

MARINE WOOD BORERS IN SOUTHAMPTON WATER

1951-1975

By J. COUGHLAN

SUMMARY

A borer monitoring programme was set up prior to the construction of Marchwood power station and was later extended to include Fawley power station.

Contrary to prediction, the shipworm *Teredo* has not proliferated and was absent from the test timbers in 17 of the 24 years covered by the investigation. Sporadic outbreaks were traced to local introduction in wrecks and driftwood.

Similarly, *Limnoria tripunctata* has not dominated the warmed zone and in fact has been completely displaced from there by *L. quadripunctata*. The boreal *L. lignorum* declined predictably in the warm zone and has attained a balance over the rest of the area with *L. tripunctata*; *L. quadripunctata* has been confined to the warm zone since the severe 1962-63 winter. *Limnoria* populations have fluctuated widely but with no spatial or temporal relationship to warmed discharges.

INTRODUCTION

Dock and Harbour authorities have feared that artificial warming of their waters by industry could lead to the introduction of new and potentially harmful species, to the advancement of breeding seasons and to protracted periods of colonization and growth of existing fouling and boring organisms. Such effects have been described by Crisp and Molesworth (1951) for the barnacle *Balanus amphitrite*; by Naylor (1965a) for the seasquirts *Botryllus schlosseri*, *Diplosoma listerianum*, *Asciidiella aspersa* and *Ciona intestinalis*; by Pannell, Johnson and Raymond (1962) for the barnacle *Elminius modestus*, the mussel *Mytilus edulis* and the borers *Limnoria* sp. and *Teredo* sp., and by Eltringham and Hockley (1961) for *Limnoria*.

Economically, it is the boring rather than the fouling organisms that pose the greater threat to dock installations. From the early

1930's it became impracticable to use wooden mooring tenders in Swansea docks as a result, it has been suggested, of increased *Teredo* activity following the use of the docks as cooling ponds (Bell 1949; Naylor 1965b), and timber jetties were replaced by concrete structures. In 1959, when a 480 MW power station was completed at Marchwood, discharging at full load $33 \text{ m}^3 \text{ s}^{-1}$ of cooling water with a temperature rise of up to 9°C ($26 \times 10^6 \text{ g.p.h.}$ and $\Delta T \cdot 16^\circ\text{F}$) close to Southampton's Western Docks (Fig. 1), a wood borer monitoring programme was already in progress. This programme was subsequently extended to monitor the influence of Fawley power station.

The chief concern was the possibility of shipworm (*Teredo* and its allies) becoming established in the port with the secondary concern that the indigenous gribble (*Limnoria* and *Chelura*) would become more destructive.

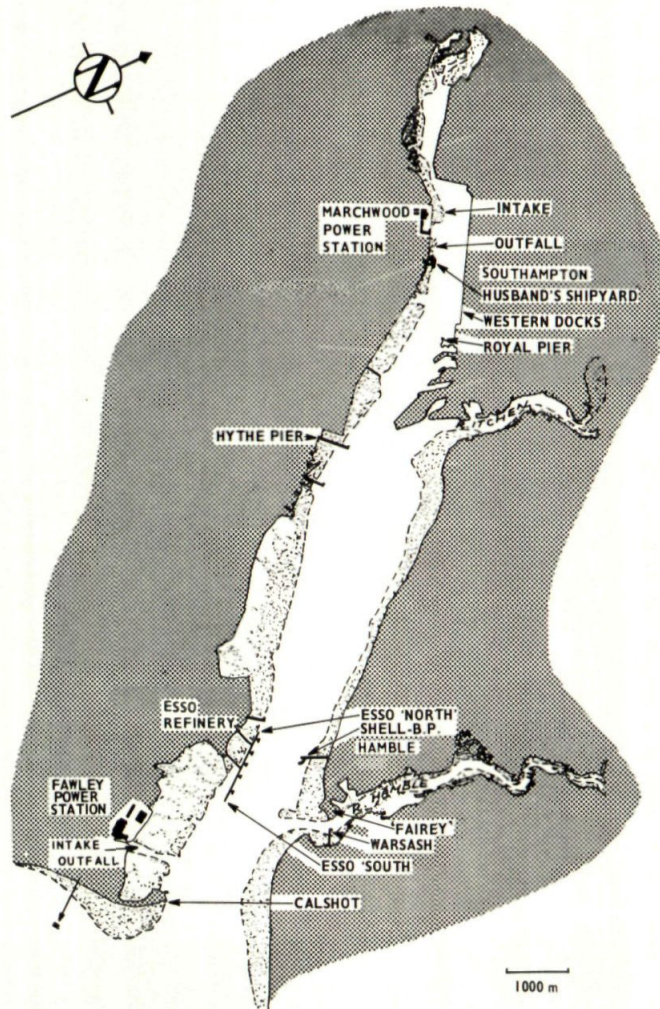


FIG. 1 LOCATION MAP, SOUTHAMPTON WATER.

A Committee comprising representatives from the Harbour Board (now the British Transport Docks Board), the University of Southampton and the Generating Board initiated and carried out a series of studies of which the wood borers programme was part.

LOCAL SPECIES

(a) Shipworms

These are bivalve molluscs of the superfamily *Pholadacea*; having highly modified

bodies and shells enabling them to bore deeply into timber. The adult can never leave its burrow, which tapers from the heading to a pinhole corresponding to the point of entry. Hence the danger—apparently sound timbers may be hollowed out from within, leaving a mere shell. The eggs of *Teredo navalis* are fertilized and brooded within the burrow prior to liberation; locally, brooding and release as free-swimming larvae some $60\ \mu$ in diameter take place between July

and late September. In November 1962, P. A. Board (pers. comm.) found the related *Lyrodus pedicellatus* in timber from the upper reaches of the Hamble river; this species broods its larvae until they attain settlement size, about 200 μ . Shipworm burrows may reach 400 mm in length and 10 mm maximum diameter in a single year.

Both gribble and shipworm can attack new wood, but shipworm will not readily attack wood already mined by gribble. Severe attack by gribble on wood inhabited by shipworm can expose the calcareous tunnel linings and destroy the integrity of the remaining timber. Shipworms attack floating timber (ships!) and prefer continuous immersion.

(b) Gribble

These are small members of the crustacean order Isopodea measuring approximately 3-4 mm in length. Unlike shipworm, they burrow shallowly along the surface grain and their attack is always visible. Entry is oblique and the hole is longer and more elliptical than that of *Teredo*. This is soon followed by a row of small ventilation shafts which may coalesce to form an open trench. Wave action can break away the honeycombed surface enabling attack to be continued to a deeper level. Gribble will also penetrate cracks and splits in timber to cause a more internal destruction, often bypassing surface impregnations of preservative. One species, *Limnoria tripunctata*, appears better able than the others to attack creosote impregnated timber. It is suspected that, unlike *Teredo*, gribble cannot digest wood but feed upon the surface organic film. Gribble are not deterred by harder woods and can live for up to a fortnight out of water. The head bears a strong pair of mandibles used to gnaw the wood whilst the walking legs terminate in sharp hooks with which to grip the timber. Adult gribble characteristically undertake seasonal migrations (as described by Eltringham and Hockley 1961, p. 467). The timing varies between the species (see below) but virtually ceases during the winter months

(October-March). Reproduction always follows the invasion of new wood, but it is also repeated in non-migrants. On leaving the brood pouch the young generally bore out laterally from the parent burrow. Gribble are found sub-littorally but are most abundant around MLW and up to tidal levels corresponding to 60-63% emergence (about 1 m below MHW in Southampton Water), or even higher in shaded situations.

Until 1953 only one species, *Limnoria lignorum* had been described from British waters, but re-examination of preserved material showed that *L. quadripunctata* had been present at Plymouth since at least 1930 (M.B.A. 1957; Jones 1963). At this time a third species *L. tripunctata*, was also found but there is evidence that this was a fairly recent introduction.

The boreal *L. lignorum* is the only species found all round the British coast, reaching the southern limit of its range on south and south-west coasts; for this reason it may be considered an endemic species. In Southampton Water it breeds from November through to May or June, commencing when water temperatures fall below 8° or 9°C and ceasing when they exceed 14°-16°C.

L. tripunctata is a temperate-tropical species, breeding in Southampton Water from May to September in water temperatures exceeding 14°C. When Queen's Dock, Swansea, was artificially heated by Tir John power station ovigerous females were present in samples throughout the year since the temperature did not fall below 14°C (Naylor 1959). The sporadic distribution of *L. tripunctata* suggests its relatively recent introduction; its dominance at Poole indicates that the south coast population may have started there (Jones 1963).

The British distribution of *L. quadripunctata* is essentially that of a temperate species, occurring along the south coast and north-west to the Isle of Man. In Southampton Water it breeds from April to December

(Eltringham and Hockley 1961; Jones 1963). Eltringham (1957) demonstrated that post migrant female *L. quadripunctata* carried significantly larger broods than non-migrants; this difference was less marked in *L. tripunctata* and not fully investigated in *L. lignorum*.

The migratory seasons, during which fresh

timber is infested, correspond to the respective breeding seasons, thus: mainly during March and April for *L. lignorum*, April to September for *L. quadripunctata* and May to August for *L. tripunctata* (Jones 1960). Migration is minimal during the winter months. The breeding and migrational information is summarized in Fig. 2.

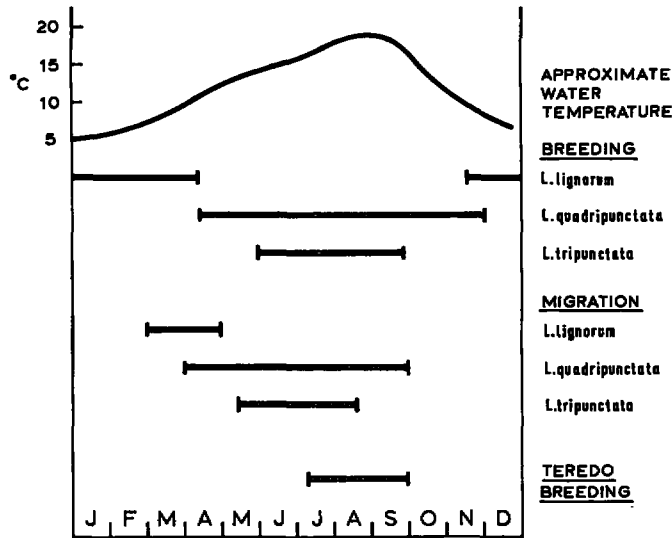


FIG.2 SCHEMATIC SEASONAL TEMPERATURE, BREEDING AND MIGRATION CHART

It is apparent from the geographical distribution of the three species and from physiological comparisons (Eltringham 1961a, b; Jones 1960) that they have a graded tolerance to environmental change; *L. lignorum* being the least tolerant. *L. tripunctata* the most tolerant and *L. quadripunctata* occupying an intermediate position. In mixed populations the three species tend to occupy different levels; *L. lignorum* at the bottom, *L. quadripunctata* in the middle and *L. tripunctata* at the upper limit of attack, with a variable degree of overlapping. Freed from competition on the north and east coasts *L. lignorum* occupies the entire vertical range.

In Poole Harbour *L. tripunctata* now dominates the entire intertidal range and *L.*

lignorum has been confined to the sublittoral. Only relicts of *L. quadripunctata* are to be found and it is assumed to have been ousted by *L. tripunctata*. In the 1960s *L. tripunctata* was expanding its range in Southampton Water and it was postulated that here too it would displace *L. quadripunctata*, encouraged by the artificial warming (Jones 1963).

A fourth species of crustacean, the Amphipod *Chelura terebrans* occurs frequently on timber after preliminary working by *Limnoria*. This animal is larger (4-9 mm in length) than *Limnoria* but tends to burrow even more shallowly, producing bores and trenches some 2-4 mm wide. Eltringham (A. R. Hockley, pers.comm.) found that *Chelura* was incapable of boring into or

maintaining itself upon sound wood and hence was to be found exclusively on wood already damaged extensively by *Limnoria*. Consequently it was of little relevance and no further attention was paid to this species *per se*.

METHODS

The initial distribution and relative abundance was determined by examining timber facings and pilings (i.e. the standing populations); subsequent work was concerned solely with immigrant specimens newly arrived on battens of untreated softwood.

To test for the presence of shipworm and to gain information on the rates of settlement and of attack by gribble, blocks of Douglas fir were submerged at Marchwood and at Hythe in 1951 (Fig. 1). Knot-free blocks were selected, measuring 125 × 75 × 63 mm, but were soon found to be too small and blocks measuring 200 × 100 × 100 mm were substituted. In 1953 the Hythe site was discontinued in favour of Calshot following the adoption of that site as the baseline temperature point. It became evident that the blocks were not suited to numerical analysis of gribble activity and so from 1955 separate approaches were adopted for shipworm and for gribble.

(a) Batten Tests

Lengths of softwood measuring 1.5 m × 50 × 25 mm were exposed for two-month periods throughout the year. The battens were supported intertidally in metal frames (for details see Pannell, Johnson and Raymond, 1962) designed to minimize metal/timber contact. Initially counts were made of the numbers (and species) of gribble per unit area on the faces of the battens but this was later modified to a count of the number of bores into each of the four faces. The end grains were ignored. Some underestimation can occur since females often enter burrows made by males.

With the development of a 2,000 MW power station at Fawley, the programme was

extended in 1962 to include sites lower down Southampton Water (Esso and Shell) and in Hamble River (Warsash and Fairey): the latter were to monitor activity in an important yacht haven. Commencing April, 1969, batten exposures were confined to four successive two-month periods at each site; April-May, June-July, August-September, October-November. Fouling was scraped from the batten surfaces at the end of the first month's exposure.

(b) Block Tests

Block tests were continued by the Harbour Board engineers until the end of 1958. The periods of exposure were not standardized and ranged from 12 months to 45 months. Assessment was on the basis of lost cross-sectional area (i.e. a monitoring technique bearing direct relationship to structural integrity). The blocks were sectioned 25 mm from either end and the exposed perimeters traced. The residual area was determined by cutting and weighing or by planimeter. It was suspected that the blocks could become 'reservoirs of infestation' and in any case they were yielding little more than a rough indication of borer activity, with great variation (10%-40% loss of cross section) even between adjacent blocks. The presence of knots, openness of grain and porosity were significant. For this reason it was suggested that a continuous succession of battens, as was being employed in the gribble survey, would give a more rapid and more reliable guide to borer activity. Few borers (either gribble or shipworm) could produce migrant brood within two months of settlement and hence the argument that the battens provided reservoirs could not be raised.

RESULTS

Southampton appears to have been almost free from shipworm in the 1950s. Thus between 1951 and 1956, only one *Teredo* was found at Marchwood. A block set out at Calshot in 1954 and recovered in 1956 also yielded a single *Teredo*. Another series, re-

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covered late in 1957, having been submerged at Calshot 45 months previously, included two infested blocks. In August 1958, a piece of driftwood taken from near Royal Pier (Fig. 1) was found to contain at least 20 gravid *Teredo* and blocks recovered from both sites that year were infested. A heavily infested wreck appeared on the Marchwood foreshore at about this time and undoubtedly was the source of the 1958 and subsequent infestations. In 1959 there was massive *Teredo* attack on the battens (Table 1) and during July it was discovered that some of these *Teredo* had made sufficient growth to become sexually mature (i.e. within the two months period of batten submergence). The wreck was removed in 1961 and the infestation rate declined. However, at Calshot over the same

period there was a drastic invasion of shipworm, increasing from zero in 1958, to 104 in 1959 to 1,599 in 1961. It was recognized that a vigorous population must have become established close to the site but several visits at low water failed to locate it. At the same time the Hamble river became infested (P. A. Board reports that his November 1961 references to *Teredo* were in fact *Lyrodus*). Early in 1962 a piece of infested wreckage was found and dragged high up the beach. The infestation rate diminished during 1962 and subsequently no shipworm have been found at Calshot. A follow-up survey of the Hamble in 1963 found few signs of living shipworm but many unoccupied burrows. No shipworm were found at Marchwood between 1963 and 1967 but in that year another hulk appeared

TABLE 1 INCIDENCE OF SHIPWORM IN SOUTHAMPTON WATER, 1951-1975

Year	Calshot	Marchwood	Other	Notes
1951	0	0		
1952	0	0		
1953	0	0		
1954	} 1 } 2*	0		First 60 MW Set commissioned (Marchwood)
1955		0		
1956		1		
1957		1		
1958	0	2	A	
1959	104	92	B	8 x 60 MW Full Load
1960	41	21	B	
1961	1599	15	B	
1962	75	5	C	
1963	0	0		
1964	0	0		
1965	0	0		
1966	0	0		
1967	0	0	D	
1968	0	0	D	
1969	0	0	D	First 500 MW Set commissioned (Fawley)
1970	0	0		
1971	0	0		
1972	0	0	E	
1973	0	0		
1974	0	0		
1975	0	0		

Notes *2 infested blocks, not individuals. Bracketed entries are long-term blocks.

A = Driftwood

B = Hulk at Marchwood

C = Date of Removal of Calshot wreckage

D = Hulk at Marchwood

E = Driftwood.

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on the foreshore and a live *Teredo* was found in timber removed from it; this wreck was not removed until 1969 but there was no infestation of the battens such as occurred in 1959. In July 1972 a floating baulk picked up by the Harbour engineers was found to be riddled with shipworm. There was no evidence as to when or where infestation had occurred and there was again no incidence of *Teredo* in the battens.

All three species of *Limnoria* were found at both Marchwood and Calshot, and following the extension of the batten programme in 1962, at the Esso, Shell, Warsash and Fairey sites.

Until November 1958 immigrant *Limnoria* were more abundant at Calshot than at Marchwood. However, in the November-December series of that year the situation was reversed, interpreted as an extension of the migration period at Marchwood. Migration thereafter accelerated, with Calshot also showing increases, although these were proportionally less than at Marchwood. The numbers of immigrants rose at both sites in

the summer of 1962 to over 4,000 individuals but the following year dropped to a quarter of that number, perhaps as a result of the intervening severe winter. Numbers of immigrants at Marchwood never regained the levels reached at this time and the battens there were discontinued in 1968. The Calshot battens revealed a short-lived build up between 1963 and 1966 but numbers of migrants here also have now declined.

Since the batten programme was not extended until the autumn of 1962, few pre-1962-63 winter data are available for some sites. In 1966 a five-fold increase in migration onto battens at Shell was detected and high levels persisted until 1969 when there was an equally dramatic fall; this pattern was repeated at Warsash but not at Fairey (the other east shore site) where infestation continued at a steady level. The Fairey total remained appreciable and in 1971 migrants rose to 2,182 of which 1,093 were recovered in the April-May sample (Table 2).

The 1962-63 winter dramatically changed

TABLE 2 INCIDENCE OF MIGRANT GRIBBLE ON THE STANDARD TEST BATTENS, SOUTHAMPTON WATER BETWEEN 1955-1974

	Marchwood	Calshot	Esso N.	Shell	Warsash	Hamble	Fairey
1955	72	492					
1956	352	1099					
1957	426	1179					
1958	443	1178					
1959	1019	1423					
1960	1195*	562*					
1961	2452*	255*					
1962	4106	4706					
1963	1116	1370	917	149 56	1299 652	2097 1187	61 30 1535 855
1964	554	1833	888	205 122	542 275	1181 597	28 11 292 194
1965	729	2997	1297	617 186	621 278	2128 893	197 83 484 265
1966	1650	1784	621	462 359	2398 1185	3299 1183	115 67 544 253
1967	1148	536	296	— 140	3959 1910	3155 1289	† — — 574
1968	902	857	483	— 53*	3964 1997	2239 1369	† — — 334
1969	†	—	86*	— 3*	— 69*	— 59*	† — — 324*
1970	†	—	171	— 21	— 467	— 1241	† — — 277*
1971	†	—	292	— 91	— 365*	— 1025*	† — — 2182*
1972	†	—	294	— 88*	— 965	— 799*	† — — 398*
1973	†	—	67*	— 14*	— 497*	1 1097*	† — — 480*
1974	†	—	157	— 246	— 522	— 505	† — — 34

Notes: 1963 Marks the beginning of the enlarged programme. From 1969 only four battens were exposed, each for a two-month period. Bore counts for these same eight-months, back to 1963, are presented for comparison. It will be seen that the reduced frequency yields the same trends. *Incomplete series.

†Discontinued.

the relative abundances of the three species and it is fortunate that some data were obtained for the new sites in the preceding autumn. With the exception of Marchwood, *L. quadripunctata* was eliminated from all sites. At Calshot, the vacant niche was filled initially by *L. lignorum* but eventually a

balance was achieved between this species and *L. tripunctata*. At Shell, *L. lignorum* became and has remained dominant, while at Warsash *L. tripunctata* was initially more successful but *L. lignorum* became dominant by 1968; there appears now to be more of a balance (Table 3).

TABLE 3 PROPORTION OF *Limnoria* SPECIES

	Marchwood			Calshot			Esso N			Shell			Fairey			Warsash		
	Q	T	L	Q	T	L	Q	T	L	Q	T	L	Q	T	L	Q	T	L
1958 a	—	—	—	46	35	19	—	—	—	—	—	—	—	—	—	—	—	—
1959	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1960	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1961	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1962 b	0.5	99	0.5	—	—	—	—	—	—	88	12	0	—	—	—	95	9	1
1963	98	1.5	0.5	1	31	68	0	33	67	0	83	17	0	95	5	0	89	11
1964	99	0	1	0	19	81	0	36	64	0	65	35	0	90	10	0	85	15
1965	100	0	0	0	38	62	0	24	76	0	24	76	0	25	75	0	48	52
1966	100	0	0	0	29	71	0	20	80	0	20	80	0	38	62	0	45	55
1967	100	0	0	0	52	48	0	7	93	0	1	99	0	66	34	0	38	62
1968	100	0	0	0	52	48	0	14	86	0	18	82	0	36	64	0	31	69
1969 c	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1970	—	—	—	0	28	72	—	—	—	0	35	65	0	38	62	0	60	40

Q = *quadripunctata*, T = *tripunctata*, L = *lignorum*

Notes: (a) 1958 survey at Town Quay, Southampton gave 9% Q, 91% T.

(b) Regular sampling commenced 1962

(c) Few records of species abundance following adoption of reduced programme.

With the adoption of a restricted programme in 1969 bore counts only were made with a few spot identifications.

DISCUSSION

An earlier review of the effects of warmed water from Marchwood power station concluded that 'the breeding period of *Limnoria* has been extended and the incidence of *Teredo* appears to have increased' (Pannell, Johnson and Rayment 1962). It is now apparent that they were observing a short lived phenomenon: the increase by *Teredo* owed more to the presence of an abandoned hulk at Marchwood than to the discharge of warmed water, and the build up by *Limnoria* has been attributed to the exceptionally warm summers of 1958 and 1959. With the removal of the hulk in 1961 the incidence of *Teredo* again declined to zero. At about this time the related *Lyrodus pedicellatus* was identified in

material from the Hamble river. The effects of *Lyrodus* and *Teredo* are identical and they are unlikely to be distinguished by casual examination, so that the reported absence of *Teredo* can be taken to include both. *Teredo* was, in any case, more common at Calshot than at Marchwood (i.e. outside the port rather than within it). The policy for control is one of hygiene, infested timber is removed as speedily as possible, although legal requirements may delay the removal of abandoned, beached vessels.

Observations on *Teredo* were limited by the scarcity of this animal and no conclusions can be drawn about the effects of warming (c.f. Fleming and Coughlan 1969) other than that there has been no upsurge in abundance.

The *Limnoria* investigation was more detailed since not only were the organisms abundant but three species having differing

temperature optima co-existed. The possibility that one at least would be favoured by the new conditions was supported by their respective geographical distributions, from physiological comparisons and from past experience (e.g. Naylor 1965, a, b), which indicated that *L. tripunctata* was that species.

The rate and degree of infestation of the battens by immigrant species appears to be a function of season and of proximity to other infested timber; thus until late 1958 the infestation at Calshot greatly exceeded that at Marchwood, attributable to the lack of local populations at Marchwood following the reconstruction of Husband's Jetty in 1956. The proportion of migrant *L. tripunctata* never approached that found in the standing populations but this species more or less maintained its relative abundance at Calshot. After the 1962-63 winter *L. quadripunctata* was eliminated from Calshot, although it had been dominant the preceding summer, as well as from a number of sites in lower Southampton Water and the Solent. The total numbers of *Limnoria* spp. also fell and have not since regained the peak reached in 1962. In general, *L. lignorum* has spread to occupy the space vacated by *L. quadripunctata*. In the warmed area at Marchwood, *L. quadripunctata* was well able to survive the 1962-63 winter and though its numbers were reduced the species recovered and has become dominant. *L. tripunctata* and *L. lignorum* were never strongly established or represented among the immigrants at that site and in

competition with *L. quadripunctata* are now failing (Table 3) (Hockley 1965). The failure of the boreal *L. lignorum* in a warmed area is not unexpected but *L. tripunctata* was predicted to succeed. Hockley (1965) suggests that these results confirm the eurythermic status of *L. tripunctata* and the reproductive stenothermy of *L. quadripunctata*. The former may tolerate a broader range of temperature or a higher rate of change than *L. quadripunctata* but its population growth is no more successful in waters ranging between 5° and 25°C.

With the benefit of hindsight, Jones' (1963) figures showing that *L. tripunctata* dominated the higher levels and *L. lignorum* the lower, may be reinterpreted to indicate a shift in the balance of species. From May 1958 to July 1959 moderate numbers of *L. lignorum* were found at the lower levels whereas the last four samples—August to December 1959—revealed none (Jones 1963, Table 2). At the same time *L. quadripunctata* was increasing at the Marchwood site which was within the influence of the warm effluent.

The loss of section tests (Table 4) indicated removal of 5-12% of the test block each year; loss at Marchwood being up to 50% greater than at Calshot. The rate of loss appears to decrease with time; this could be due to less surface being available as the square section becomes more circular. The loss rate is of course a function of infestation and rate of boring and it is perhaps significant that fewer *Limnoria* were recorded at Marchwood than

TABLE 4 Loss of cross section from comparable test blocks at Marchwood and Calshot.

Date of Submergence	Duration (months)	Loss of Section		Loss Per Annum		Ratio M : C
		Marchwood %	Calshot %	Marchwood %	Calshot %	
12.2.54	45	32.6		8.7		
11.2.54	43		20.6		5.5	1.58:1
12.2.54	31	33.0		12.8		
11.2.54	31		23.0		8.9	1.40:1
31.10.56	14	11.7		10.0		
31.10.56	12		8.7		8.7	1.14:1

First discharge of warm water from Marchwood occurred in 1955.

at Calshot during this period. It will be noted that the lowest 'destructive ratio' between Marchwood and Calshot (1.14:1) was found in 1956-57 in the only series of blocks immersed *after* the first 60 MW set was commissioned in December 1955. Eltringham (1965), working mainly with *L. tripunctata*, found that boring fell off rapidly below 10°C: temperatures below 10°C occur for four or six months of the year at Calshot whereas weekly maximum temperatures exceeded 10°C throughout the year at Marchwood. However, there are difficulties in attempting to analyze loss of section data relating to varying periods of submergence and with great variability between samples. It was for this and other reasons that the blocks were discontinued.

The rises and falls in the numbers of *Limnoria* seem to bear no relation to the output of warmed water from the power station. Thus between 1959 and 1962 there was a dramatic increase in the populations near Marchwood and an equally sharp decline between 1963 and 1966 although the output of the power station remained relatively constant. This apparent absence of effect on the wood borers is in keeping with the predicted and the observed temperature rise in Southampton Water of approximately 0.7°C (Jarman and de Turville 1974). Only very small areas, close to the outfall, experience temperature increases greater than this (Raymont, Pannell and Johnson 1962).

In conclusion, it is apparent that there has been no upsurge in the abundance or activity of shipworms following the commissioning and operation of Marchwood (480 MW) or Fawley (2,000 MW) power stations. Attacks that have been detected, some of them severe, could in all cases be attributed directly to the introduction of infested timber adjacent to the monitoring sites. No shipworm have been detected since 1963.

Populations of gribble, as evidenced by migration onto softwood battens, have fluctuated through the period of review, but with no spatial or temporal relationship to warmed discharges.

The predicted increase of the temperate/tropical *Limnoria tripunctata* at the expense of the temperate *L. quadripunctata* and boreal *L. lignorum* did not materialize: in fact *L. tripunctata* was ousted by *L. quadripunctata* at the warmest site.

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