

# THE DISTRIBUTION OF *OSILINUS LINEATUS* (*MONODONTA LINEATA*) (DA COSTA) AT ITS EASTERN ENGLISH CHANNEL LIMIT IN 2004

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*Abstract* Populations of *Osilinus lineatus* on Isle of Portland and east Dorset shores have been assessed for the year 2004. The numbers recorded for sites between Portland Harbour and White Nothe indicate a significant increase in population size in recent years. Comparison with populations recorded before the 1963 winter shows that the sparse populations of that time are now represented by only those east of White Nothe. Western Ledges in Portland Harbour support a thriving, apparently breeding, population.

*Key words* *Osilinus lineatus*, distribution, Dorset

## INTRODUCTION

The toothed topshell *Osilinus lineatus* is an intertidal gastropod that lives on rocky or stony shores. It has a predominantly western distribution in Britain, and in the English Channel it reaches its northern and eastern limit in east Dorset. These east Dorset populations are among the best studied in Britain, with population data going back to 1961 (Hawthorne, 1965). Before the hard winter of 1963, populations of *O. lineatus* east of Portland Bill were very sparse, but extended as far east as Chapman's Pool (Figure 2). The winter of 1963, appeared to eliminate the species from all Dorset sites except for a small population at Clay Ope, below West Cliff, Portland (Hawthorne, 1964). This population appeared to be the most easterly English Channel breeding population before 1963. Aspects of the subsequent recovery have been reported by Hawthorne (1967, 1971 and 1995), but these all indicated only very small populations east of Portland, as did casual visits reported later (Hawthorne, 2001).

This study provides data on the population of this intertidal species at the northern limit of its English Channel distribution at a time of rapid warming of inshore sea temperatures. Intertidal organisms are exposed to different conditions from those of the infralittoral and offshore. Shore temperatures in east Dorset before the 1963 cold winter were probably at least as favourable to the species as those of Cornwall and the low populations east of Portland Bill were attributed to poor larval dispersal around the headland.

Hiscock, Southward, Tittley and Hawkins (2004) have considered the likely extension of the northern limits of southern species such as *O. lineatus* as sea temperatures rise and have emphasised the need for accurate baseline data to test predictions. Reports of increased numbers in east Dorset, since published by Mieszkowska, Hawkins, Burrows and Kendall (2007), emphasised the need for a detailed resurvey, which is reported here and is related to the earlier monitoring carried out since 1963. It was carried out mostly in 2004 with some additional data from 2005 and 2006.

## METHOD

In mild, humid conditions, adult *O. lineatus* are normally found on the upper surface of rocks. After storms or cold weather, they may be out of their normal zone and are likely to be hidden under the stones and boulders that are characteristic of the east Dorset habitats. Good weather conditions enable a direct count of most or all adults in a specified area of suitable habitat. Small boulders may be turned to find those that are hidden. Earlier surveys of east Dorset by Hawthorne are based on counts of all *O. lineatus* with a basal shell diameter of 10mm or more found within the study area of each site. The evidence suggested that very few, if any, juveniles were present, and the chances of finding them remote.

The initial aim of the 2004 survey was again

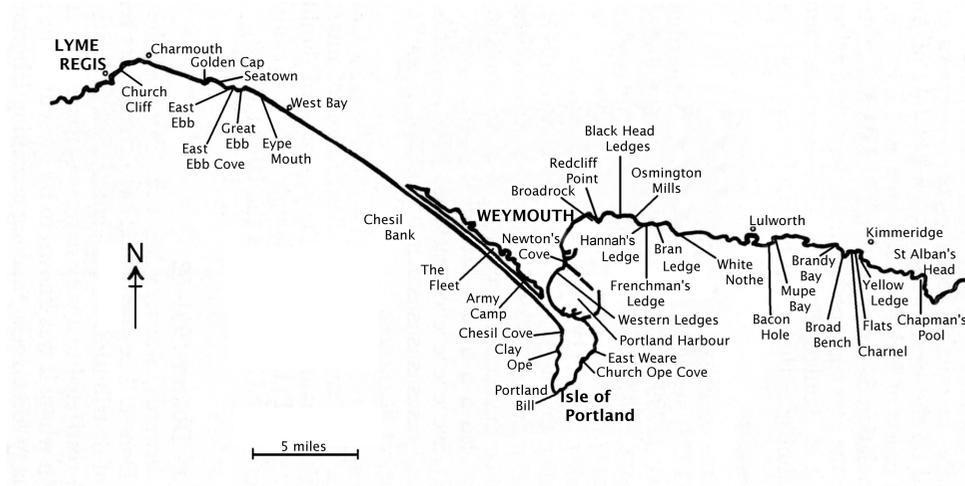


Figure 1 Location of sites visited for the 2004 survey and others mentioned in the text

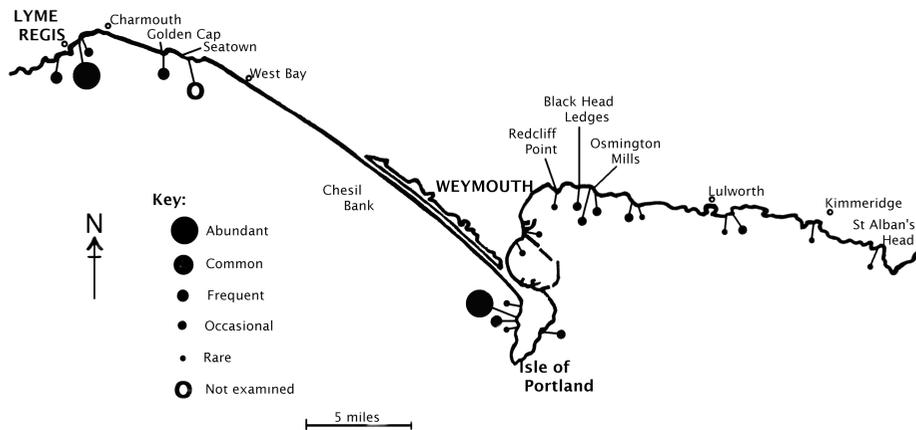


Figure 2 The distribution of *Osilinus lineatus* in Dorset 1961/62 adapted from Hawthorne (1965 and 1966)

to attempt to record all post-juvenile specimens. It became apparent, however, that densities at some sites were so high that such a census was impractical. Conditions for searching were ideal for most of the survey with almost all *O. lineatus* active and on the surface: very few were hidden underneath stones and boulders. Timed searches were used most often. At some sites two observers recorded the complete habitat. Timed searches do not allow comparison of populations at different sites as shores requiring much stone turning or at which a small number of individuals are widely spaced may yield fewer snails per unit time than habitats such as rock ledges. Suitable habitat for *O. lineatus* to the east of Portland is very patchy (Hawthorne 1965 and 1966). The size and configuration of the patches of appropriate habitat at the east Dorset sites determined the amount of time spent on attempted total counts. Some areas were assessed by two workers in three minute counts, some in five minute and others in ten

minute counts. Other beaches, as at Bacon Hole, provide a large amount of habitat and extensive searching is necessary to find the few specimens present. The data will have value in monitoring particular sites. As many snails were measured and examined for growth checks (see below), a stopwatch was used to eliminate the time taken to measure and make notes. Most specimens which were recorded were immediately replaced in the position in which they were found.

Sea conditions in the days before a search affect results markedly. Many of the very large boulders below West Cliff, Portland, are moved by storms and the *O. lineatus* may temporarily disappear between the boulders and stones. A population at Chesil Cove may also disappear in cold weather when the animals may release their normally strong attachment to the substrate. A large population recorded above Hannah's Ledge at Osmington Mills was observed in warm calm weather. A few days later, after strong onshore

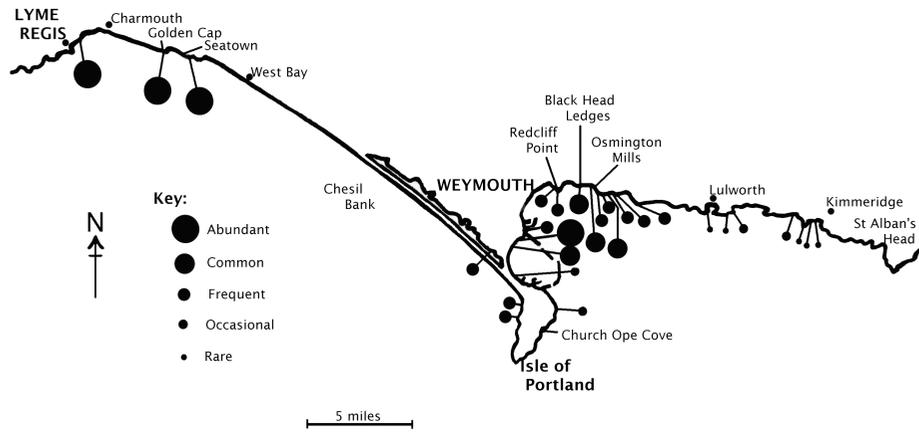


Figure 3 The distribution of *Osilinus lineatus* in Dorset in 2004

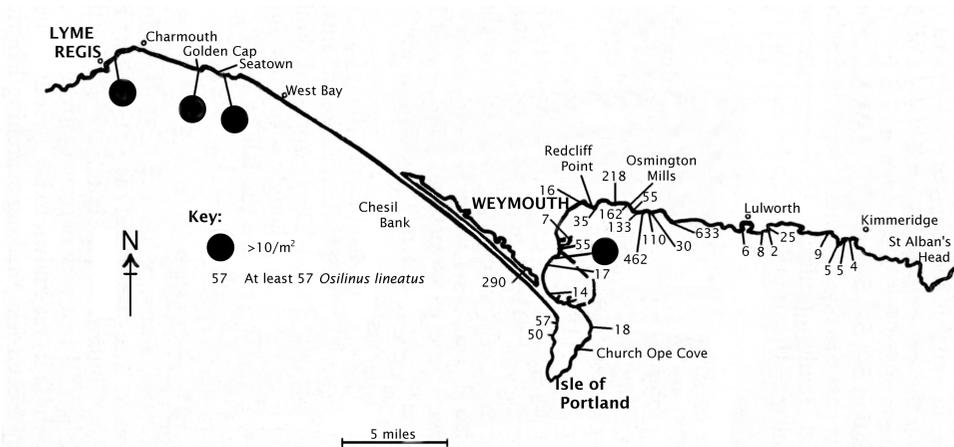


Figure 4 Minimum population sizes of *Osilinus lineatus* in Dorset, 2004

winds there was little sign that there were more than the occasional *O. lineatus* every metre or so. Populations at Church Cliff, Lyme Regis and at the west of East Ebb Cove near Seatown, surveyed to compare with those of east Dorset, were so abundant that they were sampled by counts within 0.25 sq m quadrats. The population at Western Ledges in Portland Harbour is so dense that it was recorded in the same manner.

*O. lineatus* may lay down growth checks, visible on the shell, when disturbed or over winter. Combined with maximal basal shell diameter they can give a reasonable assessment of age as discussed by Williamson and Kendall (1981). Care was taken to limit disturbance to a minimum when measuring so that growth will not have been interrupted. Although clear winter checks are not always seen in east Dorset populations, the relationship between growth checks and maximum basal diameter of the *O. lineatus*

measured in this survey has justified a separate study (Wiffen, in preparation).

At most locations eastward from Newtons Cove, the number of *O. lineatus* counted is thought to be close to the total present. Where limited time searches were the best method of indicating the numbers present without attempting to count all specimens, or where it was not possible to survey the whole of a stretch of beach (eg East Portland), then the number given is clearly a minimum.

Williamson and Kendall (1981) considered estimates of absolute abundance could be unreliable in open, heterogeneous habitats. In this study, repeat counts by the two authors gave identical scores for sites of small area and up to 5% error for more complex habitats with larger numbers. Repeat visits reduced possible effects of weather conditions on numbers recorded at the time of surveying. It is believed that numbers recorded

**Table 1** Sites east of Portland, listed from west to east, selected for paired samples analysis.

SITE	Grid ref	1961/62	2004
Broadrock	SY 710817	0	16
Redcliff Point	SY 712816	1	35
Black Head Ledges	SY 728818	18	218
Osmington Mills	SY 734817	3	55
Hannah's Ledge	SY 737815	8	133
Frenchman's Ledge	SY 738814	0	462
Bran Point	SY 742813	0	110
White Nothe	SY 767810	6	633
Lulworth Cove	SY 824798 and SY 828797	0	6
Bacon Hole	SY 840797	1	8
South Mupe Bay	SY 844797 to SY 843797	5	25
Brandy Bay	SY 889795	0	9
Broad Bench	SY 897787	0	5
Charnel Ledge	SY 902789	1	5
Kimmeridge Flats	SY 904790	0	4
Chapman's Pool	SY 953770	1	0

provide a reliable base for monitoring and for comparing sites. In comparing results from 2004 with earlier records based on total counts, any increases noted are likely to be real, whether comparing two absolute counts, or when comparing an absolute count before 1963 with a timed search in 2004.

#### DORSET RECORDS FROM 1963 TO 2004

The winter of 1963 appeared to eliminate all but one Dorset population of *O. lineatus*, that at Clay Ope on the west coast of Portland (Hawthorne, 1964). Various surveys have tracked the recovery, mainly from Portland westward. Young *O. lineatus*, were present below Church Cliff, Lyme Regis, in July 1967. Most were about 17mm basal diameter and were probably one year old. A few of 19 or 20mm basal diameter were probably a 1965 year group. A 12mm specimen and two 5mm specimens provided evidence of settlement in 1966 and 1967 below Golden Cap. Return to pre-1963 population size was noted at Church Cliff, Lyme Regis in 1970 and below Golden Cap in 1971.

The population at Clay Ope, Portland, was hard to find by 1966. Three visits yielded 13 specimens in March, 10 in June and 11 in July. All these were large old individuals. A survey in November 1971 found 46 specimens most of which appeared to have settled in the years from 1968. Two survivors of the 1963 winter were still alive: growth checks suggested one was at least eleven years old and the other at least thirteen years old. In the late 1970s the population became very small (probably less than 50) after the configuration of the beach was changed by storms. 165 specimens at a density up to 5/m<sup>2</sup> were recorded in September 1994.

Comments on the recovery from the effects of the 1963 winter have been published intermittently (Hawthorne, 1967, 1971, 1995.). Populations eastward from Western Ledges, Portland Harbour, were considered sparse and similar to the pre-1963 distribution as a result of casual beach visits reported in 2001 (Hawthorne, 2001). Three specimens were found at Western Ledges in September 1994; only one was found in November 1995.

#### RESULTS

24 sites from west Portland to Kimmeridge were surveyed in 2004. At the limit of its range, east of Kimmeridge, a large *O. lineatus* recorded at Yellow Ledge in 2001 could not be found. An attempt to resurvey Chapman's Pool was curtailed by the dangerous state of the cliffs; no specimens were found in the limited area searched. Possible sites near Swanage yielded no specimens, although a single animal has been recorded at Freshwater Bay on the Isle of Wight and reported by Hawkins (2005) and Herbert (2005). Additional counts were made at White Nothe in 2005 and Mupe Bay in 2006, as the original searches were incomplete. Individuals from the 2004 and 2005 cohorts were not included in these counts. Estimates were made for populations west of Portland Bill at Church Cliff, Lyme Regis; below Golden Cap; at the west of East Ebb Cove near Seatown; at Chesil Cove, Portland and at Clay Ope, Portland, for comparison with east Dorset populations.

The locations of the sites are shown in Figure 1.

## DISCUSSION

The presence of *O. lineatus* on the shore of the Fleet was reported by Dr Lin Baldock of the Fleet Study Group, in 2005. The number given for the site, which is close to the Army Bridging Camp, is a minimal estimate consisting of an attempted total count of 140m length of shore and a minimal estimate of 110m of shore where numbers were recorded up to 3 per square metre. These counts were made early in 2006 and exclude animals of the 2004 and 2005 cohorts.

Figures 2 and 3 give ACFOR values (Southward and Crisp, 1954) for *O. lineatus* recorded at each sampling site for 1961/62 and for 2004. The values for 1961/62 are an adaptation of the data given by Hawthorne in 1966 to match the 2004 data. The latter have been treated to conform to the methodology of MarClim.

Detail of the population records for 2004 are given in Figure 4. Records that were revised after repeat or new visits in 2005 or 2006 do not include snails from the 2004 or 2005 cohorts.

It is evident from figures 2 and 3 that many populations of *O. lineatus* east of Portland Bill have increased substantially.

There were 16 sites where repeat samples were made (Table 1). Increases from White Nothe westward are very substantial; on the Wilcoxon Matched Pairs Signed Rank Test, the differences between numbers recorded in 1961/2 and 2004 is highly significant ( $P < 0.01$ ). Further east, differences are clearly smaller, but still significant ( $P < 0.05$ ) despite the inclusion of Chapman's Pool, where no snails were found in 2004 (see above). The mean change in abundance is significantly greater in the west than in the east ( $P < 0.01$ ).

Populations west of Portland were recorded as abundant or common before 1963 at Church Cliff Ledges, Lyme Regis; below Golden Cap and at Clay Ope, West Portland (Hawthorne, 1965). Shores between East Ebb and Great Ebb between Seatown and Eype Mouth were not surveyed at that time. The population at Clay Ope below West Cliff, Portland has not recovered to its pre-1963 density but the shore configuration has changed.

Archaeological evidence indicates that some 7,000 years ago, *O. lineatus* was a common food item for Mesolithic settlements at Portland Bill (Thomas and Mannino, 1999) and at a site near Chapman's Pool in east Dorset (Palmer 1977). Milder climate and more extensive rocky intertidal habitat exposed by the lower sea level of those times favoured *O. lineatus*. In recent times it appears that severe winters such as that of 1963 may eliminate eastern English Channel populations. Eastward recolonisation is limited by Chesil Bank and the Isle of Portland. Data given by Hogg (1965) indicated that in the period before 1963, summer temperatures were likely to be more favourable for breeding in east Dorset than further west in its range (Hawthorne, 1966).

Recruitment to east Dorset shores in the latter half of the twentieth century has been believed to be through exceptional tidal and wind conditions drifting larvae from west Dorset sites around Portland Bill. Tidal currents in the vicinity of Portland Bill flow strongly to the east at high tide (illustrated by Bruce and Watson, 1998). Patterns of onshore residual drift described in *Exercise Mermaid* (Bowles, Burns, Hudswell and Whipple, 1958) and also by Pingree and Maddock (1977) may account for larvae settling on east Dorset shores if wind conditions are suitable. A coincidence of several favourable years could lead to an unusual build up of east Dorset populations. Recent Channel temperatures may indicate stronger easterly flow than in previous decades. Mild winters may have permitted an increase in winter feeding by *O. lineatus*, possibly allowing earlier breeding and a resulting extended period of larval dispersal from the populations west of Portland. Desai (1966) recorded prolonged spawning after the mild winter of 1956/7. Such an extended period of spawning would increase the opportunity for larvae to be caught in good eastward drifting conditions. These possibilities have been suggested previously by Hawthorne (1966). Hiscock *et al.* (2004) suggested that more frequent successful gonad development or more broods leading to greater reproductive output are among mechanisms of climate-change effects likely to be influential in increasing the distribution and abundance of southern species.

There can be little doubt that the large population at Western Ledges in Portland Harbour has been a breeding population since the year 2000: the oldest specimens in the Fleet appear to be from the year 2000 age group. Local experience is that objects drifting from Portland Harbour, beach at White Nothe. The westward residual drift indicated in Exercise Mermaid data (Bowles *et al.*, 1958) may be limiting the distance that larvae from Western Ledges may travel before settling. Near-shore westward tidal currents around low water are stronger than eastward currents around high water from White Nothe eastward (Bruce and Watson, 1998). Wind effects may be carrying larvae from Portland Harbour as far as White Nothe but it would seem likely that local breeding will be necessary for there to be opportunity for significant numbers of larvae to reach Lulworth and shores further east.

The difference in population sizes west and east of White Nothe may be explained if the Western Ledges population has been responsible for most of the recent build up of numbers as far east as White Nothe and if the numbers further east reflect the occasional arrival of a few larvae from the west of Portland Bill, as is thought to explain the distribution before 1963 and until late in the 1990s.

The nature of the habitat at Western Ledges, which gives shelter in crevices and under scattered stones on the reefs, encourages clustering of the *O. lineatus*, which may be necessary for successful breeding. Clustering at shallow pools containing eggs in early stages of cleavage was observed by Desai (1966). The habitats of east Dorset sites make clustering difficult and populations may need to increase more at these sites before there is enough local larval production to give further eastward population increase or extension. If the population densities near Osmington Mills or at White Nothe continue to increase and become a source of large quantities of larvae, suitable wind conditions could lead to further eastward extension of increased populations. Mieszkowska *et al.* (2005) thought the Osmington Mills population was breeding in 2002, 2003 and 2004.

## CONCLUSIONS

The populations of *Osilinus lineatus* at sites on the Dorset coast east of Portland Bill have increased significantly in recent years.

Populations between Portland and White Nothe have increased significantly more than those further east.

A large breeding population has become established in Portland Harbour at Western Ledges and may be responsible for increased larval settlement since 1998 as far as White Nothe and for new settlement in the Fleet.

The origin of the Western Ledges population may be related to recent warm winters in addition to favourable wind conditions.

The configuration of the shore at Western Ledges encourages clustering of adult snails and has abundant "nursery" sites, which may make this site particularly significant to the maintenance of the increased populations east of Portland.

The extension of the breeding range of *Osilinus lineatus* appears to be from west Portland (recorded in 1961 - Hawthorne, 1965) and more recently from between Seatown and Eype, to Portland Harbour. This is somewhat less than the 55km suggested by Mieszkowska *et al.* (2007).

Build up of the Osmington Mills and White Nothe populations is likely to increase the breeding range further.

Further study may shed light on the hypotheses proposed. The 1962/63 winter demonstrated how an exceptional event can limit eastward penetration of the English Channel shores by *O. lineatus*. Analysis of the year groups and relative size of the specimens measured in this study may suggest that an exceptional event - a single settlement of large numbers of larvae at Western Ledges - could explain the recent increase in population sizes east of Portland.

The detailed results of the 2004 survey are lodged with the MarClim Project of the Marine Biological Association (UK). Further analysis of these data may allow firmer conclusions to be drawn on the causes of the recent increase of the populations of *Osilinus lineatus* east of Portland Bill and possibly provide links with changes at other limits of its range referred to by Mieszkowska *et al.* (2005).

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