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Skomer Marine Nature Reserve
Scallop, *Pecten maximus* Survey 2000
CCW West Area Report No.16

Kate Lock
November 2001

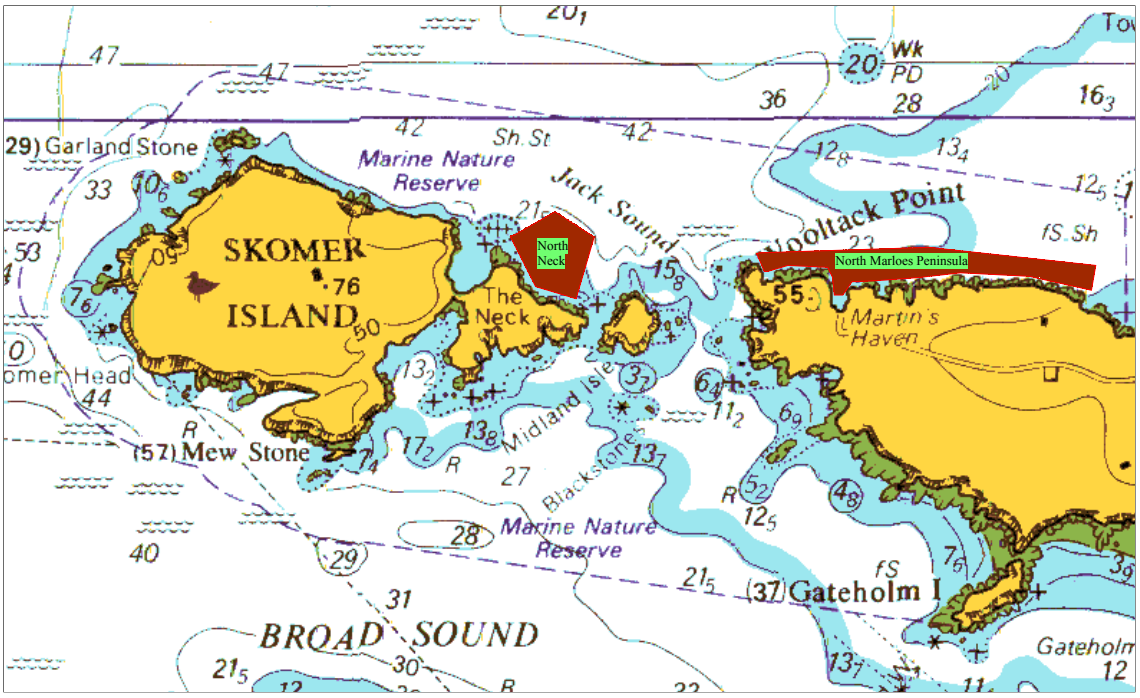
CONTENTS

APPENDICES

1 INTRODUCTION

Scallops, *Pecten maximus*, are found in the Skomer Marine Nature Reserve (SMNR), at sites to the north of the Neck of Skomer and along the north coast of the Marloes peninsula, see Figure 1.1. These sites have mixed sediment habitats and moderate currents, which are typical conditions for scallops.

FIGURE 1.1 Known areas of scallop populations in the Skomer Marine Nature Reserve.



Local anecdotal information indicates a formerly healthy scallop population that was severely depleted by over-fishing in the 1970s. Surveys have been carried out by various workers from 1979 to 1984 (Jones & Hodgson, 1979; Jones, 1989; Bunker, in prep; Bullimore 1985a). Although the population was found to be "rich", it occupied a very restricted area that was small in fisheries terms. It appeared to have continually suffered low recruitment and was almost certainly unsustainable as a fishery (Bullimore, 1985a).

The principal conservation interest in the scallop fishery has not lain with the scallop population itself but with the damage caused to the benthos by the fishing technique of scallop dredging (Bullimore, 1985b). Concerns were first formally expressed in the 1976 Voluntary Reserve Management Plan (Skomer Marine Reserve Committee (SMRC), 1976). In the early 1980s a proposal was made by the Nature Conservancy Council (NCC), for the designation of Skomer Marine Nature Reserve through the provision of the Wildlife and Countryside Act (1981). The NCC regarded the practise of bottom dredging to be incompatible with the objectives of an MNR; however, constraints on any fishing activities within the proposed MNR had to be imposed by the South Wales Sea Fisheries Committee (SWSFC).

In 1985, with the assistance of the SWSFC and the cooperation of a local fisherman, an investigation was undertaken to assess the effects and impacts of scallop dredging on the seabed and its associated marine life. The study included filming the action of dredges on the seabed and the seabed before and after dredging. The investigation concluded that considerable damage was caused to the communities and species present and that the sediment compositions of the dredged areas were adversely altered, (Bullimore, 1985b). The SWSFC accepted that the level of damage demonstrated would be unacceptable in an MNR, and agreed to prohibit the practice upon designation of the Reserve. The Skomer Marine Nature Reserve was designated in July 1990, with SWSFC byelaws in force to prohibit the use of dredges and beam trawls, and prohibiting the removal of scallops from the Reserve area by any means, (see Appendix 1 for SWSFC bylaw).

Scallop dredging was last recorded within the Reserve area in 1987. A Scottish fishing vessel dredged for scallop north of Skomer and the Marloes Peninsula for several days until it was compelled to leave by the SWSFC (Bullimore, 1987). Bullimore (1988) reported one observation of a vessel thought to be dredging about a half mile north of North Haven, Skomer. Although close to the northern boundary, it was almost certainly outside the proposed MNR. Since 1990 there have been no observations of commercial scallop fishing in the Reserve, however, MNR officers have recorded and reported divers with scallops that have been collected within the Reserve area (Newman 1999, Newman & Lock 2001).

The scallop population is a feature of the SMNR and as such is required to be monitored under the SMNR management plan. Any incidents of scallop dredging or collecting have to be recorded and enforcement of the SWSFC bylaw maintained. Information about the SWSFC bylaw is included in the SMNR User Regulation leaflet (see Appendix 2) that is distributed by MNR officers during on-water patrol and at local dive shops and marinas.

1.1 REVIEW OF SCALLOP *PECTEN MAXIMUS* SURVEYS IN THE SKOMER MNR

Surveys were conducted in 1979 and 1980 by Jones and Hodgson and then in 1981 and 1982 by Francis Bunker and the Pembrokeshire BSAC 417 Branch. These surveys operated under the auspices of the Underwater Conservation Society (now Marine Conservation Society, MCS). The last survey to be completed was in 1984 by Blaise Bullimore for the NCC, contributing to the Skomer Marine Reserve Monitoring Project.

The surveys were completed at sites north of the Neck and north of the Marloes Peninsula, which were areas known to have scallop populations and had been subject to scallop dredging or collecting by divers. Each survey varied in the total area covered and thus amount of data collected. In these surveys divers either swam along a compass bearing or on a depth contour, the seabed characteristics were noted including assessing the seabed for damage by dredges. In the 1979 survey the size (breadth) of most scallops was recorded in situ on the seabed. This recording was expanded in1980 and subsequent surveys, where pairs of divers collected all scallops from a strip of seabed 2m wide into net bags so that they could be measured on land. The age, length and breadth of each scallop were recorded and distances from the umbo to each annual growth ring measured for most scallops. The scallops were tagged by cutting a small notch on lower valves before returning to the survey sites.

In 1984 Bullimore reviewed the data from the 1979 to 1982 surveys and compared it where

possible to the 1984 survey data (Bullimore 1985a). The results are summarised as follows:

1. The extent of the habitat suitable for scallops within the Reserve is unknown, but is estimated as covering 1-2 square kilometres.

2. Scallop density is low in the nearshore areas surveyed, 1 scallop/83m^2 at North of the Neck site and 1scallop/100m^2 at North of Marloes Peninsula sites.

3. Age frequency distribution showed considerable fluctuation in the years surveyed, this is most likely attributable to the small number of individuals aged in each survey and also possible inaccurate age estimations. The strongest year classes were 1973, 1974 and 1975 recruitment to the population since 1976 is shown to have been very low although a slight improvement may have occurred in 1981. Scallop age frequency comparison graphs are shown in Appendix 3.

4. First growth band graphs showed a bimodal distribution (see Appendix 3). The population was arbitrarily divided at 26mm first growth period width into spring and autumn spawned individuals. 84% had small first year growth bands and were deemed autumn spawned. Comparable distributions had been found in Manx (Mason, 1957) and western Irish (Gibson, 1956) scallops.

5. Annual growth rates were calculated for spring and autumn spawned scallops using von Bertalanffy growth curves (see Appendix 3). Values for the growth constant were in close agreement for autumn spawned individuals and varied slightly between the spring spawned individuals, probably due to the small sample size. The growth curve for the 1984 combined data closely resembled those of two Manx samples taken from comparable depths in areas with similar geographical aspect.

Since 1984 there have been no further full surveys of the scallop population in the Reserve. In 1993 some survey dives were completed north of the Neck, by MNR staff, following methods used in the previous surveys, but insufficient data was collected for analysis.

1.2 SURVEY OBJECTIVES

This survey aimed to establish the current status of the scallop population in the Reserve and compare this to the previous surveys. The objectives of this survey were:

1. To determine the density of scallops at selected sites;

2. To determine scallop population dynamics: size and age distributions, growth rates;

3. To compare the results with previous surveys;

4. To establish positions for permanent sites for use in future surveys;

5. To develop a method appropriate for establishing the survey as a volunteer diving project.

2. METHOD

2.1 SITE SELECTION

Four fixed sites were pre-selected within the areas previously surveyed, see Figure 2.1. Each site was marked with a buoyed site marker and a differential Geographical Positioning System (GPS) position established, see Table 2.1.

FIGURE 2.1 Scallop Survey 2000, site locations.

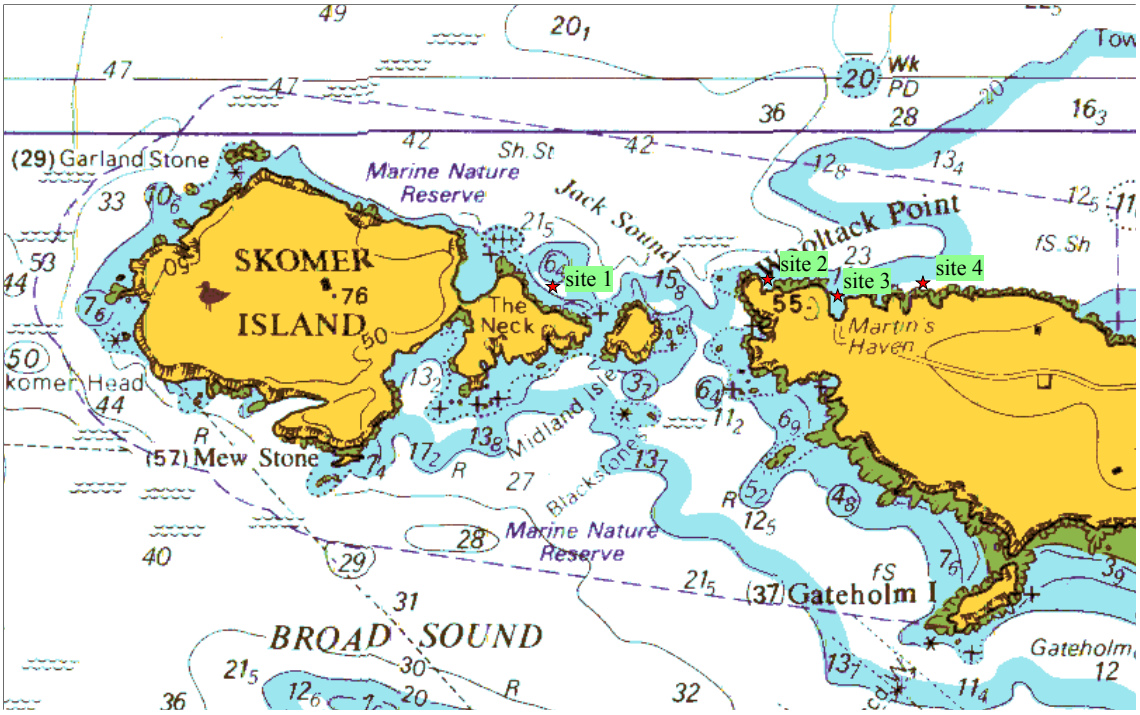


TABLE 2.1 Differential GPS positions for pre-selected sites.

Site Name	Differential GPS position
North of the Neck	51 44.282N 5 16.322E
Wooltack Bay	51 44.311N 5 15.051E
Martins Haven Martins Haven East	Skalmey mooring
Low Point	51 44.304N 5 14.161E

Survey transects were to be conducted at each site from the site marker, following compass bearing directions: N, NE, E, SE, S, SW, W and NW where topographic features allow.

2.2 DIVING FIELD METHOD

Divers were issued with the following instructions:

Diving equipment: One Surface Marker Buoy (SMB), a compass and a 50m tape measure or line marked at 50m on reel per pair of divers.
A net bag and a torch per diver.

Diving pair complete one transect per dive.

1. Diver pair descend site marker. Attach the end of the tape measure or marked transect line to the fixed marker. Diver pair take agreed compass bearing and swim together laying out the line for 50m. Check the direction of the line by pulling tight and taking a reciprocal compass bearing with the compass lying on the line.

2. Divers orientate themselves, one diver either side of the line. Diver pair swim together, each diver search and collect (into net bag) scallops in a 2m corridor on their side of the line until returned to the site marker. Any scallops bearing notches (see below) to be left in situ. It is important that the diver pair swims at the same rate to ensure regular buddy checks.

3. Diver pair repeat the search and collection procedure, swimming back either side of the line collecting any missed scallops. On completion rewind and retrieve the line, note substrate type (% silt, shell, sand, stones) and depth range, ascend with scallops to the boat.

4. Place scallops into buckets of clean seawater.

2.3 FIELD RECORDING

Field equipment per boat: 3 Buckets, scrubbing brush, ruler, recording forms and pen, notching file.

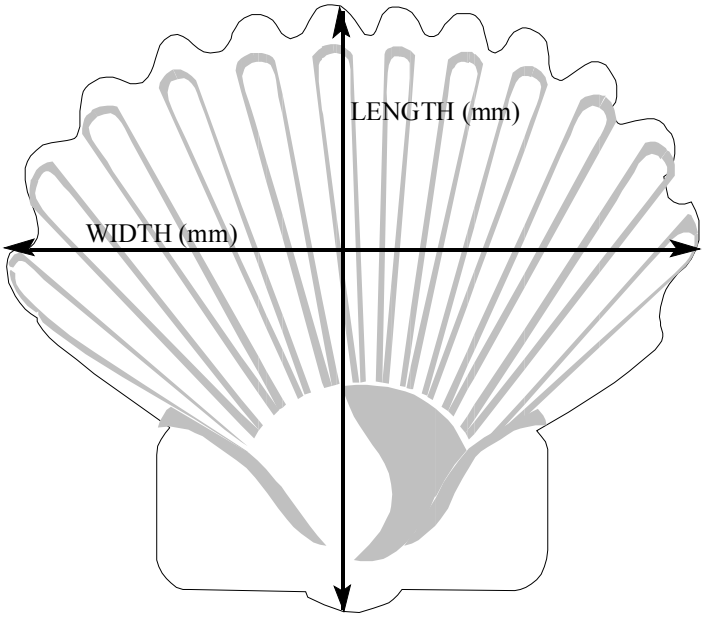
Field recording is completed in the boat.

1. Record dive details onto prepared recording forms: site name, direction of transect, date, dive time in and out, depth range and substrate, see Appendix 4.

2. Gently clean the scallops on the shells flat side using a scrubbing brush and seawater, until the growth check rings are clearly visible. Store scallops in buckets of clean seawater.

3. For each scallop measure and record the following onto the prepared recording forms, see Appendix 4.

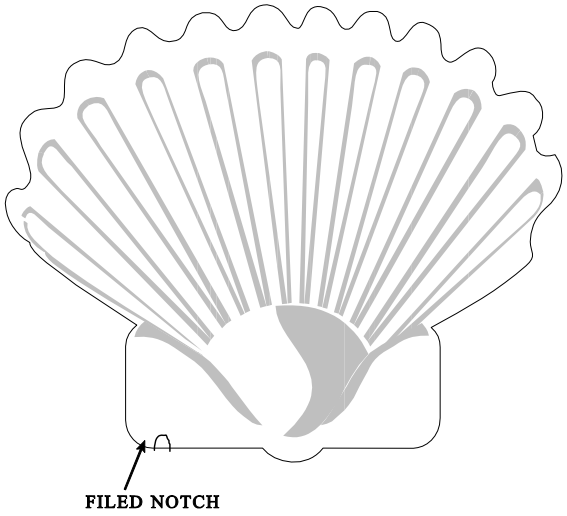
a) Length and width: Measure flat side using ruler, record in mm.



b) Age: Count and record total number of annual growth check rings on the shells flat side.

c) Growth: Measure distances from the umbo (hinge line) to each annual growth check ring on the flat valve, measure using ruler, record in mm.

4. For each scallop file a notch 2-3mm into the edge of the wing (hinge).



5. Return the scallops to the approximate area where collected, by gently dropping them over the side of the boat as soon as possible.

3 RESULTS

3.1 DENSITY AND DISTRIBUTION

The main survey was completed over 3 days (6-8th August 2000) by a team of 9 divers, additional dives were completed by a team from Cardiff University on the 21st October 2000, as summarised in Appendix 5.

The 4 pre-selected sites, (Table 2.1), were surveyed. 1 site, Wooltack Bay, was found to be of unsuitable habitat (coarse sand) for scallop populations, therefore the area surveyed at this site has been omitted from the density calculations. 17 dives were completed at the 3 suitable sites, North of the Neck, Martins Haven and Low Point covering an area of 4200m^2, scallop densities and substrates found at these sites are summarised in Table 3.1. A total of 155 scallops were collected giving a mean scallop density of 1 scallop per 27m^2 for all sites surveyed.

TABLE 3.1 Estimated densities of scallop populations at selected sites

SITE	Substrate	Area surveyed (m^2)	No. scallops collected	m^2 per scallop
North of the Neck	Mixed sediments: shell, gravel, small stones and silt at the interface	800	54	15
Martins Haven	Fine silty sediments with occasional shell and gravel. Shallow bedrock with algae and animal turf.	1800	18	100
Low Point	Mixed sediments: shell, gravel, small stones and silt at the interface	800	83	9.6
ALL SITES		**4200**	**155**	**27**

3.2 AGE FREQUENCY DISTRIBUTION

The age distribution of all the scallops collected is shown in Figure 3.1. The population is dominated by the 6-7 year olds. The age distribution of scallops collected from North of the Neck, Martins Haven and Low Point are shown separately in Figures 3.2-3.4. The North of the Neck site results indicate good recruitment between 1992-1994 (6-8 year olds), and Low Point site shows good recruitment in 1992 and 1993 (7-8 year olds). The Martins Haven site shows highest recruitment between 1994-96 (4-6 year olds), however this data should be viewed cautiously due to the low sample of scallops collected at this site and difficulty in finding smaller individuals.

FIGURE 3.1 Age frequency of Scallops, Skomer Marine Nature Reserve, 2000 Survey.

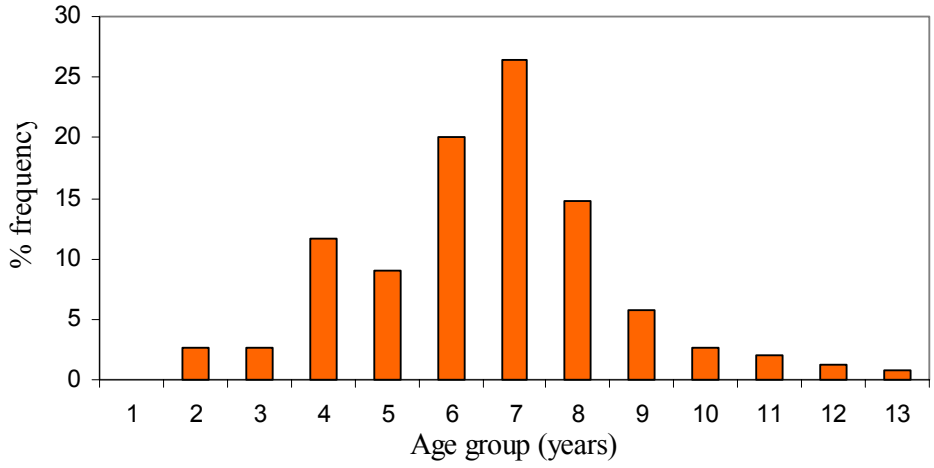
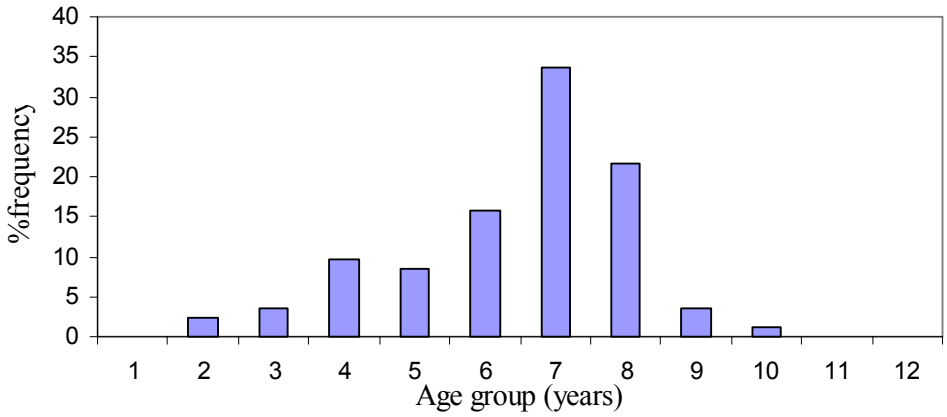


FIGURE 3.2 Age frequency of Scallops, North of the Neck site, 2000

FIGURE 3.3 Age frequency of Scallops, Martins Haven site, 2000

FIGURE 3.4 Age frequency of Scallops, Lowpoint site, 2000

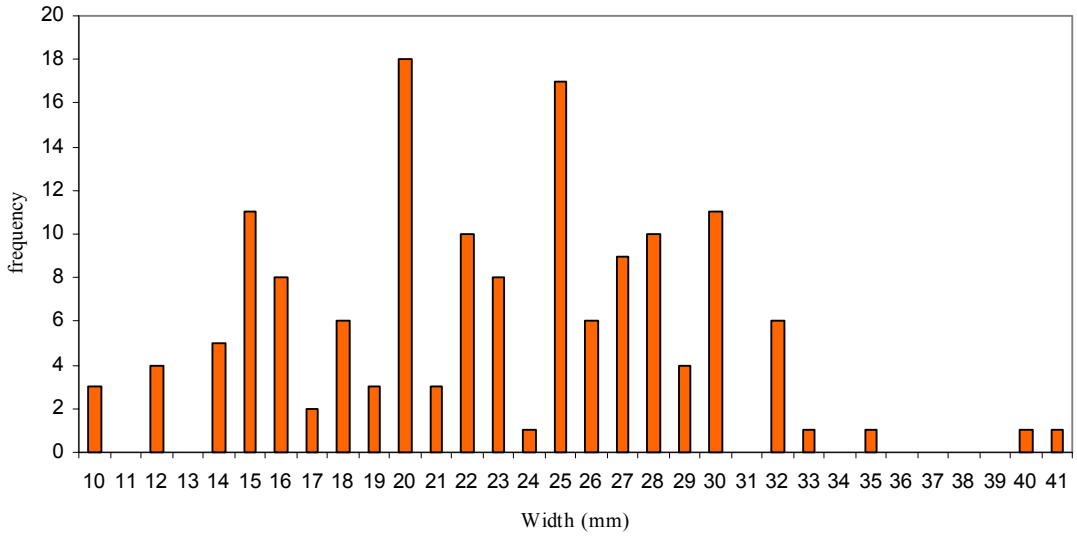


3.3 GROWTH

3.3.1 The first growth band

The frequency distributions of the first growth band width of all scallops collected is shown in Figure 3.5.

FIGURE 3.5 Width frequency of Scallop first growth band, Skomer Marine Nature Reserve, 2000



The graph shows a general pattern of normal distribution. The data has been tested for normal distribution where 70% of the data should fall within the range of mean data plus/minus the standard deviation, see Appendix 5. The data gives 72.5%, suggesting a normal distribution, the mean width is 22.7mm.

3.3.2 Annual growth rate

Various mathematical functions describe the relationship between average growth of animals and time. The von Bertalanffy growth curve equation, widely used to describe growth in length of many marine organisms, has shown to be the most suitable for scallop growth (Pope & Mason 1980; Mason 1984). Breadth of the flat valve at each successive growth line is one of the parameters that maybe employed in the construction of the growth curve.

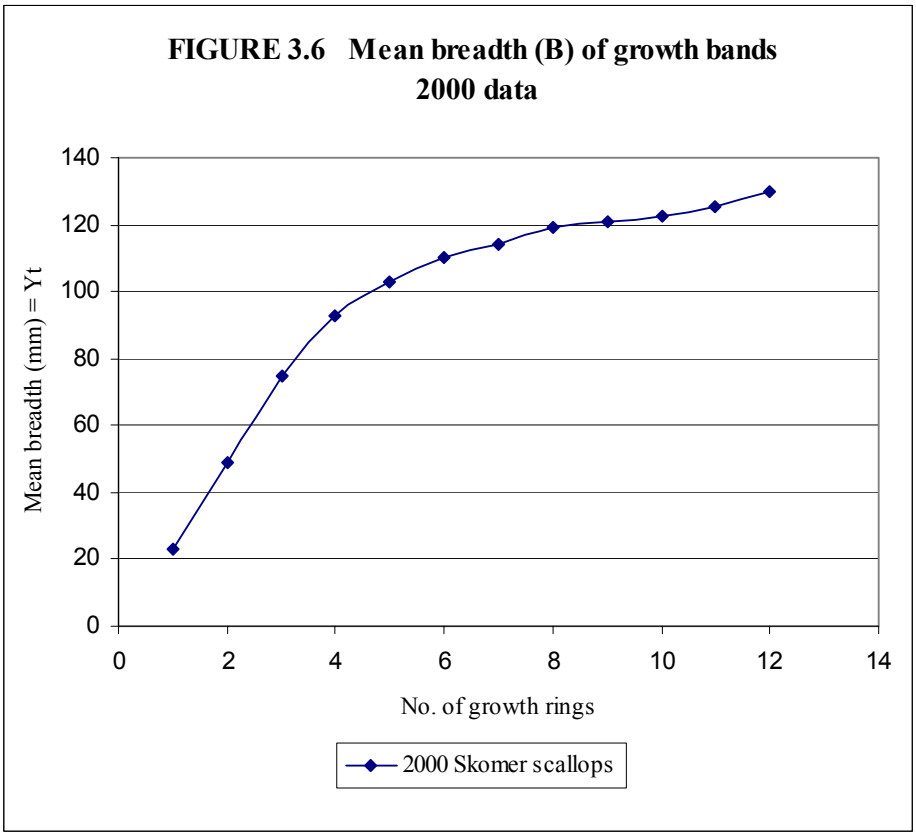
The mean values of breadth at each growth line are calculated for all scallops collected and plotted, see Table 3.2 and Figure 3.6. Using the von Bertalanffy growth curve equation values for growth constant (k) can be calculated. The following form of the von Bertalanffy growth curve equation was applied (as for previous data 1980-1984, Bullimore 1985a).

$$Yt = B\infty \left(1 - e^{-k(t-t_0)} \right)$$

Where Yt is the breadth at time t, B∞ is the final breadth and k is the growth constant. see Figure 3.6.

TABLE 3.2 Mean distances of growth rings from umbo, 2000.

Growth ring	1	2	3	4	5	6	7	8	9	10	11
Mean distance (mm)	23	49	75	93	103	110	114	119	121	122.5	125



Parameters of fitted curve: $B\infty = 125$
$K = 0.382$
$t_0 = 0.5$

4 DISCUSSION

4.1 METHODOLOGY

Buoyed markers were easily deployed and suitable for the duration of the survey, differential GPS positions taken for each station allows for accurate re-location of the stations for future surveys. Only three days were available for the survey, this restricted the area that could be surveyed and as a result only four stations were established.

The divers deployed the transect lines easily and collected the scallops into bags with no problems. There was only one occasion when a transect was not completed due to insufficient diving time available at the survey depth.

Measuring the scallops and determining the growth rings was completed with care, the surveyors made extra efforts to double check with each other to try and minimise inaccuracies. The proforma sheets allowed for clear scallop data recording and habitat descriptions for each transect.

The method limits the survey to fixed stations and thus provides restricted distribution data; this limitation could be reduced if the number of stations were increased. The use of volunteer divers restricts the survey to shallow survey stations (maximum depth 25m) and thus data for scallops in deeper waters is unknown. The established stations however do provide an indication of the status of the scallop population for the two known geographical areas of scallops in the Reserve.

The fixed positions of the stations and the method do allow for direct comparisons to be made with future surveys and the method is suitable for use by volunteer divers.

4.2 DENSITY AND DISTRIBUTION

An overall density of 1 scallop/27 m^2 has been recorded, this is much higher than in the 1984 survey where an overall density of 1 scallop/93 m^2 was calculated. The highest densities were recorded at Low Point (North Marloes Peninsula), density of 1 scallop/10 m^2 and North of the Neck, density of 1 scallop/16 m^2. A low density of 1 scallop/100 m^2 was recorded at Martins Haven, which is similar to the 1984 survey records. A lower density would be expected at this site compared to North of the Neck and Low Point, due to the varied habitat encountered that was not always suitable for scallop populations, (Table 3.1). In addition the Martins Haven site marker is also a swinging boat mooring and it is likely that these and other mooring chains may cause some disturbance to the seabed. It should also be noted that part of the area surveyed in Martins Haven was completed during late October in visibility less than 2 metres influencing divers ability to find all the scallops in their transects.

The significant increase in the scallop densities at Low Point and North of the Neck since 1984 is almost certainly due to the designation of the Skomer Marine Nature Reserve and the introduction of the SWSFC byelaw in 1990 prohibiting scallop fishing in the Reserve area. Since 1990 there have been no observations of commercial scallop fishing in the Reserve, however the MNR officers have recorded and reported divers with scallops, which have been collected within the Reserve area (Newman 1999, Newman & Lock 2001). The low density

of scallops recorded at Martins Haven may in part be due to high numbers of shore divers at Martins Haven, some of whom occasionally take a few scallops, despite the SWSFC bylaw.

4.2 AGE FREQUENCY DISTRIBUTION

The age distribution graph, Figure 3.1, for all the scallops collected shows that the Skomer scallop population is dominated by the 6, 7 and 8 year olds, indicating good recruitment between 1992-1994. One characteristic of the scallop *P. maximus* is extremely irregular spat settlement and/or survival, so that certain age groups (or year classes) are often entirely absent from a population, (Franklin, Pickett & Connor, 1980).

Scallop fertilisation is external and leads to free living veliger larvae, which join the zooplankton in the surface waters of the sea. After 3 to 4 weeks the larvae return to the seabed where they attach to hydroids, polyzoans and other sessile organisms by a fine thread or byssus, before developing into small adult scallops. After a while the bysus thread dissolves and the juvenile scallop (spat) join nearby adult populations, (Briggs 2000).
The larval origins of the Skomer scallops are unknown. The residual movement of water in the Skomer area is generally from south to north and much is derived from the South Wales Coastal Current (Bullimore ,1985a).

In addition to irregular spat settlement and/or survival affecting the age distribution, other influences may be due to predation by marine predators e.g. starfish or collection by divers. These different possible influences make it difficult to accurately analyse the results.

4.3 GROWTH

Scallop in British waters have two main spawnings a year. There is a spring spawning in April or May and an autumn spawning in late August or September, and there is also a small summer spawning in July or early August (Mason 1983). Although there are many possible factors that can influence the success of a brood, the difference in the number of scallops constituting the two groups can be accounted for by the amount of spawn released in each spawning. Only scallops with at least four growth rings take part in the spring spawning, and their gonads become only partially spent. However, mature scallops of all ages (2 growth rings or more) take part in the autumn spawning, and the gonads most often become completely spent. Thus more gametes are shed in autumn spawnings than in the spring spawnings (Mason 1983). The success of the brood will also be influenced by predation. Gibson (1956) noted that the spring/summer spatfall occurs during the period when predatory creatures are most active, and this might produce a higher mortality rate.

Mason (1983) reports that in Manx and Irish studies, scallop populations showed a bimodal size frequency distribution relating to a spring and autumn spawning. In the Manx study 4379 scallops were sampled, 92.5% had small (mean 19mm) and 7.5% had large (mean 39mm) first growth rings, correlating to a large autumn spawn and a small spring spawn. The 2000 Skomer sample size of 155 scallops in contrast is very small and it is possible that this is insufficient to confidently pick up the spring/autumn bimodal distribution that may be expected. The Skomer scallops show a normal distribution with a mean of 22.5mm, which corresponds to autumn spawned spat. Bullimore (1984) observed a distinct bimodal

distribution in Skomer scallops where 84% were autumn spawned. The difference in distribution patterns observed in the 1984 and 2000 scallop samples should be interpreted with caution as in both surveys the sample size was very small (less than 155 scallops).

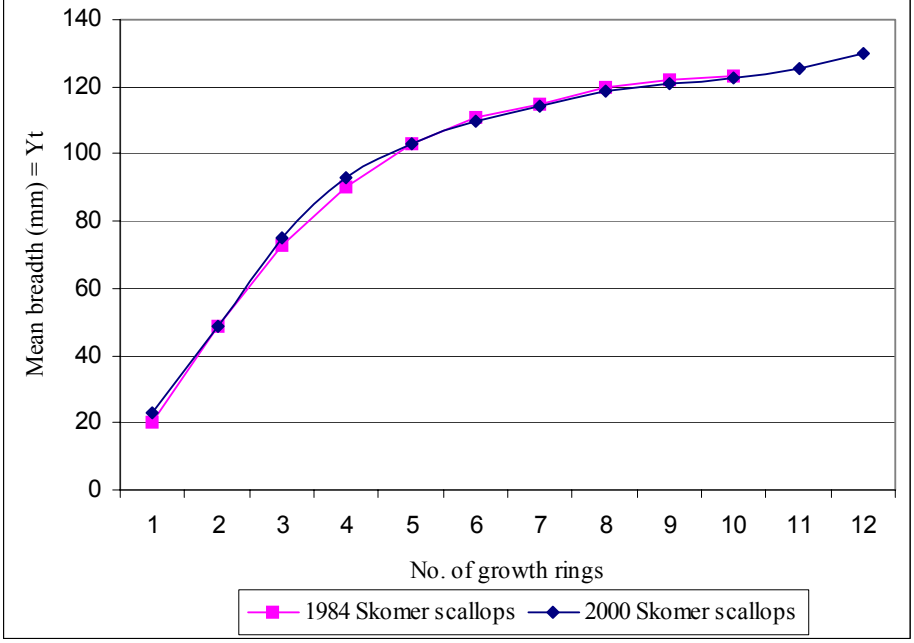
Scallop growth rate may be influenced by many factors including: depth, temperature, currents, wave exposure, seabed topography, sediment type, food availability and competition. Mason (1957) found that growth rates were higher in shallow waters suggesting that temperature and food availability may be major influences where phytoplankton is abundant. Gibson (1956) showed that growth rates on exposed, clean, sandy beds were lower than those in more sheltered, weedy areas.

In cultivation temperature is a critical factor affecting growth rate. Hatchery reared spat show highest growth rates at 17^0C and condition of king scallop spat is best between 10^0C-17^0C and worst below 8^0C (Laing, 2000). These temperatures correspond to seabed water temperature North of the Neck, Skomer where an annual average range of 7^0C to 16^0C has been recorded (temperature recorded using a temperature logger mounted to a frame 1 metre above seabed between 18-25m below chart datum) (Newman & Lock in prep).

Growth curves for the 1984 and 2000 Skomer scallop data are almost identical as shown in Figure 4.1. Bullimore (1985a) compared 1984 Skomer scallops growth curve to those in West Ireland and the Isle of Man. The growth curve closely resembled those from Manx stations with comparable depths and geographical aspects, whilst the curves for the shallow water, sheltered Irish scallops and the deep water, exposed, Manx scallops showed growth rates and maximum size to be higher and lower respectively than for Skomer.

Growth rates calculated for the 2000 Skomer scallops using von Bertalanffy growth curve equation give a mean growth constant of 0.382, this is similar to a growth constant of 0.384 for autumn spawned scallops in 1984 (Bullimore 1985a) and to 0.380 for those from the Isle of Man (Pope & Mason 1998).

FIGURE 4.1 Mean Breadth (B) of growth bands 1984 and 2000 data



5. RECOMMENDATIONS

1. It is important that the SWSFC byelaw continues to be enforced. The MNR officers must continue to patrol the Reserve area, to inform divers about the byelaws and distribute the Skomer MNR 'User regulation' leaflet as widely as possible. Incidents of divers collecting scallops must be reported to the SWSFC in order for the byelaw to be enforced and appropriate action to take place. This will help reinforce to divers that a penalty will be enforced if the byelaw is broken.

2. A survey should be repeated at a minimum of five-year intervals at stations: Low Point, North of the Neck and Martins Haven. Additional stations should be established and possibly at some deeper stations (although this would be unsuitable for volunteer divers) in order to gain better distribution data within the Reserve. Effort should be made to maximise the sample size to give a better description of Skomer scallop population dynamics.

3. The reproductive capacity, recruitment to the population and the origin of the larvae settling near Skomer need to be investigated by plankton sampling and the use of spat collectors. These will help to assess recruitment fluctuations and settlement at different times of the year.

6. ACKNOWLEDGEMENTS

The MNR staff would like to thank:

All the volunteer divers who assisted with the project: Dorothy Witcomb, Michelle Leslie, Nicola Helliwell, Maggie Shaw, Colin Deller, Colin Garlick, Edward Male and Gareth Davies.

Cardiff University divers: Lee Garbett, J Savage, K Robinson, D Clarke

Mark Burton, Ian Donovan and John Archer Thomson, crew of the *Lord Hurcomb* and Dale Fort Field Centre staff for their support.

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APPENDIX 5 Scallop survey dives competed, 2000

SITE	No.scallops collected/200m^2	Date	Divers
NORTH of the NECK			
East transect	18	7/8/00	KL, EM
North transect	18	7/8/00	CD, CG
South transect	8	7/8/00	DW, MS
West transect	10	7/8/00	NH, ML
WOOLTACK BAY			
Southeast transect	1	6/8/00	EM,GD
Southwest transect	None	6/8/00	CD, CG
West transect	None	6/8/00	DW, MS
East transect	None	6/8/00	NH, ML
MARTINS HAVEN Skalmey mooring			
East transect	2	6/8/00	EM,GD
North transect	2	6/8/00	CD,CG
Northeast transect	4	7/8/00	DW/MS
South transect	2	6/8/00	DW/MS
West transect	None	6/8/00	NH, ML
Northwest transect	None	7/8/00	NH, ML
East marker			
East transect	1	21/10/00	Cardiff Uni
North transect	1	21/10/00	Cardiff Uni
Northeast transect	6	21/10/00	Cardiff Uni
LOW POINT			
East transect	16	8/8/00	GD,EM
Northeast transect	31	8/8/00	EM,DW,MS
North west transect	17	8/8/00	NH,ML
West transect	19	8/8/00	CG,CD

Dorothy Witcomb DW, Colin Deller CD, Colin Garlick CG, Edward Male EM, Michelle Leslie ML, Nicola Helliwell NH, Maggie Shaw MS, Gareth Davies GD, Kate Lock KL.

APPENDIX 2 Skomer Marine Nature Reserve User Regulation Leaflet.

APPENDIX 1