

Cyngor Cefn Gwlad Cymru  
Countryside Council for Wales



Skomer Marine Nature Reserve  
**Distribution and Abundance of**  
*Echinus esculentus* and selected starfish  
**species**

CCW West Area Report No. 45

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M. Burton  
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## CRYNODEB

Mae'r Draenog môr (*Echinus esculentus*) yn chwarae rhan allweddol yn strwythur cymunedau islanwol. Cafodd niferoedd mawr eu symud o Warchodfa Natur Forol Ynys Sgomer yn ystod y 1970au pan fu plymwyr yn targedu'r boblogaeth ar gyfer y fasnach hen greiriau. Arolwg presennol y Draenog môr (*Echinus esculentus*) yng Ngwarchodfa Natur Forol Ynys Sgomer oedd y cyntaf ers 1979 ac fe sefydlodd ddata sylfaenol ar statws poblogaeth *E. esculentus* a rhywogaethau hawdd eu gweld o sêr môr er mwyn eu cymharu ag arolygon yn y dyfodol.

Cafodd *E. esculentus*, *Marthasterias glacialis*, *Crossaster papposus* a *Luidia ciliaris* eu cyfrif gan 30 o blymwyr gwirfoddol, a chafodd diamedr *E. esculentus* ei fesur ar hyd trawsluniau 30m mewn safleoedd yng Ngwarchodfa Natur Forol Ynys Sgomer. Roedd trwch cymedrig *E. esculentus* a *M. glacialis* yn 6.7 a 4.98 i bob 100 m<sup>2</sup> ar gyfer y Warchodfa Natur Forol i gyd. Dim ond ar un safle y gwelwyd *C. papposus* ar drwch o 0.28 i bob 100 m<sup>2</sup> ac ni welwyd *L. ciliaris* yn ystod yr arolwg.

Dangosodd trwch a lledaeniad *E. esculentus* a rhywogaethau sêr môr amrywiadau yn ôl safle a dyfnder. Dangosodd *E. esculentus* ledaeniad o amllder a maint arferol ac ychydig o amrywiaeth mewn maint a welwyd ar wahanol ddyfnderoedd y dŵr.

Mae cymharu canlyniadau gydag arolygon yn y gorffennol ac mewn ardaloedd eraill yn y DU yn awgrymu trwch naturiol isel o *E. esculentus* yng Ngwarchodfa Natur Forol Ynys Sgomer, o bosibl oherwydd recriwtio isel. Gall yr un peth fod yn wir am *C. papposus* a *L. ciliaris*.

Teitl: Lledaeniad ac amllder *Echinus esculentus* a rhywogaethau dethol o sêr môr yng Ngwarchodfa Natur Forol Ynys Sgomer. Adroddiad Rhif 45 Ardal y Gorllewin, Cyngor Cefn Gwlad Cymru. Luddington, L.R. Lock K. Newman, P & Burton, M (2003)

## 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. The present survey of *Echinus esculentus* in Skomer MNR was the first since 1979 and established baseline data on the status of both the *E. esculentus* population and conspicuous starfish species for comparison with future surveys.

A team of 30 volunteer divers counted *E. esculentus*, *Marthasterias glacialis*, *Crossaster papposus* and *Luidia ciliaris* and measured the diameter of *E. esculentus* along 30m transects at sites throughout Skomer MNR. The mean densities of *E. esculentus* and *M. glacialis* were 6.7 and 4.98 per 100 m<sup>2</sup> respectively for the whole MNR. *C. papposus* was only observed at one site at a density of 0.28 per 100 m<sup>2</sup> and *L. ciliaris* was not observed during the survey. The density and distribution of *E. esculentus* and starfish species showed variations with site and depth. *E. esculentus* showed a normal size frequency distribution and little variation in size was observed at different water depths.

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*.

## 1 INTRODUCTION

### 1.1 *ECHINUS ESCULENTUS*

*Echinus esculentus* Linnaeus (1758), is an omnivorous grazer and a key biological structuring factor in subtidal communities. During the 1970s divers targeted the Skomer MNR 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 MNR in 1978 (Earll, 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* in Skomer MNR 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. The aim of the 2003 survey was to establish the current status of the population, including distribution, abundance, density and size frequency.

### 1.2 STARFISH

*Marthasterias glacialis* (Linnaeus, 1758) Spiny starfish is common on all British coasts except the east coast of England and the east half of the English Channel; it is distributed from Finmark & Iceland to Cape Verde Isles, Azores and the Mediterranean (Hayward & Ryland, 1995). It is found in a wide range of habitats from sheltered muddy sites to fully exposed rock faces (Picton, 1993).

*Luidia ciliaris* (Philippi, 1837) Seven armed starfish is common on all British coasts except southern North Sea; it is distributed from Faeroes to Cape Verde and the Mediterranean (Hayward & Ryland, 1995). It is found on sandy or sand scoured rock, gravel and mixed sediments where it feeds on other echinoderms (Picton, 1993). Both *M. glacialis* and *L. ciliaris* show a southerly distribution whilst *Crossaster papposus* (Linnaeus, 1767) Common Sunstar shows a more northerly distribution occurring from the Arctic to the English Channel (Hayward & Ryland, 1995). It is common and widespread all around the British Isles but is rare on the south coast and is found at sheltered sites with current swept sediment or wave exposed rock. *C. papposus* preys on other starfish and is frequently found in brittle star beds (Erwin & Picton, 1987; Wood, 1988; Picton, 1993).

The distribution and abundance of *M. glacialis*, *L. ciliaris* and *C. papposus* in Skomer MNR is unknown. All three species are easily identifiable in the field and therefore ideal subjects for a volunteer survey. The aim of the 2003 survey was to record the distribution and abundance of these starfish.

### 1.3 OBJECTIVES

1. To determine the density and distribution of *E. esculentus* and identify variations with depth/habitat at selected sites
2. To determine the size frequency distribution of *E. esculentus*
3. To determine the density and distribution of sunstar, *Crossaster papposus*, spiny starfish *Marthasterias glacialis* and seven armed starfish *Luidia ciliaris*
4. To develop a method appropriate for establishing the survey as a volunteer diving project.

## 2 METHOD

Volunteer divers were issued with the following instructions.

### 2.1 SITE SELECTION

Diving team select a survey site from around Skomer Island or along the North Marloes Peninsula according to accessibility and possible presence of suitable habitat for *E. esculentus*. Record an accurate site position; if possible a GPS fix. In addition clearly mark site location on a chart or map.

**\*Dive safety information:** All divers must dive as a buddy pair with the use of a surface marker buoy for surface contact. Diving operations to be carried out at estimated slack water times as detailed in the 'Diving in the Skomer Marine Nature Reserve Safety Information' leaflet. Divers also need to be aware that at sites along the North Marloes Peninsula anglers are often present along the coast and there is the potential hazard of angling line and hooks in the water. If there is any doubt as to the safety of diving in any situation the planned dive must be aborted or rescheduled.

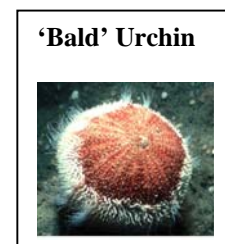
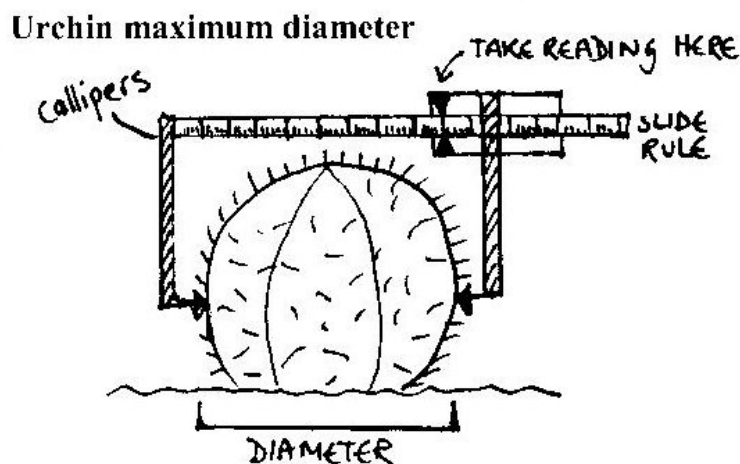
### 2.2 SURVEY METHOD

**Field equipment:** Transect tape (30m tape measure), 4lb weight, pair of callipers, underwater recording slates, proforma sheets, site maps.

**Field methods:** Diving team complete several stations at each site.

1. Diver pair selects station area (depth range 8-20m) on rocky ground. The orientation of the station should follow a depth contour.
2. Attach the end of a tape measure or marked transect line to a rock, or fix end in position using a diving weight. Diver pair swims together laying the tape/line, counting and measuring urchins and counting starfish in a 2m corridor, 1m either side of the tape.

**Sea Urchin recording:** Within the 2m corridor record the distance each urchin is found along the tape and measure the widest diameter (in millimetres) for each urchin and note if the urchin is 'bald'. Record all data on the prepared recording form (see Appendix I). The widest diameter is measured using callipers as follows:



**Starfish recording:** Within the 2m corridor, record the total number of each of the following types of starfish on the prepared recording form (see Appendix I).

Spiny starfish (*Marthasterias glacialis*)



Common sunstar (*Crossaster papposus*)



Seven armed starfish (*Luidia ciliaris*)



3. On completion of the transect record the total distance completed along the tape (this will be the tape length e.g. 30m or less if not completed to end of tape). One diver rewind the tape slowly whilst the other records the station number, depth and time and records a brief description of the dominant habitat and substratum.
4. If time allows repeat the method for a second station at a shallower depth.

## 3 RESULTS

### 3.1 SURVEY SITES AND HABITATS

The survey was conducted between June and the end of August. A team of 30 divers completed the survey on the 28<sup>th</sup> and 29<sup>th</sup> June from boats chartered by the Skomer MNR. In addition teams from Bristol University, London Imperial College and Marine Conservation Society completed surveys during weekend visits to the Reserve. Table 3.1 shows the sites surveyed. Transects were carried out at various depths between 8 and 20m. The sites surveyed were exposed to a range of wave, swell and current conditions according to their location. For example, the Wick, South Skomer is very exposed to wave action but experiences little current, whilst Martins Haven East-High Point, North Marloes Peninsula is semi-exposed to wave action from the north with low/moderate current (Table 3.1).

Table 3.1 also shows that a range of habitats was surveyed, for example at North Neck mixed sediment and shell with red algae, scallops and burrowing anemones was recorded. By contrast, at South Neck- Castle Bay the habitat was described as silt-covered rock platform with gullies and tall animal turf; some cobbles in gullies.

### 3.2 DENSITIES AND DISTRIBUTION

#### 3.2.1 *Echinus esculentus*

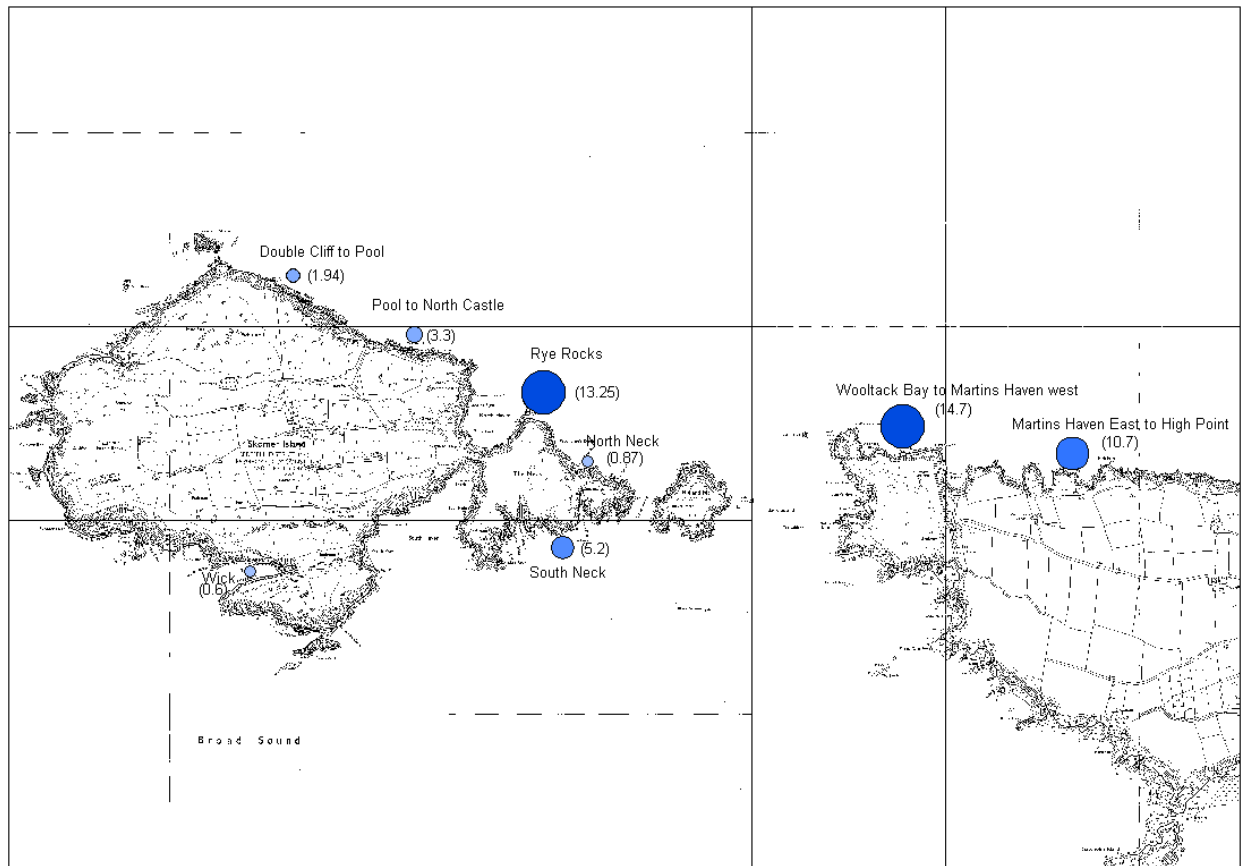
Several transects were carried out at each site and the total area surveyed calculated by adding up the area covered by each transect. For example, 12 transects were carried out from Pool to North Castle which represented a survey area of 720 m<sup>2</sup>. The total number of urchins recorded in this area was 24. Hence, density =  $24/720 = 0.033 \text{ m}^{-2}$  or 3.3 per 100 m<sup>2</sup>. The total area covered by the survey was 7488 m<sup>2</sup> within which a total of 505 *E. esculentus* were observed (see Appendix II, table1). Figure 3.1 and Table 3.2 show the density of *E. esculentus* recorded at different sites in Skomer MNR in 2003. The highest density of 14.7 individuals per 100 m<sup>2</sup> was recorded between Wooltack Bay and Martins Haven West, whilst only 0.6 individuals per 100 m<sup>2</sup> were recorded for the Wick. The mean density for the whole MNR was  $0.067 \text{ m}^{-2}$  or 6.7 per 100 m<sup>2</sup>.



**TABLE 3.1 *E. esculentus* survey sites and habitats in Skomer MNR**

<b>Site</b>	<b>Depth range (m)</b>	<b>Location &amp; current/wave action</b>	<b>Habitat description</b>
South Neck - Castle Bay	10.5 - 21	South Skomer; exposed to wave action. Moderate current.	Silt covered bedrock platform with gullies and tall animal turf; some cobbles in gullies
Wick	13 - 20	South Skomer; very exposed to wave action. Little current.	Over-hanging cliff with silt-covered boulders on bedrock beneath
North Neck	8 - 14.5	North Skomer; semi-exposed to wave action from north. Moderate tidal currents.	Mixed sediment and shell, red algae, scallops, burrowing anemones. Mixed sediment with boulders inshore
Rye Rocks	9 - 25	North Skomer; semi-exposed to wave action from north. Moderate tidal currents.	Two habitats: 1/ Boulders and cobbles with red seaweed and animal turf at 10m; small rock outcrops at 15m. 2/ Bedrock reef with sparse kelp and animal turf; mixed coarse shell gravel and sand in gullies
North Castle - Pool	10 - 20	North Skomer; semi-exposed to wave action from north and moderate currents	Mixed boulder and sand slope
Pool - Double Cliff	10 - 19.5	North Skomer; exposed to wave action from north and strong currents	Two habitats: 1/ Small outcrops of bedrock with animal (bryozoan, hydroid, sponge) and seaweed turf; kelp found at 10m. Pebbles/cobbles with tubeworms mixed with sand and gravel in gullies between. 2/ Boulders 90%, pebbles 10% with red seaweed.
Wooltack Bay - Martins Haven west	9.5 - 14.7	North Marloes Peninsula; semi-exposed to wave-action from north. Moderate current	Rocky reef with boulders, tall algal turf and kelp
Martins Haven east - High Point	10 - 19	North Marloes Peninsula; semi-exposed to wave action from north. Low/moderate current	Uneven, fairly steeply sloping bedrock forming gullies and a variety of habitats to 15m. Gently sloping plain of muddy shell gravel below. Rock covered in tall animal turf.

**FIGURE 3.1 Density ( $100\text{ m}^{-2}$ ) and distribution of *E. esculentus* in Skomer MNR 2003**



**TABLE 3.2 Density of *E. esculentus* at different sites in Skomer MNR 2003**

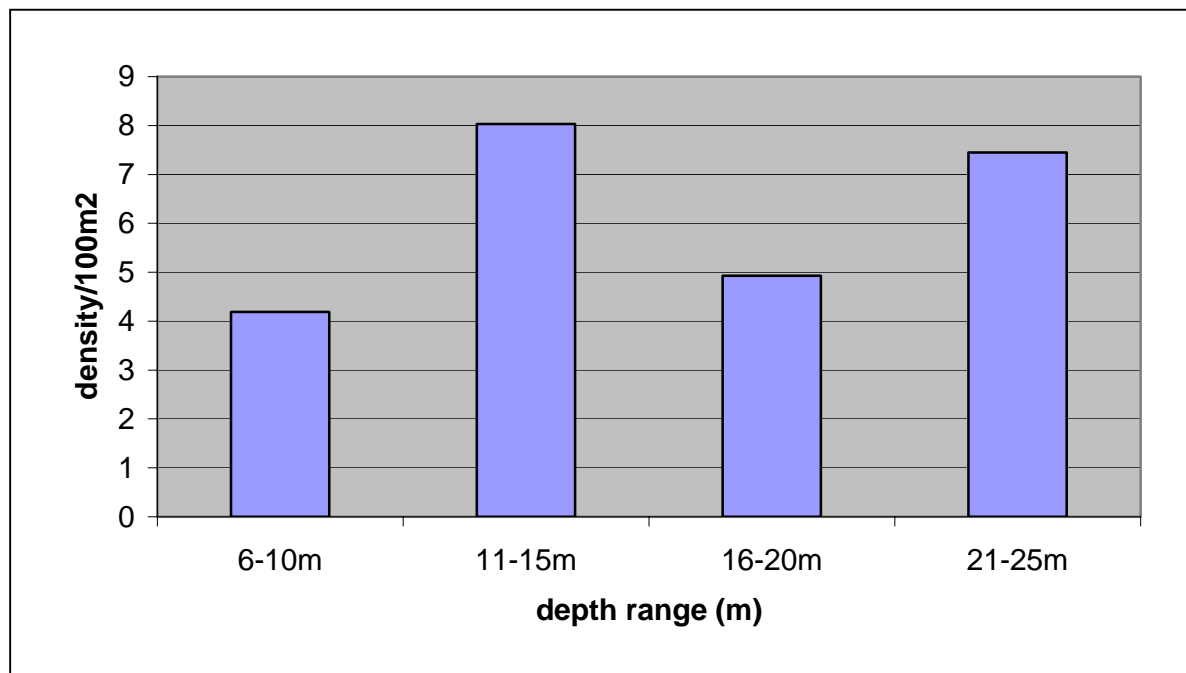
	Wick	South Neck	North Neck	Rye Rocks	Pool to North Castle	Double cliff to Pool	Wooltack Bay to Martins Haven west	Martins Haven east to High Point	All sites
Density ( $100\text{m}^{-2}$ )	0.6	5.2	0.87	13.25	3.3	1.94	14.7	10.7	6.7
Density ( $\text{m}^{-2}$ )	0.006	0.052	0.0087	0.133	0.033	0.0194	0.147	0.107	0.067

The density of *E. esculentus* at different water depths was also calculated (Table 3.3 and Figure 3.2). Twice the density of *E. esculentus* was recorded at 21-25m and 11-15m compared with 6-10m, whilst densities at 16-20m and 6-10 m were similar.

**TABLE 3.3 Density of *E. esculentus* at different depth ranges in Skomer MNR 2003**

Depth range	6-10m	11-15m	16-20m	21-25m
Survey area (m <sup>2</sup> )	1360	3298	2230	550
Mean size (mm)	119.33	126.76	123.85	121.00
Number of urchins	57	265	110	41
Density (m <sup>-2</sup> )	0.0419	0.0803	0.0493	0.0745
Density (100m <sup>-2</sup> )	4.19	8.03	4.93	7.45

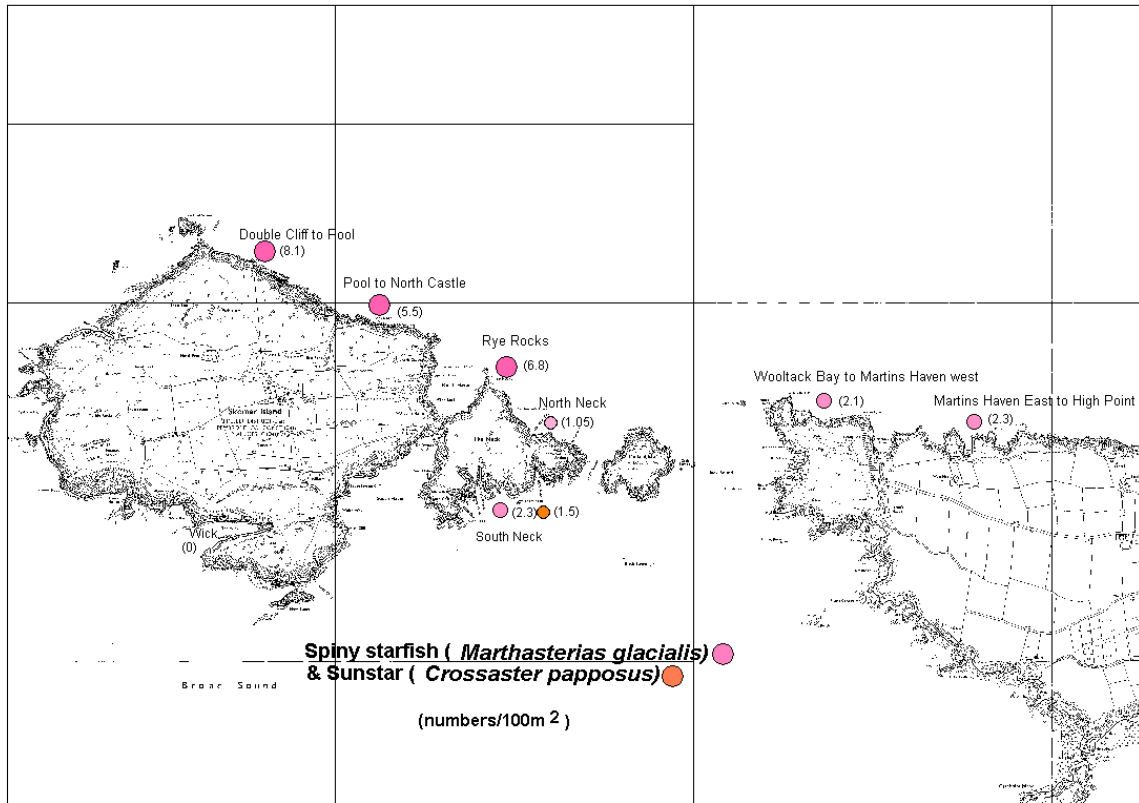
**FIGURE 3.2 Density of *E. esculentus* at different depth ranges in Skomer MNR 2003**



### 3.2.2 Starfish species

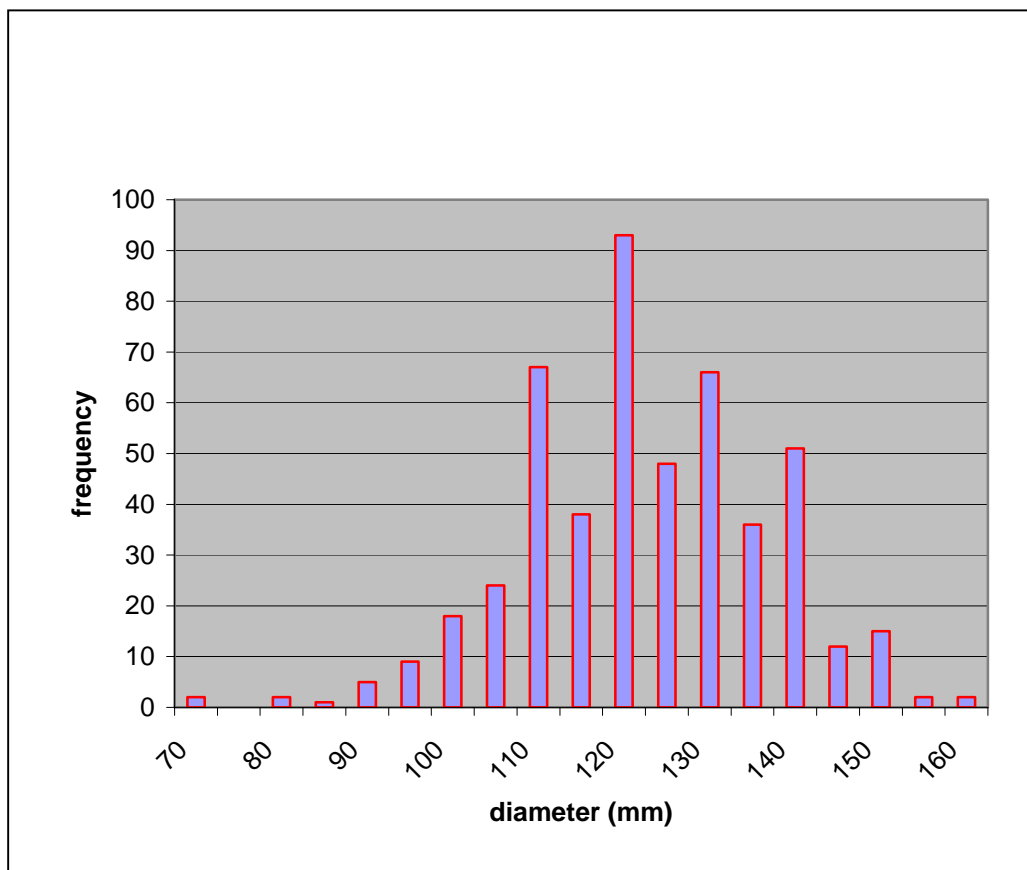
The total area surveyed for starfish species was 7380 m<sup>2</sup> within which a total of 368 and 21 *Marthasterias glacialis* and *Crossaster papposus* were observed respectively, whilst *Luidia ciliaris* was absent from all sites surveyed (Appendix II, table 2). Figure 3.3 shows the density of *Marthasterias glacialis* and *Crossaster papposus* in Skomer MNR. Density was highest from Double Cliff to Pool (8.1 per 100 m<sup>2</sup>) and lowest at North Neck of Skomer (5.1 per 100 m<sup>2</sup>), whilst none were observed in the Wick. *Crossaster papposus* was only observed at South Neck of Skomer with a density of 1.5 per 100 m<sup>2</sup>.

**FIGURE 3.3 Density and distribution of *Marthasterias glacialis* and *Crossaster papposus* in Skomer MNR 2003**



### 3.3 *E. ESCULENTUS* SIZE FREQUENCY DISTRIBUTION

**Figure 3.4 Size frequency distribution of *E. esculentus* in Skomer MNR 2003**

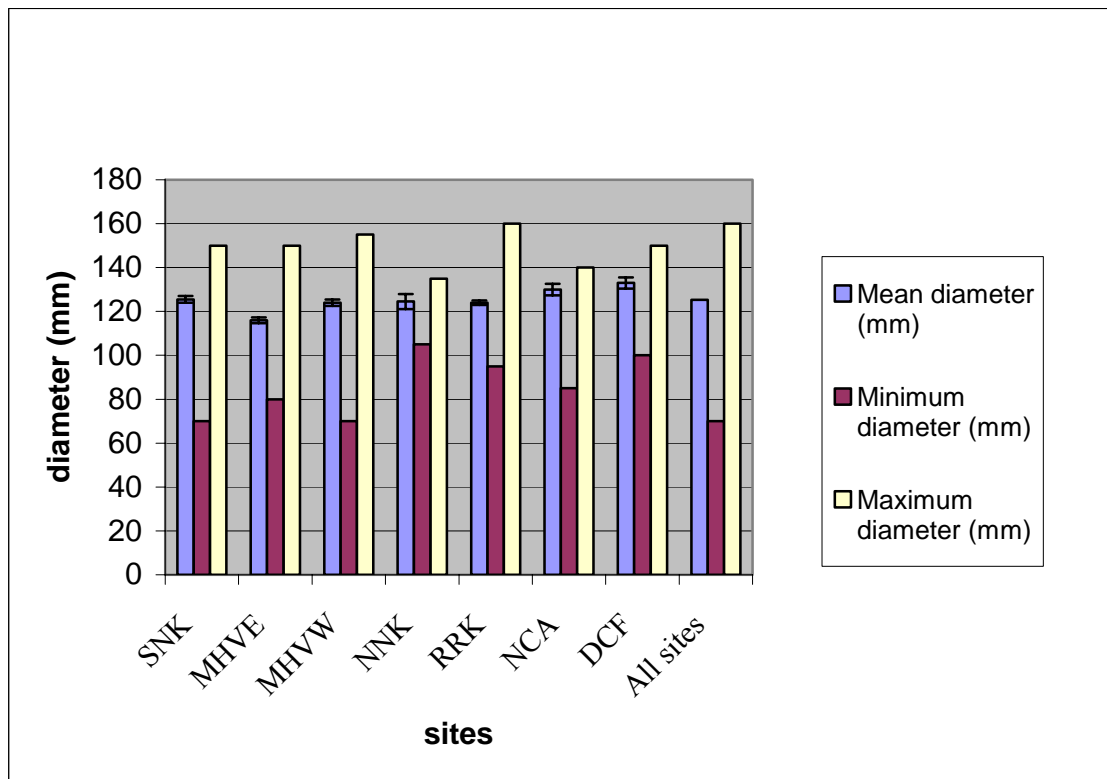


The population of *E. esculentus* in Skomer MNR showed a normal size frequency distribution. The mean, maximum and minimum diameters were 125, 160 and 70 mm respectively.

**TABLE 3.4 Size of *E. esculentus* at different sites in Skomer MNR. The Wick was not included as only one individual was observed**

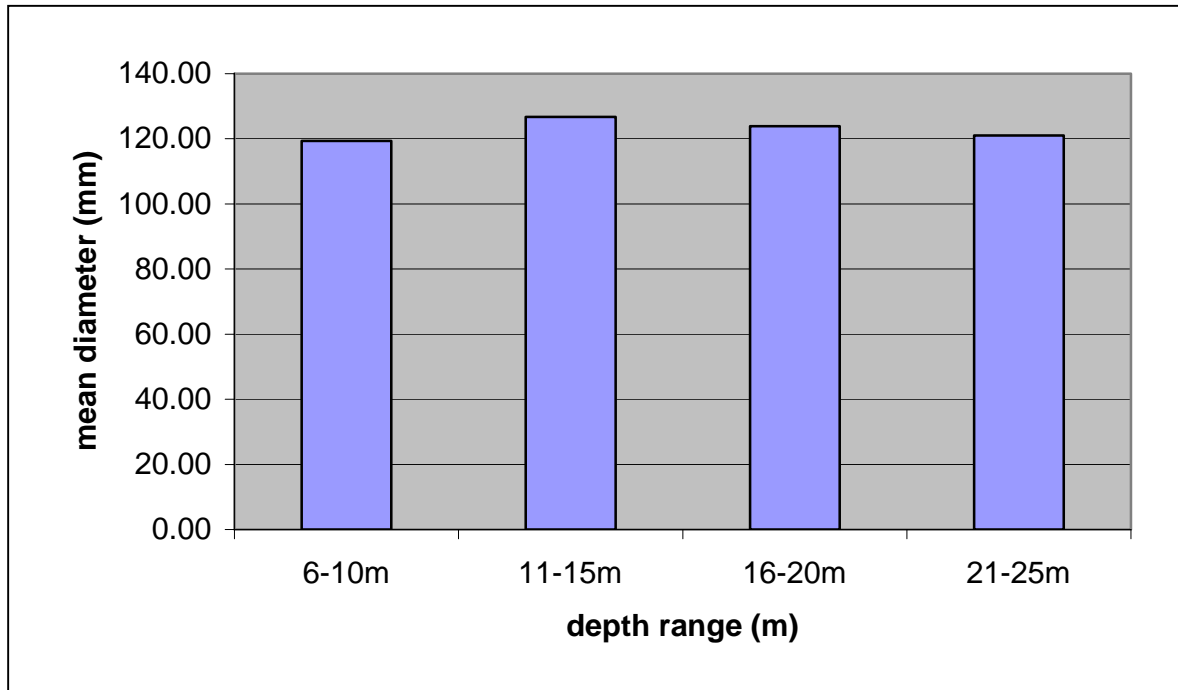
	South Neck	North Neck	Rye Rocks	Pool to North Castle	Double cliff to Pool	Wooltack Bay to Martins Haven west	Martins Haven east to High Point	All sites
Mean	125.8	124.5	124	130	133	116	124	125.3
Minimum	70	105	95	85	100	80	70	70
Maximum	150	135	160	140	150	150	155	160
Total No.	77	10	153	23	19	122	87	491

**FIGURE 3.5 Mean, minimum and maximum diameter of *E. esculentus* at each site in Skomer MNR, 2003; SNK=South Neck, MHVE= Martins Haven East, MHVW= Martins Haven West, NNK= North Neck, RRRK= Rye Rocks, NCA= North Castle, DCF= Double Cliff**



The mean diameters were similar at each site; the smallest mean diameter was 116 mm at MHVE whilst the largest was 133 mm at Double Cliff (Figure 3.5 and Table 3.4). By contrast, both minimum and maximum diameters showed variation between sites.

**FIGURE 3.6 Mean diameters of *E. esculentus* at different water depth ranges in Skomer MNR 2003**



Mean diameter was similar at all depth ranges (Figure 3.6). The smallest mean diameter was observed at 6-10m (120 mm) and the largest at 11-15m (125mm).

## 4 DISCUSSION

The density and distribution of *Echinus esculentus* and starfish species showed variations with site and depth. *E. esculentus* also showed a normal size frequency distribution, whilst little variation in size was observed at different water depths.

### 4.1 *E. ESCULENTUS* DENSITIES

The average density of *E. esculentus* in Skomer MNR in 2003 was compared with densities recorded previously for Skomer and other sites in the UK (Table 4.1). Although the average density recorded for Skomer MNR in 2003 was extremely similar to that recorded by Bishop (1982) the survey methods used were different. Bishop (1982) recorded the number of individuals seen per dive; numbers were then converted to density by assuming that approximately 100m<sup>2</sup> was surveyed in 15 minutes. However, a later study by Bishop & Earll (1984) demonstrated that timed search methods yielded similar results to those obtained by transect methods. Both the present study and Nichols (1984) used the belt transect method.

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

Mean density of <i>E. esculentus</i> (m <sup>-2</sup> )	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 & Lock (2004)
*large site variation		

The average density for Skomer in 2003 was much lower than densities recorded for both Plymouth and Millport in 1984 (Table 4.1). Other studies using comparable methods have also shown low densities for Skomer. For example, Bishop (1982) compared the densities from Skomer 1979 and 1981 with those from Lamorna Cove, which covered similar depth ranges and used the timed search method. The results showed no significant difference between the commercially exploited population at Lamorna Cove and Skomer.

Variation in densities was also observed between sites within Skomer MNR and reflects variations in exposure to wave action and prevailing currents. For example, only 0.6 urchins per 100m<sup>2</sup> were observed in the Wick, compared with 14.7 urchins per 100m<sup>2</sup> between Wooltack Bay and Martins Haven West. The prevailing swell and wind direction is from the southwest therefore coasts/sites facing this direction are exposed to the greatest wave action. Thus the low density of *E. esculentus* observed at the Wick compared with Wooltack Bay and Martins Haven may be due to greater exposure to wave action. Conversely, Rye Rocks, Wooltack Point to Martins Haven West and Martins Haven East to High Point showed the highest densities of *E. esculentus*. All are north facing and therefore sheltered from prevailing southwesterly swell and wave action with moderate to low tidal currents. In addition the habitats at these sites were similar (bedrock reefs) providing conditions that are favourable for urchins.

At Skomer in 1981 an attempt was made to analyse density in relation to habitat by distinguishing between high and low wave action sites. Bishop (1982) noted that the highest density obtained was from a habitat type sheltered from wave action, but exposed to fast tidal streams. In the present study, the density of *E. esculentus* in Skomer MNR was highest in

areas sheltered from extreme wave action but with moderate tidal currents, and in bedrock or large boulder habitats and thus is consistent with previous observations.

It is unclear why the density of *E. esculentus* is so low compared with other areas in the UK and why there are so few small individuals. Earll (1979) suggested that the urchin density in Skomer MNR is naturally low and recruitment may be low due to prevailing currents around Skomer carrying larvae away, thus reducing their contribution towards the parent population. Similar suggestions have been made for other species in Skomer MNR, for example Jones & Hodgson (1980) with reference to lack of small/juvenile *Pecten maximus*. Wood (2003) also observed low numbers of small *Eunicella verrucosa* and suggested that the population may not be recruiting new colonies at a low level, possibly due to a low rate of larval distribution in Pembrokeshire. Zooplankton studies might reveal whether echinoderm larvae are present in the plankton around Skomer. Alternatively, juveniles may be present in cryptic habitats and therefore easily overlooked or simply not visible during general searches. Careful consideration of methods is required to include additional detailed searches for small individuals in future surveys.

#### **4.2 *E. ESCULENTUS* DENSITY VS. DEPTH**

Twice the density of *E. esculentus* was recorded in deep water (21-25m) compared with shallow water (6-10m) in the present study. Previous reports have shown varied responses of urchin density 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. Bishop (1982) suggests that although the highest numbers occurred at 7 m, the mean depth of the lower edge of the kelp forest was 5.91 m  $\pm$  0.63 below chart datum and *E. esculentus* was apparently more common just below the kelp forest than within it. This supports both the present observations and those of Hunnam (1976) who suggested that urchin density increased with depth in Skomer MNR. However, it should be noted that the results of the 2004 survey may be biased as a far greater number of surveys were carried out in shallow (6-10 m) than deep water (21-25 m).

#### **4.3 *E. ESCULENTUS* SIZE**

The population of *E. esculentus* in Skomer MNR 2003 showed a normal size frequency distribution with a size range of 70-160 mm and a mean of 125 mm. Similar to the present study, Bishop & Earll (1984) found that Skomer *E. esculentus* were mostly large (above 95 mm). 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 with the majority of the population represented by the senescent part of the growth curve. It appears that the population has a similar age structure to 1982 and therefore possibly still in a senescent phase. Larsson (1968) suggested that divers were less efficient at observing/collecting urchins smaller than 50 mm diameter than they were at collecting individuals 50 mm or larger. Thus the absence of individuals less than 70 mm diameter in 2003 may be due to biased sampling. However, Bishop & Earll (1984) showed that in August 1982 12 % of the total number of observations were less than 50 mm diameter, suggesting that any small urchins present were recorded during general searching. They recommended that for urchins smaller than 20mm diameter intense searches in small areas (0.25m<sup>2</sup> quadrats) should be made. Although Bishop & Earll (1984) were confident that the Skomer data represented the true age structure of the Skomer population from age 2+ in 1982, it is suggested that thorough searches for small individuals be carried out in the future to be confident of the 2003 data. From a management perspective it is important to have convincing quantitative evidence of the true age structure



of the *E. esculentus* population. However, searches would have to be separate from the established method to allow continued comparison with previous survey data.

#### 4.4 STARFISH

*Marthasterias glacialis* was found throughout the MNR and occurred in highest densities along the north east coast of Skomer where there is a range of current regimes and wave exposures. This reflects the wide range of habitats in which *M. glacialis* commonly occurs (Picton, 1993). *Crossaster papposus* was found only at Thorn Rock, South Skomer where tidal currents are moderate and wave exposure is high. The absence of this species from all other survey sites in the MNR would suggest that current and wave conditions, habitat and prey species were most suitable at Thorn Rock. Records of *C. papposus* in previous surveys in Skomer MNR have also been sparse, for example Bunker & Hiscock (1984) observed one individual at Martins Haven Point during their surveys of sublittoral habitats and communities. An incidental photographic record of *C. papposus* also exists for North Neck in 1985 (Bullimore, 1985) during an investigation of the effects of scallop dredging.

Despite previous records in Skomer MNR, for example at North of the Neck (Bullimore, 1985) and various sites in the MNR (Bunker & Hiscock, 1984 and Bunker *et. al.* 1992) *Luidia ciliaris* was not recorded during the present survey, which may suggest low densities or that the habitat surveyed was unsuitable. Neither *C. papposus* nor *L. ciliaris* was found at Low Point or North Neck during a study of sediment epifauna in 2001 (Moore, 2002), which could suggest a decline at North Neck since 1984. Future survey should target the habitat of these species more specifically and any incidental sightings of *C. papposus* and *L. ciliaris* be recorded during routine diving operations in Skomer MNR.

## 5 RECOMMENDATIONS

1. The survey of *E. esculentus* and *C. papposus*, *M. glacialis* and *L. ciliaris* populations should be repeated every 4-5 years.
2. Future surveys should attempt to include equal numbers of shallow and deep water sites throughout the MNR with increased coverage on the south and west sides of Skomer
3. Intense searches should be carried out in small areas (0.25 m<sup>2</sup> quadrats) for *E. esculentus* smaller than 20mm diameter. Trained surveyors should be used to avoid confusion with other smaller species, for example *Paracentrotus lividus* or *Psammechinus miliaris*.
4. Sites in Skomer MNR where *C. papposus* and *L. ciliaris* have been recorded in the past should be targeted. In addition, any sightings of *C. papposus* and *L. ciliaris* should be recorded during routine dives.
5. Zooplankton studies could be carried out to investigate the presence of echinoderm larvae in Skomer MNR.

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## **APPENDIX I**

**Field recording form for *E. esculentus* survey in Skomer MNR 2003**

**TABLE 1** *Echinus esculentus* survey data: density

Location	Site	Area (m2)	No. urchins	Density urchins	Density urchins	Area (m2)
		urchins		/m2	/100m2	starfish
NMPE	MHVE- HPT	1160	124	0.107	10.7	1340
NMPE	WPT- MHVW	598	88	0.147	14.7	640
South Skomer	SNK/Castle Bay	1410	74	0.052	5.2	1350
South Skomer	Wick	150	1	0.006	0.6	0
North Skomer	NNK	1140	10	0.008	0.87	1140
North Skomer	RRK	1230	163	0.132	13.25	1230
North Skomer	NCA -POL	720	24	0.033	3.3	600
North Skomer	POL - DCF	1080	21	0.019	1.94	1080
<b>TOTAL ALL SITES</b>		<b>7488</b>	<b>505</b>	<b>0.067</b>	<b>6.7</b>	<b>7380</b>

## **APPENDIX II**

### **Survey sites, areas, total numbers and densities for *E. esculentus* and starfish species in Skomer MNR 2003**

**TABLE 2 Starfish survey data:density**

Location	Site	No. spiny	Density spiny /m2	Density spiny /100m2	No. sunstar	Density sunstar /m2	Density sunstar /100m2	No. 7-armed	7-armed /100m2
NMPE	MHVE- HPT	31	0.023	2.3	0	0	0		
NMPE	WPT- MHVW	88	0.021	2.1	0	0	0		
South Skomer	SNK/Castle Bay	32	0.023	2.3	21	0.0155	1.55		
South Skomer	Wick	0	0	0	0	0	0		
North Skomer	NNK	12	0.01	1.05	0	0	0		
North Skomer	RRK	84	0.068	6.8	0	0	0		
North Skomer	NCA -POL	33	0.055	5.5	0	0	0		
North Skomer	POL - DCF	88	0.081	8.1	0	0	0		
<b>TOTAL ALL SITES</b>		<b>368</b>	<b>0.0498</b>	<b>4.98</b>	<b>21</b>	<b>0.0028</b>	<b>0.28</b>	<b>0</b>	<b>0</b>