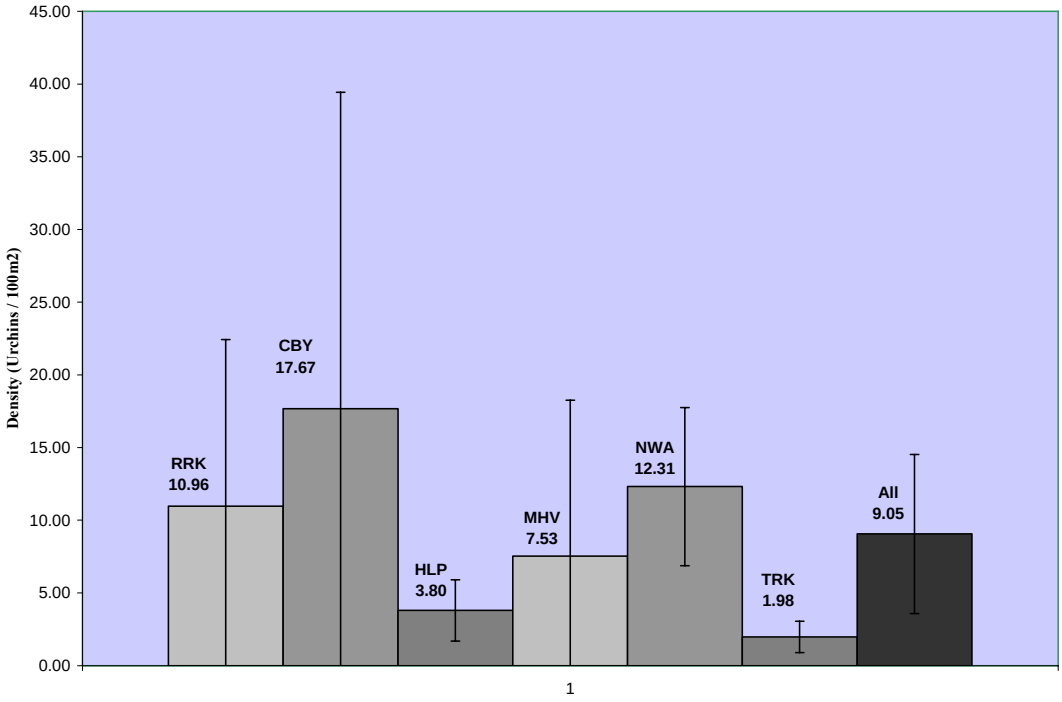
Castle Bay: Located on the south side of Skomer Island, the site is highly exposed to wave action and moderate currents. The site includes the bay area and the rocky reefs on the south western end which is often called 'High court reef'.
The rocky reef extends from 10m to 18m below chart datum. Kelp park and mix algae turf dominated the top of the reef. The rock faces are covered in bryozoan and hydroid turf along with a rich sponge community. The pink seafan *Eunicella verrucosa* is present and patches of the yellow trumpet anemone *Parazoanthus axinellae* and Indian feather hydroids *Gymnanium montagui*.
The rocky reef forms a series of rock pinnacles and ridges with wide gullies between 2 to 5 m wide. At the base of the gullies large boulders are found, in one surge gullies the scarlet and gold cup coral *Balanophylia regia* was recorded. Cobbles were also found in the gullies and these lead to a sloping plain of cobbles and mixed sediments.

3.2 *ECHINUS ESCULENTUS*

3.2.1 Density

A total of 139 transects were completed surveying an area of 8340m^2 of seabed and measured a total of 755 *E. esculentus*. The mean density of *E. esculentus* for all sites surveyed was 9.1 per 100m^2. The mean density was calculated for each transect and these were used to calculate the mean density for each site. These are shown with error bars (95% CI) in Figure 3.1

FIGURE 3.1 Density of *E. esculentus* per 100 m^{2} at survey sites in the Skomer MNR.



A wide range of mean densities were found at the different sites. The highest mean density of 17.67 per 100m^{2} was recorded at Castle Bay and the lowest was 1.98 per 100m^{2} at Thorn Rock.

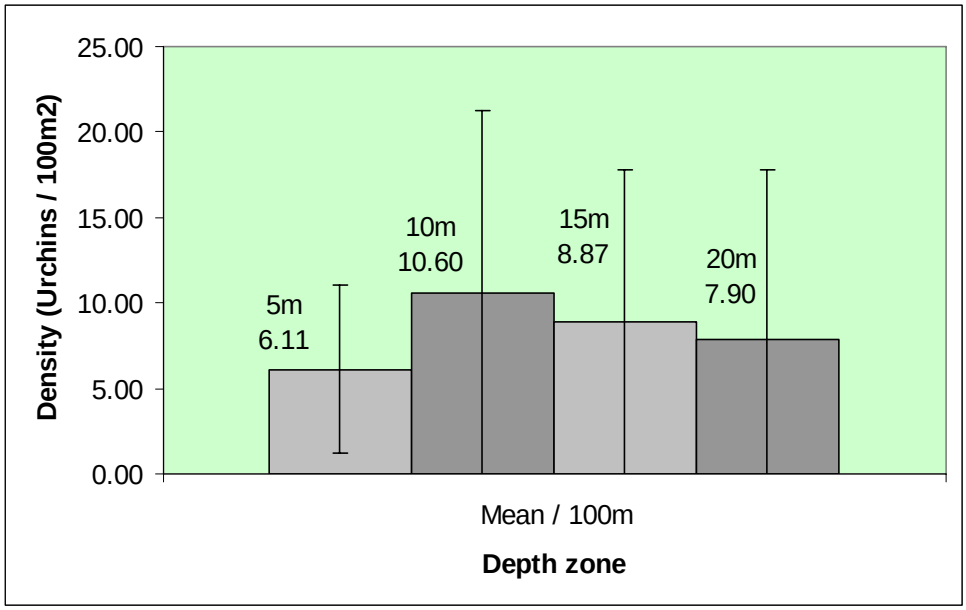
Transects were completed at the 20m 15m, 10m and 5m below chart datum depth contours at each site as shown in table 3.1.

TABLE 3.1 Number of transects completed at 20m, 15m, 10m and 5m.

Depths (bcd)	No. transects	Area m^2
5m	3	180
10m	39	2340
15m	60	3660
20m	36	2160

The density of *E. esculentus* at each depth contour with error bars (95% CI) are shown in figure 3.2.

FIGURE 3.2 Density of *E esculentus* at 10m, 15m, 20m in Skomer MNR 2011.

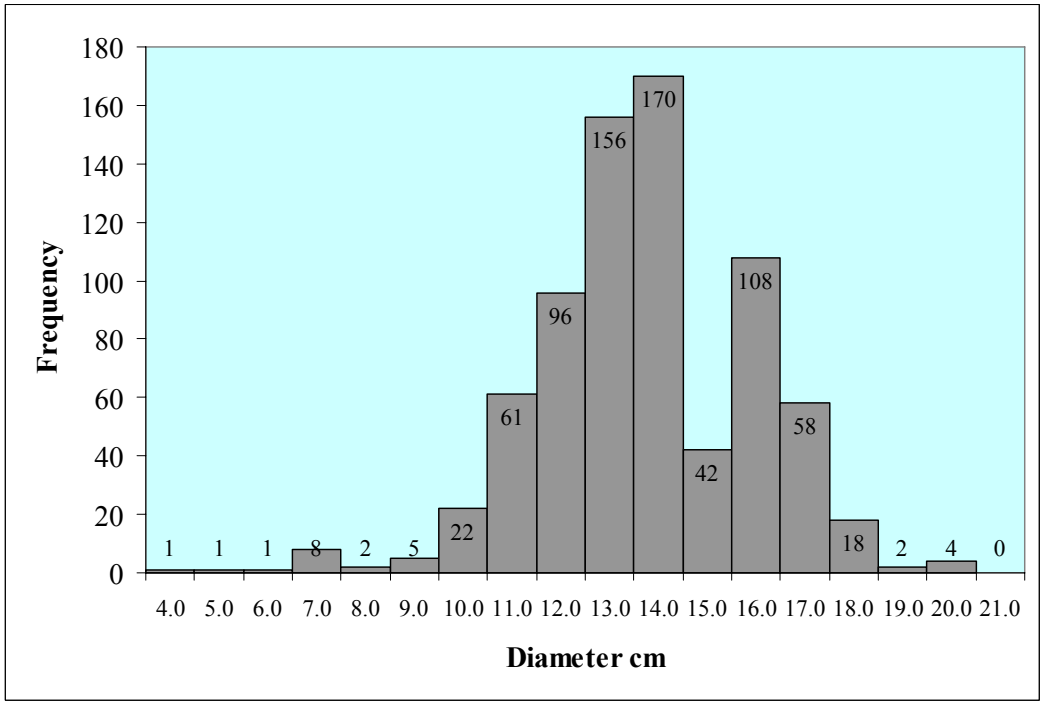


The mean density does not significantly vary between the different depths contours. The error bars show that there is no significant difference between the depths (95% CI).

3.2.2 Size frequency distribution

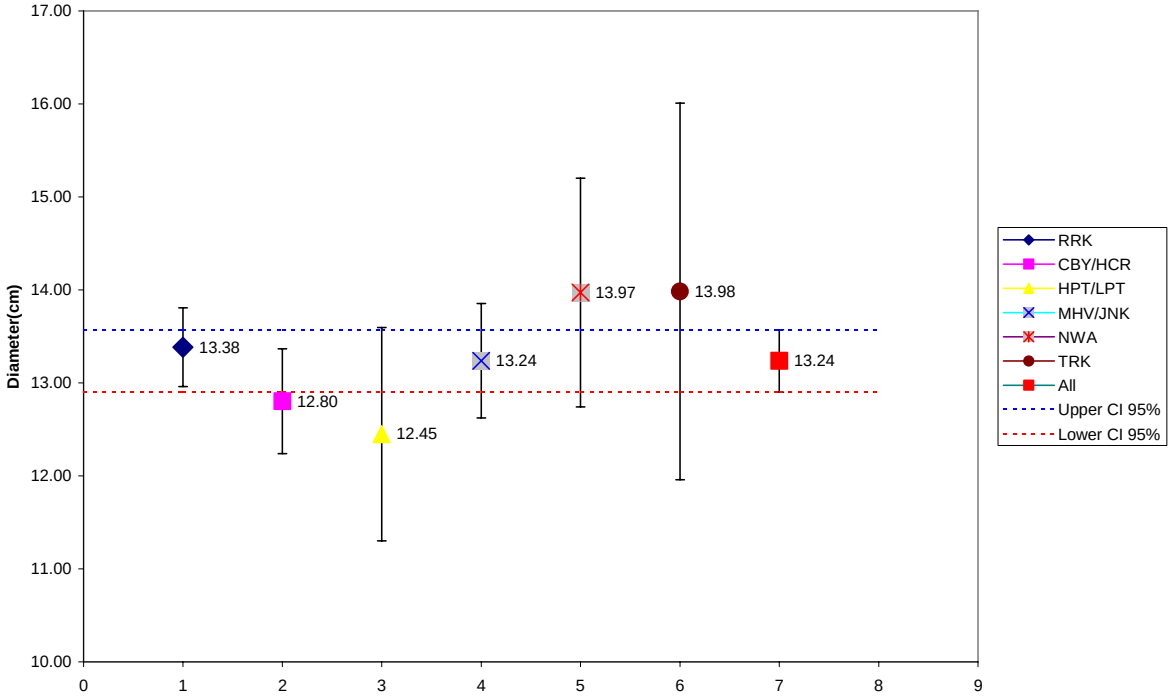
The 'Gibbs urchin divider' data was converted to *E. esculentus* diameter following the method detailed in Appendix 4.
The population of *E. esculentus* in Skomer MNR shows a normal size frequency distribution, as shown in Figure 3.3. The mean, maximum and minimum diameters were 13.24 cm, 20 cm and 4 cm respectively.

FIGURE 3.3 Size frequency distribution of *E. esculentus* in Skomer MNR 2011



The mean diameter of *E. esculentus* for each site are shown in Figure 3.4 along with the mean diameter calculated for all sites with error bars (95% CI).

FIGURE 3.4 The mean diameter of *E. esculentus* at all sites and individual sites with error bars (95% CI).



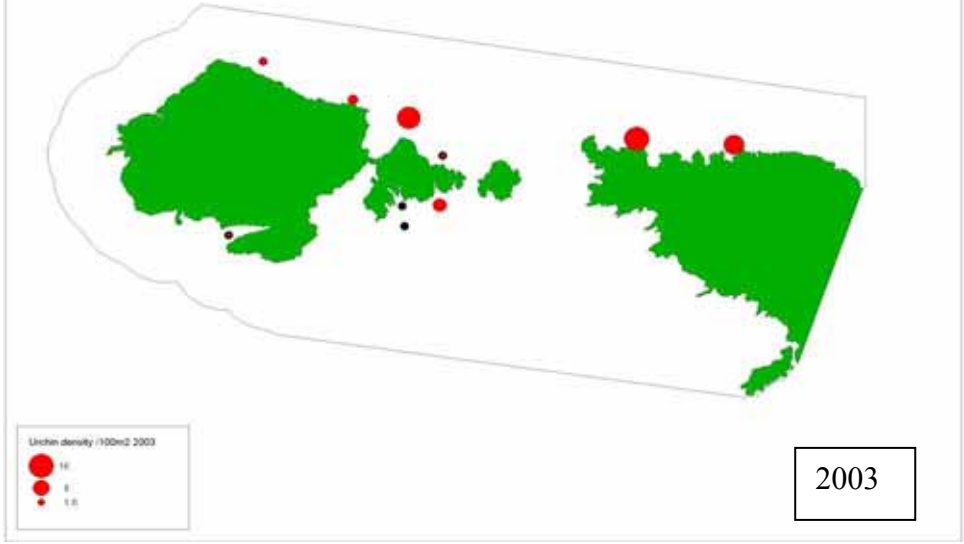
The results shows that there was little variation in the mean diameter between sites and none are significantly different at 95% CI.

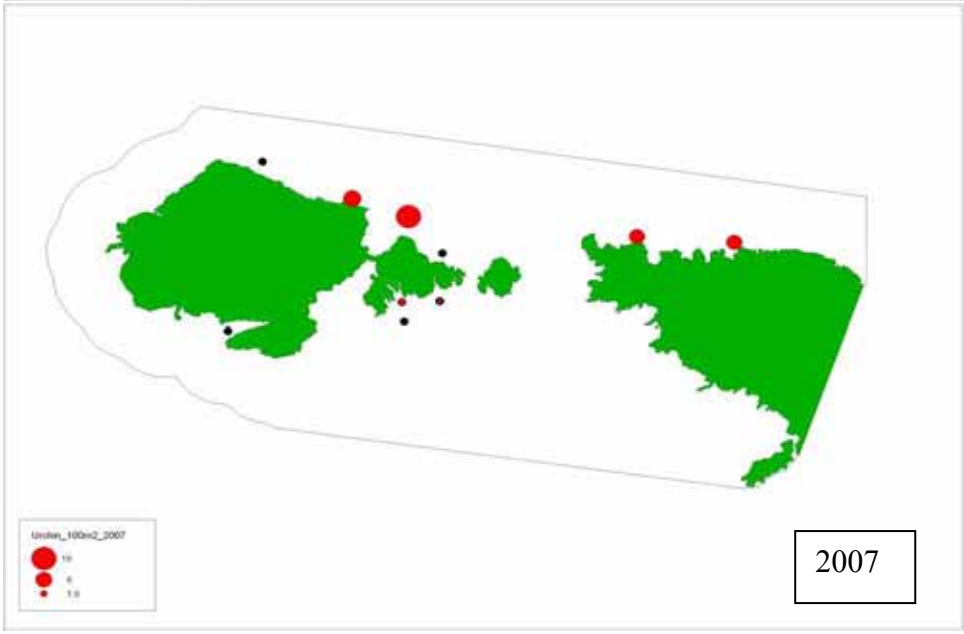
3.3 COMPARISON OF *E. ESCULENTUS* RESULTS 2011 WITH 2007 AND 2003 SURVEYS, SKOM MNR.

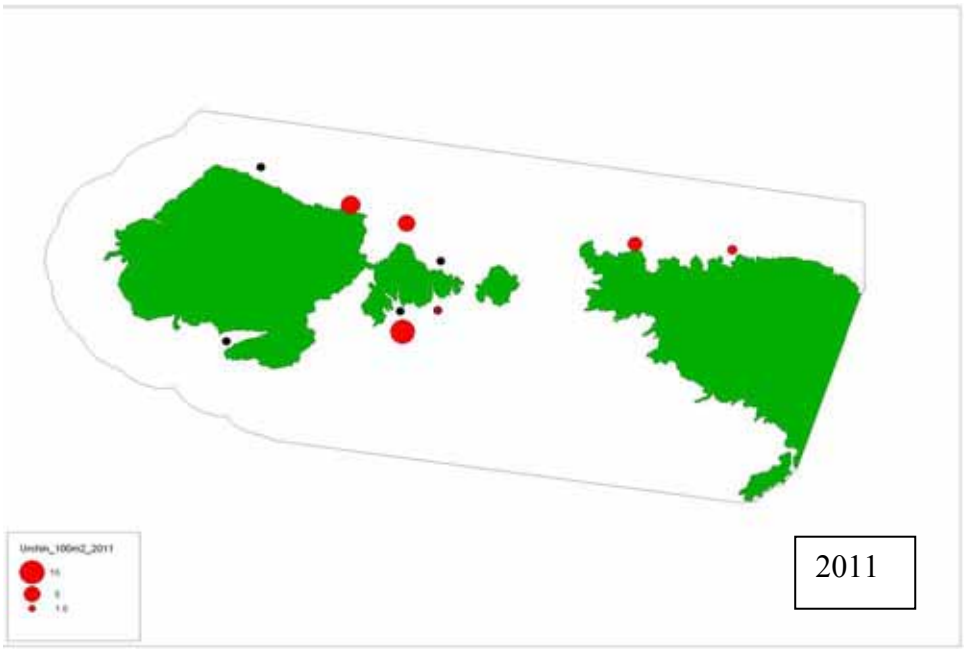
The 2003 data can not be directly compared between sites to the 2007 and 2011 data due changes in the method. The density of *E. esculentus* in 2003 was completed in general survey areas and 5m depth zones whilst in 2007 and 2011 the surveys were at marked sites and specified depths. The 2003 data is therefore used for comparing the general geographic areas but not in the specific site comparisons. The density distribution of E. esculentus in Skomer MNR in 2003, 2007 and 2011 is shown in Figure 3.4.

The distribution maps show that there has been a general decrease in densities along the North Marloes Peninsula (Martins Haven – High/Low Point) whilst densities have been reasonably consistent at the North Skomer sites and Thorn Rock. An increase in density at Castle Rock in 2011 is due to the change in site position.

FIGURE 3.4 Density (100m2) and distribution of *Echinus esculentus* in Skomer MNR

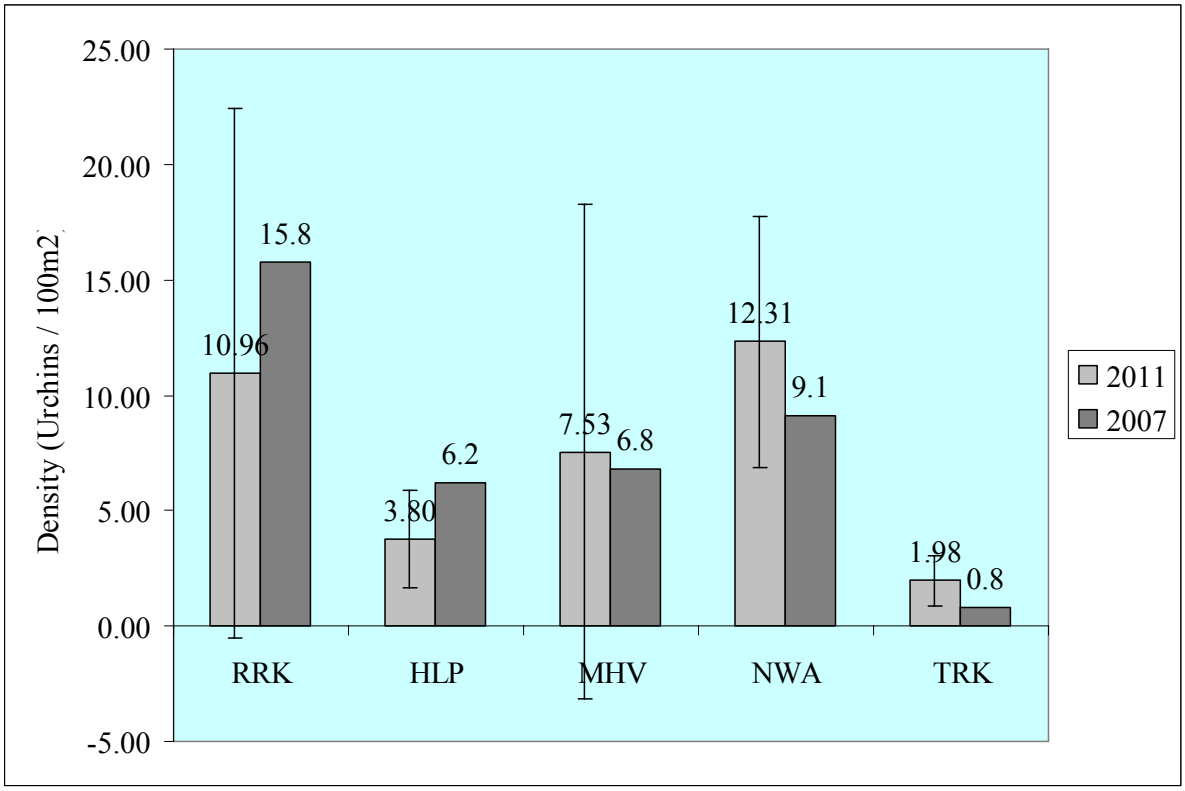






The 2011 and 2007 data can be compared where the same fixed positions were used for sites. These were at: Thorn Rock, North Wall, Rye Rocks, Martins Haven Point and High/Low Point. The Castle Bay data can not be included as different site positions were used in the surveys. The mean density of *E. esculentus* at comparable sites in the MNR in 2011 and 2007 are shown in Figure 3.5.

FIGURE 3.5 Density of *E. esculentus* per 100 m^2 **at comparable sites in the Skomer MNR 2007 and 2011.**



The 2011 data with 95% CI suggests that the 2011 means are not significant difference from the 2007 means, (Confidence interval are not available for the 2007 data).

3.4 STARFISH SPECIES

In 2011 the total area surveyed for starfish was 8340m^2, a density of 4 per 100m^2 *Marthasterias glacialis* was recorded, 10 individual *Luidia ciliaris* and no *Crossaster papposus.*

Table 3.4 compares the 2011 records to those in 2007 and 2003. *M. glacialis* records are reasonably consistent between the surveys. *C. papposus* shows 21 records in 2003 but none in either 2007 or 2011. An increase in *L. ciliaris* records in 2011 was recorded but these are still very low numbers, 7 were found at Rye Rocks, 1 at North Wall and 2 at Castle Bay. *L.ciliaris* adults can reach up to 40cm across; all records in 2011 were between 2.5cm to 10cm across.

TABLE 3.4. Starfish records in Skomer MNR surveys 2003, 2007 and 2011

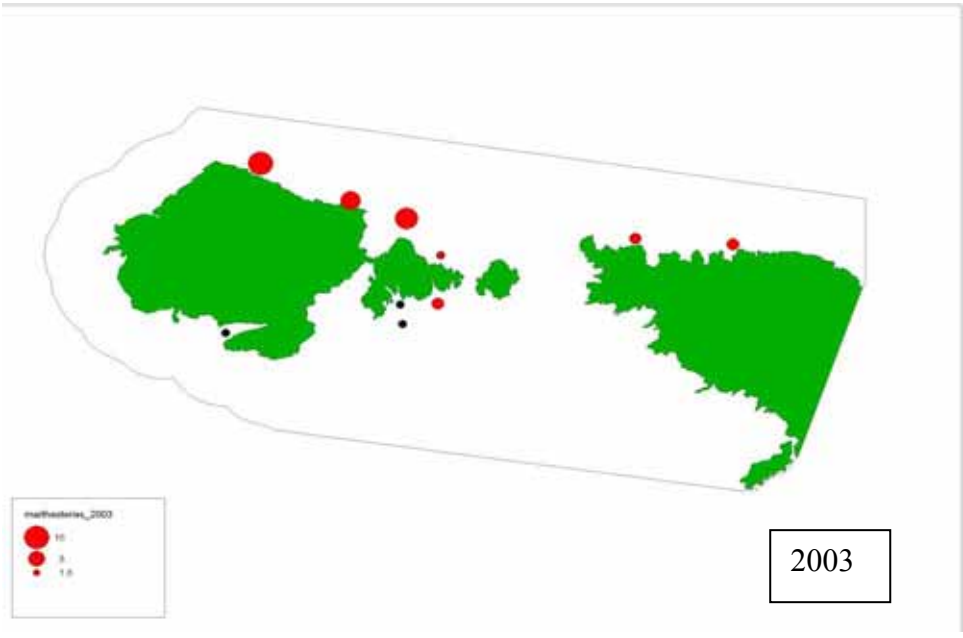
	2003	**2007**	**2011**
M. glacialis	4.98 per 100m^2	3.47 per 100m^2	4 per 100m^2
C. papposus	21	0	0
L. ciliaris	0	2	10

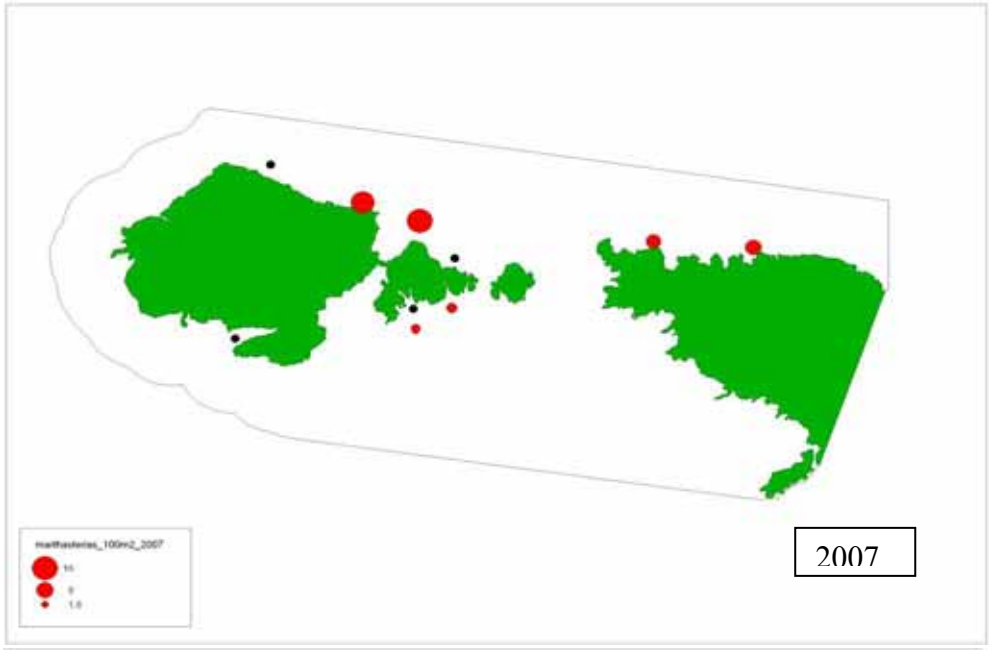
L. ciliaris juvenile (approx 2.5 cm across)

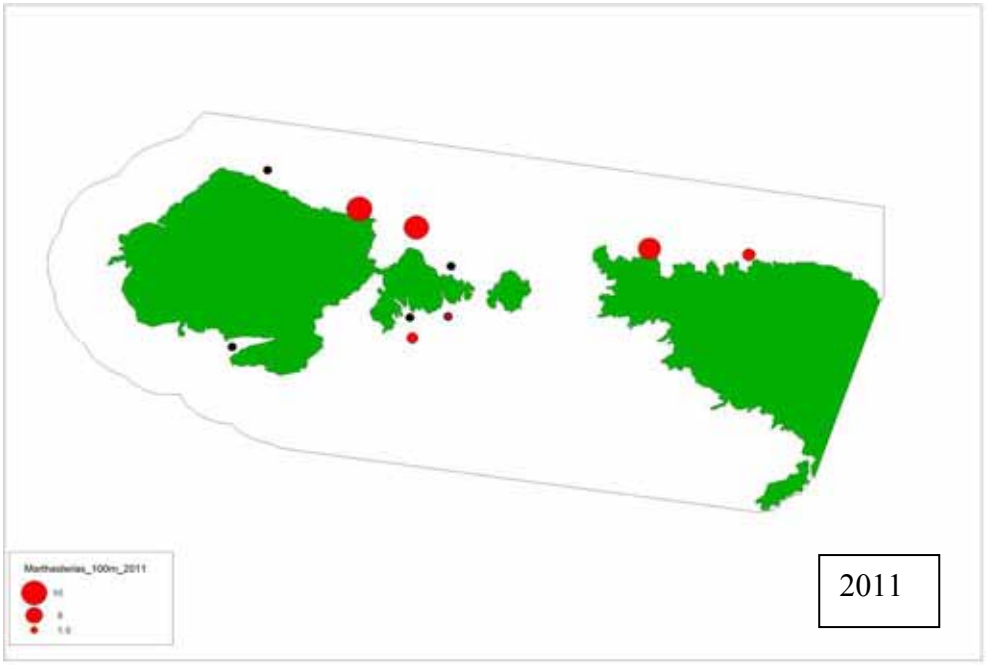
Small *L. ciliaris* (approx 10 cm across)

The density and distribution of *M. glacialis* in 2003, 2007 and 2011 for general geographic areas within the MNR are shown in Figure 3.6. The density distribution is consistent between each survey.

FIGURE 3.6 Density (100 m^{-2}) and distribution of *Marthasterias glacialis* in Skomer MNR







3.5 'BALD' E. ESCULENTUS

The numbers of 'bald' *E. esculentus* recorded on each survey was been incredibly low.

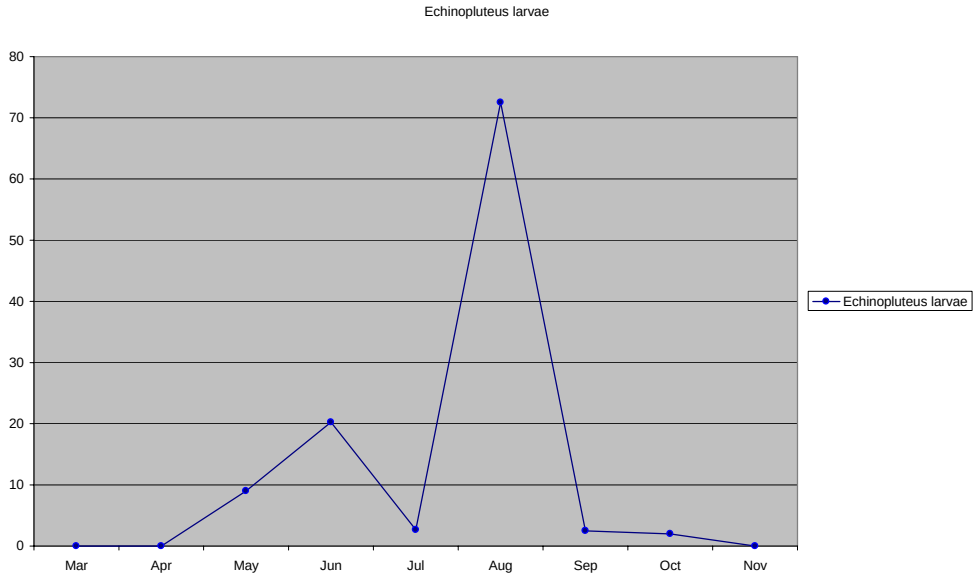
	2003	2007	2011
Total *E. esculentus*	**505**	**609**	**755**
Total 'bald' *E. esculentus*	**0**	**2**	**1**

3.6 PLANKTON SAMPLES

2011zooplankton samples were collected from March to November, these have been analysed by the Plymouth Marine Laboratory.

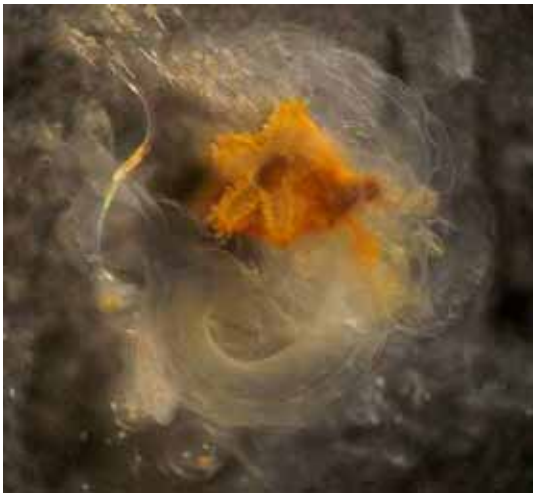
The echinoplutei are the plankton larvae of the Echinoids (Urchins) group. It was not possible complete identification to species level as no late stage larvae were found. *Echinus esculentus* larvae were therefore not identified. Winter sampling would be needed to see if the late stages of larvae development could be found then. Peak abundance for echinoplutei was recorded in August.

Figure 3.7 Percentage of abundance of Echinoplutei in Skomer MNR from March to November 2011



Large brachiolaria (late stage larvae) of *Luidia* spp were seen in September.

In the image the baby starfish is the orange disc. The large opaque structure is an anchor arm which is used to attach the larval starfish to a suitable substrate when it is ready to settle out as a fully formed juvenile. It is not known which *Luidia* species this was.



4 DISCUSSION

The density and distribution of *E. esculentus* and starfish species showed variations between sites. *E. esculentus* showed a normal size frequency and no significant variation in density or size was observed at different water depths.

4.1 *E. ESCULENTUS* DENSITIES

The average density of *E. esculentus* in Skomer MNR in 2011 was compared with densities recorded for Skomer and other locations in the UK (Table 5.1). Luddington *et al* (2004) summarised that the densities recorded in the 1981 and 2003 Skomer surveys were similar despite different methods and sample sizes being used and that these densities were much lower than those recorded for other UK sites. Lock et al (2008) reported that in 2007 mean density was again similar to those previously recorded in the Skomer MNR despite method changes. In 2011 the mean density was slightly higher but not to any significant level.

Further comparisons with other UK sites have not been possible as *E. esculentus* density surveys at other locations have not been completed since 1984.

TABLE 4.1 Comparison of mean densities of *E. esculentus* per 100m² from previous surveys

Location	Mean density per 100m²	Site variation	Source
Plymouth	20		Nichols (1984)
Millport	160	140 - 304	Nichols (1984)
Skomer	5.5		Bishop (1982)
Skomer	6	0.8 - 14	Luddington *et al* (2004)
Skomer	7.3	0.8 - 15	Lock *et al* (2008)
Skomer	9.1	1.9 - 17	Lock *et al* (2012)

In the 2003, 2007 and 2011 surveys site variation in densities was observed and reflects variations in exposure to wave action and prevailing currents. The prevailing swell and wind direction is from the southwest therefore coasts/sites facing this direction are exposed to the greatest wave action.

In 2011 the highest *E. esculentus* density was 17.67 per 100m² at Castle Bay which initially seems surprising as a density of only 1.8 per 100m² was recorded at this site in 2007. In 2007 the marker for this site was positioned on a substrate of cobbles and low lying reef exposed to the prevailing swell and wave action from the southwest. In 2011 the site position was relocated to a rocky reef area made up of steep rock pinnacles and wide gullies, the habitat here was more suitable for *E. esculentus* with lots of areas to shelter from wave action. The habitat also supported rich communities of hydroid, bryozoan and algae turf, the preferredfood sources for *E. esculentus* (Bishop & Earl, 1984).

High densities were also recorded at sites along the north side of Skomer with 12.31 per 100m² at North Wall and 10.96 per 100m² at Rye Rocks. Both these sites are exposed to moderate tidal current and sheltered from the prevailing south westerly swell and wave action. All surveys at these sites were completed on bedrock reefs and boulder slopes providing the preferred substrate for *E. esculentus* favoured habitat. Sites along the north Marloes Peninsula had lower densities of 7.53 per 100m² at Martins Haven and 3.80 per 100m² at High/Low Point. These sites are rocky reef and boulders sheltered from the prevailing south westerly swell and wave action, but these sites are exposed to slightly lower tidal currents compared to the north coast of Skomer. The deeper transects

at these sites also found mixed sediments of muddy shell gravel, a habitat not suited to *E. esculentus*. The lowest *E. esculentus* density was 1.98 per 100m^2 at Thorn Rock. The low numbers are a reflection of this site being exposed to the prevailing swell and wave action from the southwest. Thorn rock is a silt covered bedrock reef, dominated by sponge communities, not the preferred food source of *E. esculentus* (Bishop & Earl, 1984).

At Skomer, Bishop (1982) noted that the highest density of *E. esculentus* was obtained from a bedrock habitat sheltered from wave action, but exposed to fast tidal streams. Luddington *et al* (2004) and Lock *et al* (2007) both confirmed these observations and the findings of the present study are again consistent with the previous studies at Skomer.

The 2011 survey showed that there was no significant difference in density with depth as was found by Nichols (1984) who showed no significant difference in density between shallow (8-10 m) and deep (20-22 m) sites. However other studies have shown varied responses of *E. esculentus* to water depth. Bishop (1982) reported highest densities at 7m and Hunnam (1976) suggested that urchin density increased with depth. The variable trends shown in the different surveys may be a result of the different survey methods in each of the surveys. Previous Skomer surveys also show variable trends. Luddington *et al* (2004) reported that twice the density of *E. esculentus* was recorded in deeper water (21-25m) compared with shallow water (6-10m), but also noted that the results may be biased as a far greater number of surveys were carried out in shallow than deep water. In contrast Lock *et al* (2008) reported that the densities decreased with depth where an equal number of transects were completed at the specified depths.

4.2 *E. ESCULENTUS* SIZE

The mean diameter of *E. esculentus* at Skomer in 2011 was compared with mean diameters recorded for Skomer and other locations in the UK (Table 5.1).

Location	Mean diameter (cm)	Source
Isle of Skye, Scotland	7-10	Nichols (1979)
Lamorna Cove, Cornwall	11 - 12	Nichols (1979)
Skomer	11.5	Bishop (1982)
St Abbs, Scotland	7.9	Bishop & Earl (1984)
Skomer	11.5	Bishop & Earl (1984)
Skomer	12.5	Luddington *et al* (2004)
Skomer	12.2	Lock *et al* (2008)
Skomer	13.24	Lock *et al* (2012)

Bishop & Earl (1984) observed a striking contrast between mean diameters of the St Abbs and Skomer populations. Comparing with other locations the Scottish sites St Abbs and Isle of Skye closely match as do the southwest Britain sites Skomer and Lamorna Cove which suggests that *E. esculentus* growth could be influenced by water temperature.

Growth studies by Nichols et al (1985) showed that growth curves of *E. esculentus* sites 800 miles apart in Plymouth and Cumbrae, Scotland were similar; individuals aged 7 years were 10cm in Plymouth and 9cm in Cumbrae. Nichols et al (1985) suggested that growth in populations of grazing animals such as *E. esculentus* depends on a complex of factors, including sea-water quality and temperature, and food availability. Sea-water temperatures in southwest Britain are on average higher than those on the west coast of Scotland, which might favour the Plymouth populations but, on the other hand, food availability may favour certain Cumbrae populations. Nichols et al (1985) found that the upper levels of the growth curves were higher for Plymouth, diameter 11.74cm

compare to Cumbrae, diameter 9.98cm. This supports that the mean size of *E.esculentus* from Scottish waters is generally below that from southwestern Britain (Nichols, 1982). Nichols et al (1985) found no individuals > 12cm diameter in Cumbrae whilst in Plymouth individuals >14cm diameter were collected. Lock et al 2008 reported individuals up to 20cm diameter and this was also the maximum size found in the 2011 survey. This suggests that the growth patterns of the Skomer population matches more closely to the southwest Britain populations where sea temperatures are also similar than to the Scottish populations.

Bishop & Earll (1984) suggested that in 1982 Skomer had a sparse and aging population that had not had a successful recruitment of juveniles during the previous 10 years, whilst St Abbs had a dense self-recruiting population. The 2003, 2007 and 2011 Skomer surveys all had a high mean diameter of 12-13 cm which could suggest an aging population. However these surveys also show a good spread of diameters with size range of 4 to 20 cm and the repeated surveys every four years have all shown normal size frequency population graphs.

Larsson (1968) suggested that divers were less efficient at observing urchins smaller than 5 cm diameter. Luddington et al (2004) recommended intense searches in small areas (0.25m^2 quadrats) should be completed to provide evidence that the true age structure of the *E. esculentus* population is recorded. In 2007 and 2011 the divers did not complete searches in quadrats, but were briefed to search carefully for small urchins whilst completing transects. This resulted in smaller *E. esculentus* individuals being found than in the 2003 survey.

It is possible that the larval settlement at Skomer is different to the Scottish sites. Bishop (1983) suggested that the moderate and high currents around Skomer may be completely inhospitable to larval settlement and to juveniles, whose preferred habitat maybe in much deeper water (>50m) offshore, Rostron (2000) reported that deep sites offshore Skomer in St Brides bay were primarily sandy habitats and no *E.esculentus* were found. Deep sites > 35m with rock, boulder and cobble habitats close to Skomer have not been explored. Plankton sampling in the Skomer MNR from 2007 to 2011 has identified Echinoplutei with peak numbers in July and August. Identification of the Echinoplutei to species level has not been possible as larvae in late stages of development have not been found, it is therefore not know which Echinoid species are present (Lock *et al* 2012).

4.3 STARFISH

Marthasterias glacialis was found throughout the MNR in 2011 and shows a similar distribution and similar mean density to those in the 2007 and 2003 surveys. This reflects the wide range of habitats in which *M. glacialis* commonly occurs (Picton, 1993) and also that *M. glacialis* is found in similar habitats to *E. esculentus*.

Crossaster papposus was not recorded in 2011 as in the 2007 survey; this is surprising as 21 individuals were recorded in the 2003 survey. In 2003 *C. papposus* was only found at Thorn Rock and this site was again surveyed in both 2007 and 2011. Identification of this species is not difficult so reasons for its absence during the survey are unknown.

Ten small or juvenile *Luidia ciliaris* were recorded in 2011, 8 from the north side of Skomer and 2 from the south side. This compares to only 2 juveniles being recorded in 2007 and none found in the 2003 survey. Luddington *et al* (2004) suggested that this could be due to low densities in the Skomer MNR or that the habitat surveyed was unsuitable. Typical habitat for *L. ciliaris* is described by Picton (1993) as sandy or sand covered rock, gravel and mixed sediments, where it feeds on other echinoderms. Previous records of *C. papposus* and *L. ciliaris* can be found on the JNCC NBN Gateway, these show that they have been recorded at a number of sites in the Skomer MNR, but in very low numbers. The current distribution and abundance of *C. papposus* and *L. papposus* is

unknown in the Skomer MNR, it is recommended that records are maintained during all routine Skomer MNR diving operations and searches are completed at previously know sites.

5. RECOMMENDATIONS

1. The survey of *E. esculentus* and *C. papposus, M. glacialis* and *L. ciliaris* populations should be repeated every 4 years.

2. Survey methods should follow those developed in the 2007 survey to allow improved comparison between surveys.

3. Sites in Skomer MNR where *C. papposus* and *L. ciliaris* have been recorded in the past and should be targeted. In addition sightings of these species should be recorded during routine dives.

4. Plankton studies should be continued to investigate the presence of echinoderm larvae in the Skomer MNR.

5. 'Bald' *E. esculentus* studies should be continued.

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APPENDIX 1

SEASEARCH SURVEYOR RECORDING FORM

SEASEARCH SURVEY FORM

Form No (leave blank)

If anything is unclear please refer to the **Guidance Notes**
Each pair of divers should complete a form between them
Please complete all parts of the form. Where there is a * only fill in the information if you know it.

seasearch
www.seasearch.org.uk

Validated by	Date	Entered by	Date	MR Reference
Recorder leave blank - for Seasearch use				

Your details

Name	Tel No:	hm/wk
Address	Email:	
	Buddy's Name	
	Name of group or survey	
Postcode		

Dive/Site details

Site name					Date of dive: dd / mm / yy	
General location					Start of dive: : (24hr)	
					Dive duration: (mins)	
					Sea temperature: ^{0}c	
Position (degrees and decimal minutes – state if in any other format)					Underwater visibility: m	
	Latitude		Longitude		W or E	Drift dive? yes / no
Centre of site	0	.	0	.		Night dive? yes / no
For drift dives From	0	.	0	.		Did you or your buddy take any of the following?
To	0	.	0	.		photographs yes / no video footage yes / no specimens yes / no seaweeds for pressing yes / no
Or OS Grid Reference						
Position derived from: (circle) GPS Chart OS map Web mapping					GPS Datum (circle) WGS84 OSGB36	
Exposure of site: extremely exposed ☐ v exposed ☐ exposed ☐ mod exposed ☐ sheltered ☐ v sheltered ☐ ext sheltered ☐						For the area surveyed, what was the shallowest depth? (m) ☐ bsl ☐ bcd the deepest depth? (m) ☐ bsl ☐ bcd
Max tidal stream: >6kt ☐ 3-6kt ☐ 1-3kt ☐ <1kt ☐ v. weak ☐						Tidal correction to chart datum ☐ m*

Seabed summary

Summarise: a. The main features of the site, b. Any unusual features or species, c. Any human activities or impacts at the site

SS1 02/10

1

Habitat descriptions

Complete a box below for each ***habitat*** *you found on your dive. Normally the shallowest habitat is No. 1 even if you have done the dive deepest first. Each written description should tally with the information entered in the columns and diagrams on the next page. If you found more than 3 habitats, continue your descriptions on another form. Tick boxes where shown, and insert percentages (they must add up to 100%) or assign a score from 1-5 as appropriate. If you are uncertain leave the box blank. The biotope code will be assigned later from your description.*

1. DESCRIPTION (physical + community)

Seabed type: rock ☐ boulders ☐ cobbles ☐ pebbles ☐ gravel ☐ sand ☐ mud ☐ wreckage ☐ other ☐

Communities: kelp forest ☐ kelp park ☐ red seaweeds ☐ enc pink algae ☐ animal turf ☐

animal bed ☐ sediment with life ☐ barren sediment ☐ Biotope Code ☐

2. DESCRIPTION (physical + community)

Seabed type: rock ☐ boulders ☐ cobbles ☐ pebbles ☐ gravel ☐ sand ☐ mud ☐ wreckage ☐ other ☐

Communities: kelp forest ☐ kelp park ☐ red seaweeds ☐ enc pink algae ☐ animal turf ☐

animal bed ☐ sediment with life ☐ barren sediment ☐ Biotope Code ☐

3. DESCRIPTION (physical + community)

Seabed type: rock ☐ boulders ☐ cobbles ☐ pebbles ☐ gravel ☐ sand ☐ mud ☐ wreckage ☐ other ☐

Communities: kelp forest ☐ kelp park ☐ red seaweeds ☐ enc pink algae ☐ animal turf ☐

animal bed ☐ sediment with life ☐ barren sediment ☐ Biotope Code ☐

2

1	2	3	
	m		**DEPTH LIMITS**
			Upper (from sea level) (i.e. minimum)
			Lower (from sea level) (i.e. maximum)
			Upper (from chart datum) *
			Lower (from chart datum) *

	%		**SUBSTRATUM**
			Bedrock type?:
			Boulders - very large > 1.0 m
			- large 0.5 - 1.0 m
			- small 0.25 - 0.5 m
			Cobbles (fist - head size)
			Pebbles (50p - fist size)
			Gravel - stone
			- shell fragments
			Sand - coarse
			- medium
			- fine
			Mud
			Shells (empty - or as large pieces)
			Shells (living - eg mussels, limpets)
			Artificial - metal
			- concrete
			- wood
			Other (state)
100	100	100	**Total**

1	2	3	
	1-5		**FEATURES - ROCK (all categories)**
			Relief of habitat (even - rugged)
			Texture (smooth - pitted)
			Stability (stable - mobile)
			Scour (none - scoured)
			Silt (none - silted)
			Fissures > 10 mm (none - many)
			Crevices < 10 mm (none - many)
			Boulder/cobble/pebble shape (rounded - angular)
			Sediment on rock? (tick if present)

	✓		**FEATURES – SEDIMENT (1)**
			Mounds / casts
			Burrows / holes
			Waves (>10 cm high)
			Ripples (< 10 cm high)
			Subsurface coarse layer?
			Subsurface anoxic (black) layer?

	1-5		**FEATURES – SEDIMENT (2)**
			Firmness (firm - soft)
			Stability (stable - mobile)
			Sorting (well - poor)

Sketches and plans

*Draw a **profile and/or plan** of the sea bed you encountered on your dive in the space below. Mark (& number) the different habitats, corresponding to the written descriptions on p.2. Indicate conspicuous and/or characteristic species. Make sure you include **depth(s)** (vertical axis) and a **distance** scale (horizontal axis) for a profile and scale and north point for a plan. Indicate the direction of the profile or plan and the direction of any current.*

Species List

*Score the abundance of each group of animals and plants **in each habitat** alongside the name. In the blank spaces list the seaweeds & animals which you were able to identify **positively** from the different habitats. Use latin names if possible, but if you don't know them, common or descriptive names are acceptable. If you are not 100% sure about any, add a question mark. Do not enter names as guesses - it's better to exclude them than to include incorrect identifications. Give abundances in the columns: **S**uper abundant, **A**bundant, **C**ommon, **F**requent, **O**ccasional & **R**are. If you did not note abundances, simply enter a **P** for Present. Continue on a separate sheet, if necessary. If you have a photograph of the species tick the **ph** column.*

	ph	1	2	3		ph	1	2	3
sponges					echinoderms				
cnidarians: hydroids, anemones, corals,					sea squirts				
					fishes				
worms									
crustaceans					seaweeds				
molluscs									
					other or continuations				
bryozoans									
					Continue on a separate sheet if you need to				

Once completed, return the form to the Dive Organiser or to: Seasearch, Marine Conservation Society, Unit 3, Wolf Business Park, Alton Road, Ross on Wye, HR9 5NB.
Your contact details will be included on the Seasearch database and those of partner organisations and will be used to send you information about Seasearch and associated projects. They will not be passed to third parties without your consent. The location, dive details, habitats and species information and the name of the recorder will be entered into a database and made available to the participating organisations and the general public through the Seasearch and NBN websites. If you do not agree with this use of the data do not submit the form.

4

APPENDIX 2

SURVEY SITES, AREAS, TOTAL NUMBERS AND DENSITIES FOR *E. ESCULENTUS* AND STARFISH SPECIES IN SKOMER MNR 2011

Echinus esculentus and starfish species density data 2011

Site	transects	area	urchins	urchin/100m2	martha	martha/100m2	luidia
Low Point	9	540	25	4.6	14		
High point	9	540	17	3.1	9		
HLP total	18	1080	42	3.9	23	2.1	
Junkos	11	660	60	9.1	73		
MHVw	14	840	55	6.5	17		
MHV/JUN	25	1500	115	7.7	90	6	
TRK	27	1620	32	2.0	11	0.6	
CBY	9	540	135	25.0	5		
HCR	16	960	130	13.5	19		2
CBY/HCR	25	1500	265	17.7	24	1.7	2
RRKmast	15	900	104	11.6	53		
RRK2	12	720	67	9.3	53		
Rye rocks	27	1620	171	10.6	106	6.8	7
Northwall	17	1020	133	13.0	74	7.25	1
							10
Total	139	8340	758	9.1	328	4	

APPENDIX 3

SURVEY SITES SPECIES LISTS FROM SEASEARCH SURVEYOR FORM CASTLE BAY SITE

SITE: High Court Reef/Castle Bay	Habitat 1	Habitat 2	Habitat 3
ALGAE			
Laminaria digitata	A		
Laminaria hyperborea	C		
Laminaria saccharina	R		
Delesseria sanguinea	F		F
Dilsea carnosa	O		
Dictyopteris membranacea			F
Calliblepharis ciliata	F		
Dictyota dichotoma			F
Plocamium cartilaginum	O		
Cryptopleura ramosa	F		F
SPONGES			
Cliona celata		O	A
Pachymatisma jonstonia		O	
Axinella disimilis			F
Polymastia boletiformis			O
Polymastia penicillus		O	
Dercitus bucklandi		R	
Amphilectus fucorum		O	
Axinella damicornis		O	F
Axinella infundibuliformis		O	O
Stelligera stuposa		O	O
Halichondria panicea		O	
Haliclona viscosa		O	
Dysidea fragalis		F	F
Tethya citrina		F	
Hemimycale collumella		O	
Scypha ciliata		O	
Leucosolenia sp.		R	
Scypha compressa		O	
Tethyspira spinosa		R	
CNIDERIA			
Nemertisia antennina		O	F
Nemertisia ramosa		O	F
Aglophenia sp		R	
Halecium halecium		O	F
Izoanthus sulcatus			O
Alcyonium digitatum		O	
Eunicella verrucosa			R
Caryophylia smithii		A	A
Parazoanthus axinellae		O	
Obelia geniculata	A		

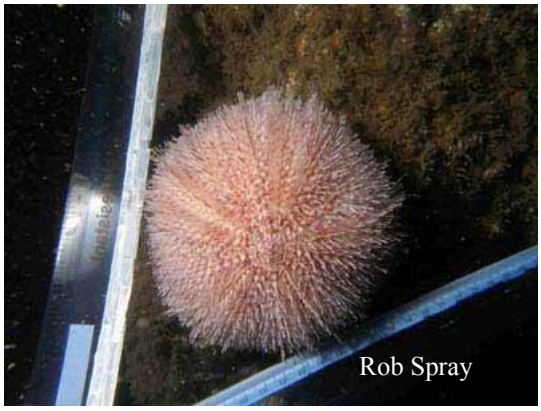
Gymnangium montagui		R	
Balanophylia regia			R
Tubularia sp		O	
Corynatis viridis		C	
Actinothoe sphyrodeta			
WORMS			
Bispira volutacornis		O	
Salmacina dysteri		R	
CRUSTACEA			
Barnacles		O	
Cancer pagarus			
Maja squimado		O	O
Necora puber	O		O
Hommarus gammarus		O	
Pycnogomida sp.		O	
Palinurus elephas		R	
Palaemon serratus			O
MOLLUSC			
Limacia clavigera		R	
Crimora papillata		O	
Tritonia lineata		O	
Facelina annulicornis		R	
Diaphoradoris luteocincta		O	
Mytilus edulis	F		
Polycera faeranosis		O	
Helcion pellucidum	O		
Polyceras quadrilineata	O		
Coryphella lineata		R	
Callistoma zizyphinum		R	
Favorinus brachialis		F	
Facelina auriculata		O	
Trivia spp		R	
Gibbula cineraria		O	
Aplysia punctata	R		
BRYOZOAN			
Crisia sp		C	
Bugula flabellata		C	
Bugula plumosa		C	
Alcyonidium diaphanum			O
Cellaria sp		O	
Membranopora membranacea	F		
Electra pilosa	F		

APPENDIX 4
'GIBBS URCHIN DIVIDER' DATA

To improve size measuring of *E. esculentus* a new set of dividers were developed, constructed from two plastic rulers, which are more robust and operationally simpler than a set of callipers. The dividers are fixed at an angle of 60º with the apex of the triangle at the 4 cm mark on the rulers.

FIGURE 4.1 E. esculentus measuring techniques (a) Dividers (b) Callipers

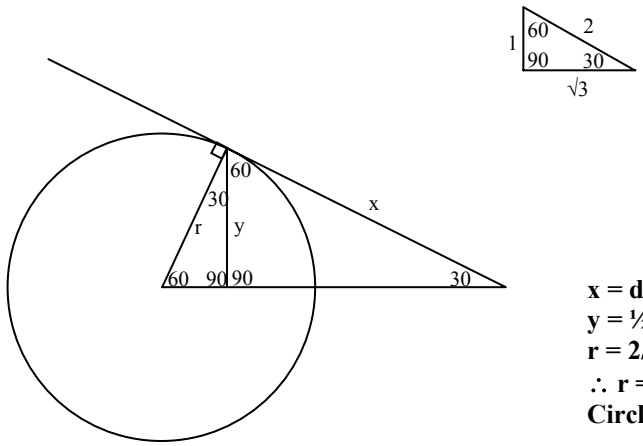
(a)



(b)

The value recorded on the dividers is the tangential meeting point of the rulers with the urchin. The trigonometry required to determine the diameter of the urchin from the value measured off the dividers (which should be equal on both rulers) is illustrated in Figure 4.2

FIGURE 4.2 Trigonometric representation of the method by which the Urchin diameter can be derived from the divider reading (measured in centimetres).



x = divider reading – 4
y = ½ · x
r = 2/(√3) · y
∴ r = x / (√3)
Circle diameter = 2r

As a result, from a divider reading *d* the urchin diameter *D* may be calculated by:

$$D = \frac{2}{\sqrt{3}} \times (d - 4)$$

During one dive 8 *E. esculentus* were measured using both the divider and a set of callipers. The correlation between the two different methods, with error bars, is presented in Figure 4.3 Six of the eight urchins are within errors of being equally measured by both methods. Two

are over measured slightly by the divider compared to the callipers. There is a general trend for the divider measurements to result in slightly larger diameters than the callipers. As the data is collated into centimetre size classes this is unlikely to cause difficulty. However, in future surveys better care should be taken in use of the dividers, and the dividers should be rechecked (and adjusted) to ensure the apex angle is exactly 60º.

FIGURE 4.3 Correlation of the diameter of urchins as measured by callipers and dividers, with errors. The red unity line represents direct correlation. Six out of eight urchins are within errors of direct correlation.