Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

SKOMER MARINE NATURE RESERVE DISTRIBUTION AND ABUNDANCE OF *ECHINUS ESCULENTUS* AND SELECTED STARFISH SPECIES 2007

CCW Regional Report CCW/WW/08/2

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2008

Photo: Rob Spray

CONTENTS

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 was completed in 1979. 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. This survey repeated the methods used in 2003 and established fixed surveys sites that can be used in future surveys.

The survey was completed over 4 days by a team of 20 volunteer divers. *E. esculentus*, *Marthasterias glacialis*, *Crossaster papposus* and *Luidia ciliaris* were counted and the diameter of *E. esculentus* were measured along 30m 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 6.1 and 3.47 per $100m^2$ respectively for the whole MNR, but 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.

Comparison of results with previous surveys and other areas in the UK suggest a naturally low density of *E. esculentus* in Skomer MNR possibly due to low recruitment. The same may be true for *C. papposus* and *L. ciliaris*. Plankton samples collected from June to September identified *Echinopluteus* larvae in samples in the last two weeks of July, confirming that spawning occurs during July.

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CRYNODEB

Mae *Echinus esculentus* yn chwarae rhan bwysig yn strwythur cymunedau islanwol. Yn ystod y 1970au, cafodd nifer fawr o'r draenogod môr hyn eu symud o Warchodfa Natur Forol Ynys Sgomer pan aeth deifars ati i dargedu'r boblogaeth er mwyn gallu masnachu mewn creiriau. Arolygwyd y boblogaeth yn 1979, ond ni chafodd arolygon o'r fath eu cynnal wedyn tan 2003, pan aethpwyd ati i gasglu data er mwyn gweld beth oedd statws poblogaeth *E. esculentus* a'r rhywogaethau amlwg eraill o sêr môr. Mae'r arolwg presennol wedi defnyddio'r un dulliau a roddwyd ar waith yn 2003 ac wedi pennu safleoedd arolygu sefydlog y gellir eu defnyddio eto yn y dyfodol.

Cynhaliwyd yr arolwg gan dîm o ugain o wirfoddolwyr dros gyfnod o bedwar diwrnod. Aethpwyd ati i gyfrif *E. esculentus*, *Marthasterias glacialis*, *Crossaster papposus* a *Luidia ciliaris*, a mesurwyd diamedr *E. esculentus* ar hyd trawsluniau 30m. Dewiswyd safleoedd ar arfordir gogleddol a deheuol yr ynys ac ar arfordir gogleddol y tir mawr. 6.1 a 3.47 fesul $100m^2$ oedd dwysedd cymedrig *E. esculentus* ac *M. glacialis* ar gyfer yr holl Warchodfa Natur Genedlaethol Forol, ond gwelwyd amrywiaeth yn y dwysedd o safle i safle ac o ddyfnder i ddyfnder. Gwelwyd bod dosbarthiad maint-amlder *E. esculentus* yn normal, ac ychydig o amrywiaeth o ran maint a welwyd, ni waeth beth oedd y dyfnder.

Trwy gymharu'r canlyniadau â chanlyniadau arolygon a gynhaliwyd yn y gorffennol ac â chanlyniadau sy'n berthnasol i ardaloedd eraill yn y DU, awgrymir bod dwysedd isel o *E. esculentus* i'w gael yn naturiol yng Ngwarchodfa Natur Genedlaethol Forol Ynys Sgomer, o bosibl gan mai nifer fach o ddraenogod môr ifanc sydd yn y boblogaeth. Efallai fod yr un peth yn wir am *C. papposus* ac *L. ciliaris*. Mewn samplau o blancton a gasglwyd rhwng Mehefin a Medi, daethpwyd o hyd i larfâu *Echinopluteus* yn y samplau ar gyfer y pythefnos diwethaf ym mis Gorffennaf. Mae hyn yn cadarnhau bod y cyfnod silio'n digwydd yn ystod Gorffennaf.

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 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. Transect width was set at 2m width and 30m length giving an overall survey area on each transect of $60m^2$. The method was designed for use with volunteer divers and is fully described in Luddington *et al* (2004).

The study sites were selected from 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. The results showed that the mean density was 6.1 per $100m^2$ for the whole MNR, but density varied between sites and depth. A normal size frequency distribution was found and little variation in size range was observed no matter what the depth.

1.2 STARFISH SURVEY IN SKOMER MNR

In 2003 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 MNR. However the survey was 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 results recorded a mean density for *M. glacialis* of 4.98 per $100m^2$ and it was found throughout the MNR, reflecting the wide range of habitats in which it lives. *C .papposus* was only found at sites south of the Neck and there were no records of *L .ciliaris* during the survey suggesting low densities or that the surveyed habitat was unsuitable.

1.3 PLANKTON SAMPLES

Zooplankton sampling has not previously been completed in the Skomer MNR. Echinoids show a seasonal pattern of oocyte and sperm development and *E .esculentus* spawns in late spring or early summer (Newell & Newell, 1977).

1.4 'BALD' *E. ESCULENTUS* RECORDS

E. esculentus with 'bald' patches have occasionally been observed within Skomer MNR and other sites within St Brides Bay. The cause of the balding, where spines are absent from the upper surface of the animal, is however unknown.

2 STUDY AIMS

The aims of the 2007 *Echinus esculentus* population study 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 survey results;
5. To identify *Echinopluteus* larvae in plankton samples.
6. To identify the cause of 'bald' *E. esculentus*.

3 METHOD

3.1 METHOD REVIEW

The following factors were considered in planning the 2007 survey:

1. Sufficient number of sites to be completed to allow distribution study;
2. Fixed sites to allow comparison with future surveys;
3. 4 available survey days;
4. Suitability of site and methodology for volunteer diving teams;
5. Improved size measuring technique;
6. Improved habitat recording of sites.
7. Changes to allow some comparison with 2003 survey.

The changes to the 2003 method proposed for the 2007 survey are summarised in table 3.1

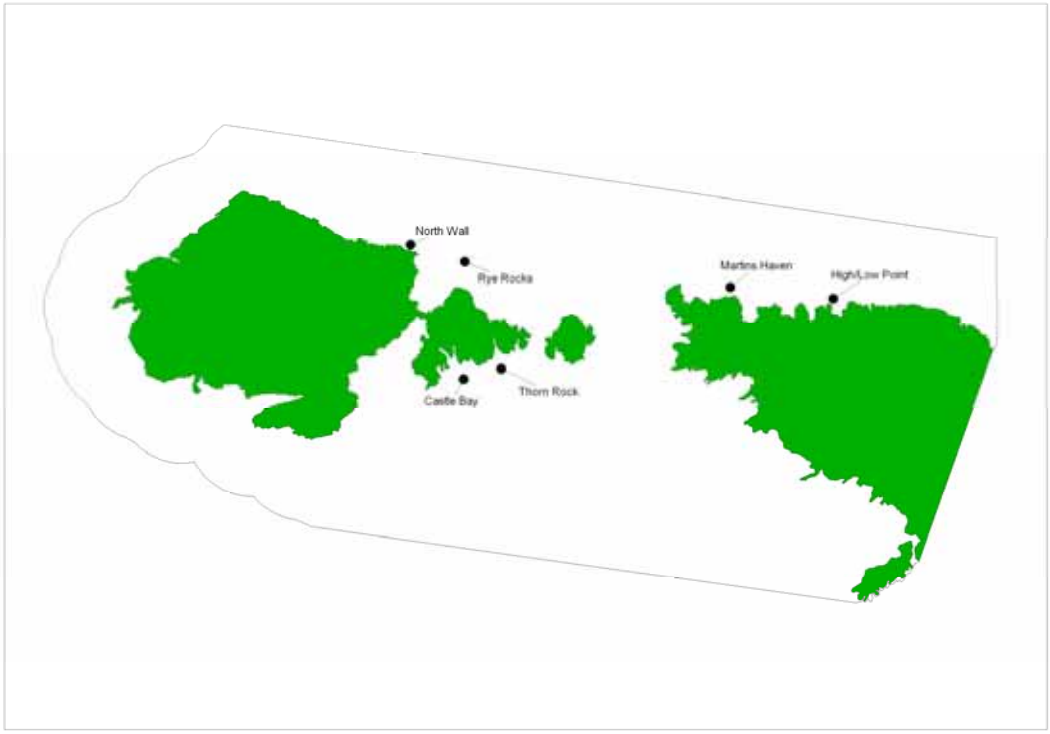
Table 3.1 Proposed method changes for the 2007 Skomer MNR *E. esculentus* survey.

Method change	**Reason for change**
Marked study sites	Allow transects to be completed at fixed sites.
GPS positions taken for study sites.	Allow relocation of sites for future surveys
Site markers positioned at 15m below chart datum (+/-2m).	Allow transects to be completed at actual chart datum depths rather than dive depth. Marker used as reference as start of 15m depth transect, 20m : 5m deeper, 10m : 5m shallower and 5m :10m shallower.
Seasearch methods for seabed substrate and habitat and recording.	Provide adequate seabed substrate and habitat data to support the urchin and starfish data for each transect.
Fixed 60 degree divider used for *E. esculentus* size measuring. '*Gibbs urchin divider*'.	Easier to use and less error than the sliding callipers.
Collect 'bald' *E. esculentus* and bring to surface.	Allow a sample of secretions and spines to be taken for laboratory testing.

3.2 SITE SELECTION

Six sites were selected for the survey to allow for coverage on the north and south coasts of the island and the north coast of the Marloes Peninsula. At each site 2 buoyed sinkers approximately 100m apart were deployed for the duration of the survey and their GPS positions taken.
The site positions are shown in Figure 3.2.

Figure 3.2. *Echinus esculentus* survey sites Skomer MNR 2007.



3.3 DIVING FIELD METHOD

3.3.1 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 both at Skomer MNR and with Seasearch. Each group of divers was briefed on the aims and methods of the survey prior to each dive session.

3.3.2 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.

3.3.3 Field method

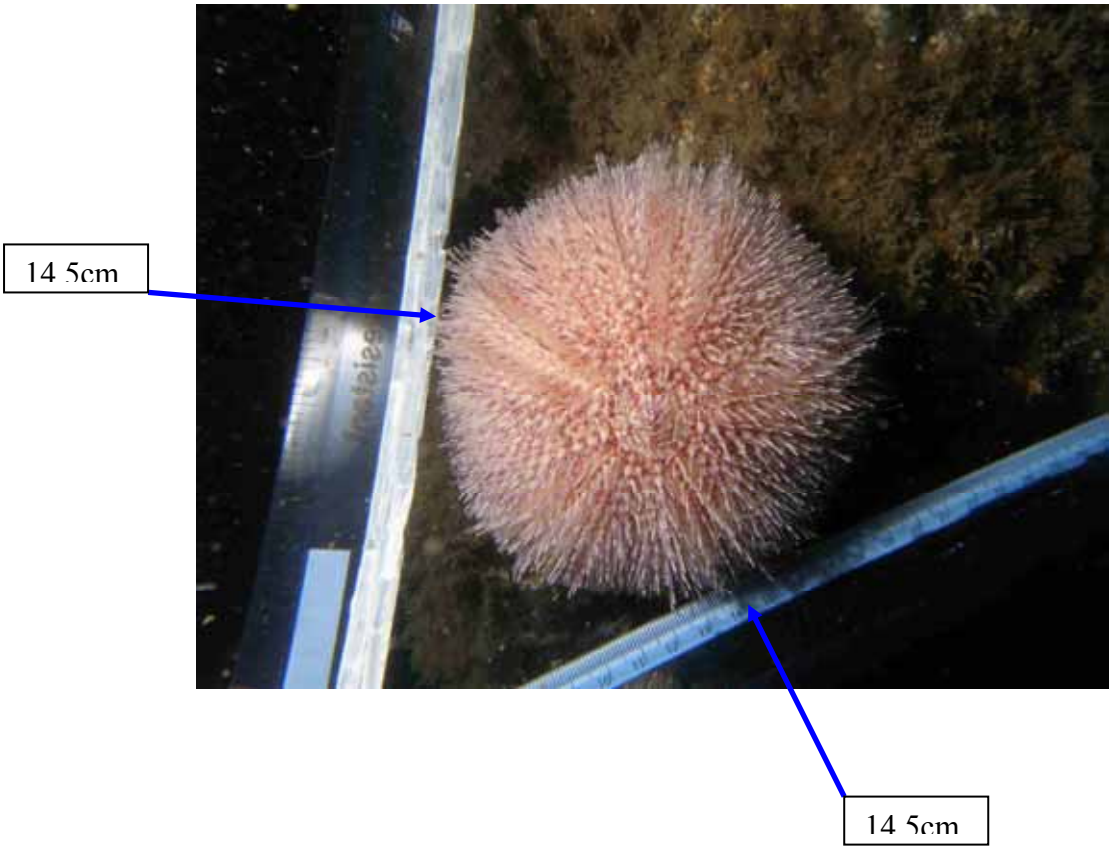
Transects were completed at 20m, 15m, 10m and 5m below chart datum (bcd) for each marked site. Site markers were positioned at 15m bcd and this was used as a reference for completing the transects at the different depths as follows: 15m bcd weight secured to site marker, 20m bcd weight secured (in a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

1. Dive pair secure weight at the allocated transect depth and swim 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.

***E .esculentus* recording:** Within the 2m corridor record the distance each urchin is found along the tape and measure the 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:



Starfish recording: Within the 2m corridor, record the total number of each of the following types of starfish

Spiny starfish (*Marthasterias glacialis*)

Common sunstar (*Crossaster papposus*)

Seven armed starfish (*Luidia ciliaris)*

3. Collect any 'bald' *E. esculentus* found and bring these to the surface at the end of the dive.

'Bald' Urchin

4. On completion of the 30m transect rewind the tape slowly recording the seabed substrate, habitat and conspicuous species.

5. Repeat the survey at shallower depth.

6. On the surface combine data from each member of the dive pair to obtain a complementary record of sightings for transects. Complete *E. esculentus* and starfish recording forms and Seasearch observer forms for each transect (see Appendix 1).

7. Collected 'bald' *E. esculentus* are placed into a bucket of seawater. A sample of the red secretions and a small number of spines are taken, these are preserved in preparation for laboratory analysis. The *E. esculentus* are then carefully returned to water at the collected site.

3.4 PLANKTON SAMPLING

Plankton trawls were taken between two fixed buoys on the north side of Skomer from 3rd June and 2nd September 2007. Trawls were conducted once fortnightly initially and once weekly from 15th June to 12th August due to *E. esculentus* being expected to spawn in early summer. The net mouth area of $0.2m^2$ was towed 500m, sampling $100m^3$ of water per trawl. Samples were stored in 1% formalin and refrigerated until larvae identification could be

carried out. *Echinopluteus* identification was in the lab at University of Wales Aberystwyth, using a light microscope at 40x magnification. Identification of *echinopluteus* larvae was made using ' Marine Plankton' by Newell & Newell (1977).

3.5 'BALD' ECHINUS ESCULENTUS ANALYSIS

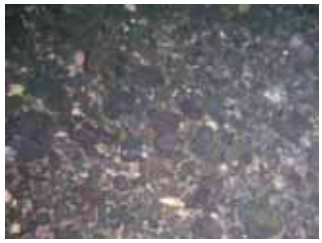
Swabs were taken from two bald *E. esculentus* and kept refrigerated for lab analysis at University of Wales Aberystwyth. One swab was smeared on to a marine agar gel and another preserved in alcohol. This meant that microbial as well as DNA testing could be conducted. Marine agar was used to create an environment with a similar nutrient content to that of sea water. This was repeated with a healthy urchin for comparison.

4. RESULTS

4.1 SURVEY SITES AND HABITATS

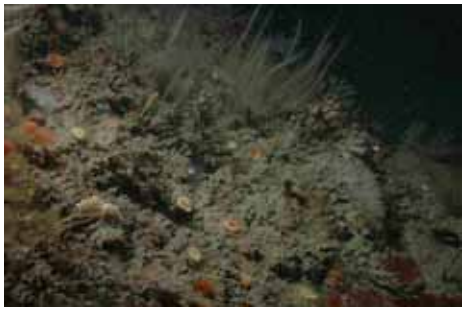
The 2007 survey was carried out over two weekends 23rd & 24th June and 7th & 8th July 2007. A team of 40 volunteer divers completed 139 transects surveying a total of 8340m^2 of seabed within which a total of 609 *E. esculentus* were observed. The densities if *E. esculentus* and the starfish species for each site are shown in Appendix 2. The survey sites and a summary of the dominant substrate and habitat found at each site is listed below and a detailed species list for each site is shown in Appendix 3.

Castle Bay: South Skomer, exposed to wave action. Moderate current.



Steep rocky reef from 10m to16m bcd. Kelp park and mix algae turf dominated the top of the reef. The rock faces were covered in bryozoan and hydroid turf along with large boring sponges *Cliona celata* and soft corals *Alcyonium digitatum*, one Pink seafan *Eunicella verrucosa* was recorded. Large boulders were at the base of the reef and this gave way to a sloping plain of cobbles with occasional boulders and patches of gravel sand levelling at 20m bcd.

Thorn Rock: South Skomer, exposed to wave action. Moderate current.



The survey area was south and east of Thorn Rock. At 15- 20m bcd silt covered bedrock platforms were found with cobble filled gullies 2-3m wide and 1-2 m deep. Sponge communities and the Devonshire cup coral *Carynophylia smithii* dominate the faunal turf. Rocky areas extended up to around 8m bcd with red algae turf and kelp dominating. Shallower areas were only found close to the shore.

North Wall: North Skomer, semi-exposed to wave action from the north. Moderate tidal currents.

The steep cliffs above the water continued to slope steeply down to a depth of 30-40m below chart datum (bcd). In places the rock wall was vertical and richly covered in bryozoan and hydroid turf, the soft coral *Alcyonium digitatum* was abundant and the pink seafan, *Eunicella verrucosa* was regularly recorded. Between the vertical rock walls steep boulder slopes were found and these along with crevices, fissures and ledges found in the rock walls provided habitats for many mobile creatures. The kelp extended to a depth of about 12m bcd.

Rye Rocks: North Skomer, semi-exposed to wave action from the north. Moderate tidal currents.

This is a rocky outcrop that extends seawards out from the east side of the mouth of North Haven. Underwater the bedrock drops down in a series of 5m plus steps to a depth of around 40m bcd. The steps provide horizontal ledges and vertical faces that are covered in marine life. In the shallow areas kelp forest and red algae meadow dominated, deeper the rocks were covered in short and long faunal turf. Between the rocky areas patches of coarse shell gravel

and sand have accumulated and boulder slopes were found. The diverse nature of the seabed substrate in turn leads to a diverse range of habitats and species living at this site.

Martins Haven Point: North Marloes Peninsula, semi-exposed to wave action from the north. Low/Moderate tidal currents.
Large bedrock ridges with north running gullies 1-3m deep and 2m wide. Gullies contained small boulders pebbles, gravel and muddy shell gravel. Below 15m bcd a gently sloping plain of shell gravel with occasional rocky outcrops were found. Kelp forest and red algae turf dominated the shallow areas with short and long animal turf in the deeper areas.

High/Low Point: North Marloes Peninsula, semi-exposed to wave action from the north. Low/Moderate tidal currents. Steeply sloping bedrock forming walls with gullies and boulder slopes down to15m bcd. Kelp forest and red algae turf dominated the shallow areas. The vertical walls are covered in the soft coral *Alcyonium digitatum* and rich in bryozoan and hydroid turf. At the bottom of the bedrock a gently sloping plain of muddy shell gravel leads down to 20m bcd.

4.2 ECHINUS ESCULENTUS

4.2.1 Density and distribution

Transects were completed at each site at the 20m 15m, 10m and 5m below chart datum depth contours. The total area surveyed for each site was calculated by adding up the area covered by all transects, for example, 30 transects were carried out at Northwall which represented a survey area of 1800m^2. The total number of *E. esculentus* recorded at North Wall was 164. Hence, density = 164/1800 = 0.091 m^{-2} or 9.1 per 100 m^2. Table 4.2 shows the density of *E. esculentus* recorded at the different sites in the MNR in 2007. The highest density of 15.8 per 100 m^2 was recorded at Rye Rocks.

Table 4.1 Density of *E. esculentus* at different sites in the Skomer MNR 2007

DENSITIES/100 m^2	
Castle Bay	1.8
North Wall	9.1
Rye Rocks	15.8
Thorn Rock	0.8
High/Low Point	7.5
Martins Haven	6.8
ALL	**7.3**

The mean density for the whole MNR was 7.3 per 100 m^2 in 2007 compared to 6.1 per 100 m^2 in 2003. The density and distribution of *E. esculentus* in 2003 and 2007 for general geographic areas within the MNR are shown in Figure 4.1 and 4.2. Overall the densities have decreased in the areas surveyed along the north Marloes peninsula (Martins Haven and

high/low point sites) and along the south side of Skomer (Thorn Rock and Castle Bay sites). In contrast the density has increased along the north side of Skomer (North Wall and Rye Rocks sites).

FIGURE 4.1 Density (100 m^{-2}) and distribution of *E. esculentus* in Skomer MNR 2003

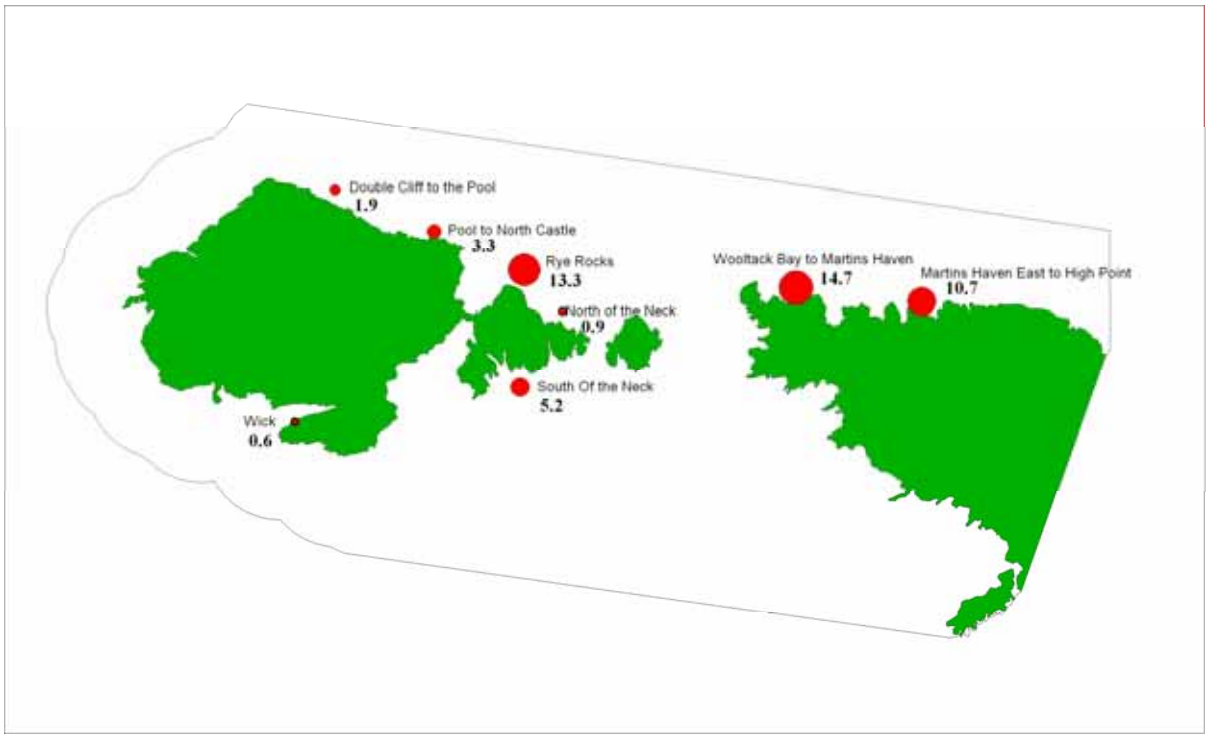
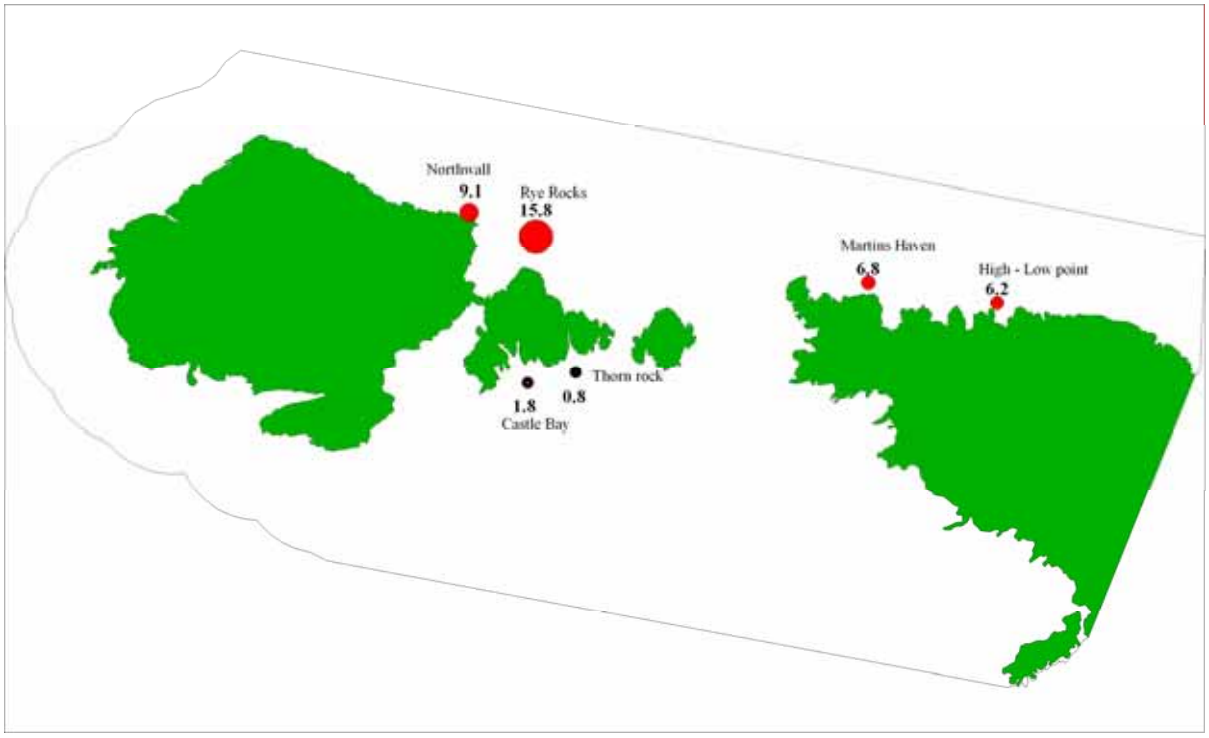


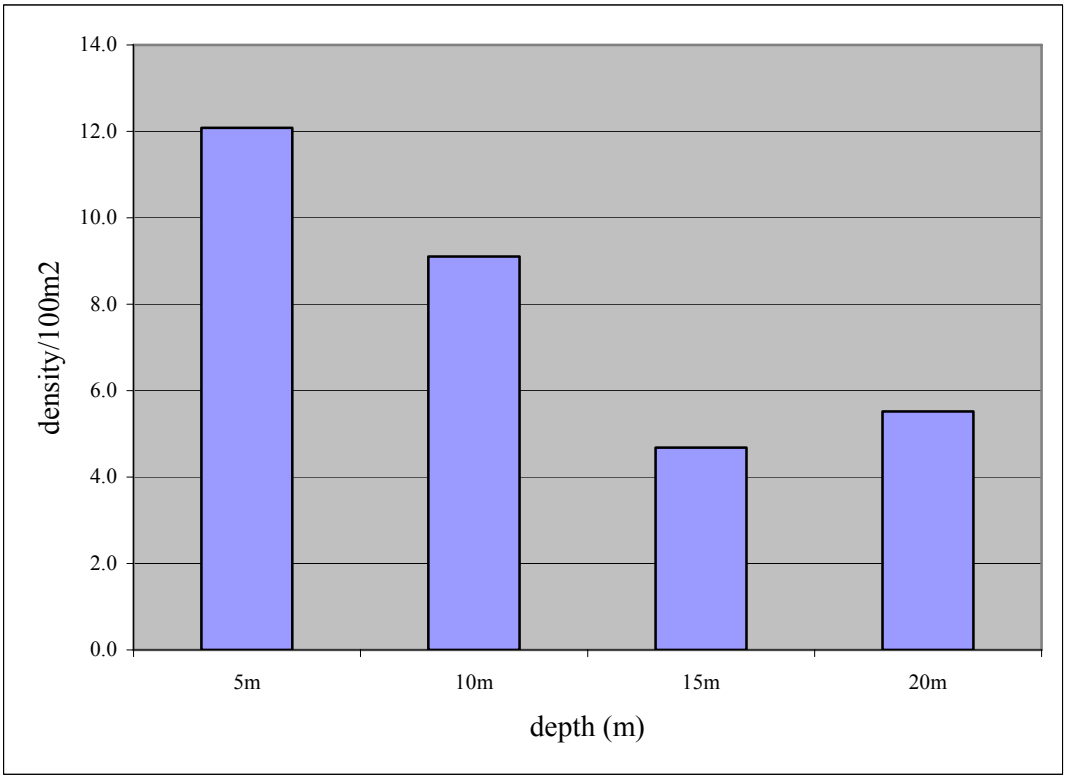
FIGURE 4.2 Density (100 m^{-2}) and distribution of *E. esculentus* in Skomer MNR 2007



The density of *E. esculentus* in 2003 and 2007 cannot be directly compared between sites and between different depths due to the method change. In 2003 the survey was completed in general survey areas and 5m depth zones whilst in 2007 the survey was at marked sites and specified depths.

In 2007 *E. esculentus* was recorded at depths from 5- 20m. The highest densities were recorded in the shallow 5m transects and the densities decreased with depth (Figure 4.3).

FIGURE 4.3 Density of *E esculentus* at different depth ranges in Skomer MNR 2007

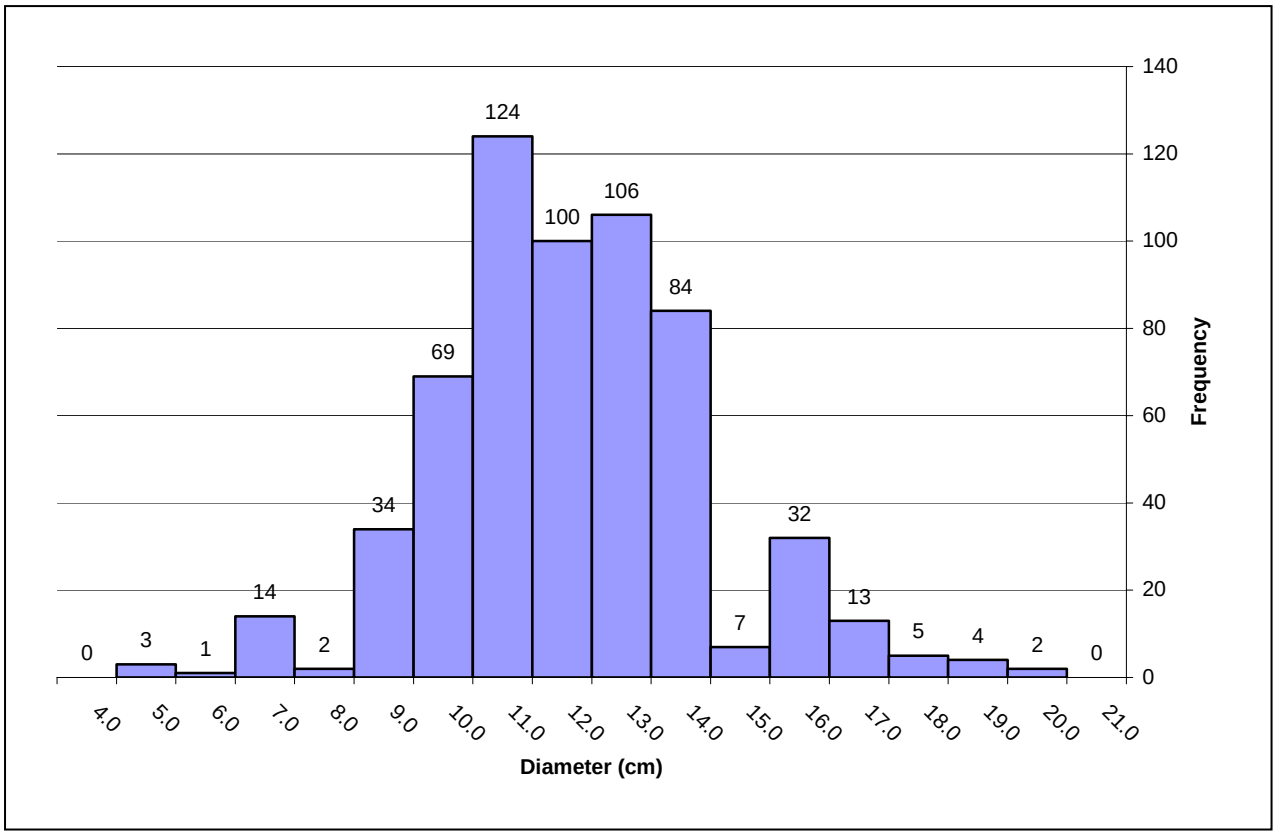


4.2.2 Size frequency distribution

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 4.4. The mean, maximum and minimum diameters were 12.2 cm, 20 cm and 5 cm respectively.

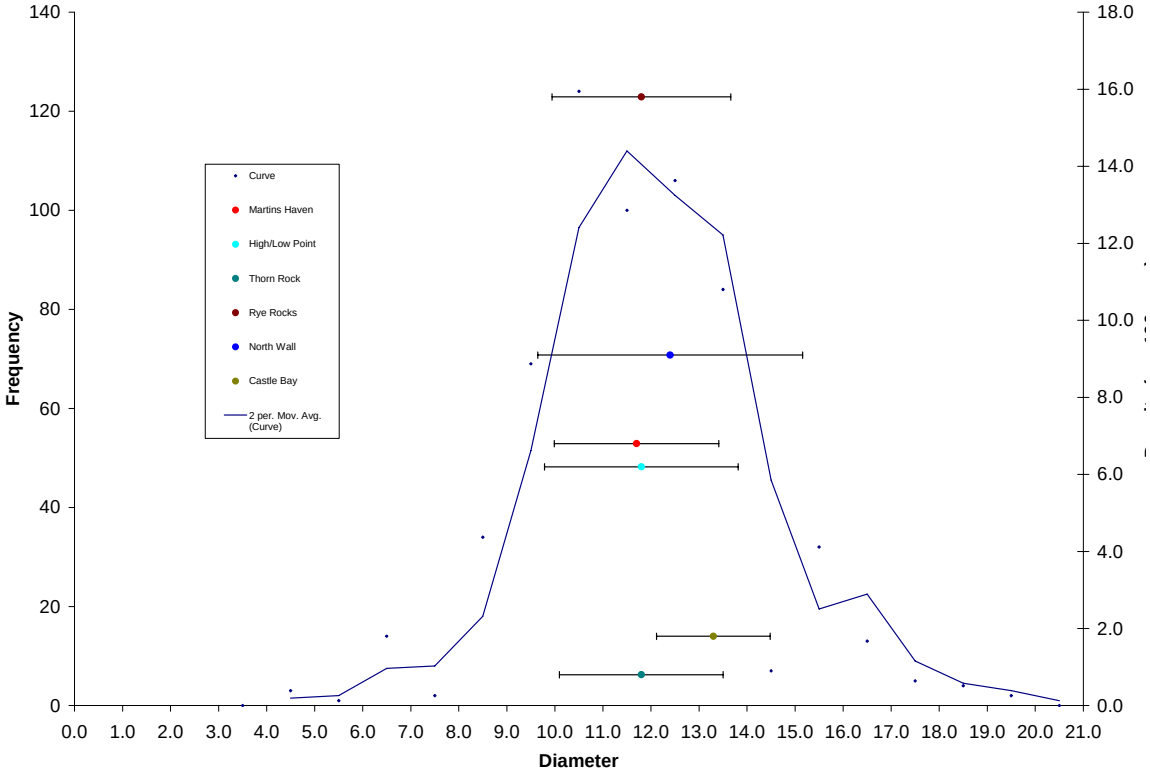
FIGURE 4.4 Size frequency distribution of *E.esculentus* in Skomer MNR 2007



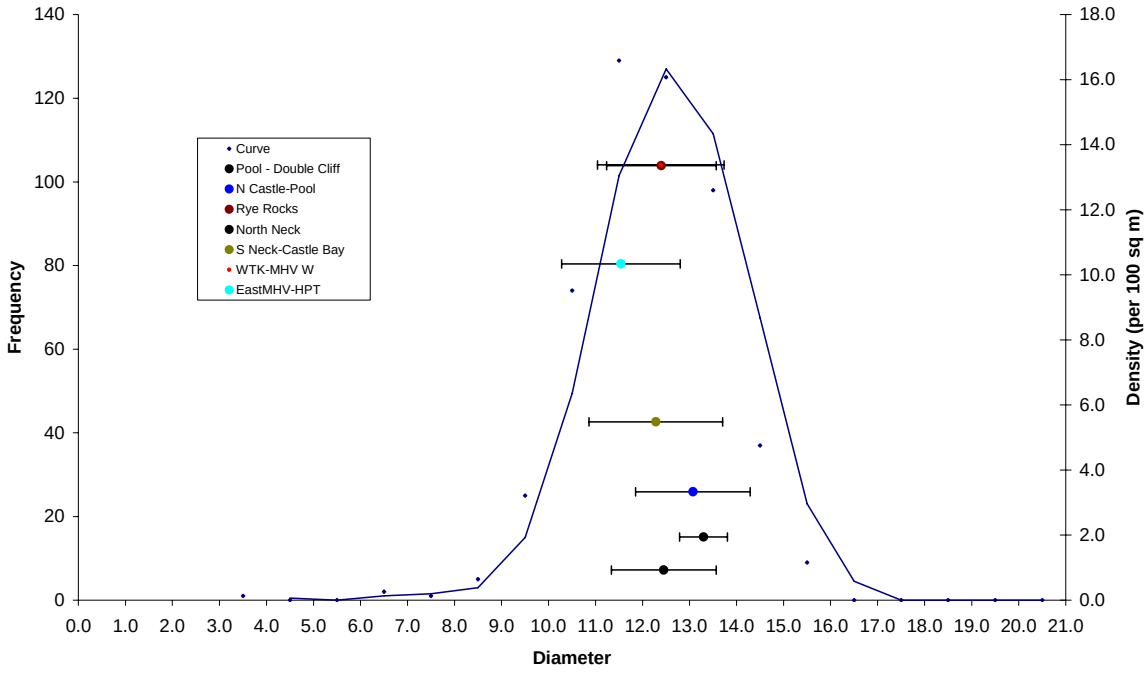
The 2007 survey shows that the mean diameters of *E. esculentus* at all the sites, except Castle Bay, are within standard deviation of the overall mean diameter of 12.2 cm as shown in Figure 4.5. The 2007 size frequency distribution covers a greater spread of diameters than found in 2003.

FIGURE 4.5 *Echinus esculentus* size frequency curves for the 2007(a) and 2003(b) surveys (frequency against diameter). The density of *E. esculentus* per 100 square metres and mean diameter of *E. esculentus* (with standard deviation bars) for each site are overlaid (density against diameter) for both 2007(a) and 2003(b). Approximately comparable sites are keyed with similar colours.

a) 2007



b) 2003



4.3 STARFISH SPECIES

The total area surveyed for starfish was 8340m^2. A total of 290 *Marthasterias glacialis* were recorded giving a density of 3.47 per 100m^2 compared to 4.98 per 100m^2 recorded in 2003. Density was highest at Rye rocks where 6.39 per 100m^2 were recorded. Figure 4.6 shows the density of *M. glacialis* in the Skomer MNR in 2003 and 2007. *Crossaster papposus* was not recorded compared to 21 individuals being found in 2003. Two juvenile *Luidia ciliaris* were recorded, 1 at Castle Bay and 1 at Rye rocks, none were seen in the 2003 survey.

Juvenile *Luidia ciliaris*,
at Castle Bay
(Emma Kenyon)

The density and distribution of *M. glacialis* in 2003 and 2007 for general geographic areas within the MNR are shown in Figure 4.6 and 4.7. The densities of *M. glacialis* were similar in 2003 and 2007 at sites along the north Marloes peninsula (Martins Haven and Low/High Point) sites and at Rye Rocks although a decline was recorded at North Wall. The overall density for the south of Skomer sites (Thorn Rock and Castle Bay) is similar in 2003 and 2007.

FIGURE 4.6 Density (100 m^{-2}) and distribution of *Marthasterias glacialis* in Skomer MNR 2003

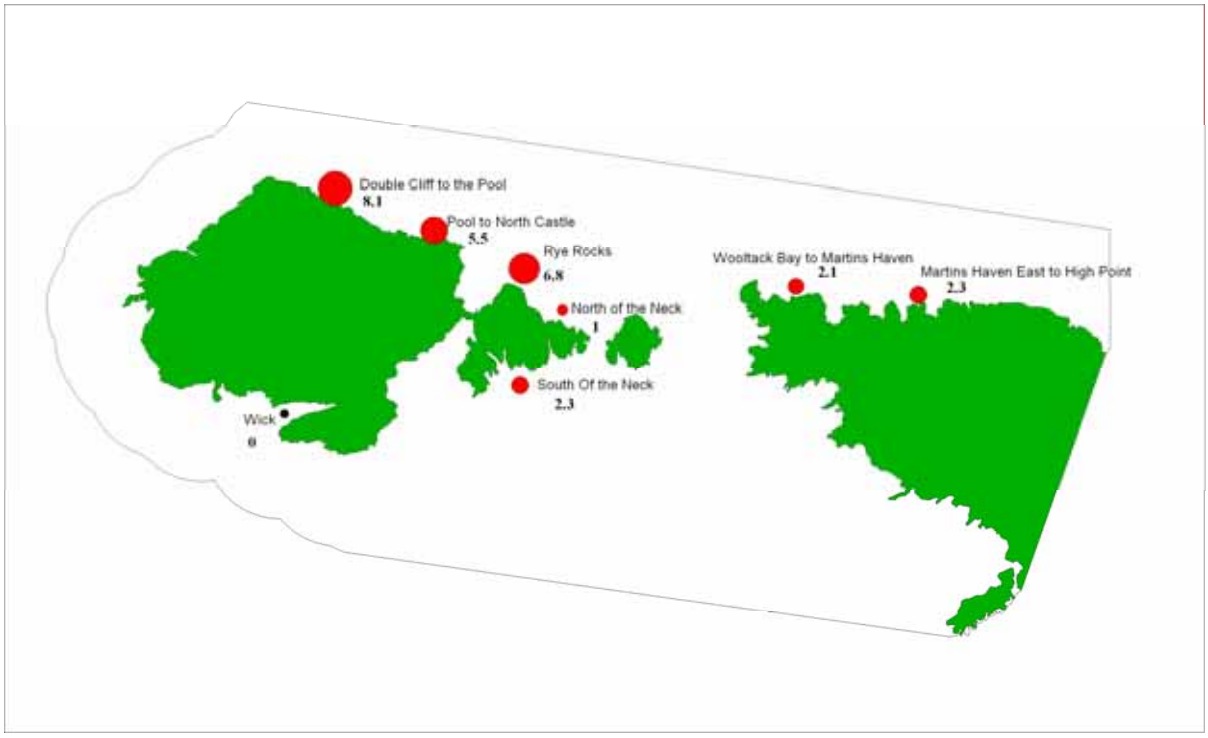


FIGURE 4.7 Density (100 m^{-2}) and distribution of *Marthasterias glacialis* in Skomer MNR 2007

4.4 PLANKTON SAMPLES

Echinopluteus larvae were identified in the plankton samples collected from 15th July to 29th July with highest numbers recorded on the 22nd July 2007 as shown in Table 4.2.

Table 4.2. The Number of *echinopluteus* larvae present over the summer period at a single site within Skomer MNR.

Sample Site	Sample Number	Date of Sample Collection	Total Number of Echinopluteus larvae per m^2
Rye Rocks (From the Lucy buoy to OMS)	1	03/06/07	0
	2	17/06/07	0
	3	01/07/07	0
	4	15/07/07	14
	5	22/07/07	86
	6	29/07/07	40
	7	05/08/07	0
	8	12/08/07	0
	9	26/08/07	0
	10	02/09/07	0

4.5 'BALD' *E. ESCULENTUS*

The bacterial swabs were not analysed close enough to the time of collection. This was due to not being able to access the required university facilities. The time lapse meant that an unidentified microbe dominated the swab samples. Therefore no differences could be detected. The swabs stored in alcohol were not sent away for genetic testing due to the lack of time available to do this in.

5 DISCUSSION

The density and distribution of *E. esculentus* and starfish species showed variations with site and depth. *E. esculentus* showed a normal size frequency and no variation in size was observed at different water depths.

5.1 E. ESCULENTUS DENSITIES

The average density of *E. esculentus* in Skomer MNR in 2007 was compared with densities recorded for Skomer and other sites in the UK (Table 5.1). Luddington *et al* (2004) summarised that the densities recorded in the Skomer surveys were similar despite different methods being used and that these densities were much lower than those recorded for other UK sites. In 2007 the overall density was again similar to those previously recorded in the Skomer MNR despite method changes. 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 5.1 Comparison of mean densities of *E. esculentus* from previous surveys

Mean density of *E. esculentus* (m^{-2})	**Location**	**Source**
0.2	Plymouth	Nichols (1984)
0.14 - 3.04* (overall mean =1.6)	Millport	Nichols (1984)
0.055	Skomer	Bishop (1982)
0.06	Skomer	Luddington *et al* (2004)
0.073	Skomer	Lock *et al*(2008)
*large site variation		

Variation in densities was observed between sites with Skomer MNR 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 this study the highest *E. esculentus* densities were recorded at sites along the north side of Skomer with 15.8 per $100m^2$ at Rye Rocks and 9.8 per $100m^2$ at North wall. 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 6.8 per $100m^2$ at Martins Haven and 7.5 per $100m^2$ 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* densities were found at sites along the south side of Skomer with 0.8 per $100m^2$ at Thorn Rock and 1.8 per $100m^2$ at Castle Bay. The low numbers are a reflection to these sites being exposed to the prevailing swell and wave action from the southwest. Bedrock reef were targeted at both sites, but they were silt covered and dominated by sponge communities in contrast to the algae, bryozoan and hydroid rich communities found at the north coast sites - the favourite food sources for *E. esculentus* (Bishop & Earll, 1984). At the

Castle Bay site *E. esculentus* was only found along the rocky reef ridge tops in the kelp habitat. 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) confirmed these observations and the findings of the present study are again consistent with the previous studies at Skomer.

The 2007 survey showed that the highest *E. esculentus* densities were recorded in the shallow 5m transects and that the densities decreased with depth. Previous studies have shown varied responses of *E. esculentus* to water depth. Nichols (1984) showed no significant difference in density between shallow (8-10 m) and deep (20-22 m) sites, whilst 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. 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. This was rectified in the present study, an equal number of transects were completed at the specified depths, 5m, 10m, 15m and 20m below chart datum. It is proposed that future surveys will be completed at the fixed sites and specified depths established in this survey to allow comparable results.

5.2 E. ESCULENTUS SIZE

The population of *E. esculentus* in Skomer MNR 2007 shows a normal size frequency distribution, with a size range of 5-20 cm. This is a greater spread of diameters than found in 2003 (7-16.5 cm) and likely to demonstrate the improvement in methodology used in measuring *E. esculentus* rather than a big change in the population. The mean diameter in 2007 of 12.2 cm is almost identical to the mean diameter of 12.5 cm in 2003. Similar to the 2003 and 2007 studies, Bishop & Earll (1984) found that Skomer *E. esculentus* were mostly large (above 9.5 cm). Morphometric studies show a good correlation of diameter with age, thus Bishop & Earll (1984) suggested a mean age of 10+ years for the Skomer population.

Larsson (1968) suggested that divers were less efficient at observing urchins smaller than 5 cm diameter than they were finding individuals 50 mm or larger. 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 the divers did not complete searches in quadrats, but were briefed to search carefully for small urchins whilst completing their transects. This resulted in smaller *E. esculentus* individuals being found than in the 2003 survey. It is likely that *E. esculentus* smaller than 5 cm are not generally found in the same habitats as the larger individuals and are possibly hidden in kelp holdfasts, rock crevices and boulder areas, it is suggested that intense searches are completed in these habitats.

5.3 STARFISH

Marthasterias glacialis was found throughout the MNR in 2007 and shows a similar distribution to 2003. 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*. The overall density of 3.47 per $100m^2$ in 2007 is slightly lower than 4.98 per $100m^2$ recorded

in 2003; this is probably because the sites between the Pool and Double Cliff, where the highest densities of *M. glacialis* were recorded in 2003, were not surveyed in 2007.

Crossaster papposus was not recorded in 2007; 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 2007. Identification of this species is not difficult so reasons for its absence during the survey are unknown. Two juvenile *Luidia ciliaris* were recorded in 2007, 1 at Castle Bay and 1 at Rye rocks and none were seen 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 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.

5.4 PLANKTON

In 2007 Plankton samples were collected along the north coast of Skomer from the beginning of June to September. Peak numbers of *Echinopluteus* larvae were identified in samples between 15th July to 29th July 2007, confirming that spawning occurs during July. It is possible that spawning may also occur early in the season and plankton samples need to be collected from March to the end of September to show the pattern during a full season.

6. 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 Observer recording form

Thank you for completing this form

All that's left for you to do is to either hand it to the Dive Organiser or fold it into thirds along the dotted lines, tuck one part into the other, add a stamp and send it off. 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. It 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. If you do not agree with this use of the data do not submit the form.

for Seasearch use only	validated by		date	
MarRec No		entered by		date

first fold

Please affix stamp here

Seasearch
Marine Conservation Society
Unit 3, Wolf Business Park
Alton Road
Ross-on-Wye
Herefordshire
HR9 5NB

second fold and tuck in

seasearch
www.seasearch.org.uk

Seasearch is a joint project co-ordinated by the Marine Conservation Society and supported by: The Heritage Lottery Fund, The Wildlife Trusts, English Nature, Countryside Council for Wales, Scottish Natural Heritage, Environment & Heritage Service Northern Ireland, Joint Nature Conservation Committee, Environment Agency, Marine Biological Association (MarLIN), British Sub-Aqua Club, Professional Association of Diving Instructors and Project Aware, Scottish Sub-Aqua Club, Sub-Aqua Association and the Nautical Archaeology Society.

Record no

Seasearch Observation Form

seasearch
www.seasearch.org.uk

This form asks for two types of information from your dive - **what the seabed was like** and **what marine life you saw**. Please read the guidance notes before completing the form. By completing this form you will be adding to our knowledge of the near-shore marine environment - helping it to remain fit for life!

Please complete the following sections in a black pen and BLOCK CAPITALS

Name	
Address	
	Postcode
Tel: Home	Mobile
Email	
Buddy's Name	

Site Name	Date of Dive / /
	Start of dive : (24hr)
	Dive duration (mins)
General Location (inc county)	Max depth of survey m
	U/W visibility m
	Sea Temperature °C
Position at start of dive or OS Grid Reference ° . N ° . W or E	
Position derived from (circle) GPS Admiralty Chart OS Map Other (state)	Drift dive? yes / no Night dive? yes / no
Did you take any photographs? yes / no or video footage? yes / no	

SO1-02/07

Description of the seabed

Please draw an approximate profile of the seabed (i.e. a side-on view), labeling features and dominant forms as appropriate. Remember to show the depth range and a distance scale.

Depth (m)

distance (m)

Types of seabed present: (please tick all that you saw and circle the dominant one)

Rocky Reef ☐ Boulders ☐ Cobbles and Pebbles ☐ Mixed Ground ☐ Sand and Gravel ☐ Mud ☐ Wreckage ☐ Other ☐

Did you notice anything unusual or noteworthy about the seabed or the marine life?

Was there any litter or were there any man-made objects apparent?

What marine life did you see on your dive?

Seabed cover types (tick all those present)

Kelp forest ☐

Kelp park ☐

Mixed seaweeds ☐

Encrusting pink algae ☐

Barren sediment
(no life or structures apparent) ☐

Animal turf on rocks

☐ **Short**

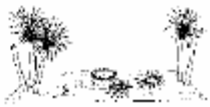
☐ **Tall**

Animal Beds
(e.g. mussels, brittlestars, scallops - state which)

☐ _____

Sediment with life apparent
(tubes, burrows etc)

☐



Illustrations by Bob Foster-Smith

Species you saw

Show abundance of each species as **R**are, **O**ccasional, **C**ommon, or if you're unsure, **P**resent.

Species	R, O, C or P

APPENDIX 2

Survey sites, areas, total numbers and densities for *E. esculentus* and starfish species in Skomer MNR 2007

Echinus esculentus and starfish species density data

Site	transects	area	urchins	urchin/100m2	martha	martha/100m2	luidia
Low Point	12	720	71		16		
High point	17	1020	53		35		
HLP total	29	1740	124	7.08	51	2.9	
MHVe	14	840	63		22		
MHVw	12	720	50		15		
MHVtotal	26	1560	113	7.24	37	2.37	
Thorn Rock	20	1200	10	0.8	17	1.4	
Castlew	9	540	9		8		1
Castlee	7	420	8		3		
CBYtotal	16	960	17	1.77	11	1.1	
Rye rocks	21	1220	193	15.8	78	6.3	
Northwall	30	1800	165	9.16	96	5.3	
Total	142	8480	622	7.33	290	3.4	

APPENDIX 3

Survey sites species lists from Seasearch Observer forms

SITE	North Wall	Rye Rock	Thorn Rock	Castle Bay	Low Point	High Point	Martins Haven Point
ALGAE							
Laminaria hyperborea	O	C	C	C	A	C	C
Sacorhiza polyschides			C	C		O	C
Laminaria saccharina						O	
Drachiella spectabilis	F	O	F	F	O	O	C
Delesseria sanguinea	F	A	C	F	F		F
Palmaria palmata	O	O	F	F		O	F
Dilsea carnosa	F	O	C	F			F
Pink encrusting algae			F	O			O
Dictyopteris membranacea		C				F	
Calliblepharis ciliata		O			F	C	
Dictyota dichotoma		P		A			
Plocamium cartilaginum		F			O	O	
Chondrus crispus				A			
Heterosiphonia plumosa							
SPONGES							
Cliona celata	F	F	C	A	C	O	O
Pachymatisma jonstonia	R		O	R			
Axinella disimilis	O	O	C	F			
Polymastia boletiformis			F	O			
Polymastia penicillus			F				
Suberites carnosa		R	O				
Raspalia ramosa			C				
Axinella damicornis			F	O			
Axinella infundibuliformis			F				
Stelligera stuposa			O				
Haliclona urceolus			O				
Thymosia gurnei			R				
Dysidea fragalis			O	O			
Tethya aurantrium			O			R	
Hemimycale collumella			O	C		O	
Scypha ciliata			O				
Suberites fiscus						R	
CNIDERIA							
Nemertisia antennina	F	C	C	O	F	C	
Nemertisia ramosa	O	O	F		F	C	
Aglophenia sp		O	C			C	
Izoanthus sulcatus			O				

Alcyonium digitatum	O			O	F	O	O
Eunicella verrucosa	R	O	R	R	O	O	
Caryophylia smithii	C	A	A	C	C	O	O
Parazoanthus axinellae			F				
Obelia geniculata		O	F	F		O	F
Gymnangium montagui		R				R	
Halecium halecium						O	
Sertularia sp		F				O	
Corynatis viridis		P					
Beroe cucumis				R			
Cerus pedunculatus							O
WORMS							
Prostheceraeus vittatus	R	C		O	O	O	O
Bispira volutacornis	O	O	O	O		O	O
Pomatocerous sp			O				O
Phoronis hippocrep			O				
Myxicola infundibulum							O
Lanice concheligera							F
Eupolymnia spp							F
CRUSTACEA							
Barnacles	F			F		F	F
Balanus crenatus			C				
Cancer pagarus	R	O		O	O	O	
Maja squimado	R	C	F	F	O	O	F
Necora puber	O	F	O	F	R	O	O
Hommarus gammarus	R	O	O	O	R	R	
Galathea strigosa	R		R				
Palinurus elephas			R			R	
Palaemon serratus			O		O		
Inacus spp			O	O			F
Pagarus berhardus			O			R	
Macropodium sp					R		
MOLLUSC							
Limacia clavigera	R	P		O			O
Crimora papillata	O		F	F			F
Tritonia lineata	O	P	R	R		R	
Facelina annulicornis	O						
Diaphoradoris luteocincta	O		O	O	R		O
Janolus cristatus			R				
Polycera faeranosis		P	O		C	R	
Acanthodoris pilosa			R				
Helcion pellucidum			O	F			F

Polyceras quadrilineata			O		O		
Coryphella sp		O	O	F			O
Callistoma zizyphinum		O		O		R	
Pecten maximus		F			C	O	F
Flaballina pedata		P		R			
Trivia spp				R			
Ancula gibbosa				F			
Acquipecten opercubris					R		
Gibbula sp						C	O
Eledone cirrhosa							R
Buccinum undatum							C
BRYOZOAN							
Crisia sp	F		C				
Bugula flabellata	F	C	C	A		C	F
Bugula plumosa	F	O	C	A		C	F
Bugula turbinata		O		A		C	F
Flustra foliacea	F		C	F			F
Alcyonidium diaphanum	O	O	F	O		O	
Cellaria sp	C	A	O				
Pentapora foliacea	R	O	F			R	O
Membranopora membranacea		F	C	F		C	
Electra pilosa		F				O	O
Securiflustra securifrons						C	
ECHINODERM							
Marthasterias glacialis	O	O		O	O	O	O
Echinus esculentus	F	O	F	O	O	O	F
Pawsonia saxicola	O		O	C	O		
Asterias rubens	R	O				O	
Henricia oculata			R	O			
Holothuria forskali			O	O			
Aslia lefevrei		O	O			O	
Ophiara Spp			O	R			
Luidia ciliaris				R			
Thyone rusravita						O	
Neopentadactyla mixta							O
ASCIDIANS							
Clavelina lepadiformis	O	F	C	C	O	O	F
Aplidium punctum	O	P	F	F			F
Morchellium argus	O		O	F			
Diplosoma spongiforme			O				
Ascidia mentula			O	O		F	O
Diplosoma listerianum			O				

Dendrodoa grossularia			F				
Stolonica socialis			R	R		F	
Perophora listeri				F			
Botrylus schlosseri				F	R		
FISH							
Scyliorhinus caniculata	R	O	R	R	O	R	
Labrus mixus	R	O		R	O		
Labrus bergylta	O	O	O	O		R	O
Trisopterus minutus	R						
Thorogobius ephippiatus		R	R	O			
Topknot			R			R	
Tompot		R	R			R	
Scorpion			R				
Ctenolabrus rupestris	O		O	O		C	
Pollachius pollachius		O	R		O	R	R
Centrolabrus exoletus		P			R		
Callionymus lyra			O	O		O	
Gobiusculus flavescens							O
MAMMALS							
Halichoreous grypus							P

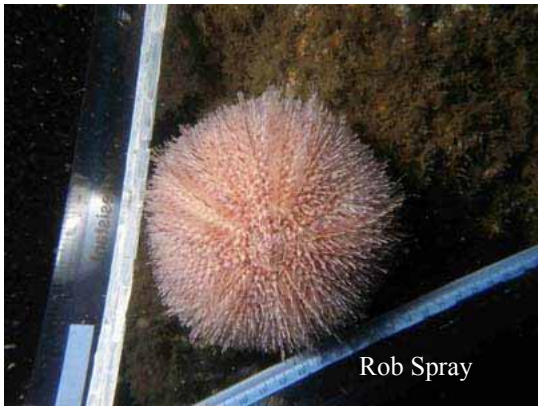
APPENDIX 4

'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

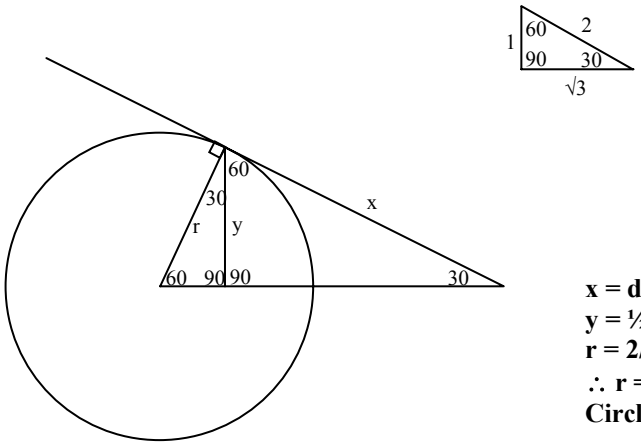
(a)



(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.