Cyngor Cefn Gwlad Cymru
Countryside Council for Wales

Skomer Marine Nature Reserve *Pecten maximus*, King scallop Survey 2008

CCW Regional Report CCW/WW/09/04

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SYNOPSIS

The present survey aimed to establish the current status of *Pecten maximus* in Skomer MNR and compare results with previous surveys in 2000 and 2004. A team of 40 volunteer divers swam transects along the seabed collecting any *P. maximus* encountered. Length, width and growth bands of each individual were measured. Each was then marked and returned to the site from which they were collected.

Scallop spat collectors were trialled within Skomer MNR in 2005 and 2006.

In 2008 the area surveyed was 9780 m^2 and 1653 individuals were measured. The total density of *P.maximus* for all sites showed an overall density increase and the density at 4 of the 7 sites showed a statistically significant increase. The results suggest a continued recovery of the population since cessation of exploitation in 1990.

Age distribution and size frequency distribution both show a normal distribution curve with no bi-modal pattern in 2008, suggesting a single annual spawning event in the Reserve. This pattern was also a feature of data from 2000 and 2004.

Comparison between the growth rings of 2000, 2004 and 2008 has shown the growth of individual *P.maximus* to be greater from those sites that have also shown an increase in population density. The results show that where a site is favourable for population increase, it is also favourable for growth of individual scallops.

CRYNODEB

Nod yr arolwg presennol oedd sefydlu statws cyfredol *Pecten maximus* yng Ngwarchodfa Natur Forol Sgomer, gan gymharu canlyniadau gydag arolygon blaenorol yn 2000 a 2004. Fe nofiodd tîm o 40 o blymwyr gwirfoddol drawsluniau ar hyd gwely'r môr gan gasglu unrhyw *P. maximus* y daethpwyd ar eu traws. Mesurwyd hyd, lled a chylchoedd tyfiant pob un unigol. Cafodd pob un ei farcio wedyn a'u dychwelyd i'r safle y casglwyd hwy ohono.

Cafodd casglwyr grawn cregyn bylchog eu treialu o fewn Gwarchodfa Natur Forol Sgomer yn 2005 a 2006.

Yn 2008 yr ardal a arolygwyd oedd 9780 m^2 a chafodd 1653 o unigolion eu mesur. Roedd trwch cyfan *P.maximus* yn yr holl safleoedd yn dangos cynnydd cyffredinol o ran trwch ac fe ddangosodd y trwch mewn 4 o'r 7 safle gynnydd sylweddol yn ystadegol. Mae'r canlyniadau'n awgrymu adferiad parhaus o'r boblogaeth ers i ecsbloetio ddod i ben yn 1990.

Mae dosbarthiad o ran oedran a maint yn dangos cromlin ddosbarthu normal heb unrhyw batrwm deufodd yn 2008, ac mae hyn yn awgrymu digwyddiad silio unigol blynyddol yn y Warchodfa. Roedd y patrwm yma hefyd yn nodwedd o'r data o 2000 a 2004.

Mae cymhariaeth rhwng cylchoedd tyfiant 2000, 2004 a 2008 wedi dangos bod tyfiant *P.maximus* unigol yn fwy o'r safleoedd hynny sydd hefyd wedi dangos cynnydd o ran trwch poblogaeth. Mae'r canlyniadau'n dangos bod safle sydd yn ffafriol ar gyfer cynnydd o ran poblogaeth hefyd yn ffafriol ar gyfer tyfiant cregyn bylchog unigol.

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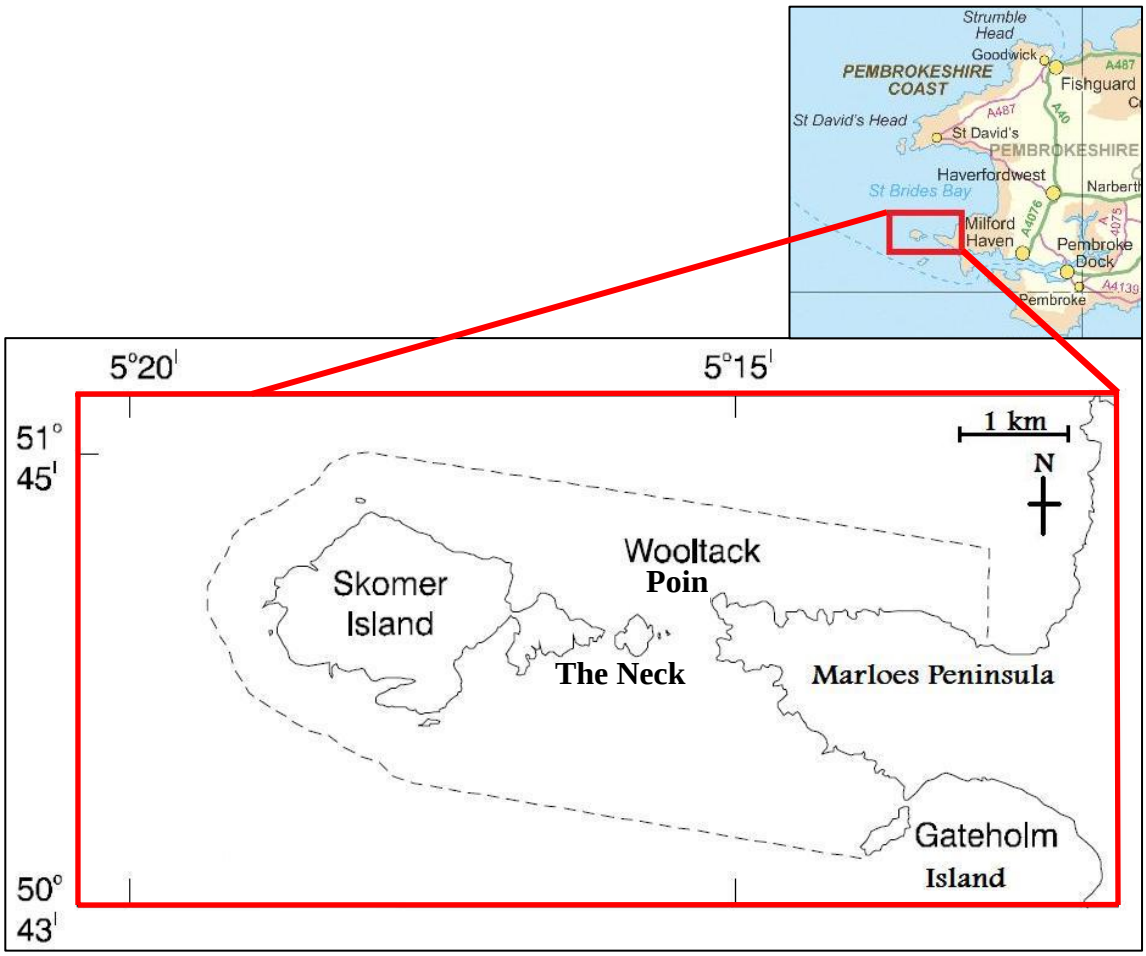
1 INTRODUCTION

Pecten maximus (Linnaeus, 1758) the King scallop is found in the Skomer Marine Nature Reserve (MNR). The *P. maximus* population in Skomer MNR has been protected since July 1990 upon designation of the Marine Nature Reserve. South Wales Sea Fisheries Committee (SWSFC) byelaws (no. 30 & 30a) prohibit the use of dredges and beam trawls as well as the removal of *P. maximus* from the MNR by any means (see Appendix I for SWSFC byelaws).

Figure 1. Map indicating (dashed line) the boundary limits of the Skomer Marine Nature Reserve. Reserve map adapted from Rogers, 1997. Scale map from Ordinance Survey.



Bullimore (1985) reviewed *P. maximus* survey data from 1979 to 1982 and 1984 in Skomer MNR to assess the status of the population at that time. These surveys estimated extent of habitat suitable for *P. maximus* in Skomer MNR, *P. maximus* density, age frequency distribution and first year growth bands and annual growth rates for individuals (Lock, 2001).

Repeat surveys have been carried out in an attempt to monitor recovery of the population since MNR designation in 1990. The survey of *P. maximus* in 2000 was carried out by a team of volunteer divers guided by MNR staff and established the field method and three survey sites. In 2004 the survey was repeated at the same 3 sites and established a further 4 sites (Luddington *et al* 2004). These field methods and 7 sites were again used in the present survey.

Survey results in 2000 showed an increase in *P. maximus* density compared to the 1984 survey data. The 2004 survey showed a continuation of this trend, with an overall increase in *P. maximus* density and modal age and size classes since 2000, and growth showed a similar pattern to 2000.

1.1 SURVEY OBJECTIVES

The survey aimed to establish the current status of the *P. maximus* population in Skomer MNR and compare the results to previous surveys. The objectives were:

1. To determine the density of *P. maximus* at selected sites;

2. To determine *P. maximus* population dynamics: age distribution and size distribution and growth rates;

3. To compare results with previous surveys.

4. To attempt to collect *P. maximus* spat.

2. METHOD

2.1 SITE SELECTION

During the Skomer MNR *P. maximus* survey in 2000 Geographical Positioning System (GPS) positions for 3 permanent sites were established. In 2004 a further 4 sites were established following reconnaissance dives to assess their suitability as *P. maximus* survey sites. Each site position was recorded using GPS and marked with a buoyed sinker for the duration of the survey. All 7 sites were again used in the 2008 survey.

2.2 DIVING FIELD METHOD

In 2000 a method suitable for volunteer divers was established and this was repeated in the 2004 and 2008 surveys. Survey transects were conducted from each site marker, following compass bearing directions: N, NE, E, SE, S, SW, W and NW where topographic features allow. Survey transects were completed by divers working in buddy pairs. Each pair was equipped with a surface marker buoy (SMB), a compass, net bags, a torch and a 50m tape.

At some sites it was not appropriate to complete full 50 m transects due to changes in benthic substrate and in these cases transects were omitted or reduced. Furthermore at 3 sites only 30 m transects were undertaken due to the high densities of *P. maximus* found and limited dive time to complete the transects.

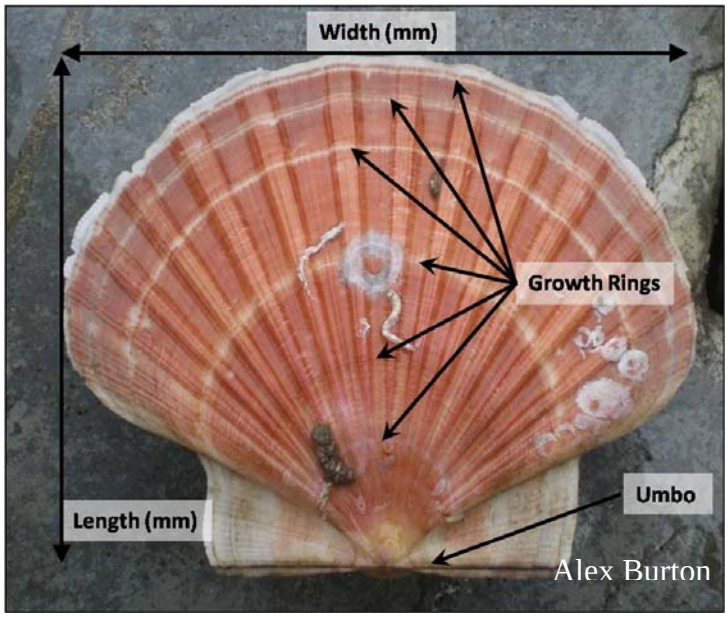
One transect was completed per dive. The divers attached the tape measure to the fixed marker on the seabed and swam together laying out the tape for 50m on an agreed compass bearing. The transect was then completed with one diver positioned on either side of the tape. The divers searched for all *P. maximus* found in a 2m wide corridor on their side of the tape, collecting the animals into net bags. This was repeated by swimming back along the tape collecting any missed *P. maximus*. The divers returned to the boat with the collected *P. maximus* where they were stored in labelled buckets of clean seawater.

2.3 FIELD RECORDING

On the boats the *P. maximus* were cleaned on the shells flat side using a scrubbing brush until the growth check rings are clearly visible. Length and width measurements were recorded. Growth rings were measured from the umbo (hinge line) to each annual growth check ring on the flat valve, as shown in figure 2. Each *P. maximus* was marked with a filed notch 2-3mm into the edge of the

hinge to ensure that no scallop was measured twice during the survey. Once all the *P. maximus* from each transect had been measured, recorded and marked they were returned to the sea in the area immediately surrounding the site marker buoy from which they had been removed. During subsequent transects any scallop collected bearing a notch was omitted from further recordings.

Figure 2. Length and width dimensions measured and the position of the six annual growth rings relative to the umbo of the shell.



2.4 SPAT COLLECTORS

Figure 3. Mesh bag ready for deployment.

Spat collectors were made using mesh bags and monofilament line as shown in Figure 3.

In May 2005 two collectors were deployed five and ten metres below sea level at the Skomer MNR oceanographic monitoring station attached to the site marker rope with cable ties. Stormy conditions however ripped the bags from the rope. Two further collectors were deployed in April 2006 and these were retrieved in July. The collectors were carefully examined for any juvenile *P. maximus*.

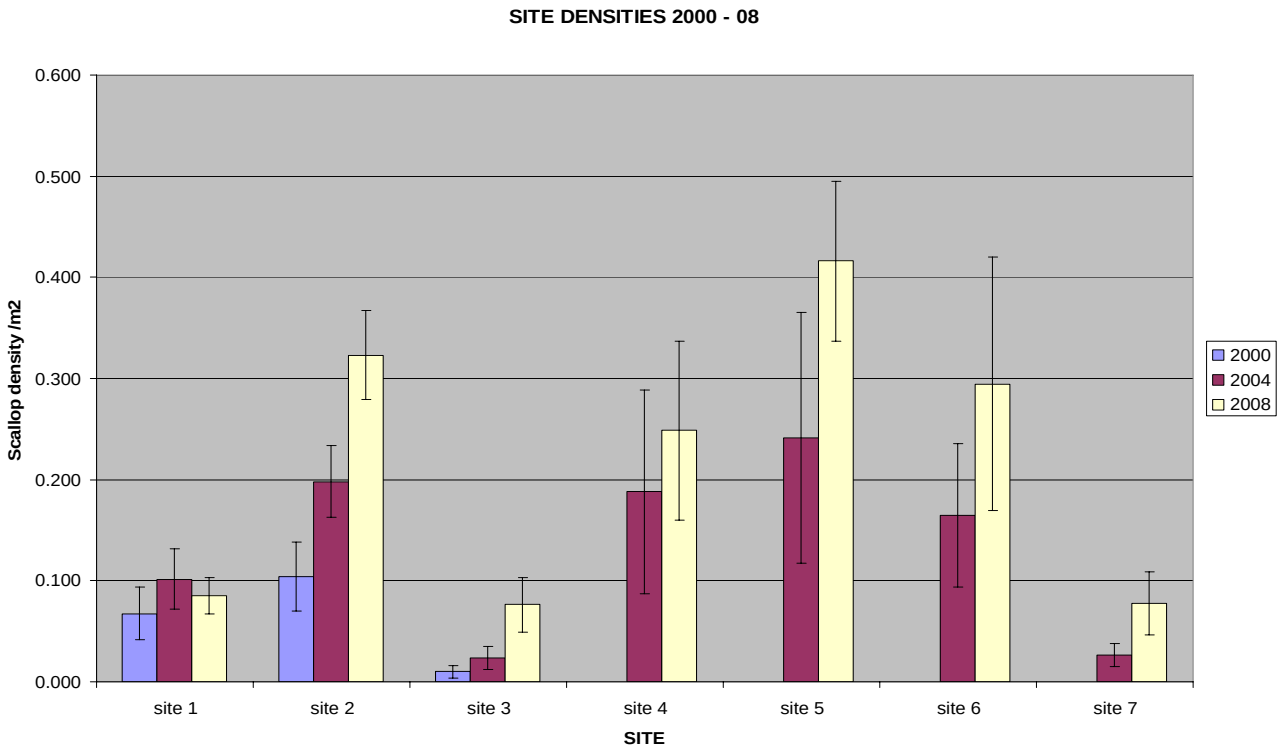
3. RESULTS

3.1 DENSITY AND DISTRIBUTION

The survey was carried out over two weekends with a total of over 40 divers. A total of 9780m^2 of seabed was surveyed at the seven pre-selected sites and 1653 *P. maximus* collected and measured. The mean density for the whole MNR was 0.169m^{-2} in 2008 compared to 0.115m^{-2} in 2004 and 0.045m^{-2} in 2000, indicating a continued overall increase in density.

The differences in scallop densities at each site over the eight years are shown in Figure 4. The error bars are the 1.96 standard error bars, representing the 95% confidence interval.

Figure 4. Pecten maximus density at sites 1-7, Skomer MNR 2000, 2004 and 2008 (95% confidence level standard error bars)



Sites 2, 3 and 7 have seen significant increase in *P. maximus* density, with three fold increase over the eight years. Site 5 has a significant increase at the 90% confidence level but not at 95%. Sites 4 and 6 have not shown significant increase, but the data has very broad error bars for these sites, indicating difficulties with the sampling. Site 1 shows a slight drop in density from that recorded in 2004.

There is a clear distinction within the Skomer MNR between sites for which the density of *P. maximus* has increased three-fold over the last eight years (sites 7, 2, 3 and site 5 (90%)) and those for which there has been no significant change in *P. maximus* density (sites 6, 1 and 4).

3.2 P. MAXIMUS AGE CLASSES

P. maximus age is determined by counting the number of growth rings present, one growth ring representing one year of growth. Growth rings up to the age of seven are reasonably distinguishable but growth rings from year eight and above are more difficult to measure as growth slows down and the distance between the rings is very small. Therefore for ages of eight years or above, the measured growth for all *P. maximus* were used to provide a calculated mean annual growth rate of 1.033 times the previous year. This calculated mean growth rate was then applied to all *P. maximus* eight years or more to extrapolate *P. maximus* sizes and estimate ages.

Figure 5. *Pecten maximus* age distribution (per 500 population) Skomer MNR 2000, 2004 & 2008

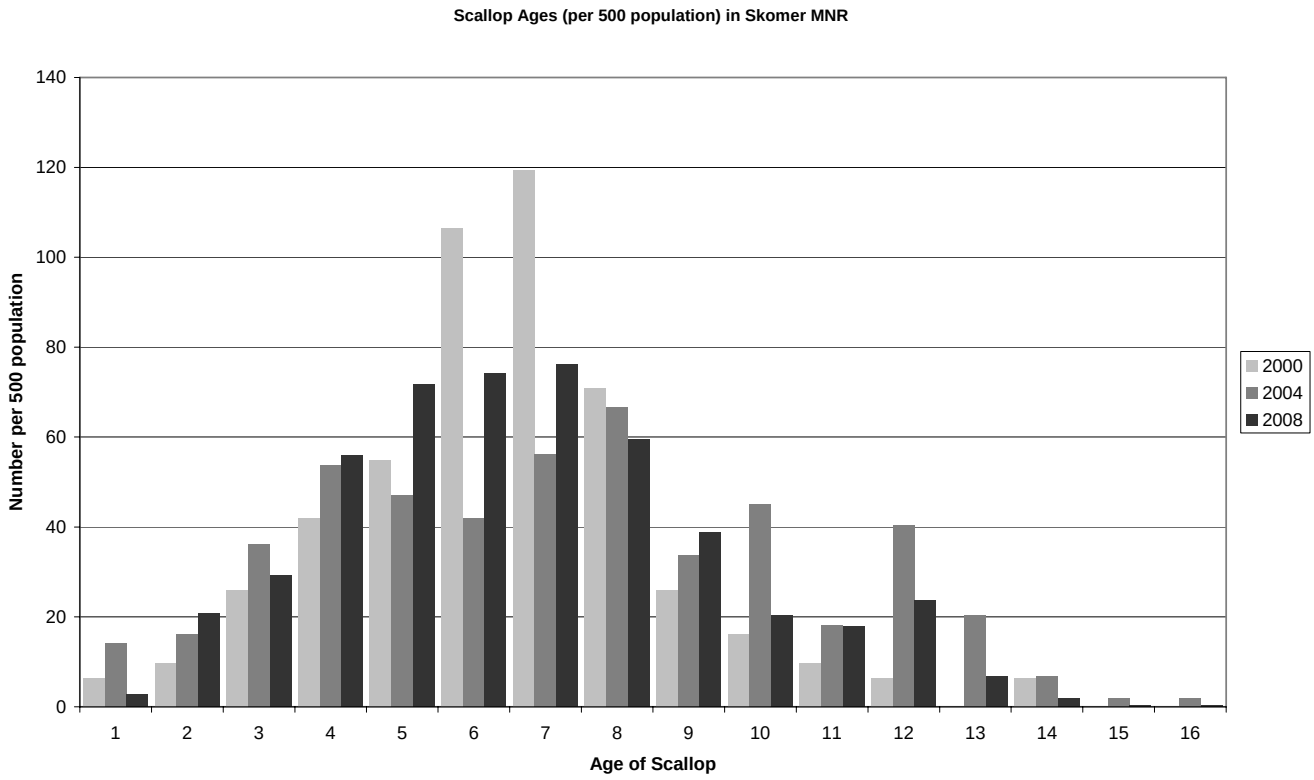


Figure 5 shows a normal *P. Maximus* age distribution for Skomer MNR in 2000, 2004 and 2008. In years 2004 and 2008, there are slightly higher numbers of the oldest individuals in the population with the oldest individual estimated as 16 years old.

3.3 P. MAXIMUS GROWTH

P. maximus growth is determined by measuring the length distance of each growth ring. Growth rings on some *P. maximus* were difficult to identify but because of the high numbers of *P. maximus* measured it is possible to smooth out this difficulty.

Figure 6. Length frequency graph, showing the first three growth rings of measured Pecten maximus 2008

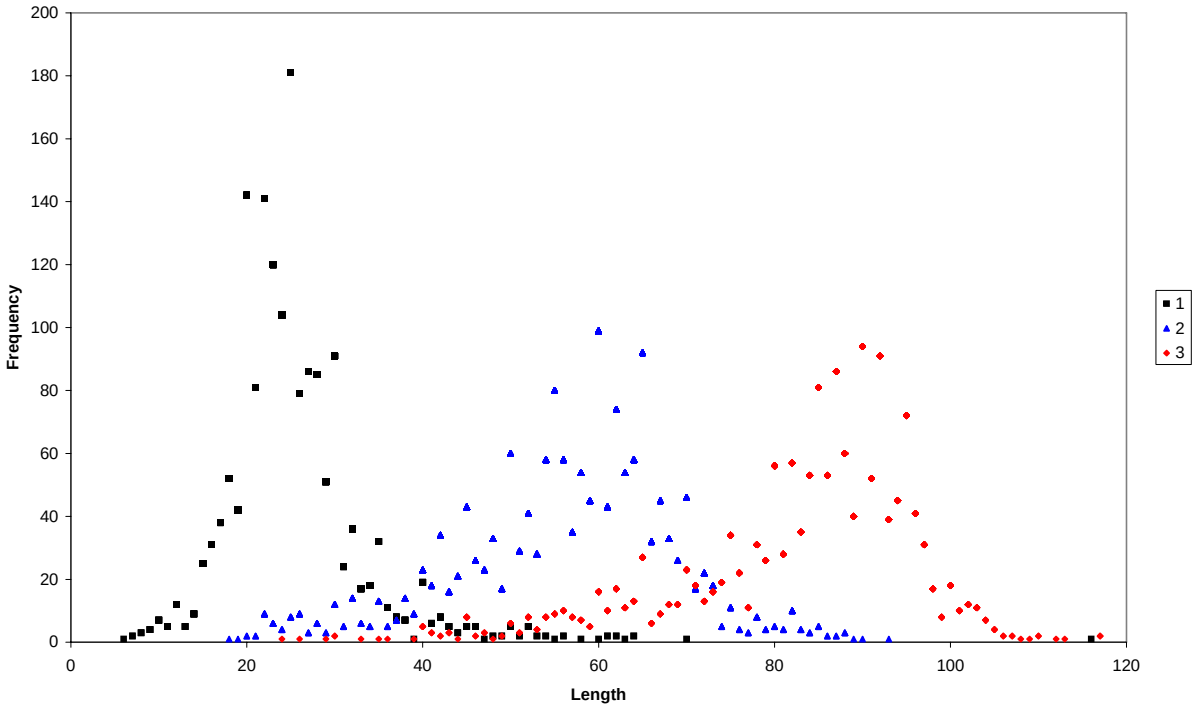
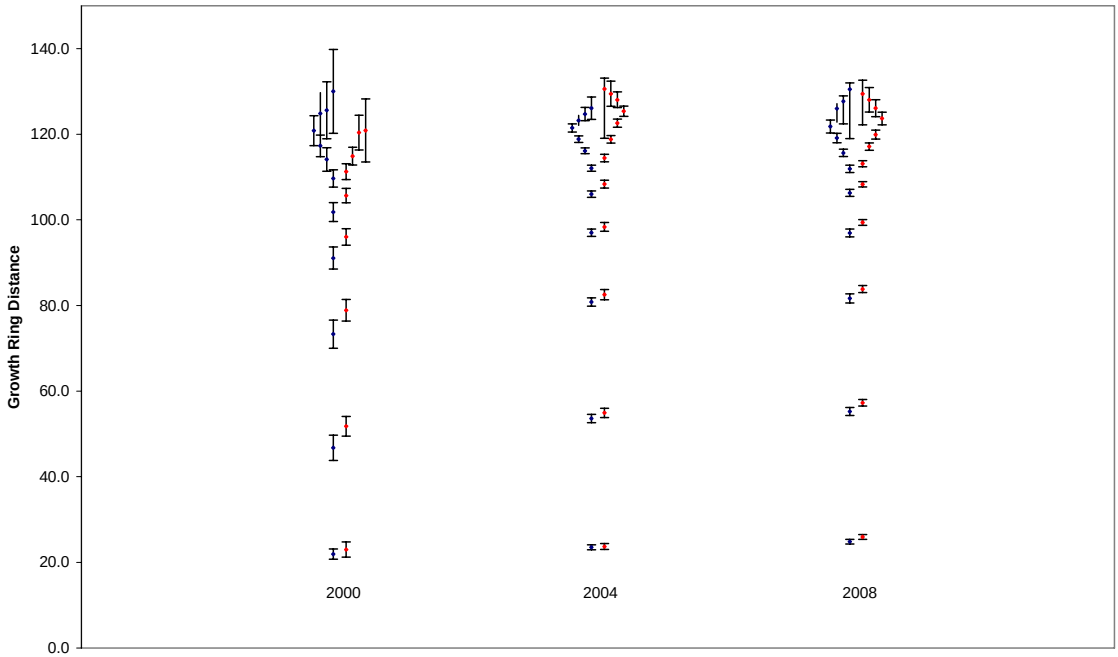


Figure 6 shows that the position of each growth ring is fairly normally distributed about a common mean and this pattern was also seen for the 2000 and 2004 data. No obvious bimodal pattern is observed in the data.

P. maximus growth patterns were analysed for each site. Population density distribution results showed that the sites divided into two clear groups: sites with a significant density increase (sites 7, 2, 3 (95%) and site 5 (90%)) and those with no significant density change (sites 6, 1 and 4). The difference in individual *P. maximus* growth between these two groups has been investigated and the results of this analysis are presented in Figure 7.

Figure 7. Mean distance of Scallop growth rings, with 95% confidence standard error bars.



Three features are presented in Figure 7:

a. The mean distance of growth rings for each age have been plotted with 95% standard error bars, progressively from the 1st year to the twelfth year. From the seventh year onwards the data points are stepped out simply for clarity in distinguishing the error bars.

b. The data from the three year sets 2000, 2004 and 2008 are separated.

c. The combined data from sites 7, 2, 3 and 5 (where an increase in density has been seen) are plotted in red, the combined data from sites 6, 1 and 4 (where no significant change in density has been seen) are plotted in blue.

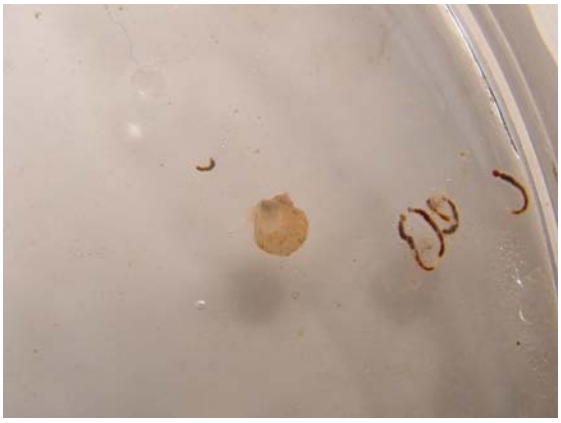
The general trend of all the points seen together show two results.

1. The distance of each growth ring is greater in 2004 than 2000 and again in 2008 than 2004, indicating an increase in scallop size at a particular age over the 8 years.

2. Points plotted in red (sites where a density increase has occurred) have a higher value than equivalent points plotted in blue (sites where no change in density has been seen), indicating that sites favourable for an increase in scallop population density are also favourable for an increase in size at age for the individual scallops.

3.4 SPAT COLLECTORS

A single juvenile *P. maximus* was found from the two spat collectors that were deployed between April and end of July 2006.



4 DISCUSSION

4.1 DENSITY & DISTRIBUTION

Seven sites were surveyed in 2008 and data compared to 2004 and 2000 surveys. The total population density of *P. maximus* for all sites showed increase compared to the previous surveys suggesting a continued recovery of the population from pre-1990 exploitation. Studies off the Isle of Man in areas closed to fishing for *P. maximus* similarly showed an increase in population densities. Between 1989 and 2003 density was seven times higher in the closed areas compared to fished areas (Beukers-Stewart *et al*, 2005).

An increase in density was seen at six of the seven sites and at four of these sites a significant increase (90% confidence interval) was recorded. Natural factors such as habitat, food availability and competition will all contribute to the density of *P. maximus* at a site and naturally *P. maximus* will thrive better at some sites. The lower densities of *P. maximus* found at sites 1, 3 and 7 may in part be explained by the topography, where for some transects rocky substrate presented an obstacle or an increase in depth made it problematic for divers to sample. In future, it may be worth reviewing these sites in terms of their suitability for long-term monitoring.

The removal of *P. maximus* by commercial fishing and recreational divers will also affect site density. In 2004 site 3 yielded a very low density compared with other sites, the low numbers were possibly due to it being a popular site with recreational shore divers and where there had been reports of divers removing *P. maximus*. In 2005 new posters were put up informing divers of the SWSFC byelaw and of the fines that could be imposed. Since then there have been no reports of divers removing *P. maximus* and the 2008 survey results show a significant increase in the density at this site.

A further interesting result is the slight drop in density of *P. maximus* at site 1. This raises the possibility that this location has reached its ‘carrying capacity’. If this is the case then it is possible that any increases in *P. maximus* at this site might be contributing to a ‘spill over effect’ either to other areas within the Skomer MNR or outside of the Reserve boundary (Gell & Roberts, 2003; Goni *et al*, 2008). This merits further investigation in future monitoring surveys.

4.2 AGE STRUCTURE & GROWTH

Age distribution and size frequency distribution both show a normal distribution curve in 2008, as was shown in 2000 and 2004. This suggests that the age distribution in the population is stable over the eight year period. In years 2004 and 2008, there are slightly higher numbers of the oldest individuals in the population and the oldest individual measured was estimated as 16 years old suggesting that *P. maximus* of this age are close to their maximum life expectancy.

The 1985 study suggested that there is a biannual nature to the growth of *P. maximus*, with two distinct spawning times during one year. No obvious bimodal pattern was present in the 2000, 2004 or 2008 data, with all growth ring data graphs indicating only a single mid point with varying degrees of spread. It is possible that the bimodal effect is so slight it is not detectable within the level of noise (spread of curve) of these data.

The spawning patterns of *P. maximus* have been described for a variety of different geographical areas and there does not appear to be any firm consistency. Research conducted by Mason (1957:1958) around the Isle of Man reveals that *P. maximus* in this area had a partial spawning in April/May and July followed by a more complete spawning in August/September depending on their age. In the Bay of St. Brieuc (France) spawning events appeared to follow a cyclic pattern with an initial (all population) spawning seen between the end of June and beginning of July. The second spawning event was recorded here during July - all gonads were fully spent by August. Spawning was seen to be initiated by water temperatures of 15.5-16^{o}C characteristic of these seasonal times (Paulet *et al.,* 1988). In the Bay of Brest (France) spawning in *P. maximus* was seen to occur continuously with numerous spawning between April and October. Mature individuals were observed throughout this period of time (Paulet *et al.,* 1988). Populations of *P. maximus* around the Western Norwegian coast were observed to spawn over an extended period of time ranging from March to September. Full adult gonads were found throughout this time, but not after September/October (Duinker & Nylund, 2002).

In general *P. maximus* is observed to spawn frequently throughout the period of spring to autumn (Isle of Man, Bay of Brest France, western Norway).

In 2008 growth of individual *Pecten maximus* is shown to be greater from those sites that have shown a significant increase in population density. The results show that where a site is favourable for population increase, it is similarly favourable for growth of individual scallops, i.e. *P. maximus*

of a given age will be larger at a site where population density is increasing than where population density is constant.
Studies in the Isle of Man showed that, in addition to an increase in *P. maximus* densities within areas closed to fishing, there was also a shift to much older and larger individuals than in the fished areas (Beukers-Stewart *et al*, 2005).

4.3 JUVENILE PECTEN MAXIMUS

In the 2008 survey emphasis was placed on a careful search by the divers for small *P. maximus,* as a result more 2-3 year old individuals were found. However the total numbers of small *P. maximus* found on the survey were still very low and it is unknown if they occupy the same areas as the adult population (Franklin *et al* 1980). Luddington *et al* 2004 recommended that spat collectors should be deployed to investigate settlement of *P. maximus* spat in the Skomer MNR. The trial completed in 2006 only found a single juvenile, and although this does show that spat are present in the plankton, it also highlights the trial's limitations including: a single style of spat collector used, single site for deployment, only two collectors deployed, sampling time only 3 months and only two depth zones sampled.

In the North Water of Mulroy Bay in County Donegal, Ireland techniques were developed during 1980 and 1981 for the prediction of *P. maximus* spatfall. The research focussed on gonad monitoring, plankton analysis, spat settlement and spat collection trials to develop a technique for prediction of the date and location of the peak *P. maximus* spatfall. The results from these investigations allowed commercial application of the technique in 2002 by the scallop culture industry (Slater 2006).
Further investigation using a combination of techniques: plankton analysis and spat settlement within the Reserve and gonad monitoring at a site outside of the Reserve boundaries, is needed to provide a clearer and fuller picture of juvenile *P. maximus* in the Skomer MNR area.

5 RECOMMENDATIONS

- Continue surveys every 4 years using volunteer divers.
- Future surveys follow the methods established in 2000, and use sites established in 2000 and 2004.
- Review current survey site suitability for long term monitoring.
- Introduce survey sites outside of the Skomer MNR boundaries.
- Support research work on the biology of *Pecten maximus*.
- Investigate gonad monitoring, plankton analysis and spat settlement in the Skomer MNR area.
- Continue to inform divers using the MNR about the SWSFC byelaws and report any incident involving the collection of *P. maximus* in the Skomer MNR to the SWSFC.
- Monitor sea temperature and suspended turbidity levels to provide background data for the biological monitoring.

6 ACKNOWLEDGEMENTS

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Lastly, but by no means least, the dive boat charter skippers: Alun Lewis *Cleddau King*, Andy Truelove *Volsung* and Brian Dilley *Overdale.*

7 REFERENCES

Beukers-Stewart B.D et al (2005) Benefits of closed area protection for a population of scallops. Mar Ecol Prog Ser. Vol. 298: 189-204.

Bullimore, B. (1985) Skomer Scallop Survey1984 and a Review of the Surveys 1979-1982. Report to the Nature Conservancy Council from the Skomer Marine Reserve Subtidal Monitoring Project SMRWMP report no. 2. 22pp.

Franklin A., Pickett, G.D. & Connor, P.M. (1980). The scallop and its fishery in England and Wales. Ministry of Agriculture Fisheries and Food Directorate of Fisheries Research. Laboratory leaflet No. 51.

Lock, K. (2001) Skomer Marine Nature Reserve Scallop, *Pecten maximus* Survey 2000. Countryside Council for Wales Science Report no. 16.

Luddington, L.R. Newman, P. Lock, K. Burton, M. (2004) Skomer Marine Nature Reserve *Pecten maximus*, King scallop survey 2004. CCW Regional Report CCW/WW/04/2

Mason, J. (1957) The age and growth of the scallop, *Pecten maximus* (L.), in Manx waters. J. mar. biol. Ass U.K. 36, 473-492.

Slater, J. (2006) Development and application of techniques for prediction of the scallop *Pecten maximus* (L.) spatfall. Journal of Shellfish Research, Vol. 25. No.3, 795-806.

APPENDIX I

SOUTH WALES SEA FISHERIES COMMITTEE BYELAWS

Fishing within the MNR is governed by national legislation and by byelaws made by the South Wales Sea Fisheries Committee, which regulate matters such as the minimum permissible landing size for certain fish species, the prohibition of the deposition or discharge of substances detrimental to sea fish and sea fishing, etc.

Byelaws which, if this order is made, the South Wales Sea Fisheries Committee propose making under Section 5 of the Sea fisheries Regulation Act 1966.

Byelaw No. 30 Prohibited area for use of dredges and beam trawls.

No person shall use in fishing for sea fish any fishing dredge or any beam trawl within the area detailed below:-

from the northern point of Gateholm due north to the mainland,

from the southern point of Gateholm a straight line in a direction of 278 ^{o} (T) to position 2¾ cables due south (T) of the western extremity of the Mewstone,

thence 2¾ cables off the mainland shore of Skomer around the west coast of the Island to a position 2 cables due north (T) of the Garland Stone,

thence a straight line in a direction of 098^{o} (T) to a position 51 ^{o} 44.50'N, 05 ^{o} 13.00'W,

thence due south (T) to the mainland coast.

Byelaw No 30A Prohibited area for scallop fishing - Skomer Island

No person shall fish for take or land any scallop of the species *Pecten maximus* or of the species *Chlamys opercularis* from the area detailed below:-

from the northern point of Gateholm due north to the mainland from the southern point of Gateholm a straight line in a direction 278 ^{o} (T) to a position 2¾ cables due south (T) of the western extremity of the Mewstone, thence 2¾ cables off the mainland shore of Skomer around the west coast of the Island to position 2 cables due north (T) of the Garland Stone, thence a straight line in a direction of 098 ^{o} (T) to a position 51 ^{o} 44.50N, 05 ^{o} 13.00'W, thence due south (T) to the mainland coast.