MARINE BIOLOGICAL STUDIES IN RELATION TO THE OPERATION OF THE TORRENS ISLAND POWER STATION.

a thesis by

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prepared in association with the Department of Zoology, Faculty of Science and submitted to

THE UNIVERSITY OF ADELAIDE

in fulfilment of the requirements for the degree of

MASTER OF SCIENCE

SUBMITTED : DECEMBER, 1977

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PROLOGUE

During the period from April, 1972 to April, 1975, I was employed in a temporary position as a marine biologist by the Electricity Trust of South Australia. I conducted research on two matters of concern to the Electricity Trust : the control of fouling by sessile animals in the cooling water ducts of the Torrens Island Power Station and the ecological effects of thermal effluent from the power station on the surrounding areas. The Electricity Trust agreed to the proposal that the results obtained during these studies may be used in the preparation of a thesis for the degree of Master of Science. This thesis is the result.

SUMMARY

Experiments were conducted to determine the effect of dosing seawater with chlorine on rates of settlement of sessile animals, with the aim of finding the optimum dose to prevent fouling in the cooling water ducts of the Torrens Island Power Station. Frosted glass plates were exposed in troughs containing running seawater. Six troughs were dosed with chlorine, five continuously and one intermittently, while two troughs were controls. Rates of settlement of fouling organisms on the plates were examined. The results showed that chlorine was effective in reducing rates of settlement. Of particular interest from the practical viewpoint was the fact that a low continuous dose of chlorine (0.2 ppm) was more effective in minimizing fouling than a higher dose (6 ppm) applied intermittently (10 minutes every 4 hours). Not only were rates of settlement lower but in addition, those animals which did settle in the troughs receiving the continuous dose were stunted in growth while those that settled in the trough receiving the intermittent dose grew normally.

The effect of the thermal effluent on epifauna of the Torrens Island area was examined by placing glass plates, held in specially constructed brass frames, at six different locations. A regular series of observations on plates exposed for two, four and eight weeks were made. Animals present on the plates were counted and the weights of growth measured. From the data on weights of growth, it was concluded that the thermal effluent had little effect on the total production of the epifauna. However, considerable differences in weights of growth were observed at two adjacent locations in the cooler water, one in turbulent water and the other in still water. Much greater weights of growth were found on plates from the turbulent water where three species were very abundant, apparently favoured by the greater current speeds.

Amongst the other species present, a variety of effects of the warmed water on distribution and abundance were noted. Several species showed seasonal differences in occurrence, settlement being found in spring in areas influenced by the warmer water and during summer in other areas. Some species were favoured by the warmed water, some were little affected in abundance, while others were adversely affected. When the positive effects of the thermal effluent were balanced against the negative effects, there was little evidence of any damage to the epifauna caused by the thermal effluent.

DECLARATION

I, William Muir Host, declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any university and that, to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except when due reference is made in the text of the thesis.

Signed ....

W. M. Host

ACKNOWLEDGEMENTS

I wish to thank my supervisors, firstly Mr. I. M. Thomas and following his retirement Dr. A. J. Butler, for their helpful advice and encouragement throughout. I am also indebted to Mr. M. Bosio, Chemical Engineer, the Electricity Trust of S.A. for his influence in the creation of the temporary position of marine biologist and for his continued interest throughout the study. My thanks are also extended to Mr. C. M. Beer, Senior Chemist, Torrens Island Power Station, and his staff for their help during my stay at Torrens Island. In particular, Messrs. A. J. Arthur, C. J. Steer and J. Vingelis helped in collection of plates from Angas Inlet by small boat and maintained the chlorinating apparatus used in the experiments. Mechanical Design Section of the Electricity Trust and Messrs. B. Gepp and P. Zed conducted several temperature surveys and their results have been included. Several persons helped with identification of the species found in this study and this help was much appreciated : Miss L. M. Angel, Dr. S. J. Edmonds, Mr. B. J. Brock and Mr. W. Zeidler (see also p. 132).

SECTION A. THE CONTROL OF FOULING IN THE COOLING WATER SYSTEM

1. Introduction

At the Torrens Island Power Station, electrical power is produced from the combustion of natural gas. The gas is used as a fuel to heat water in the boiler, resulting in the production of steam of high temperature and pressure. This steam is used to run the turbines and electricity is produced. The water which is supplied to the boiler must be of very high purity, in order to minimize the corrosion that eventuates at high temperature and pressure. Thus, it is necessary to condense the steam which has passed through the turbine and return the water to the boiler. This is achieved by using a large volume of seawater as a coolant. However, one continuing difficulty has been experienced, namely, the fouling of the cooling water system by sessile organisms.

1.1 The cooling water system

At the time of this study, the Torrens Island Power Station comprised four generating units, each with a generating capacity of 120 megawatts (MW). These four units require in aggregate 22 m^3/s of seawater for cooling. At full load, the cooling water removes from the condensers a heat flux equivalent to 690 MW. In doing so, the water is raised in temperature by 7.8^oC.

At present, construction of a second stage, 'B' section, of the power station is in progress. Ultimately, 'B' section will comprise four units, each with a capacity of 200 MW. The first unit of this section commenced operation early in 1976.

Each unit of 'A' section has its own cooling system. The heat exchange surface in the condenser is provided by 10 000 aluminium brass tubes, each 6 m long of 25.4 mm O.D. and 18 S.W.G. thick. The coolant flows through the tubes. The exhaust steam from the turbine flows around the tubes where it is condensed. The condensate is collected and recycled to the boiler.

Each cooling water system is operated by two pumps which are housed separately in concrete-lined chambers. The outlets from the two pumps lead into a single concrete-lined duct (1.98 m high x 1.83 m wide). Seawater is drawn from the North Arm of the Port Adelaide River through coarse wire screens (mesh size about 1 cm) into the pump chambers and thence, into the duct. The screens prevent material, which might block the condenser tubes, from entering. After passing through the condenser, the water is discharged into Angas Inlet, which has been separated from the North Arm by the construction of a causeway across its western end (see Section B fig. 1.1). This prevents the warmed water from returning immediately to the cooling water intakes.

Fouling of the ducts may interfere with the operation of the power station in two ways:

(a) If the greater part of the duct surface were to be covered by sessile animals, the flow of cooling water would be impaired. However, fouling in the ducts of the Torrens Island Power Station has not reached this level.

(b) Shells or clusters of shells may be swept from the walls of the concrete ducts and elsewhere by the flowing water and, if they are sufficiently large, they block the condenser at the inlet or lodge themselves somewhere inside the tubes. If enough shells block the inlets of tubes, heat transfer is impaired and the condensers must be cleaned. When a shell lodges inside a tube, turbulence in the wake of the obstruction scours the tube metal to the point of perforating the tube. This is a serious problem as the condensate, which must be of high purity, becomes contaminated.

1.2 <u>The fouling fauna</u>

The following account of the fouling fauna is based on the inspection of two ducts, one examined in April and the other in November, 1972. Each duct had been cleaned one year before the inspection. Each of the 120 MW units is taken off load annually for a survey. During this period the duct is cleaned by hand scraping.

The predominant animal present was a serpulid *Hydroides norvegica* Gunnerus which formed dense patches in places on the walls. These patches were of greatest extent in the vicinity of bends in the ducts (fig. 1.1). The patch on the lee side of a bend was always the larger, up to 10 m^2 in area and 7-8 cm thick. Scattered amongst the *Hydroides* were specimens of the Port Melbourne mussel *Mytilus planulatus* Lamarck, most 3-5 cm in length. The number of mussels were relatively small. They were restricted to the patches of *Hydroides* and were, on average, about 50 cm apart. Also present were barnacles *Balanus amphitrite* Darwin and some oysters *Ostrea angasi* Sowerby, which together covered about 5-10% of the remaining surface area. They were scattered over the surface though tending to congregate along the corners of the ducts and around any irregularities on the concrete surface. In the duct examined in November, 1972, patches of a small mussel *Modiolus inconstans* Dunker were present on the floor.

Of the organisms growing in the ducts, the Port Melbourne mussel was considered to be the most troublesome. Although its numbers were comparatively small, it can achieve the necessary size and shape to block condenser tubes. The right valve of a dead oyster could also block a tube if it became detached. *Hydroides* and *Modiolus* would only cause concern if whole clumps were torn from the walls.

1.3 Control of the fouling fauna

At the Torrens Island Power Station, attempts are made to control fouling by dosing the cooling water with chlorine. Chlorination is effected just before the inlets of the cooling water pumps. Originally, at intervals of four hours, each duct was dosed for ten minutes with chlorine at the rate of six parts per million (ppm) by weight. However, since the fouling fauna previously described settled and grew despite chlorination, the dosing schedule was clearly not wholly successful.

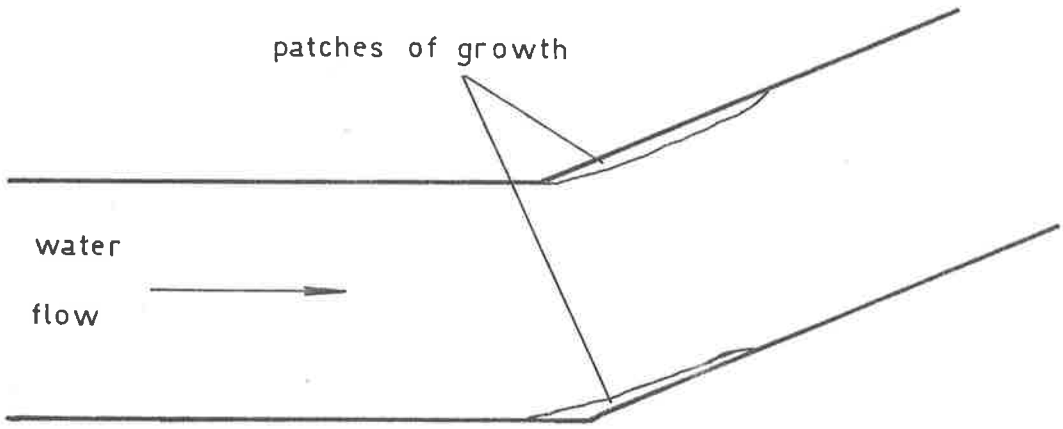

Fig. 1.1 The location of patches in the vicinity of a bend in a duct.

Accordingly, experiments were designed to find a dosing schedule which would provide better control. These experiments are described in section 2 and the results presented in section 3. Later, the Electricity Trust modified the dosing schedule, first by reducing the dose to 4 ppm and later (in August, 1974), by dosing every two hours at a rate of 2 ppm.

The original schedule of dosing employed at Torrens Island was recommended by the company of Wallace and Tiernan (Pulham, C.J., date of publication not known). The company asserts that properly spaced intermittent treatments were more economical than continuous treatment and were completely satisfactory. Using this method, most larvae that settle in the ducts should be killed before they complete metamorphosis. However, the company recognizes that some larvae will arrive in an advanced stage of development and will complete metamorphosis almost immediately. Hence, a distinction is drawn between complete prevention of fouling and a substantial reduction. Where fouling must be completely prevented, continuous chlorination during the fouling season must be used (Dobson, 1946).

Clapp (1950) reported that continuous chlorination at rates of 0.25 and 0.5 ppm resulted in a complete kill of the mussel *Brachydontes exustus*. Anderson and Richards (1966) investigated the effect of chlorination on settlement of sessile animals. They found that continuous chlorination at a rate of 0.25 ppm was completely effective in preventing survival of any fouling organisms present.

These studies were carried out in the United States of America. Studies in Great Britain have produced similar results. For example, James (1967) and Holmes (1970) reported that chlorination at low levels was effective in preventing fouling by mussels (*Mytilus edulis*).

In regard to Torrens Island, it seemed likely that the lack of complete success in controlling fouling by chlorination could be attributed to the intermittent dosing schedule. Differences in species involved and

and differences in water temperatures may also be involved. Experiments were designed to compare the effects of continuous doses of chlorine and an intermittent dose on the settlement and growth of fouling organisms.

2. Materials and methods

The apparatus provided consisted of eight polyvinyl chloride troughs. Fig. 2.1 shows a diagram of a trough. Seawater from the North Arm was pumped to the troughs through a galvanized pipe. Pipework from the offshoots of the main pipe to the troughs consisted of polyvinyl chloride. The rate of flow of water in each trough could be adjusted separately.

Two of the troughs were used as controls, while the remainder were fitted with apparatus to add chlorine to the water before it entered the trough. The chlorinating apparatus was a series 70-1710 solution feed gas dispenser system manufactured by Fischer and Porter (O. Warminster, Pennsylvania, U.S.A.). The apparatus incorporates a multiple-point chlorination system which allows the supply of chlorine to each trough to be regulated individually by the use of flow meters. Five of the meters could supply chlorine at the rate of 0-3 lb./day while the other was calibrated over the range 0-10 lb./day. The flow of water through each trough was adjusted to a rate of 35 gallons per minute. At this rate of flow 0.5 lb./day of chlorine added continuously to the water corresponded to a dose of 1.0 ppm by weight. Chlorine obtained from I.C.I. Ltd., Adelaide, was fed from 150 lb. cylinders.

Five continuous doses were chosen, 0.2, 0.4, 0.8, 1.5 and 3.0 ppm and one intermittent dose corresponding to the schedule of dosing employed in the ducts at that time, that is, 6 ppm applied every four hours for a period of ten minutes. The intermittent dose had to be applied manually, by turning the flow meter on, adjusting it to the correct level and then turning it off after ten minutes. After-hours and at weekends, staff operating the power station were entrusted with the task of manual dosing and also of checking the flow meters supplying the continuously dosed troughs. They recorded their activities on log sheets.

Periodically, the residual concentrations of chlorine in the water of

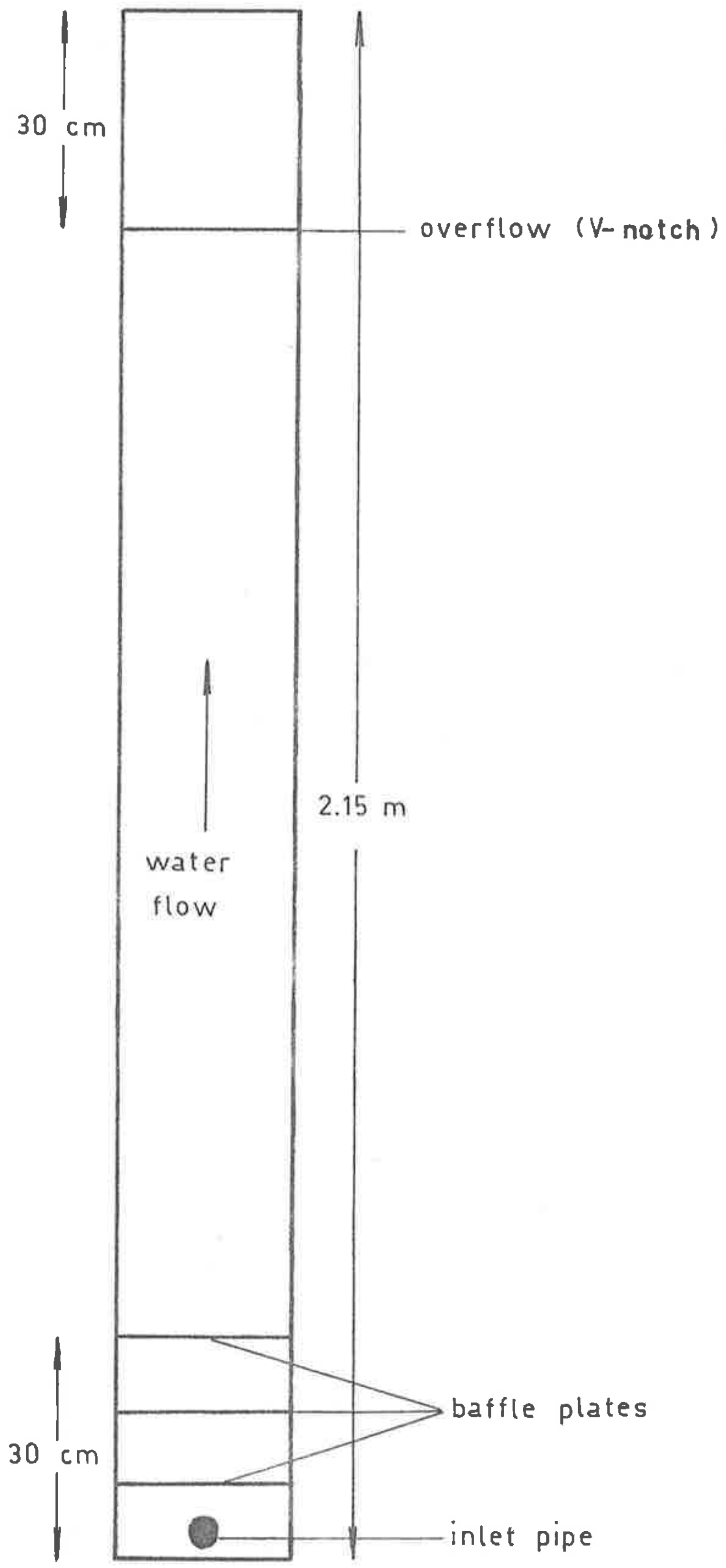

Fig. 2.1 Diagram of an experimental trough, viewed from above.

the troughs were checked. For the two lowest doses a BDH Nessleriser was used. 2½ ml of O-tolidine reagent was placed in a standard tube which was then filled with chlorinated water to a level marked on the tube. O-tolidine turns yellow in the presence of chlorine. The intensity of the colour was compared with a series of standards (obtained on a disc No. NCAB). Estimation of the chlorine residuals from the higher doses also used a colorimetric method. A BDH comparator with a disc No. 3/40 B was used with DPD No. 4 tablets as the reagent. These tablets dissolve in the water and produce a mauve colour in the presence of chlorine.

Water for these determinations was taken as it flowed over the V-notch. The average time of passage of water from the point of chlorination and through the troughs was about thirty seconds. It was found that the chlorine residuals varied little with time and were just below the levels set on the flow meters, as shown in the following table:

Flowmeter level (ppm)	Observed residual (ppm)
0.2	0.1 - 0.2
0.4	0.3 - 0.4
0.8	0.6 - 0.8
1.5	1.0 - 1.5
3.0	2.5 - 3.0
6.0	4.0

Frosted glass plates, 10 cm x 8 cm, were suspended in all of the troughs for set periods of time. During the early parts of the experiments, some concrete-asbestos plates were also used. After the period of exposure, the plates were removed from the water and examined using a binocular microscope. All fouling animals adhering were counted.

The dry weights of growth on the plates were then determined. A plate was washed with fresh water to remove excess salt and dried to a constant weight in an oven maintained at 100°C. The plate was then weighed and heated in a furnace to 500°C. for 1½ hours and weighed again.

The heat treatment has the effect of burning off all of the organic material. The plate was then cleaned in water by scrubbing with an old toothbrush. It was then dried and reweighed to obtain the dry weight of growth. Before reuse, the plates were soaked in dilute hydrochloric acid to remove all fragments of calcium carbonate that might be left attached.

Weights of growth on concrete-asbestos plates could not be determined, since this substance is hygroscopic and the plates could not be dried to a constant weight. Since concrete dissolves in hydrochloric acid, the concrete-asbestos plates could not be reused. Their use in the experiments was eventually abandoned.

Most observations were made on exposures of two, four and eight weeks, although a few longer-term exposures were also examined.

3. Results

Over the period from January to October, 1973, a regular series of observations were made, except in March (when I was ill).

3.1 Weights of growth on the plates

Fig. 3.1 shows the dry weights of growth on two-week plates from the control troughs and the intermittently dosed trough. In this diagram, the average of the two control troughs is shown. The complete results are listed in appendix 1(a). The application of chlorine is clearly effective in reducing the rate of fouling. In addition, as might be expected, the amount of growth would appear to be less over the winter months than at other times.

In order to examine the relative effectiveness of the different doses of chlorine, an analysis of variance was performed on the data from the chlorinated troughs (e.g. Sokal and Rohlf, 1969). It was felt advisable to test the data for homoscedasticity. This was achieved by using the F_{max}-test, described as a "quick and dirty" method by Sokal and Rohlf. In this case, the data were found to be homoscedastic ($F_{max}(6,15) = 2.81$). The result of the analysis of variance are shown in table 3.1.

Differences in the weights of growth between treatments were just statistically significant at the five per cent level. The treatments sum of squares was then partitioned into two groups to allow the appropriate *a priori* comparisons to be made (see Sokal and Rohlf, 1969). These comparisons (see table 3.1) showed that the amount of growth on the plates from the intermittently dosed trough was greater than that on plates from the continuously dosed troughs. However, amongst the continuous doses, no pattern was evident. The amount of growth was roughly the same in the troughs receiving doses of 0.2 and 3.0 ppm continuously and greater than that found in the other troughs. The analysis also confirmed that seasonal differences were significant.

Fig. 3.2 shows the weights of growth on four-week plates from the

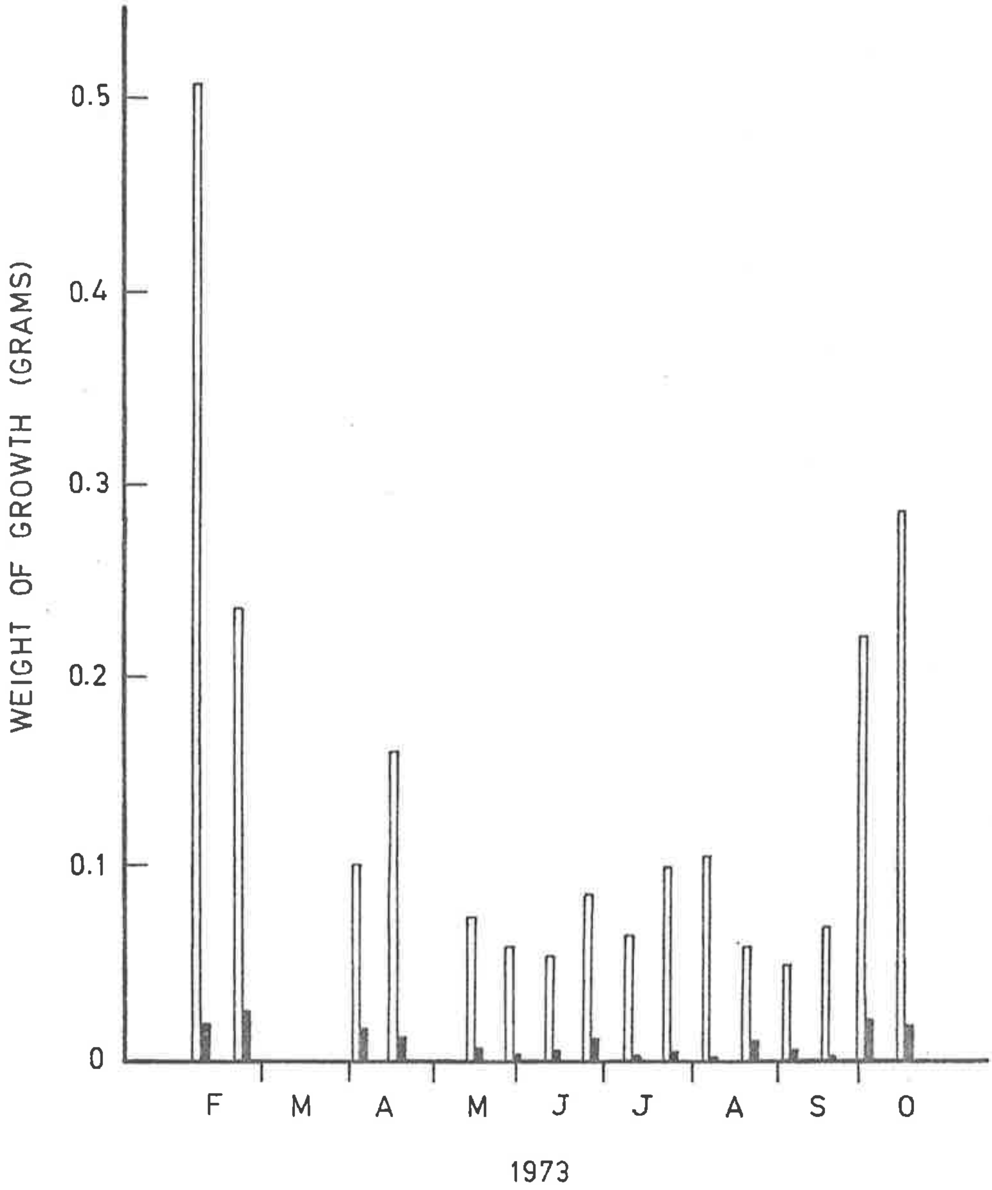

Fig. 3.1 Dry weights of growth on glass plates exposed for two weeks in troughs containing running seawater; the effect of dosing the seawater with chlorine.

Control (average of 2 controls)

6 ppm of chlorine applied for 10 minutes every 4 hours

Table 3.1 Summary of the analysis of variance conducted on the data on the weights of growth on two-week plates from the chlorinated troughs.

Source of variation	df	SS	MS	F_s	P
Treatments	5	176.59	33.52	2.44	$0.025<P<0.05$
Inter. v cont.	1	69.77	69.77	4.83	$0.025<P<0.05$
Amongst cont.	4	106.82	26.71	1.85	N.S.
Time	15	2772.49	184.83	12.79	$<<0.001$
Remainder	75	1083.58	14.45		
	95	4032.66			

controls and two of the chlorinated troughs. The complete results are listed in appendix 1(b). An analysis of variance was again applied to the data from the chlorinated troughs. However, this time heteroscedasticity was present ($F_{max}(6,16) = 11.27$, $P \ll 0.01$) but the problem was solved by transforming the data to logarithms ($F_{max}(6,16) = 1.80$). The analysis of variance is summarized in table 3.2. Variation between treatments was statistically significant and, once again, seasonal differences were evident.

The treatment sum of squares was again partitioned to allow the appropriate *a priori* comparisons to be made. These showed that weights of growth on plates from the intermittently dosed trough were significantly greater than those on plates from the continuously dosed troughs. Although differences amongst the continuously dosed troughs were statistically significant, no clear patterns were evident. Thus, least growth was present on the plates from the trough dosed at the rate of 0.4 ppm.

From the results on the weights of growth, the following conclusions would appear reasonable. Chlorine was effective in reducing the rate of fouling, at least during the first four weeks of exposure. The intermittent dose was less effective in inhibiting fouling than the continuous doses. Amongst the continuous doses, no clear patterns were evident. Seasonal differences were also observed, fouling being less severe during the winter months.

It might be expected that longer exposures would exaggerate the differences between the effects of the intermittent dose and the continuous doses. In addition, clear-cut differences amongst the continuous doses might be revealed. However, no data on weights of growth on longer term plates were obtained, since all such observations were made on concrete-asbestos plates.

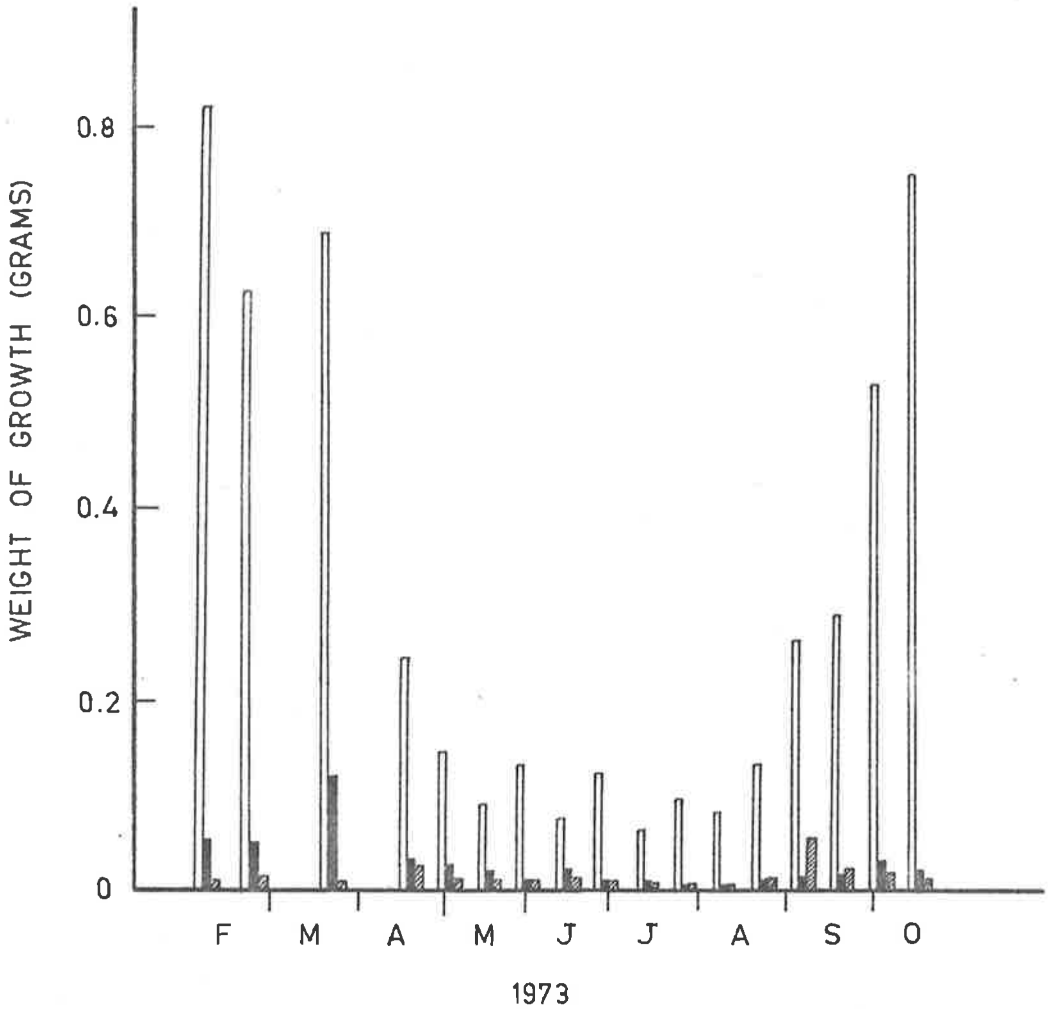

Fig. 3.2 Dry weights of growth on glass plates exposed for four weeks in troughs containing running seawater : the effect of dosing the seawater with chlorine.

Control

6 ppm of chlorine applied for 10 minutes every 4 hours

0.2 ppm of chlorine applied continuously

Table 3.2 Summary of the analysis of variance conducted on the data on the weights of growth on four-week plates from the chlorinated troughs.

Source of variation	df	SS	MS	F_s	P
Treatments	5	1.0742	0.2148	6.07	<0.001
Inter v cont.	1	0.3171	0.3171	8.96	$0.01<P<.001$
Amongst cont.	4	0.7571	0.1892	5.35	<0.001
Time	16	6.1959	0.3872	10.95	$<<0.001$
Remainder	80	2.8293	0.0354		
	101	10.0994			

3.2 Settlements on the plates

I shall consider first the following species:

(a) The serpulid *Hydroides norvegica* Gunnerus

(b) The barnacle *Balanus amphitrite* Darwin

(c) The mud-mussel *Modiolus inconstans* Dunker

(d) The oyster *Ostrea angasi* Sowerby

(e) An anemone tentatively identified *Anthothoė albocincta*.

The first four of these species, together with the mussel *Mytilus planulatus*, are the commonest fouling organisms in the ducts. The anemone may also be present, but is restricted to those areas of the duct in which the water is comparatively still, e.g. manholes.

The results on the settlement rates of these five species on two-week plates provided little information. All doses of chlorine would appear to have reduced the rate of settlement. However, the rates of settlement were too low to provide any firm conclusions, although it would appear that settlements may have been fewer in the troughs which received the higher doses. The results are listed in appendix 2(a). I shall not consider the results from two-week plates further, except for the special case of the serpulid *Eulaeospira convexis* (Wisely) (Section 3.5).

Fig. 3.3 shows the total numbers of the five species present on four-week plates from the intermittently dosed trough and the troughs dosed continuously at rates of 0.2 and 0.4 ppm. Fig. 3.4 shows the data from eight-week plates. The eight-week plates were of concrete-asbestos, while the shorter term plates were glass. The complete results are listed in appendix 2(b) and 2(c). On eight-week plates from the control troughs, competition for space between the various species was often evident. These species included several which were present in the control troughs but were not found in the chlorinated troughs. The most common of these were ascidians and the hydroid *Tubularia* sp. They often smothered *Hydroides*, barnacles, mud-mussels and oysters. In addition, accumulation

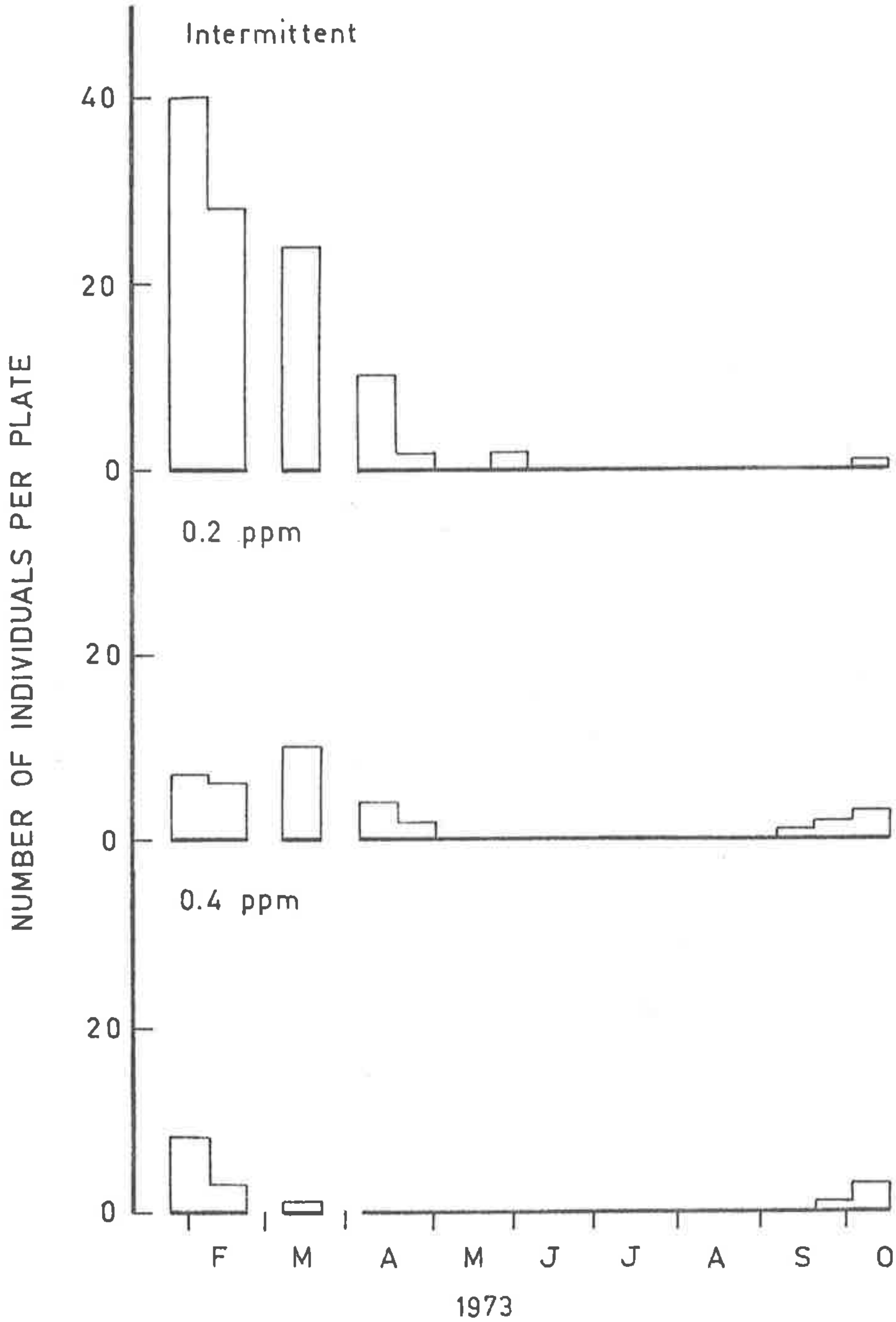

Fig. 3.3 Total numbers of five species of sessile organisms present on glass plates exposed for four weeks in troughs containing running seawater : a comparison of the relative effects of different doses of chlorine.

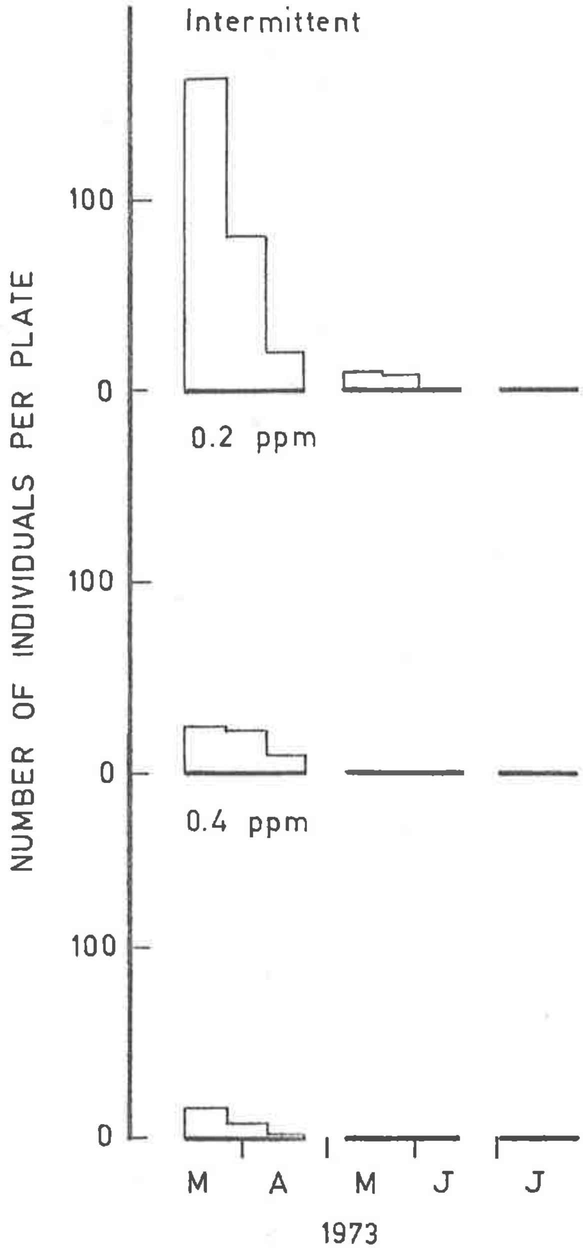

Fig. 3.4 Total numbers of five species of sessile animals present on concrete-asbestos plates exposed for eight weeks in troughs containing running seawater : a comparison of the effects of different doses of chlorine.

of mud on the plates after the first two-weeks of exposure may have inhibited any further settlement of some of the sessile animals. Mud accumulated far less readily in the chlorinated troughs, presumably because chlorine killed bacteria which might settle on the plates and aid in the accumulation of mud. Hence, for eight-week plates, comparison of the numbers of the five more important foulers between the control troughs and the chlorinated troughs were not meaningful. Thus, no data on numbers present on eight-week control plates are listed in the appendix. Competition was also evident on four-week plates from the control troughs, but was less severe.

The results would suggest that the higher doses of chlorine were more effective in reducing the settlement rate than the lower doses. However, of greatest interest from a practical point of view is a comparison of the effects of the intermittent dose with the continuous dose of 0.2 ppm. Analyses of variance for paired comparisons were performed on the data from both series of observations (Sokal and Rohlf, 1969). In those cases in which discrete periods of settlement are observed, it would seem reasonable to consider each period separately, since the effect of chlorine might be influenced by seasonal factors, such as temperature. Accordingly, when considering the results from four-week plates, only the first five pairs of observations were included in the analysis. Later rates of settlement were too low to allow any further conclusions.

The data were examined for homoscedasticity by using the two-tailed F-test for the hypothesis that the variance of two samples are equal (e.g. Sokal and Rohlf, 1969). In both cases, the data were heteroscedastic (four-week plates, $F(4,4) = 24.48$, $0.002 < P < 0.01$; eight-week plates, $F(4,4) = 37.84$, $0.002 < P < 0.01$). Since the data consisted of counts, a square root transformation was applied. In both cases, this rendered the data homoscedastic (four-week plates, $F(4,4) = 8.12$; eight-week plates, $F(4,4) = 4.51$). The results of the analyses are shown in table 3.3. In both cases, the differences between the effects of the two doses are significant at the 5% level.

3.3 Settlement and growth of the serpulid *Hydroides norvegica* Gunnerus

The numbers of the serpulid *Hydroides norvegica* present on four-week and eight-week plates from two of the chlorinated troughs are shown in Figs. 3.5 and 3.6 respectively. The complete results are listed in appendix 3. The analysis of variance for paired comparisons would have been the appropriate statistical test for comparing the effects of the intermittent dose with those of the continuous dose of 0.2 ppm. However, for each series of observations, the data were heteroscedastic (four-week plates $F(4,4) = 22.63$, $0.01<P<0.02$; eight-week plates $F(4,4) = 726.4$, $P<0.002$) and remained so after transformation to square roots (four-week plates $F(4,4) = 25.07$, $.002<P<.01$; eight-week plates $F(4,4) = 29.59$, $.002<P<.01$).

Hence, it is necessary to turn to a non-parametric method. However, in both sets of data, there are only five pairs of observations. This is too few to provide a significant difference when using a suitable non-parametric method, such as the Wilcoxon matched-pairs signed-ranks test or the randomization test for matched-pairs (e.g. Siegel, 1956). Since these non-parametric tests make no assumptions of normality, this difficulty can be overcome by amalgamating the data from four-week and eight-week plates. The randomization test for matched pairs yields a probability of 0.0078 that the observed differences may be attributed to chance. Thus, it may be concluded that the continuous dose was more effective in inhibiting the settlement of *Hydroides* than the intermittent dose.

In the intermittently dosed trough, *Hydroides* grew normally in comparison with the control troughs. They appeared to be healthy and the length of the tubes commonly reached five cm on eight-week plates. However, in the troughs dosed continuously, all *Hydroides* present were

Table 3.3 Summary of analyses of variance on total numbers of five species of sessile animals present on glass and concrete-asbestos plates: analyses on data from chlorinated troughs only.

(a) Four-week glass plates: data transformed to square roots. Data obtained over the period 8/2/73 - 2/5/73.

Source of variation	df	SS	MS	Fs	P
Treatments	1	8.5378	8.5378	8.55	$.025 < P < .05$
Time	4	12.9677	3.2419	3.25	N.S.
Remainder	4	3.9957	0.9989		
	9	25.5012			

(b) Eight-week concrete-asbestos plates: data transformed to square roots. Data obtained over the period 8/2/73 - 2/5/73.

Source of variation	df	SS	MS	Fs	P
Treatments	1	33.7457	33.7457	9.52	$.025 < P < .05$
Time	4	74.3821	18.5955	5.24	N.S.
Remainder	4	14.1833	3.5458		
	9	122.3111			

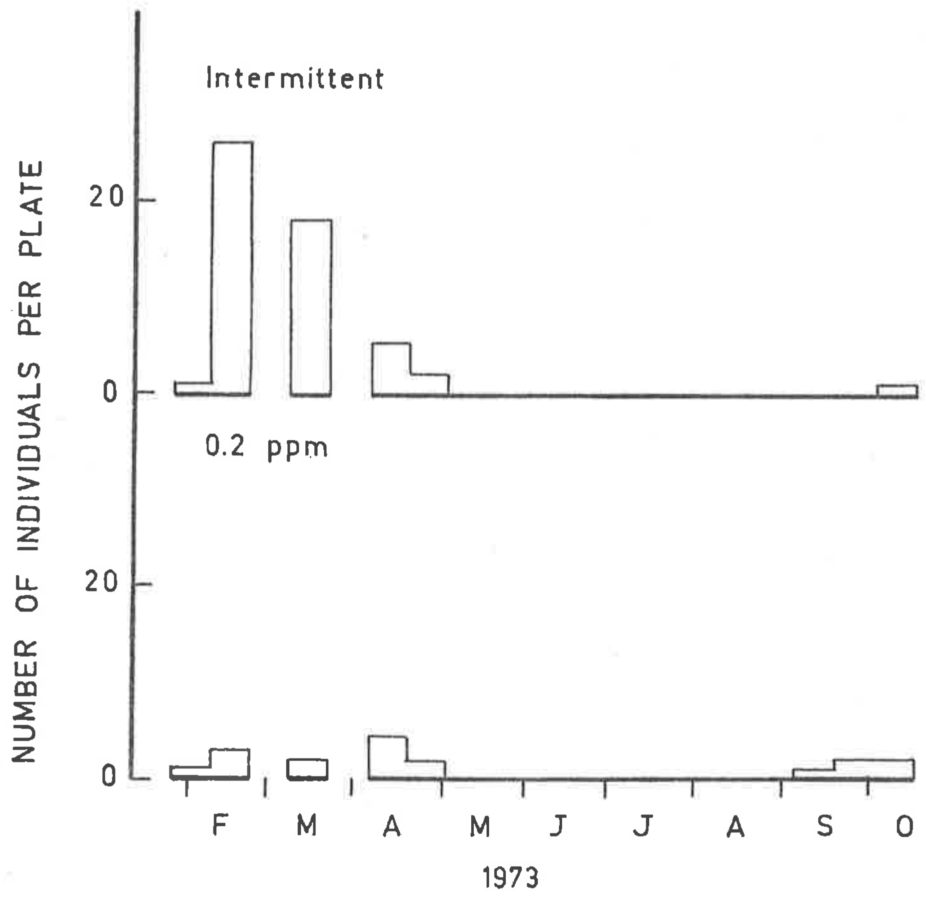

Fig. 3.5 Numbers of the serpulid *Hydroides norvegica* present on glass plates exposed for four weeks in troughs containing running seawater : a comparison of the effects of two different doses of chlorine.

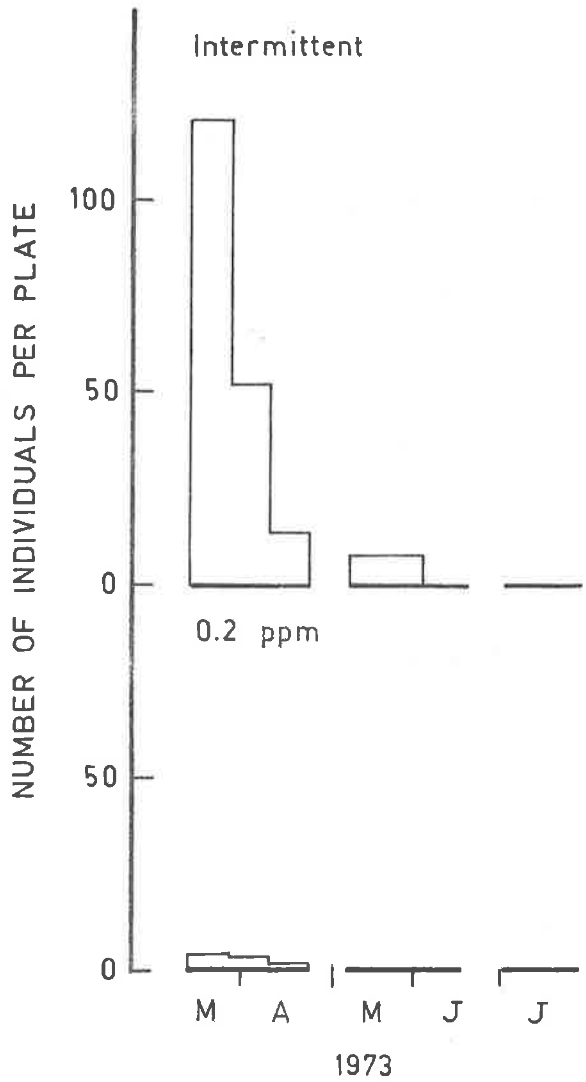

Fig. 3.6 Numbers of the serpulid *Hydroides norvegica* present on concrete-asbestos plates exposed for eight weeks in troughs containing running seawater : a comparison of the effects of two different doses of chlorine.

very thin and emaciated. In addition, the tube was very thin and fragile and the diameter of the tube hardly changed as the tube increased in length : *Hydroides* found on the plates from the continuously dosed troughs gave the appearance of thin threads of cotton.

In the control troughs, compound ascidians often spread over specimens of *Hydroides* and thus smothered them. Frequently, the tubes of *Hydroides* could be seen through the tests of the ascidians. These tubes had apparently grown normally for a time, but had then abruptly changed their pattern of growth. After the point of discontinuity, the shell was extremely thin and fragile and the diameter of the tube no longer continued to increase. It seems likely that the point of discontinuity in the pattern of growth corresponds to the stage of growth at the time when the tube was covered by the ascidian. It would be expected that a worm could put down the thin fragile shell much faster than its normal shell. Thus, an obvious conclusion presents itself : producing an abnormal thin shell is an evolutionary adaptation that gives a worm a chance to escape when it has been smothered. Presumably, normal growth would recommence when the aperture emerged from underneath the ascidian.

From the descriptions above, it can be seen that the pattern of growth of *Hydroides* found in the continuously dosed troughs is very similar to that shown by a worm that has been smothered. The fact that the worms are showing the same reaction to two rather different circumstances may indicate that this reaction is a general response to an unfavourable environment.

3.4 Presence of less common species

Barnacles (*Balanus amphitrite*), mud-mussels (*Modiolus inconstans*), oysters (*Ostrea angasi*) and anemones (*?Anthothoe albocincta*) were much rarer in the troughs than *Hydroides*. The presence of these species on four-week and eight-week plates from the chlorinated troughs is shown in appendix 4.

Barnacles were present in small to moderate numbers. The higher doses appear to have been more effective in inhibiting settlement than the lower doses. However, perusal of the data suggests that differences between the dose of 0.2 ppm and the intermittent dose are not significant.

Mud-mussels were restricted to the intermittently dosed trough and the control troughs. The effects of the intermittent dose and the continuous dose of 0.2 ppm were compared by amalgamating the data from four-week and eight-week plates and conducting a randomization test for matched pairs. This yielded a probability that the differences were due to chance of 0.0078. Hence, it can be concluded that the continuous dose was more effective than the intermittent dose in inhibiting the settlement of mud-mussels.

Anemones and oysters appeared too infrequently to allow any conclusions to be made.

3.5 The serpulid *Eulaeospira convexis* (Wisely)

Fig. 3.7 shows the settlement rate of *Eulaeospira convexis* on two-week plates from the control troughs, while Fig. 3.8 shows the numbers present on four-week plates from two of the chlorinated troughs, as well as the controls. The complete results from two-week, four-week and eight-week plates are listed in appendix 5. It would appear that the rate of settlement on the plates in one of the control troughs was consistently greater than that in the other trough and statistical analysis confirmed this. For both two-week and four-week plates, the data were heteroscedastic (two-week plates $F(15,15) = 10.00$, $P \ll 0.002$; four-week plates $F(15,15) = 16.83$, $P \ll 0.002$) and could not be rendered homoscedastic by transformation to square roots (two-week plates $F(15,15) = 4.32$, $0.002 < P < 0.01$; four-week plates $F(15,15) = 3.00$, $0.02 < P < 0.05$). Hence a non-parametric method was used. After amalgamating the data, the Wilcoxon matched-pairs signed-rank test (e.g.

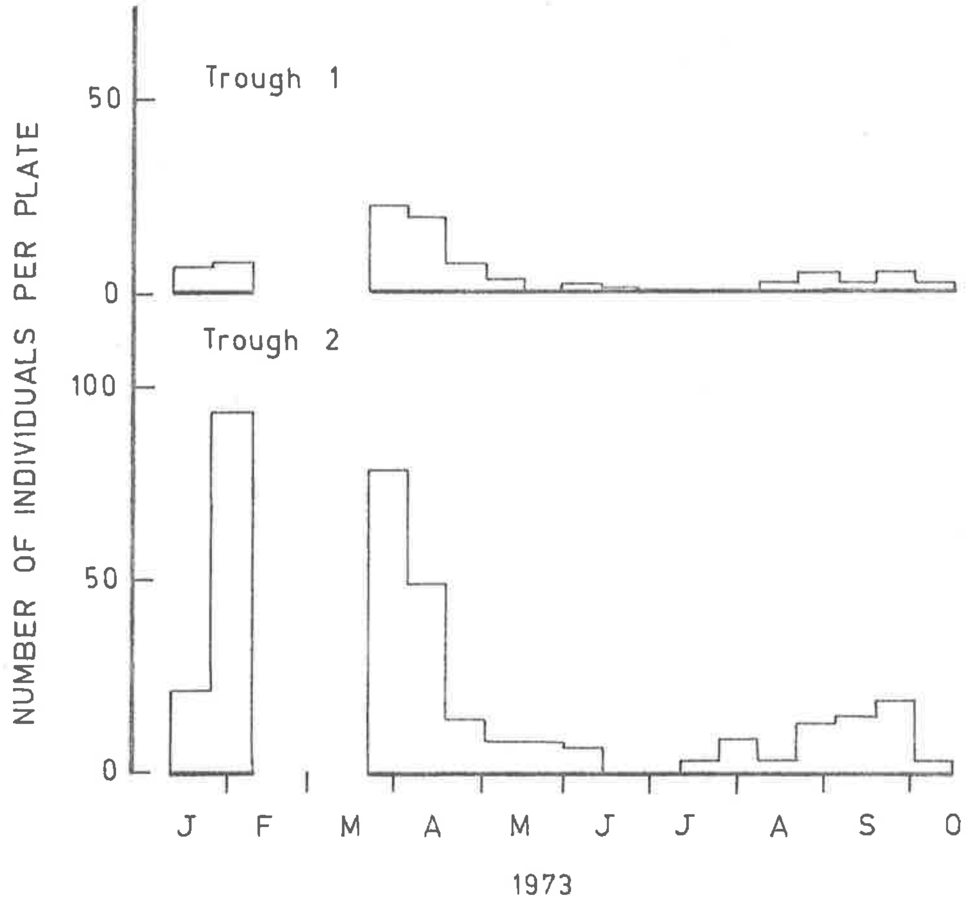

Fig. 3.7 Numbers of the serpulid *Eulaeospira convexis* present on glass plates exposed for two weeks in troughs containing running seawater : settlements in the two control troughs.

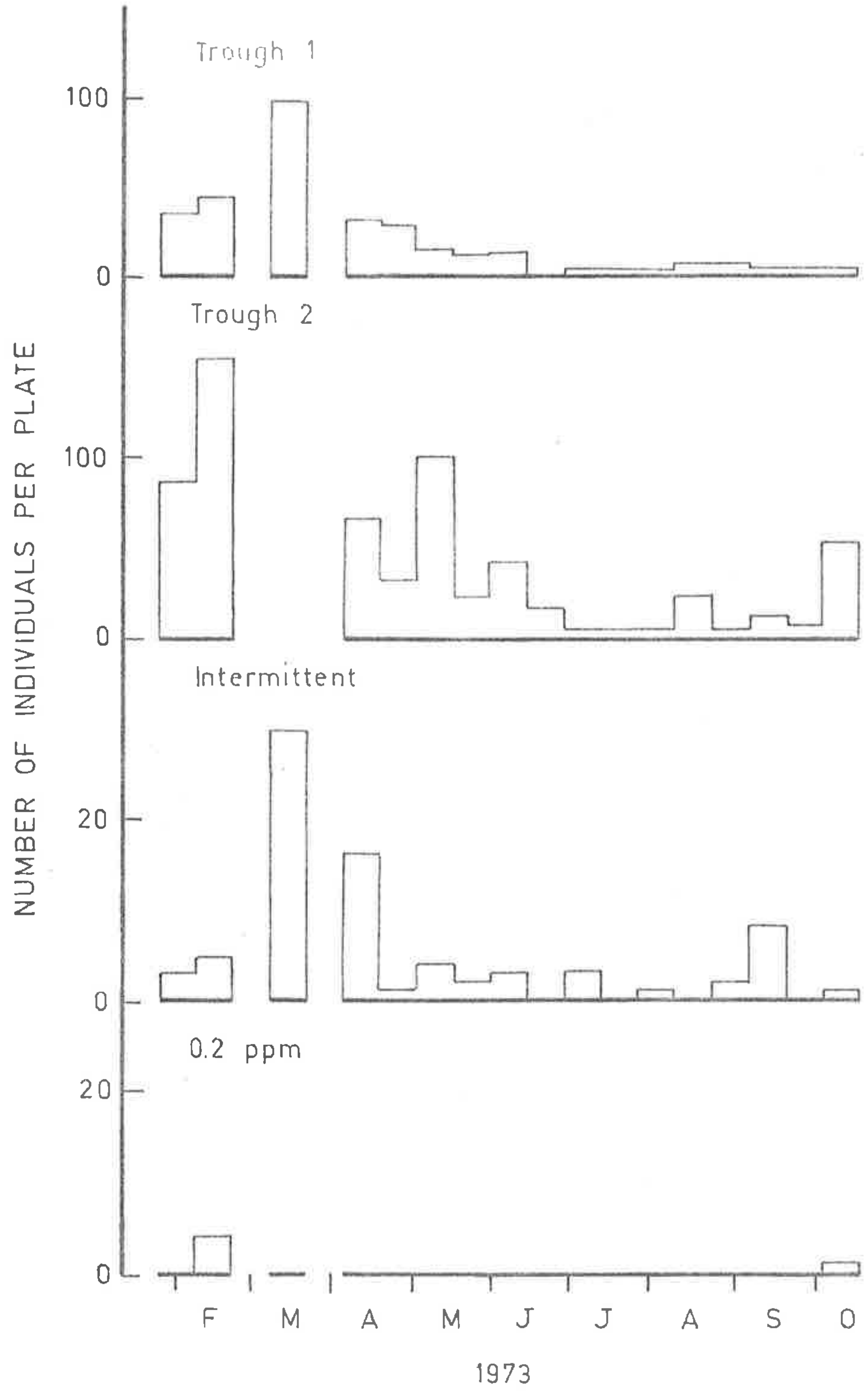

Fig. 3.8 Numbers of the serpulid *Eulaeospira convexis* present on glass plates exposed for four weeks in troughs containing running seawater : settlements in the two control troughs and in two of the chlorinated troughs. Note that the scale for the controls is different from that for the chlorinated troughs.

Siegel, 1956) yielded a highly significant result ($n = 32$, $T = 7\frac{1}{2}$, $P \ll 0.005$).

This difference in settlement rates may be explained in the following way. In the two months before the experiments commenced, seawater had been flowing through the troughs. During this period, some difficulties in the operation of the chlorinating equipment were experienced and no results were obtained. Hence, by the time the experiments were ready to begin, there was a moderate fouling fauna in the control troughs.

It has been found that some species of sessile animals are gregarious. In those cases where the situation has been examined in detail, it has been found that the larvae are able to recognize established members of their own species by using chemical cues. They then settle preferentially in the near vicinity of members of their own species. Such behaviour is one mechanism which enables the larvae to settle in a location which is favourable. Gregarious settling has been found in a variety of animals including barnacles (Knight-Jones and Stevenson, 1950; Knight-Jones, 1953; Crisp and Meadows, 1962, 1963), oysters (Bayne, 1964a; Crisp, 1967; Hidu, 1969) and serpulids (Knight-Jones, 1951; Andrews and Anderson, 1962). Hence it was felt that the presence of a fouling community in a trough may affect the rates of settlement on plates suspended in the trough, in comparison to settlements in a trough free of such a community. Thus, at the start of the experiments, all of the troughs, except one of the controls (trough 2), were cleaned as much as possible by scraping the growth from the walls.

Eulaeospira settled in greater numbers in the trough which contained an established fouling fauna. It would seem unlikely that gregarious behaviour could account for these results, since none of the species examined showed such a pattern of settlement. In addition, in those cases where gregarious behaviour has been examined in detail, it has been found that the larvae settled on the same surface adjacent to the adults : they do not swim off to a nearby surface.

The eggs of *Eulaeospira* are incubated within the tube of the adult and the larvae are later released. The larvae spend only a short time, probably not more than a few hours, in the free-swimming stage before they settle and metamorphose (Wisely, 1960, 1962). The minimum length of time in the free-swimming stage is not known, but if the larvae are capable of settling and metamorphosing as soon as they are released, the observations of Wisely may help to explain the observed settlement rates of *Eulaeospira* in the control troughs.

Larvae settling in trough 2 would have come from two separate sources. Some have been present in the water entering the trough, while others have originated from within the trough. However, larvae settling in trough 1 have come from outside the trough, at least initially. If the number of larvae originating from within trough 2 was large, in comparison to the number entering from outside, the rate of settlement in trough 2 would be greater than that in trough 1. The population of *Eulaeospira* in trough 1 would soon increase in numbers. However, if the population in trough 2 remained greater than that in trough 1, settlement in trough 2 would also remain greater.

A further factor might have contributed to the difference in rates of settlement between the control troughs. The rates of settlement of most species in the control troughs were considerably less than those recorded at locations in the North Arm adjacent to the cooling water intake (see Section B). This may probably be attributed to damage caused by mechanical and hydraulic stresses on passage through the pump and pipework leading to the troughs. Carpenter *et al.* (1974) found that about 70% of the copepods entering the cooling water system of a power station died after passage through the power station. They attributed this mortality to mechanical damage. Thus it is likely that an appreciable number of the larvae of *Eulaeospira* entering the troughs have been killed by passage through the pump and pipework. This factor would help to accentuate the differences in settlement rates between the control troughs.

I shall now consider the presence of *Eulaeospira* in the chlorinated troughs. The data from two-week, four-week and eight-week plates were amalgamated and analysed using the Wilcoxon matched-pairs signed-rank test. The numbers present in the intermittently dosed trough were significantly greater than those in the trough dosed at the rate of 0.2 ppm ($n = 21$, $T = 7\frac{1}{2}$, $P \ll 0.005$). In the early stages, this difference would have been caused by the effects of the different doses, but later, the existence of a population of *Eulaeospira* in the intermittently dosed trough would have been a contributing factor.

3.6 Growth on the walls of the troughs

I shall conclude this section with some general descriptions of the growth present in the chlorinated troughs in October, 1973. In the chlorinated troughs, the walls were virtually free of any fouling growth. However, in the 0.2 ppm trough a few *Hydroides* were present. These had all grown abnormally (as described above) and in this condition they would be unimportant as foulers in the ducts. There was a deposit of silt, up to two centimetres in depth, on the bottom of all of the troughs.

In the intermittently dosed trough, the situation was quite different. A considerable number of mud-mussels had settled on the floor of the trough. They had consolidated the mud and had accumulated more, with the result that the layer of mud was six centimetres in depth. As the mussels had grown in size and had increased in numbers, they had spread up the sides of the trough. Large numbers of *Hydroides* were also present, with a few barnacles and oysters. Anemones, which had been recorded occasionally on plates exposed in the trough, had disappeared.

The growth on the walls of the trough reached a thickness of one centimetre in places.

3.7 Supplementary results

In November and December 1973, some difficulties were experienced with the operation of the chlorinating equipment. Hence, no results were obtained during these months. Some observations recommenced in January, 1974, and continued until May, 1974. Observations were rather irregular.

The results from three series of observations on eight-week plates from the chlorinated troughs are listed in appendix 6. In the case of the anemone *Anthothoë albocincta*, it was possible to carry out a statistical analysis when the results from 1974 were amalgamated with those from 1973. A randomization test for matched pairs yielded a probability of 0.03 that differences between the numbers present in the intermittently dosed trough and the trough dosed with 0.2 ppm of chlorine may be attributed to chance. Hence, it may be concluded that the numbers were greater in the intermittently dosed trough. The data for the other species present on the plates at this time provided no new information.

Two series of longer term plates were also examined during this period. A series of eighteen-week plates were collected in early March and a series of twentyfour-week plates in early May. In both cases, growth was so profuse on the plates from the intermittently dosed trough that no attempt was made to count the number of each species that was present. *Hydroides*, *Eulaeospira* and *Modiolus* were the most common species present with smaller numbers of barnacles and anemones.

After an exposure of eighteen weeks, weights of growth on plates from the continuously dosed troughs ranged from 0.05 - 0.25 grams, while on the plate from the intermittently dosed trough, the weight was 11.3

grams. The corresponding weights from the twentyfour week plates were 0.15 - 0.60 grams and 23.2 grams.

4. Discussion

The results have shown that a low continuous dose of chlorine applied to seawater was more effective than an intermittent dose in reducing the rate of fouling in the experimental troughs. The results for *Hydroides norvegica* were the most convincing. Prior to the start of the experiments, this serpulid was the commonest species in the ducts. Rates of settlement were much lower in the continuously dosed trough than in the intermittently dosed trough. In addition, those *Hydroides* which settled in the continuously dosed trough did not grow normally, as described in the previous section (3.3). Growth was apparently normal in the intermittently dosed trough. *Eulaeospira convexis* also settled in greater numbers in the intermittently dosed trough, compared with the continuously dosed trough. However, as discussed in section 3.5, this effect will have been enhanced by the reproduction of the animals within the trough.

The mud-mussel *Modiolus inconstans* was comparatively rare on plates exposed in the troughs. However, amongst the chlorinated troughs, it was found only in the intermittently dosed trough. It was present on sufficient occasions to conclude that the difference between troughs was statistically significant. After several months, it was very common on the bottom and walls of the intermittently dosed trough, while being absent from the continuously dosed troughs. This fact lends support to the conclusion that a continuous dose is more effective than an intermittent dose in the reducing the rate of settlement of *Modiolus*.

In certain locations near the power station, mud-mussels are very common on the mud-flats. They can be found intertidally, towards the low-tide mark, and subtidally. The mussels are completely covered by the mud : only the presence of numerous slits in the surface of the mud reveals the existence of a population of mussels underneath. Thus, it seems that *Modiolus* is adapted to live in mud. Hence, when it appears on plates as part of the fouling fauna, it is only found on plates on which some mud has accumulated. These will mostly be the longer term plates. In the ducts, mud will only accumulate in hollows in the floor of the duct or amongst an existing fouling community, since the rate of flow of water in the ducts is relatively large. Since hollows in the floor are few, most mud-mussels which settle in the duct will do so amongst an existing fouling fauna. However, once mud-mussels have settled in the ducts they are able to become established, even though they are not covered by mud. The mussels are subsequently capable of becoming attached to the walls of the duct and to each other with the aid of their byssal threads.

In the case of barnacles and oysters, more data would be desirable. There was no difference for barnacles in the extent of the reduction of the rate of settlement between the continuous dose of 0.2 ppm and the intermittent dose. However, the numbers were small. Oysters were too rare to allow any conclusions to be made. The settlement season of barnacles and oysters has been found to extend from mid-spring into summer and sometimes into autumn in the Torrens Island area (see section B). The experiments started after the main period of settlement of barnacles and oysters during the 1972-73 season. The peak of settlement then was in December, 1972. In the next season, settlement rates of both species were considerably less than those observed a year earlier. Thus, only low rates of settlement were found in the troughs. In addition, the chlorinating equipment developed a malfunction during November and December of 1973 and no results were obtained for these months.

It had been hoped to obtain more results on the effect of chlorine on barnacles over the 1974-75 season. However, the rate of settlement of barnacles in the troughs was very low despite the fact that a fairly large rate of settlement was observed at a location near the cooling water intake. As an illustration, settlement rates of two and three per plate were found in the 0.2 ppm and intermittently dosed troughs, 5 and 13 in the controls and over 200 on a plate exposed for the same period (4 weeks) in the North Arm. Two factors may be responsible for this low rate of settlement in the troughs. The probable damage to larvae on passage through the pump and pipework has been mentioned in section 3.5. A further factor may be that many larvae may have been filtered out at the inlet to the pump. A wire-mesh basket (with a mesh-size of about 2 cm) had been placed at the inlet to the pump to prevent debris from entering. Over the 1974-75 season, this basket was, for the most part, completely enshrouded by a dense growth of the bryozoan *Zoobotryon verticillatum* despite frequent cleaning. This growth may filter out many of the larvae. In addition, a considerable amount of the hydroid *Tubularia* sp. grew on the basket. The polyps would probably have consumed a number of larvae which might otherwise have entered the troughs.

Oysters were again very rare over the 1974-75 season. Indeed, over the 1973-74 and 1974-75 seasons, they have been so rare that they have caused no problems in the ducts : previously, they had been moderately common, although less common than barnacles.

If further work on barnacles is attempted, the approach may have to be altered. If the number of settlements in the troughs remains low, the next best method would be to suspend in the troughs plates on which a number of young barnacles are growing. The effects of the different doses of chlorine on survival and / or growth of these young barnacles could then be compared. In order to ensure that a sufficient number of young barnacles were present on a plate, it may be necessary to make use of the fact that the larvae of barnacles settle gregariously. If a plate is soaked in a barnacle extract and then placed in seawater containing mature cyprid larvae, the resulting settlement will be much greater on this plate than on another plate identical except for its lack of treatment with barnacle extract (Knight-Jones, 1953; Crisp and Meadows, 1962, 1963).

As mentioned above (section 1.2) the mussel *Mytilus planulatus* was considered by the Electricity Trust to be the most troublesome of the animals in the ducts. However, no *Mytilus* were recorded at any stage during the course of the experiments, either in the chlorinated troughs or the control troughs. *M. planulatus* is comparatively rare in the Torrens Island area, possibly as a result of predation. In a study of Lough Ine, Ireland, strong evidence was presented that the scarcity of mussels could be attributed to predation of the crab *Portunus puber* (Kitching *et al.*, 1959; Ebling *et al.*, 1964; Kitching and Ebling, 1967). In this study mussels were found to be very rare over most of the Lough, but common in a few locations.

The blue crab *Portunus pelagicus* (Linnaeus) is commonly encountered near Torrens Island. This crab does eat mussels, particularly mud-mussels *Modiolus* (V. Neverauskas, pers. comm.) and would appear to be capable of breaking open large mussels. Predation by *P. pelagicus* may account for the rarity of *M. planulatus* in the area around Torrens Island. Predation by at least one species of fish may also be a contributing factor. The bream *Acanthopagrus butcheri* is common in the North Arm and Angas Inlet where it is often encountered close to submerged objects such as piles, wharves and wrecks. When the water is clear, the fish can be seen swimming close to the submerged object, apparently looking for food amongst epifauna. They are likely to take small mussels in this way. Mussels form part of their diet, as shown by the fact that I have caught several bream, averaging about 500 g in weight, from Angas Inlet and on several occasions have found that their stomachs were full of the remains of mud-mussels.

Mussels of the genus *Mytilus* are encountered frequently in studies of the settlement of fouling organisms. Mussels have been found to settle on solid surfaces exposed for periods of time of the same order as those used in the present study. Such results have been obtained from a variety of locations including the United States (Hewatt, 1935; Graham and Gay, 1945; Fuller, 1946; Shaw, 1967), Europe (Meadows, 1969; Bohle, 1971) and Australia, where the mussels were *Mytilus planulatus* (Allen and Wood, 1950; Wisely, 1959). Thus, despite the fact that *M. planulatus* is rare in the waters around Torrens Island, it is surprising that no individuals were encountered during the experiments, when mussels are found in the ducts. In addition no *M. planulatus* were found on any of the plates suspended at six other locations, four in Angas Inlet and two in the North Arm (section B). It is perhaps worth noting that the plates and frames used in section B of the present study are very similar to those used by Allen and Wood (1950).

In the ducts, *Mytilus* were largely restricted to the patches of *Hydroides norvegica*. This fact suggests that the larvae of mussels settle on a surface that has been fouled, in preference to a clean surface. The larvae of the European mussel *M. edulis* prefer to attach to threadlike material, such as a filamentous algae (de Blok and Geelen, 1958; Bayne, 1964b; Bohle, 1971). Bayne found that after reaching a size of 0.9 to 1.5 mm, the plantigrade larvae detached themselves from the algae and passed through a second planktonic stage before attaching to the adult mussel beds. However, Bohle (1971) found no such secondary settlement. Filamentous algae are frequently found growing on plates suspended in the North Arm and Angas Inlet. Thus, if the larvae of *M. planulatus* show similar behaviour to those of *M. edulis*, the plates should provide a suitable substrate for settlement of *M. planulatus*.

Dr. R. J. MacIntyre of the University of New South Wales has discovered that bundles of hemp rope form particularly favourable sites for the settlement of the larvae of *M. planulatus*. Hemp rope has a number of threads projecting from the main body of the rope. However, one such bundle placed in the North Arm adjacent to the cooling water inlet failed to attract any mussel settlements over a period of about a year.

In a study of the fouling conditions in Newport Harbour, California, Scheer (1945) found that the climax community was dominated by *Mytilus*. However, mussels appeared in reasonable quantities only on plates exposed for twenty weeks or longer and were not abundant even on plates exposed as long as 36 weeks. Hence, in this situation, it would appear that the larvae of *Mytilus* settled only on a surface which was covered by an established fouling fauna. Casual observations would suggest that a similar situation may exist at Torrens Island. In the control troughs, some specimens of *M. planulatus* were noticed in the overflow part of the troughs about 15 months after water started flowing through the troughs. In both cases, this section of the trough was not cleaned during the course of the experiments. Since the mussels were not noticed for a considerable length of time, it is likely that the larvae did not settle in the troughs until a fouling fauna had been allowed several months to become established. The overflow areas of the control troughs are the only places amongst the experimental material in which *M. planulatus* have been found.

After 1972, the extent of fouling in the ducts changed from that which had been recorded previously. A general description of the extent of fouling in 1972 was presented in section 1.2. From 1973, the amount of growth in the ducts has declined considerably, to about one-quarter of the 1972 levels. A significant feature of the fouling fauna found from 1973 onwards has been the predominance of *M. planulatus* over other species. Thus, while most of the other species have declined in abundance in the ducts, *M. planulatus* has held its own and possibly even increased in numbers. These observations add further confusion to the situation regarding the observed occurrence of mussels. The explanation that the larvae of mussels may settle only on a surface which is covered by a fouling fauna that has taken several months to become established is unlikely to apply, since the numbers of other fouling organisms were small. Thus, the complete absence of mussels on the plates becomes more puzzling.

An explanation of these anomalies may perhaps be sought by a consideration of the reaction of the larvae of *Mytilus* to light. Thorson (1964) classified larvae of marine bottom invertebrates into several classes according to their reactions to light. The class containing the greatest number of examples was one in which the larvae are photopositive in the early stages of their planktonic life but, as the time for settlement approaches, their reaction to light reverses. Such larvae will be attracted to the surface for most of their planktonic life. At the surface, the concentration of food (diatoms, flagellates etc.) will be the greatest. When the time to settle comes, the larvae swim downwards, since they are now reacting negatively to light, and settle in preference in shaded areas, particularly the undersurface of submerged objects. On the top and, to a lesser extent, the sides of a submerged object, sessile animals risk being smothered by sediment, particularly when very young. They may also have to compete with algae.

The larvae of *Mytilus edulis* show a similar, though not identical, response to light (Bayne, 1964c). For the greater part of their pelagic life, the larvae show no reaction to light, but exhibit negative geotaxis. However, with the development of a pair of pigmented eyespots, the larvae become photopositive. As settlement approaches, they reverse their reaction to light and settle more readily in the dark than in the light.

If the larvae of *M. planulatus* show a similar reaction, this may help to explain the greater numbers of mussels in the ducts, if it is assumed that most settlement takes place during daylight. This assumption would seem reasonable if the photonegative reaction of the larvae at settlement is an adaptation which enables them to settle in the more favourable locations. The larvae will recognize a favourable location as one in which the light intensity is less than that at nearby locations. When larvae are drawn into the ducts during daylight, they pass from a well-lighted area into one that is completely dark. This change in light is likely to provide a strong stimulus to mature trochophores to settle. Since large quantities of seawater are drawn into the ducts, mussels may settle more commonly there than elsewhere. Hence, the population of mussels in the ducts will be greater, provided that the adverse effects of current speed (see later) and intermittent chlorination are not too great. Once established in the ducts, mussels are, of course, free from predation by fish and crabs.

The same tendency for concentration in the ducts need not apply to other species. Thus, the larvae of barnacles which may settle intertidally (*Balanus amphitrite* is one such species) migrate towards light before settlement (Barnes *et al.*, 1951. Thorson (1964) states that oysters settle more abundantly in the light.

If the extent of fouling in the ducts was the same as that which has been observed in the intermittently dosed trough, one would expect to find the surfaces of the ducts to be completely covered by fouling organisms after an exposure of about a year. The thickness of the growth would be expected to reach about one or two centimetres. However, over the last two years, the ducts have been relatively free from fouling growth.

An obvious difference between the conditions in the duct and the experimental troughs is the rate of flow of water. The average velocity in the troughs was about 5 cm/s while that in the ducts is 1.5 m/s. Wood (1955) examined the effect of the rate of flow of water on settlement with the aid of a rotating disc. He found that *Balanus amphitrite* attached to the disc at water speeds up to 2.0 knots (1.0 m/s), but not at speeds greater than this. Speeds of 1.12 knots (0.58 m/s) largely prevented settlement of *Hydroides norvegica*. Walton Smith (1946) used a similar method but obtained different results. He found that the velocity of water current limiting attachment of *Balanus amphitrite* lay between 0.5 and 0.9 knots (0.26 and 0.46 m/s).

From these results it might appear that the velocity of water flow in the ducts would be too great to permit the settlement of sessile animals, although the velocities in the centres of the ducts will be greater than those along the walls. It has already been mentioned that those animals which are present in the ducts tend to congregate in the vicinity of bends, in crevices and around any irregularities in the surface of the ducts, i.e. in those areas where the flow of water over the surface is locally reduced. It may be that, in the absence of any bends, crevices or irregularities, no animals would settle in the ducts.

Crisp and Barnes (1954) described rugophilic behaviour by the larvae of three species of barnacles. Rugophilic behaviour is the tendency of larvae to settle in grooves and concavities. Orientation of the larvae to grooves was shown to be a tactile response to surface contour. The larvae explored surfaces very extensively before settling, the first to settle usually having located the concavities. Rugophilic behaviour has been found in other species including a stalked barnacle (Barnes and Reece, 1960) and a brachiopod (Wisely, 1969). Such behaviour may allow larvae to attach and metamorphose under conditions when settlement on a flat surface would be prevented by a rapid current. Once the animals have become established on the surface, it would seem likely that a rapid current would have less severe effects. Thus, Walton Smith (1946) found that, while a velocity of flow of behaviour 0.5 and 0.9 knots prevented settlement of *Balanus amphitrite*, currents of up to 1.5 knots (0.77 m/s) increased the growth rates of established barnacles.

While the growth in the ducts has been of only minor consequence from 1973 onwards, as a result of the combined effects of current and intermittent chlorination, the reasons for the decline in the amount of growth after 1972 are not clear. Several explanations are possible. Firstly the chlorine plant has been operating with less interruptions over the last two years. An alternative, but not necessarily mutually exclusive, explanation is that the difference may reflect a fall in the settlement rates of fouling organisms. However, there is no information on the rates of settlement before June, 1971 : those ducts which were examined in 1972 would have been fouled mainly before this date. Nevertheless, it is true that settlement rates may vary from year to year (see section B).

It can happen that a unit will be taken off load for a few days, usually over a weekend, for maintenance. When this happens, the cooling water pumps are usually turned off as well. Over these periods, a number of larvae which will be present in the stagnant water at the appropriate season, may settle and metamorphose in the ducts when the current would normally have prevented them from doing so. This may be of greatest significance at locations in the ducts which are not sheltered from the current. Settlements at such places may provide irregularities which will form the nuclei for later settlement. Similarly, there are occasions when a unit may operate with only one of its cooling water pumps, for a period of up to several weeks, while maintenance work is carried out on the other. The consequent reduction in velocity of water flow in the ducts may allow a greater rate of settlement in the ducts. If either of these two practices vary in frequency from year to year, this may contribute to the yearly variation in the extent of fouling in the ducts.

Although the amount of growth in the ducts has been small recently, the same concentration of fouling organisms in the ducts of 'B' section of the power station may prove troublesome. The first unit of 'B' section was due to commence operation later in 1975. The ducts of 'B' section will be about 600 m in length from the pumps to the condenser, compared with an average length of just less than 100 m in 'A' section. Hence, other factors being equal, the amount of growth in the ducts of 'B' section may be six times greater than that in 'A' section. Thus, while the amount of growth in 'A' section over the past two years has been of minor significance, it would be desirable to find a dose of chlorine that is more effective in reducing fouling. The results of the experiments reported here give hope that a continuous dose which leaves a residual of 0.1 - 0.2 ppm of chlorine in the seawater may achieve the required result. Accordingly, it has been recommended that continuous chlorination be used at the Torrens Island Power Station, initially on a trial basis.

The Electricity Trust has adopted the recommendation that continuous chlorination be used experimentally at the Torrens Island Power Station, and the first unit of 'B' section is being chlorinated continuously.

SECTION B. THERMAL EFFLUENT AND EPIFAUNA

1. Introduction

In recent years, considerable attention has been paid to the possible effects of the release of warmed water from power stations. A variety of studies have been conducted at several different power stations. Many of the studies of the effects of thermal effluent were conducted in freshwater. This concerned particularly the earlier published reports (Mihursky and Kennedy, 1967). However, I shall consider here only marine systems.

One of the earliest investigations consisted of observations on the survival of animals in seawater after its passage through the condensers of power stations (Markowski, 1959, 1962). It was found that all of the animals survived. However, such an experiment is of limited value. Such a result might be obtained even if the thermal effluent was having serious adverse effects on the nearby fauna. The time of exposure to the heated water was only a few minutes in the experiments. The temperatures which are required to kill marine animals during an exposure of a few minutes may be 10^{o}C or more higher than those which will kill the same species after an exposure of several hours (e.g. Foster, 1969). In addition, in some species of fish whose temperature tolerance has been examined, an abrupt rise in temperature, similar to that which might be experienced on passage through condensers, has no additional effect on survival in comparison to a gradual rise in temperature (Fry *et al*, 1946; Brett, 1952). Hence, temperature shock is unlikely to be important, at least in some cases.

Most of the later studies on the effects of thermal effluent have concentrated on fauna surveys, supplemented in some cases by laboratory experiments. The results have depended primarily on the location of the power stations. The warmed water from those power stations located in the cooler and temperate regions of the world has had only minor effects. In cases where some species have been adversely affected, others have benefited. Indeed, there has been an increase in biological activity near the outfall.

Thus, Markowski (1960) found no difference in the specific composition of benthic invertebrates which settled on experimental slabs placed in the intake and outfall water of a power station. However, settlement on the slabs near the outfall began earlier than that near the intake. There was prolific growth of algae near the outfall, whilst none were present near the intake. Near the Marchwood power station (Southampton), attack by the woodborers *Teredo* and *Limnoria* has increased as a result of the increased temperatures there (Pannell *et al.*, 1962; Raymont, 1972). The density of zooplankton has not decreased, while the population of the clam *Mercenaria mercenaria* has shown a marked increase.

Naylor (1965b) followed the changes in the fauna in heated docks at Swansea, South Wales, after a decline in production by a power station. While the power station was operating at full capacity (1956-60), the fauna was particularly rich, with a variety of sessile animals densely crowded on all available surfaces. At least ten exotic species were found. After the decline in production of the power station and the consequent reduction in temperature, some species showed a decline, while some native British species that were not recorded in 1956-60 reappeared.

Investigations into the effect of the Hunterston generating station (Ayrshire, Scotland) revealed some sublethal effects on the nearby fauna inhabiting sandy beaches (Barnett and Hardy, 1969; Barnett, 1971, 1972). Growth rates of the lamellibranch *Tellina tenuis* were slightly greater, but there was no evidence of spawning having been affected. The spawning times of the gastropod *Nassarius reticulatus* were advanced by about three months, compared with a locality not affected by the warmer water. In addition, snails living near the effluent developed lighter shells for a given flesh weight than animals distant from the warm water. The sand-dwelling amphipod *Urothoë brevicornis* also bred earlier and the growth of young animals was more rapid. Another species which spawned earlier than normal was the sand-dwelling copepod *Asellopsis intermedia*. There was a very high mortality amongst the larvae, since they were produced too early in the year when there was an inadequate food supply. Since the larvae are benthic and therefore not readily dispersed, there has been a reduction in the local population of *Asellopsis*.

A further effect of the thermal effluent released by power stations has been to allow the establishment of some species in areas which would normally be too cold. It was mentioned above that Naylor (1965b) had reported the occurrence of at least ten exotic species in docks heated by the effluent of a power station. Crisp and Molesworth (1951) reported the occurrence of the warm-water barnacle *Balanus amphitrite* in areas of Britain. It was found only in the areas affected by the effluent from power stations. Breeding occurred every year and was sufficient to maintain the population.

An interesting situation has been described in relation to the American hard-shell clam *Mercenaria mercenaria* which has become established and is abundant in Southampton Water (Ansell, 1963). Animals were found which spawned at 17.8°C, whereas previously, it was thought that the lowest temperature of spawning was 23.0°C. Thus, the species seems to be adapted to the cooler Southampton Water. A factor in the successful establishment and spread of the clams was the warming effect of cooling water effluent in the area. Thus, a combination of favourable circumstances and evolution has allowed *Mercenaria* to become established in the Southampton area in recent years.

The investigations described above have been conducted in Great Britain. Studies in the cooler areas of the United States of America have produced comparable results. At Morro Bay power plant (California), the influence of the thermal effluent extends up to 2400 metres from the outfall (Adams, 1969). However, changes in the fauna were detected only in the immediate vicinity of the discharge, where there was an increase in the abundance of warm water forms. The community had returned to an essentially normal complement of warm water and cold water forms 150 metres from the discharge.

Warriner and Brehmer (1966) investigated the effects of the effluent from the Virginia Electric and Power Company's generating station (Yorktown, Virginia). They found that primary production was increased during the winter but was depressed in the summer. They obtained evidence that the communities of benthic animals within 300 metres of the discharge were under stress during the summer as a result of the increase in temperature attributed to the power station.

At the Chalk Point power plant (Patuxent River estuary, Maryland), the effect of thermal effluent was investigated by observing the rate of settlement and growth of the epifauna on wooden test panels. One set was submerged near the intake and another in the effluent canal (Cory, 1967; Cory and Nauman, 1969; Nauman and Cory, 1969). The biomass production on the effluent side was nearly three times that of the intake. In the effluent canal, the settlement of sessile organisms began earlier in the season and was larger than that near the intake, but there was little change in the species composition.

A further effect of heated effluent from a power plant in the Patuxent River was reported by Roosenberg (1969). Oysters near the outfall of the power plant started to display a green colour shortly after the commencement of operation. In time, this affliction, caused by the concentration of copper by the oysters, increased in intensity and spread to oysters further removed from the outfall. An increased concentration of copper in the effluent water, due to corrosion of condenser tubes, was thought to be only partly responsible for its accumulation by oysters. Roosenberg states that oysters had been found to accumulate copper under stress and this was considered to be a contributing factor.

Young and Gibson (1973) described a situation which may potentially be very serious. The Atlantic menhaden *Brevoortia tyrannus*, which supports the largest commercial fishery in North America, inhabits estuaries from Massachusetts to Florida during its larval and juvenile stages. In Long Island Sound, the young migrate into oceanic water in August and September. In 1971, the authors observed large schools of migrating juveniles swimming from cool water into the heated surface water which had been discharged from a power plant. Many of the fish suffered immediate thermal shock, sank to the bottom within one minute and died shortly after. This situation needs to be studied in detail to determine the extent of such occurrences.

In tropical waters, thermal effluents would be expected to have more harmful effects than in cooler waters, since tropical animals may be living in water which is only slightly cooler than that which would prove lethal (e.g. Naylor, 1965a). In southern Biscayne Bay, Florida, the Turkey Point power plant has killed marine organisms for more than 1.5 km from the outfall (Johannes, 1970). Roessler (1971) found that in an area of 12 - 20 hectares, corresponding to a temperature elevation of 4 - 5°C, all of the normal green, red and brown algae disappeared and were replaced by a mat of blue-green algae. A reduced number of species and abundance of algae and a lower production of *Thalassia* were noted in an area of about 120 hectares, which corresponds to the area enclosed by the +3°C isotherm. Within the area experiencing an elevation of 4 - 5°C few animals were found. Within the +3°C area, there were fewer species of animals and fewer individuals than normal. This situation will become much more severe in the future since the cooling requirements at Turkey Point are expected to increase by 3½ times.

While most of the studies reported so far have shown that thermal effluent has produced only minor effects on the flora and fauna of marine systems, at least in the cooler waters of the world, the situation needs to be continuously scrutinized in view of the increasing demands for power. Thus, Clark (1969) states that the demand for power in the United States is doubling every ten years. The increase in the numbers of nuclear power plants will add further to any thermal pollution problems, since these plants require about twice the volume of cooling water for a given unit of power production required by a conventional coal-fired or gas-fired station (Naylor, 1965a; Sorge, 1969).

Investigations have begun to determine the effects of the thermal effluent released by the Torrens Island Power Station.

1.1 The situation at Torrens Island - present and future.

Fig. 1.1 shows the location of the Torrens Island Power Station in relation to the surrounding areas. A feature of the area is the shallowness of the water. The maximum depth encountered at low tide is about five metres. Thus, the area which comes under the influence of the thermal effluent is much greater than would be the case at a comparable station located on the open coast.

The shoreline is bounded by mangroves *Avicennia marina* var. *resinifera* (Forst. f.) Bakh, some tracts of which are quite extensive. The sea bottom consists of sandy mud and there are extensive areas of intertidal mud-flats. Despite the fact that the waters form part of a system known as the Port Adelaide River, only a little fresh water enters the area. Hence, the salinity of the water is typical of that of gulf water or slightly greater (36 - 40^{o}/oo).

As was mentioned previously (section A. 1.1), the generating capacity of the Torrens Island Power Station was 480 MW at the time of this study. 22 - 23 m^3/s of seawater are used for cooling and, at full load, this water is raised in temperature by 7.8^{o}C. It is proposed to add a second section. 'B' section, to the present 'A' section of the power station. 'B' section will consist of four generating units, each with a capacity of 200 MW. These altogether will require an amount of cooling

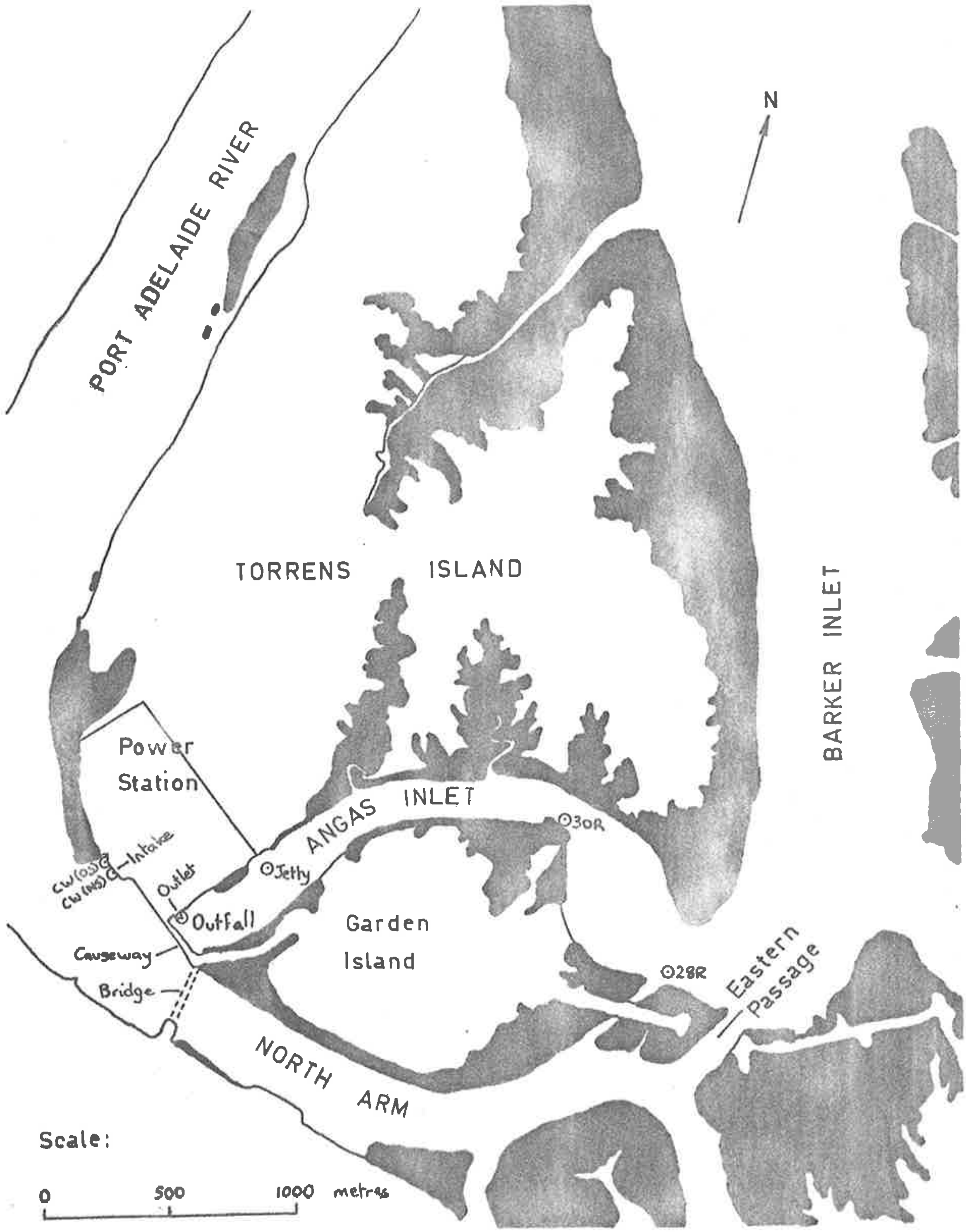

Fig. 1.1 Map showing the location of the Torrens Island Power Station in relation to the surrounding areas. Black areas indicate mangroves. ⊙ Show the positions of the sampling stations.

water roughly equivalent to that used in 'A' section. However, at full load, the water will be raised in temperature by $11.7^{o}C$. The first unit of 'B' section has since commenced operation (early 1976).

Thus, it is important to investigate the effects of the present thermal effluent as a first step in determining if the proposed increase in heat load can be tolerated by the fauna and flora of the area.

2. Materials and methods

The effect of the thermal effluent on the epifauna has been investigated by examining settlement and growth of sessile animals on artificial substrates at several different locations. Frosted glass plates, the same as those used in the work on chlorination (section A. 2.) have been used here also. The plates were suspended in brass frames. Each frame was 49 cm long and held five plates vertically and 7½ cm apart. It was decided to take observations every two weeks and, on each occasion, to examine three plates, one which had been exposed for two weeks, one for four weeks and one for eight weeks.

At each location, the frames were suspended just below the zero tide level. At this depth, they would just remain covered at the times of the lowest low tides likely to be observed. Every two weeks, the frames were raised, the appropriate plates removed and replaced with clean ones and the frames lowered back into the water. The plates which had been collected were examined under a binocular microscope and all animals present were recorded. Dry weights of growth were obtained using a method similar to that described by Cory (1967). This method was the same as that described earlier (section A. 2.) except that one additional procedure was carried out. The plate was weighed after heating at 500°C in the furnace. The loss in weight provided an organic weight. The plates were then cleaned, using the method described in the section A. 2., ready for reuse.

The first observations commenced on 2/6/72. However, observations commenced later at some of the stations. Six sampling stations were used in this study. Their locations and dates of commencement of operation are listed below :

A. In the North Arm :

(1) CW(OS) Station. This station was located in an area of still water about 20 metres from the cooling water intakes. Observations

commenced on 2/6/72. There was a gap in the observations as a result of a mishap in mid-January, 1973. In the two week period between the 3rd and 17th of that month, a broken-off mangrove branch became entangled amongst the frames. A considerable amount of mud accumulated around the frames and the branch, smothering the animals on the plates and killing most of them.

(2) CW(NS) Station. The frames were suspended immediately seawards of the cooling water pumps. They were in an area which experiences greater current speeds than elsewhere as well as a considerable amount of turbulence, as a result of the action of the cooling water pumps. Limited observations commenced on 31/1/73 since only one frame was available. The complete set of frames and plates was suspended in the water on 3/7/73.

B. In Angas Inlet :

(1) Outfall Station. The frames are suspended from an iron structure situated at the point of release of the cooling water. They were first placed in position on 16/8/72.

(2) Jetty Station. The frames are suspended from a small jetty about 400 metres from the outfall. Observations commenced on 2/6/72.

(3) No. 30 Red Beacon (30R) Station. This is a channel marking post, situated about 1610 metres from the outfall. Observations commenced on 6/12/72.

(4) No. 28 Red Beacon (28R) Station. This channel marker is located about 2480 metres from the outfall. The frames were placed in position on 3/7/73.

The locations of the stations in Angas Inlet are shown in Fig. 1.1.

During late February and March, 1973, there was a gap in the observations at all of the stations that were operating at the time, whilst I was ill.

Observations in Angas Inlet terminated in April-May, 1974 (24th April at 30R station, 8th May at 28R station and 22nd May at outfall and jetty stations). At that time, it had been scheduled that the first unit of 'B' section of the power station would commence operation late in 1974. Hence, I had proposed to recommence observations in Angas Inlet during spring of 1974 in order to document any further changes to the epifauna that 'B' section might induce. However, as a result of delays in construction, the first unit did not begin operation until early 1976. Nevertheless, some observations were taken in Angas Inlet, mainly at the jetty station, over the period from mid-November, 1974, to the end of February, 1975. It was thought that if the summer of 1974-5 happened to be unusually hot, this may duplicate the conditions in Angas Inlet when both sections of the power station are operating during a normal summer.

3. The distribution of temperatures and the dispersal of the warmed water.

Fig. 3.1 shows the average weekly inlet and outlet temperatures of cooling water over the two-year period from June, 1972 to May, 1974. The differences between the inlet and outlet temperatures are also shown. At intervals of halfan hour, the inlet and outlet temperatures of the cooling water of each unit are recorded on log sheets. The measurements, which are controlled by computer, are taken with the aid of thermocouples located just before and just after the condensers. The average weekly temperatures were calculated from these data.

It can be seen that the extent of the temperature elevation of the water on passage through the power plant varies little over the course of a year. Thus, the outlet temperatures show a similar pattern of weekly variation to that shown by the inlet temperatures. It might have been expected that the temperature elevation would have been greater in the winter than in the summer, reflecting the greater demand for power. However, the fact that the magnitude of the temperature elevation showed no seasonal variation is not surprising. The Torrens Island Power Station is the most efficient of the Electricity Trust's power-plants and therefore it is operated at full capacity as far as possible. The temperature elevation was a little greater in the second year than in the first year. The average elevation was 6.0^{o}C in the first year and 6.9^{o}C in the second year.

The inlet temperatures during winter and autumn of the second year were generally slightly greater than those observed during the first year. However, there was no consistent difference between the two years in the temperatures recorded over spring and summer. Since the temperature elevation was greater in the second year than in the first year, the difference in outlet temperatures between the two years was more marked. Only in late spring and summer was a consistent difference not evident.

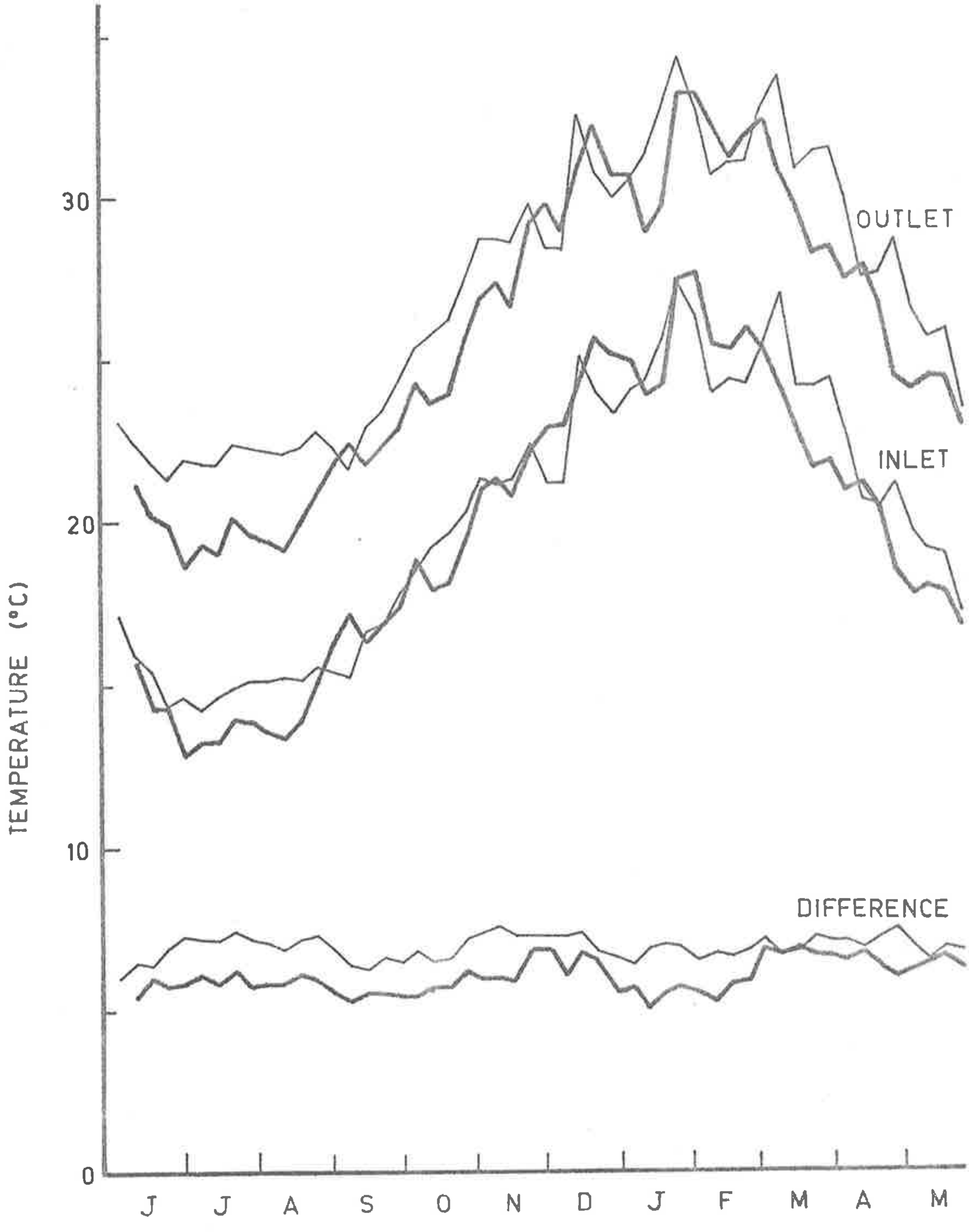

Fig. 3.1 Average weekly inlet and outlet temperatures of cooling water over the period from June, 1972 to May, 1974. The differences between the inlet and outlet temperatures are also shown.

——— June 1972 - May 1973.

——— June 1973 - May 1974.

Even here, it may be noted that the peak of high temperature was greater in the second year than in the first year.

The temperature data on the log sheets over the period from June, 1974 to February, 1975 were not examined in as great detail as during the previous two years. However, it can be said that the inlet temperatures over this period followed a similar pattern to those observed a year earlier up until summer, when temperatures were as much as 4^{o}C less than those of 1973-4. This difference was probably due to a cooler summer in 1974-5.

I shall turn now to consider the dispersal of the warmed water after it has left the power station. In September, 1972, three temperature surveys were conducted in Angas Inlet and surrounding waters. Temperatures were measured at intervals down Angas Inlet and also in Barker Inlet, Eastern Passage and North Arm. At each location, measurements were taken at the surface and the bottom and at intermediate depths one metre apart using the temperature scale on a QMI portable dissolved oxygen metre, model QM 10T. From the data, temperature profiles in Angas Inlet were drawn. These are shown in Fig. 3.2. The profile of the sea bottom was drawn from the measurements of depth taken at each location at which temperatures were measured. The fact that this profile differed in each of the surveys would indicate that the bottom of Angas Inlet is rather uneven.

It can be seen that some stratification was present. In addition, all of the water in Angas Inlet was at a higher temperature than would have been observed in the absence of the power station because the outlet temperature was about 6-7^{o}C above intake temperature. Each of these surveys was conducted during the latter half of the ebb-tide. It may be expected that, at high tide, both the degree of the temperature stratification in Angas Inlet and the rate of decline in temperature with distance from the outlet would be greater.

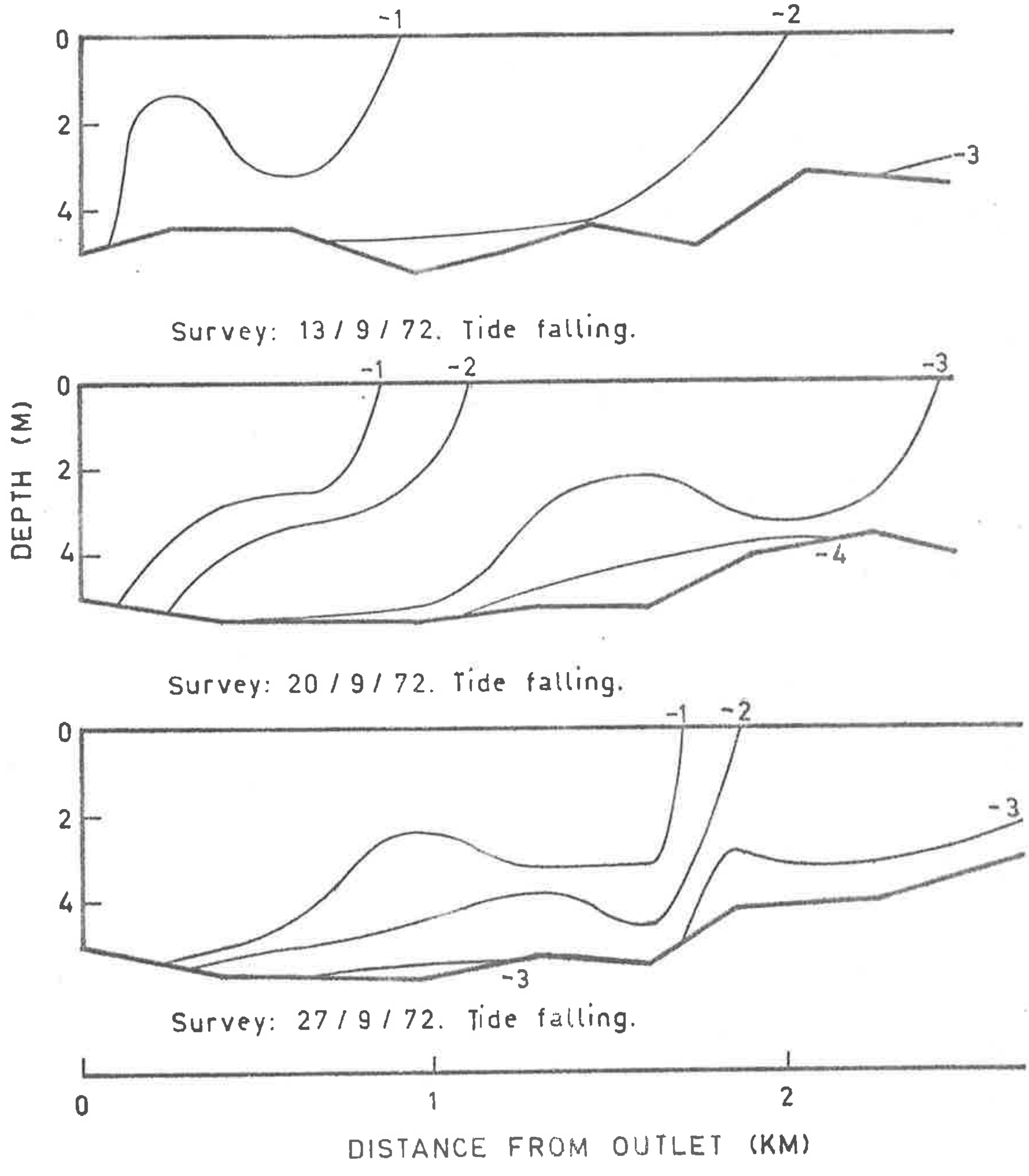

Fig. 3.2 Temperature profiles observed in Angas Inlet during early spring, 1972. Isotherms are shown in relation to the highest temperature observed during each survey.

It was discovered during these surveys that warmed water was recirculating to the cooling water inlet via Eastern Passage and North Arm. On 13/9 and 27/9, on entering Barker Inlet from Angas Inlet, an abrupt drop in temperature was found. However, when proceeding into Eastern Passage and then down North Arm, it was found that the temperature fell only gradually. There was a very rapid current flowing through Eastern Passage from Angas Inlet to North Arm and a current flowing down North Arm towards the cooling water inlet. The results on 20/9 were different. On this occasion, some of the warmed water dispersed northwards along Barker Inlet, while the rest flowed into Eastern Passage and North Arm.

A report presenting these results was submitted to the Electricity Trust and caused some concern. It had been previously assumed that all of the warmed water dispersed northwards along Barket Inlet. As well as compounding any possible damage to the environment, recirculation also affects the operation of the power station, since the units operate more efficiently the lower the temperature of the cooling water. The Electricity Trust decided that recirculation should be investigated in greater detail and mechanical design section were entrusted with this task. Design section have since conducted a number of temperature surveys of the waters around Torrens Island. However, most of their measurements have been taken in areas outside of Angas Inlet, except for a section of the eastern end (in the vicinity of post 28R).

However, mechanical design section did conduct several surveys of Angas Inlet on 3/4/73. Temperature profiles drawn from these results are shown in Fig. 3.3. In that part of Angas Inlet between about 400 and 1200 metres from the outlet, several hundred small boats are moored. In taking the surveys, design section skirted around the boats instead of proceeding down the middle of Angas Inlet amongst the boats, where the water is deeper. As would be expected, temperature stratification was more evident when the tide was higher. Similarly, the rate of decline

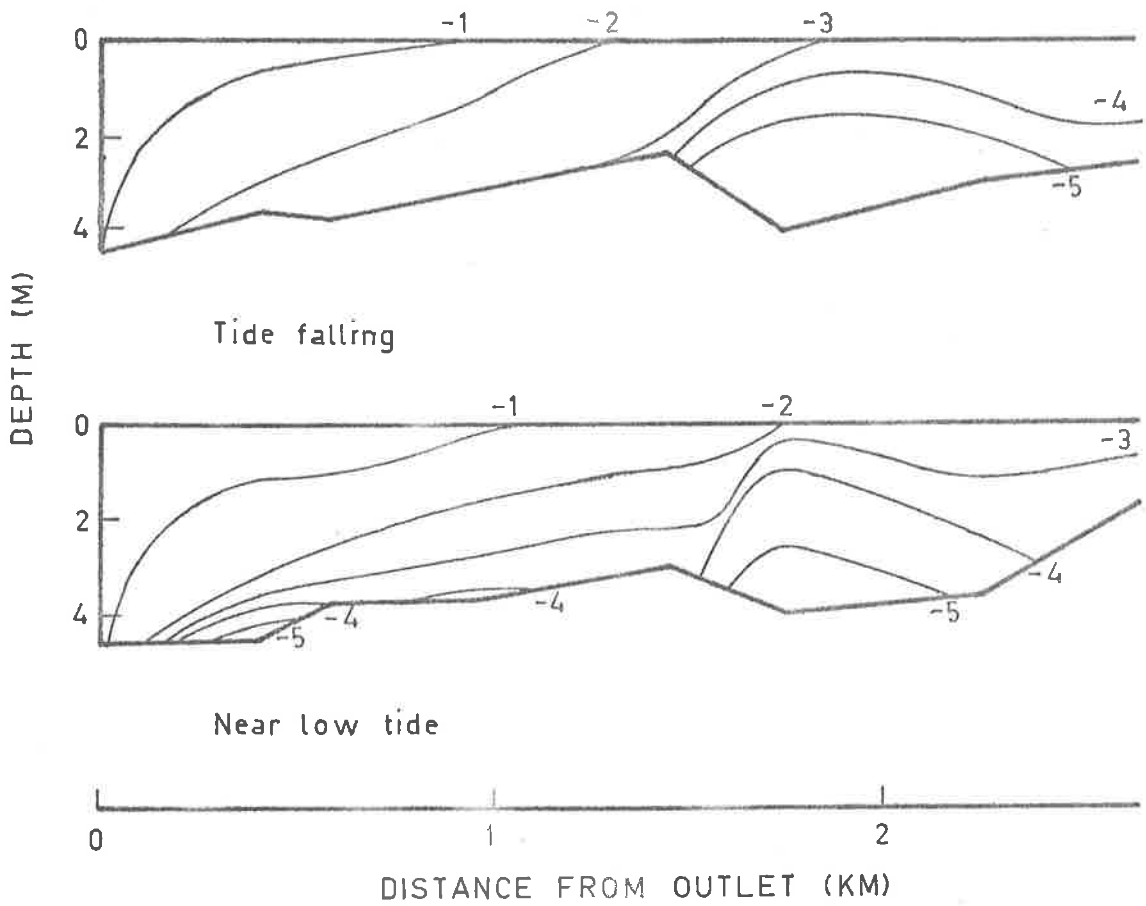

Fig. 3.3 Temperature profiles observed in Angas Inlet on 3/4/73. Isotherms are shown in relation to the highest temperature observed during each survey.

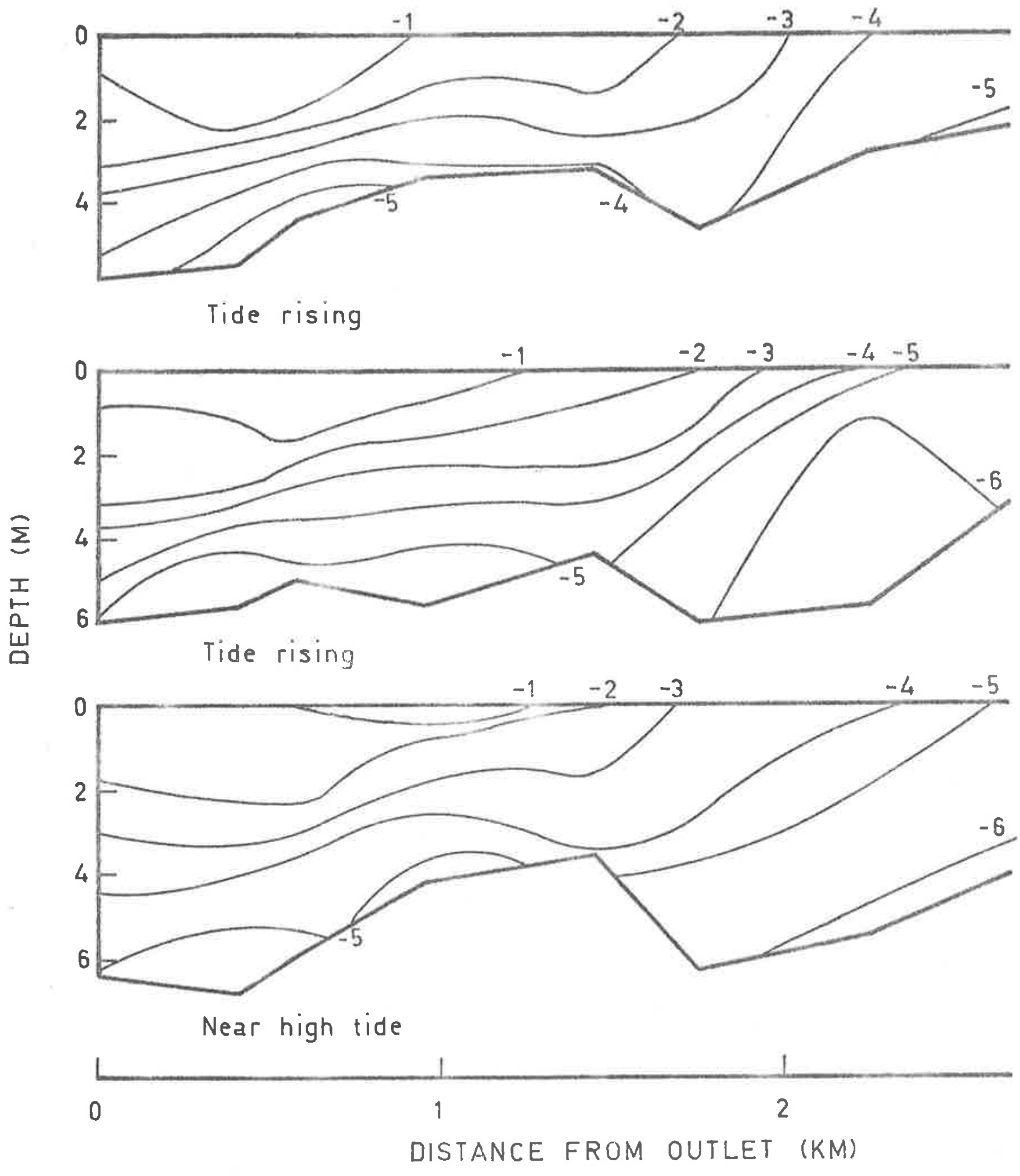
-1
-2
-3
-4
-5
-5
-4
Tide rising
-1
-2
-3
-4
-5
-6
-5
Tide rising
-1
-2
-3
-4
-5
-6
-5
Near high tide
DEPTH (M)
0
2
4
6
0
1
2
DISTANCE FROM OUTLET (KM)

Fig. 3.3 (cont.)

in temperature with distance from the outlet increased as the tide rose.

In late winter and early spring of 1973, some surveys were conducted by Messrs. P. Zed and B. Gepp of the Department of Zoology, University of Adelaide. The results of their surveys are shown in Figs. 3.4 and 3.5. The results show similar trends to those obtained previously (Figs. 3.2 and 3.3), except on 8th of September. On this occasion, cooler surface water was observed in the eastern part of Angas Inlet. The salinity of this water was lower than that of the water elsewhere in Angas Inlet (about $32^{o}/oo$ compared with $36\text{-}36.5^{o}/oo$). This lower salinity water was traced to Barker Inlet, into which the Little Para River empties near Swan Alley Creek. This river is quite small and consequently, the volume of fresh water which flows into Barker Inlet will also be small. The rainfall during the winter of 1973 was considerably higher than normal and hence the occurrence of a significant volume of lower salinity water in Barker Inlet would be comparatively rare.

Since the rate of decline in temperature with distance from the outlet varies, estimates of the difference in temperature between the different sampling stations in Angas Inlet (section B,2.) may not be reliable if the data from Figs. 3.2 - 3.5 were considered by themselves. However, design department conducted surveys on a total of 21 days over the period from 27/6/73 to 12/9/74. On each occasion, at least five surveys were taken. The average temperatures at 28R station were calculated for each set of surveys, at the depth at which the plates were located. These temperatures were then compared with the data on the log sheets. Thus, it was found that the temperatures at 28R station averaged $4.5^{o}C$ less than the outlet temperatures, with extreme average differences of 3.3^{o} and $5.8^{o}C$. Extrapolating from this figure, and considering the results shown in Figs. 3.2 - 3.5, it seems that the temperature at the jetty station may be, on average, about $1^{o}C$ less than that at the outlet and that at 30R station may be about $3^{o}C$ less than the outlet.

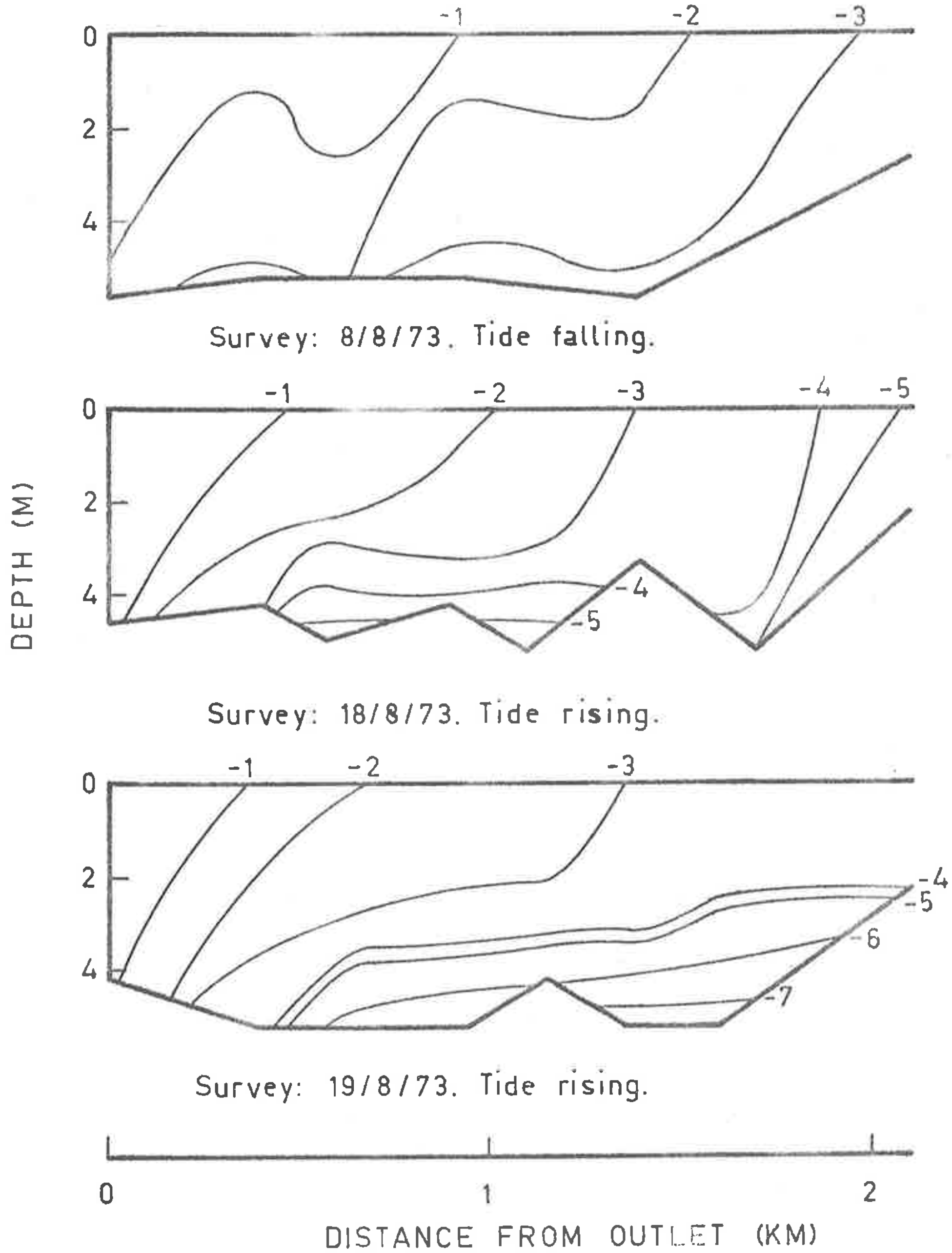

Fig. 3.4 Temperature profiles observed in Angas Inlet during late winter, 1973. Isotherms are shown in relation to the highest temperature observed during each survey.

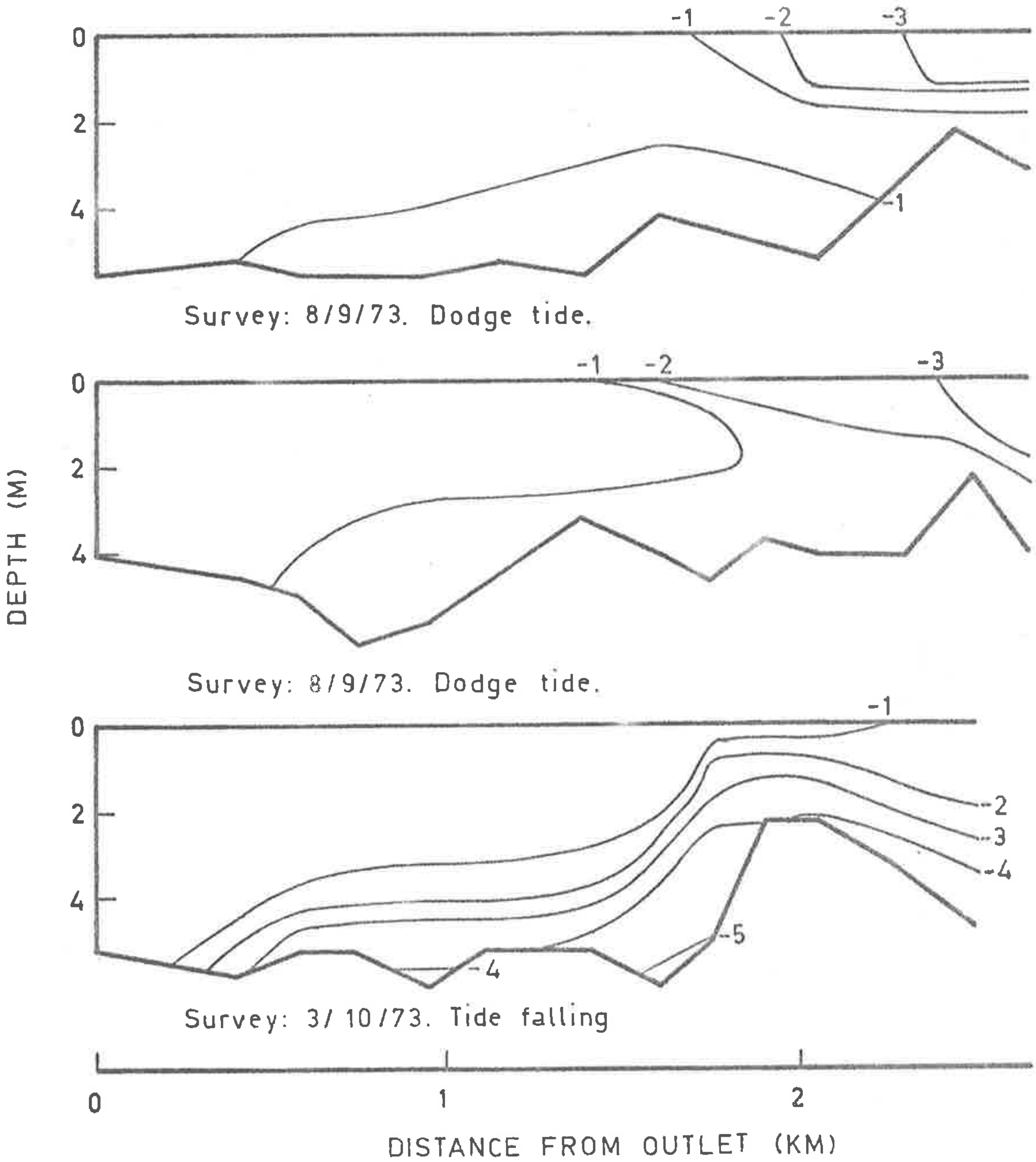

Fig. 3.5 Temperature profiles observed in Angas Inlet during early spring, 1973. Isotherms are shown in relation to the highest temperature observed during each survey.

The results obtained by design department confirm that warmed water recirculates towards the cooling water inlet. Recirculation is most obvious at times of maximum tidal movement. At dodge tide and times when tidal currents are slow, water disperses northwards along Barker Inlet as well as flowing into North Arm.

4. Results

4.1 Weights of growth

The complete results on weights of growth are listed in appendix 1. Consideration of the data was complicated by the fact that observations commenced at different times at the different stations and there were some gaps in the observations. The data were separated into several groups, mainly on the basis of these complications. Analyses of variance were conducted on each of the groups separately, with the aim of comparing differences between the stations in the amount of growth.

(a) Two-week plates

The first group consisted of the CW(OS), Outfall and Jetty stations and covered the period from 30/8/72, when observations at the Outfall station started, to 4/7/73 (i.e. just before observations at the 28R station started). A summary of the analyses of variance is shown in table 4.1. In the analyses, it was necessary to use the method for the special case where one value is missing from a randomized block design (Sokal and Rohlf, 1969). As would be expected, seasonal differences were highly significant, with growth being greatest in spring and summer. Differences between stations were also significant. Decomposition of the locations sum of squares allowed the appropriate *a priori* comparisons to be made. These comparisons revealed a highly significant difference in the amounts of growth at the CW(OS) station compared with the stations in Angas Inlet : the amount of growth on plates from Angas Inlet was greater than that on the plates from CW(OS) station. In Angas Inlet, total weights of growth at the Outfall station were just significantly greater, at the 5% level, than those at the Jetty station. However, there was no significant difference in organic weights between these two stations. The data from the 30R station were not included in the analyses, since observations commenced later at this station. However, after perusal of the data, it would seem that the weights obtained were consistent with the

Table 4.1 Summary of the analyses of variance conducted on the data on weights of growth on two-week plates from the CW(OS), Outfall and Jetty stations over the period 30/8/72 - 4/7/73. The data were transformed to logarithms.

(a) Total weights of growth.

($F_{max}(3,19) = 15.6$, $P<0.01$; after transformation, $F_{max}(3,19) = 1.65$).

Source of variation	df	SS	Corr.SS	MS	Fs	P
Locations	2	1.452	1.390	0.695	15.8	<0.001
CW(OS) v. others	1	1.257		1.257	28.8	<0.001
Outfall v. Jetty	1	0.194		0.194	4.43	0.025<P<0.05
Time	19	9.946	9.915	0.522	11.9	<0.001
Remainder	37	1.623		0.0439		
	58	13.021				

(b) Organic weights

($F_{max}(3,19) = 9.30$, $P<0.01$; after transformation, $F_{max}(3,19) = 1.81$).

Source of variation	df	SS	Corr.SS	MS	Fs	P
Locations	2	1.763	1.656	0.828	12.7	<0.001
CW(OS) v. others	1	1.584		1.584	24.4	<0.001
Outfall v. Jetty	1	0.179		0.179	2.75	N.S.
Time	19	11.882	11.774	0.620	9.54	<0.001
Remainder	37	2.404		0.0650		
	58	16.049				

results of the analyses. Similarly, the data obtained before 30/8/72, when only the CW(OS) and Jetty stations were in operation, were consistent with the conclusions drawn. The difference in weights of growth between Angas Inlet and North Arm is illustrated in Figs. 4.1 and 4.2, which show the weights of growth obtained on plates from the CW(OS) and Jetty stations during the first year of the study.

The second group for consideration comprised all stations, except CW(NS) station, and extended over the period from 18/7/73 to 24/4/74. Although some observations continued after this date, 24/4/74 was the last occasion when measurements were taken at all of the stations. The analyses of variance are summarized in table 4.2. Once again, seasonal differences were highly significant. However, on this occasion there were no significant differences in weights of growth between the stations.

Next, a comparison was made of the amount of growth on plates from the CW(OS) and CW(NS) stations. The first analyses were conducted on data obtained during the period 31/1/73, when observations at the CW(NS) station commenced, to 16/1/74. The results from the CW(NS) station were not considered during the period from mid-January to April, 1974, since the bryozoan *Zoobotryon verticillatum* covered the frames and plates at that time (see later, section 4.2(b)). A summary of the analyses are shown in table 4.3. Differences between the two stations are statistically significant, showing that the faster current at the CW(NS) station has increased the amount of growth. Figs. 4.3 and 4.4 show the weights of growth on two-week plates from the CW(OS) and CW(NS) stations during the second year of the study. The effect of the faster current at the CW(NS) station can be clearly seen.

A second set of frames and plates was placed at the CW(NS) station late in Arpil, 1974. Observations continued until 19/12/74. After this date, *Zoobotryon* again covered the frames and plates. A summary of the analyses of variance comparing the weights of growth at the CW(NS) and

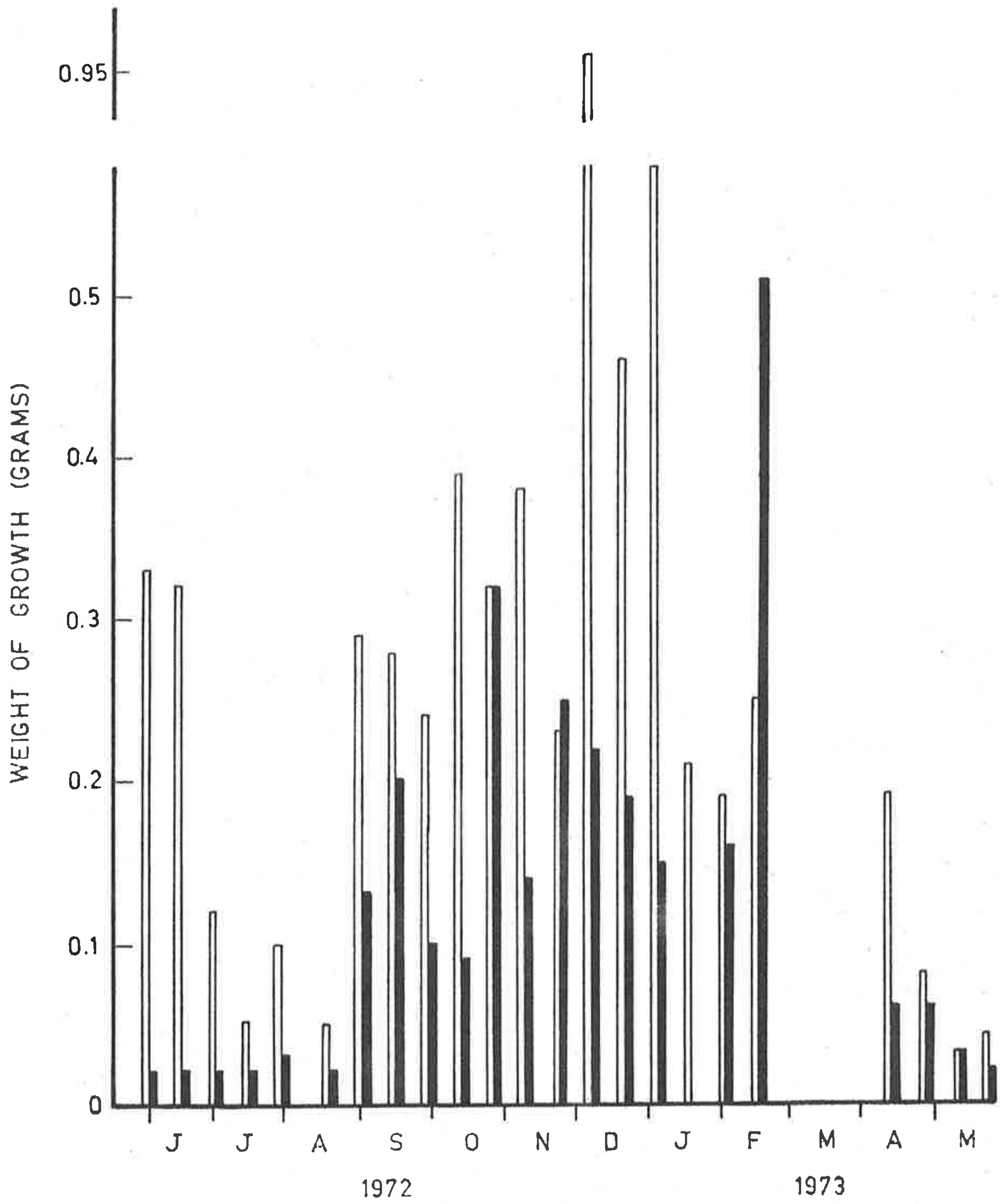

Fig. 4.1 Total weights of growth on 2-week plates from the CW(OS) and Jetty stations over the period from June, 1972 to May, ~~1974~~. 1973

CW(OS) station

Jetty station

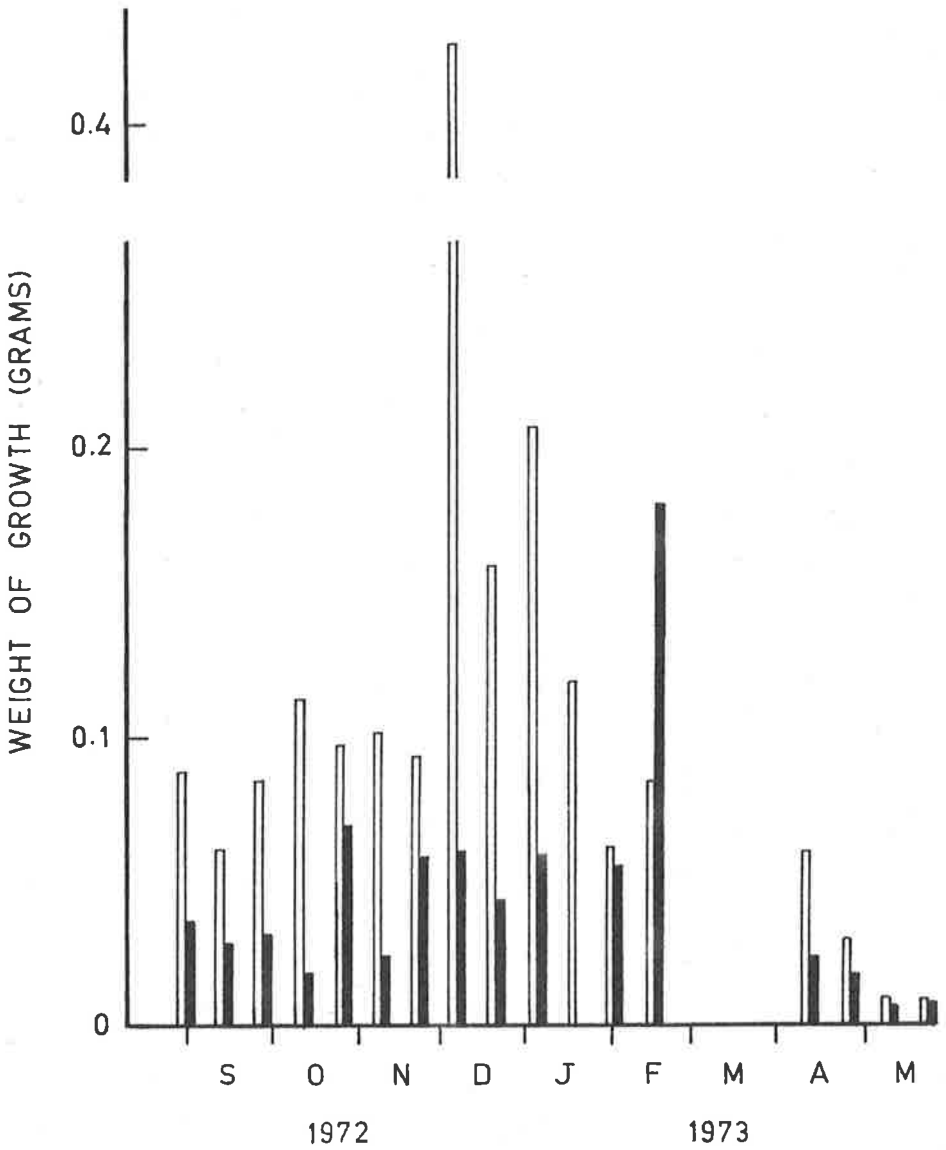

Fig. 4.2 Organic weights of growth on 2-week plates from the CW(OS) and Jetty stations over the period from September, 1972 to May, 1973.

CW(OS) station

Jetty station

Table 4.2 Summary of the analyses of variance conducted on the data on weights of growth on two-week plates from all stations, except CW(NS), over the period 18/7/73 - 24/4/74. The data were transformed to logarithms.

(a) Total weight of growth.

Fmax(5,20) = 6.44, P<0.01; after transformation,

Fmax(5,20) = 1.93.

Source of variation	df	SS	MS	Fs	P
Location	4	0.1325	0.0331	<1	N.S.
Time	20	18.070	0.9035	14.2	< 0.001
Remainder	80	5.079	0.0635		
	104	23.282			

(b) Organic weights

Fmax(5,20) = 3.84, 0.01<P<0.05; after transformation,

Fmax(5,20) = 1.92

Source of variation	df	SS	MS	Fs	P
Location	4	0.2438	0.2438	1.01	N.S.
CW(OS) v. others	1	0.0013	0.0013	<1	N.S.
Amongst others	3	0.2425	0.0808	1.29	N.S.
Time	20	19.382	0.969	16.1	<0.001
Remainder	80	4.821	0.0603		
	104	24.447			

Table 4.3 Summary of the analyses of variance on the data on weights of growth on 2-week plates from the CW(OS) and CW(NS) stations over the period from 31/1/73 - 16/1/74. The data were transformed to logarithms.

(a) Total weights of growth.

$F(21,21) = 5.05$, $P<0.002$; after transformation, $F(21,21) = 1.04$.

Source of variation	df	SS	MS	Fs	P
Place	1	0.638	0.638	10.3	$0.001<P<0.005$
Time	21	18.134	0.864	13.9	<0.001
Remainder	21	1.307	0.0622		
	43	20.079			

(b) Organic weights

$F(21,21) = 6.13$, $P<0.002$; after transformation, $F(21,21) = 1.71$

Source of variation	df	SS	MS	Fs	P
Place	1	0.666	0.666	8.17	$0.005<P<0.01$
Time	21	20.327	0.968	11.89	<0.001
Remainder	21	1.710	0.0814		
	43	22.703			

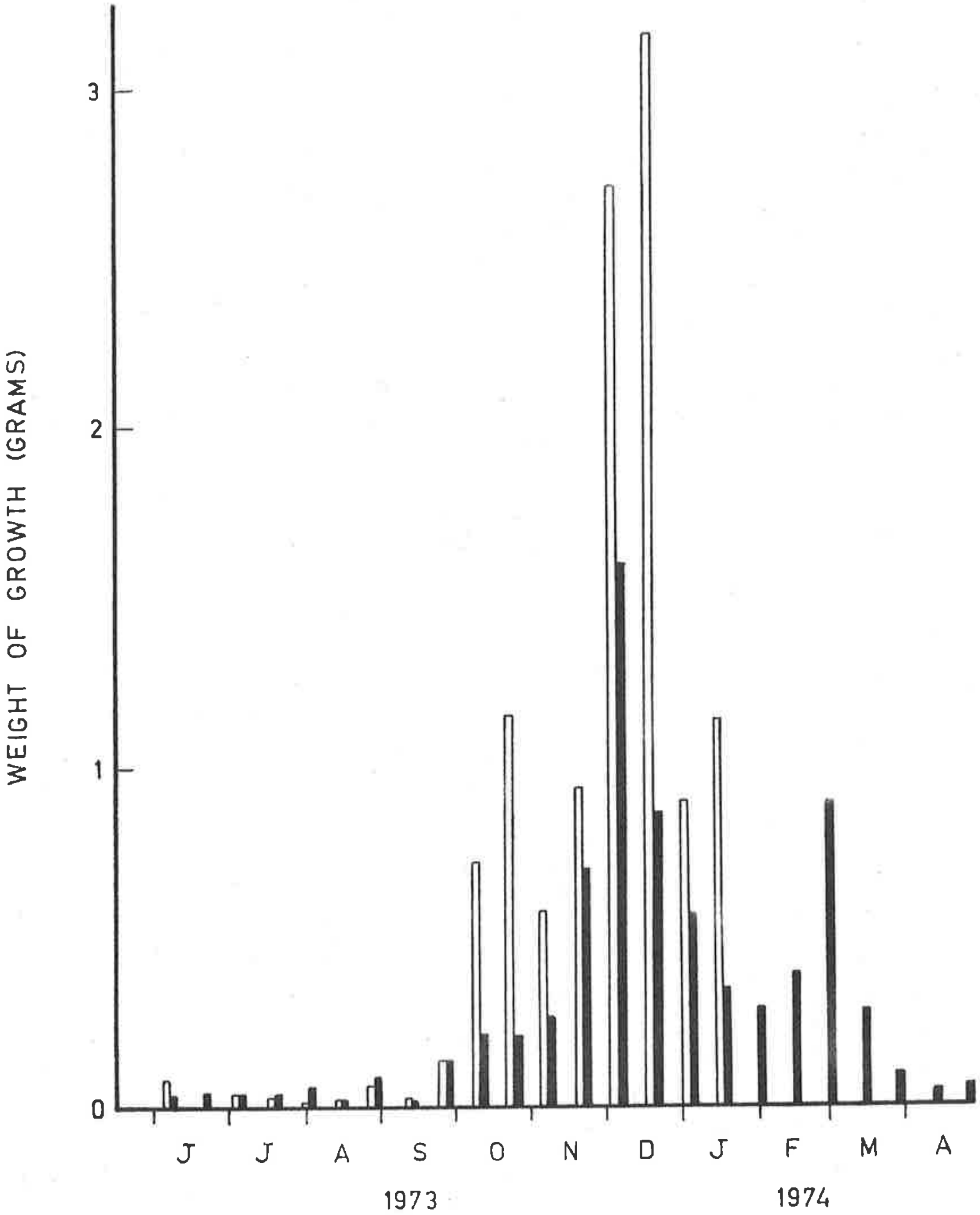

Fig. 4.3 Total weights of growth on 2-week plates from the CW(OS) station over the period from June, 1973 to April, 1974 and from the CW(NS) station over the period June, 1973 to mid-January, 1974.

CW(OS) station

CW(NS) station

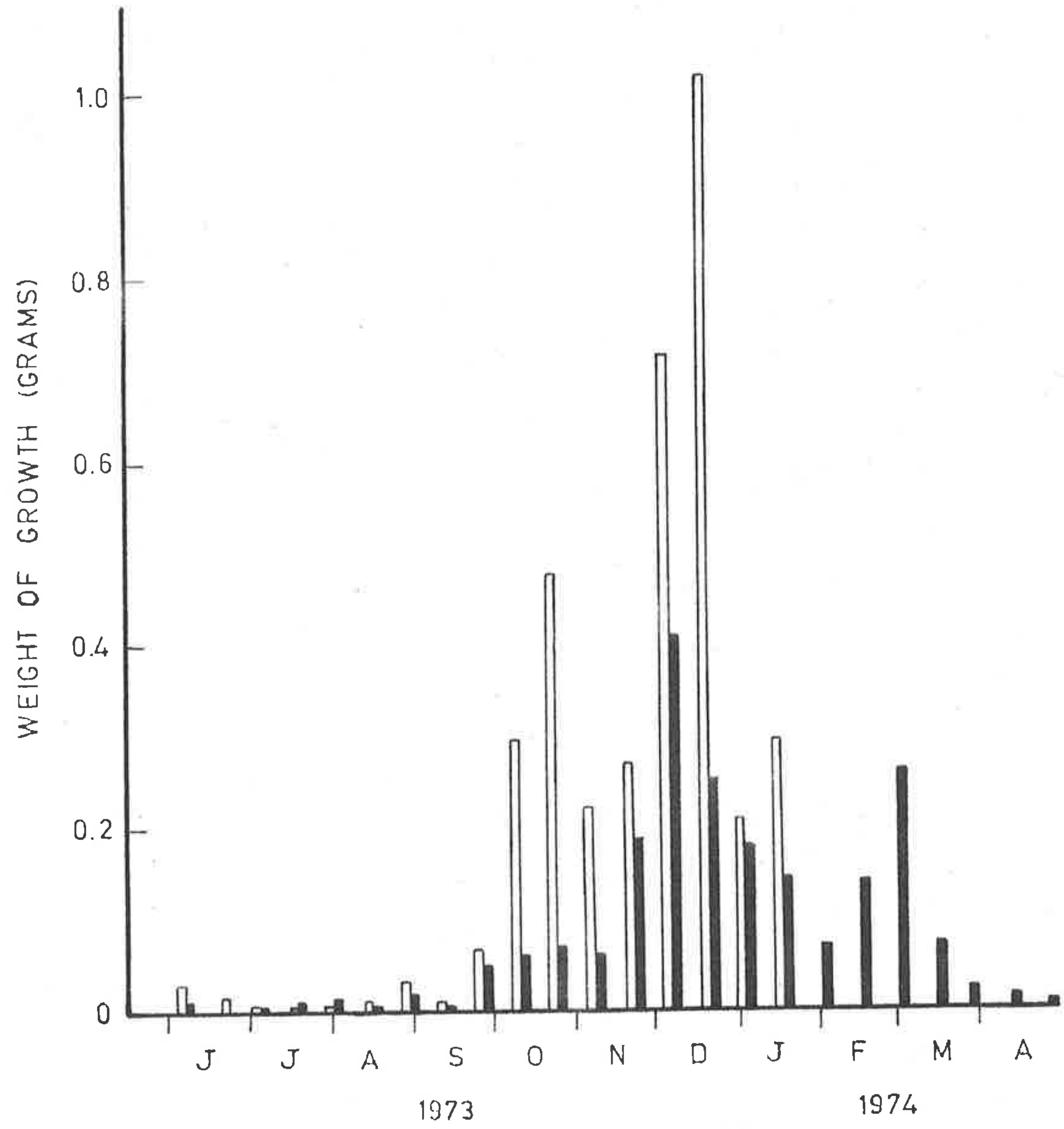

Fig. 4.4 Organic weights of growth on 2-week plates from the CW(OS) station over the period from June, 1973 to April, 1974 and from the CW(NS) station over the period June, 1973 to mid-January, 1974.

CW(OS) station

CW(NS) station

CW(OS) station during 1974 is shown in table 4.4. The results of the analyses again showed that the weights of growth at the CW(NS) station were significantly greater than those at the CW(OS) station. This difference is illustrated in Figs. 4.5 and 4.6.

Finally, the weights of growth at the Jetty station during late spring and summer of 1974-75 were compared with those at the CW(OS) station (table 4.5). It would appear that the amount of growth in Angas Inlet during this period was greater than that at the CW(OS) station. The two sets of data obtained from the Outfall station (see Appendix 1(a)) are consistent with this conclusion. The greater weights of growth at the Jetty station over this period are illustrated in Figs. 4.5 and 4.6.

(b) Four-week plates

The first section for analysis covered the period from 13/9/72 to 3/1/73 and consisted of the CW(OS), Outfall and Jetty stations. Table 4.6 presents a summary of the analyses of variance. The analyses showed that both total weights and organic weights of growth at the CW(OS) station were significantly less than those at the stations in Angas Inlet. There was no significant difference between the two stations in Angas Inlet. Figs. 4.7 and 4.8 show the weights of growth obtained on four-week plates from the CW(OS) and Jetty stations during the first year. Comparing these diagrams with Figs. 4.1 and 4.2 it appears that the differences between the CW(OS) and Jetty stations were a little less marked on four-week plates than on two-week plates.

From mid-January to mid-April, 1973, only one observation was taken at the CW(OS) station. Hence, the results over this period provided little information on the effects of the warmed water on growth rate.

The next group of results extended over the cooler months of 1973, from 26/4 to 26/9, and included the CW(OS), Outfall, Jetty and 30R stations. A summary of the analyses of variance is shown in table 4.7. On this occasion, it was again necessary to use the method for the special case of a missing value in a randomized block design. There was

Table 4.4 Summary of the analyses of variance conducted on the data on weights of growth on 2-week plates from the CW(OS) and CW(NS) stations over the period from 8/5/74 - 19/12/74. The data were converted to logarithms.

(a) Total weights of growth.

$F(15,15) = 32.7$, $P<0.002$; after transformation, $F(15,15) = 2.15$.

Source of variation	df	SS	MS	Fs	P
Place	1	.9695	.9695	11.3	$0.001<P<0.005$
Time	15	8.0585	.5372	6.28	<0.001
Remainder	15	1.2839	.0856		
	31	10.3120			

(b) Organic weights

$F(14,14) = 135$, $P<0.002$; after transformation, $F(14,14) = 2.06$.

Source of variation	df	SS	MS	Fs	P
Place	1	1.7744	1.774	22.4	<0.001
Time	14	7.1543	0.511	6.45	<0.001
Remainder	14	1.1094	0.0792		
	29	10.0381			

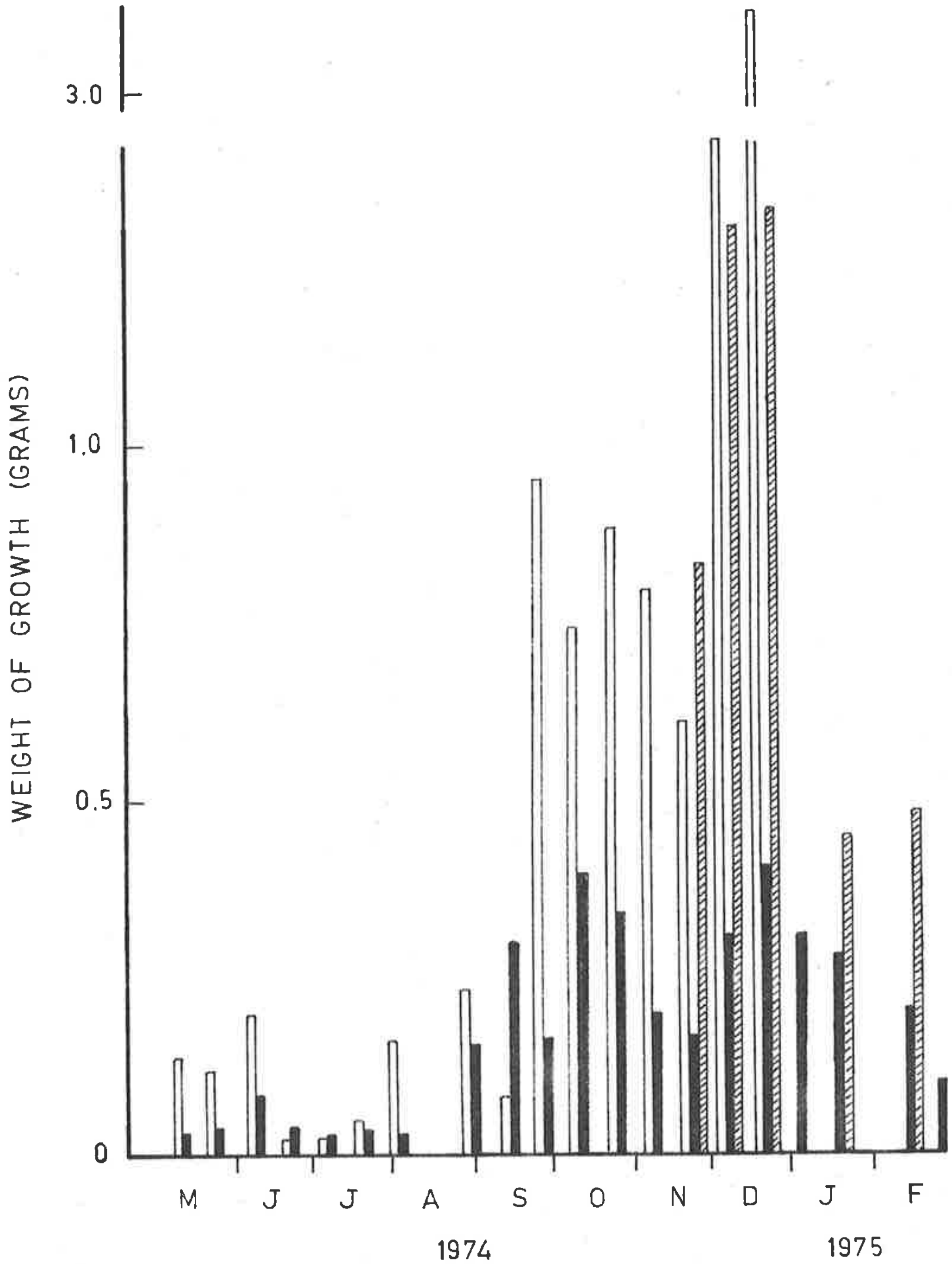

Fig. 4.5 Total weights of growth on 2-week plates from the CW(OS) station during May, 1974 to February, 1975, the CW(NS) station during May-December, 1974 and the Jetty station during November, 1974 to February, 1975.

CW(OS) station

CW(NS) station

Jetty station

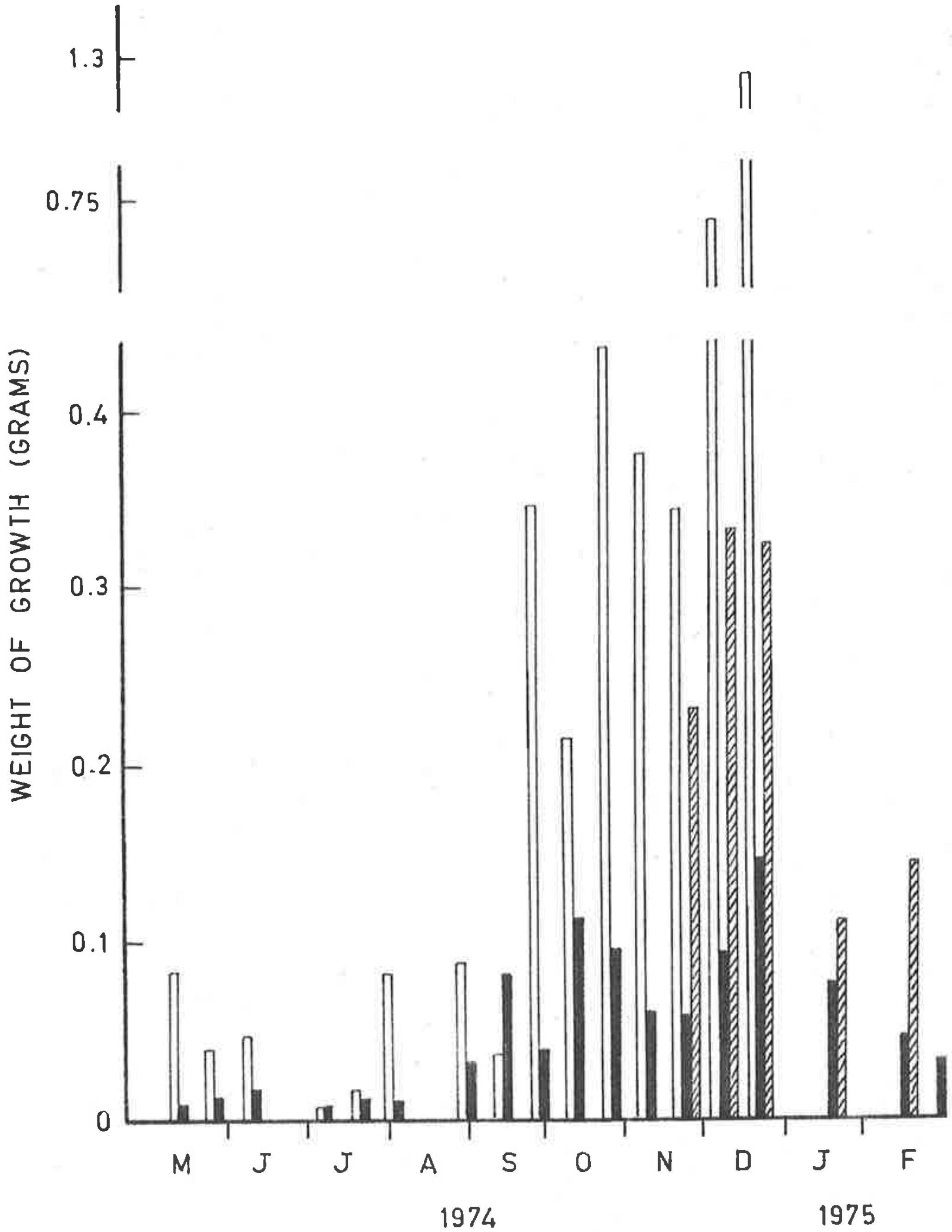

Fig. 4.6 Organic weights of growth on 2-week plates from the CW(OS) station during May, 1974 to February, 1975, the CW(NS) station during May-December, 1974 and the Jetty station during November, 1974 to February, 1975.

CW(OS) station

CW(NS) station

Jetty station

Table 4.5 Summary of the analyses of variance conducted on the data on weights of growth on two-week plates from the CW(OS) and Jetty stations over the period from 21/11/74 - 13/2/75.

(a) Total weights of growth.

$F(4,4) = 21.2$, $0.01 < P < 0.02$; hence the data were converted to logarithms $(F4,4) = 2.35)$.

Source of variation	df	SS	MS	Fs	P
Place	1	.5794	.5794	31.5	<0.005
Time	4	.2211	.0553	3.00	N.S.
Remainder	4	.0736	.0184		
	9	.8740			

(b) Organic weights. $F(4,4) = 6.99$.

Source of variation	df	SS	MS	Fs	P
Place	1	51123	51123	16.3	0.01<P<0.025
Time	4	33557	8389	2.67	N.S.
Remainder	4	12575	3144		
	9	97255			

Table 4.6 Summary of the analyses of variance conducted on the data on weights of growth on four-week plates from the CW(OS), Outfall and Jetty stations over the period 13/9/72 - 3/1/73. The data were transformed to logarithms.

(a) Total weights of growth.

Fmax (3.8) = 67.3, P<0.01; after transformation, Fmax(3,8) = 5.05.

Source of variation	df	SS	MS	Fs	P
Location	2	0.3300	0.1650	2.63	N.S.
CW(OS) v. other	1	0.2480	0.2480	4.52	0.025<P<0.05
Outfall v. Jetty	1	0.0460	0.0460	<1	N.S.
Time	8	1.9483	0.2435	3.88	0.01<P<0.025
Remainder	16	1.0047	0.0628		
	26	3.2830			

(b) Organic weights.

Fmax(3,8) = 25.9, P<0.01; after transformation, Fmax(3,8) = 3.39.

Source of variation	df	SS	MS	Fs	P
Location	2	0.7904	0.3952	5.57	0.01<P<0.025
CW(OS) v. others	1	0.7757	0.7757	10.9	0.001<P<0.01
Outfall v. Jetty	1	0.0147	0.0147	<1	N.S.
Time	8	2.0555	0.2569	3.62	0.01<P<0.025
Remainder	16	1.1439	0.0709		
	26	3.9808			

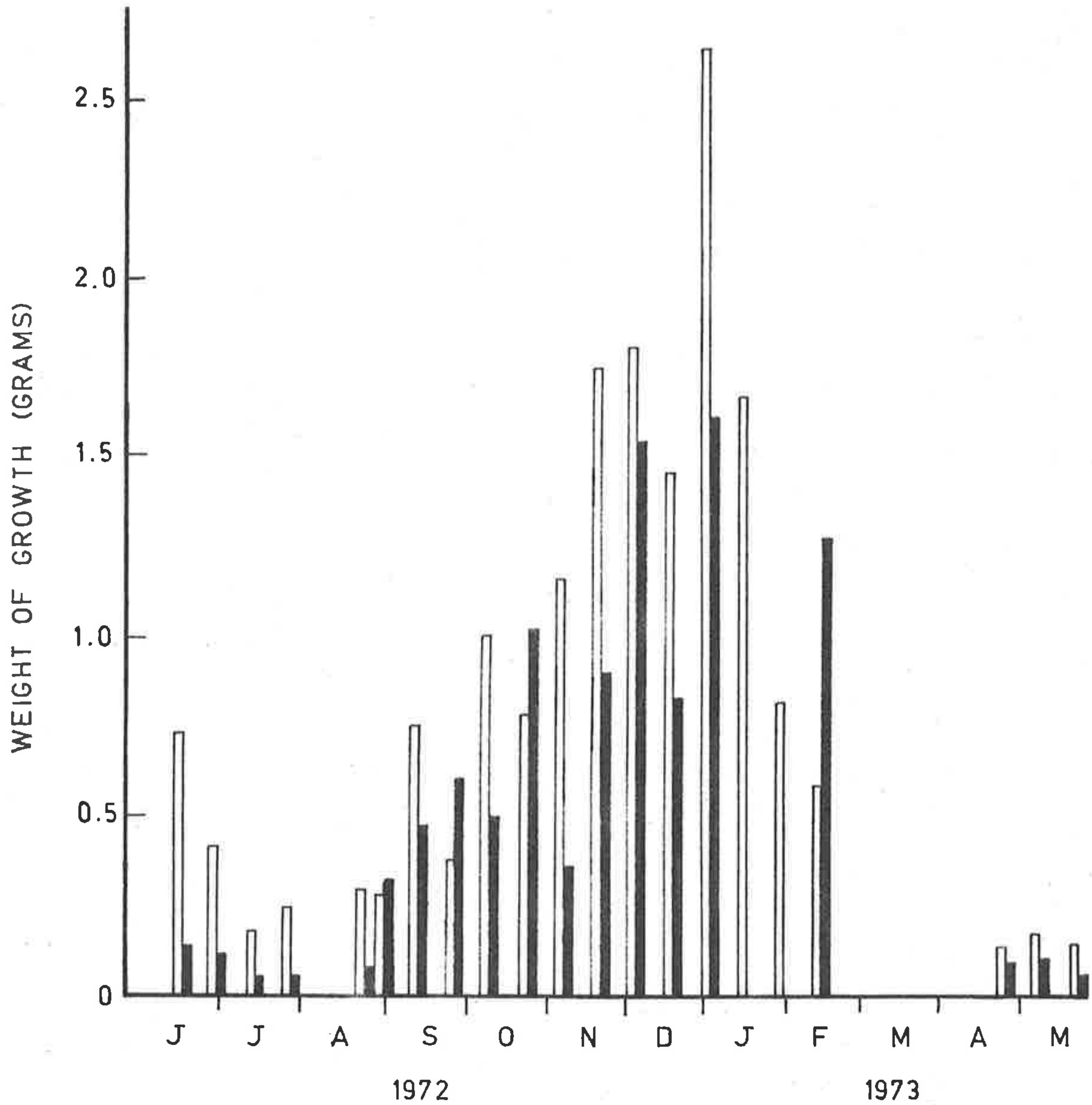

Fig. 4.7 Total weights of growth on 4-week plates from the CW(OS) and Jetty stations over the period from June, 1972 to May, 1973.

CW(OS) station

Jetty station

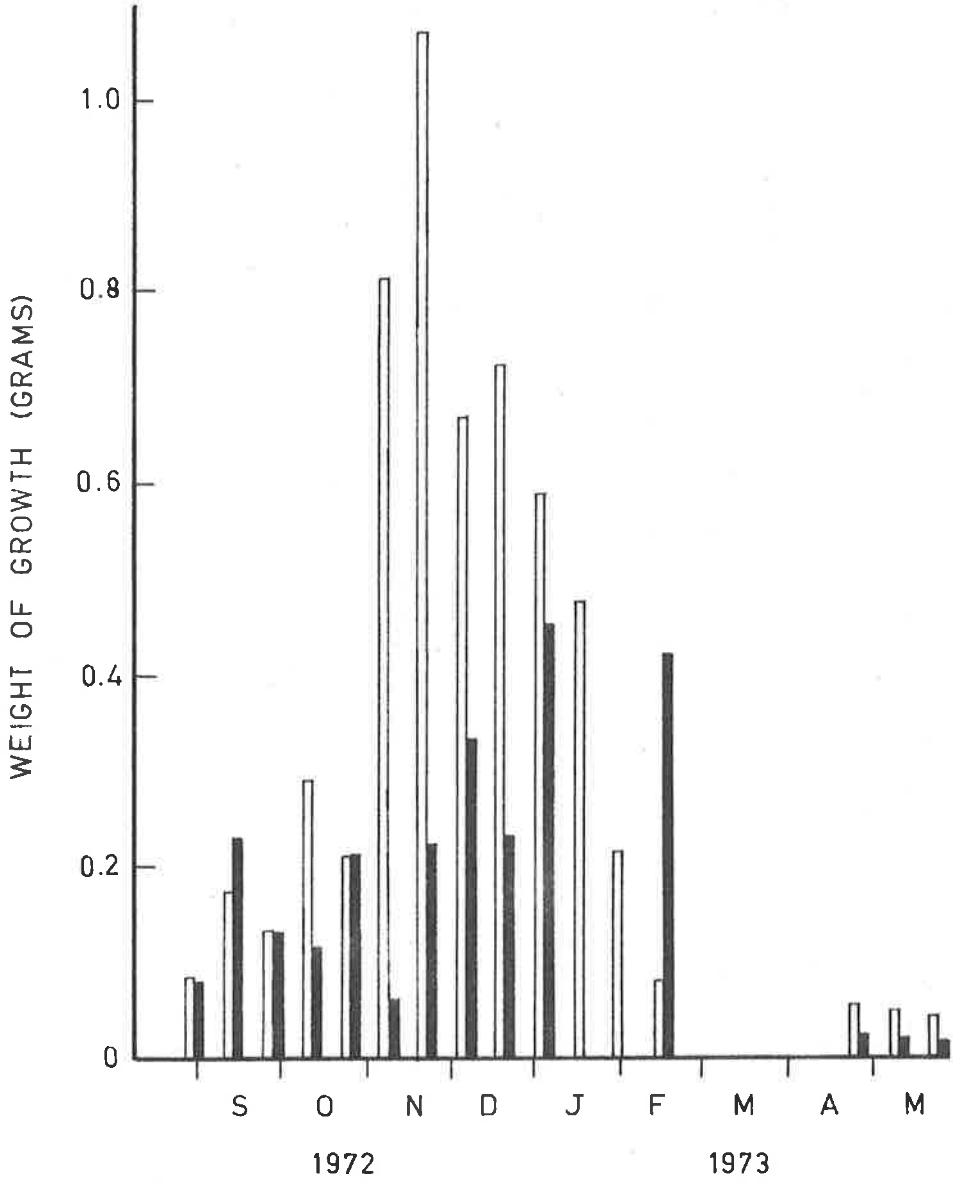

Fig. 4.8 Organic weights of growth on 4-week plates from the CW(OS) and Jetty stations over the period from late August, 1972 to May, 1973.

CW(OS) station

Jetty station

Table 4.7 Summary of the analyses of variance conducted on the data on weights of growth on four-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period from 26/4/73 - 26/9/73.

(a) Total weights of growth (Fmax = 2.64).

Source of variation	df	SS	Corr.SS	MS	Fs	P
Location	3	0.0408	0.0406	0.0135	2.26	N.S.
CW(OS) v. others	1	0.0165		0.0165	2.74	N.S.
Amongst others	2	0.0243		0.0122	2.03	N.S.
Time	11	0.1256	0.1255	0.0114	1.90	N.S.
Remainder	32	0.1920		0.006		
	46	0.3584				

(b) Organic weights. Fmax(4,11) = 5.72, 0.01<P<0.05 : hence data were converted to logarithms (Fmax(4,11) = 2.11).

Source of variation						
Location	3	0.3075	0.3064	0.1021	3.40	0.025<P<0.05
CW(OS)v. others	1	0.2039		0.2039	6.79	0.01<P<0.025
Amongst others	2	0.1036		0.0518	1.72	N.S.
Time	11	0.9065	0.8898	0.0809	2.69	0.01<P<0.025
Remainder	32	0.9616		0.03005		
	46	2.1756				

no significant difference in total weights of growth between stations. However, the organic weights at CW(OS) station were significantly less than those at the stations in Angas Inlet.

Table 4.8 shows the results of the analyses carried out on the data from all stations, except CW(NS) station, over the period from 10/10/73 to 24/4/74. Again, there was a missing value from the randomized blocks. In the case of total weights of growth, although the test for heteroscedasticity provided a probability that was only on the verge of significance at the 5% level, it was considered advisable to transform the data to logarithms. Examination of the data suggested that some multiplicative interaction was present. The analyses showed that differences between stations were significant. Differences between the CW(OS) station and the stations in Angas Inlet were significant, as were differences amongst the Angas Inlet stations. Examination of the transformed data suggested that average weights of growth at the CW(OS), Outfall and Jetty stations were similar to each other, but greater than those at the 30R and 28R stations. In order to test this hypothesis it is necessary to use the method for *a posteriori* comparisons (Sokal and Rohlf, 1969). The results of this analyses supported the hypotheses for both total and organic weights (table 4.9).

The next group of data for consideration consisted of the CW(OS) and CW(NS) stations over the period from 14/2/73 to 16/1/74. After perusing the data, it seemed likely that a fairly large interaction was present. A major part of this interaction may be attributed to the fact that large fluctuations in weights of growth at the CW(NS) station over spring and summer were not reflected at the CW(OS) station. Hence, transformation of the scale would not have solved the problem. Thus, it was necessary to compare weights between the stations by using the Wilcoxon matched-pairs signed-rank test. For both total and organic weights, this test showed that the amount of growth was greater at the CW(NS) station

Table 4.8 Summary of the analyses of variance conducted on the data on weights on four-week plates from all stations, except CW(NS), over the period 10/10/73 - 24/4/74. The data were converted to logarithms.

(a) Total weights of growth.

$F_{max}(5,14) = 4.50$; after transformation, $F_{max}(5,14) = 3.22$.

Source of variation	df	SS	Corr.SS	MS	Fs	P
Location	4	0.5908	0.5814	0.1453	3.92	$.005<P<.01$
CW(OS) v. others	1	0.1677		0.1677	4.52	$.025<P<.05$
Amongst others	3	0.4232		0.1411	3.80	$.01<P<.025$
Time	14	5.316	5.2425	0.3745	10.09	<0.001
Remainder	55	2.0398		0.0371		
	73	7.9466				

(b) Organic weights.

$F_{max}(5,14) = 5.31$, $0.01<P<0.05$; after transformation, $F_{max}(5,14) = 3.29$.

Source of variation	df	SS	Corr.SS	MS	Fs	P
Location	4	0.5238	0.5168	0.1292	4.46	$.005<P<0.01$
CW(OS) v. others	1	0.1380		0.1380	4.76	$.025<P<0.05$
Amongst others	3	0.3859		0.1246	4.44	$.005<P<0.01$
Time	14	4.9643	4.8495	0.3464	11.96	<0.001
Remainder	55	1.5936		0.0290		
	73	7.0817				

Table 4.9 Results of the *a posteriori* tests extending the results shown in table 4.8 : comparison of the group comprising CW(OS), Outfall and Jetty stations with the group comprising 28R and 30R stations.

Comparison	SS(total weights)	SS(organic weights)
Amongst CW(OS), Outfall, Jetty	0.0671	0.0222
Between 28R, 30R	0.0582	0.0174
Between the two groups	0.4657	0.4843
Critical SS	0.3740	0.2920

($n = 18$, $T = 35$, $0.01<P<0.025$ in both cases). Fluctuations in the amount of growth at the CW(NS) station were caused by predation on the hydroid *Tubularia* sp. (see later, section 4.2(c)). Figs. 4.9 and 4.10 show the weights of growth at the CW(OS) and CW(NS) stations during the second year of the study.

During the next year, the same interaction between the two factors location and time was not observed. The results of the analyses of variance conducted on the data obtained during the period 5/7/74 to 19/12/74 are shown in table 4.10. Differences in weights of growth were highly significant. For total weights, the amount of growth at the CW(NS) station averaged five times more than that at the CW(OS) station, while for organic weights the amount of growth was nearly eight times greater at the CW(NS) station. The data obtained from the CW(OS) and CW(NS) stations during the third year are shown in Figs. 4.11 and 4.12.

Finally, weights at the CW(OS) and Jetty stations during the summer of 1974-75 were compared (table 4.11). Unlike the situation with two-week plates, it could not be concluded that any difference between the stations was present. Differences due to the time of observation were significant for total weights, but not for organic weights. This was due to the fact that no data for organic weights were obtained on 2/1/75 when the total weights were much greater than those found at any other time during the summer.

(c) <u>Eight-week plates</u>

The first section for consideration consists of the observations at the CW(OS), Outfall and Jetty stations over the period from 11/10/72 to 3/1/73. For total weights, the data were heteroscedastic ($F_{max}(3.6) = 30.3$, $P<0.01$) and remained so after transformation to logarithms ($F_{max}(3,6) = 10.6$, $0.01<P<0.05$). The appropriate non-parametric test is the Friedman two-way analysis of variance by ranks (Siegel, 1956, p.166). This test provided a non-significant result ($X^2(k=3, n = 7) = 4.57$, $p = 0.11$)

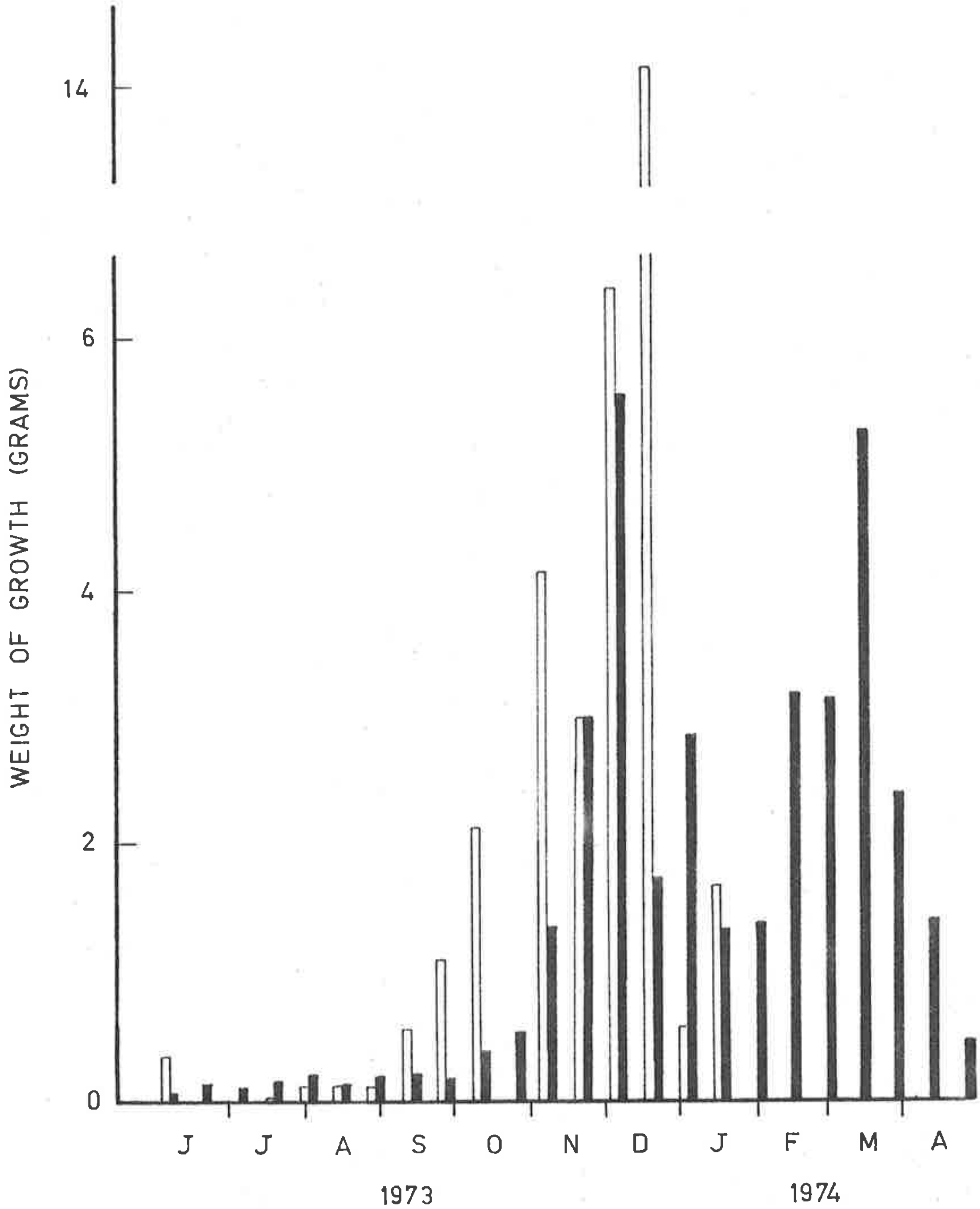

Fig. 4.9 Total weights of growth on 4-week plates from the CW(OS) station during the period from June, 1973 to April, 1974 and from the CW(NS) station during June, 1973 to January, 1974.

CW(OS) station

CW(NS) station

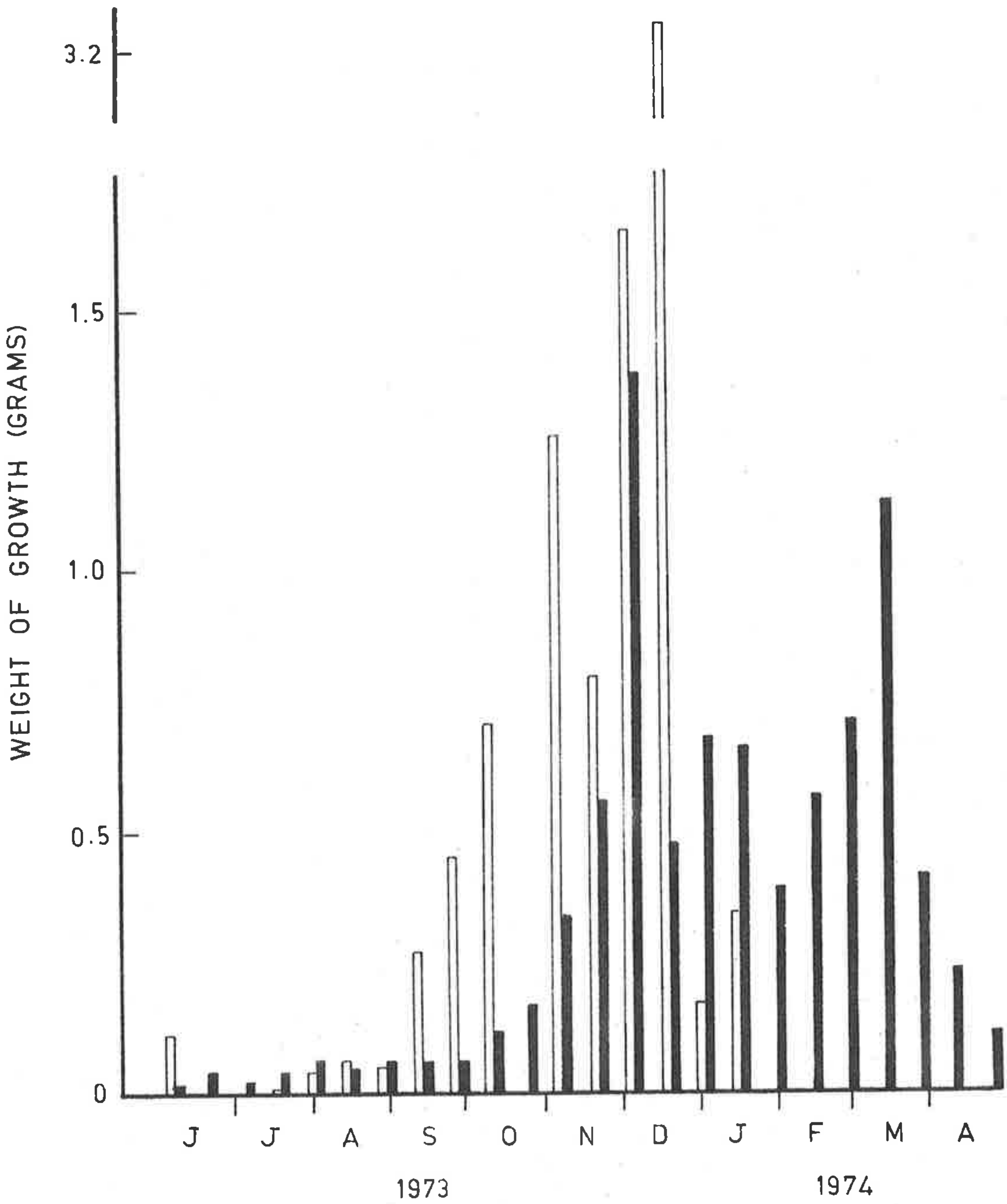

Fig. 4.10 Organic weights of growth on 4-week plates from the CW(OS) station during the period from June, 1973 to April, 1974 and from the CW(NS) station during June, 1973 to January, 1974.

CW(OS) station

CW(NS) station

Table 4.10 Summary of the analyses of variance conducted on the data on weights of growth on four-week plates from the CW(OS) and CW(NS) stations over the period from 5/7/74 - 19/12/74. The data were converted to logarithms.

(a) Total weights of growth.

$F(10,10) = 14.5$, $P<0.002$; after transformation, $F(10,10) = 1.99$.

Source of variation	df	SS	MS	Fs	P
Location	1	1.9858	1.9858	30.7	<0.001
Time	10	5.1461	0.5146	7.96	0.001<P<.01
Remainder	10	0.6465	0.0646		
	21	7.7784			

(b) Organic weights

$F(10,10) = 103$, P 0.002; after transformation, $F(10,10) = 2.89$.

Source of variation	df	SS	MS	Fs	P
Location	1	3.3431	3.3431	40.5	<0.001
Time	10	4.2479	0.4248	5.14	0.001<P<0.01
Remainder	10	0.8258	0.0826		
	21	8.4168			

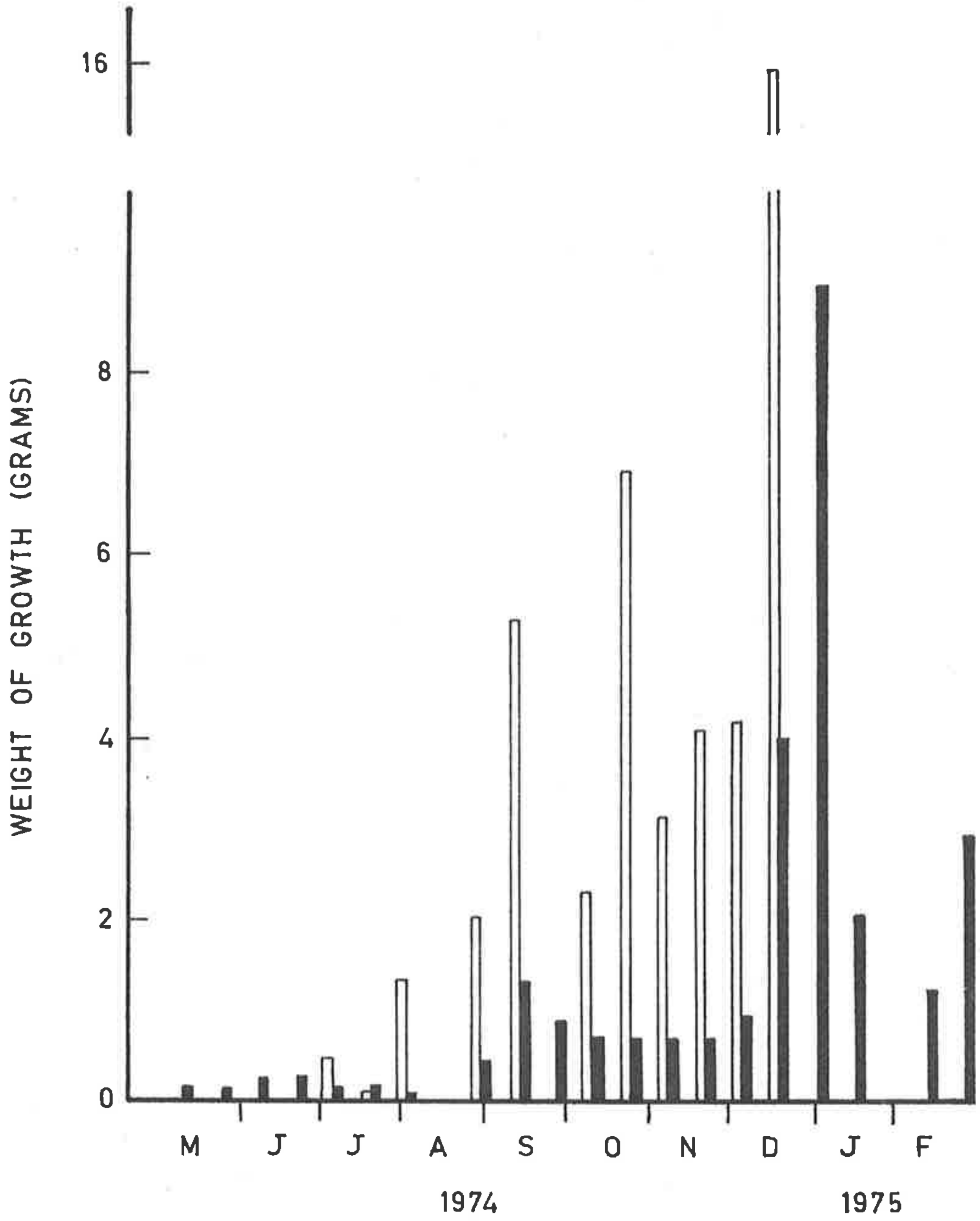

Fig. 4.11 Total weights of growth on 4-week plates from the CW(OS) station during the period from May, 1974 to February, 1975 and from the CW(NS) station over July-December, 1974.

CW(OS) station

CW(NS) station

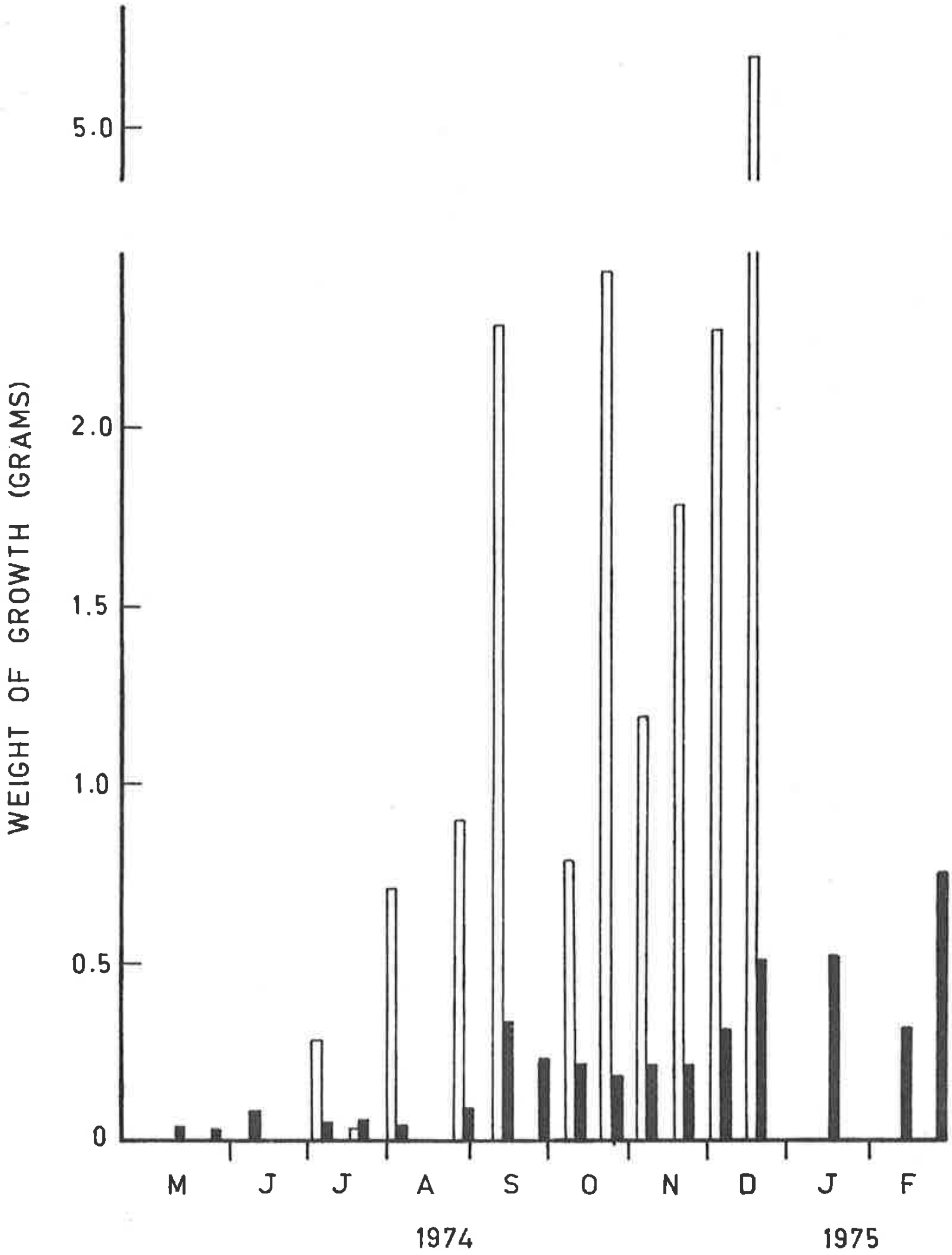

Fig. 4.12 Organic weights of growth on 4-week plates from the CW(OS) station during the period from May, 1974 to February, 1975 and from the CW(NS) station over July-December, 1974.

CW(OS) station

CW(NS) station

Table 4.11 Summary of the analyses of variance conducted on the data on weights of growth on four-week plates from the CW(OS) and Jetty stations over the period from 4/12/74 - 13/2/75.

(a) Total weights of growth (F(4,4) = 1.56).

Source of variation	df	SS	MS	Fs	P
Location	1	6.225	6.225	5.22	N.S.
Time	4	108.078	27.020	22.7	$0.001<P<0.01$
Remainder	4	4.762	1.190		
	9	119.065			

(b) Organic weights (F(3,3) = 5.76)

Source of variation	df	SS	MS	Fs	P
Location	1	222444.5	222444	6.40	N.S.
Time	3	154716.5	51572	1.48	N.S.
Remainder	3	104126.5	34709		
	7	481287.5			

The results of the analysis of variance for organic weights is shown in table 4.12. Again, no significant differences between the stations were evident. This contrasts with the results obtained on two-week and four-week plates.

Table 4.13 shows a summary of the analyses carried out on data collected over the period from 28/3/73 to 10/10/73 at the CW(OS), Outfall, Jetty and 30R stations. Incomplete data obtained in late April-early May (as a result of my earlier illnes) and again in July (when some plates were lost) were not included in the analyses. The results of the analyses again showed no significant differences in weights of growth between the stations.

The next section considered the weights taken at all stations, except CW(NS) station, over the period from 7/11/73 - 24/4/74. The results of the analyses are shown in table 4.14. Once again, there was a value missing from the randomized blocks. Total weights at the CW(OS) station were greater than those at the other stations, while differences amongst the stations in Angas Inlet were not significant. The situation with organic weights was the reverse. However, *a posteriori* comparisons cannot reveal the direction of any significant differences amongst the stations in Angas Inlet, since the initial sum of squares was 6.676 (i.e. greater than the total sum of squares for the stations in Angas Inlet). However, it can be said that any differences between the stations seem unrelated to differences in temperature : average weights of growth at the different stations increased in the order 30R, Outfall, 28R and Jetty.

Finally, there were the two comparisons between the CW(OS) and CW(NS) stations (tables 4.15 and 4.16), the first covering the period from 23/5/73 to 16/1/74 and the second from 2/8/74 to 19/12/74. In each case, both total and organic weights at the CW(NS) station were greater than those at the CW(OS) station. Figs. 4.13 - 4.16 show weights of

Table 4.12 Summary of the analysis of variance conducted on data on the organic weights of growth on eight-week plates from the CW(OS), Outfall and Jetty stations over the period from 11/10/72 - 3/1/73.
(Fmax(3,6) = 4.39).

Source of variation	df	SS	MS	Fs	P
Location	2	0.0069	0.00345	1	N.S.
Time	6	4.6414	0.7736	4.48	$0.01 < P < 0.025$
Remainder	12	2.0722	0.1727		
	20	6.7205			

Table 4.13 Summary of the analyses of variance conducted on the data on weights of growth on eight-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period 28/3/73 - 10/10/73.

The data were transformed to logarithms.

(a) Total weights of growth.

$F_{max}(4,10) = 18.6$, $P<0.01$; after transformation,

$F_{max}(4,10) = 2.32$

Source of variation	df	SS	MS	Fs	P
Location	3	0.1038	0.0346	<1	N.S.
Time	10	7.6148	0.7615	14.67	<0.001
Remainder	30	1.5558	0.0519		
	43	9.2744			

(b) Organic weights.

$F_{max}(4,10) = 12.3$, $P<0.01$; after transformation,

$F_{max}(4,10) = 2.35$.

Source of variation	df	SS	MS	Fs	P
Location	3	0.0509	0.0170	<1	N.S.
Time	10	5.0555	0.5056	7.09	<0.001
Remainder	30	2.1407	0.0714		
	43	7.2471			

Table 4.14 Summary of the analyses of variance conducted on the data on the growth on eight-week plates from all stations, except CW(NS), over the period 7/11/73 - 24/4/74.

(a) Total weights of growth. Fmax(5,12) = 9.50, P<0.01; hence, the data was transformed to logarithms (Fmax(5,12) = 5.29).

Source of variation	df	SS	Corr.SS	MS	Fs	P
Location	4	0.4225	0.4110	0.1028	2.28	N.S.
CW(OS) v. others	1	0.2637		0.2637	5.83	.01<P<.025
Amongst others	3	0.1588		0.0529	1.17	N.S.
Time	12	1.2162	1.1965	0.0997	2.21	~.025
Remainder	47	2.1225		0.0452		
	63	3.7612				

(b) Organic weights (Fmax(5,12) = 4.11).

Source of variation	df	SS	Corr.SS	MS	Fs	P
Location	4	7.1091	6.7678	1.6920	2.56	N.S.
CW(OS) v. others	1	0.8356		.8356	1.27	N.S.
Amongst others	3	6.2735		2.0912	3.17	.025<P<.05
Time	12	24.3939	24.1656	2.0138	3.05	.001<P<.005
Remainder	47	31.0077		.6597		
	63	62.5107				

growth on eight-week plates from the CW(OS) and CW(NS) stations during the second and third years of the study.

Table 4.15 Summary of the analyses of variance conducted on the data on weights of growth on eight-week plates from the CW(OS) and CW(NS) stations over the period 23/5/73 - 16/1/74. The data were transformed to logarithms.

(a) Total weights of growth.

$F(11,11) = 3.56$, $0.02<P<0.05$; after transformation, $F(11,11) = 1.62$.

Source of variation	df	SS	MS	Fs	P
Location	1	1.5327	1.5327	13.3	0.001<P<0.005
Time	11	9.0537	0.8231	7.12	0.001<P<0.005
Remainder	11	1.2719	0.1156		
	23	11.8583			

(b) Organic weights.

$F(11,11) = 6.09$, $0.002<P<0.01$; after transformation, $F(11,11) = 1.54$.

Source of variation	df	SS	MS	Fs	P
Location	1	2.0539	2.0539	18.4	0.001<P<0.005
Time	11	6.8130	0.6194	5.55	0.001<P<0.005
Remainder	11	1.2266	0.1115		
	23	10.0935			

Table 4.16 Summary of the analyses of variance conducted on the data on weights of growth on eight-week plates from the CW(OS) and CW(NS) stations over the period 2/8/74 - 19/12/74. The data were transformed to logarithms.

(a) Total weights of growth.

$F(8,8) = 24.1$, $P<0.002$; after transformation, $F(8,8) = 1.32$

Source of variation	df	SS	MS	Fs	P
Location	1	4.2079	4.2079	25.1	<0.001
Time	8	3.6845	0.4606	2.75	N.S.
Remainder	8	1.3403	0.1675		
	17	9.2327			

(b) Organic weights.

$F(8,8) = 47.3$, $P<0.002$; after transformation, $F(8,8) = 1.47$.

Source of variation	df	SS	Ms	Fs	P
Location	1	5.4781	5.4781	43.4	<0.001
Time	8	2.7503	0.3438	2.72	N.S.
Remainder	8	1.0103	0.1263		
	17	9.2387			

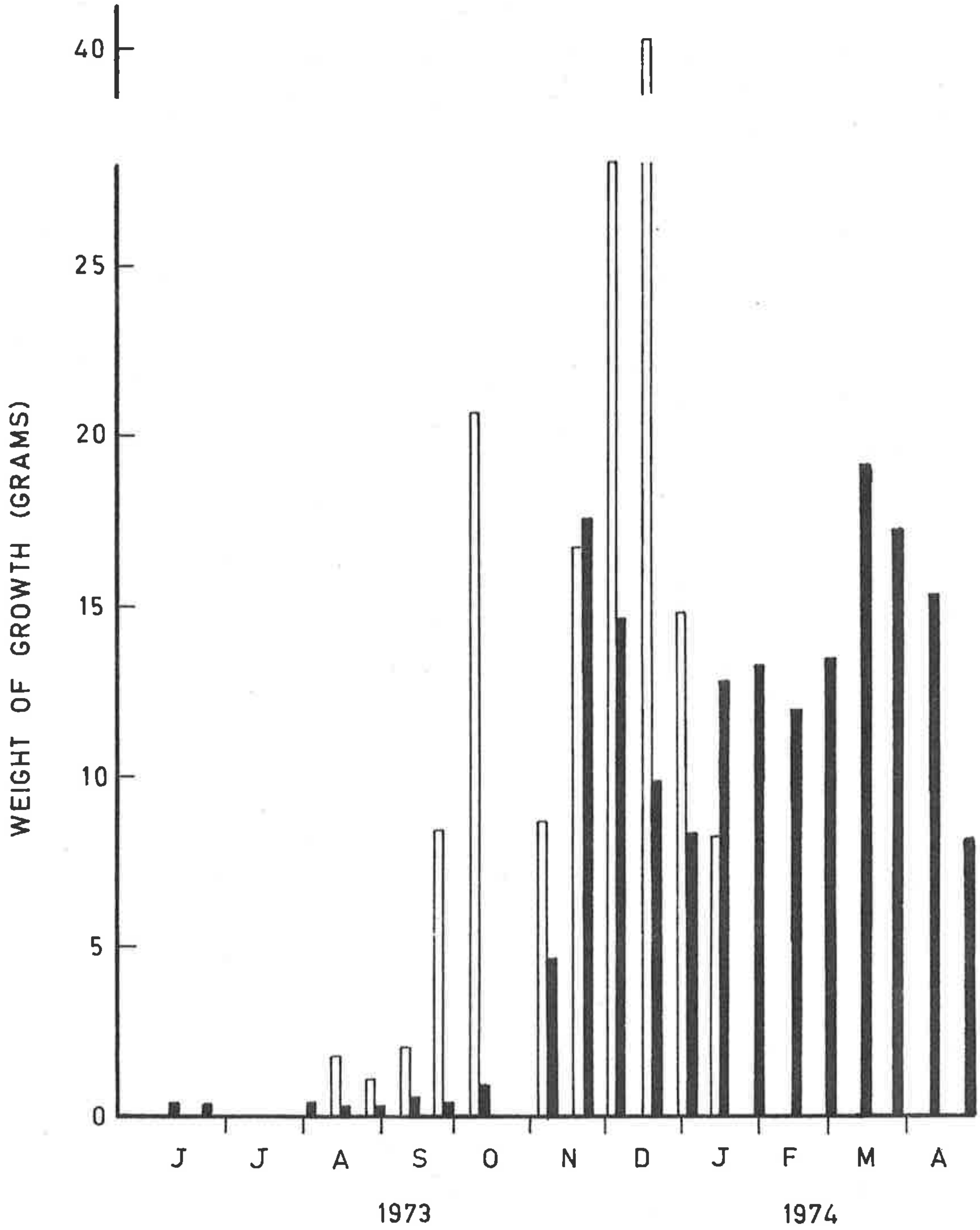

Fig. 4.13 Total weights of growth on 8-week plates from the CW(OS) station during the period from June, 1973 to April, 1974 and from the CW(NS) station over August, 1973 to January, 1974.

CW(OS) station

CW(NS) station

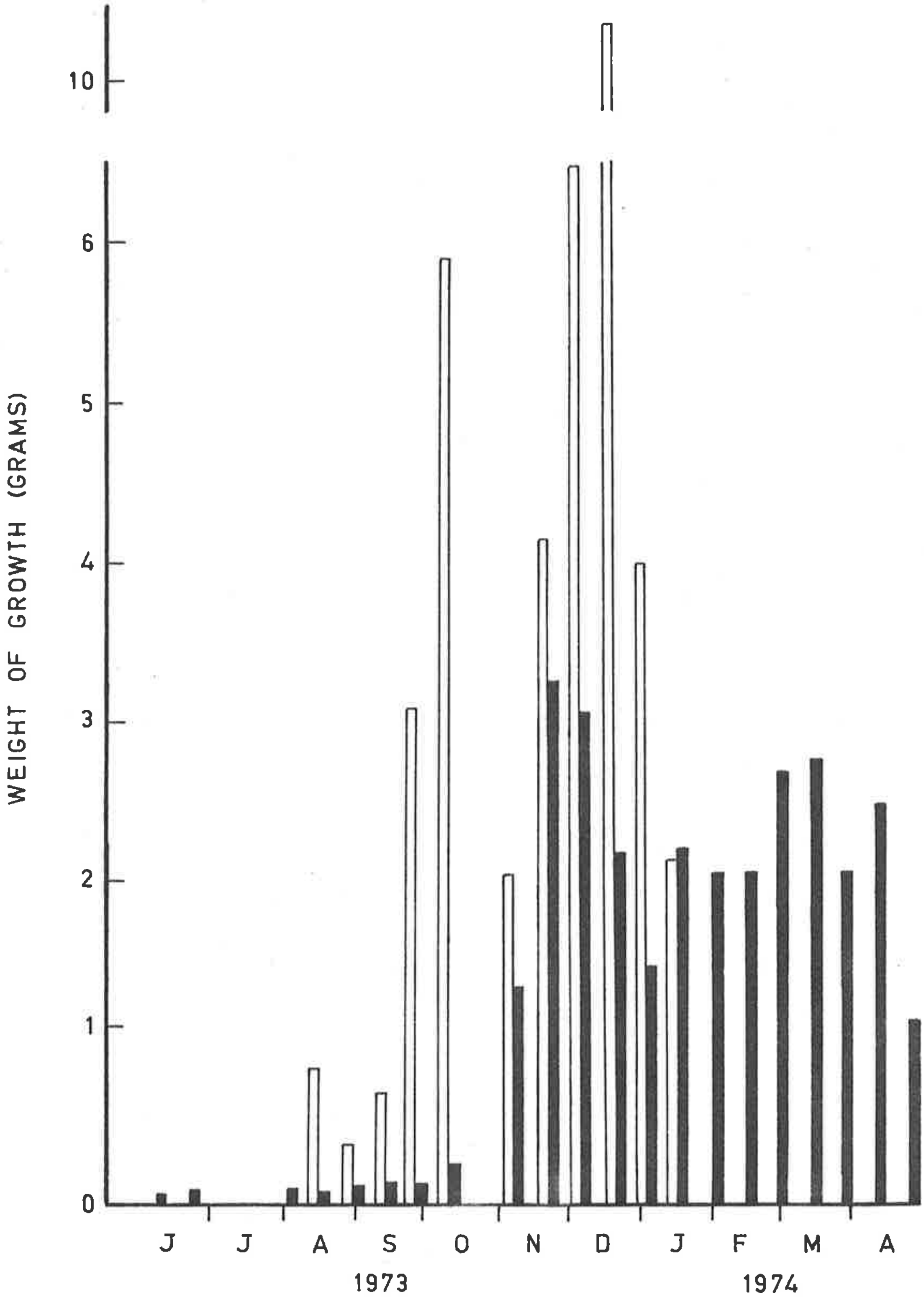

Fig. 4.14 Organic weights of growth on 8-week plates from the CW(OS) station during the period from June, 1973 to April, 1974 and from the CW(NS) station over August, 1973 to January, 1974.

CW(OS) station

CW(NS) station

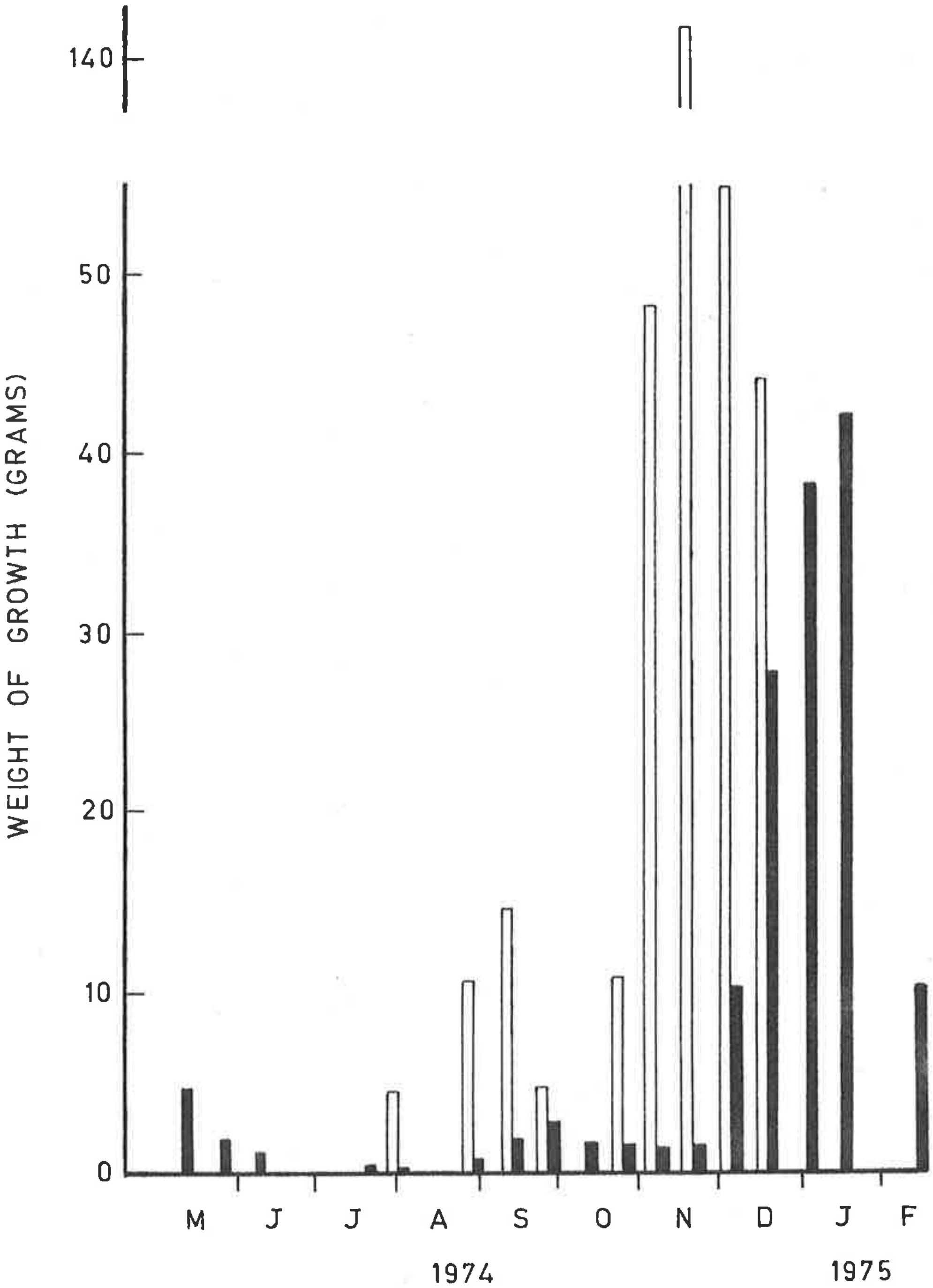

Fig. 4.15 Total weights of growth on 8-week plates from the CW(OS) station during the period from May, 1974 to February, 1975 and from the CW(NS) station over August-December, 1974.

CW(OS) station

CW(NS) station

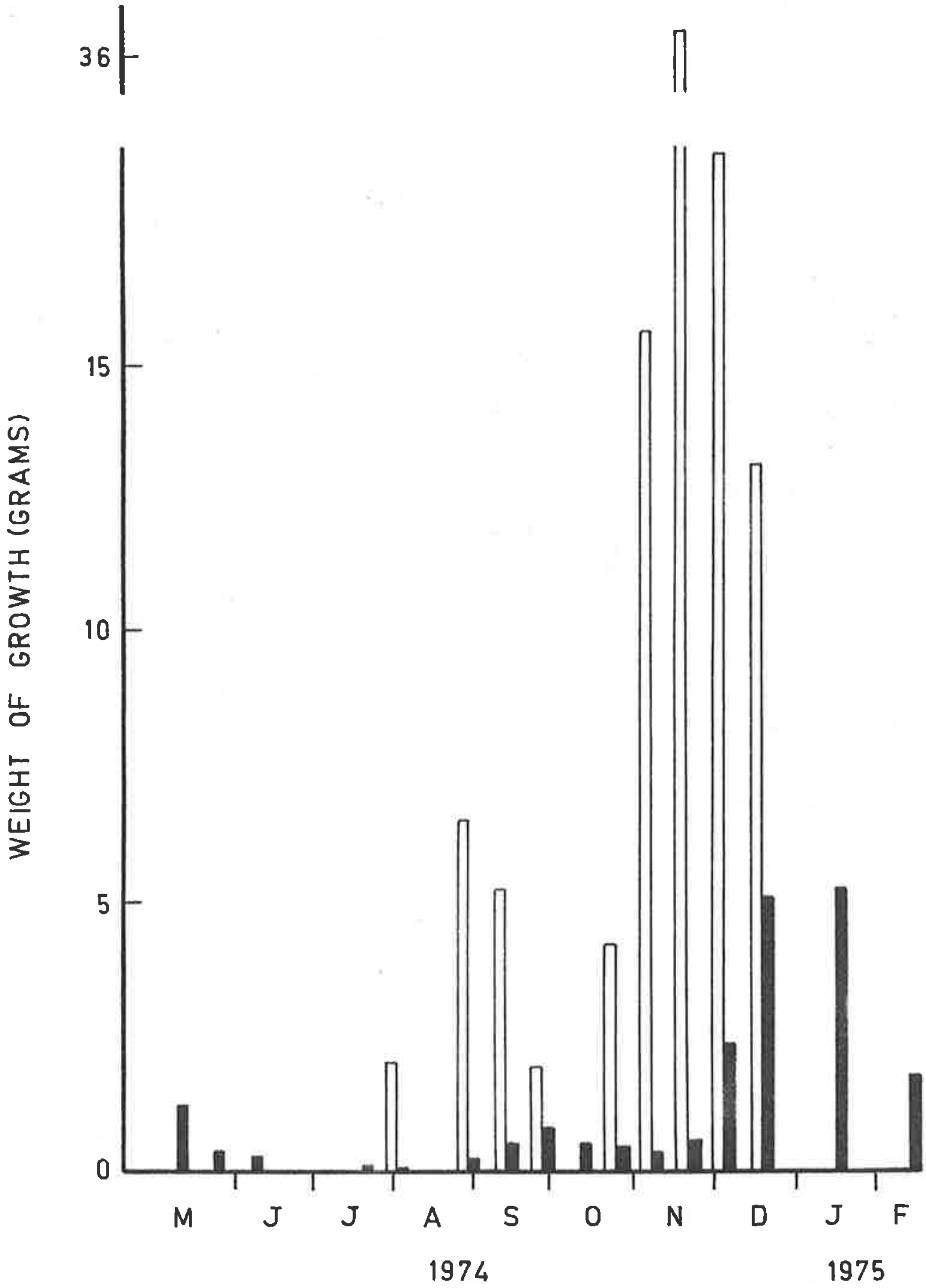

Fig. 4.16 Organic weights of growth on 8-week plates from the CW(OS) station during the period from May, 1974 to February, 1975 and from the CW(NS) station over August-December, 1974.

CW(OS) station

CW(NS) station

4.2 Species present on the plates

It is appropriate to commence with three special cases, since the presence of these species affects the rates of settlement of other species on the plates.

(a) The compound ascidian *Leptoclinum (Leptoclinum) rayneri* (MacDonald).

At its peak of abundance, *Leptoclinum rayneri* grew extremely rapidly, forming a thin investing layer over the surface. Colonies merged into each other, even on two-week plates, and hence, settlement rates could not be measured. In addition, colonies sometimes spread from the frames onto the plates, despite efforts to keep those parts of the frame adjacent to the plates clean. In order to quantify the occurence of *Leptoclinum*, abundance was calculated as the proportion of a plate covered by the ascidian.

The occurrence of *Leptoclinum rayneri* during the first two years of the study is shown in figs. 4.17 - 4.22. The results are listed in appendix 2. Examination of the diagrams suggests that seasonal differences were present. The one-sample runs test (Siegel, 1956, p.52) was used to determine the existence of any statistically significant differences between stations in the seasonal occurrence of *Leptoclinum* during the second year of the study. This test was applied by conducting a series of pair-wise comparisons between the stations. The results of the analyses are shown in table 4.17. Within each comparison, each pair of observations was assigned a plus or minus sign, according to which station had the greater amount of *Leptoclinum*. Thus, in table 4.17, n_1 represents the total number of occasions when *Leptoclinum* was more abundant at the first-named station and n_2 the number of times when the ascidian was less abundant at that station. It should be noted here that since there are a large number of separate tests shown in table 4.17, the chance is rather high that at least one test may show a significant result purely by chance

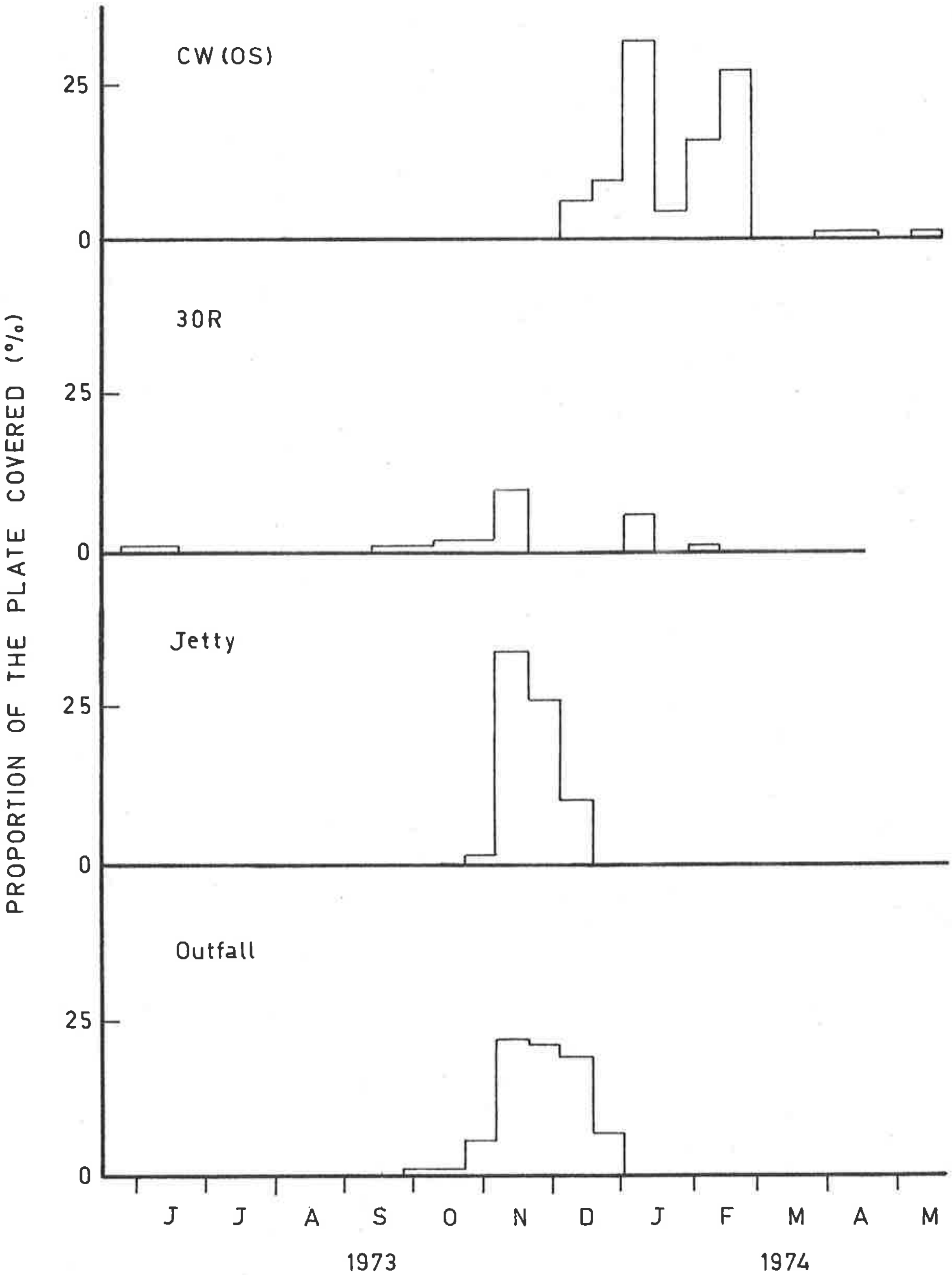

Fig. 4.17 Presence of the compound ascidian *Leptoclinum rayneri* on 2-week plates over the period from June, 1973 to May, 1974.

Abundance is shown as the proportion of the plate covered by the ascidian.

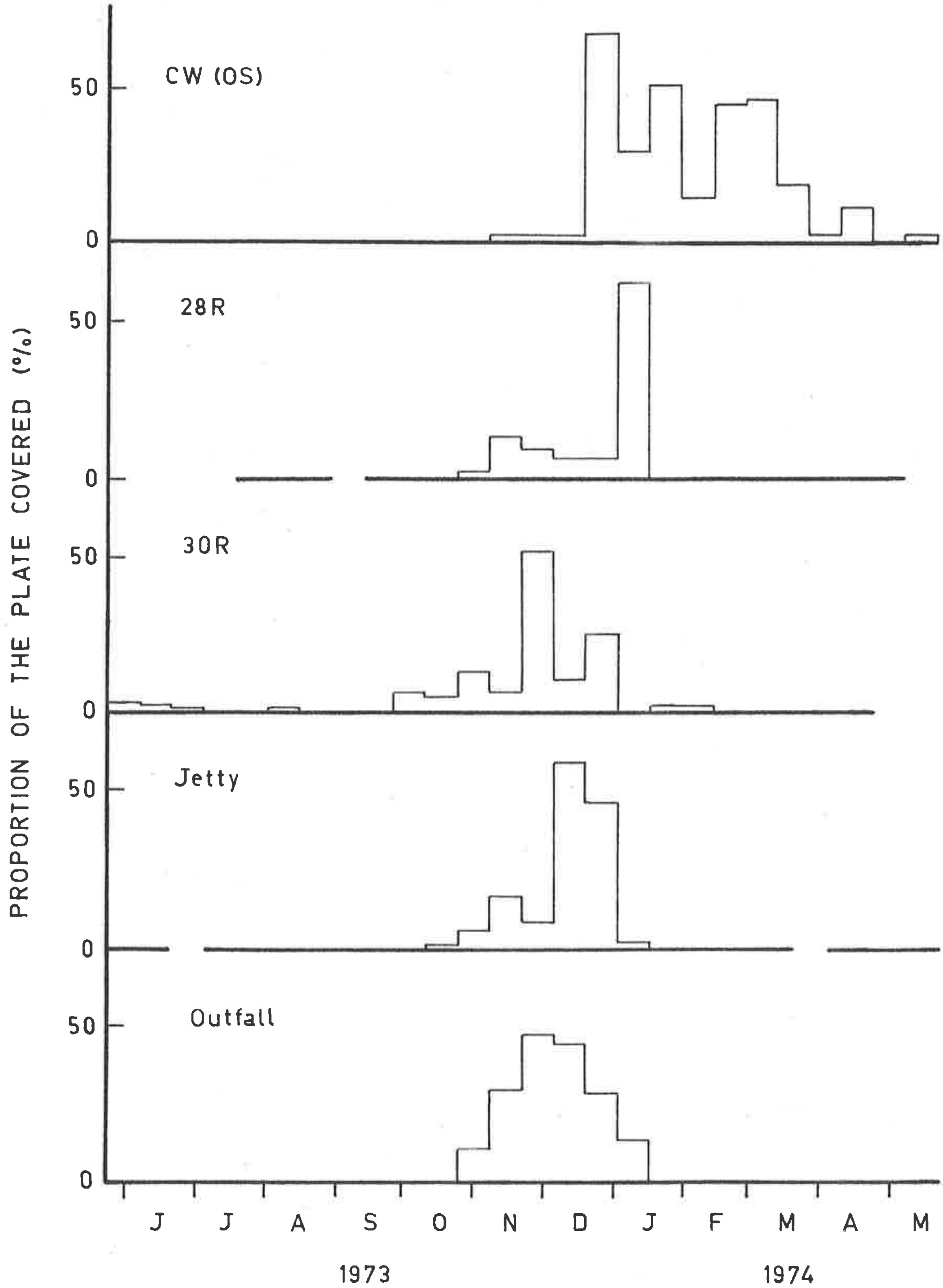

Fig. 4.18 Presence of the compound ascidian *Leptoclinum rayneri* on 4-week plates over the period from June, 1973 to May, 1974.

Abundance is shown as the proportion of the plate covered by the ascidian.

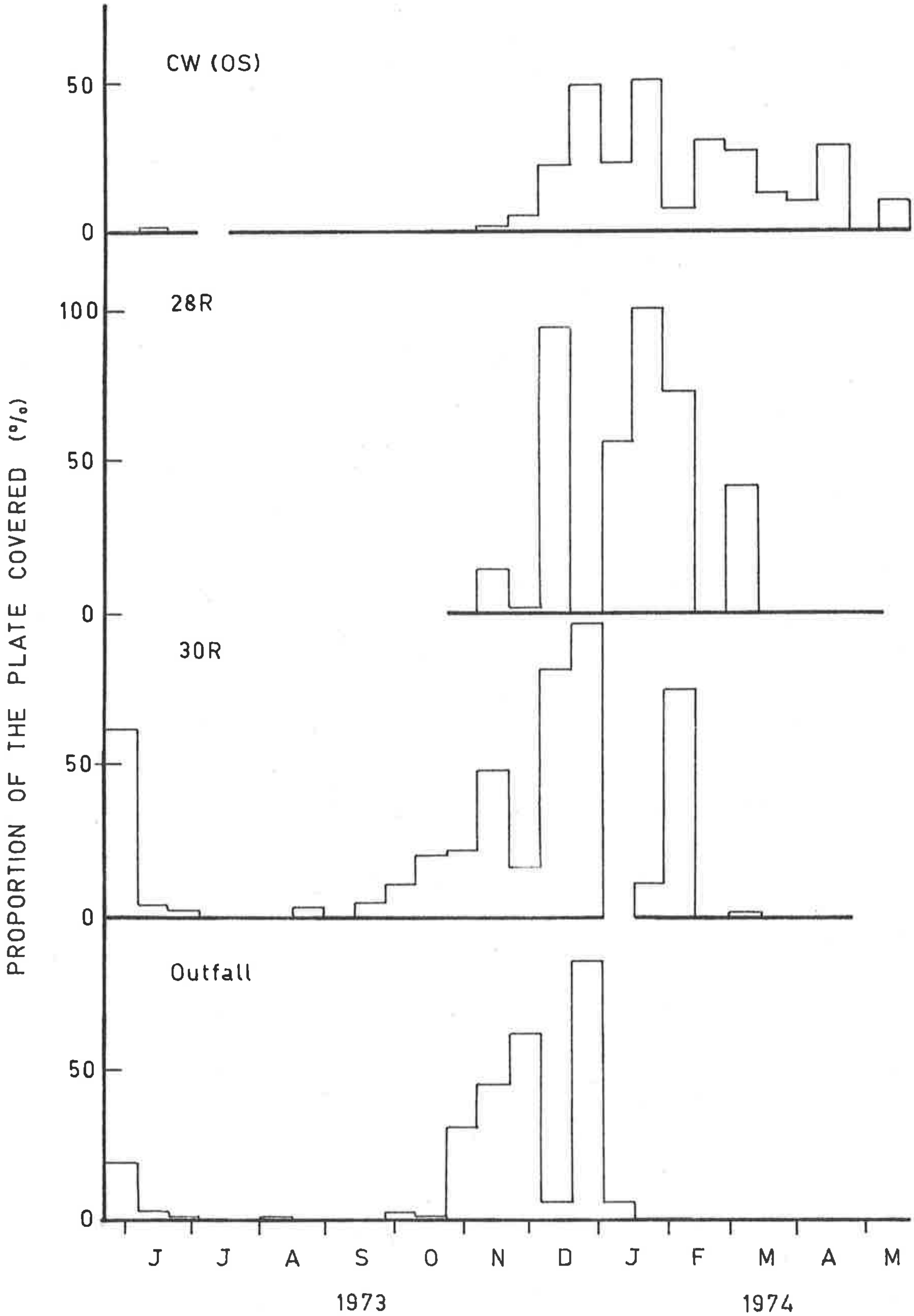

Fig. 4.19 Presence of the compound ascidian *Leptoclinum rayneri* on 8-week plates over the period from June, 1973 to May, 1974.

Abundance is shown as the proportion of the plate covered by the ascidian.

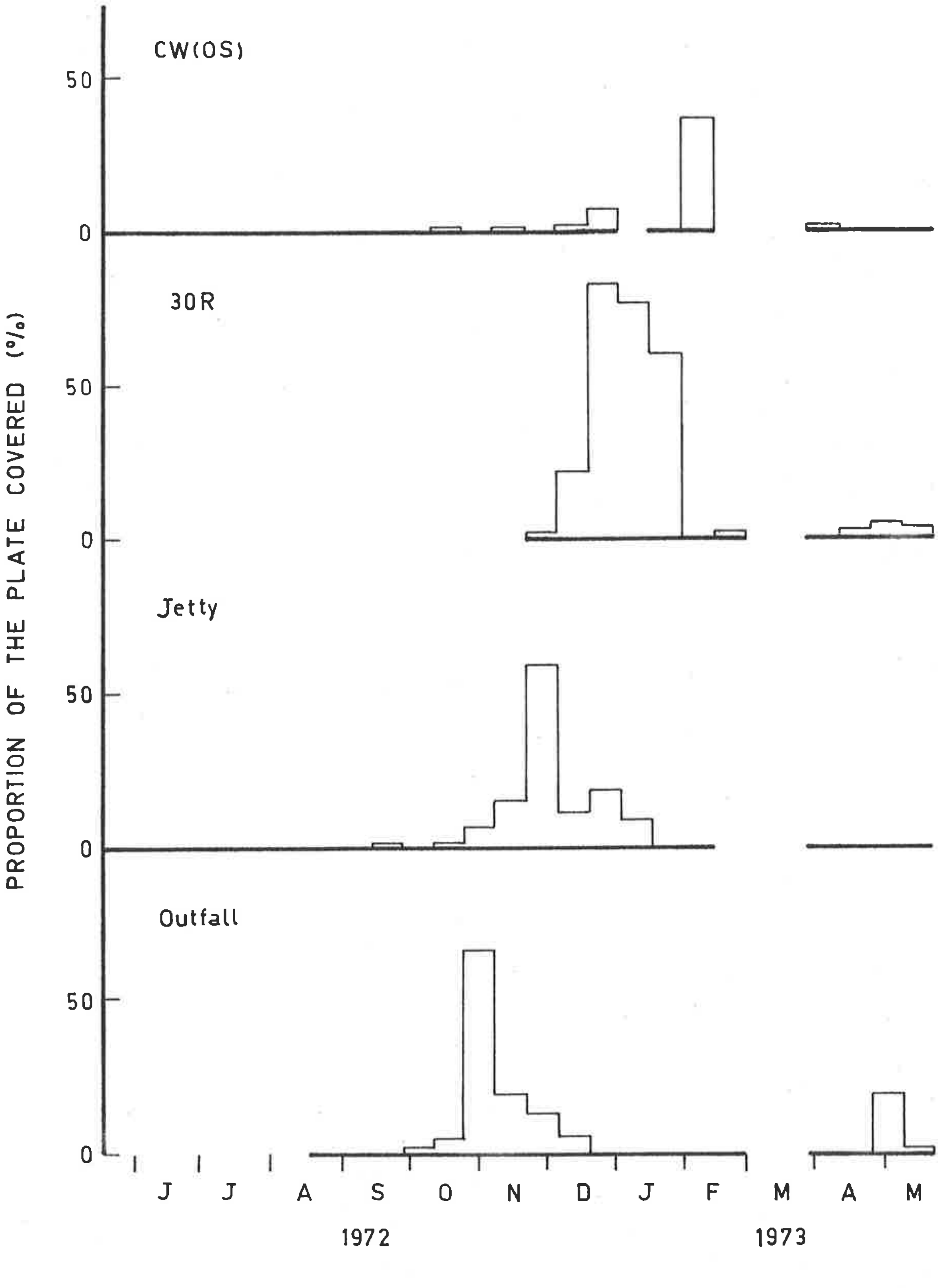

Fig. 4.20 Presence of the compound ascidian *Leptoclinum rayneri* on 2-week plates over the period from June, 1972 to May, 1973.
Abundance is shown as the proportion of the plate covered by the ascidian.

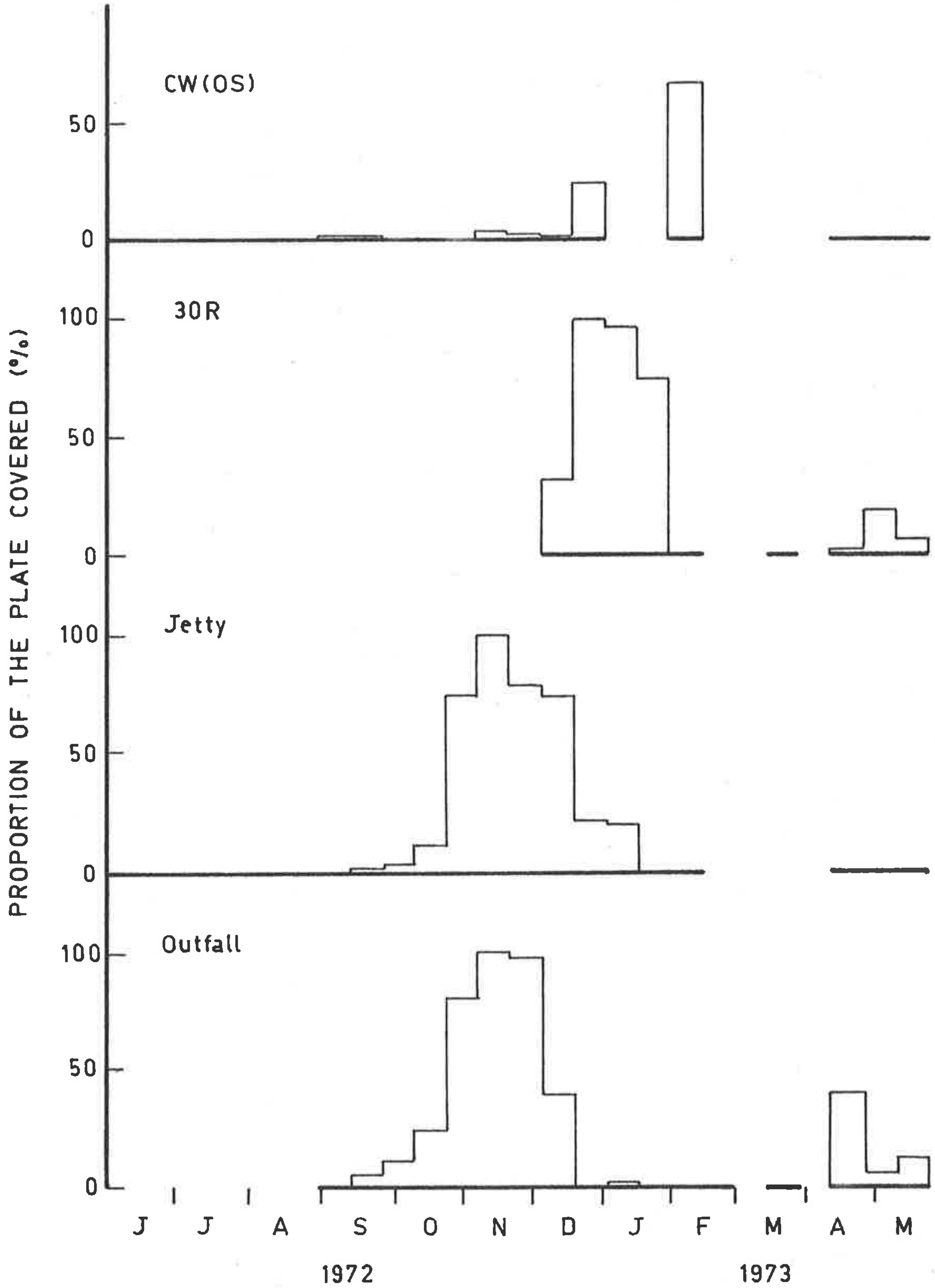

Fig. 4.21 Presence of the compound ascidian, *Leptoclinum rayneri* on 4-week plates over the period from June, 1972 to May, 1973.

Abundance is shown as the proportion of the plate covered by the ascidian.

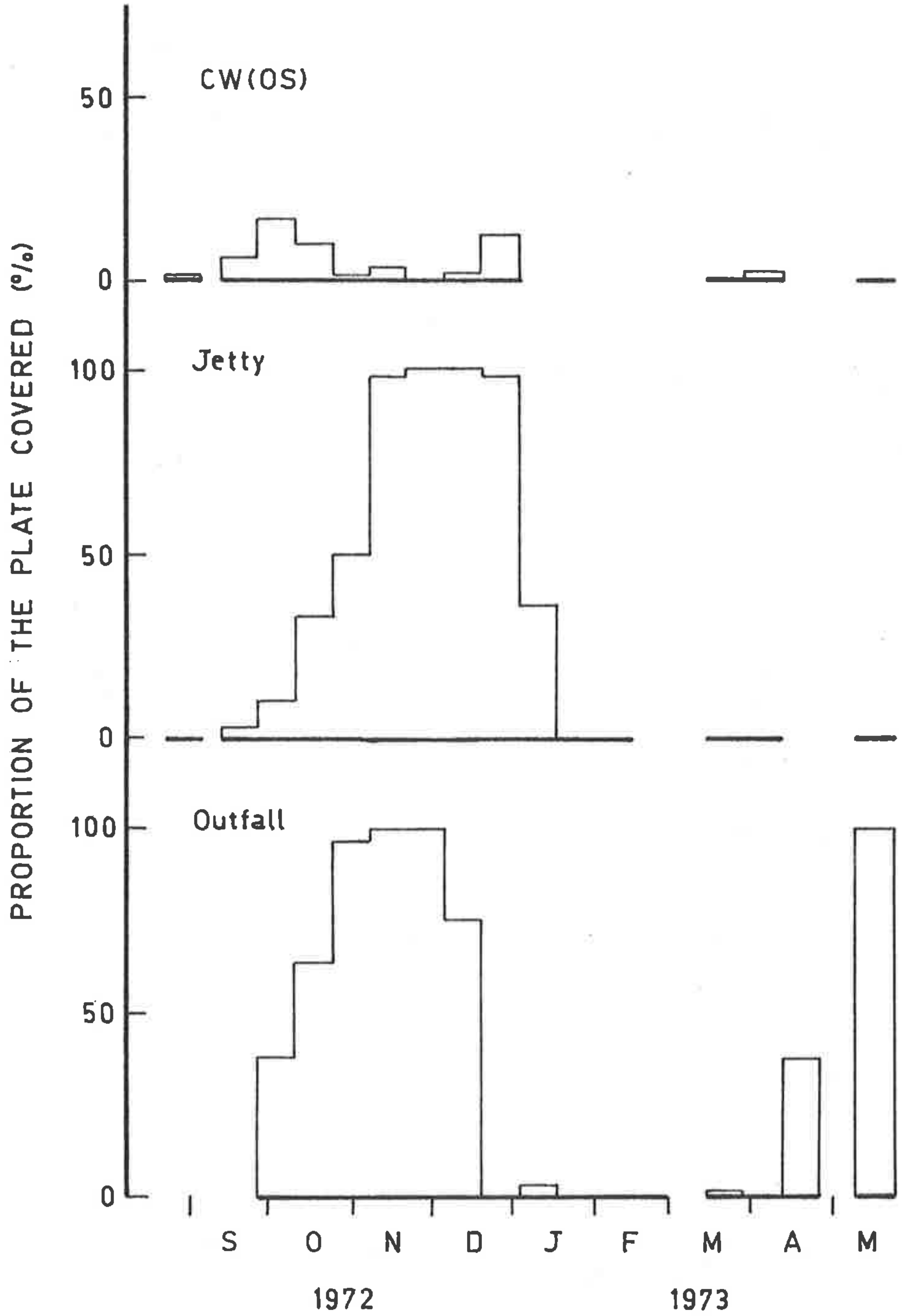

Fig. 4.22 Presence of the compound ascidian *Leptoclinum rayneri* on 8-week plates over the period from September, 1972 to May, 1973.

Abundance is shown as the proportion of the plate covered by the ascidian.

Table 4.17 Results of a series of one-sample runs tests conducted on the data on the presence of *Leptoclinum rayneri* on plates from all stations, except CW(NS), obtained over the period from 1/8/73 to 22/5/74.

The analyses were employed to examine seasonal differences in occurrence.

Comparison		n_1	n_2	Observed r	Critical r (5% level)	Significance (5% level)
(a) Two-week plates (not including 28R station).						
CW(OS)	v Outfall	8	6	2	3	Yes
	v Jetty	8	4	2	3	Yes
	v 30R	8	5	2	3	Yes
Outfall	v Jetty	5	2			No
	v 30R	5	4	3	2	No
Jetty	v 30R	3	5			No
(b) Four-week plates						
CW(OS)	v Outfall	10	4	2	3	Yes
	v Jetty	9	5	2	3	Yes
	v 30R	9	7	2	4	Yes
	v 28R	8	5	4	3	No
Outfall	v Jetty	4	3			No
	v 30R	4	8	5	3	No
	v 28R	5	1			No
Jetty	v 30R	4	8	5	3	No
	v 28R	5	2			No
30R	v 28R	8	2			No

Table 4.17 (cont.) (c) 8-week plates

Comparison		n_1	n_2	Observed r	Critical r (5% level)	Significance (5% level)
CW(OS)	v Outfall	10	7	4	5	Yes
	v Jetty	9	7	2	4	Yes
	v 30R	6	10	4	4	Yes
	v 28R	6	6	8	3	No
Outfall	v Jetty	5	5	7	2	No
	v 30R	3	10	6	2	No
	v 28R	4	5	4	2	No
Jetty	v 30R	2	10	3	2	No
	v 28R	4	5	4	2	No
30R	v 28R	5	4	6	2	No

or vice-versa. Hence, it is the general trend of the tests taken as a whole that is the more crucial factor rather than the results of the individual tests.

During the autumn of 1973, *Leptoclinum* was present in moderate amounts at the Outfall and 30R stations and was present virtually throughout the winter although usually in very small quantities. Hence, it was inappropriate to try to determine at what point the autumn breeding season ended at these stations and the spring season began. There were some occasions when *Leptoclinum* was present, but in insufficient amounts to be recorded as a percentage of the plate covered. Such data (denoted as x in appendix 2) were not included in the analyses.

For two-week plates, data from the 28R station were not included in the analysis, since *Leptoclinum* was comparatively rare : n_2 was either 0 or 1 and hence, a runs test could not be applied. Data from the CW(NS) station were also excluded from the analyses (see sections 4.2(b) and (c)).

The analyses showed that seasonal differences were evident between the CW(OS) stations and all stations in Angas Inlet, except 28R station. *Leptoclinum* was abundant in Angas Inlet from mid-spring until mid-summer. The ascidian disappeared from the Outfall and Jetty stations when water temperatures reached their summer peak, but at the 30R and 28R stations it remained abundant on eight-week plates until the end of summer. Since only very small amounts were found on two-week and four-week plates from Angas Inlet after mid-January, it would appear that breeding had virtually ceased after that date. However, colonies present at the 28R and 30R stations at that time managed to survive and grow, whereas those colonies at the Jetty and Outfall stations died out.

At the CW(OS) station, *Leptoclinum* did not appear in any abundance until early summer but remained moderately abundant until well into autumn. Thus, it would appear that the warmed water advanced the breeding season of *Leptoclinum* at the Outfall, Jetty and 30R stations but the water apparently became too hot in mid-summer. Since no significant seasonal differences were found between the 28R station and the other stations, the situation there may be intermediate between those at the other stations in Angas Inlet and that at the CW(OS) station.

The results during the first year were generally consistent with those of the second year. *Leptoclinum* was abundant in Angas Inlet from mid-spring to mid-summer. However, the picture in North Arm was confused, since the gaps in the data from the CW(OS) station coincided with the period from mid-summer to autumn i.e. that period when, based on the results of the second year, one may have expected *Leptoclinum* to have been abundant. During the third year, *Leptoclinum* was comparatively rare on two-week plates. However, the results from four- and eight-week plates showed a similar trend to those of the previous year.

Leptoclinum may interfere with the settlement and survival of other sessile animals in two ways. Firstly, the presence of the compound ascidian renders that part of the surface covered by the colony unsuitable for the settlement of other larvae. In addition, colonies may smother other animals already present on the plates, and this would be expected to kill them. The results have shown that the seasonal abundance of *Leptoclinum* varied between stations. Hence, interpretation of the rates of settlement of other species, in relation to the effects of thermal effluent, may be complicated by the presence of *Leptoclinum*. On two-week plates, in addition to providing a surface on which other larvae could not settle, an advancing colony seemed to be capable of completely smothering all recently settled animals in its path. Thus, one could allow for the presence of *Leptoclinum* by considering the numbers of settlements in relation to the area of the plate not covered by the ascidian. This was achieved by calculating an expected number of settlements per plate, which is that number of settlements which would have been observed if

Leptoclinum had not been present and the same rate of settlements per unit area had been observed. Thus, the expected number of settlements was calculated according to the following formula:

$$\text{Expected no.} = \text{Actual no.} \times \frac{\text{Total area}}{\text{Area free of } Leptoclinum}$$

On four-week and eight-week plates, the colonies of *Leptoclinum* were not always able to smother other animals, since these had grown to a larger size. Hence, the same allowance for the presence of *Leptoclinum* could not be made.

(b) The bryozoan *Zoobotryon verticillatum* (Della Chiaji)

Macroscopically, a colony of *Zoobotryon verticillatum* consists of a large mass of long branching gelatinous threads. Wood and Allen (1958) state that when a piece is broken from the parent colony, it will go on living and, on contact with another object, will attach and continue growth. Similarly, strands still connected to the parent colony may attach to other objects. Thus, a colony may spread from one substrate to another even when the different substrates are not in contact with each other. In this way, a colony, although attaching at one point, may extend completely over a set of frames and plates.

At times, the amount of growth on a set of frames and plates was so great that the frames and plates could not be seen through the growth. At these times, strands of the colonies were attached to all of the plates and over the frames. Abundance of *Zoobotryon* was assessed using a scale of 0 - 5, according to the total amount of growth present on a set of frames and plates. In this scale of growth, five represented the situation where the frames and plates were completely covered and could not be seen beneath the mass of growth.

The occurrence of *Zoobotryon* is shown in table 4.18. During the 1973-74 season, no *Zoobotryon* was found at the CW(OS), Outfall and Jetty stations, while none was found at the Outfall and Jetty stations during the 1974-75 season. The results during the last two seasons showed that

Table 4.18 The occurrence of *Zoobotryon verticillatum* on the sets of frames and plates. Abundance is expressed using a scale 0 - 5, where 5 represents maximum abundance. x denotes a very small amount was present.

(a) Summer - autumn, 1972-73.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
20/12/72	x		0	0	
3/1/73	x		0	0	1
17/1	x		x	0	x
31/1	x	0	2	x	4
14/2	x	0	x	0	4
28/2	No data	No data	1	No data	3
14/3			No data		
28/3	0	No data	x	x	2
11/4	0	0	x	0	x

(b) Summer - autumn, 1973-74.

Date of examination	CW(NS)	30R	28R
16/1/74	x	x	0
31/1	1	3	1
13/2	4	2	1
27/2	5	2	x
13/3	5	2	0
27/3	5	1	0
10/4	5	x	0
24/4	1	0	0

Table 4.18 (cont.)

Date of Examination	CW(NS)	30R	28R
8/5/74	2	No data	0
22/5	4	No data	No data

(c) Summer, 1974-75

Date of Examination	CW(OS)	CW(NS)
19/12/74	0	x
2/1/75	x	5
16/1	x	5
30/1	2	5
13/2	2	5
27/2	x	5

Zoobotryon thrived at the CW(NS) station, presumably favoured by the turbulent water there. This conclusion was supported by casual observations on the presence of *Zoobotryon* in the vicinity of the cooling water intakes. *Zoobotryon* could be seen growing in great profusion on those parts of the concrete walls immediately adjacent to the inlet of the pump chambers, but was absent from other areas of the intake structure. Colonies appeared in early summer and disappeared in the latter part of autumn. Colonies usually reached a length of about one metre.

The results during the first season appear, at first sight, to contradict those of the next two seasons, since *Zoobotryon* was not found at the CW(NS) station but was present at the other stations. However, as in the next two seasons, it was abundant on the walls of the intake structure adjacent to the inlet of the pump chambers. One could explain the absence of *Zoobotryon* from the frames and plates if the bryozoan was unable to colonize freshly immersed frames and plates. Before the gap in the observations (late February and March) the frames at the CW(NS) station had been immersed for only four weeks. They then disappeared and were not replaced until the growing season of *Zoobotryon* was nearing its conclusion.

Zoobotryon was less abundant in Angas Inlet than at the CW(NS) station, but this can probably be attributed to slower water currents in Angas Inlet, compared with the currents at the CW(NS) station. Within Angas Inlet, there was no clear relationship between the distribution of *Zoobotryon* and the distribution of the warmed water.

(c) The hydroid *Tubularia* sp.

The presence of *Tubularia* on two-week plates during each of the three years of the study is shown in Figs. 4.23 - 4.25. The results for the 30R station are not shown since only a very small number of settlements were observed there. The complete results are listed in appendix 3. In general, the number of colonies on a two-week plate was equal to, or

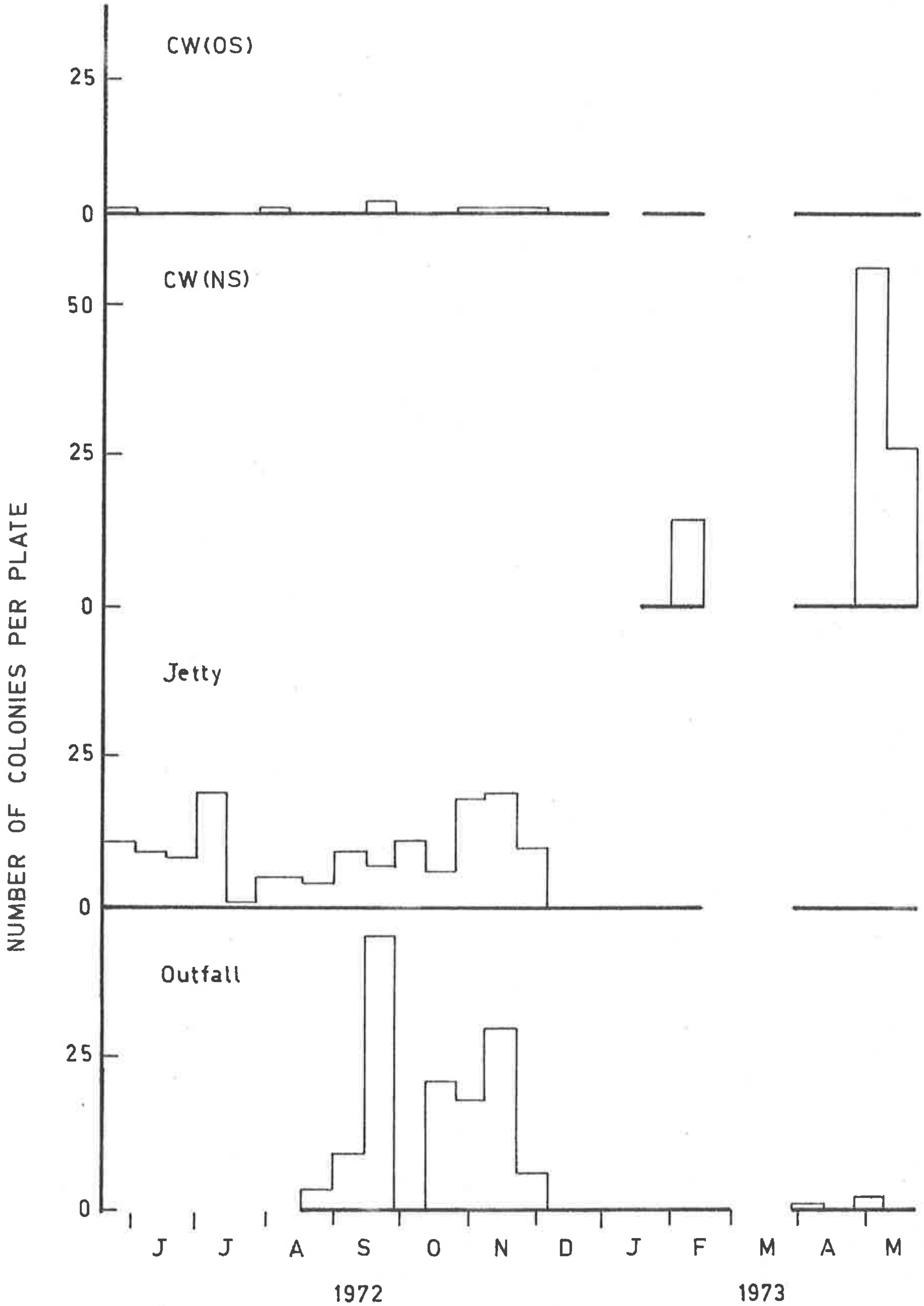

Fig. 4.23 Presence of the hydroid *Tubularia* sp. on 2-week plates over the period from June, 1972 to May, 1973.

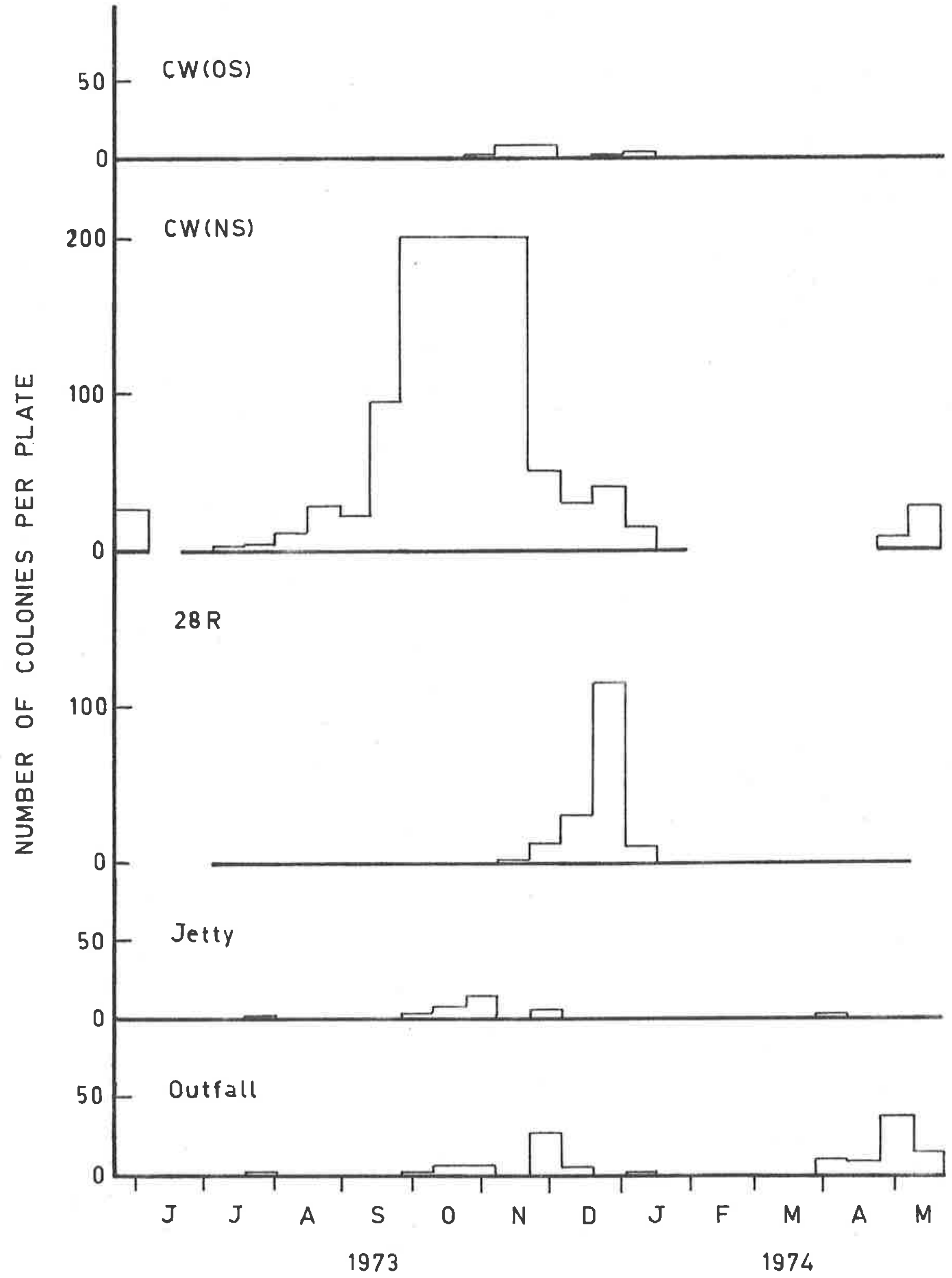

Fig. 4.24 Presence of the hydroid *Tubularia* sp. on 2-week plates over the period from June, 1973 to May, 1974.

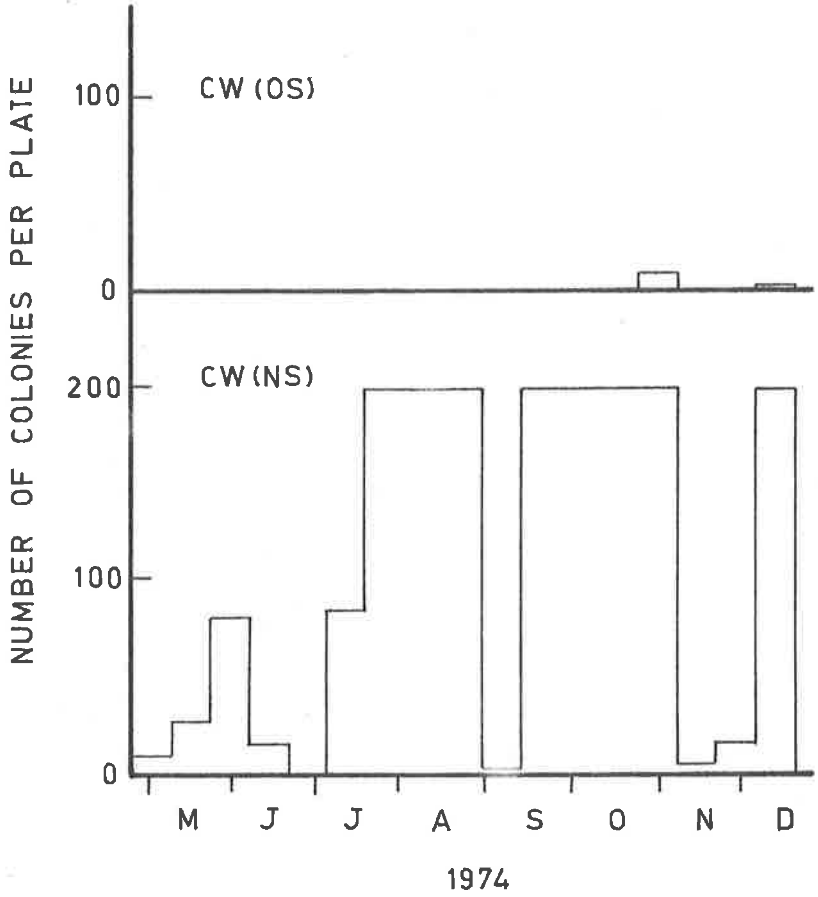

Fig. 4.25 Presence of the hydroid *Tubularia* sp. on 2-week plates from the CW(OS) and CW(NS) stations during the period from May to December, 1974.

slightly less than, the number of settlements. Since the rate of growth may be rapid, particularly at the CW(NS) station, some colonies on two-week plates may merge into each other. On occasions, one could recognize that a group of polyps had resulted from the combination of two or more settlements but have been scored as only one colony. In general, such cases would have been few in number, except during the periods of greatest settlement at the CW(NS) station. At these times, the rates of settlement were so great that many colonies had merged into each other forming one or two "macro-colonies" on a plate, together with a number of smaller colonies. In such cases, it was impossible to determine the number of settlements that had resulted in a macro-colony. The data were then listed as many (appendix 3) and shown as 200 colonies per plate in figs. 2.24 and 2.25. This figure of 200 represents the probable minimum number of settlements. On four-week and eight-week plates from the CW(NS) station, colonies had usually merged into each other, forming large aggregations of polyps. Hence, it was not feasible to count individual colonies.

The data from the CW(OS), Outfall and Jetty stations over the period from 30/8/72 - 6/12/72 were analysed to compare differences in rates of settlement between stations using the Friedman two-way analysis of variance by ranks (heterogeneity of variances was clearly evident in the data). This test showed that differences were statistically significant ($X^2(k=3,n=8) = 10.6$, $0.0024 < P < 0.0048$). The numbers of settlements in Angas Inlet were greater than those at the CW(OS) station. The results obtained before 30/8/72, when only the CW(OS) and Jetty stations were in operation, were consistent with this conclusion. Thus, the first data on settlement rates suggested that *Tubularia* was favoured by the warmed water in Angas Inlet (Fig. 4.23).

However, after the observations at the CW(NS) station commenced it became clear that the rates of settlement at the CW(NS) station were much greater than those at the CW(OS) station. Hence, *Tubularia* appeared to have been favoured to a considerable extent by the turbulent water. Growth rates at the CW(NS) station were extremely rapid. Colonies up to three cm in height were found on two-week plates, up to 6 cm on four-week plates and 8 cm on eight-week plates. On a few occasions, polyps with mature gonophores were present on two-week plates and such polyps were usually abundant on four-week and eight-week plates.

Most of the larvae which originate from the colonies of *Tubularia* growing adjacent to the cooling water intake, and which do not settle immediately, will be drawn into the cooling water ducts and thence into Angas Inlet. Since *Tubularia* is more abundant in the vicinity of the cooling water intake than elsewhere, it follows that the concentration of larvae may be greater in the areas of Angas Inlet near the cooling water outlet, i.e. near the Outfall and Jetty stations, than in many areas of North Arm. Hence, if the larvae were not killed on passage through the power plant and could survive in the warmer water of Angas Inlet, rates of settlement at the Outfall and Jetty stations may be greater than those at the CW(OS) station. This consideration may account for the greater rate of settlement at the Outfall and Jetty stations during the period from June to early December 1972, since one could presume that *Tubularia* would have been abundant in the vicinity of the cooling water intake at that time. However, this does not necessarily mean that *Tubularia* was favoured by the warmer water in Angas Inlet.

In fact, other considerations suggest that *Tubularia* was placed at a disadvantage by the warmed water. All of the colonies that appeared at the CW(OS) and 28R stations developed normally. The same applied to those colonies at the Jetty station during June-August, 1972. However, all colonies that appeared at the Outfall, Jetty and 30R stations from September, 1972, onwards were stunted in appearance. The colonies reached only about 1 cm in height and the polyps were small and degenerative.

The data from all stations, except the CW(NS) station, during the period 10/10/73 - 16/1/74 were analysed using the Friedman two-way analysis of variance by ranks. On this occasion, there were no significant differences between stations (X_4^2 = 2.43), unlike the situation during the previous settlement season when *Tubularia* was more abundant at the Outfall and Jetty stations. If *Tubularia* was adversely affected by the warmed water, as suggested above, this difference in results between 1972 and 1973 may be correlated with the differences in water temperatures between the two years. During winter and spring of 1973, both the temperatures of the water in North Arm and the temperature elevation of the water on passage through the power station were greater than for the corresponding period of 1972. Hence, it may be expected that fewer larvae of *Tubularia* would have survived on passage through the power plant and been capable of settling in Angas Inlet in 1973 compared with 1972. However, this explanation, although fitting the results, is rather speculative. It may just be that *Tubularia* was even more abundant in the vicinity of the cooling water intake in 1972 than in 1973.

From late winter to mid-summer, colonies of *Tubularia* covered the frames at the CW(NS) station to a height of 8 cm. Many of the larvae of other species which approached the set of frames may have been consumed by the polyps or have failed to find the plates beneath the enshrouding growth. Similarly, when *Zoobotryon* was abundant, from mid-summer to autumn, it is likely that most larvae of other species would have been unable to find the plates. Hence, when *Tubularia* or *Zoobotryon* were abundant, i.e. most of the year at the CW(NS) station, settlement of other species would have been inhibited. Thus, the results on the abundance of other species at the CW(NS) station will generally not be considered in detail, except in the case of one species of amphipod which was abundant despite the presence of *Tubularia*.

(d) An endoproct (which is probably) *Loxosomella kefersteini*.

This species was present as small single polyps up to 1 mm in total length, although most individuals were only about ½ mm in length. It reproduces asexually by forming small lateral buds which separate off to form small polyps (Borradaile *et al.*, 1967). These lateral buds could clearly be seen on the polyps present on the plates. It would seem likely that the polyps will attach soon after they have been budded off from their parents.

Presence of *Loxosomella* on two-week plates during the first year is shown in fig. 4.26. Settlement rates during the second and third years were very low. The complete results are listed in appendix 4. It was decided not to attempt to record the numbers present on four-week and eight-week plates. Since the polyps were difficult to perceive amongst other growth as a result of their small size, the time which would have been required to count the numbers present on longer term plates was the critical factor in making this decision.

The gaps in the observations complicated the interpretation of the results to some extent. However, it would appear that settlement at the CW(OS) station commenced in late spring, reached a peak in late summer and declined over autumn. At the Jetty station, settlement commenced earlier but had almost ceased by early summer. The rate of settlement remained low during summer, presumably because the water was too hot to encourage breeding, but as the water cooled in autumn, a second period of reproduction commenced. The one-sample runs test confirmed that these apparent seasonal differences in occurrence of *Leptoclinum* were statistically significant (n_1=5, n_2=10, observed r=3, critical r=3). Although the results from the 30R station were incomplete, as a result of the later start there, it would appear that the seasonal occurrence was similar to that at the Jetty station.

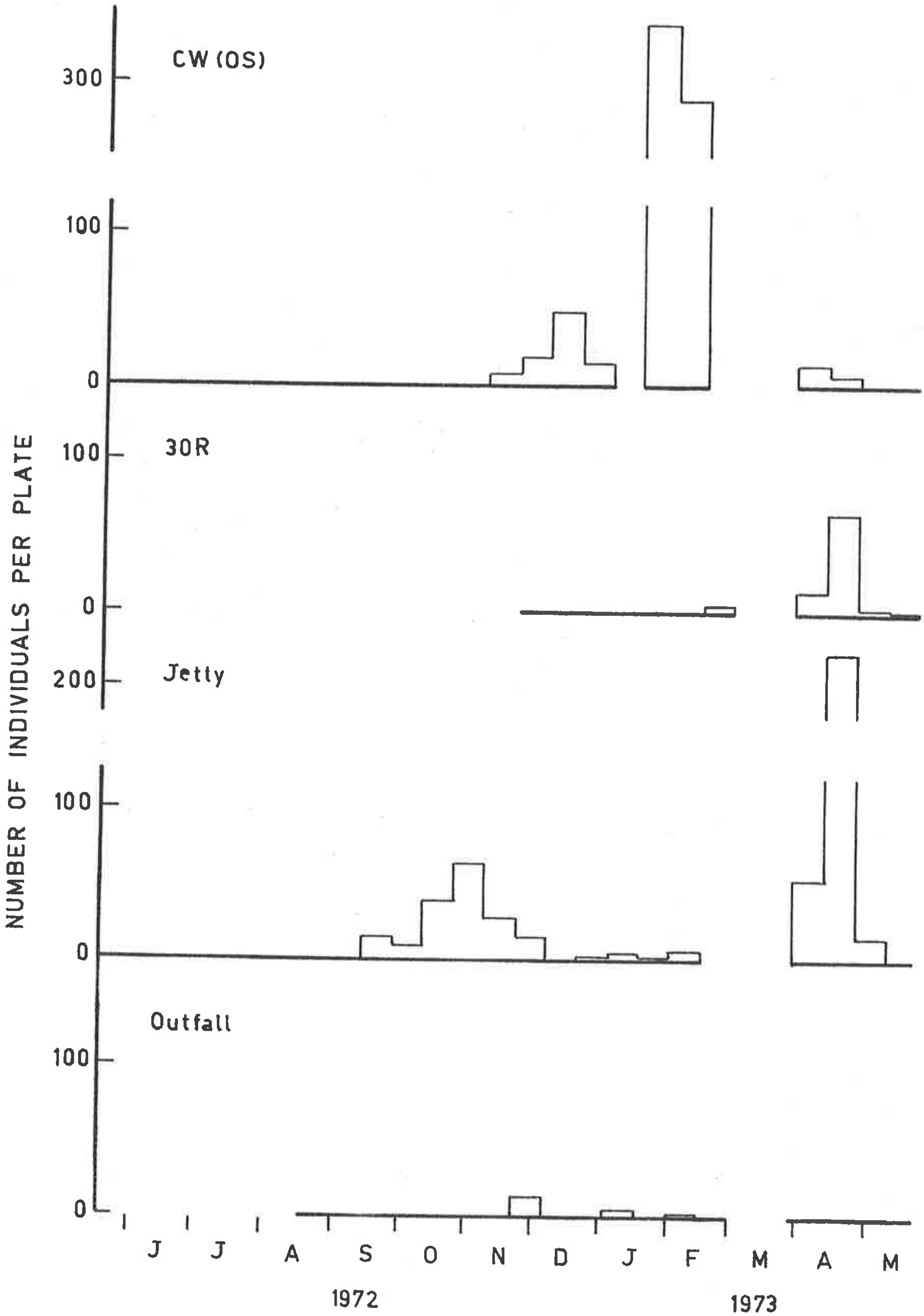

Fig. 4.26 Presence of the endoproct probably *Loxosomella kefersteini* on 2-week plates over the period from June, 1972 to May, 1973.

In view of the seasonal differences in the occurrence of *Loxosomella*, it was necessary to use non-parametric methods of analysis when examining the data for differences in abundance between stations. The Friedman two-way analysis of variance by ranks was applied to the data from the CW(OS), Outfall and Jetty stations over the period from 27/9/72 to 20/6/73 and showed that significant differences in abundance were present ($X_2^2 = 14.2$, $P<0.001$). Pair-wise comparisons between stations were then made by using the Wilcoxon matched-pairs signed-rank test. There were no significant differences between the CW(OS) and Jetty stations ($n = 15$, $T = 46\frac{1}{2}$) but *Loxosomella* was less abundant at the Outfall station than at the other two stations (for CW(OS) v Outfall, $n = 8$, $T = 0$, $P<0.01$; for Jetty v Outfall, $n = 15$, $T = 2$, $P<0.01$).

The results have shown that the timing of the settlement season of *Loxosomella* was altered in Angas Inlet under the influence of the warmed water. In addition, the results suggested that, during the summer, the water became too hot to allow the survival of *Loxosomella* in Angas Inlet near the Outfall Station. If *Loxosomella* was able to survive at the Outfall station during summer, a greater rate of settlement should have been observed there, with a seasonal pattern of distribution similar to that found at the Jetty station.

If a species is killed by the hot water in all or part of Angas Inlet during summer, recolonization may be possible during the cooler months of the year. However, recolonization may be more difficult at the Outfall station than at the other stations in Angas Inlet. Recolonizing larvae may come from two sources. Firstly, they may come from the North Arm and pass through the power plant. However, the survival rate may be low after passage through the power plant. Hence, as a source of recolonizing larvae, the North Arm (via the power plant) may be of minor significance. This would apply especially to species, like *Loxosomella*, which breed during the summer in the North Arm. Secondly, larvae may be carried up Angas Inlet in a westerly direction on a rising tide. However, very few larvae are likely to reach the Outfall station in this way, since the tidal currents in the vicinity of the cooling water outlet are very slow and would generally be masked by the flow of water from the power station.

Hence, although a species which is killed in certain areas (or all) of Angas Inlet during the summer may return during the cooler months of the year, such recolonization may be limited at the Outfall station. This appears to be the case with *Loxosomella*.

(e) The bryozoan *Watersipora subovoidea* (d'Orbigny).

The complete data on the presence of *Watersipora* on two-week, four-week and eight-week plates are shown in appendix 5. The colonies of *Watersipora* are encrusting. As a result of its pattern of growth, *Watersipora* is liable to be smothered by other species on longer term plates, while smaller colonies may be covered by larger colonies. Hence, on eight-week plates, it was sometimes impractical to record the number of colonies present. If competition for space with other species was of minor significance, a few large colonies of *Watersipora* were found, while if the amount of competition was great, a few small patches would be seen amongst the other growth. In both such cases, abundance was expressed as the total area of the plate covered.

Fig. 4.27 and 4.28 show the abundance of *Watersipora subovoidea* on two-week and four-week plates from all stations (except CW(NS) station) during the period June, 1973 to May, 1974. Some spasmodic settlement extended over spring, summer and autumn. Seasonal differences in settlement rates between the stations appeared to be present. The statistical significance of the differences was examined by conducting a series of one-sample runs tests on all possible pair-wise comparisons between stations (table 4.19). These tests were conducted on the data obtained over the period 10/10/73 - 22/5/74.

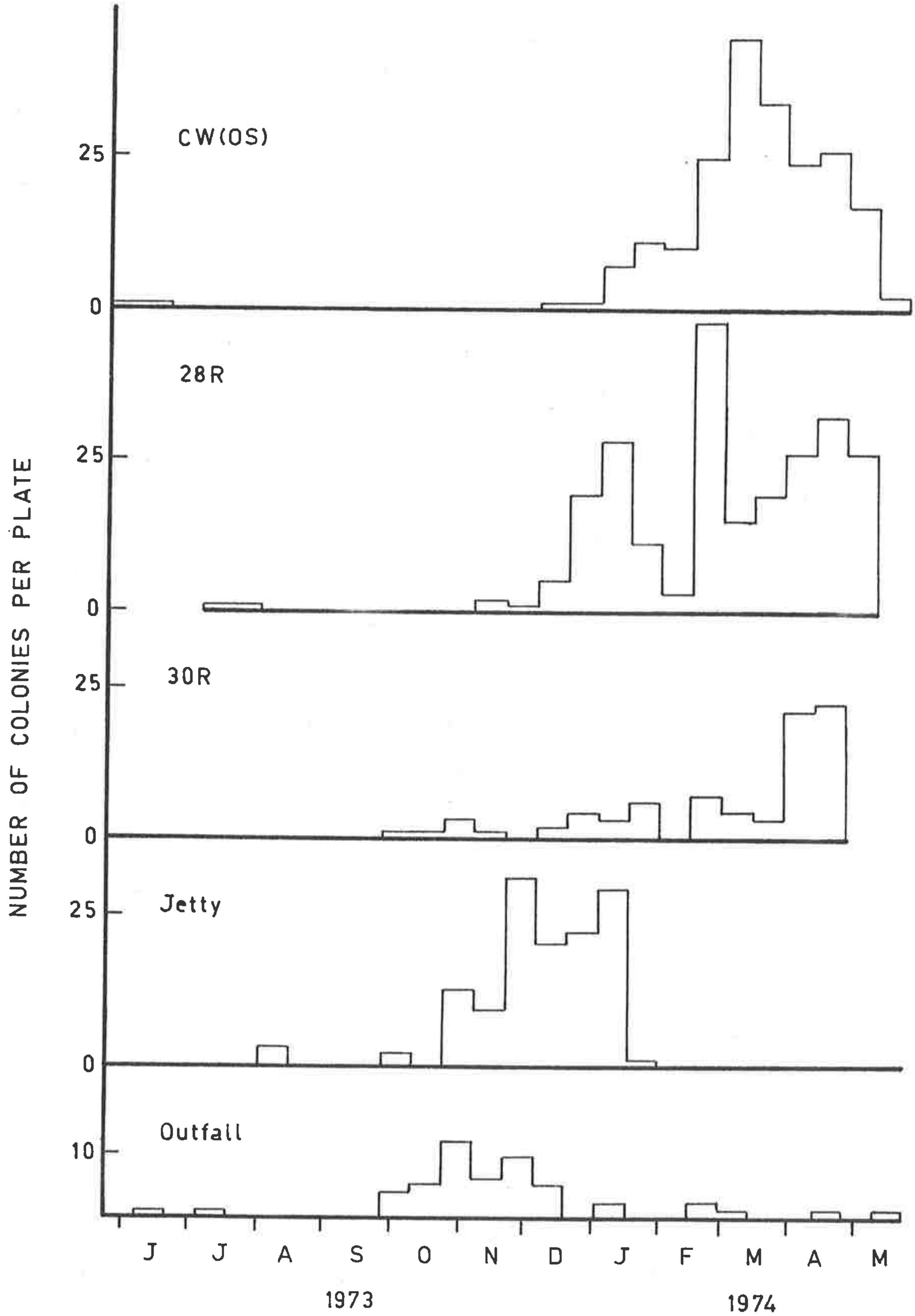

Fig. 4.27 Settlement of the bryozoan *Watersipora subovoidea* on 2-week plates over the period from June, 1973 to May, 1974.

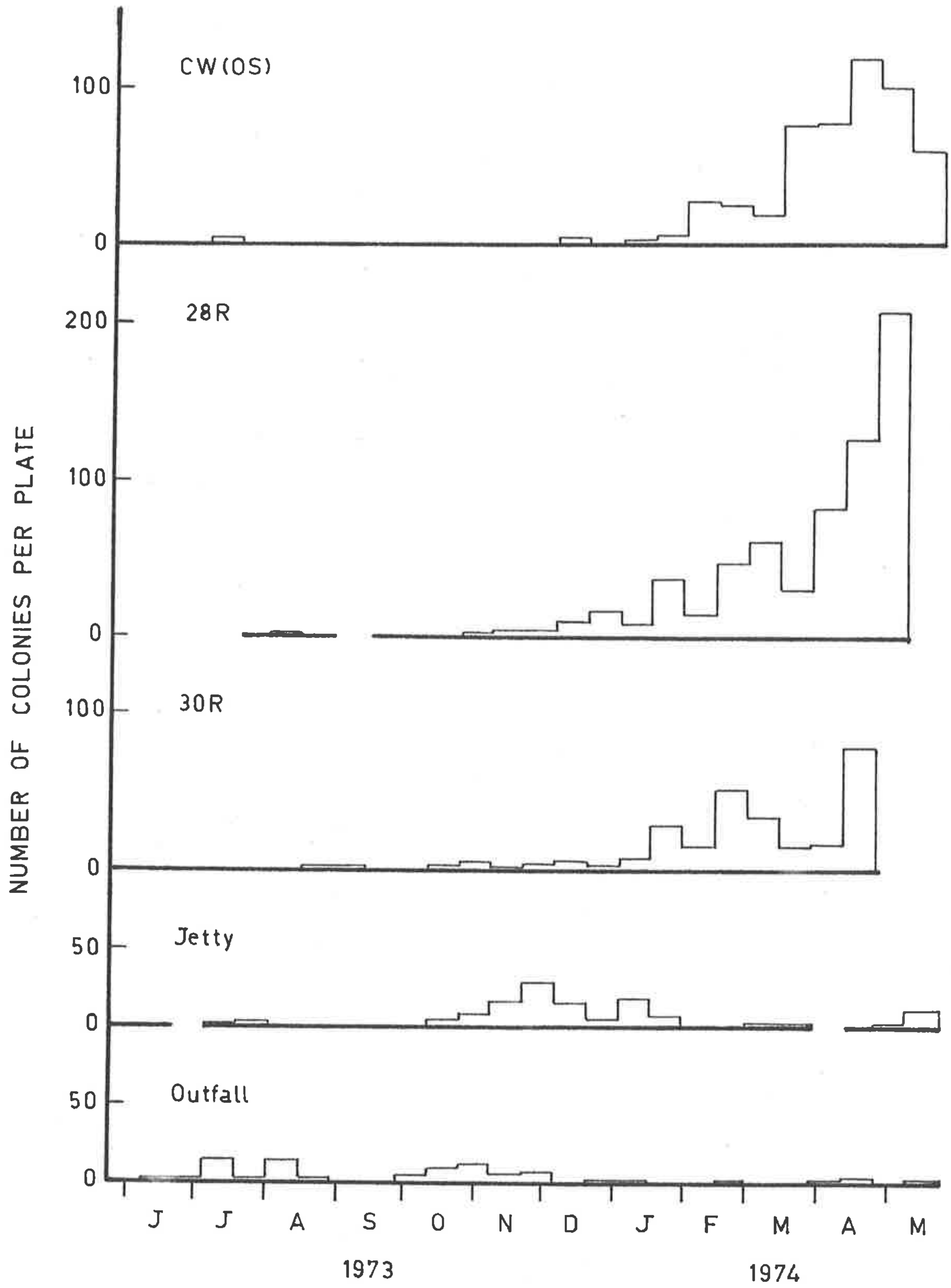

Fig. 4.28 Presence of the bryozoan *Watersipora subovoidea* on 4-week plates over the period from June, 1973 to May, 1974.

Table 4.19 Results of a series of one-sample runs tests conducted on the data on the presence of *Watersipora subovoidea* on plates from all stations, except CW(NS), obtained over the period from 10/10/73 - 22/5/74. The analyses were employed to examine seasonal differences in occurrence.

Comparison		n_1	n_2	Observed r	Critical r (5% level)	Significance (5% level)
	(a) Two-week plates					
CW(OS)	v Outfall	11	6	2	4	Yes
	v Jetty	8	8	3	4	Yes
	v 30R	8	6	2	3	Yes
	v 28R	3	9	5	2	No
Outfall	v Jetty	5	7	4	3	Yes
	v 30R	6	8	2	3	Yes
	v 28R	5	10	2	3	Yes
Jetty	v 30R	7	7	4	3	No
	v 28R	7	8	2	4	Yes
30R	v 28R	3	12	2	2	Yes
	(b) Four-week plates					
CW(OS)	v Outfall	10	7	3	5	Yes
	v Jetty	7	8	2	4	Yes
	v 30R	4	10	4	3	No
	v 28R	2	12	5	2	No
Outfall	v Jetty	5	10	6	3	No
	v 30R	5	10	2	3	Yes
	v 28R	5	11	2	4	Yes

Table 4.19 (cont.)

Comparison		n_1	n_2	Observed r	Critical r	Significance
Jetty	v 30R	7	6	2	3	Yes
	v 28R	6	8	4	3	No
30R	v 28R	4	8	4	3	No

From the results of the analyses, the following conclusions can be made. At the CW(OS) station, the main breeding season extended over the period from mid-summer to the end of autumn. In Angas Inlet near the cooling water outlet, the main season of settlement was earlier than that in North Arm, covering the period from early spring to early summer. In the remaining areas of Angas Inlet, settlement was observed at successively later times as the distance from the cooling water outlet increased until, at the 28R station, the breeding season corresponded with that at the CW(OS) station. On eight-week plates, *Watersipora* showed the same pattern of occurrence (see appendix 5).

The Friedman test was applied to the data from all stations, except the CW(NS) station, obtained during the period 10/10/73 to 24/4/74, with the aim of comparing the rates of settlement at the different stations. This test showed that differences were not statistically significant (for two-week plates, $X_4^2 = 3.37$; for four-week plates, $X_4^2 = 4.46$).

During the first year, *Watersipora* was much rarer than was the case during the second year. However, although the number of settlements was small, settlements appeared to follow the same seasonal pattern. The data obtained during the third year provided no new information.

(f) The bryozoan *Bugula avicularia* (L).

The data on the presence of *Bugula avicularia* are listed in appendix 6.

Figs. 4.29 and 4.30 show the presence of *B. avicularia* on four-week and eight-week plates during the second year of the study. During this period, the bryozoan was rare on two-week plates and on plates from the Outfall and 28R stations. However, the apparent scarcity at the 28R station may be principally caused by the later start to the observations there : settlement at the other stations in Angas Inlet had almost ceased when observations at the 28R station commenced.

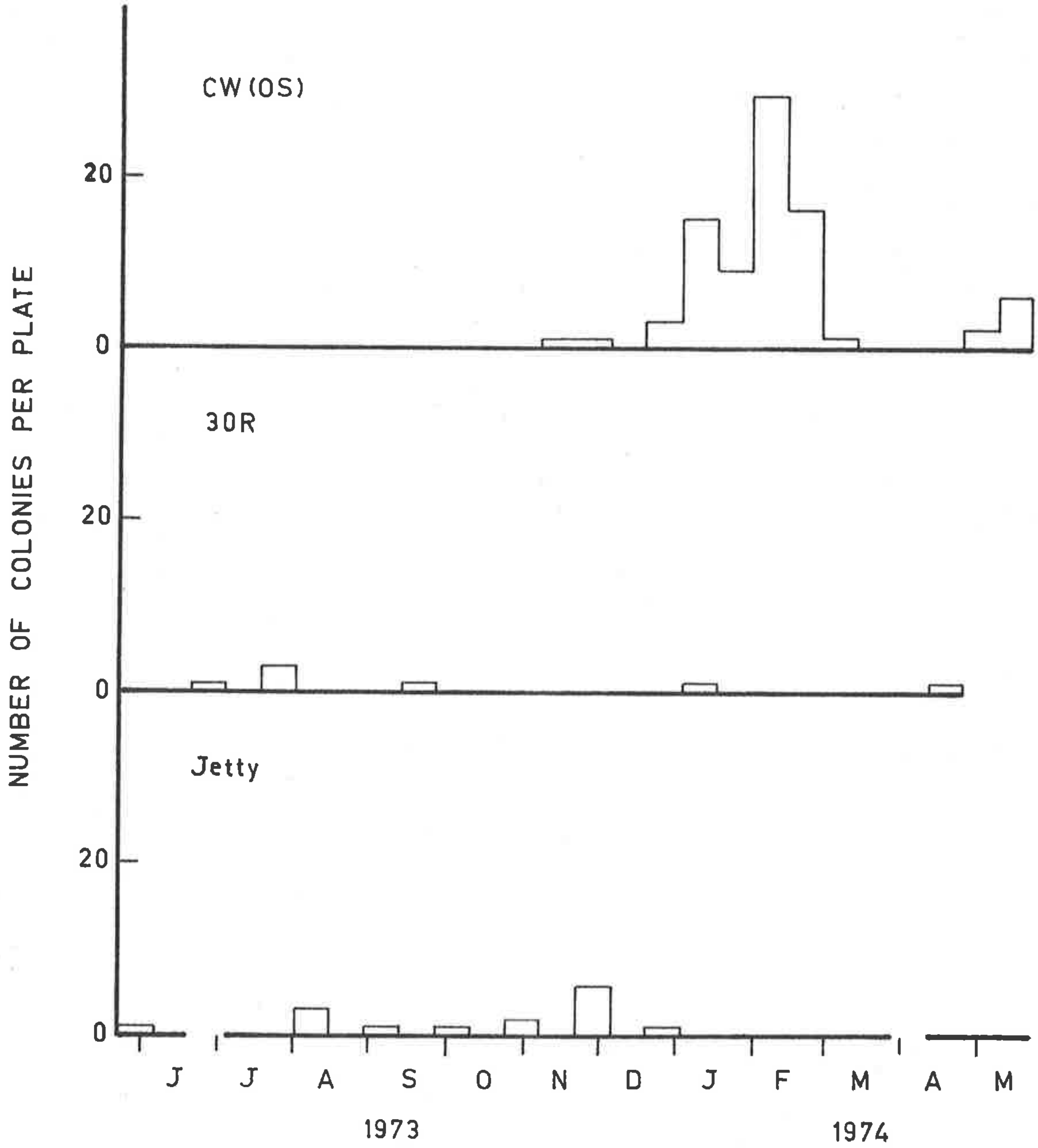

Fig. 4.29 Presence of the bryozoan *Bugula avicularia* on 4-week plates from the CW(OS), 30R and Jetty stations over the period from June, 1973 to May, 1974.

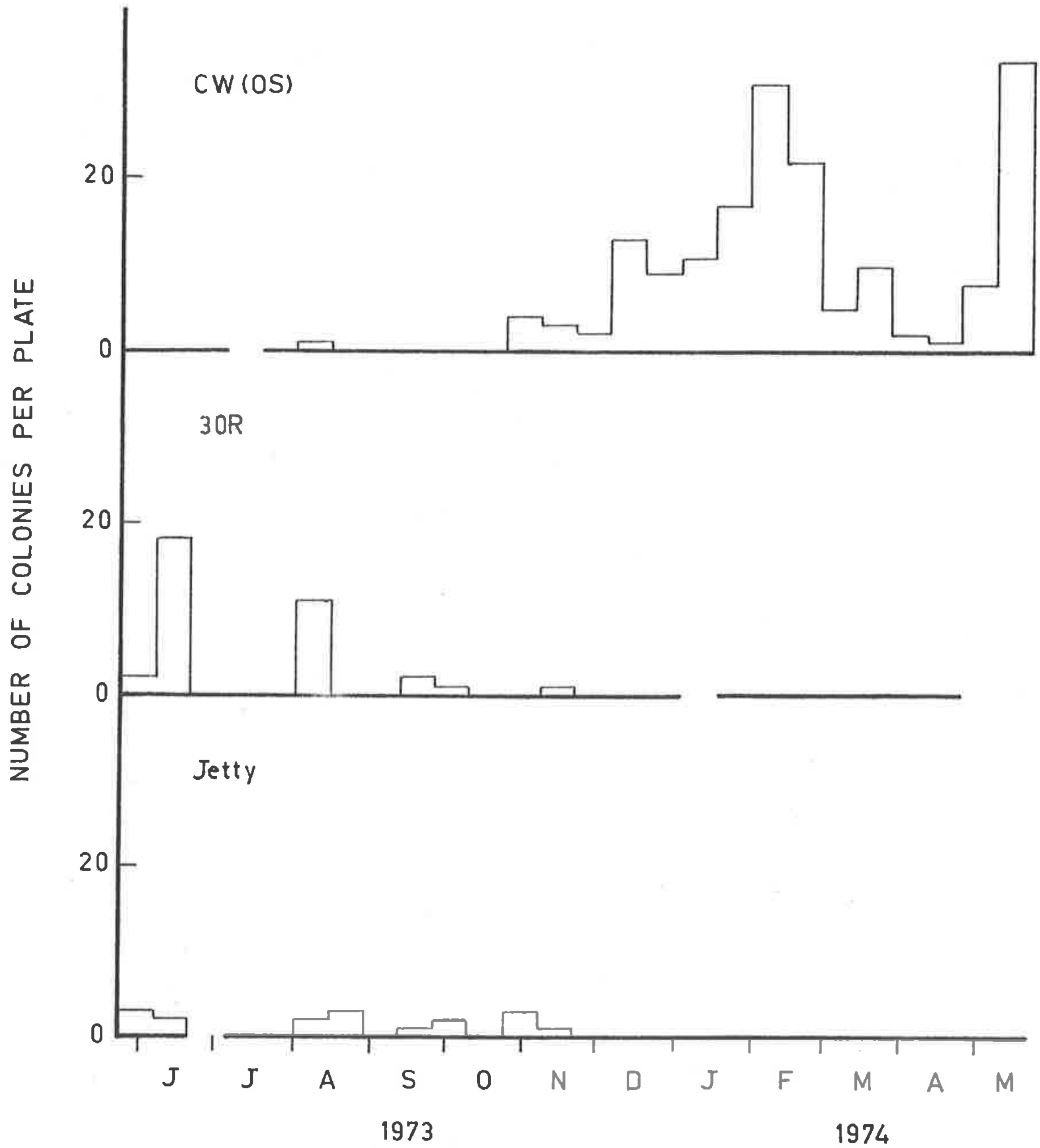

Fig. 4.30 Presence of the bryozoan *Bugula avicularia* on 8-week plates from the CW(OS), 30R and Jetty stations over the period from June, 1973 to May, 1974.

At the Jetty and 30R stations, most settlements were observed during winter and spring, while at the CW(OS) station, colonies were found on the plates from mid-spring through summer and autumn. A series of one-sample runs tests were conducted to determine if these apparent seasonal differences were statistically significant. The results of the analyses are shown in table 4.20 and confirmed the presence of seasonal differences.

Friedman tests were conducted on the data obtained during the second year from the CW(OS), Outfall, Jetty and 30R stations to compare the rates of settlement between the stations. Overall, differences were not statistically significant on four-week plates ($X_3^2 = 5.82$) but were significant on eight-week plates ($X_3^2 = 11.3$, $0.01<P<0.02$). In order to clarify the situation, a series of Wilcoxon tests were conducted (table 4.21). The results showed that *B. avicularia* was less abundant at the Outfall station than at the CW(OS), Jetty and 30R stations. In addition, there were significantly fewer colonies on eight-week plates from the Jetty station than from the CW(OS) station.

The same explanation that was used to account for differences between the stations in the abundance of *Loxosomella* (section 4.2(d)) may also be invoked here. Thus, it would appear that most colonies in the vicinity of the cooling water outlet were killed during the summer months. Although it would have been possible for such areas to have been recolonized when the temperature was favourable, recolonization may be of limited extent, as discussed in section 4.2(d).

The presence of *B. avicularia* on two-week, four-week and eight-week plates during the first year of the study is shown in figs. 4.31-4.33. Seasonal differences in occurrence between stations were less evident than during the second year. However, at the CW(OS) station, most settlements were observed in late spring and summer, while few settlements were observed during summer in Angas Inlet.

Table 4.20 Results of a series of one-sample runs tests conducted on the data on the presence of *Bugula avicularia* on plates from the CW(OS), Jetty and 30R stations obtained during the second year. The analyses were conducted to examine seasonal differences in occurrence.

Comparison	n_1	n_2	Observed r	Critical r	Significance
(a) Four-week plates.					
CW(OS) v Jetty	9	6	4	4	Yes
v 30R	8	4	3	3	Yes
Jetty v 30R	7	5	6	3	No
(b) Eight-week plates.					
CW(OS) v Jetty	14	6	2	5	Yes
v 30R	12	5	2	4	Yes
Jetty v 30R	4	3			No

Table 4.21 Results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the presence of *Bugula avicularia* on plates from the CW(OS), Outfall, Jetty and 30R stations obtained during the second year. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
	(a) Four-week plates.			
CW(OS)	v Outfall	10	0	<0.01
	v Jetty	15	35	N.S.
	v 30R	12	18	N.S.
Outfall	v Jetty	7	0	$0.02<P<0.05$
	v 30R	7	0	$0.02<P<0.05$
Jetty	v 30R	13	34	N.S.
	(b) Eight-week plates.			
CW(OS)	v Outfall	17	2	<0.01
	v Jetty	20	37	<0.01
	v 30R	17	38	N.S.
Outfall	v Jetty	8	0	<0.01
	v 30R	7	2½	N.S.
Jetty	v 30R	7	13	N.S.

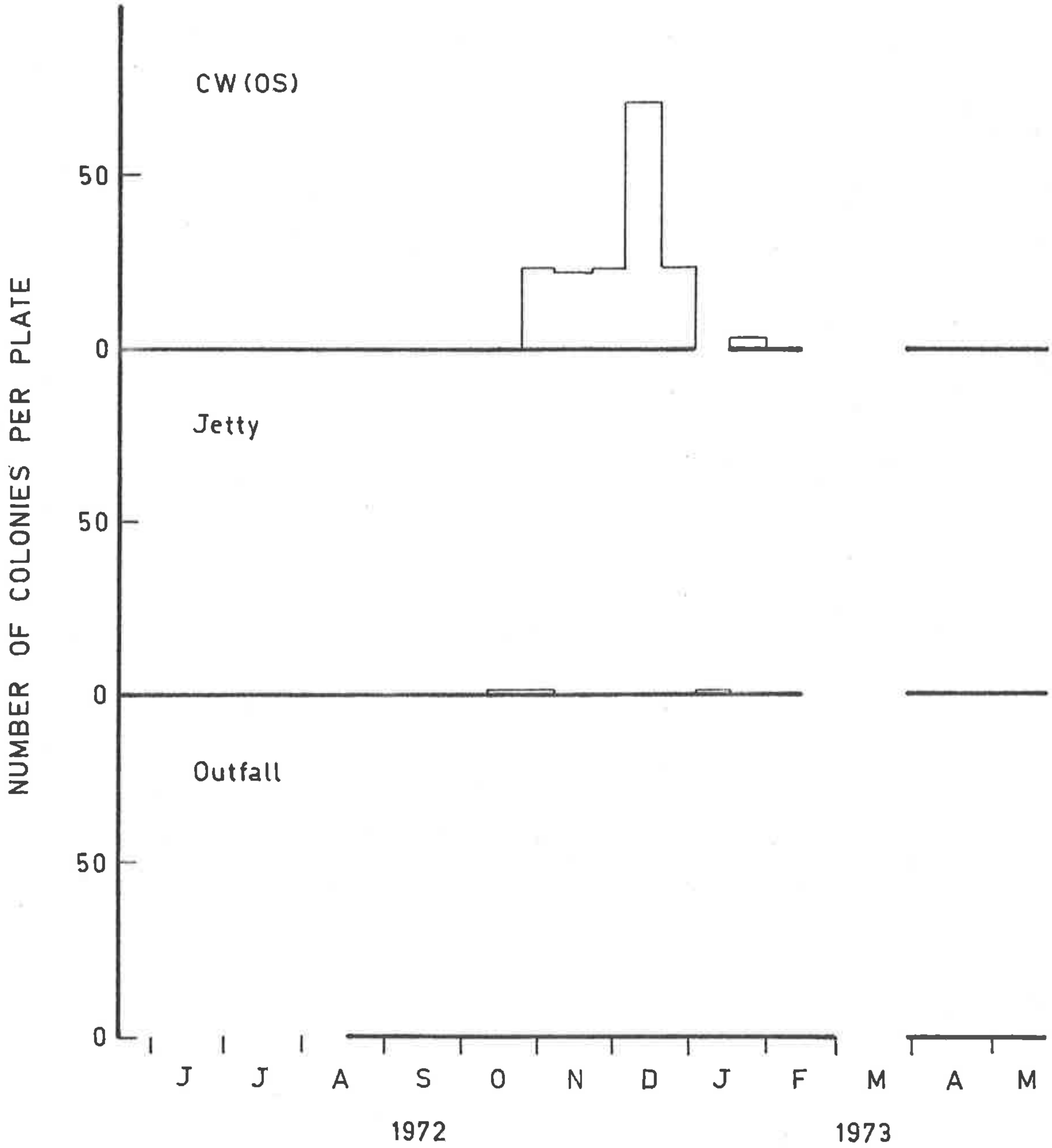

Fig. 4.31 Presence of the bryozoan *Bugula avicularia* on 2-week plates from the CW(OS), Outfall and Jetty stations over the period from June, 1972 to May, 1973.

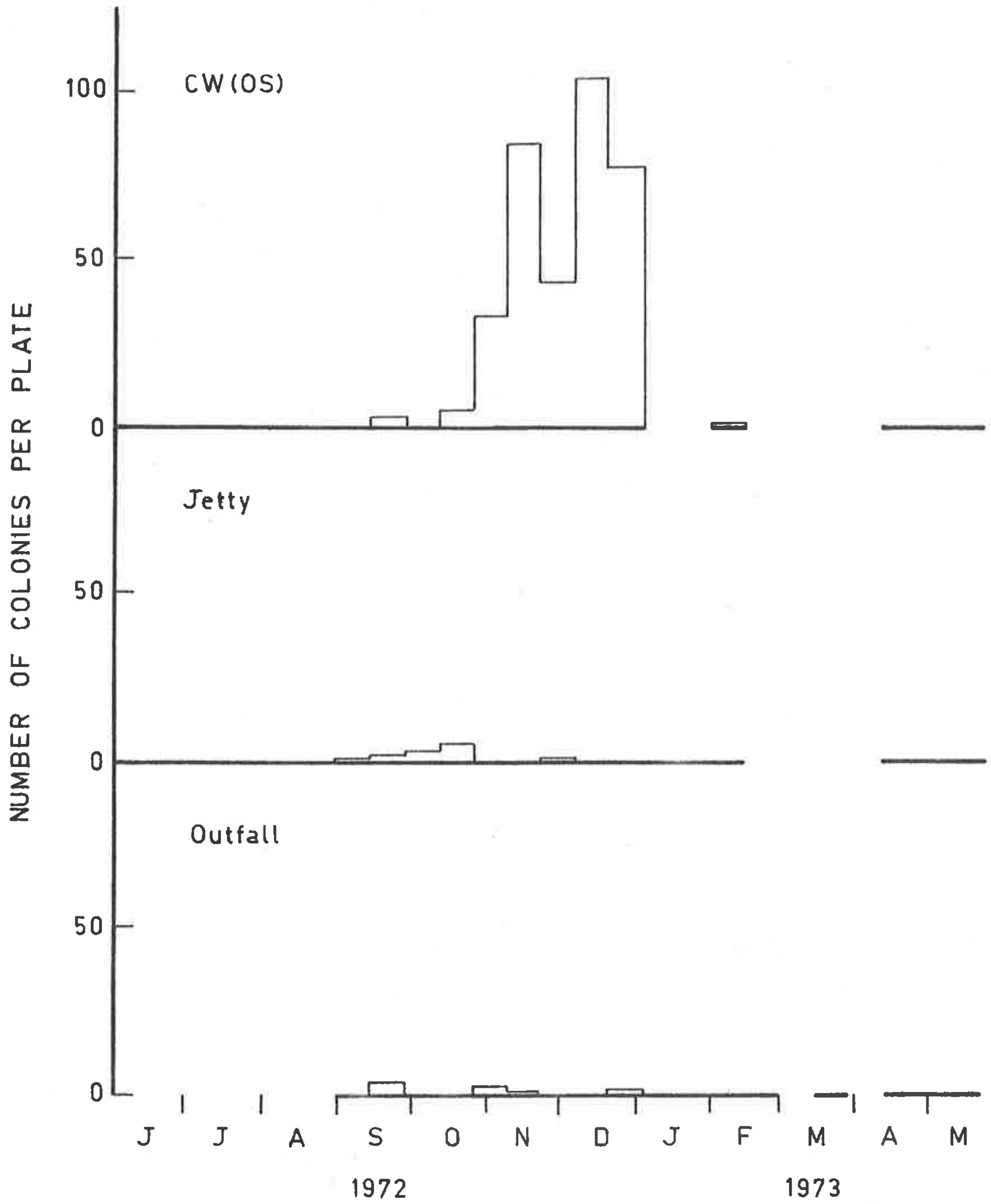

Fig. 4.32 Presence of the bryozoan *Bugula avicularia* on 4-week plates from the CW(OS), Outfall and Jetty stations over the period from June, 1972 to May, 1973.

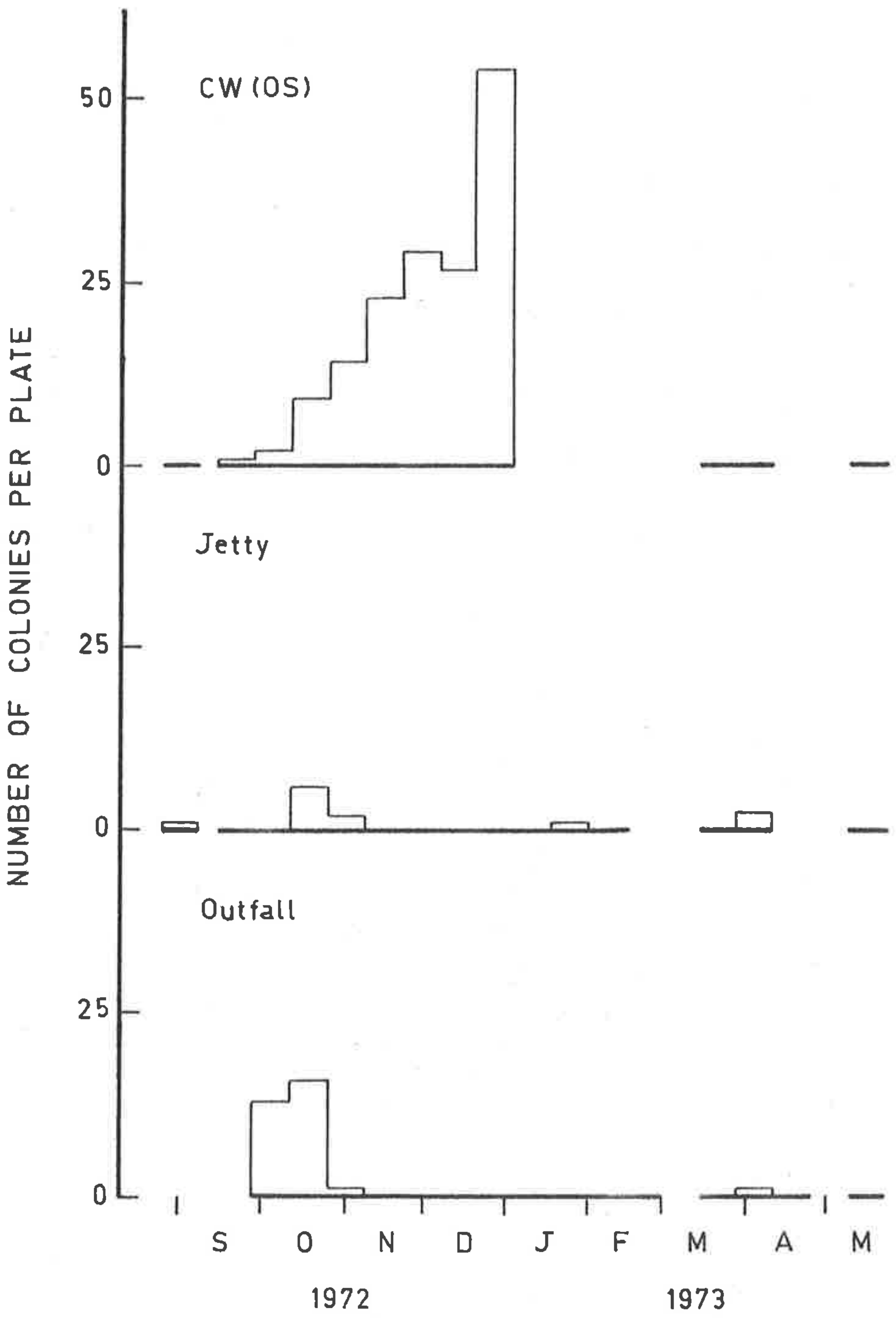

Fig. 4.33 Presence of the bryozoan *Bugula avicularia* on 8-week plates from the CW(OS), Outfall and Jetty stations over the period from September, 1972 to May, 1973.

Greater numbers of settlements were observed at the CW(OS) station than in Angas Inlet. However, when the results from two-week, four-week and eight-week plates were analysed using the Friedman test, none of the analyses produced a significant result (two-week plates, $X^2(k = 3, n = 8) = 5.25$; four-week plates, $X^2(k = 3, n = 8) = 3.25$; eight-week plates, $X_2^2 = 5.77$). Nevertheless, since the results from the different series of exposures were consistent with each other, it seems unlikely that the differences were caused by chance alone. In addition, it would appear that the gaps in the observations occurred during the breeding season of *B. avicularia* at the CW(OS) station.

The results during the third year of the study were consistent with those from the second year.

(g) <u>The bryozoan *Bugula neritina* (L).</u>

Bugula neritina appeared only occasionally on the plates until autumn of 1973. It was then present on four-week and eight-week plates at one or more stations until the end of May, 1974 (see appendix 7). Figs. 4.34 and 4.35 show the presence of *B. neritina* on four-week and eight-week plates from the CW(OS), Jetty and 30R stations during this period. The bryozoan was rare at the Outfall and 28R stations.

A series of one-sample runs tests were conducted on the data, as some seasonal differences in abundance appeared to be present (table 4.22). The results confirmed that seasonal differences were present, with most settlements in Angas Inlet being found during the cooler months, while most in the North Arm were observed during the warmer months. However, the comparison between the CW(OS) and Jetty stations for four-week plates did not produce a significant result.

The relative abundance of *B. neritina* at the different stations was examined initially by conducting Friedman tests on the results from the CW(OS), Outfall, Jetty and 30R stations obtained over the period 26/4/73 - 24/4/74. The data from the 28R station was not included in the

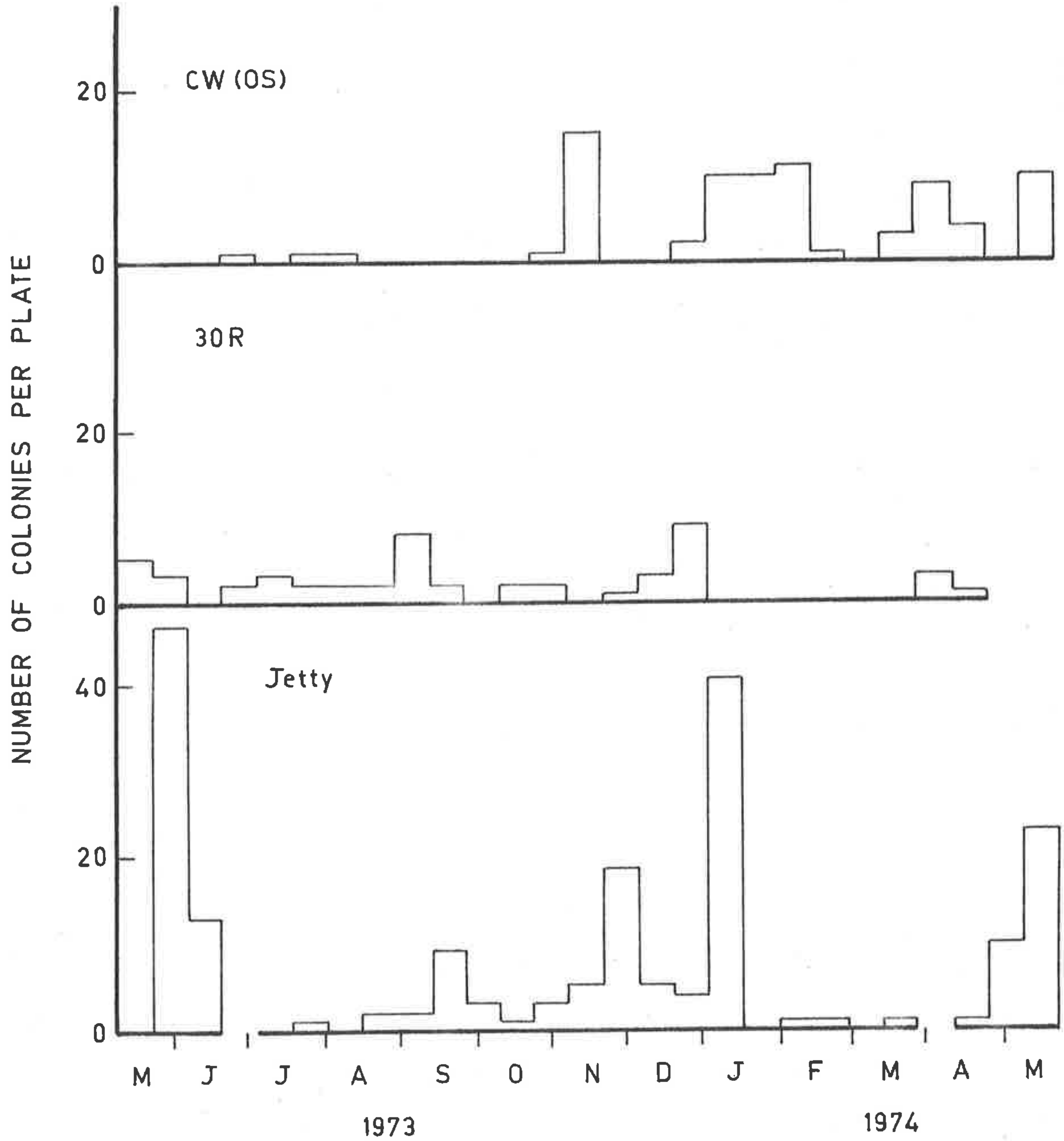

Fig. 4.34 Presence of the bryozoan *Bugula neritina* on 4-week plates from the CW(OS), 30R and Jetty stations over the period from May, 1973 to May, 1974.

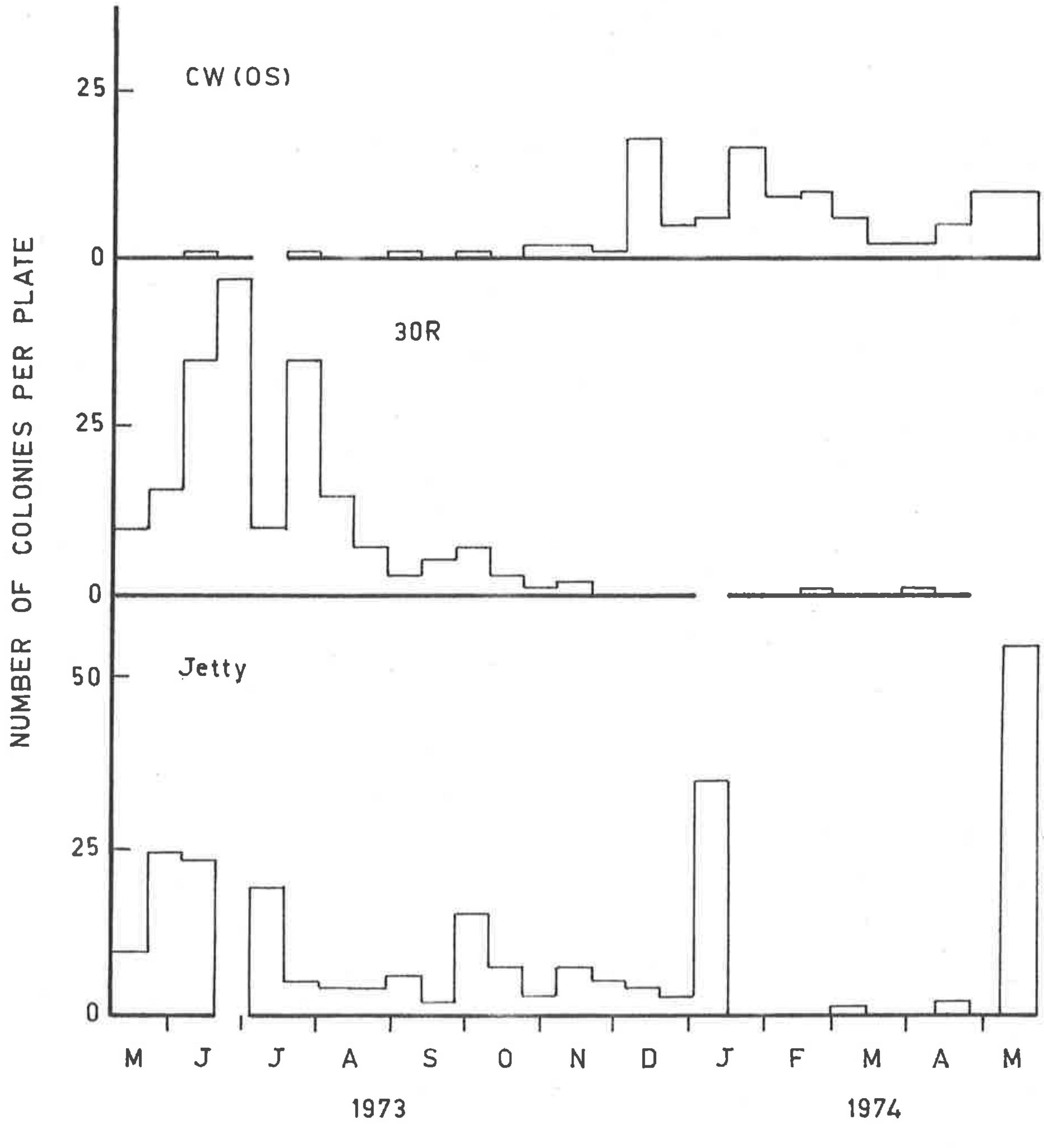

Fig. 4.35 Presence of the bryozoan *Bugula neritina* on 8-week plates from the CW(OS), 30R and Jetty stations over the period from May, 1973 to May, 1974.

Table 4.22 Results of a series of one-sample runs tests conducted on the data on the presence of *Bugula neritina* on plates from the CW(OS), Jetty and Outfall stations obtained over the period 26/4/73 - 22/5/74. The analyses were employed to compare seasonal differences.

Comparison	n_1	n_2	Observed r	Critical r	Significance
	(a) Four-week plates.				
CW(OS) v Jetty	7	14	8	5	No
v 30R	8	16	4	6	Yes
Jetty v 30R	12	9	8	6	No
	(b) Eight-week plates.				
CW(OS) v Jetty	10	15	5	7	Yes
v 30R	11	11	2	7	Yes
Jetty v 30R	12	8	12	6	No

tests in view of the later start to the observations there. Significant differences in abundance between stations were evident on both four-week and eight-week plates (four-week plates, $X_3^2 = 19.7$, $P < 0.001$; eight-week plates, $X_3^2 = 17.8$, $P < 0.001$). The situation was examined in greater detail by conducting a series of Wilcoxon tests on the data (table 4.23). The results showed that *B. neritina* was less common at the Outfall station than at the other stations. This type of distribution was similar to that observed for *Loxosomella kefersteini* and *Bugula avicularia* (sections 4.2(d) and (f), where it was discussed in some detail.

Although observations at the 28R station started later than at the other stations, inspection of the data suggested that *B. neritina* was less abundant there than at the CW(OS), Jetty and 30R stations. No explanation for this difference (if it is significant) presents itself. The data obtained during the third year provided no new information.

(h) <u>The simple ascidian *Ciona intestinalis* L.</u>

The complete data on the presence of *Ciona intestinalis* are listed in appendix 8. Figs.4.36 - 4.38 summarize the picture during the first year. *Ciona* was very rare at the Outfall and 30R stations during this period. However, its rarity at the 30R station was probably a result of the late start to the observations at that station. The appropriate method of analysis for examining differences in settlements on two-week plates was the Friedman two-way analysis of variance by ranks. This test was conducted on the data from the CW(OS), Outfall and Jetty stations obtained over the period 30/8/72 - 26/4/73 and revealed a statistically significant difference in the rates of settlement between the stations ($X_2^2 = 17.8$, $P < 0.001$). The Wilcoxon test showed that the numbers of settlements were greater at the CW(OS) station than at the other stations (for CW(OS) v Outfall, n = 14, T = 0, $P < 0.01$; for CW(OS) v Jetty, n = 14, T = 9½, $P < 0.01$). In addition, there were significantly greater settlements at the Jetty station than at the Outfall station (n = 7, T = 0, $0.01 < P < 0.02$).

Table 4.23 Results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the presence of *Bugula neritina* on plates from the CW(OS), Outfall, Jetty and 30R stations obtained over the period 26/4/73 - 22/5/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
	(a) Four-week plates			
CW(OS)	v Outfall	16	4	<0.01
	v Jetty	21	63½	N.S.
	v 30R	24	139½	N.S.
Outfall	v Jetty	20	0	<0.01
	v 30R	18	0	<0.01
Jetty	v 30R	21	89	N.S.
	(b) Eight-week plates			
CW(OS)	v Outfall	20	15½	<0.01
	v Jetty	25	119½	N.S.
	v 30R	22	101	N.S.
Outfall	v Jetty	20	0	<0.01
	v 30R	16	0	<0.01
Jetty	v 30R	20	81	N.S.

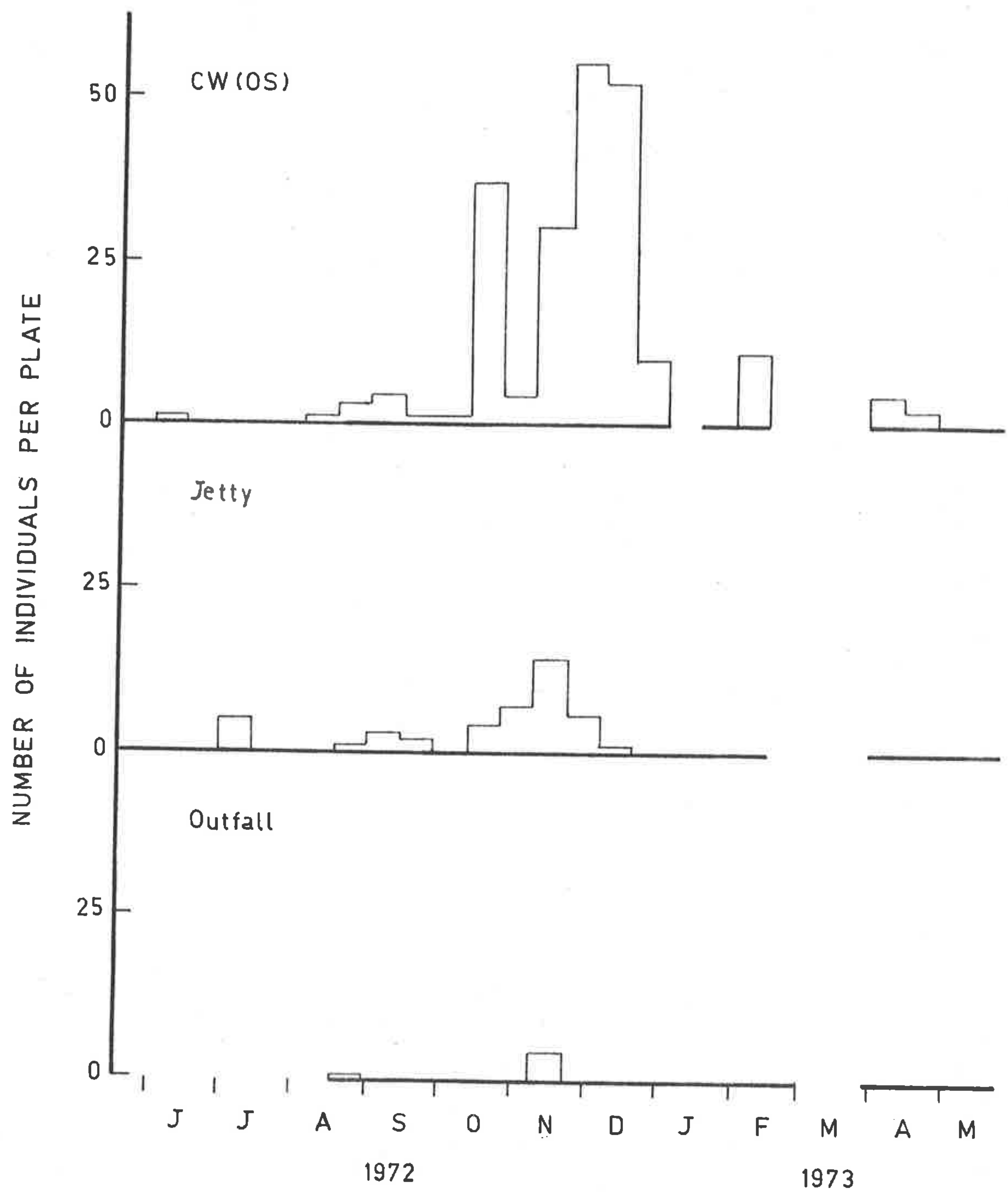

Fig. 4.36 Presence of the simple ascidian *Ciona intestinalis* on 2-week plates over the period from June, 1972 to May, 1973.

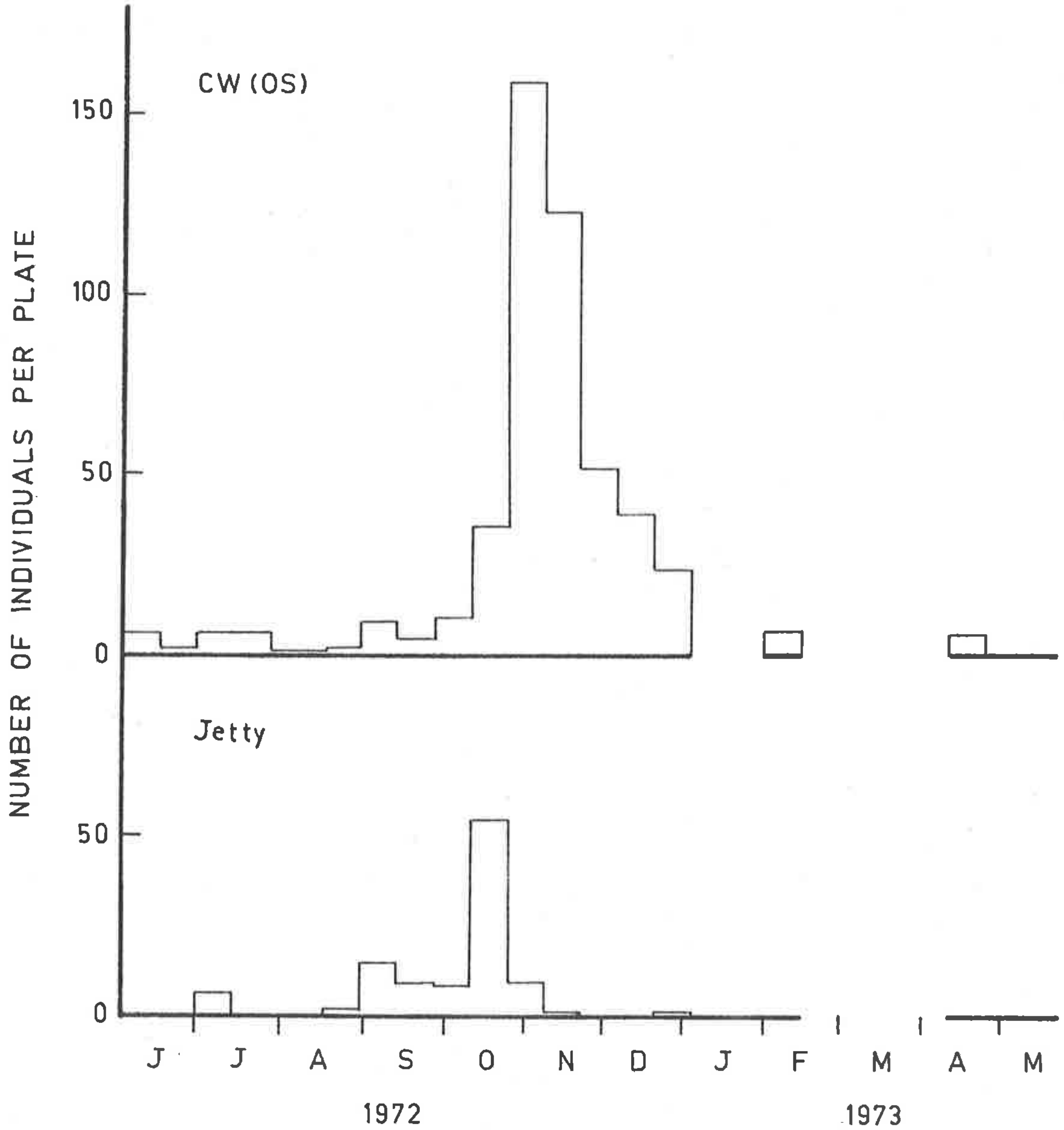

Fig. 4.37 Presence of the simple ascidian *Ciona intestinalis* on 4-week plates from the CW(OS) and Jetty stations over the period from June, 1972 to May, 1973.

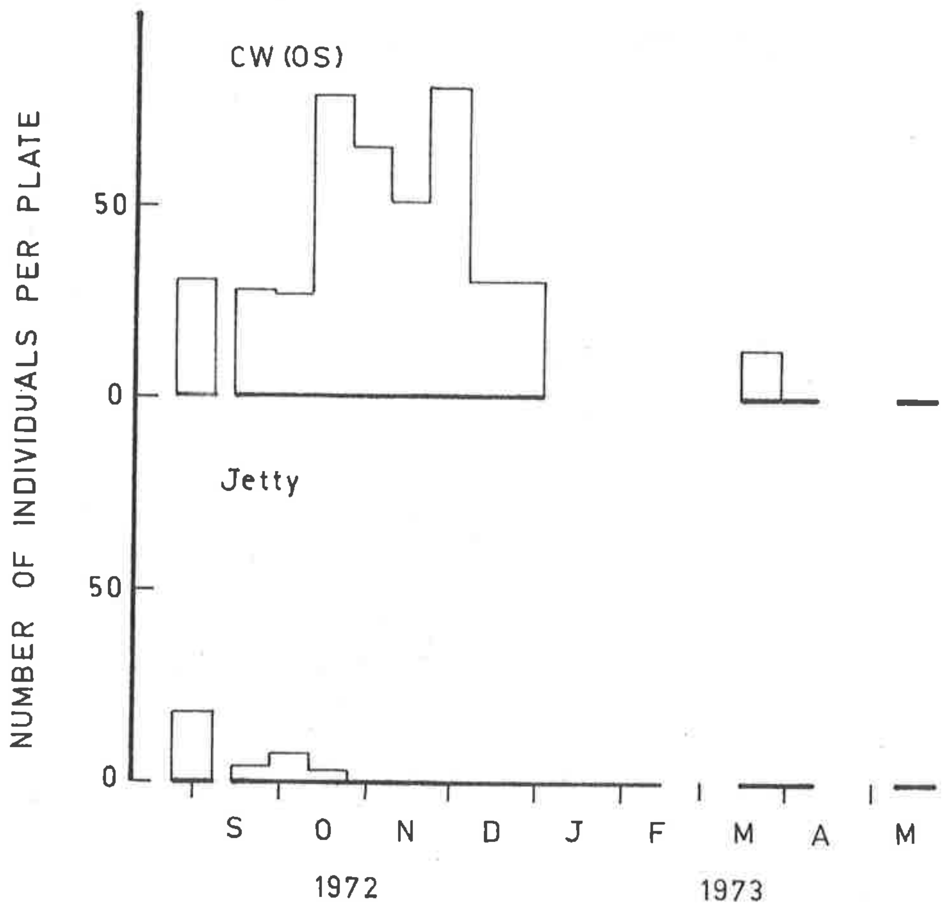

Fig. 4.38 Presence of the simple ascidian *Ciona intestinalis* on 8-week plates from the CW(OS) and Jetty stations over the period from September, 1972 to May, 1973.

The data from four-week and eight-week plates were consistent with those from two-week plates. However, at the time when *Ciona* was at its greatest abundance at the CW(OS) station, the compound ascidian *Leptoclinum rayneri* (section 4.2 (a)) was at its peak of abundance at the Jetty station. Although *Leptoclinum* appears unable to smother established individuals of *Ciona*, small individuals are likely to succumb. Hence the difference in numbers between the CW(OS) and Jetty stations on four-week and eight-week plates may have been accentuated by the abundance of *Leptoclinum* at the Jetty station.

During the second year, the rate of settlement of *Ciona* on two-week plates was very low. There did not appear to be any differences in abundance between the stations. Figs. 4.39 and 4.40 show the presence of *Ciona* on four-week and eight-week plates during the second year. There appeared to be seasonal differences in the main periods of occurrence. Accordingly, a number of one-sample runs tests were conducted to determine the significance of any seasonal differences. The results are shown in table 4.24 and confirm that differences between the CW(OS) and Jetty stations were statistically significant, with the main period of occurrence being found earlier at the Jetty station. The differences between the CW(OS) and 30R stations were not statistically significant. However, if the results from both four-week and eight-week plates were taken as a whole, it would seem that the period of greatest abundance at the 30R station was also earlier than that at the CW(OS) station. Hence, the results suggest that the breeding season of *Ciona* in Angas Inlet occurred earlier than in the North Arm. The water in Angas Inlet apparently became too hot to allow breeding during summer. Although, the observations at the 28R station started later and were interrupted during the early stages, the data were consistent with the general pattern of occurrence.

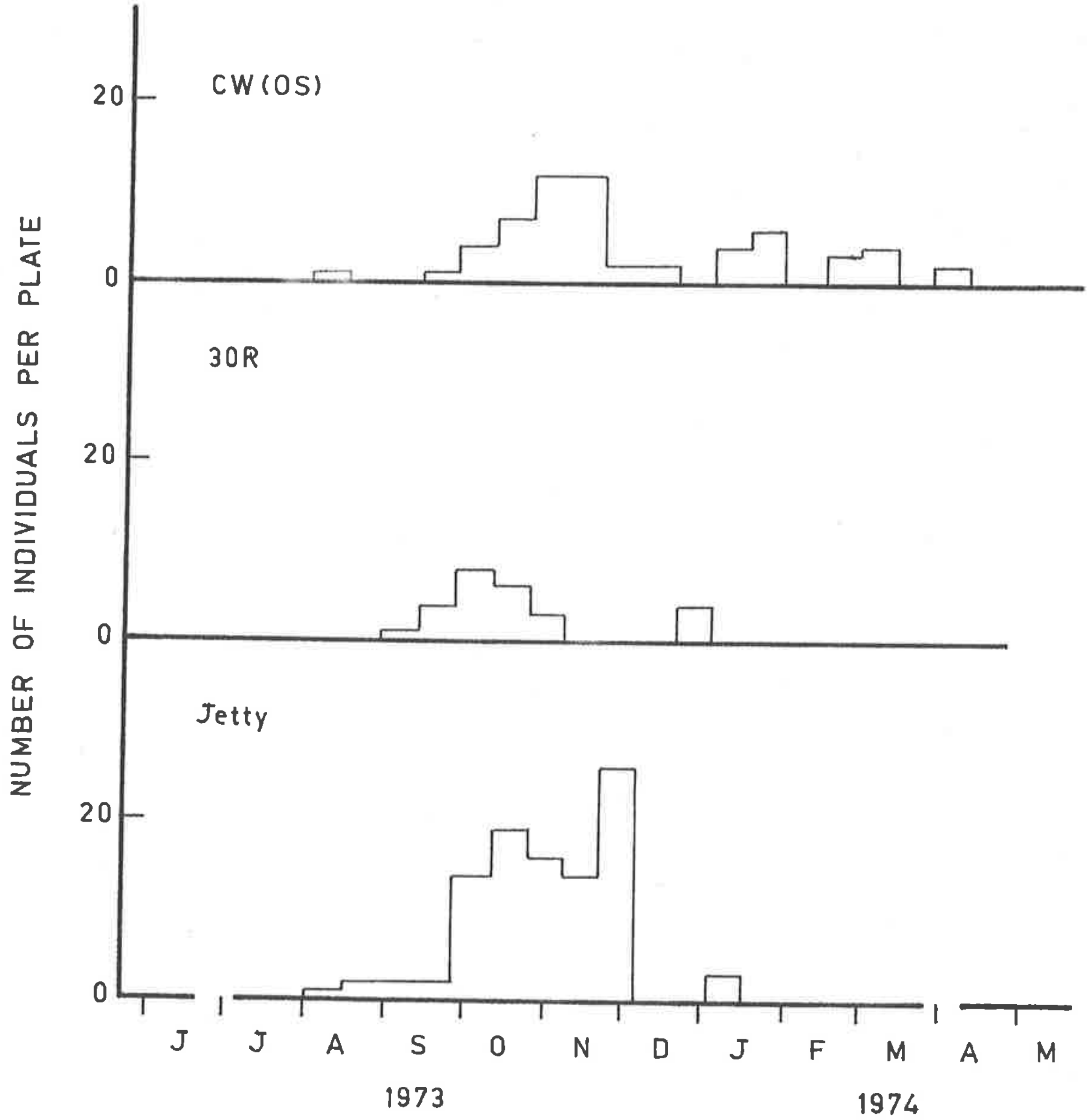

Fig. 4.39 Presence of the simple ascidian *Ciona intestinalis* on 4-week plates from the CW(OS), 30R and Jetty stations over the period from June, 1973 to May, 1974.

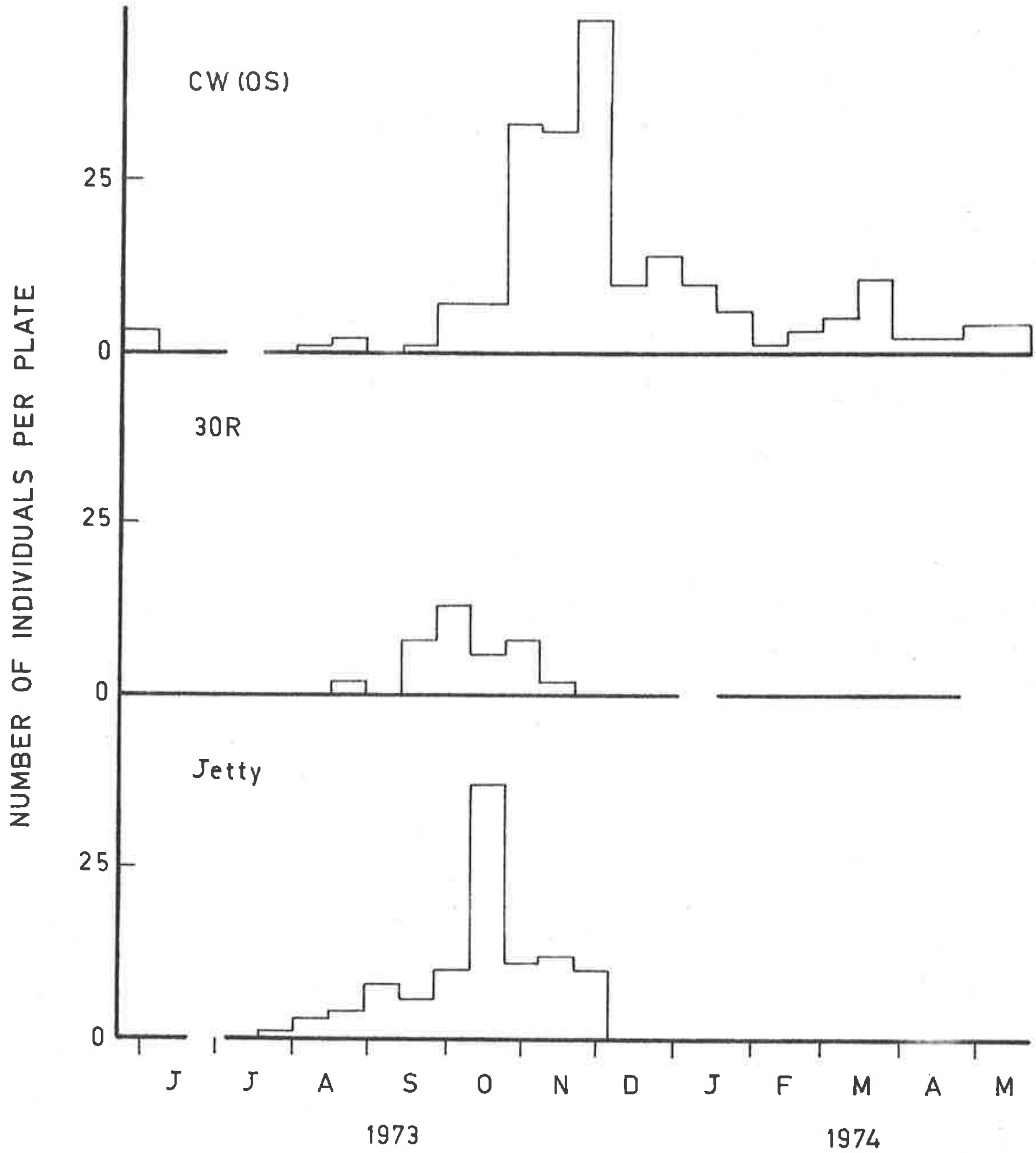

Fig. 4.40 Presence of the simple ascidian *Ciona intestinalis* on 8-week plates from the CW(OS), 30R and Jetty stations during the period from June, 1973 to May, 1974.

Table 4.24 Results of one-sample runs tests conducted on the data on the presence of *Ciona intestinalis* on four-week and eight-week plates from the CW(OS), Jetty and 30R stations over the period 1/8/73 - 22/5/74. The analyses were employed to examine seasonal differences.

Comparison	n_1	n_2	r	Critical r	Significance
(a) Four-week plates.					
CW(OS) v Jetty	6	8	2	3	Yes
v 30R	11	4	5	3	No
Jetty v 30R	9	2			No
(b) Eight-week plates.					
CW(OS) v Jetty	14	7	2	5	Yes
v 30R	14	2	3	2	No
Jetty v 30R	9	2			No

Since seasonal differences between stations were observed, the appropriate methods of analysis in examining differences in abundance were non-parametric. The Friedman test was used to examine overall differences between the CW(OS), Outfall, Jetty and 30R stations over the period from August, 1973 to April, 1974. Differences between stations were significant for both four-week and eight-week plates (for four-week plates $X_3^2 = 14.5$, $0.001 < P < 0.01$; for eight-week plates $X_3^2 = 18.6$, $P < 0.001$). In order to examine the direction of these differences, a series of pair-wise comparisons between stations were made, using the Wilcoxon test. The results of these analyses are shown in table 4.25. Nearly all comparisons involving the Outfall station were statistically significant, *Ciona* being very rare at the Outfall station. *Ciona* was also less abundant at the 30R station than at the CW(OS) and Jetty stations. There were no significant differences in abundance between the CW(OS) and Jetty stations.

The fact that *Ciona* was very rare at the Outfall station suggests that the water near the cooling water outlet was too hot during summer to allow the survival of *Ciona*. Such a situation was discussed in greater detail in section 4.2(d). However, there seems no ready explanation for the smaller numbers found at the 30R station compared with the Jetty station.

Those results obtained during the third year suggested that rates of settlement at the Jetty station were lower than those at the CW(OS) station. However, this apparent difference may simply be a result of seasonal differences similar to those observed in the previous year.

(i) The compound ascidian *Botryllus schlosseri* (Pallas).

Figs. 4.41 - 4.43 show the presence of *Botryllus schlosseri* on two-week, four-week and eight-week plates, respectively, during the first year. The data are listed in appendix 9. Differences in abundance between stations were examined by conducting Friedman tests on the data from the CW(OS), Outfall and Jetty stations obtained over the period 30/8/72 -

Table 4.25 Results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the presence of *Ciona intestinalis* on plates from the CW(OS), Outfall, Jetty and 30R stations obtained over the period 1/8/73 - 22/5/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
	(a) Four-week plates.			
CW(OS)	v Outfall	14	0	<0.01
	v Jetty	14	38	N.S.
	v 30R	15	31	N.S.
Outfall	v Jetty	9	0	<0.01
	v 30R	7	0	$0.01<P<0.02$
Jetty	v 30R	11	9½	$0.02<P<0.05$
	(b) Eight-week plates.			
CW(OS)	v Outfall	20	2	<0.01
	v Jetty	21	60	N.S.
	v 30R	16	18½	<0.01
Outfall	v Jetty	12	0	<0.01
	v 30R	6	1	N.S.
Jetty	v 30R	11	9	$0.02<P<0.05$

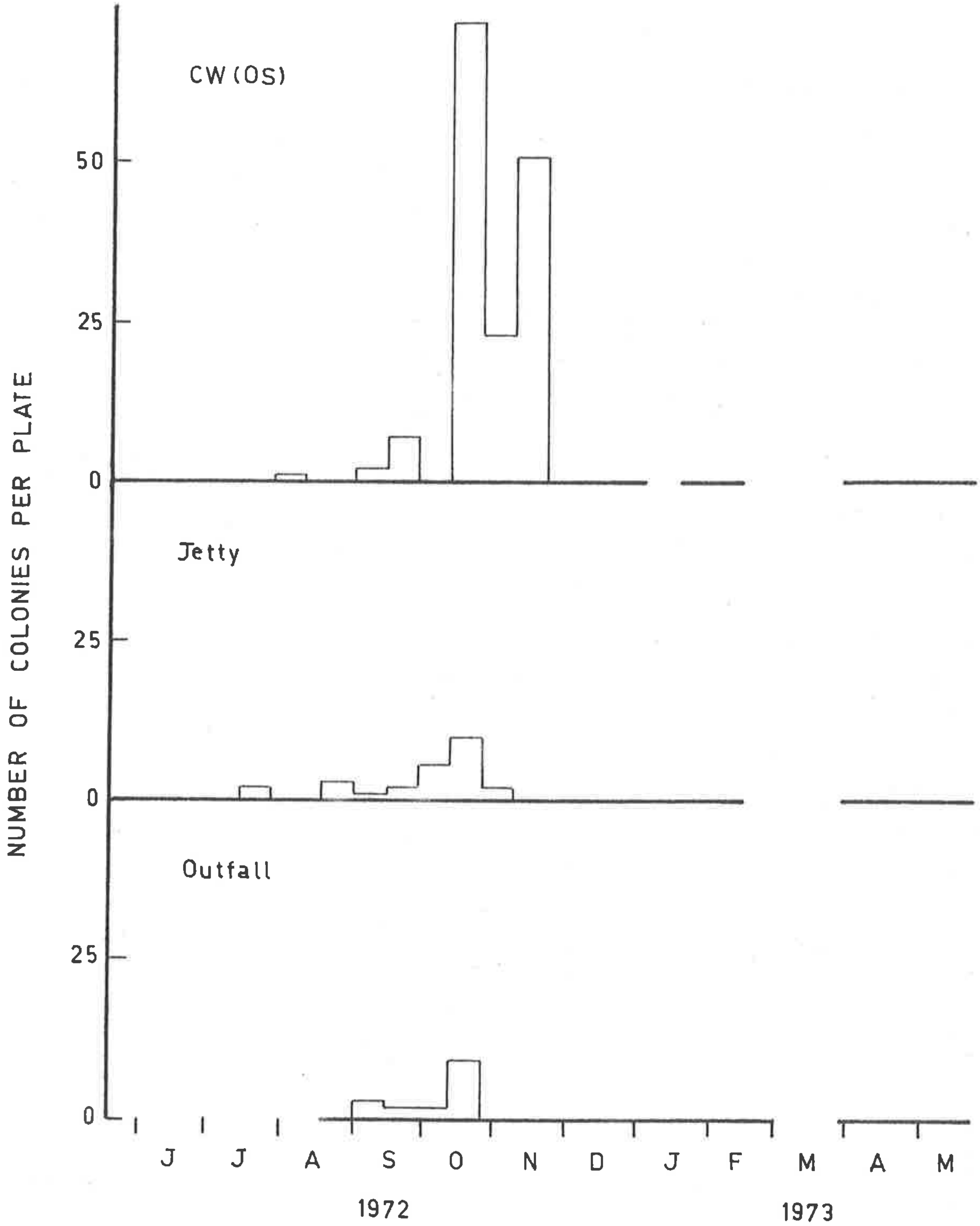

Fig. 4.41 Settlement of the compound ascidian *Botryllus schlosseri* on 2-week plates over the period from June, 1972 to May, 1973.

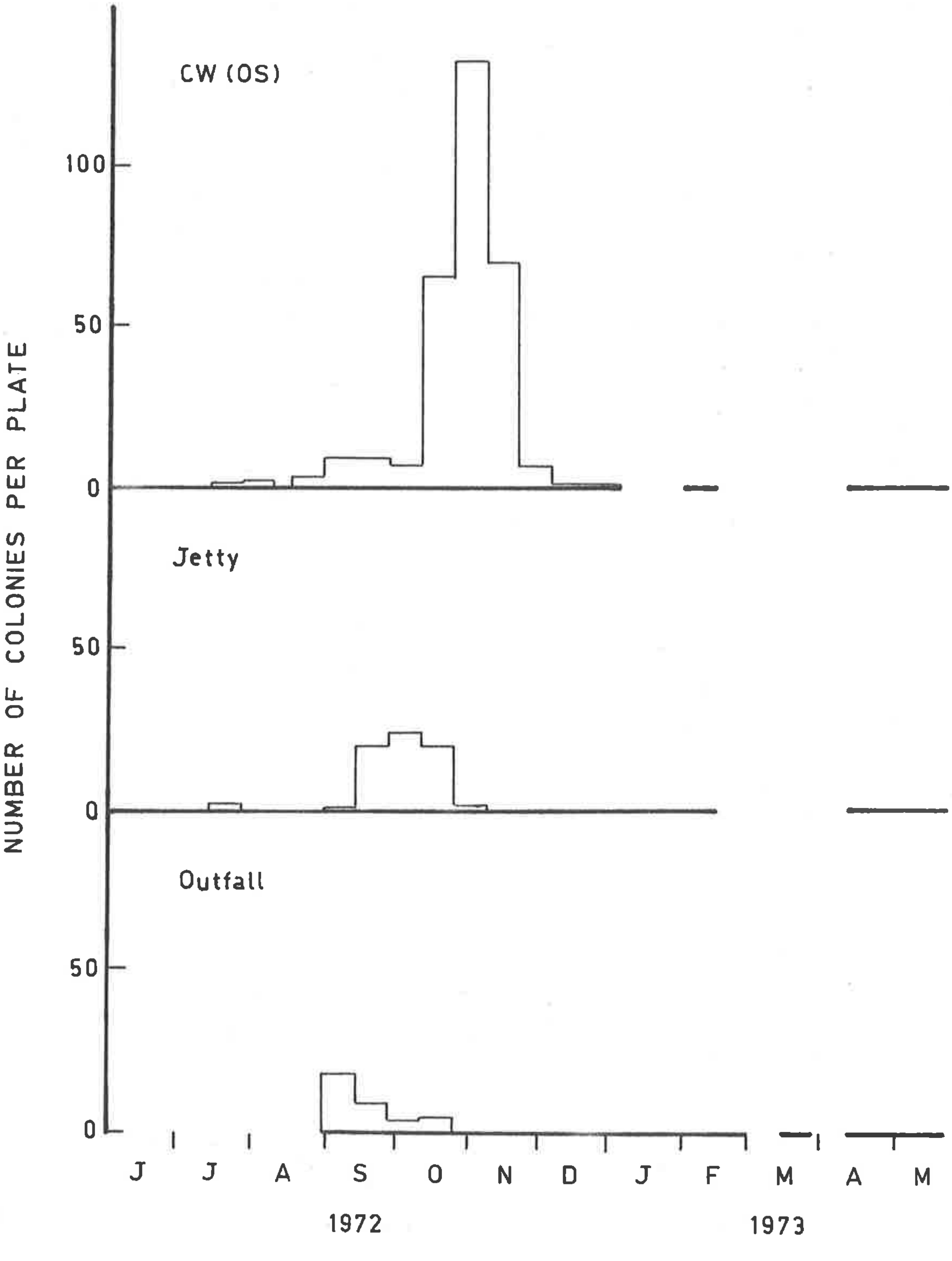

Fig. 4.42 Presence of the compound ascidian *Botryllus schlosseri* on 4-week plates from the CW(OS), Outfall and Jetty stations over the period from June, 1972 to May, 1973.

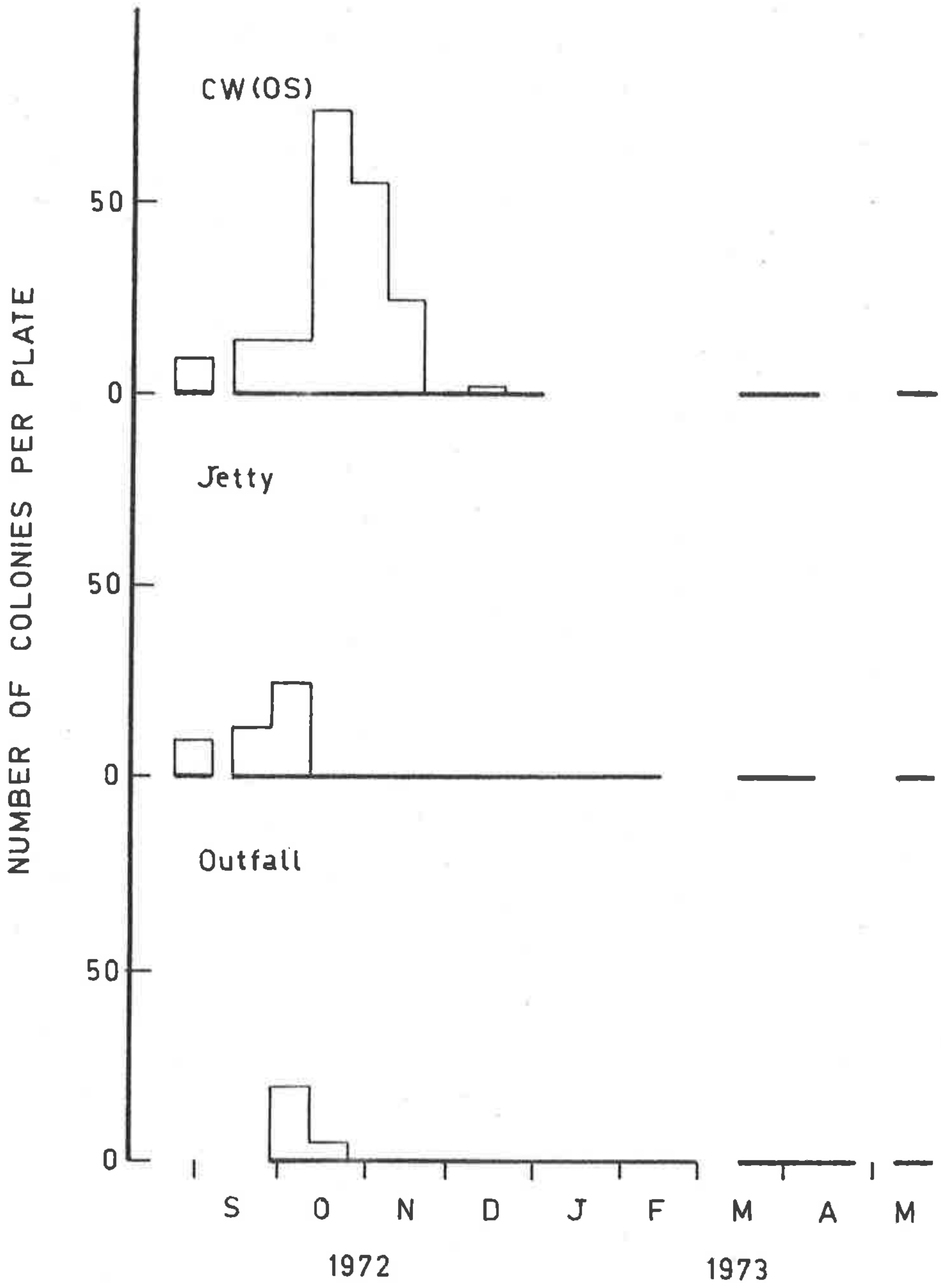

Fig. 4.43 Presence of the compound ascidian *Botryllus schlosseri* on 8-week plates from the CW(OS), Outfall and Jetty stations over the period from September, 1972 to May, 1973.

22/11/72 for two-week plates and 13/9/72 - 3/1/73 for four-week plates. In both cases, differences were not statistically significant (two-week plates, $X^2(k = 3, n = 7) = 1.79$; four-week plates, $X^2(k = 3, n = 9) = 5.72$). However, when the data from two-week, four-week and eight-week plates are inspected together, it can be seen that, during a brief period in mid to late spring, *Botryllus* was considerably more abundant than at other times. This period of abundance was found only at the CW(OS) station. Hence, considering the data as a whole, it would appear that *Botryllus* may have been more abundant at the CW(OS) station than in Angas Inlet. Indeed, when a Friedman test is conducted on the combined data from two-week and four-week plates, a significant result is obtained ($X^2_2 = 7.13$, $0.02<P<0.05$).

However, it may be noted that the period of abundance at the CW(OS) station coincided with the time when *Leptoclinum rayneri* was extremely abundant at the Outfall and Jetty stations. Thus, it could not be said categorically that the smaller numbers of *Botryllus* in Angas Inlet were a result of the harmful effects of hot water rather than competition for space with *Leptoclinum*.

During the second and third years, *Botryllus* was found in very small numbers. However, most of the colonies which were found were present at the CW(OS) station. Thus, during the second year, *Botryllus* was found once only on two-week plates from Angas Inlet, where one colony was present on a plate from the Outfall station. On two-week plates from the CW(OS) station, *Botryllus* was present on seven separate occasions with a maximum of five colonies per plate. The randomization test for matched pairs confirmed that the numbers of settlements at the CW(OS) station were significantly greater than at the Outfall station ($P = .031$). The data from four-week and eight-week plates showed similar trends.

(j) The compound ascidian *Botrylloides nigrum* Herdman.

Although *Botrylloides nigrum* was never particularly abundant, some clear patterns of occurrence were evident. In particular, there were seasonal differences between Angas Inlet and the North Arm. This can be seen in Figs. 4.44 - 4.46 which show, respectively, the presence of *Botrylloides* on four-week plates during the first year and on four-week and eight-week plates during the second year. The complete data are listed in appendix 10. In the North Arm, settlement commenced in late spring and extended over the warmer months of the year. In Angas Inlet, settlement commenced in late winter or early spring but had ceased by late spring, presumably because the water had become too hot to allow reproduction. The statistical significance of the differences was confirmed by conducting runs tests on the data obtained during the second year (table 4.26).

During the first year, there was no evidence of any differences in rates of settlement between stations, although the situation may have been different if there had not been any gaps in the observations at the CW(OS) station. However, some differences in abundance between stations appeared to be present during the second year. The Friedman analysis of variance was applied to the data for four-week plates from all stations (except CW(NS) station) obtained over the period 10/10/73 - 10/4/74 and to the data for eight-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period 29/8/73 - 24/4/74. In both cases, the differences in abundance between stations were found to be statistically significant (four-week plates, $X_4^2 = 16.0$, $0.001<P<0.01$); eight-week plates, $X_3^2 = 10.6$, $0.01<P<0.02$).

In order to examine the differences in abundance in greater detail, a series of pair-wise comparisons was made, using the Wilcoxon test. However, in the case of four-week plates, *Botrylloides* was present on insufficient occasions for many meaningful comparisons to be made amongst

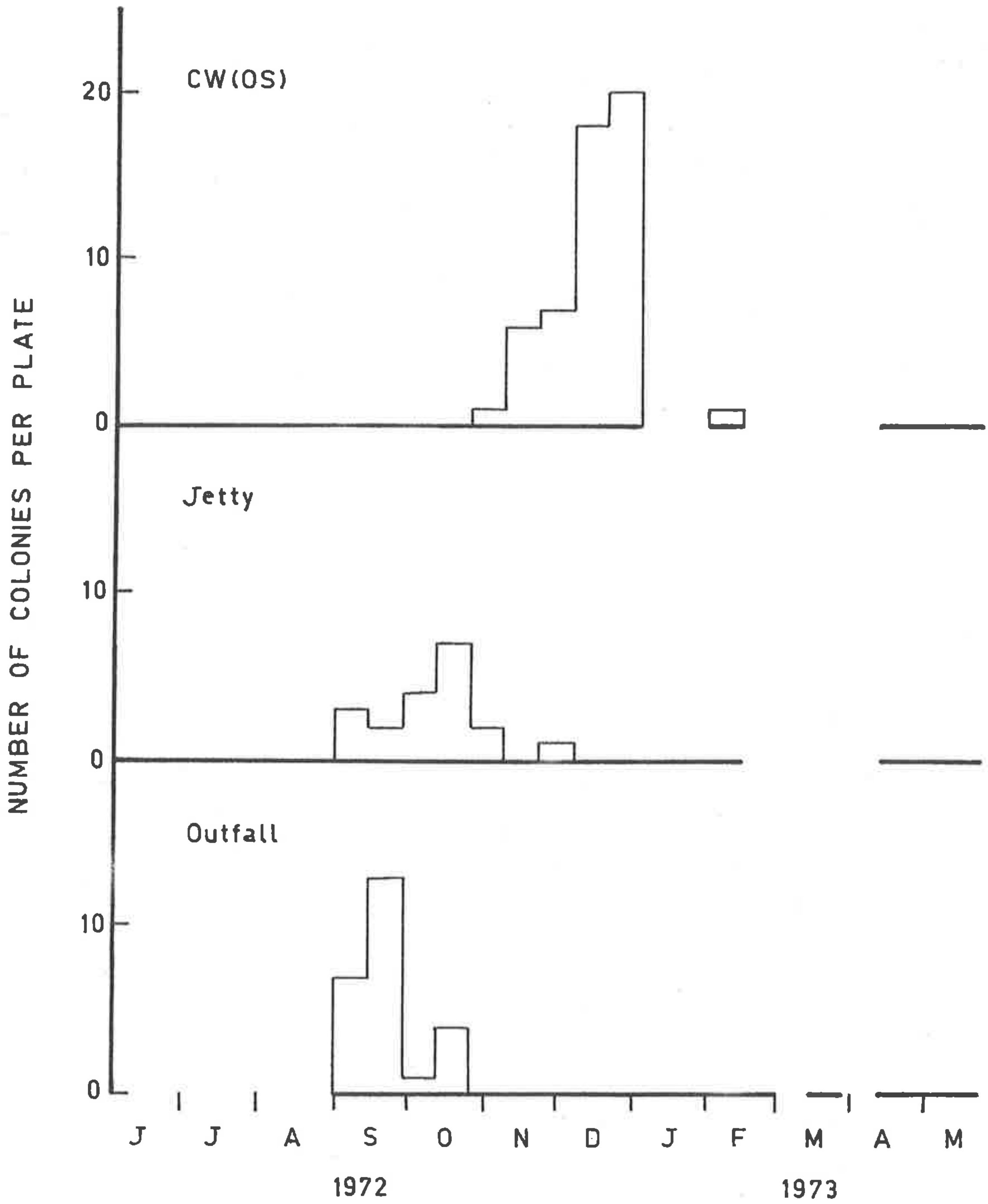

Fig. 4.44 Presence of the compound ascidian *Botrylloides nigrum* on 4-week plates from the CW(OS), Outfall and Jetty stations over the period from June, 1972 to May, 1973.

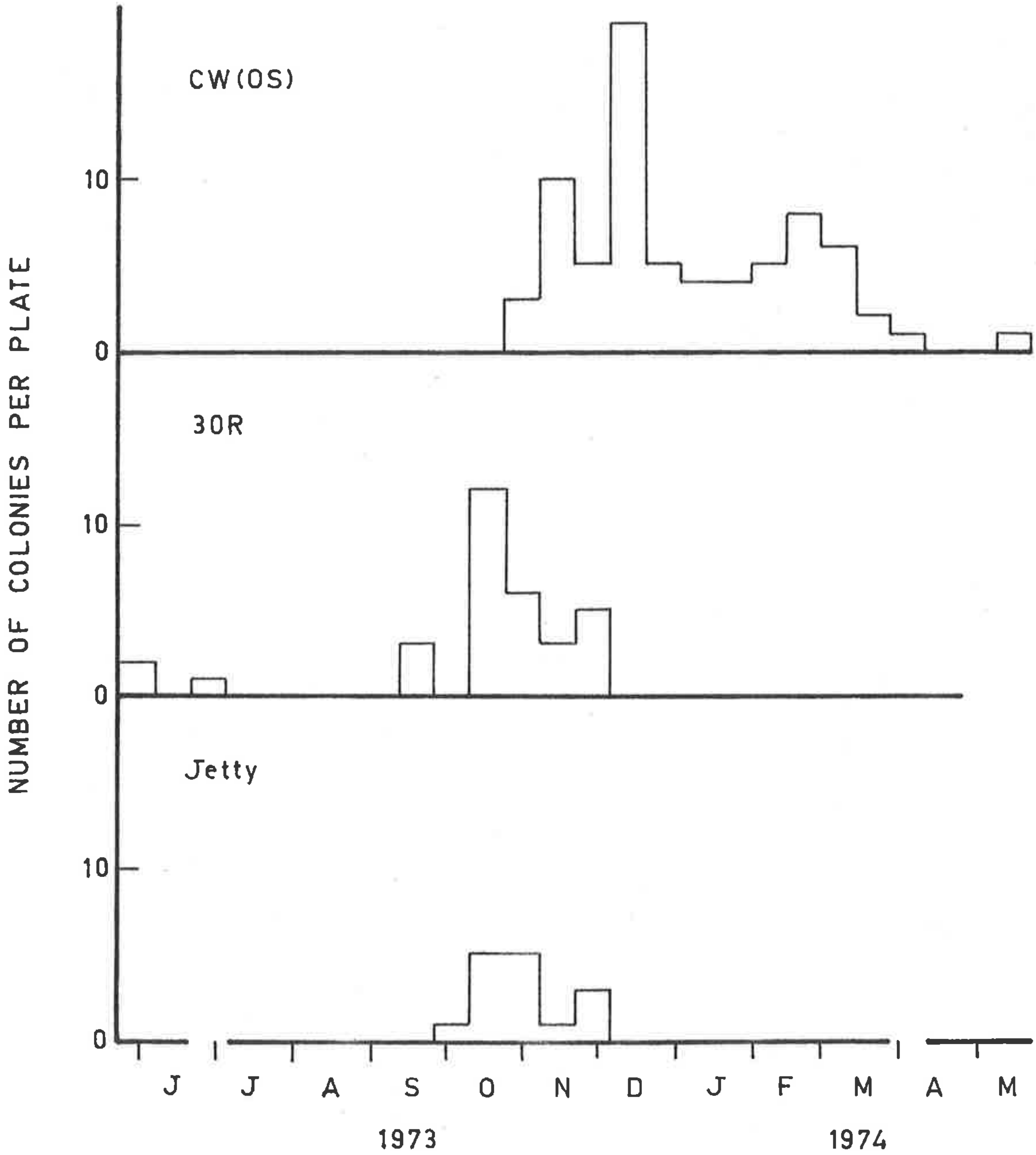

Fig. 4.45 Presence of the compound ascidian *Botrylloides nigrum* on 4-week plates from the CW(OS), 30R and Jetty stations over the period from June, 1973 to May, 1974.

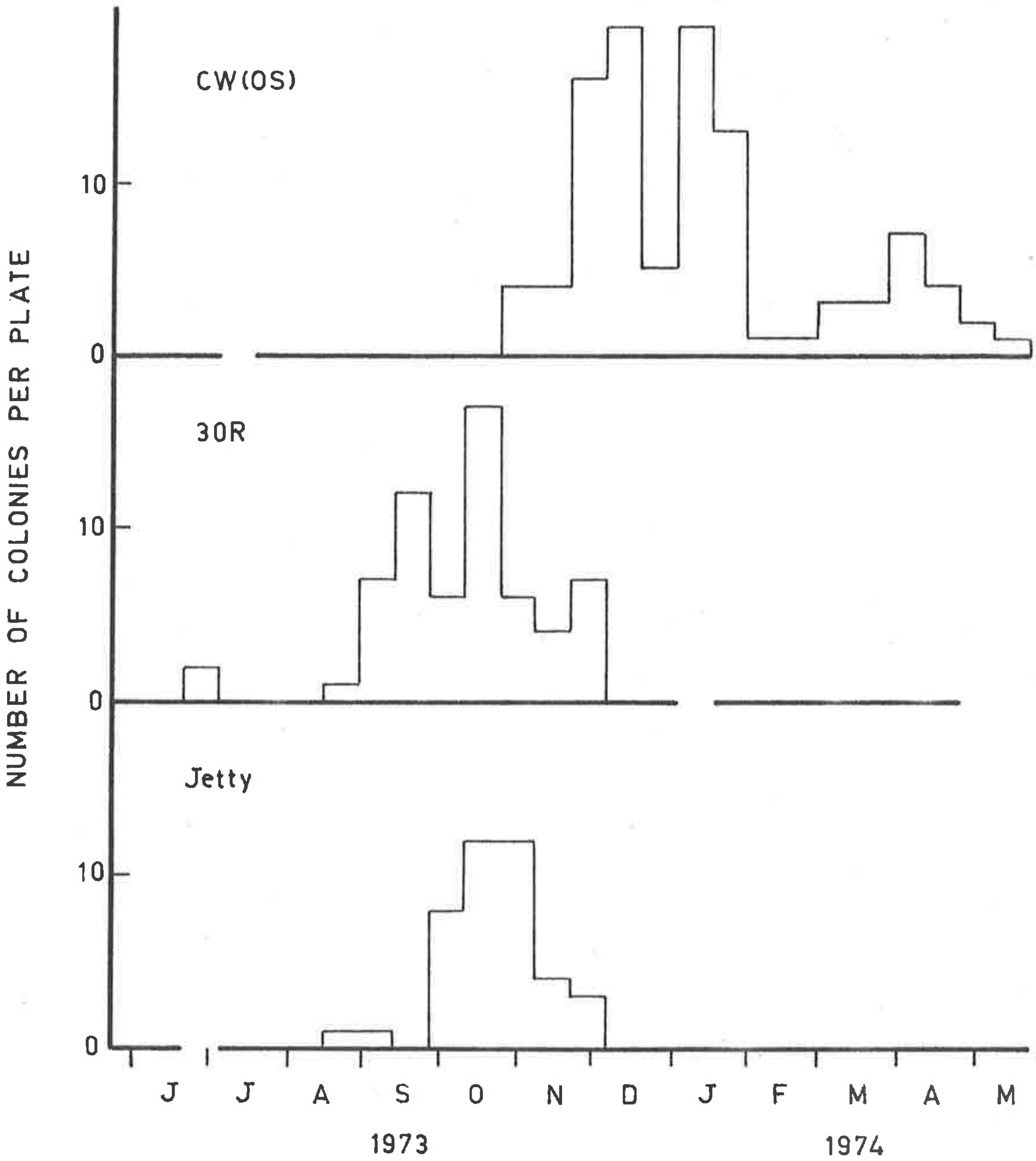

Fig. 4.46 Presence of the compound ascidian *Botrylloides nigrum* on 8-week plates from the CW(OS), 30R and Jetty stations over the period from June, 1973 to May, 1974.

Table 4.26 Results of a number of one-sample runs tests conducted on the data on the presence of *Botrylloides nigrum* on plates from the CW(OS), Jetty and 30R stations obtained over the period 29/8/73 - 22/5/74. The analyses were employed to examine seasonal differences.

Comparison	n_1	n_2	Observed r	Critical r	Significance
(a) Four-week plates.					
CW(OS) v Jetty	11	3	2	2	Yes
v 30R	10	3	2	2	Yes
Jetty v 30R	1	5			No
(b) Eight-week plates.					
CW(OS) v Jetty	13	5	2	4	Yes
v 30R	11	6	2	4	Yes
Jetty v 30R	2	4			No

the stations in Angas Inlet. The results of these comparisons are shown in table 4.27. It can be seen that *Botrylloides* is yet another example of a species which was rare at the Outfall station (see especially section 4.2(d). In addition, there were fewer colonies on four-week plates from the Jetty and 28R stations than on plates from the CW(OS) station. While the result at the Jetty station is a reasonable one in view of the rarity of *Botrylloides* at the Outfall station, there appears to be no ready explanation for the result at the 28R station.

The results during the 1974-75 season provided no new information on the effect of the thermal effluent on the distribution of *Botrylloides*.

(k) The serpulid *Eulaeospira convexis* (Wisely).

The presence of *Eulaeospira convexis* on two-week, four-week and eight-week plates during the two years from June, 1972 to May, 1974 is shown in figs. 4.47 - 4.52. The complete data are listed in appendix 11. I shall consider first the results on settlement on two-week plates (Figs. 4.47 and 4.50). Settlement was observed virtually throughout the year, but was somewhat greater during the warmer months. The rates of settlement at the Outfall, Jetty and 30R stations were clearly much greater than those at the CW(OS) and (during the second year) 28R stations. Thus, *Eulaeospira* appears to have been favoured by the warmer water in Angas Inlet. The results obtained during the summer of 1974-75 showed the same trend of greater rates of settlement at the Outfall and Jetty stations than at the CW(OS) station.

Analyses of variance were conducted on the data from the Outfall, Jetty and 30R stations with the aim of comparing any differences in rates of settlement between the stations. The first analysis covered the period from 6/12/72 - 20/6/73 and the second from 18/7/73 - 24/4/74. The results of the analyses are shown in table 4.28. The first analysis showed a significant difference between stations. It appeared likely that this result was caused by a greater rate of settlement at the Jetty

Table 4.27 Summary of the results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the presence of the compound ascidian *Botrylloides nigrum* on four-week and eight-week plates from the CW(OS), Outfall, Jetty and 30R stations (and 28R station for four-week plates) over the period from 29/8/73 - 22/5/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
	(a) Four-week plates.			
CW(OS)	v Outfall	13	0	<0.01
	v Jetty	15	17	0.01<P<0.02
	v 30R	14	22	N.S.
	v 28R	11	0	<0.01
Jetty	v 30R	6	1½	N.S.
	(b) Eight-week plates.			
CW(OS)	v Outfall	15	0	<0.01
	v Jetty	18	45	N.S.
	v 30R	17	49½	N.S.
Outfall	v Jetty	7	0	0.01<P<0.02
	v 30R	8	0	<0.01
Jetty	v 30R	6	5½	N.S.

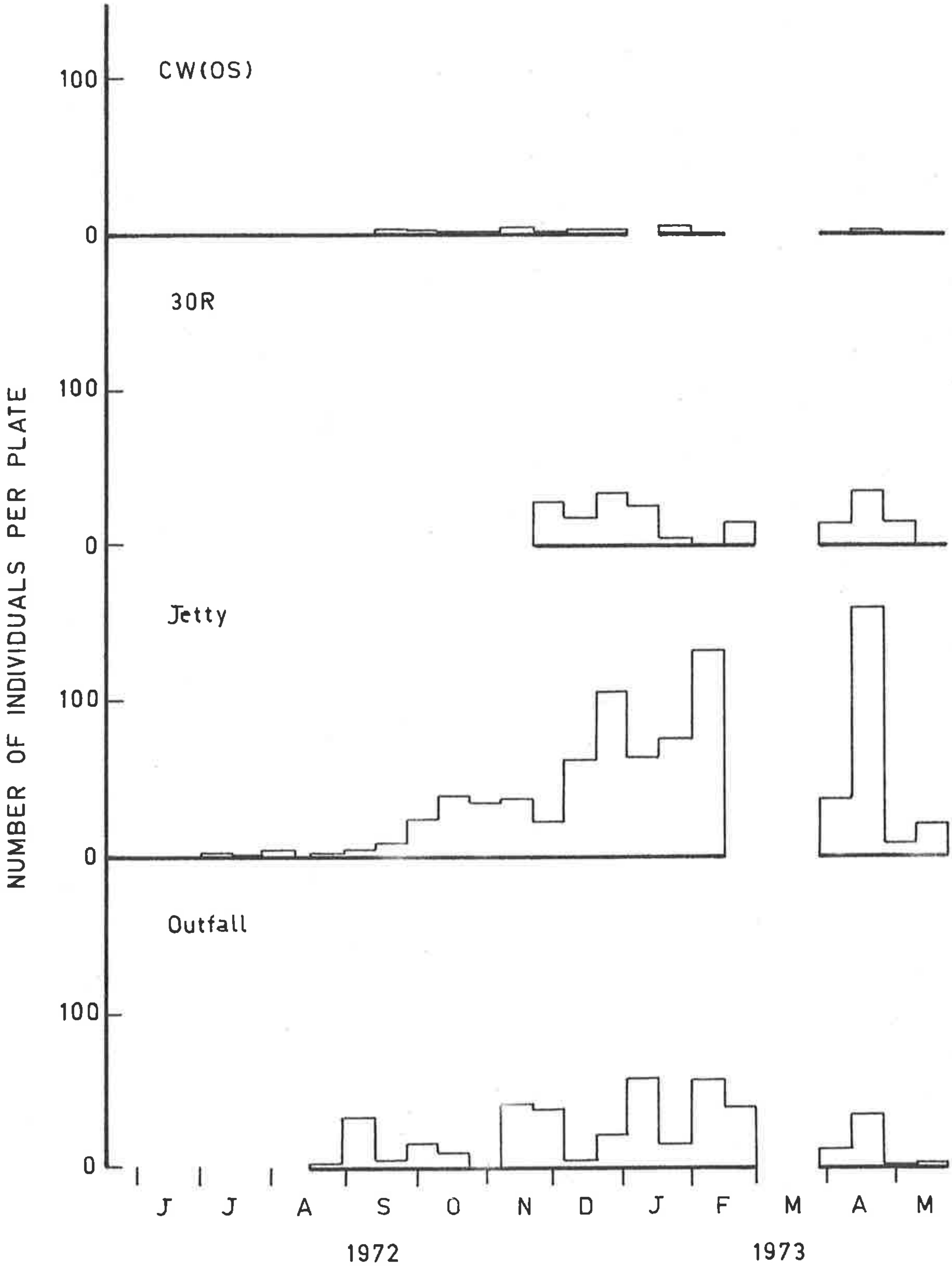

Fig. 4.47 Settlement of the serpulid *Eulaeospira convexis* on 2-week plates over the period from June, 1972 to May, 1973.

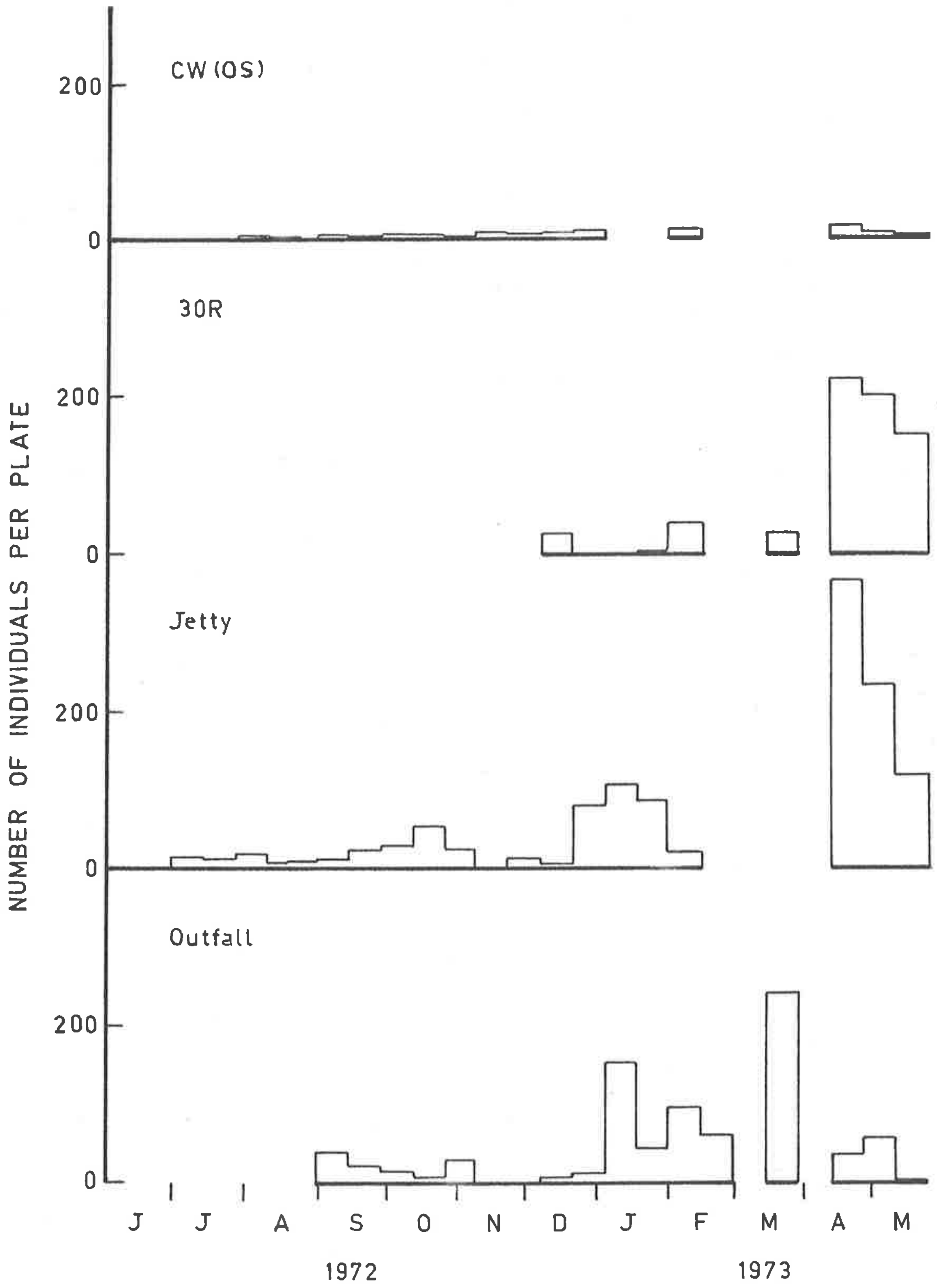

Fig. 4.48 Presence of the serpulid *Eulaeospira convexis* on 4-week plates over the period from June, 1972 to May, 1973.

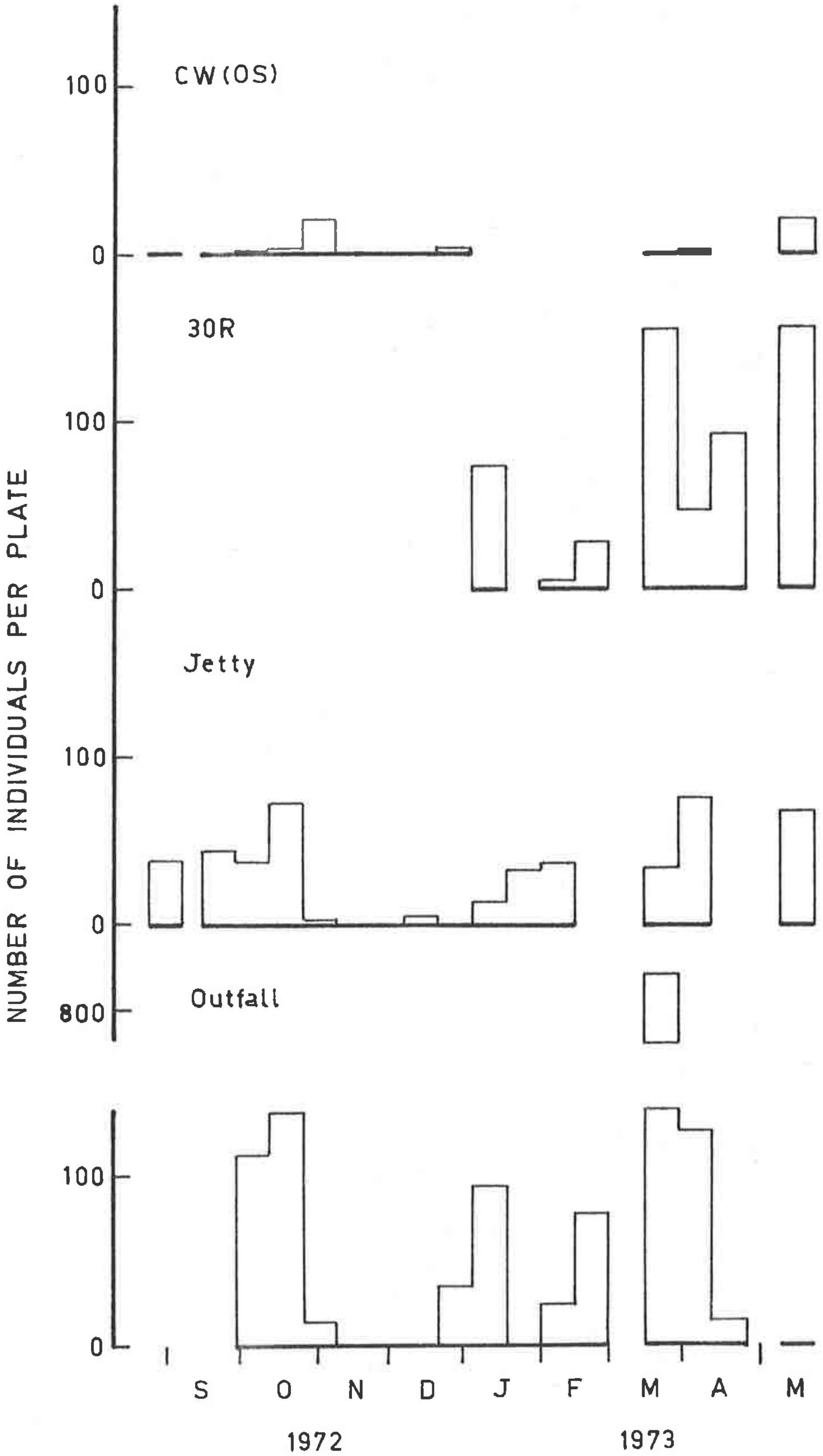

Fig. 4.49 Presence of the serpulid *Eulaeospira convexis* on 8-week plates over the period from September, 1972 to May, 1973.

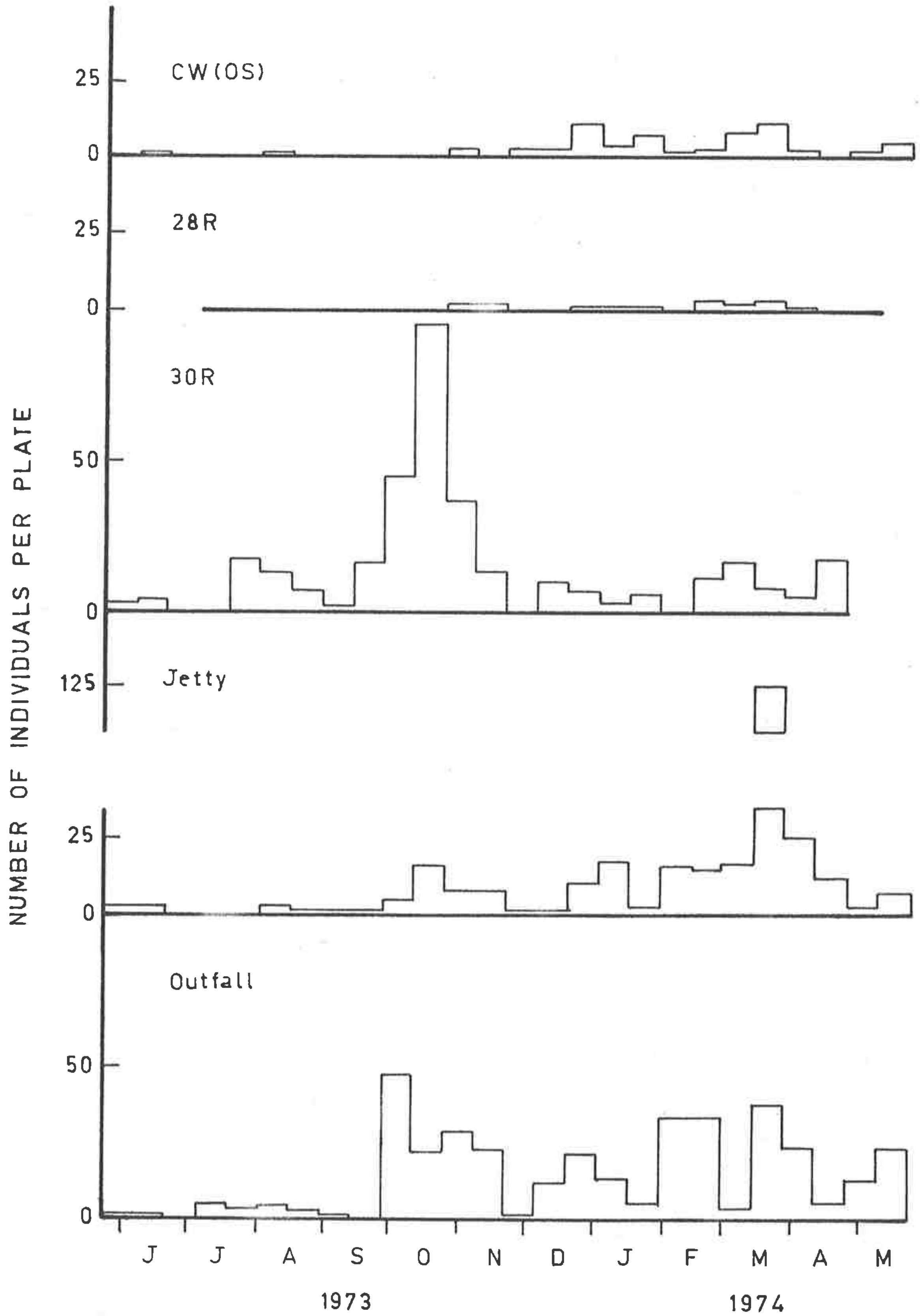

Fig. 4.50 Settlement of the serpulid *Eulaeospira convexis* on 2-week plates over the period from June, 1973 to May, 1974.

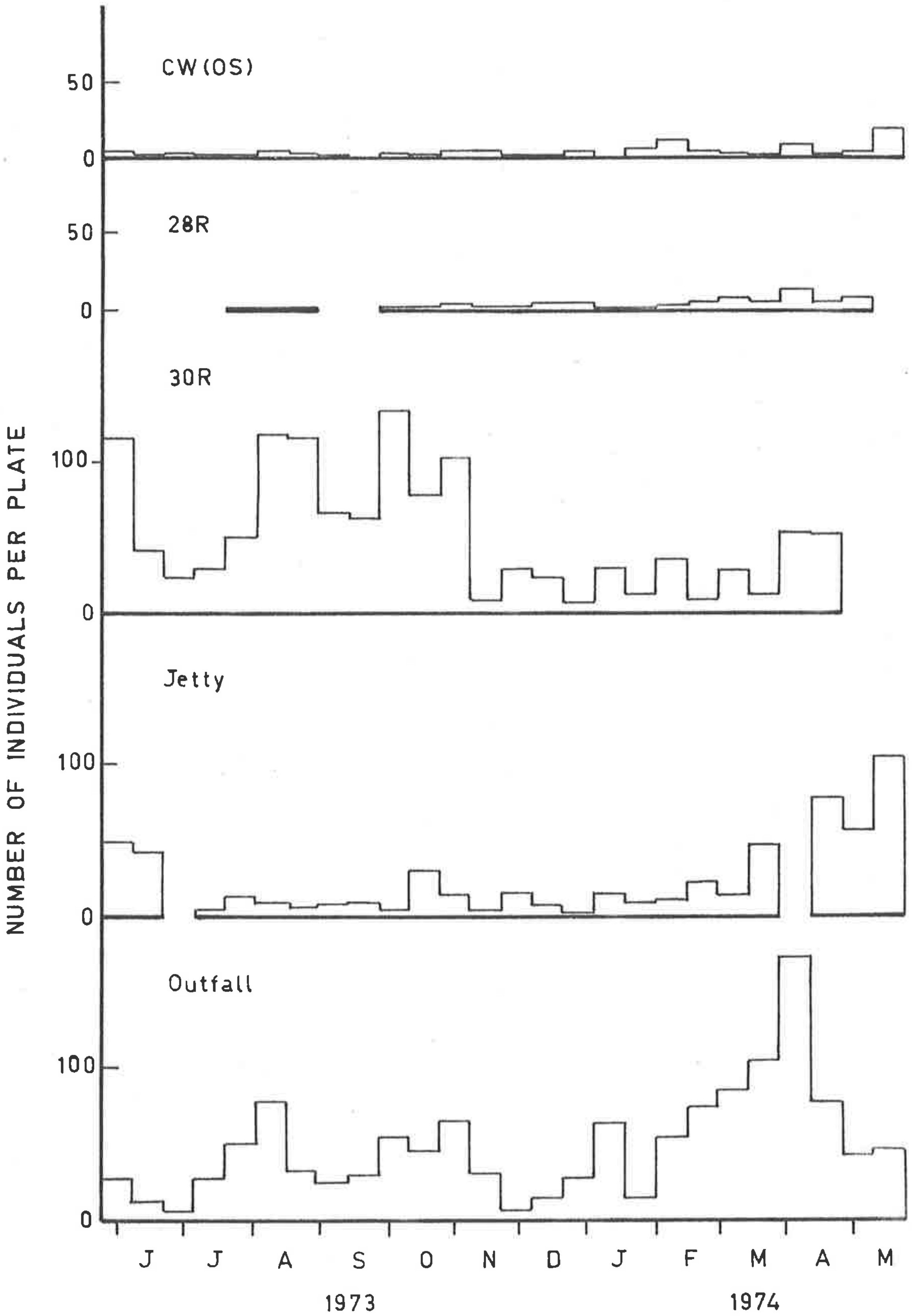

Fig. 4.51 Presence of the serpulid *Eulaeospira convexis* on 4-week plates over the period from June, 1973 to May, 1974.

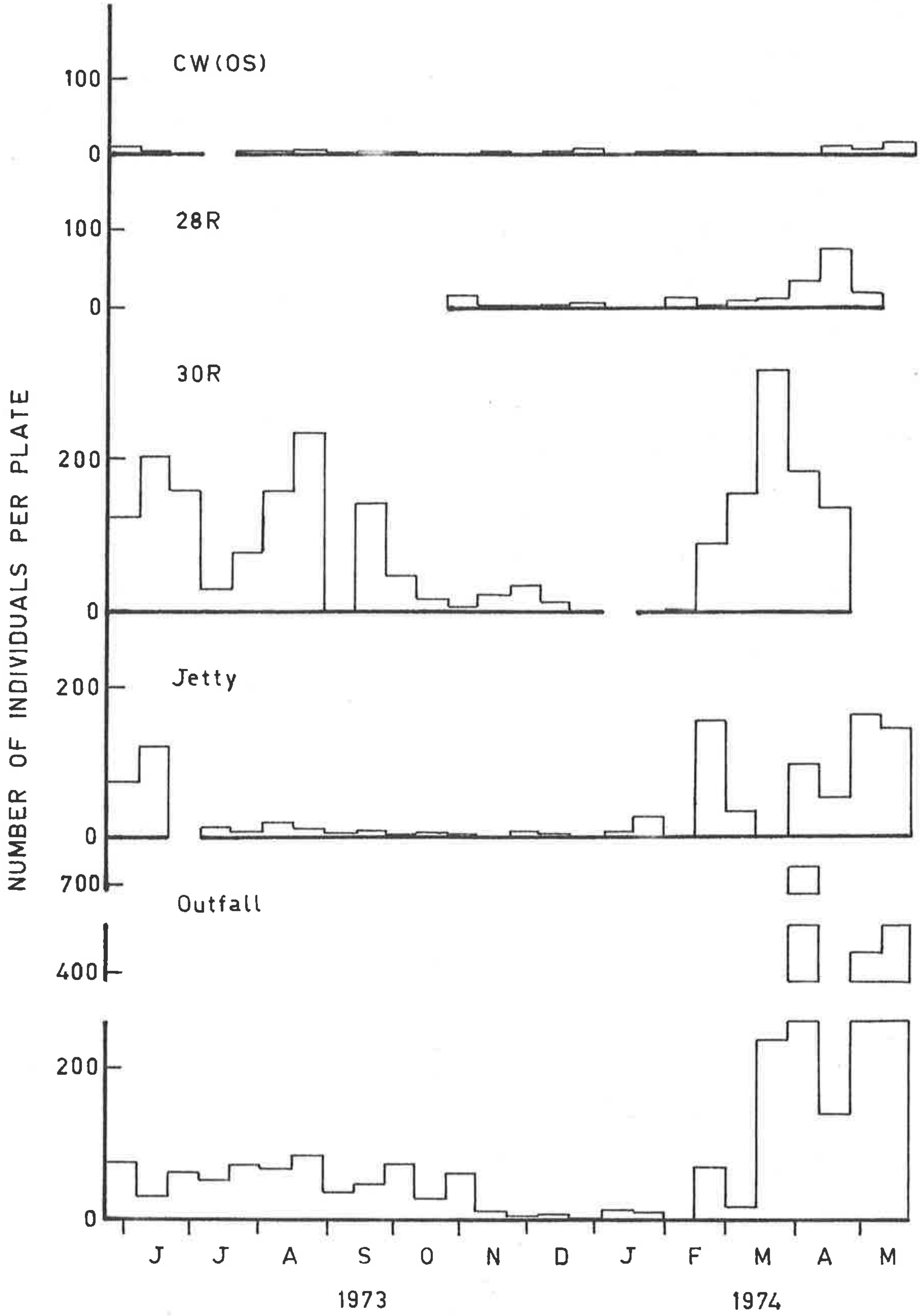

Fig. 4.52 Presence of the serpulid *Eulaeospira convexis* on 8-week plates over the period from June, 1973 to May, 1974.

Table 4.28 Summary of the analyses of variance conducted on the data on rates of settlement of the serpulid *Eulaeospira convexis* on two-week plates from the Outfall, Jetty and 30R stations. The data were transformed to square roots.

(a) 6/12/72 - 20/6/73 - method for the special case of a value missing from the randomized block.

$F_{max}(3,12) = 15.03$, $P<0.01$; after transformation, $F_{max}(3,12) = 3.53$.

Source of variation	df	SS	Corr.SS	MS	Fs	P
Location	2	84.150	78.834	39.417	9.64	<0.001
Time	12	172.063	170.479	14.207	3.48	<0.005
Remainder	23	93.996		4.087		
	37	350.209				

(b) 18/7/73 - 24/4/74.

$F_{max}(3,20) = 3.54$, $0.01<P<0.05$; after transformation $F_{max}(3,20) = 1.54$.

Source of variation	df	SS	MS	Fs	P
Location	2	3.086	1.543	<1	N.S.
Time	20	144.671	7.234	2.34	0.01<P<0.025
Remainder	40	123.564	3.089		
	62	271.321			

station than at the other two stations. The appropriate *a posteriori* comparisons confirmed this (SS (Outfall v 30R) = 2.73, SS (Jetty v (Outfall, 30R)) = 81.4; critical SS = 10.78). The explanation for this pattern of distribution in Angas Inlet may be sought by a consideration of the water currents. Those larvae which are present in the water near the cooling water outlet must settle immediately or they are likely to be carried away in an easterly direction by the current caused by the discharge of water from the power station. However, in other areas of Angas Inlet free-swimming larvae are less likely to be carried further away from the outlet, at least on a rising tide, since the tidal component of the water currents will increase with increasing distance from the cooling water outlet. Thus, a greater proportion of the larvae which originate from the areas near the cooling water outlet are likely to be carried away by the current before they settle than would be the case at locations some distance from the outlet. Hence, the observed distribution of settlements of *Eulaeospira* in Angas Inlet may be a result of the fact that the tendency of larvae to settle in the warmest locations was being counteracted by the current moving away from the warmest areas.

During the second year, there were no differences in rates of settlement between the three stations.

The results from four-week and eight-week plates were generally consistent with those from two-week plates, with greater numbers of *Eulaeospira* at the Outfall, Jetty and 30R stations than at the other stations. Since full-grown individuals of *Eulaeospira* are relatively small, they are liable to be smothered by other growth on longer term plates, particularly on eight-week plates. Thus, during the first year, the relatively small numbers present in late spring and early summer at the Outfall, Jetty and 30R stations were associated with the abundance of the compound ascidian *Leptoclinum rayneri*. During the second year, *Leptoclinum* could also have smothered many individuals. In addition, the relatively smaller numbers of *Eulaeospira* present during summer at the Outfall and Jetty stations corresponded with the abundance of the simple ascidian *Microcosmus squamiger* (see section 4.2(1)).

During the second year, *Microcosmus* was considerably more abundant than during the first year and was also more common at the Jetty station than elsewhere. For reasons stated above, it may be expected that greater rates of settlement of *Eulaeospira* may be observed on two-week plates from the Jetty station than on plates from the Outfall and 30R stations. However, this would not occur if fewer larvae of *Eulaeospira* were produced in the vicinity of the Jetty station than near the Outfall and 30R stations. In view of the abundance of *Microcosmus* at the Jetty, this situation may have eventuated during the second year. This would explain the differences in relative rates of settlement at the Jetty station between the first and second years.

(1) The simple ascidian *Microcosmus squamiger* Michaelson.

The data on the presence of *Microcosmus squamiger* are listed in appendix 12. *Microcosmus* was rare on two-week plates, reached moderate abundance on four-week plates and at times was extremely abundant on eight-week plates. During the first year, greater numbers were found in Angas Inlet. However, the breeding season included those times when there were gaps in the observations.

During the second year, much greater numbers of *Microcosmus* were found on the plates. Figs. 4.53 and 4.54 show the presence of *Microcosmus* on four-week and eight-week plates, respectively, during the second year. *Microcosmus* appeared to have been favoured by the warmer water in Angas Inlet but there also appeared to be differences in abundance between all stations. Inspection of the data suggested that extreme heterogeneity of variances was present and hence, non-parametric methods of analysis were required in order to investigate the statistical

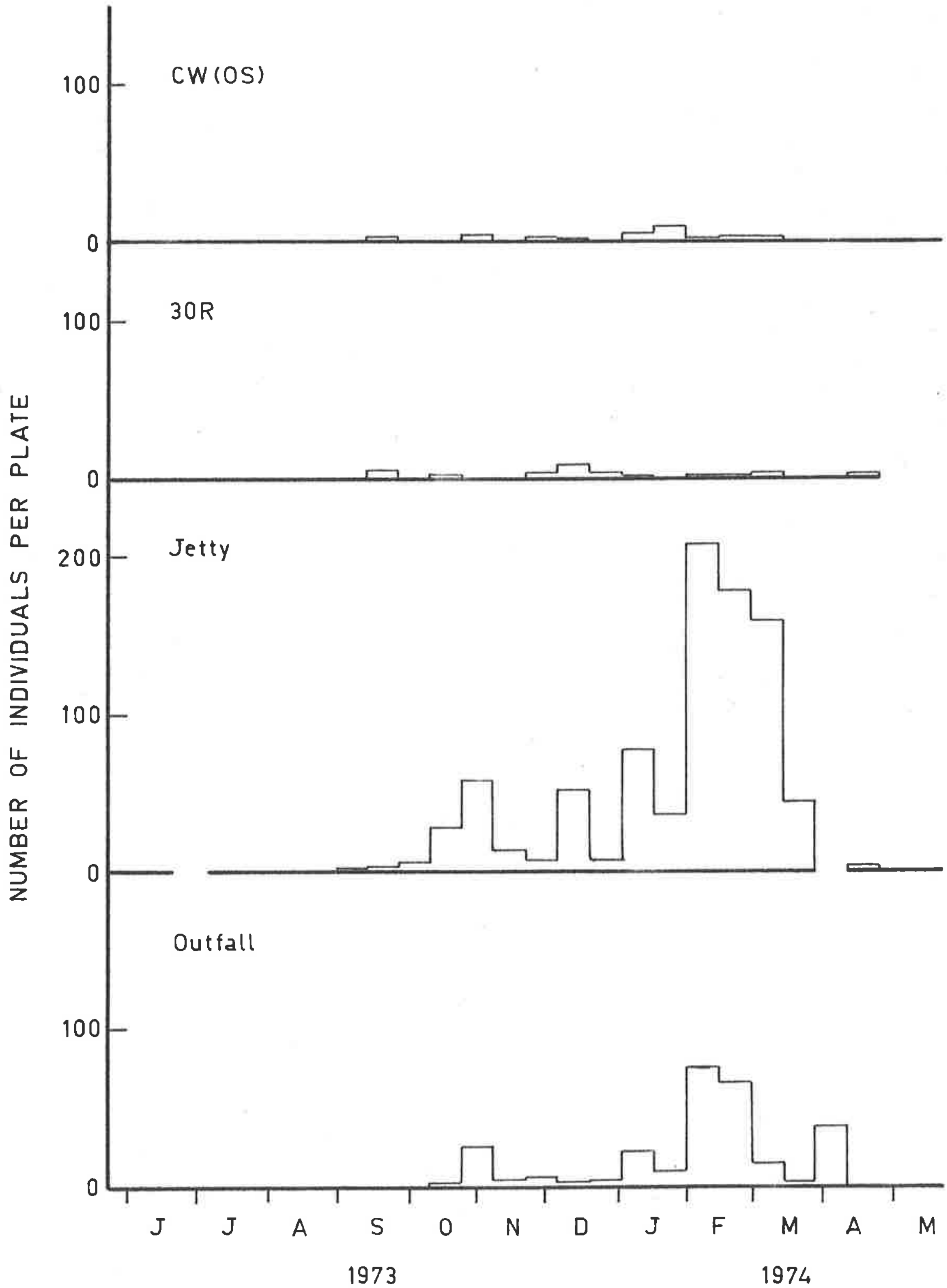

Fig. 4.53 Presence of the simple ascidian *Microcosmus squamiger* on 4-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period from June, 1973 to May, 1974.

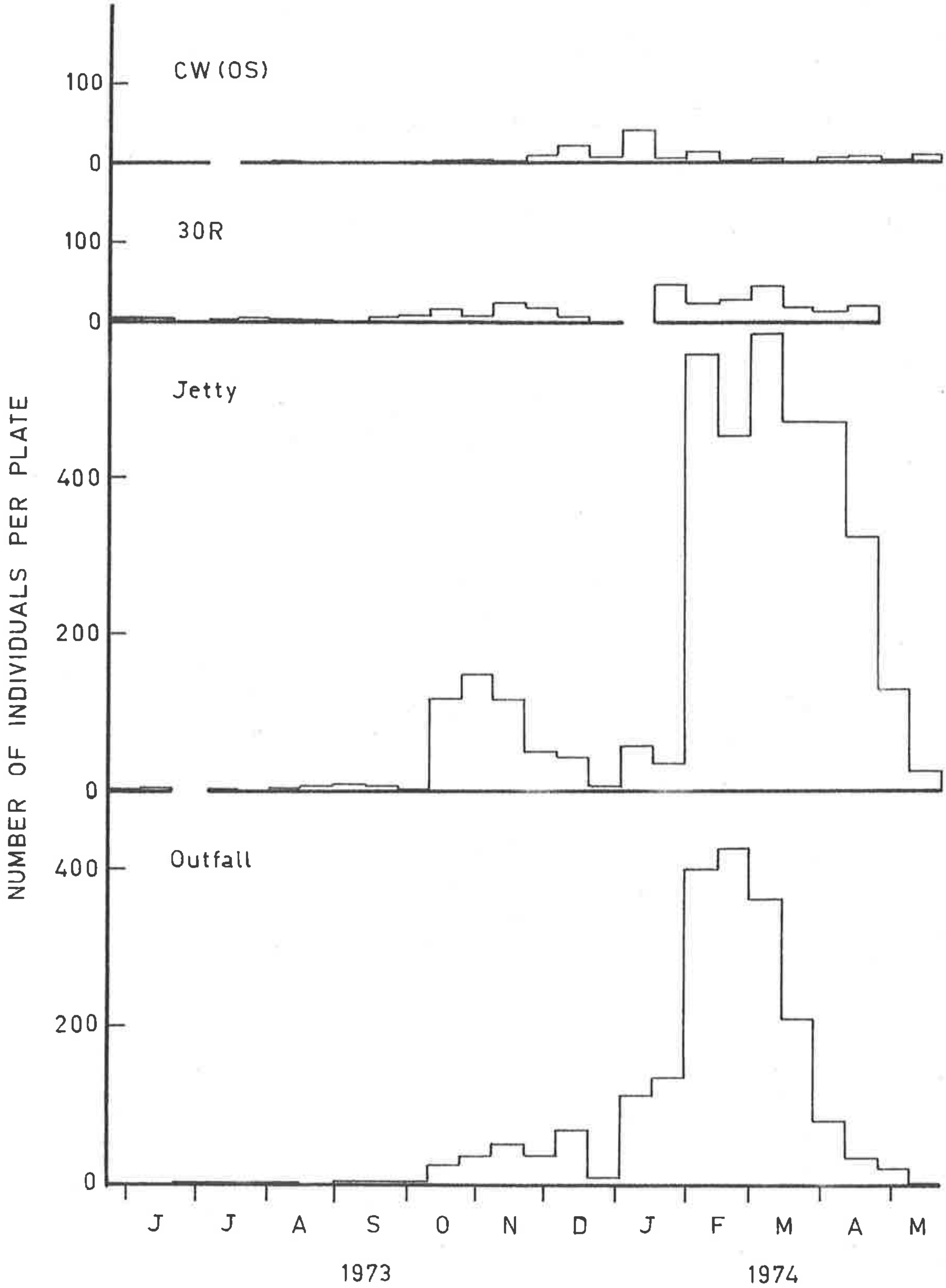

Fig. 4.54 Presence of the simple ascidian *Microcosmus squamiger* on 8-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period from June, 1973 to May, 1974.

significance of differences in abundance. The Friedman test was applied to the data from the CW(OS), Outfall, Jetty and 30R stations obtained over the period 12/9/73 - 24/4/74 for four-week plates and over the period 23/5/73 - 24/4/74 for eight-week plates. In both cases, differences were highly significant (four-week plates, $X_3^2 = 28.8$, $P<0.001$; eight-week plates, $X_3^2 = 32.1$, $P<0.001$).

A series of Wilcoxon tests were then conducted on the data (table 4.29). Significant differences in abundance were evident between all stations. *Microcosmus* was most abundant at the Jetty station and progressively less common at the Outfall, 30R and CW(OS) stations. The greater abundance of ascidians at the Jetty station may be attributed to the opposing factors of a tendency to settle in the warmest regions and a current tending to carry larvae ready to settle away from these areas. The data obtained during the third year were consistent with those from the previous year.

(m) An unidentified polychaete (family Sabellidae).

The data on the presence of this sabellid are listed in appendix 13. This sabellid was rare on two-week plates but progressively much more common on four-week and eight-week plates. During the first year, the peak of abundance in Angas Inlet coincided with the gaps in the observations at the CW(OS) station. Hence, little information on relative abundance was obtained.

Figs. 4.55 and 4.56 show the presence of the sabellid on four-week and eight-week plates during the second year. Breeding commenced in spring and extended over the warmer months of the year. Inspection of the data indicated that heterogeneity of variances was present. The Friedman test was applied to the data for four-week and eight-week plates from the CW(OS), Outfall, Jetty and 30R stations covering the period from September, 1973 to April 1974. Significant differences in abundance between stations were evident for both series of exposures (four-week

Table 4.29 Summary of the results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the presence of *Microcosmus squamiger* on plates from the CW(OS), Outfall, Jetty and 30R stations obtained over the period 23/5/73 - 22/5/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
	(a) Four-week plates.			
CW(OS)	v Outfall	14	3½	<0.01
	v Jetty	15	0	<0.01
	v 30R	11	29	N.S.
Outfall	v Jetty	16	0	<0.01
	v 30R	14	15	$0.01<P<0.02$
Jetty	v 30R	15	2	<0.01
	(b) Eight-week plates.			
CW(OS)	v Outfall	21	0	<0.01
	v Jetty	23	5	<0.01
	v 30R	20	24½	<0.01
Outfall	v Jetty	24	41	<0.01
	v 30R	22	37½	<0.01
Jetty	v 30R	19	13	<0.01

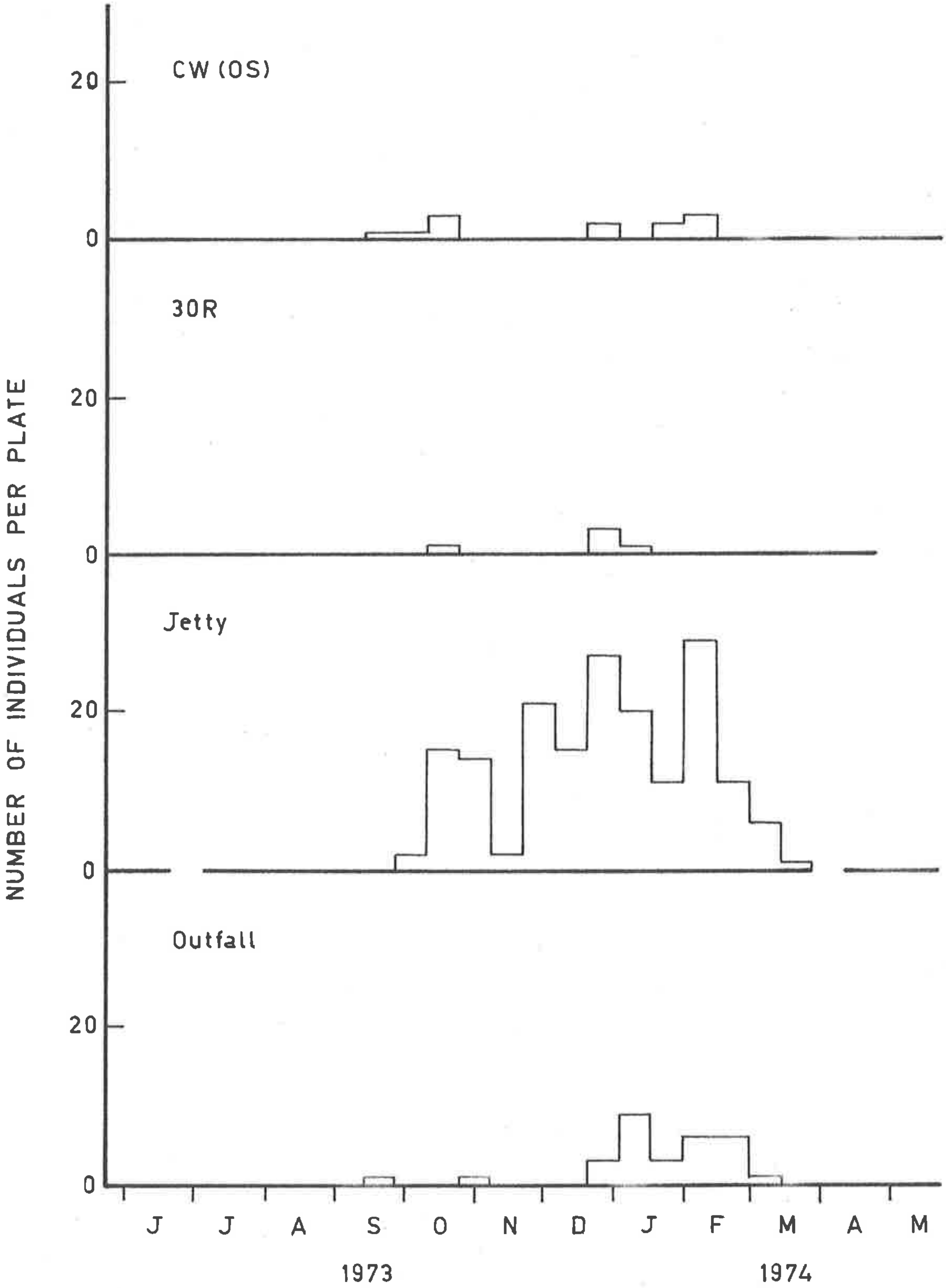

Fig. 4.55 Presence of an unidentified polychaete (family Sabellidae) on 4-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period from June, 1973 to May, 1974.

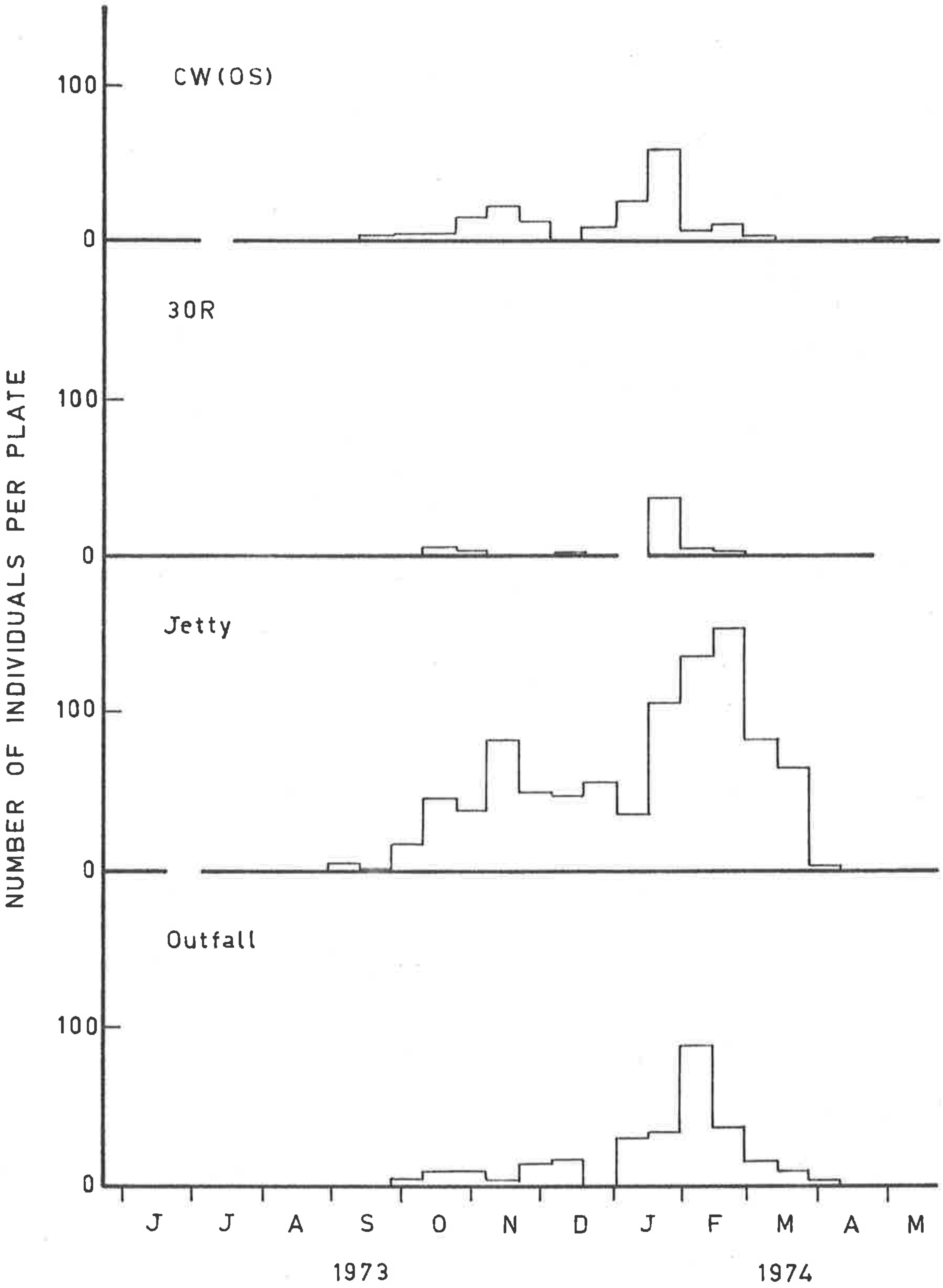

Fig. 4.56 Presence of an unidentified polychaete (family Sabellidae) on 8-week plates from the CW(OS), Outfall, Jetty and 30R stations over the period from June, 1973 to May, 1974.

plates, X_3^2 = 21.0, P. 0.001; eight-week plates, X_3^2 = 28.5, P 0.001). A series of Wilcoxon tests were then conducted on the same data in order to clarify the situation (table 4.30). For both four-week and eight-week plates, the sabellid was more abundant at the Jetty station. This would suggest that the sabellid was favoured, but only to a small extent, by the warmed water in Angas Inlet. The tendency for species favoured by the warmed water to be more common at the Jetty station than at the other stations in Angas Inlet was discussed in section 4.2(k).

On eight-week plates, the sabellid was less common at the 30R station than at the CW(OS), Outfall, Jetty and 30R stations. The data from the 28R station were not included in the analyses, in view of the later start to the observations there, but it did appear that the situation was similar to that at the 30R station. On all plates a surface layer incorporating mud and detritus was evident and was of greater prominence on larger term plates. The amount of mud in this surface layer was greater at the CW(OS), Outfall and Jetty stations (i.e. those closest to the power station) than at the 30R and 28R stations. Since the sabellids incorporate mud into their tubes it is likely that the amount of mud present on a plate may be of importance in determining the attractiveness of a plate to settling larvae of sabellids. Thus, the smaller numbers of sabellids at the 30R station, particularly in comparison to the CW(OS) and Outfall stations, may be a result of the smaller quantities of mud present in the surface film.

(n) The serpulid *Hydroides norvegica* Gunnerus.

Fig. 4.57 shows the settlement of *Hydroides norvegica* on two-week plates during the first year of the study, while figs. 4.58 - 4.60 show the presence of *Hydroides* on two-week, four-week and eight-week plates during the second year. The complete results are listed in appendix 14. The main settlement season during the first year apparently extended from mid-summer to mid-autumn. However, consideration of the results was

Table 4.30 Summary of the results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the presence of an unidentified sabellid on plates from the CW(OS), Outfall, Jetty and 30R stations obtained over the period 12/9/73 - 8/5/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
	(a) Four-week plates.			
CW(OS)	v Outfall	8	13½	N.S.
	v Jetty	14	2	<0.01
	v 30R	7	5	N.S.
Outfall	v Jetty	14	1½	<0.01
	v 30R	7	2½	N.S.
Jetty	v 30R	13	0	<0.01
	(b) Eight-week plates.			
CW(OS)	v Outfall	16	46	N.S.
	v Jetty	17	1½	<0.01
	v 30R	11	4	<0.01
Outfall	v Jetty	15	0	<0.01
	v 30R	12	2	<0.01
Jetty	v 30R	15	0	<0.01

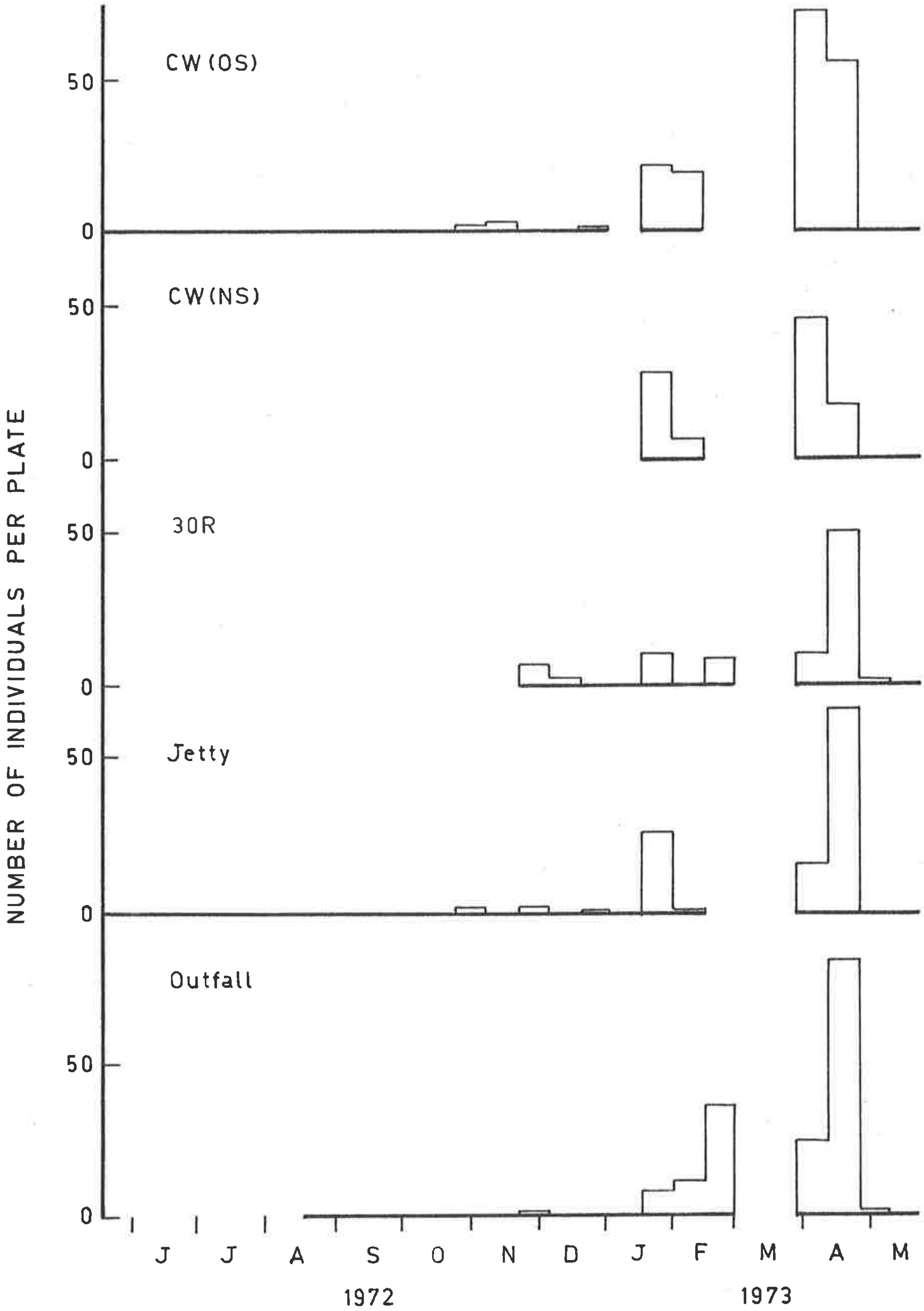

Fig. 4.57 Settlement of the serpulid *Hydroides norvegica* on 2-week plates over the period from June, 1972 to May, 1973.

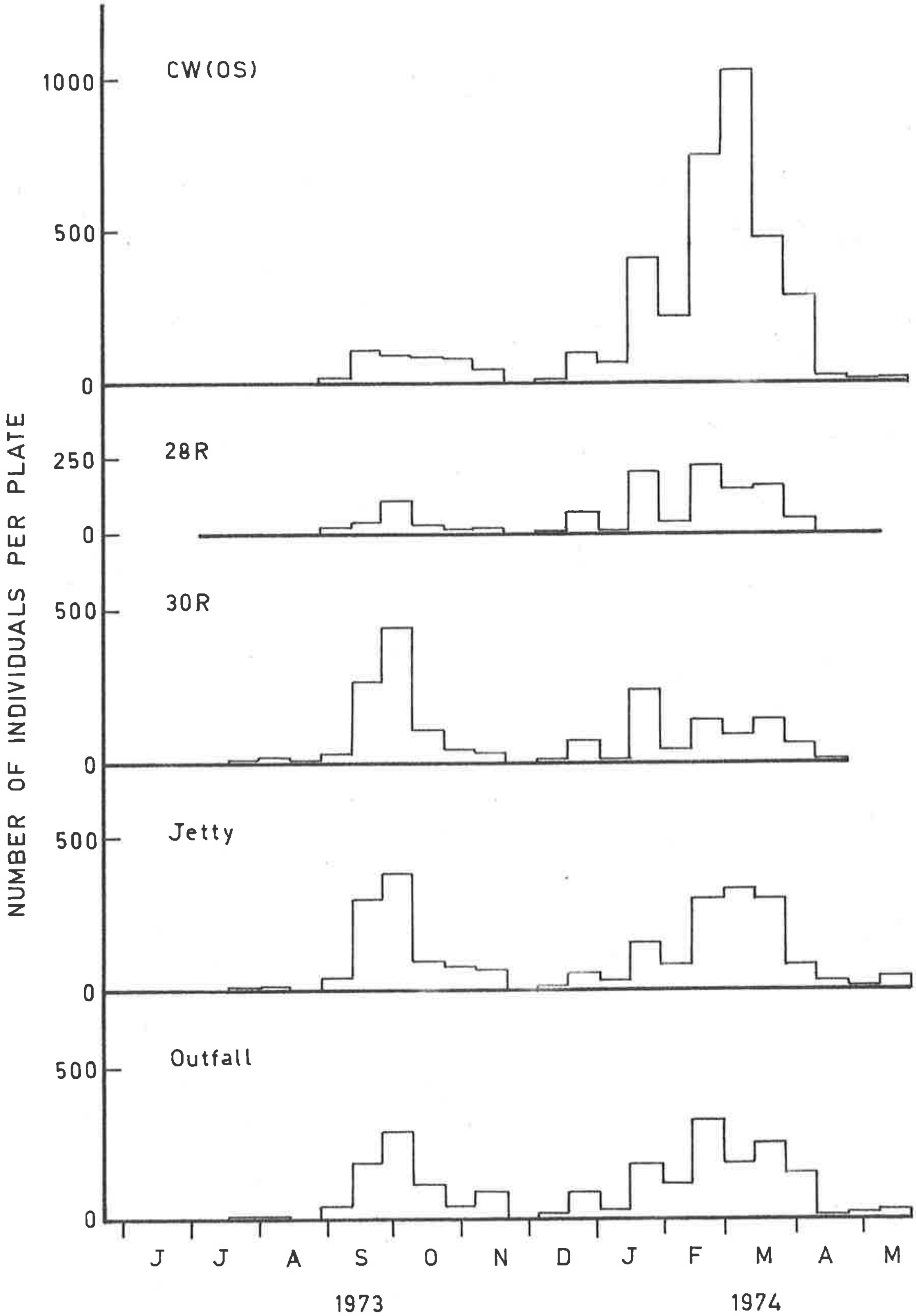

Fig. 4.58 Settlement of the serpulid *Hydroides norvegica* on 2-week plates over the period from June, 1973 to May, 1974.

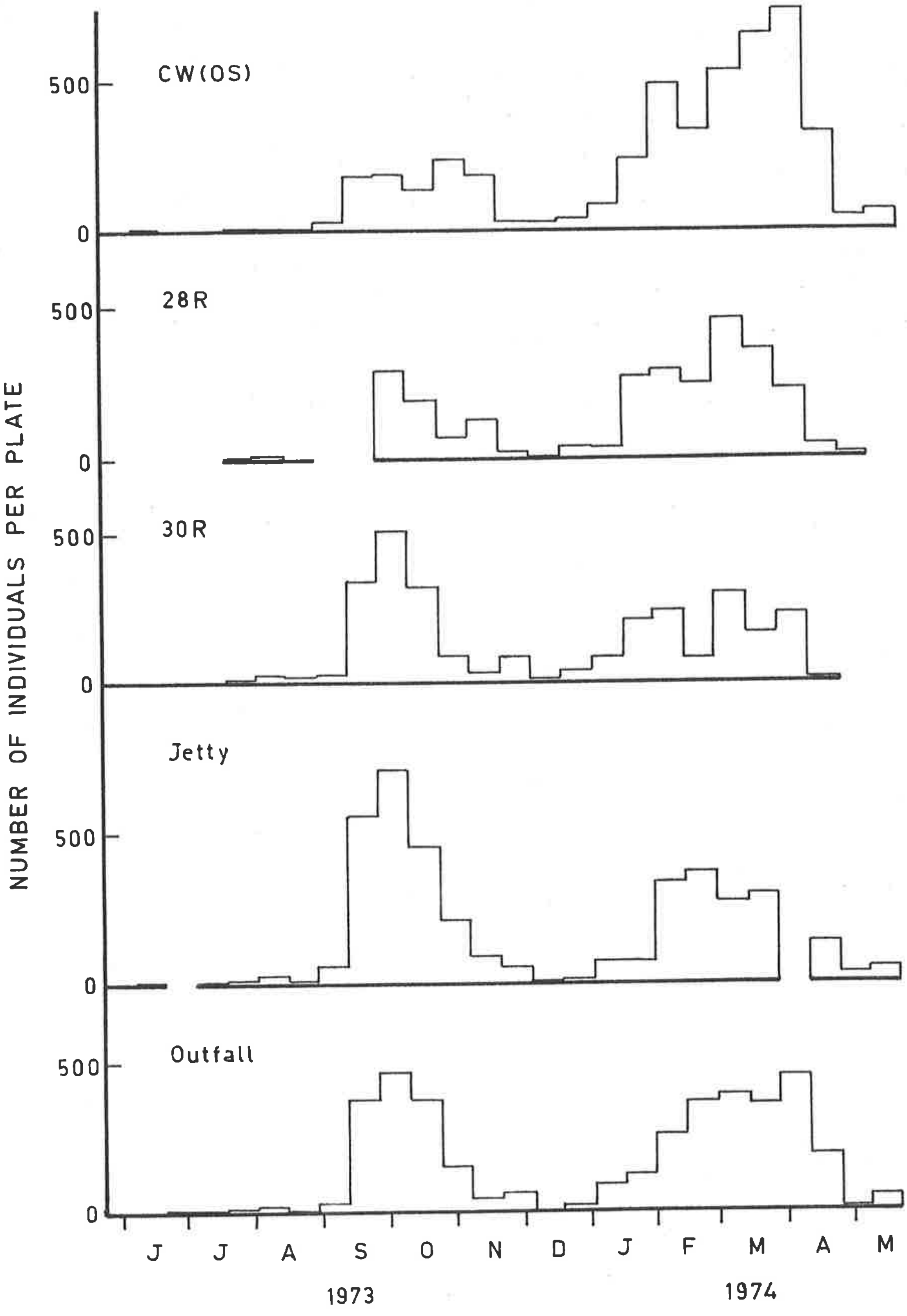

Fig. 4.59 Presence of the serpulid *Hydroides norvegica* on 4-week plates over the period from June, 1973 to May, 1974.

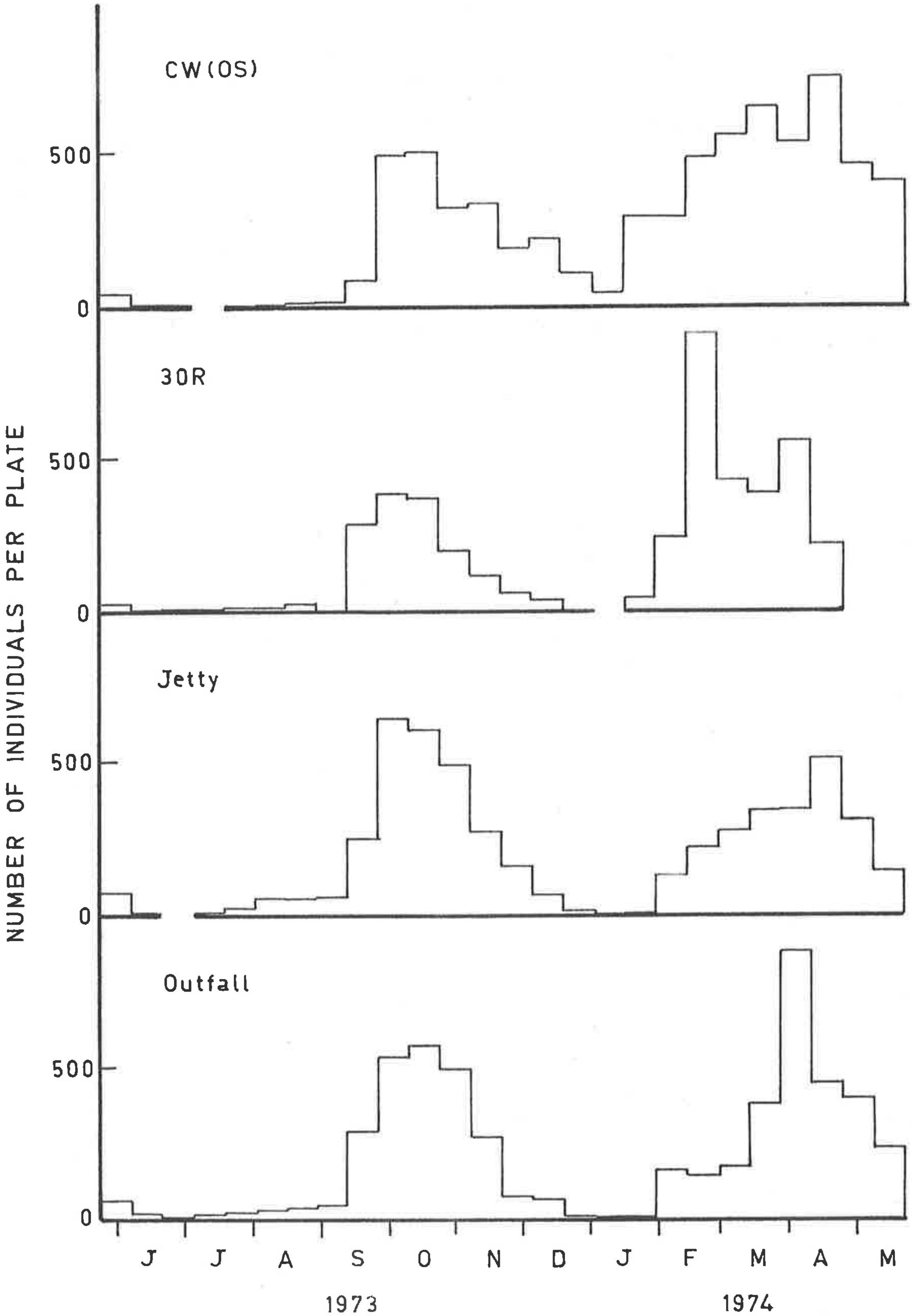

Fig. 4.60 Presence of the serpulid *Hydroides norvegica* on 8-week plates over the period from June, 1973 to May, 1974.

seriously complicated by the gaps in the observations in the middle of the settlement season. There appeared to be no evidence of any differences in the rates of settlement between the stations. The results from the CW(NS) station were included in fig. 4.57 since *Tubularia* had not yet become abundant. There was no suggestion that the faster current had any effect on the settlement of *Hydroides*.

The situation during the second year was completely different. *Hydroides* settled in much greater numbers and the periods of settlement were much longer than in the first year. Two distinct periods of settlement were observed, the first in spring and the second in summer and autumn. Analyses of variance were conducted on the data from two-week plates from all stations (except CW(NS) station) with the aim of examining differences in settlement rates between stations. A separate analysis was carried out for each period of settlement. The results of these analyses are shown in table 4.31.

Differences between stations were statistically significant during both periods. For the first period, the *a priori* comparisons showed no significant differences between the CW(OS) station and the stations in Angas Inlet, but significant differences were evident amongst the stations in Angas Inlet. However, perusal of the results suggested that the stations could be separated into two groups, in which differences in rates of settlement within each group appeared not to be statistically significant but differences between the groups were. Settlement was greater at the group which comprised the Outfall, Jetty and 30R stations and the other group consisted of the CW(OS) and 28R stations. The appropriate *a posteriori* comparisons revealed that these impressions were correct (SS (CW(OS) v 28R) = 9.23, SS (Outfall v Jetty v 30R) = 2.79, SS (between the groups) = 104.05, critical SS = 46.5).

For the second period, the *a priori* comparisons showed that the rates of settlement at the CW(OS) station were greater than those at the stations

Table 4.31 Summary of the analyses of variance conducted on the data on rates of settlement of the serpulid *Hydroides norvegica* on two-week plates from all stations, except CW(NS) station, over the period from 1/8/73 - 24/4/74.

The data were transformed to square roots.

(a) 1/8/73 - 22/11/73.

Fmax (5,8) = 23.0, $P<0.01$; after transformation,

Fmax (5,8) = 5.01.

Source of variation	df	SS	MS	Fs	P
Location	4	116.067	29.017	6.52	<0.001
CW(OS) v other	1	14.780	14.780	3.32	N.S.
Amongst others	3	101.287	33.762	7.58	<0.001
Time	8	992.067	124.008	27.9	<0.001
Remainder	32	142.487	4.453		
	44	1250.621			

(b) 19/12/73 - 24/4/74.

Fmax(5,9) = 21.6, $P<0.01$; after transformation,

Fmax (5,9) = 5.40.

Source of variation	df	SS	MS	Fs	P
Location	4	398.26	99.57	11.7	<0.001
CW(OS) v others	1	337.06	337.06	39.7	<0.001
Amongst others	3	61.20	20.40	2.40	N.S.
Time	9	1434.92	159.43	18.8	<0.001
Remainder	36	306.02	8.500		
	49	2139.21			

in Angas Inlet. In addition, there were no significant differences in rates of settlement between the stations in Angas Inlet. Thus, the results agree with the hypothesis that settling larvae may discriminate between different locations on the basis of temperature. In spring, the favourable temperatures were found in Angas Inlet at the Outfall, Jetty and 30R stations, while in summer, the temperatures at the CW(OS) station fell within the favourable range.

On longer term plates, *Hydroides* was liable to be smothered by other growth, but much less liable than *Eulaeospira convexis* (section 4.2(k)). Typically, the tubes of *Hydroides* grow with one side attached to the substrate and reach several centimetres in length. However, the tubes may grow away from the substrate, apparently in response to competition for space both with other individuals of *Hydroides* and with other species. The results from four-week and eight-week plates during 1973-1974 were generally consistent with those from two-week plates. However, differences between stations became progressively less marked as the length of exposure of the plates increased. The numbers of individuals found on two-week plates during the times of maximum settlement rates were of the same order of magnitude as those found on eight-week plates. Further increases in numbers after two weeks were limited by the restricted amount of space. In contrast, when the number of settlements on a two-week plate was smaller, a further increase in number with increased exposure was possible.

Only a comparatively small number of observations were made during the summer of 1974-75. During this period, *Hydroides* was present in greater abundance at the CW(OS) station than in Angas Inlet. A Wilcoxon test was conducted on the data from two-week and four-week plates together from the CW(OS) and Jetty stations and provided a statistically significant result.

(n = 12), T = 2½, P 0.01). The results from the Outfall station showed the same trend.

(o) The barnacle *Balanus amphitrite* Darwin.

The complete results on the presence of *Balanus amphitrite* on two-week, four-week and eight-week plates are listed in appendix 15. Figs. 4.61 and 4.62 show the settlement of barnacles on two-week plates during the first two years of the study. The results showed that the season of settlement of *Balanus* coincided with the warmer months of the year. The statistical significance of differences in settlement rates between stations were examined by conducting analyses of variance on the data for each season of settlement. Table 4.32 shows the results of the analyses. During the first year, the rates of settlement at the CW(OS) station were just significantly less than those at the Outfall and Jetty stations. There were no significant differences between stations during the second year.

The results from four-week and eight-week plates during the first year were seriously affected by the interruptions to the observations, particularly at the CW(OS) station. The results from four-week and eight-week plates during the second year are shown in figs. 4.63 and 4.64. The data were not analysed in detail since a reasonably complete set of results were obtained from two-week plates. In addition, some barnacles were smothered on longer term plates, complicating interpretation of the results. However, the data from four-week and eight-week plates during the second year appeared to be generally consistent with those from two-week plates, with little or no differences in abundance between stations.

Fig. 4.65 shows the presence of barnacles on two-week and four-week plates from the CW(OS) and Jetty stations during late spring and summer of 1974-75. Barnacles were much more abundant at these times than was the case during the previous settlement season. The data from two-week

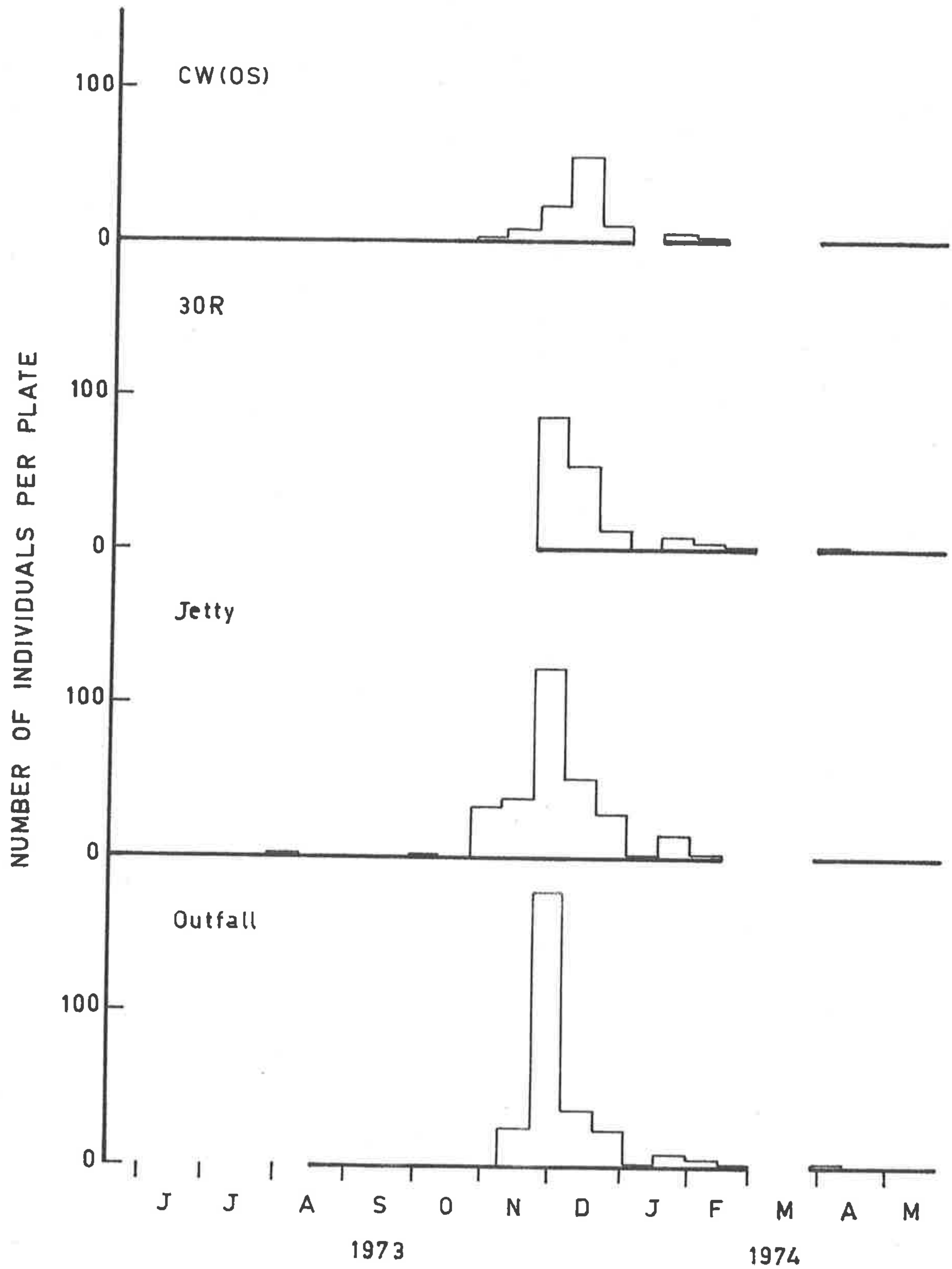

Fig. 4.61 Settlement of the barnacle *Balanus amphitrite* on 2-week plates over the period from June, 1972 to May, 1973.

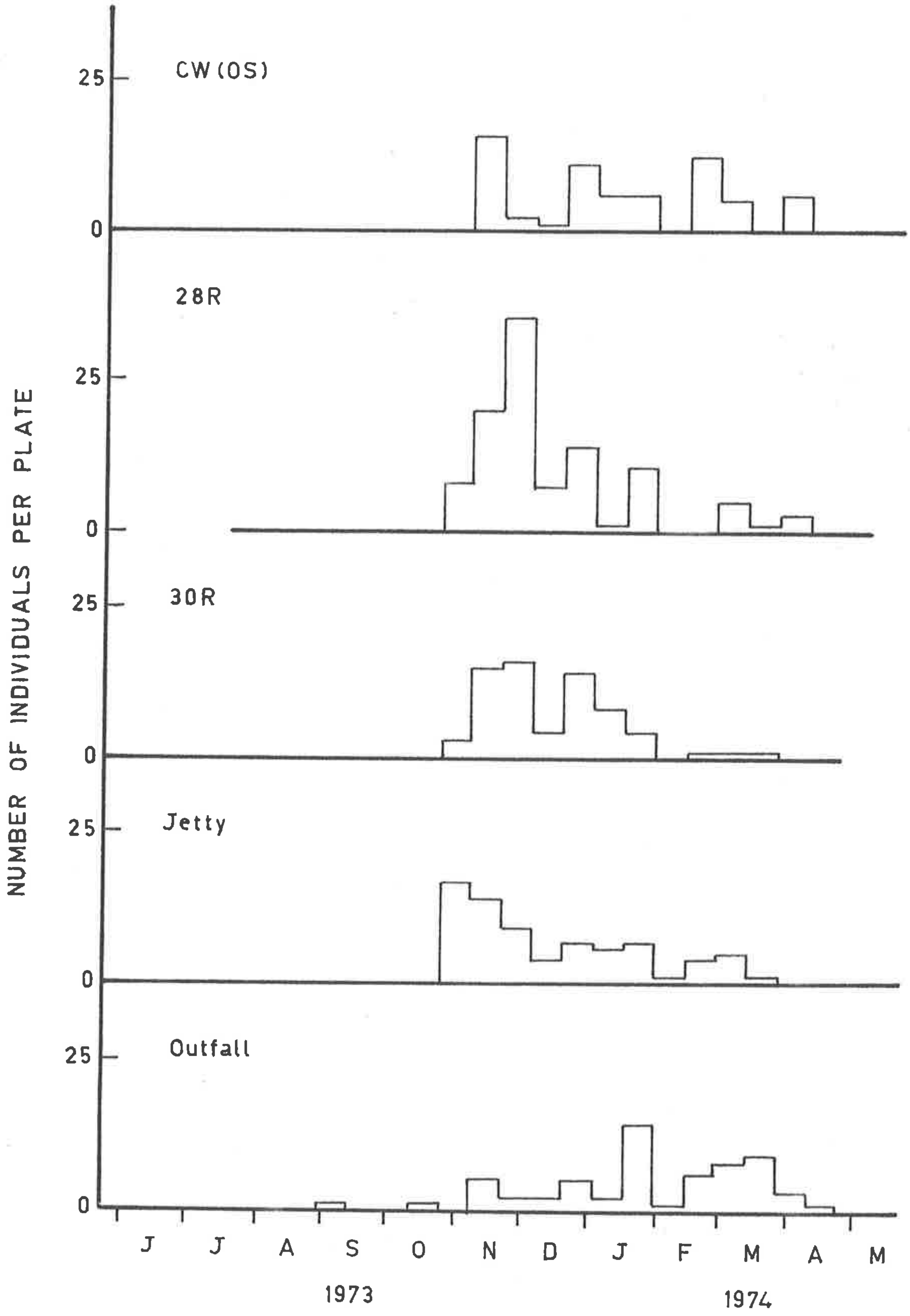

Fig. 4.62 Settlement of the barnacle *Balanus amphitrite* on 2-week plates over the period from June, 1973 to May, 1974.

Table 4.32 Summary of the analyses of variance conducted on the data on rates of settlement of the barnacle *Balanus amphitrite* on two-week plates at locations in Angas Inlet and North Arm.

The data were transformed to square roots.

(a) Data from the CW(OS), Outfall and Jetty stations collected over the period 8/11/72 - 14/2/73.

Fmax (3,6) = 11.6, $0.01<P<0.05$; after transformation, Fmax (3,6) = 3.82.

Source of variation	df	SS	MS	Fs	P
Location	2	21.522	10.761	3.00	N.S.
CW(OS) v others	1	19.069	19.069	5.31	$0.025<P<0.05$
Outfall v Jetty	1	2.453	2.453	<1	N.S.
Time	6	135.759	22.626	6.30	$0.001<P<0.005$
Remainder	12	43.112	3.593		
	20	200.392			

(b) Data from all stations, except CW(NS) station, collected over the period 24/10/73 - 24/4/74.

Source of variation	df	SS	MS	Fs	P
Location	4	2.7693	0.6923	<1	N.S.
Time	13	46.9391	3.6107	3.88	<0.001
Remainder	52	48.3403	0.9296		
	69	98.0487			

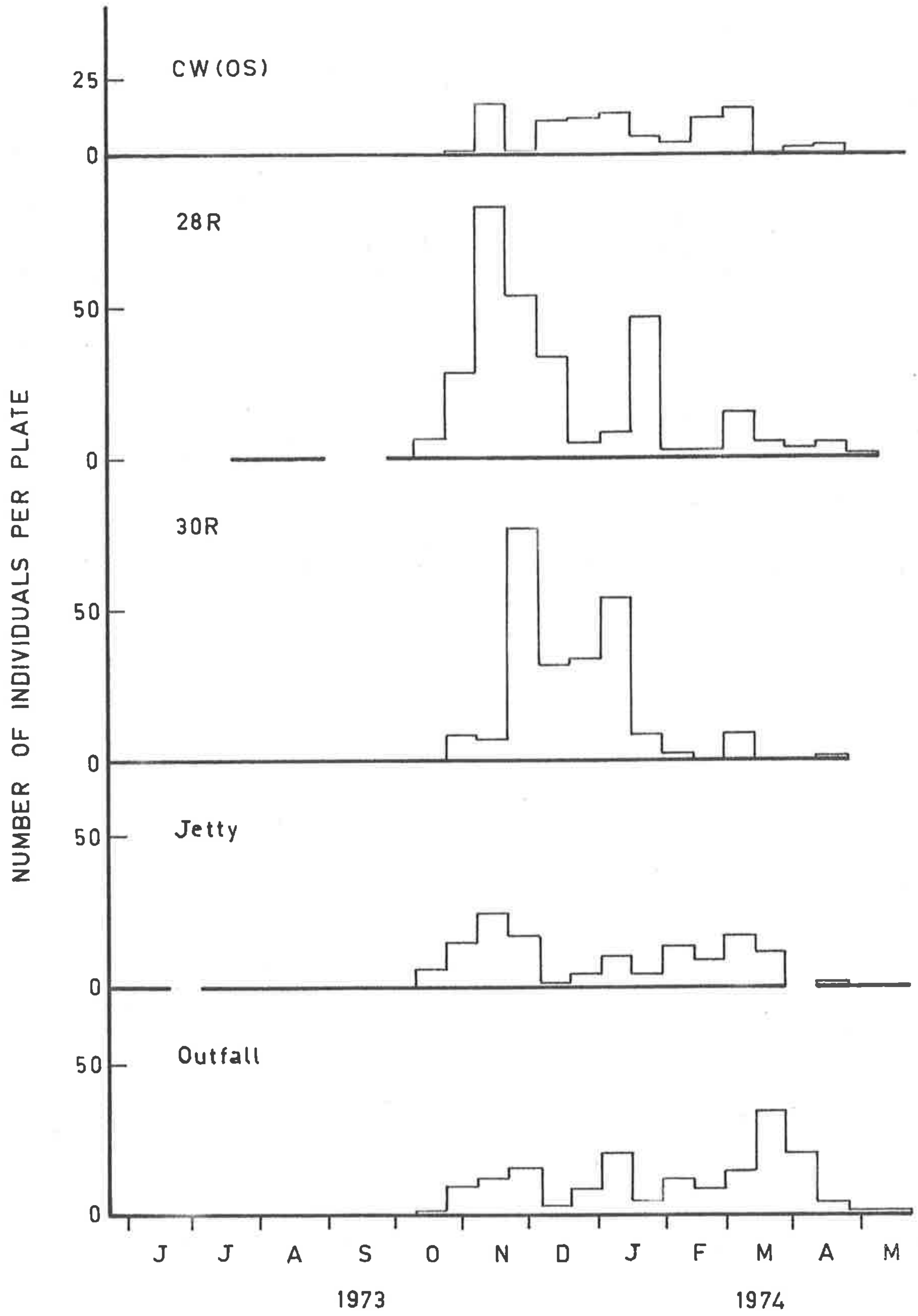

Fig. 4.63 Presence of the barnacle *Balanus amphitrite* on 4-week plates over the period from June, 1973 to May, 1974.

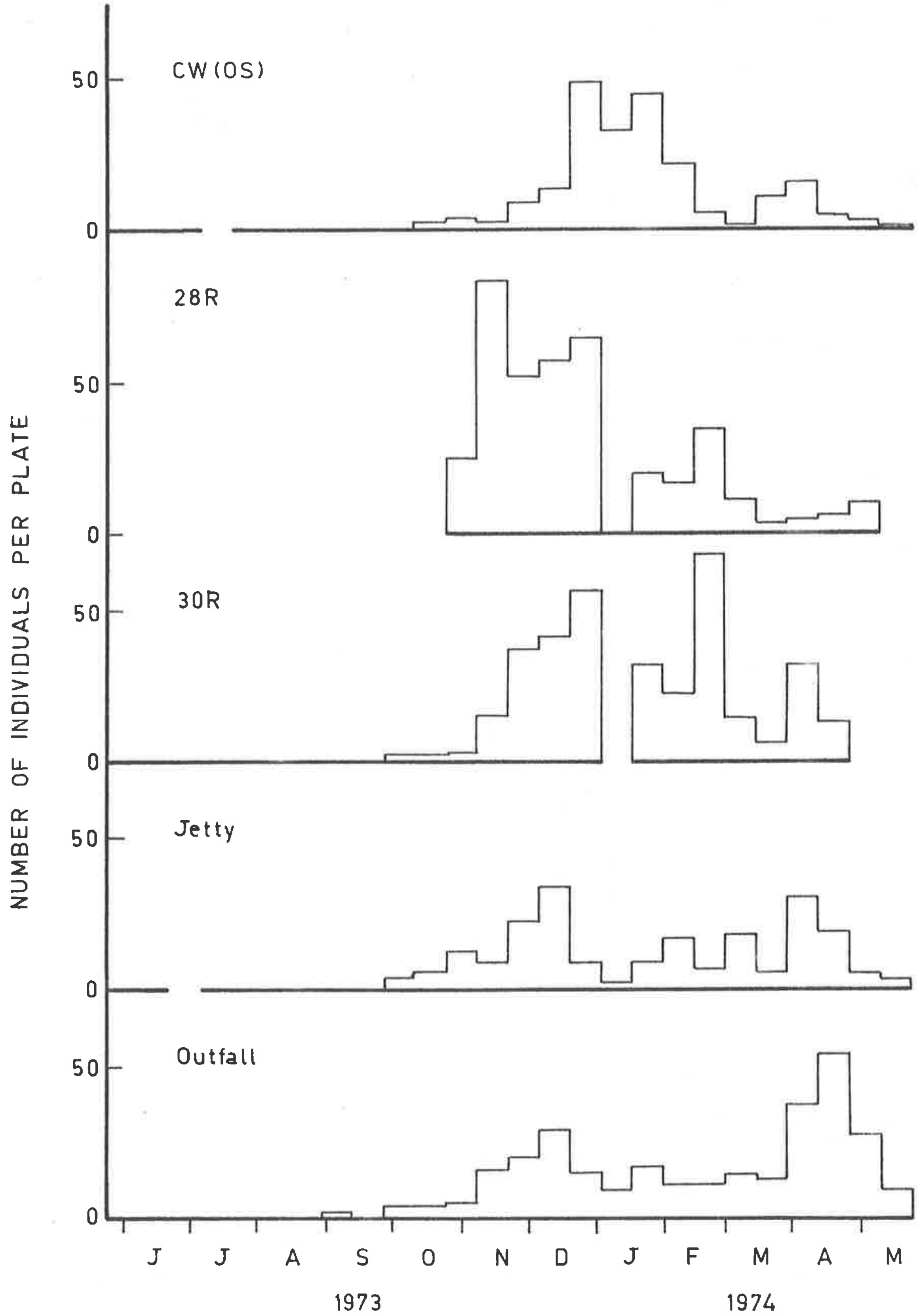

Fig. 4.64 Presence of the barnacle *Balanus amphitrite* on 8-week plates over the period from June, 1973 to May, 1974.

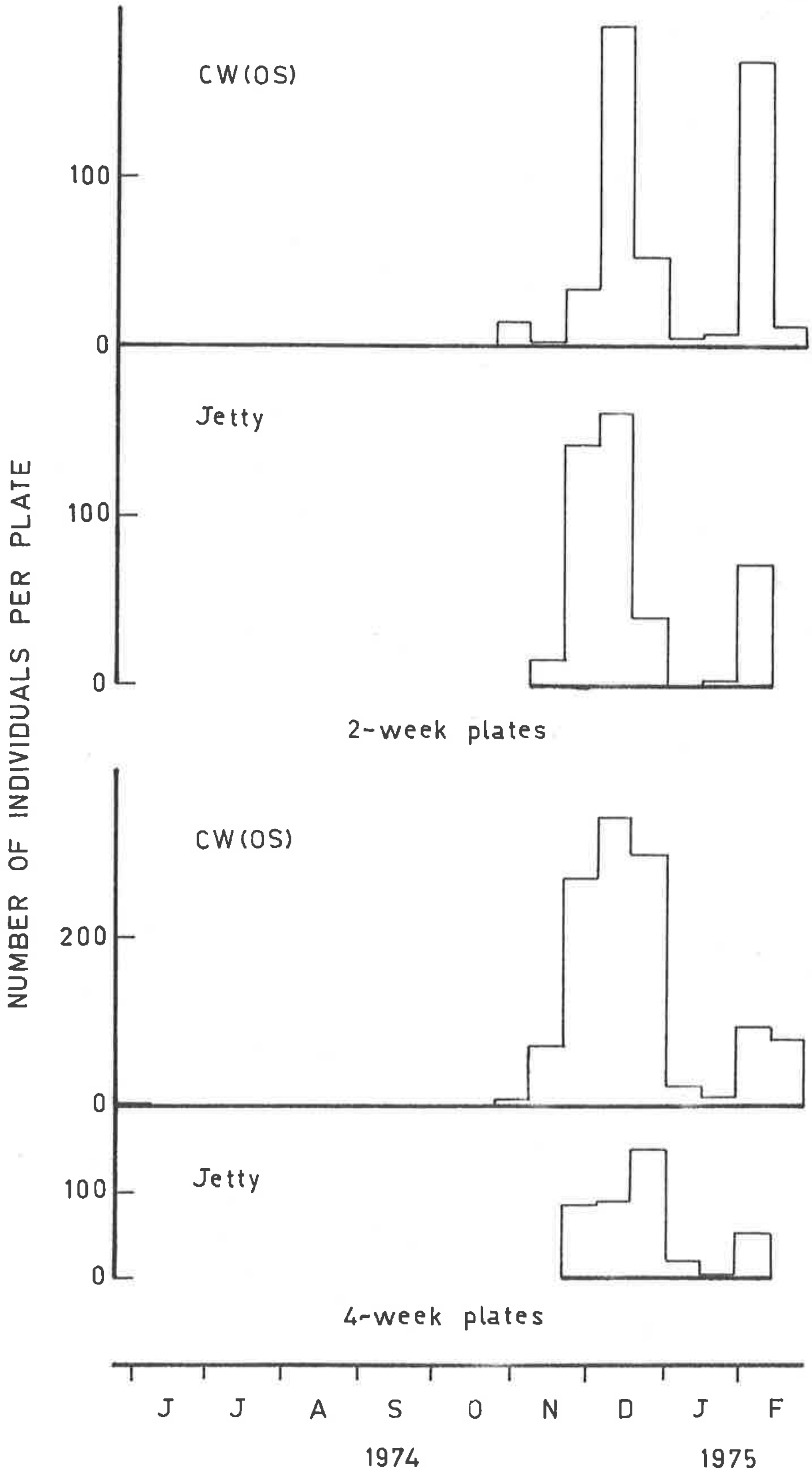

Fig. 4.65 Presence of the barnacle *Balanus amphitrite* on 2-week and 4-week plates from the CW(OS) and Jetty stations over the period from June, 1974 to February, 1975.

and four-week plates were amalgamated and analysed using the Wilcoxon test. This test showed that the numbers of barnacles were just significantly greater at the CW(OS) station than at the Jetty station ($n = 13$, $T = 15$, $0.025 < P < 0.05$).

(p) The oyster *Ostrea angasi* Sowerby.

The complete data on the presence of *Ostrea angasi* are listed in appendix 16. Figs. 4.66 and 4.67 show the settlement on two-week plates during the two years from June, 1972 to May, 1974. In both years, the season of settlement extended over late spring and summer. Oysters were more abundant during the first year. An analysis of variance was conducted on the data from the CW(OS), Outfall and Jetty stations obtained over the period 25/10/72 - 14/2/73. There were no significant differences in rates of settlement between the stations (table 4.33).

The appropriate method of analysis for the data from the second year was the Friedman test, since inspection of the data would indicate that heterogeneity of variances was present. This test was conducted on the data from all stations, except the CW(NS) station, collected over the period from 7/11/73 - 10/4/74. Differences in settlement rates between stations were found to be statistically significant ($X^2_4 = 10.2$, $0.02 < P < 0.005$). A series of Wilcoxon tests were conducted to examine the situation in greater detail (table 4.34). The analyses showed that oysters were more abundant at the Outfall and 30R stations than at the other stations. Thus, the differences in settlement rates showed no clear relationship to the distribution of temperature.

Figs. 4.68 and 4.69 show the presence of oysters on four-week and eight-week plates during the second year. The data showed the same trend as that for two-week plates.

(q) A tube-dwelling amphipod *Corophium* sp.

This species is one of three tube-dwelling crustaceans which were found on the plates. In counting the numbers present on a plate, it was

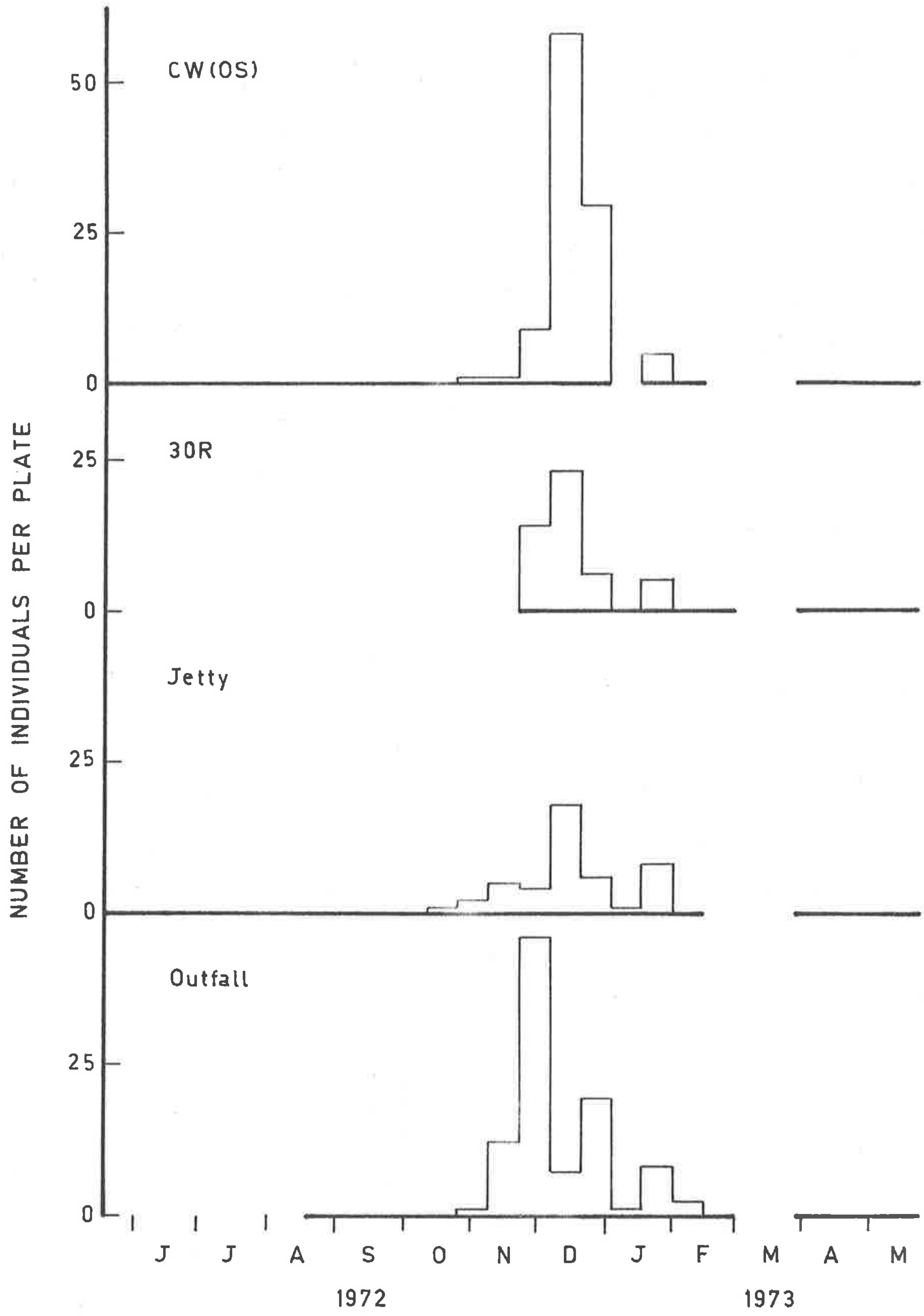

Fig. 4.66 Settlement of the oyster *Ostrea angasi* on 2-week plates over the period from June, 1972 to May, 1973.

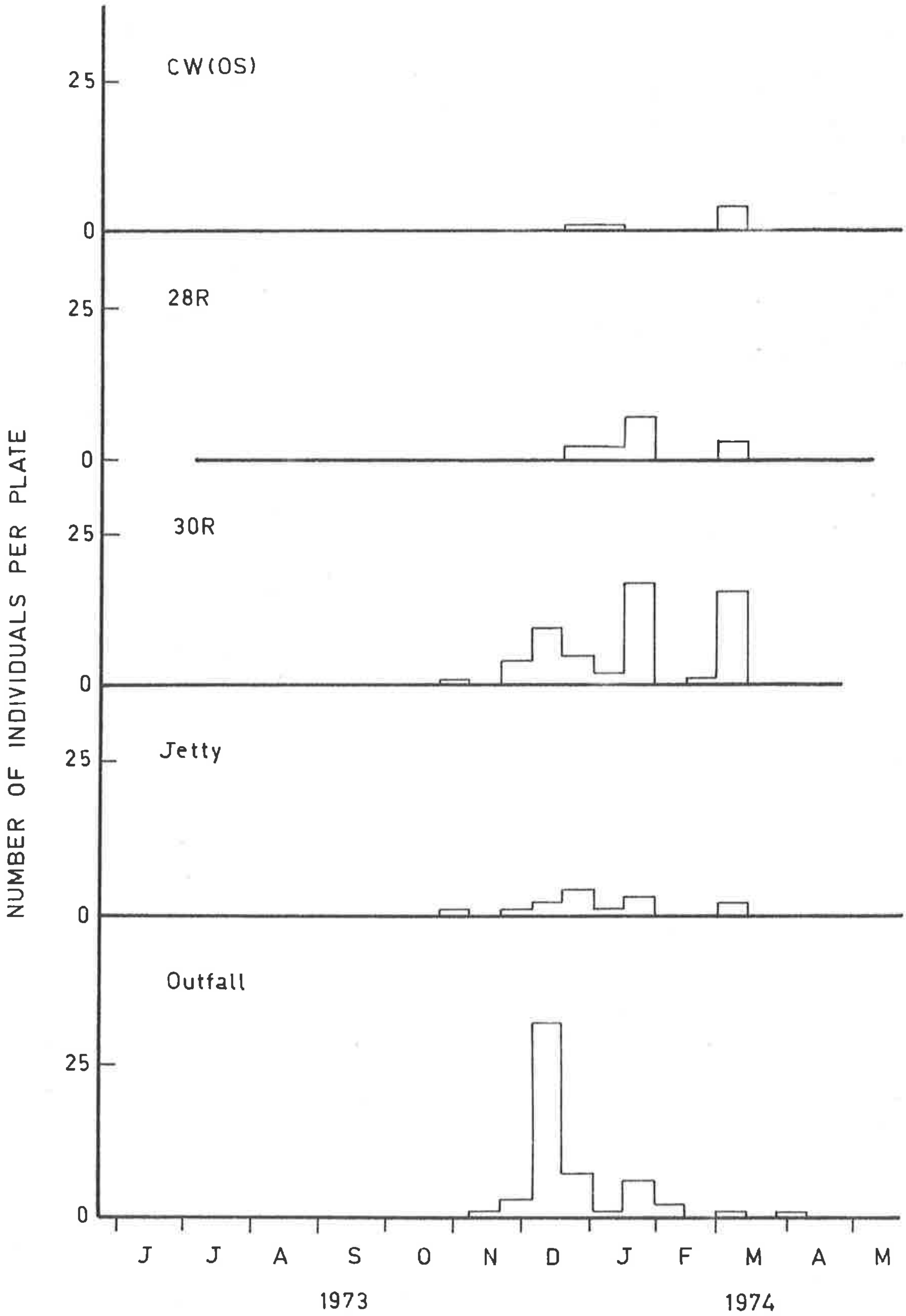

Fig. 4.67 Settlement of the oyster *Ostrea angasi* on 2-week plates over the period from June, 1973 to May, 1974.

Table 4.33 Summary of the analyses of variance conducted on the data on rates of settlement of the oyster *Ostrea angasi* on two-week plates from the CW(OS), Outfall and Jetty stations obtained over the period 25/10/72 - 14/2/73.
The data were transformed to square roots (Fmax $(3,7) = 9.98$, $0.01<P<0.05$; after transformation, Fmax $(3,7) = 4.42$).

Source of variation	df	SS	MS	Fs	P
Location	2	2.440	1.220	<1	N.S.
Time	7	47.111	6.730	3.48	$0.01<P<0.025$
Remainder	14	27.094	1.935		
	23	76.645			

Table 4.34 Results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on rates of settlement of the oyster *Ostrea angasi* on two-week plates from all stations, except CW(NS) station, obtained over the period 7/11/73 - 10/4/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
CW(OS)	v Outfall	9	5½	$0.02<P<0.05$
	v Jetty	7	4½	N.S.
	v 30R	8	0	<0.01
	v 28R	4	Not applicable	
Outfall	v Jetty	9	5	$0.02<P<0.05$
	v 30R	11	33	N.S.
	v 28R	9	10½	N.S.
Jetty	v 30R	7	0	$0.01<P<0.02$
	v 28R	7	12	N.S.
30R	v 28R	7	0	$0.02<P<0.01$

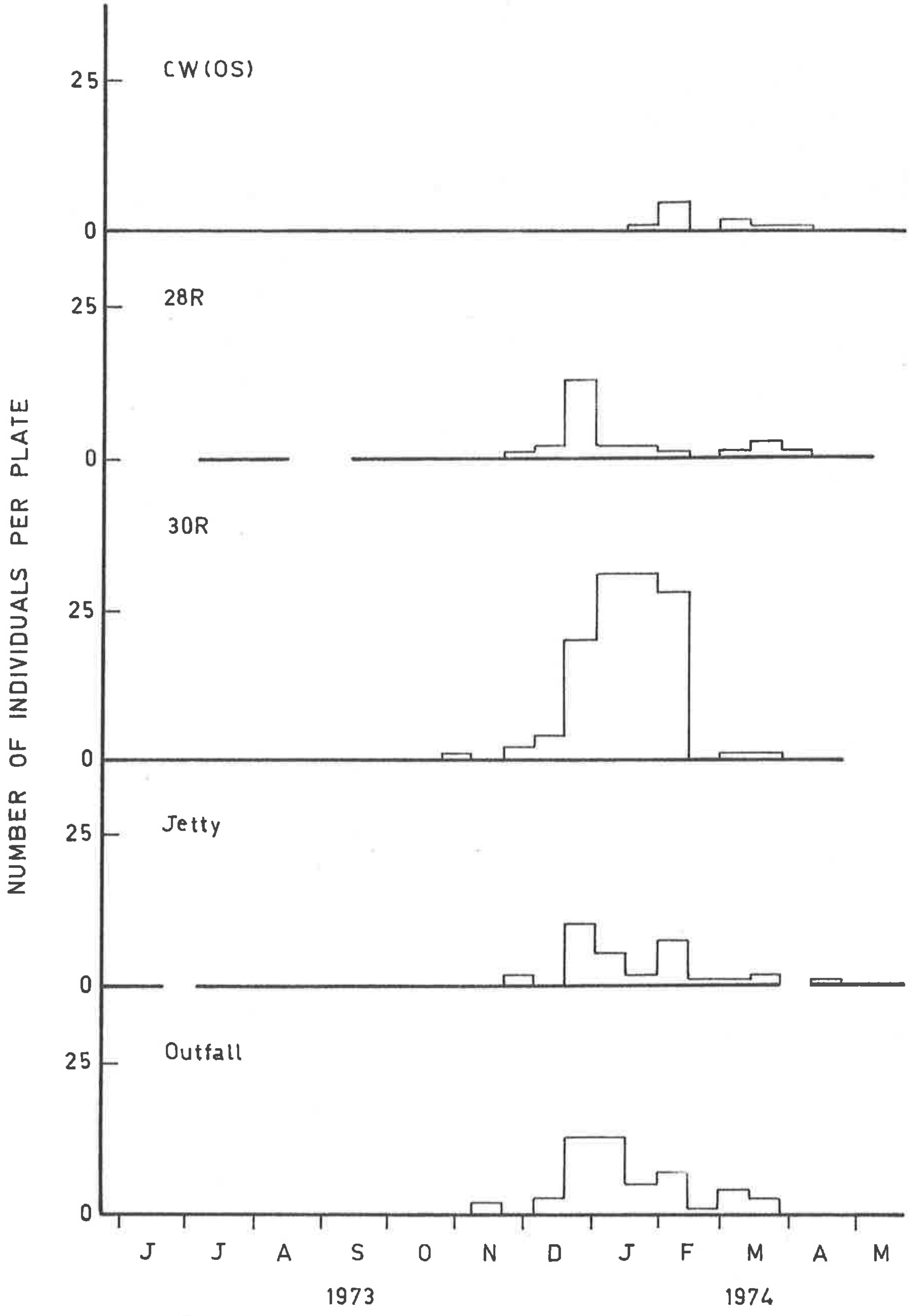

Fig. 4.68 Presence of the oyster *Ostrea angasi* on 4-week plates over the period from June, 1973 to May, 1974.

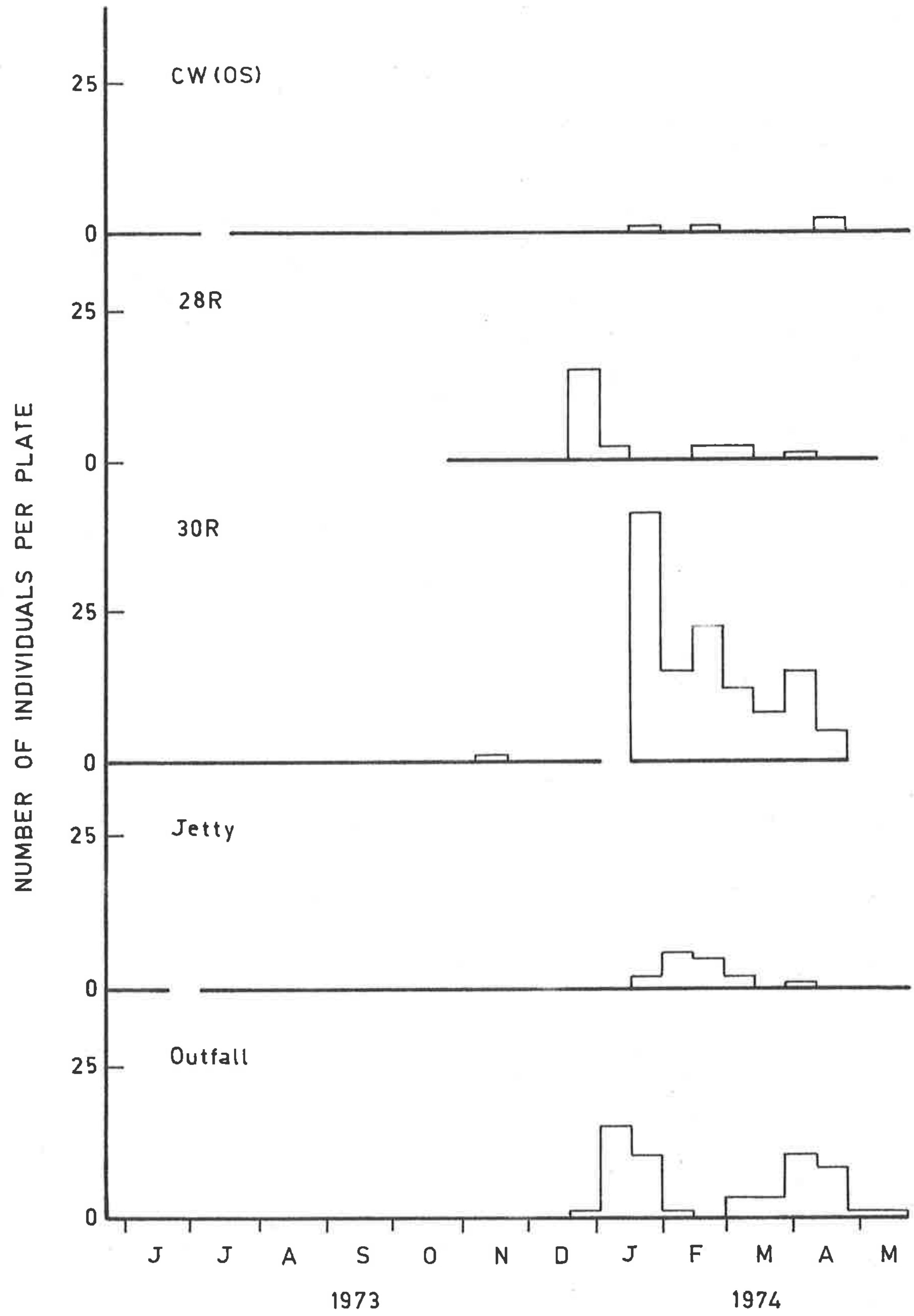

Fig. 4.69 Presence of the oyster *Ostrea angasi* on 8-week plates over the period from June, 1973 to May, 1974.

often necessary to touch a tube with a needle to determine if it was occupied and, if so, by which species of crustacean. Thus, counting was often time-consuming and, for this reason, counts were confined to two-week plates.

Figs. 4.70 and 4.71 show the presence of *Corophium* on two-week plates during each of the first two years of the study. The complete results are listed in appendix 17. Differences in abundance between stations during the first year were examined by conducting an analysis of variance on the data from the CW(OS), Outfall and Jetty stations (table 4.35). No significant differences in abundance were evident.

Inspection of the data from the second year showed that heterogeneity of variances was present. In addition, some interaction appeared to be present. The Friedman test was applied to the data from all stations, except CW(NS) station, obtained over the period 18/7/73 - 24/4/74. Once again, no significant differences in abundance were evident ($X_4^2 = 9.43$).

(r) An unidentified tube-dwelling amphipod (family Corophiidae).

Figs. 4.72 and 4.73 show the presence of this amphipod on two-week plates collected during the first two years. The complete results are listed in appendix 18. The Friedman test was applied to the data from the CW(OS), Outfall and Jetty stations obtained over the period 27/9/72 - 3/1/73. No significant differences in abundance were found during this period ($X^2(k=3,n=8) = 4.75$).

However, after the results from the CW(NS) station had commenced, it soon became clear that the amphipod was favoured by the turbulence of the water there even despite the presence of *Tubularia* (section 4.2(c)). The greater abundance at the CW(NS) station was confirmed by conducting a Wilcoxon test on the data from the CW(OS) and CW(NS) stations obtained over the period 14/2/73 - 16/1/74 ($n = 17$, $T = 0$, $P < 0.01$). After 16/1/74, *Zoobotryon* was abundant at the CW(NS) station and possibly affected the occurrence of the amphipod.

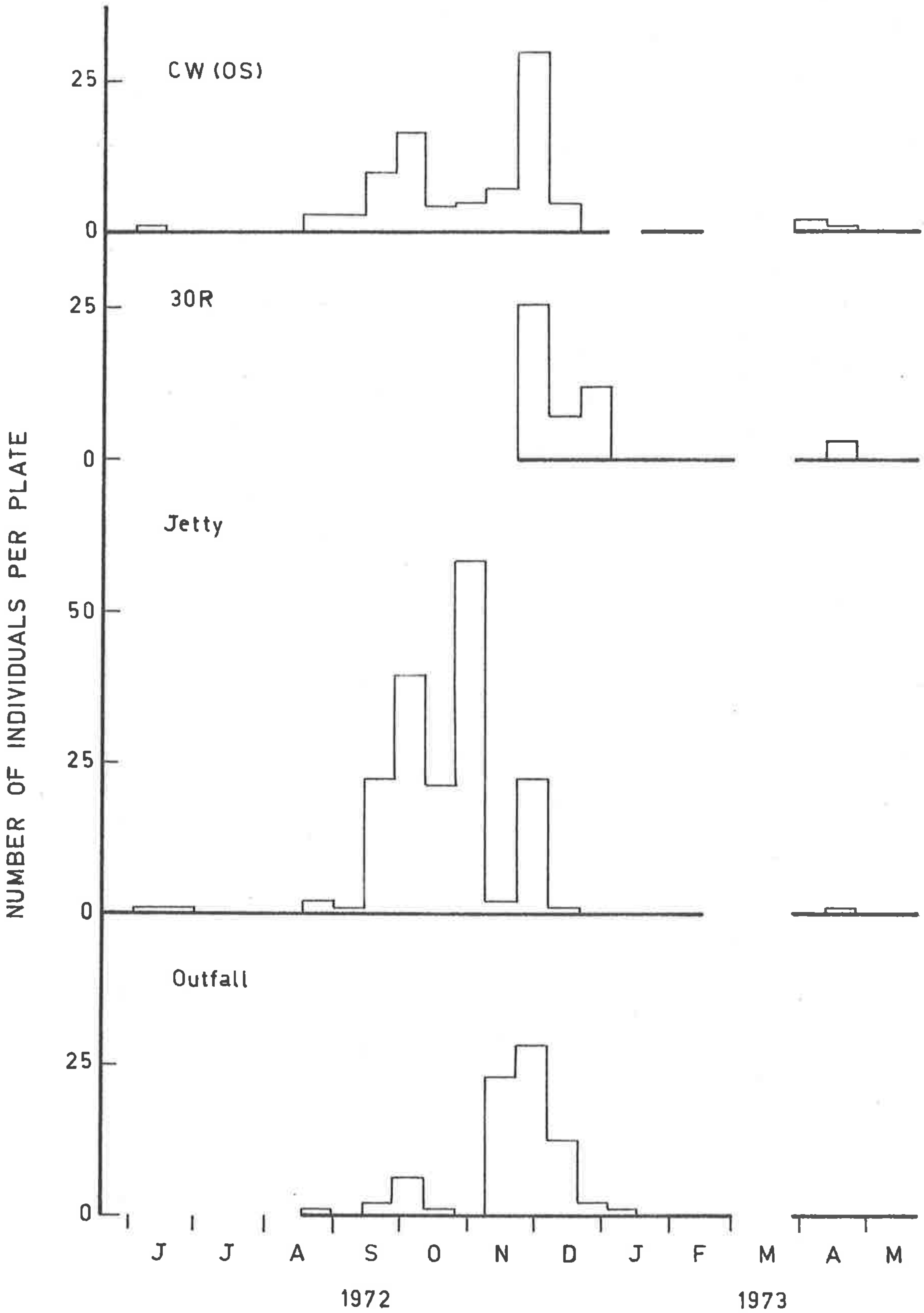

Fig. 4.70 Presence of the tube-dwelling amphipod *Corophium* sp. on 2-week plates over the period from June, 1972 to May, 1973.

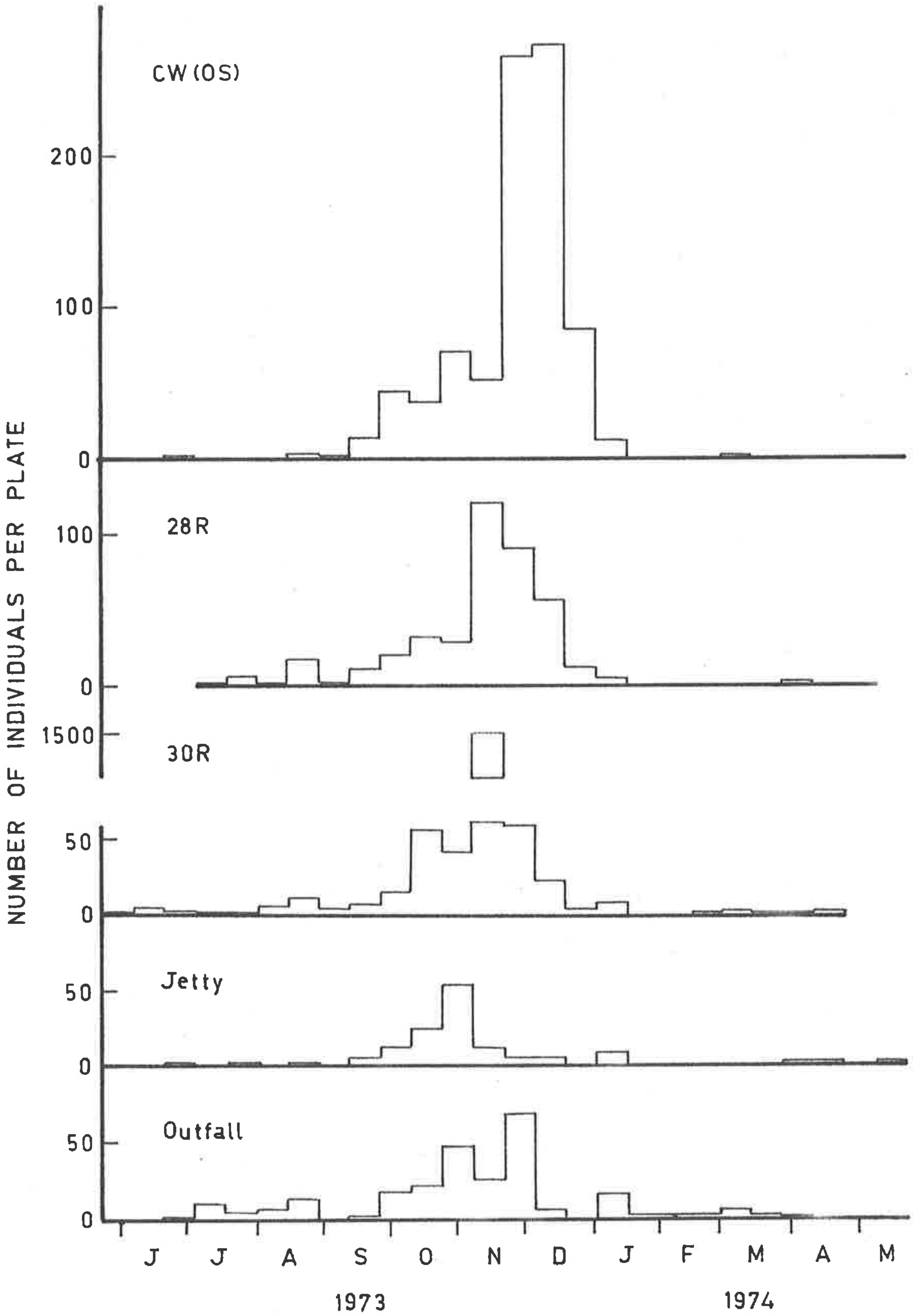

Fig. 4.71 Presence of the tube-dwelling amphipod *Corophium* sp. on 2-week plates over the period from June, 1973 to May, 1974.

Table 4.35 Summary of the analysis of variance conducted on the data on the presence of the amphipod *Corophium* on two-week plates from the CW(OS), Outfall and Jetty stations obtained over the period 30/8/72 - 3/1/73.
($F_{max}(3,9) = 4.62$).

Source of variation	df	SS	MS	Fs	P
Place	2	516.5	258.2	1.61	N.S.
Time	9	2292.3	254.7	1.59	N.S.
Remainder	18	2884.2			
	29	5693.0			

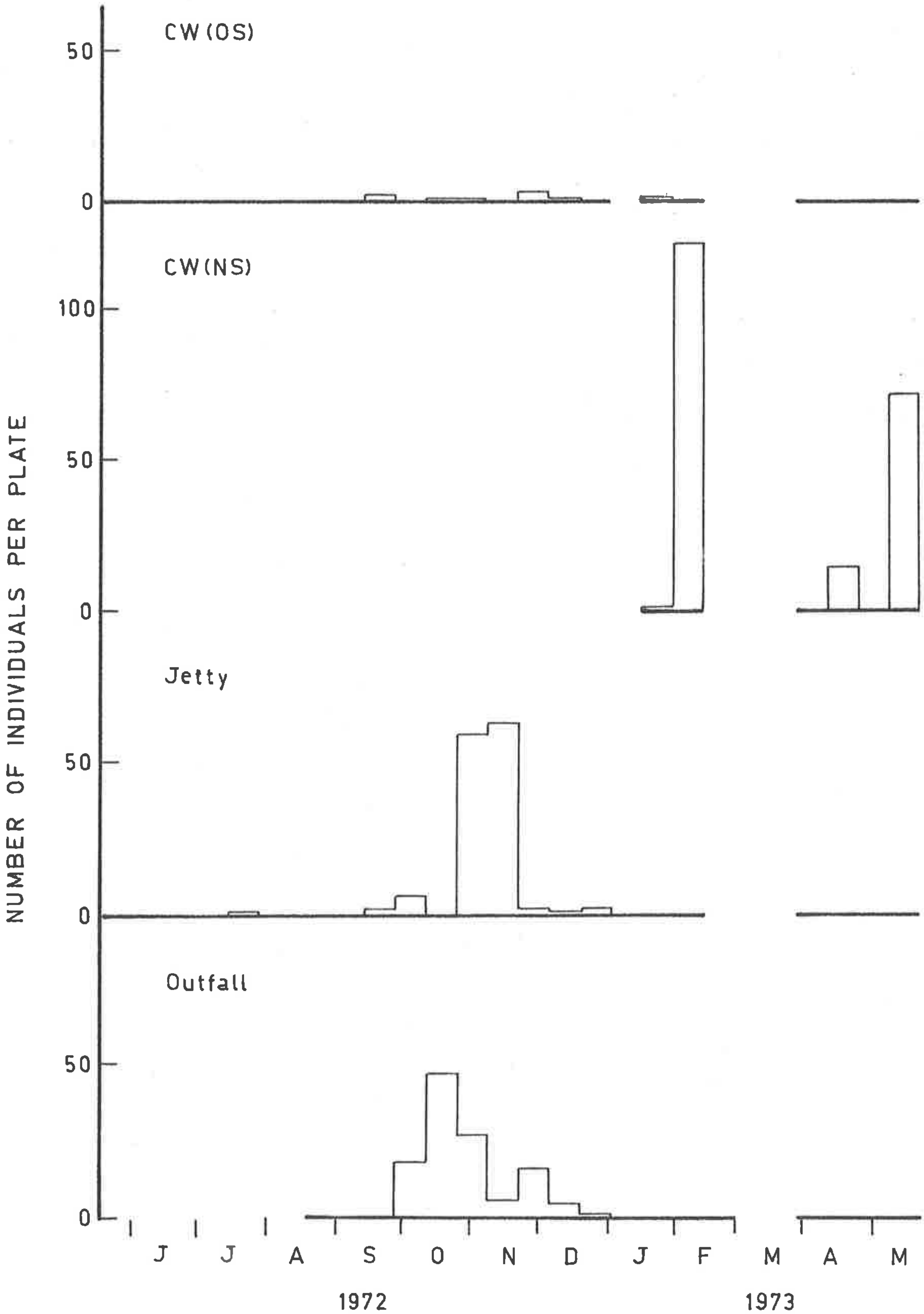

Fig. 4.72 Presence of an unidentified tube-dwelling amphipod (family Corophiidae) on 2-week plates over the period from June, 1972 to May, 1973.

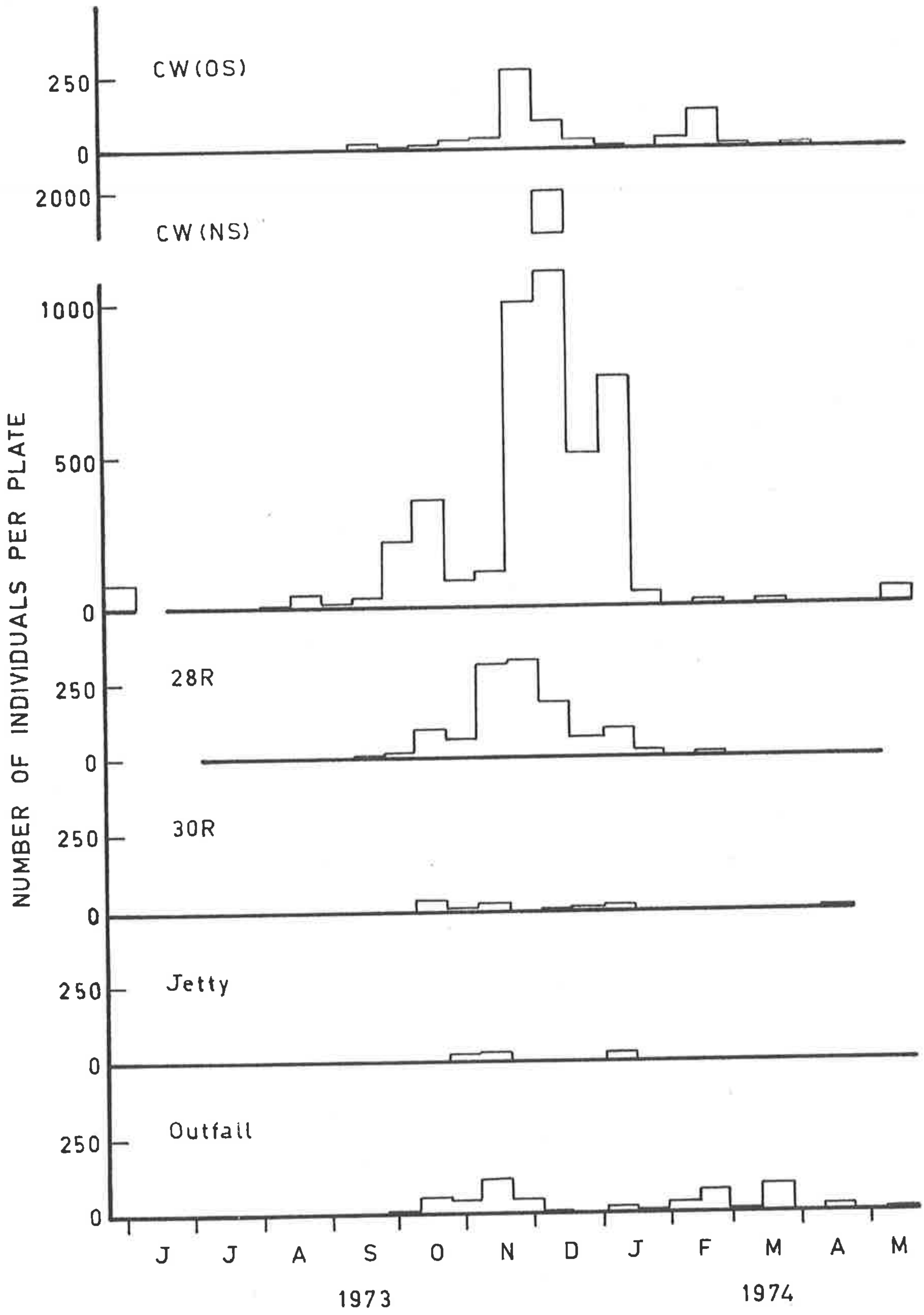

Fig. 4.73 Presence of an unidentified tube-dwelling amphipod (family Corophiidae) on 2-week plates over the period from June, 1973 to May, 1974.

The Friedman test was then applied to the data from all stations, except CW(NS) station, obtained over the period 29/8/73 - 24/4/74. Differences in abundance were found to be statistically significant (X^2_4 = 26.1, $P<0.001$). In order to elucidate the direction of these differences, a series of Wilcoxon tests were conducted on the data (table 4.36). The analyses showed that the amphipod was less abundant at the Jetty and 30R stations than at the CW(OS), Outfall and 28R stations. The greater rate of occurrence at the Outfall station in comparison to the Jetty and 30R stations may be caused by the abundance of the amphipod at the CW(NS) station. A similar situation was discussed above with regard to *Tubularia* (section 4.2(c)). Taking this factor into account, the results suggested that the amphipod was adversely affected by the warmed water.

(s) A tanaid crustacean (Tanaidacea : Tanaidae), possibly *Paratanais ignotus*.

Fig. 4.74 shows the presence of *Paratanais* on two-week plates during the first year. The crustacean was virtually absent after January, 1973. The complete results are listed in appendix 19. The Friedman test was applied to the data from the CW(OS), Outfall and Jetty stations obtained over the period 27/9/72 - 3/1/73. Differences in abundance between stations were found to be significant ($X^2(k=3,n=8)$ = 6.44, $0.31<P<.048$). Application of the Wilcoxon test showed that the crustacean was more abundant at the Outfall station than at the CW(OS) and Jetty stations (Outfall v CW(OS), n = 8, T = 1, $0.01<P<0.02$; Outfall v Jetty, n = 7, T = 1, $0.02<P<0.05$). Differences between the CW(OS) and Jetty stations were not significant (n = 8, T = 5). Thus, the results suggested that *Paratanais* may have been favoured by the warmed water during its brief period of occurrence.

Table 4.36 Results of a series of Wilcoxon matched-pairs signed-rank tests conducted on the data on the occurrence of an unidentified amphipod on two-week plates from all stations, except CW(NS) station, obtained over the period 29/8/73 - 22/5/74. The analyses were employed to examine differences in abundance.

Comparison		n	T	P
CW(OS)	v Outfall	18	86	N.S.
	v Jetty	16	12½	<0.01
	v 30R	14	15½	$0.01<P<0.02$
	v 28R	17	37	N.S.
Outfall	v Jetty	17	9	<0.01
	v 30R	15	7	<0.01
	v 28R	17	42½	N.S.
Jetty	v 30R	13	35	N.S.
	v 28R	17	0	<0.01
30R	v 28R	17	6½	<0.01

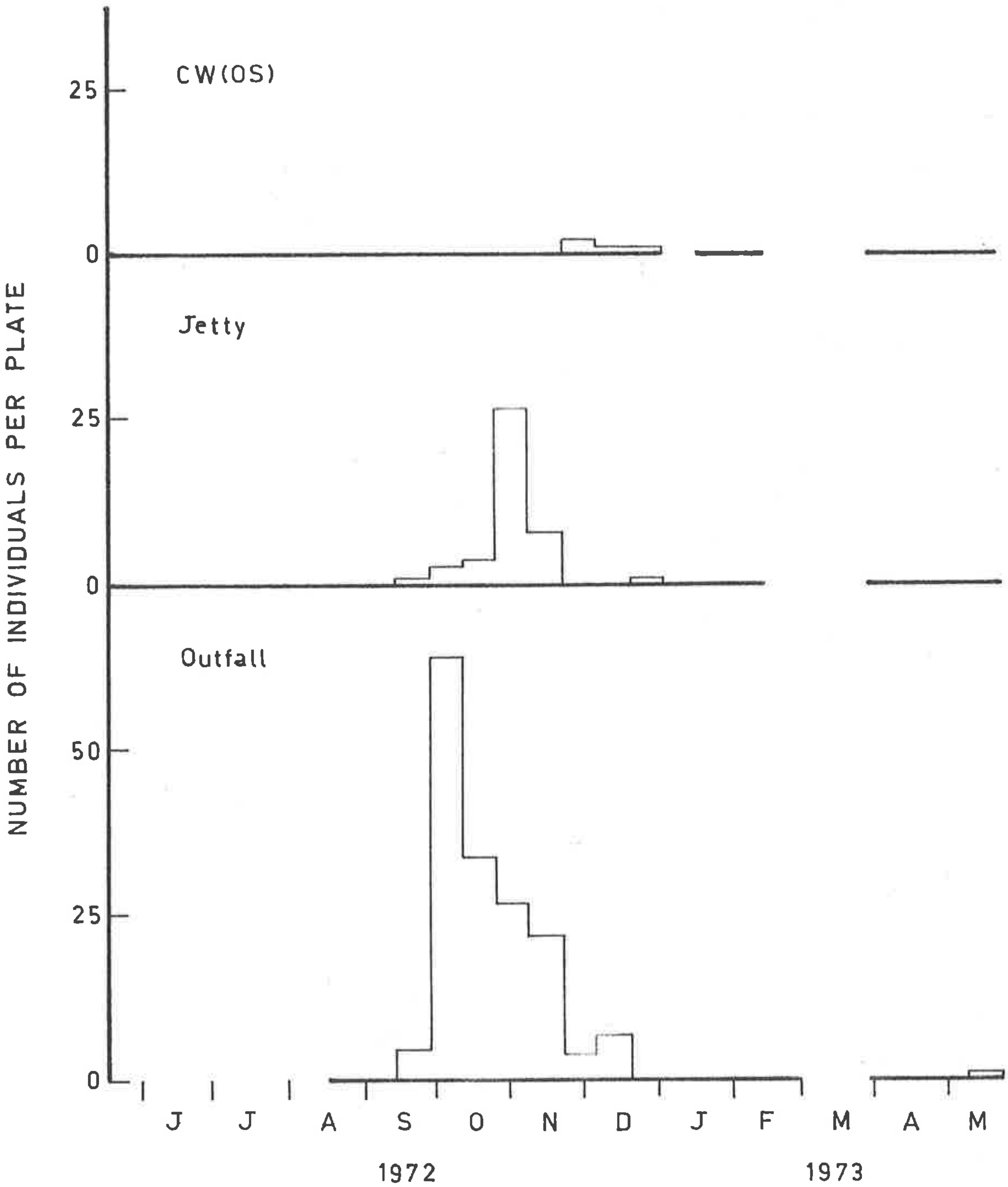

Fig. 4.74 Presence of a tube-dwelling crustacean (Tanaidacea: Tanaidae) on 2-week plates over the period from June, 1972 to May, 1973.

5. Discussion

The results have shown a consistent difference in weights of growth between the CW(OS) and CW(NS) stations. Greater weights of growth were observed at the CW(NS) station for all series of exposures. The greater weights were caused by the extreme abundance of three species at the CW(NS) station, namely the bryozoan *Zoobotryon verticillatum*, the hydroid *Tubularia* sp. and the unidentified tube-dwelling amphipod (sections B.4.2 (b), (c) and (r) respectively).

It would appear that these three species were strongly favoured by the turbulent water at the CW(NS) station. Kitching and Ebling (1967) discussed the advantages and difficulties to sessile animals in inhabiting areas which experience strong currents.

However, when we come to consider the results from all stations excluding the CW(NS) station, no consistent patterns emerged. For several analyses, the results showed significant differences between the CW(OS) station and the stations in Angas Inlet, with weights of growth being greater in Angas Inlet. This was the situation for the analyses for two-week plates covering the periods 30/8/72 - 4/7/73 and 21/11/74 - 13/2/75 and for four-week plates over the periods 13/9/72 - 3/1/73 and 24/4/73 - 26/9/73, the latter being for organic weights only. In none of the other analyses were significant differences that could be related to differences in temperature evident.

When a clean surface is allowed to stand in seawater, a film of bacteria soon builds up over the surface (Zobell, 1946). This film increases in thickness for at least a few days and imparts a slimy feel to the surface. The presence of this film may aid in inducing settlement of larvae of sessile animals on a clean surface (Crisp and Ryland, 1960). With increasing exposure, the slimy film entraps particles of detritus and silt and the film becomes muddy in appearance.

Frequently in this study, this muddy film together with some filamentous algae produced the major contribution to weights of growth on shorter term plates. Thus, the greater weights of growth observed in Angas Inlet for some two-week and four-week plates would appear to have been caused mainly by faster rates of growth of algae and of formation of the bacterial film. With increasing exposure of the plates the contribution by sessile animals to the weights of growth increased. At the same time, differences between stations in the amounts of growth became less marked. Thus, on eight-week plates no significant differences that could be attributed to differences in temperature were observed. Overall, temperature differences appeared to be of minor significance in relation to production of epifauna as measured by the total biomass.

We now come to consider the effects of temperature on individual species. It will be necessary to commence with some remarks on the significance that can be attached to the data. Amongst sessile animals, there is a wide variation between species in the length of time that the larvae may spend in the free-swimming stage before settlement and metamorphosis. In some species, the larvae settle within a few hours while in others, they spend at least several days in the free-swimming stage.

In this latter case, larvae may be dispersed considerable distances from their point of origin by the prevailing currents. As was discussed in section B.3., there is a circular current system from North Arm to Angas Inlet via the cooling water system of the power-station and from Angas Inlet to North Arm via Eastern Passage. Tidal currents are superimposed on this system and there is some interchange of water from Barker Inlet and the Port Adelaide River. It would be expected that larvae originating at any point in the Angas Inlet - North Arm system would be dispersed throughout this system within a few days, if they could survive the mechanical and thermal stresses they experience on passage through the cooling water system. Thus for species whose larvae have a long planktonic existence, differences in the rates of settlement between stations would reflect differences in the reactions of the larvae at the time of settlement. The presence or absence of differences in settlement rates need not be indicative of the presence or absence of long-term effects of temperature on the distribution and abundance of the species concerned. Seasonal differences in the timing of the breeding season may not be noted, even if they did exist.

However, when larvae spend only a short time in the free-swimming stage, most will be carried only a short distance before they settle. Thus, differences in rates of settlement between stations would reflect differences in abundance and /or fecundity of the populations adjacent to the stations. In addition, seasonal differences in the timing of the breeding season would be expected to be revealed if they did exist. Thus, for species whose larvae have only a short planktonic life, any differences in settlement rates should reflect the effect of differences in temperature on the distribution and abundance of these species.

Of the species in this study, larvae with a long planktonic life are characteristic of barnacles (Pyefinch, 1948), oysters (Loosanoff and Davis, 1963) and are part of the life cycle of the serpulid *Hydroides norvegica* (Wisely, 1958). Neither the barnacle *Balanus amphitrite* nor the oyster *Ostrea angasi* (sections B.4.2 (o) and (p) respectively) showed any consistent differences in rates of settlement between stations to suggest that the larvae were discriminating between different temperatures at the time of settlement. The larvae of *Hydroides norvegica* (section A.4.2 (n)) however, appeared to show a preference for settling under temperature regimes that are characteristic of normal summer conditions in North Arm.

Larvae with a short planktonic life are found in ascidians (Borradaile *et al.*, 1967), bryozoa (Ryland, 1967), *Tubularia* (Pyefinch and Downing, 1949), *Eulaeospira convexis* (Wisely, 1962) and *Loxosomella* (Borradaile *et al.*, 1967). It is uncertain in which class the unidentified sabellid should be placed. Of the other polychaetes in this study *Hydroides* produces larvae with a long planktonic life, while *Eulaeospira* is the reverse.

Several different types of distribution in relation to temperature and current were observed. Two species were strongly favoured by the turbulent water at the CW(NS) station, namely the bryozoan *Zoobotryon verticillatum* and the hydroid *Tubularia* sp. (sections B4.2 (b) and (c) respectively). Two species showed seasonal differences in abundance between Angas Inlet and North Arm but no differences in abundance: the compound ascidian *Leptoclinum rayneri* and the bryozoan *Watersipora subovoidea* (sections B 4.2 (a) and (e) respectively). The settlement season of these two species was observed at temperatures characteristic of the summer conditions in the North Arm.

Similar seasonal differences were observed for five other species, but for these species, some differences in abundance were present: the endoproct *Loxosomella kefersteini*, the bryozoans *Bugula avicularia* and *B. neritina* and the ascidians *Ciona intestinalis* and *Botrylloides nigrum* (sections B. 4.2 (d), (f), (g), (h) and (j) respectively. The significant feature of the differences in abundance was that each of these species was very rare at the Outfall station while being reasonably abundant at other locations in Angas Inlet. It was suggested (see especially section 4.2 (d)) that this type of distribution would result if individuals living in Angas Inlet, particularly near the cooling water outlet, were unable to survive during the summer when water temperatures reached high levels. Indeed, it may be that all of the individuals in Angas Inlet would be killed by the hot water during the summer but the species could then recolonize most of the decimated areas, during the cooler parts of the year.

Next, there are the species which show differences in abundance between Angas Inlet and North Arm. The ascidian *Botryllus schlosseri* (section B. 4.2 (i)) was adversely affected by the warmed water in Angas Inlet. In contrast, the serpulid *Eulaeospira convexis* and the ascidian *Microcosmus squamiger* (sections B. 4.2 (k) and (l) respectively) were strongly favoured by the warmed water. The unidentified sabellid (section B. 4.2 (m)) was also favoured by the warmed water but not to the same extent as *Eulacospira* and *Microcosmus*.

Finally, there are the three species of crustaceans that colonized the plates where they constructed tubes of mud. The unidentified amphipod (section B. 4.2 (r)) was extremely abundant at the CW(NS) station where it was favoured by the turbulent water. It was also adversely affected to a small extent by the warmed water in Angas Inlet. In its brief period of occurrence, the tanaid *Paratanais ignotus* (section B. 4.2 (s)) was favoured by the warmed water, while the warmed water had no effect on the abundance of the amphipod *Corophium* sp. (section B. 4.2 (q)).

Summarising the results, the heated water from the power station had little effect on the total production of the epifauna. However, a variety of effects on the species present were noted, with regard to both abundance and seasonal occurrence. When the positive effects of the warmed water on abundance are balanced against the negative effects, it would appear that there has been little damage inflicted on the epifaunal communities in Angas Inlet.

However, it is worth recalling the five species which showed seasonal differences in occurrence between Angas Inlet and North Arm and which were very rare at the Outfall Station. It was suggested that the water in Angas Inlet became too hot in summer to allow survival of these species, at least near the cooling water outlet and possibly, to a considerable distance from the outlet. Thus, depending on the extent of the hypothesised kills, the fact that these species were found in reasonable abundance in Angas Inlet may be due to the ability of the free-swimming larvae to recolonize previously decimated areas. Species without the same powers of dispersal would remain rare in Angas Inlet.

In conclusion, no overall harmful effects of heated water from the Torrens Island Power Station have been demonstrated. However, investigation of species with limited powers of dispersal may reveal some damage to the environment. In addition, the situation needs to be watched closely with the expected rise in temperatures in Angas Inlet as 'B' station begins operating in earnest. It would be expected that as the temperatures rise some of the species which are presently little affected in abundance may show a decline in numbers in Angas Inlet. In addition, species at present favoured by the warmed water may be favoured to lesser degrees.

NOTES ON IDENTIFICATION

Several persons helped with identification of the species found in this study. Identifications were provided by Miss L. M. Angel (Department of Zoology, University of Adelaide) : *Loxosomella kefersteini*, Dr. S. J. Edmonds (Marine Invertebrate Section, South Australian Museum) : annelids and *Ostrea angasi*, and Mr. B. J. Brock (Marine Invertebrate Section, South Australian Museum) : bryozoa, while Mr. W. Zeidler (Curator of Marine Invertebrates, South Australian Museum) helped with other species. Ascidians corresponded to the species described by Kott (1952, 1962, 1972). Specimens of the amphipods have been forwarded to Dr. J. L. Barnard (Department of Biological Sciences, University of Arizona, U.S.A.) but at the time of writing, identifications have not been received.

REFERENCES

Adams, J. R. (1969). Ecological observations around some thermal power stations in California tidal waters. *Chesapeake Sci.* 10, 145-154.

Allen, F. E. and Wood, E. J. F. (1950). Investigations on underwater fouling. II. The biology of fouling in Australia : results of a year's research. *Aust. J. mar. freshw. Res.* 1, 92-105.

Anderson, D. B. and Richards, B. R. (1966). Chlorination of sea water - effects on fouling and corrosion. *Trans. Amer. Soc. Mech. Eng.*, July 1966, 203-208.

Andrews, J. C. and Anderson, D. T. (1962). The development of the polychaete *Galeolaria caespitosa* Lamarck (fam. Serpulidae). *Proc. Linn. Soc. N.S.W.* 87, 185-188.

Ansell, A. D. (1963). *Venus mercenaria* (L) in Southampton Water. *Ecology* 44, 396-397.

Barnes, H., Crisp, D. J. and Powell, H. T. (1951). Observations on the orientation of some species of barnacles. *J. anim. Ecol.* 20, 227-241.

Barnes, H. and Reese, E. S. (1960). The behaviour of the stalked intertidal barnacle *Pollicipes polymerus* J. B. Sowerby, with special reference to its ecology and distribution. *J. anim. Ecol.* 29, 169-185.

Barnett, P. R. O. (1971). Some changes in intertidal sand communities due to thermal pollution. *Proc. R. Soc. Lond. B* 177, 353-364.

Barnett, P. R. O. (1972). Effects of warm water effluents from power stations on marine life. *Proc. R.Soc. Lond. B* 180, 497-509.

Barnett, P. R. O. and Hardy, B. L. S. (1969). The effects of temperature on the benthos near the Hunterston Generating Station, Scotland. *Chesapeake Sci.* 10, 255-256.

Bayne, B. L. (1964a). The gregarious behaviour of the larvae of *Ostrea edulis* L. at settlement. *J. mar. biol. Ass. U.K.* 49, 327-356.

Bayne, B. L. (1964b). Primary and secondary settlement in *Mytilus edulis* L. (Mollusca). *J. anim. Ecol.* 33, 513-523.

Bayne, B. L. (1964c). The responses of the larvae of *Mytilus edulis* L. to light and gravity. *Oikos* 15, 162-174.

de Blok, J. W. and Geelen, H. J. F. M. (1958). The substratum required for the settling of mussels (*Mytilus edulis* L.). *Arch Neerl. de Zool.* 13 (Suppl.1), 446-460.

Bohle, B. (1971). Settlement of mussel larvae *Mytilus edulis* on suspended collectors in Norwegian waters. Fourth European Marine Biology Symposium (D. J. Crisp ed.). Cambridge University Press, pp. 63-69.

Borradaile, L. A., Potts. F. A., Eastham, L. E. S. and Saunders, J. T. (1967). "The Invertebrata". Fourth edition revised by G. A. Kerkut. Cambridge University Press, Cambridge.

Brett, J. R. (1952). Temperature tolerance in the young Pacific salmon, genus *Oncorhynchus*. *J. Fish. Res. Bd. Can.* 9, 265-323.

Carpenter, E. J., Peck, B. B. and Anderson, S. J. (1974). Survival of copepods passing through a nuclear power station on northeastern Long Island Sound, U.S.A. *Mar. Biol.* 24, 49-55.

Clapp, W. F. (1950). Some biological fundamentals of marine fouling. *Trans. Amer. Soc. Mech. Eng.* 72, 101-107.

Clark, J. R. (1969). Thermal pollution and aquatic life. *Sci. Amer.* 220, (3), 19-27.

Cory, R. L. (1967). Epifauna of the Patuxent River estuary, Maryland, for 1963 and 1964. *Chesapeake Sci.* 8, 71-89.

Cory, R. L. and Nauman, J. W. (1969). Epifauna and thermal additions in the upper Patuxent River estuary. *Chesapeake Sci.* 10, 210-217.

Crisp, D. J. (1967). Chemical factors inducing settlement in *Crassostrea virginia* (Gmelin). *J. anim. Ecol.* 36, 329-355.

Crisp, D. J. and Barnes, H. (1954). The orientation and distribution of barnacles at settlement with particular reference to surface contour. *J. anim. Ecol.* 23, 142-162.

Crisp, D. J. and Ryland, J. S. (1960). Influence of filming and of surface texture on the settlement of marine organisms. *Nature, Lond.* 185, 119.

Crisp, D. J. and Meadows, P. S. (1962). The chemical basis of gregariousness in cirripedes. *Proc. R. Soc. Lond. B.* 156, 500-520.

Crisp, D. J. and Meadows, P. S. (1963). Adsorbed layers : the stimulus to settlement in barnacles. *Proc. R. Soc. Lond. B.* 158, 364-387.

Crisp, D. J. and Molesworth, A. H. N. (1951). Habitat of *Balanus amphitrite* var. *denticulata* in Britain. *Nature, Lond.* 167, 489-490.

Dobson, J. G. (1946). The control of fouling organisms in fresh and saltwater circuits. *Trans. Amer. Soc. Mech. Eng.* 68, 247-265.

Ebling, F. J., Kitching, J. A., Muntz, L. and Taylor, C. M. (1964). The ecology of Lough Ine. XIII. Experimental observations of the destruction of *Mytilus edulis* and *Nucella lapillus* by crabs. *J. anim. Ecol.* 33, 73-82.

Foster, B. A. (1969). Tolerance of high temperature by some intertidal barnacles. *Mar. Biol.* 4, 326-332.

Fry, F. E. J., Hart, J. S. and Walker, K. F. (1946). Lethal temperature relations for a sample of young speckled trout, *Salvelinus fontinalis*. *Univ. Toronto Stud. Biol. Ser. 54, Pub. Ont. Fish. Res. Lab. 49.*

Fuller, J. L. (1946). Season of attachment and growth of sedentary marine organisms at Lamoine, Maine. *Ecology* 27, 150-158.

Graham, H. W. and Gay, H. (1945). Season of attachment and growth of sedentary marine organisms at Oakland, *California*. *Ecology* 26, 375-386.

Hewatt, W. G. (1935). Ecological succession in the *Mytilus californianus* habitat as observed in Monterey Bay, California. *Ecology* 16, 244-251.

Hidu, H. (1969). Gregarious setting in the American oyster *Crassostrea virginia* Gmelin. *Chesapeake Sci.* 10, 85-92.

Holmes, N. (1970). Mussel fouling in chlorinated cooling systems. *Chem. & Ind.* Sept. 1970, 1244-1247.

James, W. G. (1967). Mussel fouling and use of exomotive chlorination *Chem. & Ind.* June 1967, 994-996.

Johannes, R. E. (1970). How to kill a coral reef - 1. *Marine Pollution Bulletin* 1 (NS), 186-187.

Kitching, J. A., Sloane, J. F. and Ebling, F. J. (1959). The ecology of Lough Ine. VII. Mussels and their predators. *J. anim. Ecol.* 28, 331-341.

Kitching, J. A. and Ebling, F. J. (1967). Ecological studies at Lough Ine. *Adv. ecol. Res.* 4, 197-291.

Knight-Jones, E. W. (1951). Gregariousness and some other aspects of the setting behaviour of *Spirorbis*. *J. mar. biol. Ass. U.K.* 30, 201-222.

Knight-Jones, E. W. (1953). Laboratory experiments on gregariousness during setting in *Balanus balanoides* and other barnacles. *J. exp. Biol.* 30, 584-598.

Knight-Jones, E. W. and Stevenson, J. P. (1950). Gregariousness during settlement in the barnacle *Elminius modestus* Darwin. *J. mar. biol. Ass. U.K.* 29, 281-297.

Kott, P. (1952). The ascidians of Australia. I. Stolidobranchiata Lahille and Phlebobranchiata Lahille. *Aust. J. mar. freshw. Res.* 3, 205-333.

Kott, P. (1962). The ascidians of Australia. III. Aplousobranchiata Lahille : Didemnidae Giard. *Aust. J. mar. freshw. Res.* 13, 265-334.

Kott, P. (1972). The ascidians of South Australia. I. Spencer Gulf, St. Vincent Gulf and Encounter Bay. *Trans. R. Soc. S. Aust.* 96, 1-52.

Loosanoff, V. L. and Davis, H. C. (1963). Rearing of bivalve molluscs. *Adv. mar. Biol.* 1, 1-136.

Markowski, S. (1959). The cooling water of power stations : a new factor in the environment of marine and freshwater invertebrates. *J. anim. Ecol.* 28, 243-258.

Markowski, S. (1960). Observations on the response of some benthonic organisms to power station cooling water. *J. anim. Ecol.* 28, 347-357.

Markowski, S. (1962). Faunistic and ecological investigations in Cavendish Dock, Barrow-in-Furness. *J. anim. Ecol.* 31, 43-51.

Meadows, P. S. (1969). Sublittoral fouling communities on northern coasts of Britain. *Hydrobiologia* 34, 273-294.

Mihursky, J. A. and Kennedy, V. S. (1967). Water temperature criteria to protect aquatic life. *Amer. Fish. Soc. Spec. Publ. No. 4*, 20-32.

Nauman, J. W. and Cory, R. L. (1969). Thermal additions and epifaunal organisms at Chalk Point, Maryland. *Chesapeake Sci.* 10, 218-226.

Naylor, E. (1965a). Effects of heated effluents upon marine and estuarine organisms. *Adv. mar. Biol.* 3, 63-103.

Naylor, E. (1965b). Biological effects of a heated effluent in docks at Swansea, S. Wates. *Proc. Zool. Soc. Lond.* 144, 253-268.

Pannell, J. P. M., Johnson, A. E. and Raymont, J. E. G. (1962). An investigation into the effects of warmed water from Marchwood Power Station into Southampton water. *Proc. Inst. Civ. Eng.* 23, 35-62.

Pulham, C. J. (date unknown). "Chlorination of condenser cooling water". Technical Publication S/155, Wallace and Tiernan, London.

Pyefinch, K. A. (1948). Notes on the biology of cirripedes. *J. mar. biol. Ass. U.K.* 27, 464-503.

Pyefinch, K. A. and Downing, F. S. (1949). Notes on the general biology of *Tubularia larynx* Ellis and Solander. *J. mar. biol. Ass. U.K.* 28, 21-44.

Raymont, J. E. G. (1972). Some aspects of pollution in Southampton Water. *Proc. R. Soc. Lond. B* 180, 451-468.

Roessler, M. A. (1971). Environmental changes associated with a Florida power plant. *Marine Pollution Bulletin* 2, 87-90.

Roosenburg, W. H. (1969). Greening and copper accumulation in the American oyster, *Crassostrea virginica*, in the vicinity of a steam electric generating station. *Chesapeake Sci.* 10, 241-252.

Ryland, J. S. (1967). Polyzoa. *Oceanogr. mar. biol. Ann. Rev.* 5, 343-369.

Scheer, B. T. (1945). The development of marine fouling communities, *Biol. Bull., Woods Hole* 89, 103-121.

Shaw, W. N. (1967). Seasonal fouling and oyster setting on asbestos plates in Broad Creek, Talbot County, Maryland, 1963-65. *Chesapeake Sci.* 8, 228-236.

Siegel, S. (1956). "Nonparametric statistics for the behavioural sciences". McGraw Hill, New York.

Sokal, R. R. and Rohlf, F. J. (1969). "Biometry. The principles and practice of statistics in biological research". W. H. Freeman & Co., San Francisco.

Sorge, E. V. (1969). The status of thermal discharges east of Mississippi River. *Chesapeake Sci.* 10, 131-138.

Thorson, G. (1964). Light as an ecological factor in the dispersal and settlement of larvae of marine bottom invertebrates. *Ophelia* 1, 167-208.

Walton Smith F. G. (1946). Effect of water currents upon the attachment and growth of barnacles. *Biol. Bull, Woods Hole* 90, 51-70.

Warinner, J. E. and Brehmer, M. L. (1966). The effects of thermal effluents on marine organisms. *Air Wat. Pollut. Int. J.* 10, 277-289.

Wisely, B. (1958). The development and settling of a serpulid worm, *Hydroides norvegica* Gunnerus (Polychaeta). *Aust. J. mar. freshw. Res.* 9, 351-361.

Wisely, B. (1959). Factors influencing the settling of the principal marine fouling organisms in Sydney Harbour. *Aust. J. mar. freshw. Res.* 10, 30-34.

Wisely, B. (1960). Observations on the settling behaviour of larvae of the tubeworm *Spirorbis borealis* Daudin (Polychaeta). *Aust. J. mar. freshw. Res.* 11, 55-72.

Wisely, B. (1962). Two Spirorbid tubeworms (Serpulidae, Polychaeta) from Eastern Australia. *Rec. Aust. Mus.* 25, 243-248.

Wisely, B. (1969). Preferential settlement in concavities (rugophilic behaviour) by larvae of the brachiopod *Waltonia inconspicua* (Sowerby, 1846). *N.Z. J. mar. freshw. Res.* 3, 273-280.

Wood, E. J. F. (1955). Effect of temperature and rate of flow on some marine fouling organisms. *Aust. J. Sci.* 18, 34-36.

Wood, E. J. F. and Allen, F. E. (1958). Common marine fouling organisms of Australian waters. Dept. of the Navy Publication, Melbourne, 23 pp.

Young, J. S. and Gibson, C. I. (1973). Effect of thermal effluent on migrating menhaden. *Marine Pollution Bulletin* 4, 94-95.

Zobell, C. E. (1946). "Marine Microbiology". Chronica Botanica Press, Waltham, Mass.

APPENDICES

LIST OF APPENDICES

List of Appendices, Section B (cont.)

APPENDICES

SECTION A : Control of fouling in the cooling water system.

Appendix 1. Weights of growth on plates from the experimental troughs.

(a) Weights of growth on 2-week plates.

Weights are listed in milligrams; for the controls, they are rounded to the nearest 10 milligrams.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
9/2/73	20	22	8	8	19	20	800	220
22/2	26	14	20	20	28	20	260	210
4/4	16	4	6	6	6	5	90	110
18/4	12	16	7	10	12	21	200	120
16/5	6	7	4	6	4	5	70	80
30/5	2	3	4	3	4	2	60	60
13/6	5	4	3	4	3	7	40	70
27/6	11	10	11	9	9	17	80	100
11/7	2	4	2	1	2	2	60	70
25/7	3	3	5	4	5	3	110	90
10/8	1	2	1	1	2	4	100	110
23/8	9	5	2	4	4	3	60	60
5/9	5	25	4	17	6	8	50	50
19/9	2	7	1	2	2	4	80	60
3/10	20	9	6	5	8	8	260	180
18/10	16	5	6	9	7	8	400	170

Appendix 1 (cont.)

(b) Weights of growth on four-week plates.

Weights are listed as milligrams; for the controls, they are rounded to the nearest 10 milligrams.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
8/2/73	52	11	6	16	14	9	770	850
22/2	48	18	32	28	28	24	510	740
22/3	116	12	34	29	47	22	730	680
18/4	34	29	10	8	11	9	130	360
2/5	27	16	11	13	10	20	110	180
16/5	22	12	12	6	6	4	60	120
30/5	12	10	6	8	9	8	100	160
13/6	23	14	12	17	16	26	90	60
27/6	10	10	9	8	9	5	160	80
11/7	10	7	4	6	6	8	60	70
26/7	5	6	4	6	7	3	110	80
10/8	5	4	3	3	4	7	110	50
23/8	10	14	7	9	10	24	160	100
6/9	14	58	21	63	19	15	210	310
21/9	16	22	7	27	11	16	370	200
4/10	29	20	11	13	18	8	480	570
18/10	20	10	6	14	5	4	970	520

Appendix 2. Total numbers of five species present on plates from the experimental troughs.

The species were the serpulid *Hydroides norvegica*, the barnacle *Balanus amphitrite*, the mud-mussel *Modiolus inconstans*, the oyster *Ostrea angasi* and the anenome *Anthothoë albocincta*.

(a) Total numbers present on glass plates exposed for two weeks.

Date of	Dose of chlorine (ppm)						Controls	
Examination	Intermittent	0.2	0.4	0.8	1.5	3.0	1	2
25/1/73	1	1	-	-	-	-	12	13
9/2	4	3	3	1	2	1	5	9
22/2	17	2	-	-	-	-	No data	
4/4	-	1	-	-	-	-	4	1
18/4	-	-	-	-	-	-	8	9
2/5 - 13/6	-	-	-	-	-	-	-	-
27/6	-	-	-	-	-	-	-	1
11/7	-	-	-	-	-	-	1	-
25/7 - 5/9	-	-	-	-	-	-	-	-
19/9	-	-	-	-	-	-	3	2
3/10	-	-	-	-	-	-	8	10
18/10	-	-	-	-	-	-	3	5

Appendix 2 (cont.)

(b) Total numbers present on glass plates exposed for four-weeks.

Date of	Dose of chlorine (ppm)						Controls	
Examination	Intermittent	0.2	0.4	0.8	1.5	3.0	1	2
8/2/73	40	7	8	5	2	1	48	30
22/2	28	6	3	1	-	1	80	72
22/3	24	10	1	1	-	-	61	No datum
18/4	10	4	-	-	-	-	11	13
2/5	2	2	-	-	-	-	19	25
16/5 - 30/5	-	-	-	-	-	-	-	-
13/6	2	-	-	-	-	-	-	1
27/6	-	-	-	-	-	-	1	-
11/7	-	-	-	-	-	-	-	-
26/7	-	-	-	-	-	-	1	-
10/8 - 6/9	-	-	-	-	-	-	-	-
21/9	-	1	-	-	-	-	4	10
4/10	-	2	1	-	-	-	30	28
18/10	1	2	3	-	-	-	25	48

Appendix 2 (cont.)

(c) Total numbers present on concrete-asbestos plates exposed for eight weeks.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0
26/3/73	162	22	15	9	-	-
9/4	80	21	8	8	2	-
19/4	20	10	1	2	-	-
22/5	10	-	-	-	-	-
1/6	8	-	-	-	-	-
15/6 - 27/7	-	-	-	-	-	-

Appendix 3. Numbers of the serpulid *Hydroides norvegica* present on plates from the experimental troughs.

(a) Numbers present on four-week glass plates.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
8/2/73	1	1	1	-	-	-	13	7
22/2	26	3	1	1	-	1	51	41
22/3	18	2	-	1	-	-	No data	
18/4	7	4	-	-	-	-	10	11
2/5	2	2	-	-	-	-	-	-
16/5 - 11/7	-	-	-	-	-	-	-	-
26/7	-	-	-	-	-	-	1	-
10/8 - 6/9	-	-	-	-	-	-	-	-
21/9	-	1	-	-	-	-	4	10
4/10	-	2	1	1	1	-	14	28
18/10	1	2	3	-	-	-	24	48

(b) Numbers present on eight-week concrete-asbestos plates.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0
26/3/73	122	4	2	-	-	-
9/4	52	3	-	-	-	-
19/4	14	1	-	-	-	-
22/5	8	-	-	-	-	-
1/6	8	-	-	-	-	-
15/6 - 27/7	-	-	-	-	-	-

Appendix 4. Presence of four comparatively rare species on the plates from the experimental troughs.

(a) The barnacle *Balanus amphitrite*.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
	(i) Four-week glass plates.							
8/2/73	7	6	6	5	2	1	32	14
22/2	1	3	2	-	-	-	14	31
22/3	5	7	1	-	-	-	11	No datum
18/4	-	-	-	-	-	-	1	-
2/5 - 18/10	-	-	-	-	-	-	-	-
	(ii) Eight-week concrete- asbestos plates.							
26/3/73	21	18	13	9	-	-		
9/4	12	18	8	8	2	-		
19/4	5	9	1	2	-	-		
22/5	1	-	-	-	-	-		
1/6 - 27/7	-	-	-	-	-	-		

Appendix 4 (cont.)

(b) The mud-mussel *Modiolus inconstans*.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
(i) Four-week glass plates.								
8/2/74	3	-	-	-	-	-	2	3
22/2	1	-	-	-	-	-	1	-
22/3	1	-	-	-	-	-	2	No datum
18/4	2	-	-	-	-	-	-	1
2/5	-	-	-	-	-	-	1	-
16/5	-	-	-	-	-	-	-	-
30/5	-	-	-	-	-	-	3	-
13/6	2	-	-	-	-	-	-	1
27/6	-	-	-	-	-	-	1	-
11/7 - 18/10	-	-	-	-	-	-	-	-
(ii) Eight-week concrete asbestos plates.								
26/3/73	17	-	-	-	-	-		
9/4	6	-	-	-	-	-		
19/4	1	-	-	-	-	-		
22/5 - 27/7	-	-	-	-	-	-		

Appendix 4 (cont.)

(c) The oyster *Ostrea angasi*.

On four-week plates, oysters were found on one date only : 8/2/73, one in each of intermittent and 0.2 ppm troughs.

On eight-week plates, oysters were again found on only one date : 26/3/73, 2 in intermittent trough.

(d) The anemone *Anthothoë albocincta*.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
(i) Four-week glass plates.								
8/2/73	28	-	-	-	-	-	1	5
22/2	-	1	-	-	-	-	14	-
22/3	-	-	-	-	-	-	14	No datum
18/4 - 21/9	-	-	-	-	-	-	-	-
4/10	-	-	-	-	-	-	16	-
18/10	-	-	-	-	-	-	-	-
(ii) Eight-week concrete-asbestos plates.								
26/3/73	-	-	-	-	-	-		
9/4	10	-	-	-	-	-		
19/4	-	-	-	-	-	-		
22/5	1	-	-	-	-	-		
1/6 - 27/7	-	-	-	-	-	-		

Appendix 5. Presence of the serpulid *Eulaeospira convexis* on plates from the experimental troughs.

(a) Two-week glass plates.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
25/1/73	-	-	-	-	-	-	6	21
9/2	1	1	1	-	-	-	7	94
22/2	2	4	-	-	-	-	No data	
4/4	-	-	-	-	-	-	23	78
18/4	2	-	-	-	-	-	20	49
2/5	-	-	-	-	-	-	7	14
16/5	-	-	-	-	-	-	3	8
30/5	-	-	-	-	-	-	-	8
13/6	-	-	-	-	-	-	2	7
27/6	-	-	-	-	-	-	1	-
11/7	-	-	-	-	-	-	-	-
25/7	-	-	-	-	-	-	-	3
10/8	-	-	-	-	-	-	-	9
23/8	1	-	-	-	-	-	2	3
5/9	4	-	-	-	-	-	5	13
19/9	-	-	-	-	-	-	2	14
3/10	-	-	-	-	-	-	5	19
18/10	-	-	-	-	-	-	2	3

Appendix 5 (cont.)

(b) Four-week glass plates.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0	Controls 1	2
8/2/73	3	-	-	-	-	-	35	86
22/2	5	4	-	-	-	-	44	155
22/3	30	-	-	-	-	-	97	No datum
18/4	16	-	-	-	-	-	31	66
2/5	1	-	-	-	-	-	28	32
16/5	4	-	-	-	-	-	15	100
30/5	2	-	-	-	-	-	11	21
13/6	3	-	-	-	-	-	12	41
27/6	-	-	-	-	-	-	-	17
11/7	3	-	-	-	-	-	3	5
26/7	-	-	-	-	-	-	3	5
10/8	1	-	-	-	-	-	3	5
23/8	-	-	-	-	-	-	7	22
6/9	2	-	-	-	-	-	7	5
21/9	8	-	-	-	-	-	4	11
4/10	-	-	-	-	-	-	4	7
18/10	1	1	-	-	-	-	4	52

Appendix 5 (cont.)

(c) Eight-week concrete-asbestos plates.

Date of	Dose of chlorine (ppm)					
Examination	Intermittent	0.2	0.4	0.8	1.5	3.0
26/3/73	70	2	-	-	-	-
9/4	13	-	-	-	-	-
19/4	3	-	-	-	-	-
22/5	3	-	-	-	-	-
1/6	-	-	-	-	-	-
15/6	1	-	-	-	-	-
27/7	-	-	-	-	-	-

Appendix 6. Numbers of six species present on eight-week glass plates sampled in early 1974.

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0
(a) *Hydroides norvegica.*						
24/1/74	22	4	-	-	-	-
7/2	33	19	-	-	-	-
7/3	28	5	-	-	-	-
(b) *Balanus amphitrite.*						
24/1	3	1	2	1	-	-
7/2	4	10	-	1	-	-
7/3	2	1	-	-	-	-
(c) *Modiolus inconstans.*						
24/1	24	-	-	-	-	-
7/2	8	-	-	-	-	-
7/3	11	-	-	-	-	-
(d) *Ostrea angasi.*						
24/1	1	-	-	-	-	-
7/2	2	-	-	-	-	-
7/3	-	-	-	-	-	-

Appendix 6 (cont.)

Date of Examination	Dose of chlorine (ppm) Intermittent	0.2	0.4	0.8	1.5	3.0
(e) *Anthothoë albocincta.*						
24/1	19	-	-	-	-	-
7/2	19	-	-	-	-	-
7/3	99	-	-	-	-	-
(f) *Eulaeospira convexis.*						
24/1	47	6	-	-	-	-
7/2	420	6	-	-	-	-
7/3	32	-	-	-	-	-

SECTION B : Thermal effluent and epifauna.

Appendix 1. (a) Weights of growth on two-week plates from 6 locations, 2 in North Arm and 4 in Angas Inlet.

(i) Total weights (listed in grams).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72	0.02			0.33	
16/6	0.02			0.32	
30/6	0.02			0.12	
13/7	0.02			0.05	
27/7	0.03			0.10	
16/8	0.02			0.05	
30/8	0.13		0.29	0.29	
13/9	0.20		0.20	0.28	
27/9	0.10		0.25	0.24	
11/10	0.09		0.26	0.39	
25/10	0.32		0.45	0.32	
8/11	0.14		2.15	0.38	
22/11	0.25		0.42	0.23	
6/12	0.22		0.41	0.96	0.32
20/12	0.19		0.97	0.46	0.35
3/1/73	0.15		0.96	0.58	1.16
17/1	No datum		0.45	0.21	0.71
31/1	0.16	0.76	0.67	0.19	0.69
14/2	0.52	1.04	0.41	0.25	0.10
28/2	No datum	No datum	0.09	No datum	0.50
14/3 - 28/3	No data				
11/4	0.06	0.08	0.20	0.19	0.17

Appendix 1. (a) (i) (cont.).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
26/4/73	0.06	0.09	0.09	0.08	0.16	
10/5	0.03	0.10	0.12	0.03	0.11	
23/5	0.02	0.12	0.03	0.04	0.13	
6/6	0.03	0.08	0.05	0.03	0.08	
20/6	0.04	No datum	0.03	0.03	0.06	
4/7	0.03	0.03	0.07	0.09	0.04	
18/7	0.03	0.02	0.09	0.07	0.06	0.06
1/8	0.06	0.01	0.05	0.05	0.07	0.04
15/8	0.02	0.02	0.06	0.03	0.06	0.03
29/8	0.08	0.06	0.06	0.11	0.09	0.09
12/9	0.02	0.03	0.03	0.06	0.09	0.25
26/9	0.14	0.14	0.05	0.06	0.14	0.12
10/10	0.22	0.72	0.23	0.31	0.22	0.17
24/10	0.21	1.15	0.51	0.26	0.41	0.21
7/11	0.27	0.58	0.63	0.56	0.49	0.31
22/11	0.70	0.94	0.90	0.56	2.36	0.67
5/12	1.59	2.71	0.88	0.33	0.38	0.69
19/12	0.86	3.16	0.31	0.28	0.12	1.16
3/1/74	0.57	0.90	0.61	0.23	0.09	0.32
16/1	0.35	1.14	0.49	0.23	0.17	0.46
31/1	0.29	0.55	0.49	0.25	0.43	0.23
13/2	0.40	1.10	0.27	0.37	0.10	0.14
27/2	0.89	1.76	0.51	0.75	0.34	0.22
13/3	0.28	1.57	0.12	0.32	0.21	0.13
27/3	0.08	2.81	0.30	0.27	0.40	0.06
10/4	0.04	No datum	0.04	0.06	0.03	0.03
24/4	0.05	No datum	0.05	0.06	0.06	0.04
8/5	0.03	0.14	0.05	0.02	No datum	0.02

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
22/5/73	0.04	0.12	0.07	0.02	No	data
7/6/74	0.09	0.20				
21/6	0.04	0.02				
5/7	0.03	0.02				
19/7	0.04	0.05				
2/8	0.03	0.16				
16/8	No datum	No datum				
30/8	0.16	0.23				
12/9	0.30	0.08				
26/9	0.17	0.95				
10/10	0.39	0.74				
24/10	0.34	0.88				
7/11	0.20	0.79				
21/11	0.17	0.61		0.83		
5/12	0.31	1.43		1.31		
19/12	0.41	3.11		1.33		
2/1/75	0.31	No datum		No datum		
16/1	0.27	No datum		0.45		
30/1	No datum	No datum		No datum		
13/2	0.21	No datum	0.35	0.48		
27/2	0.10	No datum	0.37	No datum		

Appendix 1 (a) (cont.)

(ii) Organic weights (data listed in milligrams).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
30/8/72	36		57	87		
13/9	28		59	61		
27/9	31		68	84		
11/10	18		82	113		
25/10	68		226	96		
8/11	24		464	101		
22/11	59		184	92		
6/12	61		136	427	104	
20/12	44		312	159	140	
3/1/73	60		299	207	647	
17/1	No datum		178	119	436	
31/1	55	222	176	61	282	
14/2	181	313	124	85	34	
28/2	No datum	No datum	27	No datum	185	
14/3 - 28/3	No data					
11/4	24	23	63	60	51	
26/4	16	20	29	30	58	
10/5	6	25	65	9	46	
23/5	8	46	6	9	45	
6/6	11	31	8	3	25	
20/6	14	No datum	11	10	20	
4/7	5	5	15	21	8	
18/7	7	2	20	15	14	18
1/8	15	2	8	10	18	5
15/8	6	9	17	7	17	7
29/8	19	33	18	28	26	24

Appendix 1 (a) (ii) cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
12/9/73	6	9	10	15	31	53
26/9	49	63	20	19	62	48
10/10	61	294	67	89	93	60
24/10	72	479	149	69	88	90
7/11	66	225	222	137	171	124
22/11	191	269	217	195	528	153
5/12	412	719	284	120	107	189
19/12	257	1017	128	97	42	353
3/1/74	183	202	168	92	33	120
16/1	147	297	127	47	54	115
31/1	74	168	164	74	115	55
13/2	145	413	105	109	44	22
27/2	263	624	163	186	95	61
13/3	75	539	46	113	71	45
27/3	26	916	93	94	151	19
10/4	19	No datum	18	18	12	9
24/4	10	No datum	28	25	19	12
8/5	10	84	12	5	No datum	6
22/5	13	41	16	6	No data	
7/6	19	49				
21/6	No data					
5/7	8	7				
19/7	12	18				
2/8	11	81				
16/8	No data					
30/8	33	90				
12/9	81	37				

Appendix 1 (a) (ii) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty
26/9/74	40	346		
10/10	113	215		
24/10	97	435		
7/11	61	375		
21/11	60	345		231
5/12	94	738		332
19/12	146	1289		323
2/1/75	No datum	No datum		No datum
16/1	78	No datum		112
30/1	No datum	No datum		No datum
13/2	49	No datum	94	144
27/2	34	No datum	128	No datum

Appendix 1 (cont.)

(b) Weights of growth on four-week plates from 6 locations, 2 in North Arm and 4 in Angas Inlet.

(i) Total weights (listed in grams).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R
16/6/72	0.15			0.74	
30/6	0.13			0.42	
13/7	0.06			0.18	
27/7	0.06			0.26	
23/8	0.08			0.30	
30/8	0.34			0.29	
13/9	0.48		0.50	0.76	
27/9	0.61		0.67	0.38	
11/10	0.50		0.41	1.01	
25/10	1.02		0.55	0.79	
8/11	0.37		1.42	1.16	
22/11	0.90		1.56	1.76	
6/12	1.55		2.26	1.81	
20/12	0.83		11.44	1.45	3.98
3/1/73	1.61		6.17	2.64	2.54
17/1	No datum		4.05	1.67	0.93
31/1	No datum		2.15	0.82	0.62
14/2	1.28	5.60	1.40	0.59	0.43
28/2	No datum	No datum	0.96	No datum	No datum
14/3	No data				
28/3	No datum	No datum	0.83	No datum	0.58
11/4	No data				
26/4	0.09	0.14	0.56	0.14	0.28

Appendix 1 (b) (i) cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/5/73	0.10	0.20	0.22	0.17	0.27	
23/5	0.06	0.38	0.18	0.14	0.26	
6/6	0.07	0.36	0.12	0.12	0.13	
20/6	0.15	No datum	0.15	0.08	0.09	
4/7	0.12	No datum	0.16	No datum	0.14	
18/7	0.15	0.03	0.25	0.09	0.16	
1/8	0.22	0.11	0.18	0.15	0.15	0.21
15/8	0.16	0.13	0.14	0.13	0.11	0.11
29/8	0.22	0.13	0.31	0.37	0.15	0.39
12/9	0.24	0.59	0.26	0.22	0.18	No datum
26/9	0.19	1.10	0.19	0.28	0.20	No datum
10/10	0.42	2.17	0.81	1.30	0.90	0.52
24/10	0.57	No datum	1.54	2.05	1.16	0.70
7/11	1.39	4.15	1.20	2.77	1.88	1.23
22/11	3.03	2.99	3.43	2.93	1.17	2.52
5/12	5.56	6.40	3.53	1.63	4.96	2.91
19/12	1.77	14.15	1.05	1.49	1.64	1.85
3/1/74	2.89	0.56	1.63	2.12	2.02	4.40
16/1	1.35	1.70	1.87	1.77	1.33	1.60
31/1	1.42	1.65	1.32	1.20	0.85	1.29
13/2	3.22	6.53	1.45	2.46	1.76	2.26
27/2	3.17	2.03	1.89	2.68	0.57	2.42
13/3	5.28	9.75	1.98	2.91	1.38	1.89
27/3	2.40	7.24	1.56	1.95	0.30	1.06
10/4	1.50	No datum	1.13	No datum	0.46	0.40
24/4	0.47	0.58	0.34	0.42	0.17	0.12
8/5	0.15	No datum	0.15	0.14	No datum	0.08
22/5	0.12	No datum	0.17	0.09	No datum	No datum

Appendix 1 (b) (i) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty
7/6/74	0.27	No datum		
21/6	0.29	No datum		
5/7	0.19	0.48		
19/7	0.18	0.08		
2/8	0.11	1.34		
16/8	No data			
30/8	0.43	2.0		
12/9	1.33	5.3		
26/9	0.89	No datum		
10/10	0.73	2.30		
24/10	0.71	6.88		
7/11	0.70	3.1		
21/11	0.71	4.06		
5/12	0.94	4.17		4.38
19/12	3.98	15.9		4.87
2/1/75	8.97	No datum		12.00
16/1	2.03	No datum	1.43	2.18
30/1	No data			
13/2	1.23	No datum	1.55	1.61
27/2	2.92	No datum	1.18	No datum

Appendix 1 (b) (cont.)

(ii) Organic weights (listed in milligrams).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
30/8/72	81			87		
13/9	233		103	179		
27/9	136		173	138		
11/10	116		123	288		
25/10	216		303	214		
8/11	62		778	816		
22/11	226		928	1071		
6/12	338		1224	671		
20/12	235		1800	724	740	
3/1/73	453		1181	590	1244	
17/1	No datum		867	479	568	
31/1	No datum		405	218	306	
14/2	423	423	430	85	110	
28/2	No datum	No datum	303	No datum	No datum	
14/3	No	data				
28/3	No datum	No datum	185	No datum	196	
11/4	No	data				
26/4	26	40	200	54	78	
10/5	24	57	59	49	93	
23/5	18	125	54	46	76	
6/6	14	115	23	32	42	
20/6	44	No datum	47	29	34	
4/7	21	No datum	48	No datum	45	
18/7	39	6	59	26	45	
1/8	68	41	43	40	34	54
15/8	45	67	35	35	27	29

Appendix 1 (b) (ii) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
29/8/73	60	46	98	92	52	91
12/9	65	273	78	51	52	No datum
26/9	63	454	67	70	84	No datum
10/10	118	708	245	275	210	139
24/10	172	No datum	327	429	351	176
7/11	335	1261	429	588	566	313
22/11	566	798	612	702	385	569
5/12	1378	1650	824	363	1089	720
19/12	485	3247	580	569	330	353
3/1/74	685	169	507	673	506	1690
16/1	668	339	412	336	222	567
31/1	391	576	422	320	174	300
13/2	570	1693	333	634	411	387
27/2	713	1020	422	600	158	311
13/3	1134	1852	343	663	330	392
27/3	418	1804	419	457	131	181
10/4	240	No datum	240	No datum	120	86
24/4	114	201	97	101	48	41
8/5	43	No datum	51	72	No datum	27
22/5	32	No datum	46	17	No datum	No datum
7/6	83	No datum				
21/6	No datum	No datum				
5/7	56	292				
19/7	55	27				
2/8	43	710				
16/8	No data					
30/8	98	900				
12/9	338	2300				

Appendix 1 (b) (ii) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty
26/9/74	241	No datum		
10/10	224	790		
24/10	193	2440		
7/11	223	1200		
21/11	225	1790		
5/12	313	2280		944
19/12	506	5200		979
2/1/75	No datum	No datum		No datum
16/1	525	No datum	469	689
30/1		No data		
13/2	328	No datum	359	394
28/2	752	No datum	254	

Appendix 1 (cont.)

(c) Weights of growth on eight-week plates from 6 locations, 2 in North Arm and 4 in Angas Inlet.

(i) Total weights (listed in grams).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R
7/9/72	0.94			0.32	
27/9	1.04			0.77	
11/10	2.60		1.19	1.91	
25/10	1.83		1.06	1.24	
8/11	0.63		1.67	2.71	
22/11	4.33		2.03	2.70	
6/12	7.13		1.47	1.72	
20/12	3.75		1.01	1.74	
3/1/73	8.97		11.29	2.10	
17/1	No datum		19.89	5.62	7.76
31/1	No datum		40.3	9.53	No datum
14/2	No datum		19.78	9.13	0.91
28/2	No datum		2.58	No datum	3.47
14/3		No data			
28/3	8.18		1.40	6.16	2.98
11/4	5.51		1.57	2.67	4.84
26/4	No datum		4.24	No datum	2.95
10/5		No data			
23/5	0.27	0.63	1.01	1.17	0.67
6/6	0.35	No datum	0.32	0.66	0.77
20/6	0.34	No datum	0.21	0.32	0.25
4/7	No datum	No datum	0.18	No datum	0.26
18/7	No datum	No datum	0.18	0.16	0.31
1/8	0.33	No datum	0.28	0.20	0.29

Appendix 1 (c) (i) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
15/8/73	0.27	1.62	0.33	0.18	0.20	
29/8	0.35	1.02	0.47	0.42	0.20	0.51
12/9	0.53	1.88	0.92	0.91	3.74	No datum
26/9	0.36	8.32	0.76	0.54	0.36	No datum
10/10	0.89	20.55	2.01	3.07	1.34	No datum
24/10		No data				
7/11	4.70	8.59	4.90	10.73	3.67	4.85
22/11	17.57	16.53	11.30	15.16	2.74	16.38
5/12	14.71	28.00	7.09	10.04	4.59	18.03
19/12	9.82	40.21	4.71	10.80	12.13	26.42
3/1/74	8.31	14.88	5.67	8.54	18.15	3.52
16/1	12.84	8.03	6.18	5.02	No datum	5.79
31/1	13.25	7.85	14.02	6.80	19.22	25.67
13/2	11.96	12.19	9.39	14.12	9.89	15.59
27/2	13.41	16.36	7.00	14.50	15.47	14.54
13/3	19.15	37.12	9.28	15.40	6.39	5.99
27/3	17.24	21.93	6.53	16.05	3.65	6.18
10/4	15.31	No datum	8.81	6.52	9.73	6.28
24/4	7.88	5.23	7.11	3.60	3.75	3.36
8/5	4.90	7.00	3.97	1.30	No datum	2.94
22/5	1.87	No datum	1.84	1.24	No datum	No datum
7/6	1.10	No datum				
21/6 - 5/7	No data					
19/7	0.38	No datum				
2/8	0.24	4.40				
16/8	No data					
30/8	0.86	10.5				

Appendix 1 (c) (i) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty
12/9/74	1.90	14.7		
26/9	2.92	4.8		
10/10	1.76	No datum		
24/10	1.66	10.8		
7/11	1.36	48.2		
21/11	1.54	141.8		
5/12	10.30	54.7		
19/12	27.9	44.1		
2/1/75	38.1	No datum		28.3
16/1	42.1	No datum		28.9
30/1	No data			
13/2	10.0	No datum	6.2	6.7

Appendix 1 (c) (cont.)

(ii) Organic weights (listed in grams).

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	0.25			0.14		
27/9	0.26			0.27		
11/10	0.41		0.60	0.50		
25/10	0.49		0.45	0.39		
8/11	0.17		0.96	1.15		
22/11	0.83		1.28	1.46		
6/12	1.57		0.81	1.01		
20/12	0.94		0.52	1.04		
3/1/73	2.53		2.01	1.24		
17/1	No datum		1.77	1.45	1.13	
31/1	No datum		5.12	1.32	No datum	
14/2	No datum		2.62	1.66	0.20	
28/2	No datum		0.69	No datum	0.46	
14/3		No data				
28/3	1.56		0.26	0.61	0.34	
11/4	1.24		0.37	0.71	0.71	
26/4	No datum		0.87	No datum	0.24	
10/5		No data				
23/5	0.09	0.19	0.52	0.33	0.23	
6/6	0.07	No datum	0.10	0.19	0.34	
20/6	0.09	No datum	0.07	0.12	0.08	
4/7	No datum	No datum	0.05	No datum	0.08	
18/7	No datum	No datum	0.05	0.06	0.09	
1/8	0.10	No datum	0.07	0.06	0.07	
15/8	0.09	0.84	0.09	0.05	0.06	
29/8	0.11	0.36	0.14	0.12	0.06	0.51

Appendix 1 (c) (ii) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
12/9/73	0.14	0.70	0.25	0.22	1.94	No datum
26/9	0.12	3.09	0.21	0.15	0.13	No datum
10/10	0.23	5.89	0.44	0.07	0.34	No datum
24/10		No data				
7/11	1.36	2.05	1.02	2.12	1.21	1.55
22/11	3.27	4.14	1.81	3.11	0.84	2.49
5/12	3.07	6.46	1.47	1.99	1.05	3.66
19/12	2.19	10.39	1.31	1.82	1.78	4.44
31/1/74	1.49	3.98	1.46	2.28	2.73	1.20
16/1	2.21	2.14	1.28	1.21	No datum	1.95
31/1	2.06	1.81	3.61	2.26	3.86	3.27
13/2	2.07	1.96	2.43	3.51	1.51	4.03
27/2	2.68	3.15	2.43	3.95	1.92	2.25
13/3	2.75	6.77	2.49	3.26	0.84	0.98
27/3	2.07	4.04	1.20	3.05	0.53	1.10
10/4	2.48	No datum	1.17	1.22	1.28	0.99
24/4	1.13	1.15	0.86	0.64	0.53	0.52
8/5	1.24	2.57	0.62	0.45	No datum	0.56
22/5	0.34	No datum	0.24	0.31	No data	
7/6	0.29	No datum				
21/6 - 5/7	No data					
19/7	0.13	No datum				
2/8	0.08	2.07				
16/8	No data					
30/8	0.23	6.5				
12/9	0.53	5.2				
26/9	0.78	2.0				

Appendix 1 (c) (ii) (cont.)

Date	CW(OS)	CW(NS)	Outfall	Jetty
10/10/74	0.49	No datum		
24/10	0.46	4.25		
7/11	0.37	15.6		
21/11	0.58	36.5		
5/12	2.41	18.9		
19/12	5.1	13.1		
2/1/75	No data			No datum
16/1	5.2	No datum		2.6
30/1	No data			
13/2	1.8	No datum	1.2	1.4

Appendix 2. Presence of the compound ascidian *Leptoclinum rayneri* on plates from six locations, two in North Arm and four in Angas Inlet. Abundance is shown as the percentage of the plate covered by the ascidian.

x denotes that a small amount was present.

(a) Two-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	3OR
2/6/72 - 13/7/72	-			-	
27/7	-			x	
10/8	-			-	
16/8	-			x	
30/8	-		x	x	
13/9	-		x	x	
27/9	x		x	1	
11/10	x		2	x	
25/10	1		5	1	
8/11	-		66	6	
22/11	1		19	15	
6/12	x		13	59	2
20/12	2		6	10	22
3/1/73	7		x	18	83
17/1	No datum		-	9	77
31/1	x	1	x	-	60
14/2	37	29	x	-	-
28/2	No datum	No datum	-	No datum	2
14/3 - 28/3	No data				
11/4	2	-	-	-	-
26/4	-	-	-	-	3

Appendix 2 (a) (cont.)

Date of Examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/5/73	-	-	19	-	5	
23/5/73	-	-	2	-	4	
6/6	-	-	2	-	1	
20/6	-	No datum	-	-	1	
4/7	-	-	1	-	-	
18/7	-	-	-	-	x	-
1/8	-	-	-	-	x	-
15/8	-	-	x	-	x	-
29/8	-	-	-	-	-	-
12/9	-	-	-	-	x	-
26/9	-	-	-	-	1	-
10/10	-	-	1	x	1	x
24/10	-	-	1	x	2	-
7/11	-	-	6	2	2	x
22/11	x	-	22	34	10	x
5/12	x	1	21	26	x	x
19/12	6	x	19	10	x	-
3/1/74	9	-	7	-	x	x
16/1	32	1	-	-	6	2
31/1	4	-	-	-	-	-
13/2	16	-	-	-	1	-
27/2	27	-	-	-	-	-
13/3	x	-	-	-	-	-
27/3	x	x	-	x	-	-
10/4	1	No datum	-	-	-	x
24/4	1	No datum	-	-	x	-
8/5	x	-	-	-	No datum	x

Appendix 2 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
22/5	1	x	-	-	No data	
7/6/74 - 26/9/74	-	-				
10/10	x	-				
24/10	-	-				
7/11	1	-				
21/11	1	-		3		
5/12	x	-		x		
19/12	1	-		4		
2/1/75	1	No datum		5		
16/1	4	No datum	4	3		
30/1	2	No datum	x	x		
13/2	-	No datum	-	-		
27/2	3	No datum	-	No datum		

Appendix 2 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
16/6/72-30/6/72	-			-	
13/7	-			x	
27/7	-			x	
10/8	-			x	
23/8	x			x	
30/8	x			x	
13/9	1		x	x	
27/9	1		6	1	
11/10	x		11	3	
25/10	x		24	11	
8/11	x		80	74	
22/11	3		100	100	
6/12	2		98	78	
20/12	1		39	75	33
3/1/73	24		-	21	100
17/1	No datum		1	20	97
31/1	No datum		-	-	75
14/2	66	58	x	-	-
28/2-14/3		No data			
28/3	No datum	No datum	-	No datum	-
11/4		No data			
26/4	-	-	40	-	2
10/5	-	-	5	-	19
23/5	-	-	12	-	7
6/6	-	-	5	-	3

Appendix 2 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
20/6/73	-	No datum	-	-	2	
4/7/73	-	No datum	-	No datum	1	
18/7	-	-	x	-	-	
1/8	-	-	-	-	-	-
15/8	-	-	-	-	1	-
29/8	-	-	x	-	x	-
12/9	-	-	-	x	x	No datum
26/9	-	-	x	-	x	No datum
10/10	-	-	x	x	6	-
24/10	-	No datum	x	1	5	-
7/11	x	-	12	6	13	2
22/11	2	-	30	16	6	13
5/12	2	1	47	8	51	9
19/12	2	x	44	59	10	6
3/1/74	67	10	29	46	25	6
16/1	29	2	13	2	-	62
31/1	50	10	-	-	2	-
13/2	14	2	-	-	2	-
27/2	44	-	-	-	-	-
13/3	45	-	-	-	-	-
27/3	18	-	-	-	x	-
10/4	2	No datum	x	No datum	-	-
24/4	11	-	-	x	x	-
8/5	x	No datum	-	-	No datum	x
22/5	2	No datum	x	-	No data	
7/6	x	-				

Appendix 2 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
21/6/74-2/8/74	-	-		
16/8	x	-		
30/8-12/9	-	-		
26/9	x	-		
10/10	x	-		
24/10	x	-		
7/11	2	-		
21/11	x	-		
5/12	x	-		3
19/12	5	-		64
2/1/75	10	No datum		65
16/1	62	No datum	11	20
30/1	5	No datum	No datum	22
13/2	30	No datum	-	-
27/2	17	No datum	-	No datum

Appendix 2 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	1			x		
27/9	6			3		
11/10	16		38	10		
25/10	10		64	33		
8/11	1		96	50		
22/11	3		100	98		
6/12	x		100	100		
20/12	2		75	100		
3/1/73	12		x	98		
17/1	No datum		3	36	52	
31/1-28/2	-		-	-	-	
14/3	No data					
28/3	-		1	-	-	
11/4	2		-	-	-	
26/4	No datum		37	No datum	4	
10/5	No data					
23/5	1	1	100	-	39	
6/6	-	No datum	19	2	61	
20/6	1	No datum	3	-	4	
4/7	-	No datum	1	No datum	2	
18/7	No datum	No datum	x	x	x	
1/8	-	No datum	-	-	x	
15/8	-	-	1	-	x	
29/8	-	-	x	x	3	-
12/9	-	-	x	x	-	No datum

Appendix 2 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
26/9/73	-	-	x	x	5	No datum
10/10	-	-	3	1	11	No datum
24/10	x	-	1	12	20	No datum
7/11	x	2	31	15	22	x
22/11	1	-	45	51	48	14
5/12	5	3	62	58	16	1
19/12	21	3	6	24	81	94
3/1/74	48	18	85	88	97	-
16/1	22	18	6	1	No datum	56
31/1	50	93	-	-	11	100
13/2	7	48	-	-	74	72
27/2	30	28	-	-	-	-
13/3	26	-	-	-	1	41
27/3	12	-	-	-	-	-
10/4	10	No datum	-	x	-	-
24/4	28	-	-	-	-	-
8/5	x	-	-	-	No datum	-
22/5	10	No datum	-	1	No datum	No datum
7/6-30/8	-	-				
12/9	x	-				
26/9	1	-				
10/10	2	No datum				
24/10	1	-				
7/11	10	-				
21/11	33	-				
5/12-19/12	-	-				

Appendix 2 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
2/1/75	24	No datum		88
16/1	53	No datum		64
30/1	26			93
13/2	95		-	21

Appendix 3. Presence of the hydroid *Tubularia* sp. on two-week plates from six locations, two in North Arm and four in Angas Inlet. On those occasions where the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual number of settlements is show in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72	1			11	
16/6	-			9	
30/6	-			8	
13/7	-			19	
27/7	-			1	
10/8	1			5	
16/8	-			5	
30/8	-		3	4	
13/9	-		9	9	
27/9	2		45	7	
11/10	-		-	11	
25/10	-		21 (20)	6	
8/11	1		18 (6)	18 (17)	
22/11	1		30 (24)	19 (16)	
6/12	1		6	10 (4)	-
20/12	-		-	-	-
3/1/73-17/1/73	-	-	-	-	-
14/2	-	14	-	-	-
28/2	-	-	-	-	-
14/3-28/3		No data			
11/4	-	-	1	-	-
26/4	-	-	-	-	1
10/5/73	-	-	2	-	-

Appendix 3 (cont.)

Date of Examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
23/5/73	-	56	-	-	-	
6/6	-	26	-	-	-	
20/6	-	No datum	1	-	-	
4/7	-	-	-	-	-	
18/7	-	2	-	-	-	-
1/8	-	3	1	1	-	-
15/8	-	11	-	-	-	-
29/8	-	28	-	-	-	-
12/9	-	21	-	-	-	-
26/9	-	95	-	-	-	-
10/10	-	many	1	2	-	-
24/10	-	many	6	9	-	-
7/11	1	many	6	15	2	-
22/11	9	many	-	-	-	1
5/12	9	50	27 (21)	6 (5)	1	12
19/12	-	30	5 (4)	-	3	30
3/1/74	1	40	-	-	3	114
16/1	3 (2)	14	1	-	1	10
31/1-27/3	-	-	-	-	-	-
10/4	-	No datum	10	1	-	-
24/4	-	No datum	8	-	1	-
8/5	-	9	37	-	No datum	-
22/5	-	26	13	-	No data	
7/6	-	80				
21/6	-	14				
5/7	-	-				

Appendix 3 (cont.)

Date of examination	CW(OS)	CW(NS)	Jetty
19/7	-	84	
2/8	-	many	
16/8/74	-	many	
30/8	-	many	
12/9	-	2	
26/9	-	many	
10/10	-	many	
24/10	-	many	
7/11	9	many	
21/11	-	5	5
5/12	-	15	6
19/12	1	many	-
2/1/75	-	No datum	1
16/1/75-27/2/75	-	-	-

Appendix 4. Presence of the endoproct *Loxosomella kefersteini* on two-week plates from six locations, two in North Arm and four in Angas Inlet. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual number present is shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72-13/9/72	-		-	-	
27/9	-		-	15	
11/10	-		-	10	
25/10	-		-	40	
8/11	-		-	64 (60)	
22/11	8		-	29 (25)	
6/12	18		13 (11)	15 (6)	-
20/12	49 (48)		-	-	-
3/1/73	15 (14)		-	1	-
17/1	No datum		4	3	-
31/1	340	2	-	1	-
14/2	289 (182)	1	1	7	-
28/2	No datum	No datum	-	No datum	5
14/3-28/3			No data		
11/4	14	-	-	52	13
26/4	7	-	-	222	64
10/5	-	-	-	14	2
23/5	-	-	-	-	1
6/6	-	-	-	16	5
20/6	-	No datum	-	5	-
4/7	-	-	-	-	1
18/7-24/10	-	-	-	-	-

Appendix 4 (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/11/73	-	-	-	6	-	-
22/11-5/12	-	-	-	-	-	-
19/12	-	-	1	-	-	-
3/1/74	-	-	-	-	8	-
16/1	-	-	-	-	1	-
31/1	-	-	-	-	-	-
13/2	1	-	-	-	-	-
27/2	22 (16)	-	-	-	-	-
13/3-10/4	-	-	-	-	-	-
24/4	-	-	-	-	1	-
8/5/74-27/2/75	-	-	-	-	-	-

Appendix 5. Presence of the bryozoan *Watersipora subovoidea* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-27/9/72	-		-	-		
11/10	-		-	1		
25/10	-		1	-		
8/11	-		-	2		
22/11	-		1	6 (5)		
6/12	-		-	1	1	
20/12	1		-	7 (6)	-	
3/1/73	-		-	-	-	
17/1	No datum		1	-	-	
31/1	1	1	-	-	-	
11/4	7	-	-	-	-	
26/4	1	-	-	-	-	
10/5	1	-	-	-	-	
23/5	-	-	-	-	1	
6/6	1	-	-	-	-	
20/6	1	No datum	1	-	-	
4/7	-	-	-	-	-	
18/7	-	-	1	-	-	1
1/8	-	-	-	-	-	1
15/8	-	-	-	3	-	-

Appendix 5 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
29/8/73-26/9/73	-	-	-	-	-	-
10/10	-	-	4	2	1	-
24/10	-	-	5	-	1	-
7/11	-	-	12 (11)	12	3	-
22/11	-	-	6 (5)	9 (6)	1	2
5/12	-	-	10 (8)	31 (23)	-	1
19/12	1	-	5 (4)	20 (18)	2	5
3/1/74	1	1	-	22	4	19
16/1	7 (5)	-	2	29	3	28
31/1	11	3	-	1	6	11
13/2	10 (8)	-	-	-	-	3
27/2	25 (18)	1	2	-	7	48
13/3	45	-	1	-	4	15
27/3	34	1	-	-	3	19
10/4	24	No datum	-	-	21	26
24/4	26	No datum	1	-	22	32
8/5	17	6	-	-	No datum	26
22/5	2	1	1	27	No data	
7/6-7/11	-	-	-	-	-	-
21/11	-	-		5		
5/12	2	-		2		
19/12	-	-		7		
			Outfall			
2/1/75	2	No datum		28		
16/1	8	No datum	26	64		
30/1	5	No datum	3	70		
13/2	6	No datum	-	6		
27/2	15	No datum	-	No datum		

Appendix 5 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-13/9/72	-		-	-		
27/9	-		3	1		
11/10	1		-	-		
25/10	1		4	1		
8/11	-		1	-		
22/11	1		-	-		
6/12	-		-	-		
20/12	2		-	1	-	
3/1/73	-		-	6	-	
17/1-31/1	-	-	-	-	-	
14/2	2	-	-	-	-	
28/2-24/3	No data					
28/3	No data		1	No datum	-	
11/4	No data					
26/4	8	-	-	1	3	
10/5	2	-	1	-	1	
23/5	4	1	1	-	4	
6/6	-	-	-	-	-	
20/6	-	No datum	1	-	-	
4/7	-	No datum	1	No datum	-	
18/7	3	-	15	1	-	
1/8	-	1	1	2	-	-
15/8	-	1	13	-	-	1
29/8	-	-	2	-	2	-
12/9	-	-	-	-	2	No datum

Appendix 5 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/10/73	-	-	5	-	-	-
24/10	-	No datum	10	4	2	-
7/11	-	-	12	8	4	2
22/11	-	2	5	17	1	4
5/12	-	-	6	29	4	4
19/12	4	1	-	14	6	10
3/1/74	-	-	1	4	3	16
16/1	2	-	1	19	8	8
31/1	6	3	-	7	29	37
13/2	28	3	-	-	17	14
27/2	26	3	1	-	52	45
13/3	19	-	-	1	34	60
27/3	76	-	-	1	15	30
10/4	78	No datum	1	No datum	17	81
24/4	120	-	2	-	78	126
8/5	101	No datum	-	2	No datum	208
22/5	61	No datum	1	11	No data	
7/6	3	-				
21/6	1	-				
5/7	4	-				
19/7	2	-				
2/8	1	-				
16/8	-	-				
30/8	3	-				
12/9	2	-				
26/9	-	-				

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
10/10/74	1	-		
24/10	-	-		
7/11	1	-		
21/11	3	-		
5/12	4	-		2
19/12	2	-		2
2/1/75	10	No datum		4
16/1	6	No datum	5	23
30/1	36	No datum	No datum	43
13/2	36	No datum	-	3
27/2	-	-	-	-

Appendix 5 (cont.)

(c) Eight-week plates. Figures in brackets show the proportion of the plate covered, expressed as a percentage.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	-			2		
27/9	-			-		
11/10	-		2	7		
25/10	-		6	3		
8/11	1		-	-		
22/11-6/12	-		-	-		
20/12	2		-	-		
3/1/73	1		1	-		
17/1	No datum		-	2	1	
31/1	No datum		-	1	No datum	
28/3	5		-	-	-	
11/4	12		1	-	-	
26/4	No datum		2	No datum	2	
10/5		No data				
23/5	9	-	-	-	4	
6/6	11	No datum	2	-	3	
20/6	-	No datum	1	4	11	
4/7	-	No datum	4	No datum	4	
18/7	No datum	No datum	8	-	1	
1/8	-	No datum	3	-	3	
15/8	1	-	10	3	2	
29/8	2	-	5	1	1	2
12/9	-	-	3	-	-	No datum
26/9	3	-	2	-	-	No datum

Appendix 5 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/10/73	2	-	4	1	1	No datum
24/10	2	-	6	1	1	No datum
7/11	2	-	11	1	1	-
22/11	-	-	(7)	-	-	2
5/12	1	-	7	(5)	7	2
19/12	2	-	6	8	2	-
3/1/74	2	-	-	-	-	23
16/1	2	-	2	13	No datum	(20)
31/1	6	1	-	-	(2)	-
13/2	2	-	-	-	1	(18)
27/2	(17)	(3)	-	-	(10)	(21)
13/3	(22)	-	-	-	9	(22)
27/3	(26)	-	-	-	(22)	(93)
10/4	(20)	No datum	-	-	(24)	(91)
24/4	(28)	-	1	-	(20)	(22)
8/5	(47)	-	-	4	No datum	(78)
22/5	(18)	No datum	-	11	No datum	No datum
7/6-4/7	-	-				
19/7	4	-				
2/8-12/9	-	-				
26/9	1	-				
10/10	1	-				
24/10	-	-				
7/11	2	-				
21/11	4	-				
5/12	2	-				

Appendix 5 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Jetty
19/12/74-2/1/75	-	-	
16/1	-		(9)

Appendix 6: Presence of the bryozoan *Bugula avicularia* on plates from six locations, two in North Arm and four in Angas Inlet. Abundance is shown as the number of colonies per plate.

(a) Two-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-13/9/72	-		-	-		
27/9	-		-	-		
11/10	-		-	1		
25/10	-		-	1		
8/11	18		-	-		
22/11	17		-	-		
6/12	18		-	-	-	
20/12	71		-	-	-	
3/1/73	19		-	-	-	
17/1	No datum		-	1	-	
31/1	3	2	-	-	-	
14/2-22/11	-	-	-	-	-	
5/12	-	-	-	2	-	-
19/12/73-3/1/74	-	-	-	-	-	-
16/1	-	-	-	-	-	1
31/1-8/5	-	-	-	-	-	-
22/5	4	-	-	-	No	data
7/6-5/12	-	-	-	-	-	-
19/12	2	-		-		

Appendix 6 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-30/8/72	-		-	-		
13/9	-		-	1		
27/9	3		4	2		
11/10	-		-	3		
25/10	5		-	5		
8/11	33		3	-		
22/11	85		1	-		
6/12	43		-	1		
20/12	104		-	-	-	
3/1/73	78		2	-	-	
17/1-31/1	-	-	-	-	-	
14/2	1	-	-	-	-	
26/4	1	-	-	-	-	
10/5	-	-	-	-	-	
23/5	-	-	-	-	1	
6/6	-	-	-	1	-	
4/7	-	-	-	No datum	1	
18/7	-	-	-	-	-	
1/8	-	-	-	-	3	-
15/8	-	-	-	3	-	-
29/8	-	-	-	-	-	-
12/9	-	-	-	1	-	No datum
26/9	-	-	-	-	1	No datum
10/10	-	-	-	1	-	-
24/10	-	-	-	-	-	-

Appendix 6 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/11/73	-	-	-	2	-	-
22/11	1	-	-	-	-	-
5/12	1	-	-	6	-	-
19/12	-	-	-	-	-	-
3/1/74	3	-	-	1	-	-
16/1	15	-	-	-	1	-
31/1	9	-	-	-	-	-
13/2	29	-	-	-	-	-
27/2	16	-	-	-	-	-
13/3	1	-	-	-	-	-
27/3-10/4	-	-	-	-	-	-
24/4	-	-	-	-	1	-
8/5	2	-	-	-	No datum	-
22/5	6	-	-	-	No datum	No datum

			Outfall	Jetty
7/6	1	-		
21/6-7/11	-	-		
21/11	9	-		
5/12	17	-		1
19/12	16	-		-
2/1/75	2	No datum		-
16/1	2	No datum	-	-
30/1	1	No datum	No datum	-
13/2	1	No datum	-	-

Appendix 6 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	-			1		
27/9	1			-		
11/10	2		13	-		
25/10	9		16	6		
8/11	14		1	2		
22/11	23		-	-		
6/12	29		-	-		
20/12	27		-	-		
3/1/73	54		-	-		
17/1	-		-	-		
31/1	No datum		-	1		
11/4	-		1	2	-	
6/6	-		-	3	2	
20/6	-		-	2	18	
4/7-1/8	-	-	-	-	-	
15/8	1	-	-	2	11	
29/8	-	-	-	3	-	-
12/9	-	-	-	-	-	-
26/9	-	-	1	1	2	No datum
10/10	-	-	-	2	1	No datum
24/10	-	-	-	-	-	-
7/11	4	-	1	3	-	-
22/11	3	-	-	1	1	-
5/12	2	-	-	-	-	-

Appendix 6 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
19/12	13	-	-	-	-	-
3/1/74	9	-	-	-	-	-
16/1	11	-	-	-	-	-
31/1	17	-	-	-	-	-
13/2	31	-	-	-	-	-
27/2	22	-	-	-	-	-
13/3	5	-	-	-	-	-
27/3	10	-	-	-	-	-
10/4	2	No datum	-	-	-	-
24/4	1	-	-	-	-	-
8/5	10	-	-	-	No datum	-
22/5	34	No datum	-	1	No datum	No datum
26/9	13					
10/10	1	No datum				
24/10	-	-				
7/11	4	-				
21/11	14	-				
5/12	31	No datum				
				Jetty		
19/12	8	No datum				
2/1/75	5	No datum		-		
16/1/75	6	No datum		-		

Appendix 7: Presence of the bryozoan *Bugula neritina* on plates from six locations, two in North Arm and four in Angas Inlet. Abundance is shown as the number of colonies per plate.

(a) Two-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-11/10/72	-		-	-		
25/10	-		-	2		
8/11	-		-	1		
22/11	-		-	1		
6/12	1		-	-	-	
20/12/72-20/6/73	-	-	-	-	-	
4/7/73	-	-	1	-	-	
18/7-29/8	-	-	-	-	-	
12/9	2	-	-	-	-	-
26/9	-	-	-	1	-	-
10/10-24/10	-	-	-	-	-	-
7/11	-	-	-	-	1	1
22/11	-	-	3	1	1	3
5/12	-	-	-	1	-	-
19/12	-	-	-	-	-	-
3/1/74	1	-	-	10	2	-
16/1	1	-	-	6	-	-
31/1	1	-	-	-	-	-
13/2-10/4	-	-	-	-	-	-
24/4	-	-	-	10	-	-
8/5	-	-	-	1	No datum	-
22/5	-	-	-	1	No data	

Appendix 7 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
21/11/74	-	-		1
5/12	-	-		-
19/12	1	-		-
2/1/75	2	No datum	-	3
16/1	-	No datum	-	1

Appendix 7 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-13/9/72	-		-	-		
27/9	-		-	3		
11/10	-		-	-		
25/10	-		-	2		
8/11	-		-	1		
22/11	-		-	-		
6/12	2		-	-		
20/12	3		-	-	-	
3/1/73	2		-	2	-	
26/4	-	-	-	-	2	
10/5	1	-	-	-	3	
23/5	-	-	-	-	5	
6/6	-	-	-	47	3	
20/6	-	No datum	-	13	-	
4/7	1	No datum	-	No datum	2	
18/7	-	-	-	-	3	
1/8	1	-	-	1	2	3
15/8	1	-	-	-	2	-
29/8	-	-	-	2	2	-
12/9	-	-	-	2	8	No datum
26/9	-	-	1	9	2	No datum
10/10	-	-	-	3	-	-
24/10	-	No datum	-	1	2	-
7/11	1	-	-	3	2	1
22/11	15	-	-	5	-	-

Appendix 7 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
5/12/73	-	-	-	19	1	-
19/12	-	-	-	5	3	1
3/1/74	2	-	-	4	9	-
16/1	10	-	-	41	-	-
31/1	10	-	-	-	-	-
13/2	11	-	-	1	-	-
27/2	1	-	-	1	-	-
13/3	-	-	-	-	-	-
27/3	3	-	-	1	-	-
10/4	9	No datum	-	No datum	3	-
24/4	4	-	-	1	1	-
8/5	-	No datum	-	10	No datum	-
22/5	10	No datum	-	23	No datum	No datum
5/7	1	-				
19/7	1	-				
2/8	-	-				
16/8	1	-				
30/8	-	-				
12/9	1	-				
26/9-10/10	-	-				
24/10	1	-				
7/11	1	-				
				Jetty		
21/11	2	-				
5/12	4	-		-		
19/12	5	-		1		
			Outfall			
2/1/75	10	No datum		-		
16/1	-	No datum	-	8		

Appendix 7 (b) (cont.)

Date of examination	CW(OS)	Outfall	Jetty
30/1/75	4	-	15
13/2	4	-	8

Appendix 7 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	-			-		
27/9	-			1		
11/10	-		-	1		
25/10	-		1	2		
8/11	1		-	-		
22/11	-		-	-		
6/12	2		-	-		
20/12	-		-	1		
3/1/73	-		-	-		
17/1	No datum		-	-	1	
23/5	-	-	-	9	10	
6/6	-	No datum	-	24	16	
20/6	1	No datum	-	23	35	
4/7	-	No datum	1	No datum	47	
18/7	No datum	No datum	-	19	10	
1/8	1	No datum	-	5	35	
15/8	-	-	2	4	15	
29/8	-	-	-	4	7	3
12/9	1	-	1	6	3	No datum
26/9	-	-	-	2	5	No datum
10/10	1	-	1	15	7	No datum
24/10	-	-	1	7	3	No datum
7/11	2	-	-	3	1	No datum
22/11	2	-	1	7	2	-

Appendix 7 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
5/12/73	1	-	-	5	-	-
19/12	18	-	-	4	-	-
3/1/74	5	-	-	3	-	1
16/1	6	-	-	35	No datum	-
31/1	17	-	-	-	-	1
13/2	9	-	-	-	-	-
27/2	10	-	-	-	1	-
13/3	6	-	-	1	-	-
27/3	2	-	-	-	-	-
10/4	2	No datum	-	-	1	-
24/4	5	-	-	2	-	-
8/5	10	-	-	-	No datum	-
22/5	10	No datum	-	55	No datum	No datum
19/7	3	-				
12/9	1	-				
10/10	1	No datum				
7/11	2	-				
5/12	2	-				

Appendix 8. Presence of the simple ascidian *Ciona intestinalis* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates. On those occasions when the data were corrected to allow for the presence of *Leptoclinum rayneri*, the actual numbers are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72	-			-	
16/6	1			-	
30/6	-			-	
13/7	-			5	
27/7-10/8	-			-	
16/8	1			-	
30/8	3		1	1	
13/9	4		-	3	
27/9	1		-	2	
11/10	1		-	-	
25/10	37		-	4	
8/11	4		-	7	
22/11	30		4	14 (12)	
6/12	55		-	6 (3)	
20/12	52		-	1	9
3/1/73	10 (9)		-	-	2
17/1	-	-	-	-	-
31/1	-	1	-	-	-
14/2	11 (7)	4 (3)	-	-	-
11/4	4	-	-	-	-

Appendix 8 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
26/4/73	2	-	-	-	-	
10/5	-	-	-	-	-	
23/5	-	1	-	-	-	
6/6-15/8	-	-	-	-	-	
29/8	1	-	-	-	-	-
12/9	-	-	-	-	1	-
26/9	2	-	-	-	1	-
10/10	-	-	1	-	1	1
24/10	3	-	-	1	-	2
7/11	1	2	-	8	1	3
22/11	1	-	-	3	-	1
5/12	2	-	-	1	3	-
19/12	-	1	-	-	-	-
3/1/74	3	2	-	1	1	3
16/1	1	-	-	-	-	-
31/1-13/2	-	-	-	-	-	-
27/2	2	-	-	-	-	-
13/3-27/3	-	-	-	-	-	-
10/4	-	-	1	-	-	-
24/4-8/5	-	-	-	-	-	-
22/5	2	-	-	-	No data	
21/6	1	-				
4/7-16/8	-	-				
30/8	1	-				
12/9	2	-				
26/9	-	-				

Appendix 8 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
10/10	1	-		
24/10	-	-		
7/11	9	-		
21/11	14	-		5
5/12	12	-		2
19/12	-	-		-
2/1/75	1	No datum		1
16/1	-	No datum	1	-
30/1	-	No datum	-	-
13/2	1	No datum	-	-

Appendix 8 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
16/6/72	6			-	
30/6	2			-	
13/7	6			6	
27/7	6			-	
10/8	1			-	
23/8	1			-	
30/8	2			2	
13/9	9		1	15	
27/9	4		1	9	
11/10	10		-	8	
25/10	35		-	54	
8/11	158		-	9	
22/11	123		-	1	
6/12	51		-	18	
20/12	39		-	-	38
3/1/73	23		-	1	-
17/1-31/1	-		-	-	-
14/2	7	-	-	-	-
28/2-14/3	No data				
28/3	No datum	No datum	4	No datum	-
11/4	No data				
26/4	6	-	-	-	1
10/5	-	-	-	-	2
23/5	-	-	-	-	1
6/6-18/7	-	-	-	-	-

Appendix 8 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
1/8/73	-	-	-	-	-	1
15/8	1	-	-	1	-	-
29/8	-	-	-	2	-	2
12/9	-	-	-	2	1	No datum
26/9	1	-	-	2	4	No datum
10/10	4	-	-	14	8	-
24/10	7	-	2	19	6	2
7/11	12	-	2	16	3	14
22/11	12	-	-	14	-	4
5/12	2	-	-	26	-	-
19/12	2	-	-	-	-	1
3/1/74	-	-	-	-	4	-
16/1	4	-	-	3	-	-
31/1	6	-	-	-	-	-
13/2	-	-	-	-	-	-
27/2	3	-	-	-	-	-
13/3	4	-	-	-	-	-
27/3	-	-	-	-	-	-
10/4	2	-	-	No datum	1	-
24/4	-	-	-	-	-	-
8/5	-	-	-	-	No datum	1
22/5	-	-	-	-	No data	
5/7	1	-				
19/7-30/8	-	-				
12/9	3	-				
26/9	1	-				

Appendix 8 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
10/10/74	4	-		
24/10	4	-		
7/11	62	-		
21/11	192	-		
5/12	151	-		17
19/12	19	-		5
2/1/75	12	No datum		2
16/1	4	No datum	3	6
30/1	1	No datum	No datum	2
13/2	3	No datum	-	2

Appendix 8 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	31			18		
27/9	28			4		
11/10	27		-	7		
25/10	79		-	3		
8/11	65		-	-		
22/11	51		-	-		
6/12	81		-	-		
20/12	31		-	-		
3/1/73	31		-	-		
17/1-14/3	-		-	-		
28/3	12		1	-	-	
11/4	-		-	-	-	
26/4	No datum		-	No datum	-	
10/5	No data					
23/5	-	-				
6/6	3	No datum	-	-	-	
20/6-18/7	-	-	-	-	-	
1/8	-	-	-	1	-	
15/8	1	-	-	3	-	
29/8	2	-	-	4	2	10
12/9	-	-	1	8	-	No datum
26/9	1	-	1	6	8	No datum
10/10	7	-	-	10	13	No datum
24/10	7	-	1	37	6	No datum
7/11	33	-	1	11	8	7

Appendix 8 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
22/11	32	-	-	12	2	9
5/12	48	-	-	10	-	1
19/12	10	-	-	-	-	-
3/1/74	14	-	-	-	-	-
16/1	10	-	-	-	No datum	1
31/1	6	-	-	-	-	-
13/2	1	-	-	-	-	-
27/2	3	-	-	-	-	-
13/3	5	-	-	-	-	-
27/3	11	-	-	-	-	-
10/4	2	No datum	-	2	-	-
24/4	2	-	-	-	-	-
8/5	4	-	-	-	No datum	-
22/5	4	No datum	-	1	No datum	No datum
19/7	1	-				
2/8-30/8	-	-				
12/9	5	-				
26/9	10	-				
10/10	18	No datum				
24/10	17	-				
7/11	102	-				
21/11	93	-				
5/12	302	-				
19/12	374	-		Jetty		
2/1/75	152	No datum		-		
16/1	16	No datum		-		

Appendix 9. Presence of the compound ascidian *Botryllus schlosseri* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-13/7/72	-			-		
27/7	-			2		
10/8	1			-		
16/8	-			-		
30/8	-		-	3		
13/9	2		3	1		
27/9	7		2	2		
11/10	-		2	6		
25/10	72		9	10		
8/11	23		-	2		
22/11	51		-	-		
6/12	-		-	-	-	
20/12/73-24/10/73	-	-	-	-	-	-
7/11	-	-	1	-	-	-
22/11	1	-	-	-	-	-
5/12	-	-	-	-	-	-
19/12	3	-	-	-	-	-
3/1/74	5	-	-	-	-	-
16/1	2	-	-	-	-	-
13/2/74-10/4/74	-	-	-	-	-	-
24/4	1	-	-	-	-	-
8/5	-	-	-	-	No datum	-
22/5	1	-	-	-	No data	

Appendix 9 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
7/6/74-16/8/74	-	-		
30/8	1	-		
12/9	1	-		
26/9-21/11	-	-		-
5/12	3	-		-
19/12	-	-		-
2/1/75	1	-		-
16/1-27/2	-	-	-	-

Appendix 9 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-13/7/72	-			-		
27/7	1			2		
10/8	2			-		
23/8	-			-		
30/8	3			-		
13/9	9		18	1		
27/9	9		9	20		
11/10	7		4	24		
25/10	66		5	20		
8/11	133		-	2		
22/11	70		-	-		
6/12	7		-	-		
20/12	1		-	-	-	
3/1/73	1		-	-	-	
17/1-26/9	-	-	-	-	-	-
10/10	-	-	-	-	3	-
24/10	1	-	-	-	-	-
7/11-3/1/74	-	-	-	-	-	-
16/1	5	-	-	-	-	-
31/1	2	-	-	-	-	-
13/2	-	-	-	-	-	-
27/2	1	-	-	-	-	-
13/3-22/5	-	-	-	-	-	-
7/6-12/9	-	-				
26/9	1	-				

Appendix 9 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
10/10	1	-		
24/10	1	-		
7/11	3	-		
21/11	3	-		
5/12	-	-		-
19/12	4	-		-
2/1/75	2	No datum		-
16/1-27/2	-	No datum	-	-

Appendix 9 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	9			9		
27/9	13			12		
11/10	13		19	24		
25/10	73		5	-		
8/11	55		-	-		
22/11	24		-	-		
6/12	-		-	-		
20/12	2		-	-		
3/1/73-1/8/73	-	-	-	-	-	
15/8	-	-	-	-	1	
29/8-26/9	-	-	-	-	-	-
10/10	-	-	-	-	1	No datum
24/10	-	-	-	-	-	No datum
7/11	1	-	-	1	-	-
22/11	4	-	-	-	-	-
5/12	-	-	-	1	-	-
19/12	2	-	-	-	-	-
3/1/74	3	-	-	-	-	-
16/1-31/1	-	-	-	-	-	-
13/2	8	-	-	-	-	-
27/2	1	-	-	1	-	-
13/3-22/5	-	-	-	-	-	-
7/6/74-5/7/74	-	-				
19/7	1	-				
2/8-16/8	-	-				

Appendix 9 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
30/8	1	-		
12/9	-	-		
26/9	1	-		
10/10	6	-		
24/10	4	-		
7/11	4	-		
21/11	3	-		
5/12	4	-		
19/12/74-13/2/75	-	-	-	-

Appendix 10. Presence of the compound ascidian *Botrylloides nigrum* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-30/8/72	-		-	-		
13/9	-		1	3		
27/9	-		-	-		
11/10	-		3	1		
25/10	-		2	-		
8/11	-		-	-		
22/11	-		2	-		
6/12	4		1	-	-	
20/12	12		-	-	-	
3/1/73	7		2	-	-	
17/1-26/9	-	-	-	-	-	-
10/10	-	-	-	1	7	-
24/10	-	-	-	-	7	-
7/11	1	-	-	1	7	-
22/11	1	-	3	-	5	1
5/12	4	-	3	-	-	1
19/12	4	-	-	-	-	-
3/1/74	2	1	-	-	-	-
16/1	1	-	-	-	-	-
31/1-13/2	-	-	-	-	-	-
27/2	4	-	-	-	-	-
13/3	-	-	-	-	-	-
27/3	1	-	-	-	-	-

Appendix 10 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/4-22/5	-	-	-	-	-	-
				Jetty		
7/6-21/11	-	-				
5/12	3	-		6		
19/12	11	-		1		
			Outfall			
2/1/75	12	No datum		1		
16/1	2	No datum	-	-		
30/1-27/2	-	No data	-	-		

Appendix 10 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-30/8/72	-			-		
13/9	-		7	3		
27/9	-		13	2		
11/10	-		1	4		
25/10	-		4	7		
8/11	1		-	2		
22/11	6		-	-		
6/12	7		-	1		
20/12	18		-	-	-	
3/1/73	20		-	-	-	
17/1	No datum		2	-	-	
31/1	No datum		-	-	-	
14/2	1	-	-	-	-	
28/2-23/5	-	-	-	-	-	
6/6	-	-	-	-	2	
20/6	-	-	-	-	-	
4/7	-	-	-	No datum	1	
18/7-12/9	-	-	-	-	-	-
26/9	-	-	-	-	3	No datum
10/10	-	-	-	1	-	-
24/10	-	-	-	5	12	-
7/11	3	-	1	5	6	3
22/11	10	-	-	1	3	3
5/12	5	-	3	3	5	1
19/12	19	-	-	-	-	-

Appendix 10 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
3/1/74	5	-	-	-	-	-
16/1	4	-	-	-	-	-
31/1	4	-	-	-	-	-
13/2	5	-	-	-	-	-
27/2	8	-	-	-	-	-
13/3	6	-	-	-	-	-
27/3	2	-	-	-	-	-
10/4	1	-	-	No datum	-	-
8/5	-	-	-	-	No datum	-
22/5	1	-	-	-	No data	
7/6-24/10	-	-				
7/11	2	-				
				Jetty		
21/11	2	-				
5/12	11	-		3		
19/12	65	-		1		
			Outfall			
2/1/75	107	No datum		-		
16/1	10	No datum	4	-		
30/1	16	No datum	No datum	-		
13/2	5	No datum	-	-		
27/2	-	No datum	-	No datum		

Appendix 10 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	-			-		
27/9/72	-			3		
11/10	-		2	20		
25/10	-		1	-		
8/11	1		-	-		
22/11	3		-	-		
6/12	1		-	-		
20/12	3		-	-		
3/1/73	5		-	-		
17/1-14/3	-		-	-	-	
28/3	24 sq cm		-	-	-	
11/4-10/5	-		-	-	-	
23/5	-	-	-	-	5	
6/6	-	No datum	-	1	-	
20/6	-	No datum	-	-	-	
4/7	-	No datum	-	No datum	2	
18/7-15/8	-	-	-	-	-	
29/8	-	-	-	1	1	-
12/9	-	-	-	1	7	No datum
26/9	-	-	-	-	12	No datum
10/10	-	-	-	8	6	No datum
24/10	-	-	-	12	17	No datum
7/11	4	-	1	12	6	2
22/11	4	-	-	4	4	6
5/12	16	-	1	3	7	-

Appendix 10 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
19/12/73	19	-	-	-	-	-
3/1/74	5	-	-	-	-	-
16/1	19	-	-	-	-	-
31/1	13	-	-	-	-	-
13/2	1	-	-	-	-	-
27/2	1	-	-	-	-	-
13/3	3	-	-	-	-	-
27/3	3	-	-	-	-	-
10/4	7	-	-	-	-	-
24/4	4	-	-	-	-	-
8/5	2	-	-	-	No datum	-
22/5	1	-	-	-	No datum	No datum
7/6-24/10	-	-				
7/11	1	-				
21/11	2	-				
5/12	9	-				
			Outfall	Jetty		
19/12/74-13/2/75	-	-	-	-		

Appendix 11. Presence of the serpulid *Eulaeospira convexis* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates.

On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72-30/6/72	-			-	
13/7	-			2	
27/7	-			1	
10/8	-			3	
16/8	-			-	
30/8	-		3	2	
13/9	-		34	4	
27/9	3		6	10	
11/10	2		17	26	
25/10	1		11	40	
8/11	1		-	35 (33)	
22/11	4		42 (34)	38 (32)	
6/12	1		39 (34)	24 (10)	29
20/12	2		6	62 (56)	19 (15)
3/1/73	2		23	107 (88)	35 (6)
17/1	No datum		59	64 (57)	26 (6)
31/1	5	1	17	76	4 (2)
14/2	-	-	58	133	-
28/2	No datum	No datum	40	No datum	14
14/3-28/3	No data				

Appendix 11 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
11/4/73	-	-	14	38	14	
26/4	2	-	35	163	37 (36)	
10/5	-	-	1	9	15	
23/5	-	-	2	21	-	
6/6	-	-	1	3	3	
20/6	1	No datum	1	3	4	
4/7	-	-	-	-	-	
18/7	-	-	5	-	-	-
1/8	-	-	3	-	17	-
15/8	1	-	4	3	12	-
29/8	-	-	3	1	7	-
12/9	-	-	1	1	2	-
26/9	-	-	-	1	16	-
10/10	-	-	47	5	44	-
24/10	-	-	21	16	95 (93)	-
7/11	2	-	28 (26)	8	36	2
22/11	-	-	22 (17)	8 (5)	13 (12)	2
5/12	2	-	1	1	-	-
19/12	2	-	11 (9)	1	9	-
3/1/74	11 (10)	1	20 (19)	10	7	1
16/1	4 (3)	-	13	17	3	1
31/1	7	1	5	2	6	1
13/2	1	-	33	16	-	-
27/2	2	-	33	15	11	3
13/3	8 (7)	-	3	16	16	2
27/3	11 (8)	-	37	125	7	3

Appendix 11 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/4	2	No datum	23	25	5	1
24/4	-	No datum	5	12	17	-
8/5	1	-	12	2	No datum	-
22/5	5	-	23	7	No datum	No datum
7/6-2/8	-	-				
16/8	1	-				
30/8	-	-				
12/9	1	-				
26/9	1	-		Jetty		
10/10-21/11	-	-		-		
5/12	-	-		1		
19/12	-	-	Outfall	3		
2/1/75	3	No datum		7		
16/1	-	No datum	26	2		
30/1	-	No datum	13	5		
13/2	-	No datum	12	4		
27/2	-	No datum	8	No datum		

Appendix 11 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
16/6/72-30/6/72	-			-	
13/7	-			14	
27/7	-			9	
10/8	2			19	
23/8	1			4	
30/8	-			6	
13/9	2		40	8	
27/9	3		25	23	
11/10	4		17	28	
25/10	4		7	55	
8/11	2		30	24	
22/11	6		-	-	
6/12	5		-	12	
20/12	7		7	6	26
3/1/73	10		10	80	-
17/1	No datum		156	107	-
31/1	No datum		43	86	1
14/2	13	-	98	21	40
28/2	No data		61	No data	
14/3	No data				
28/3	No data		244	No datum	25
11/4	No data				
26/4	17	-	39	367	226
10/5	7	-	57	235	201
23/5	2	1	1	119	153

Appendix 11 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
6/6/73	3	-	27	49	114	
20/6	1	No datum	11	42	40	
4/7	2	No datum	5	No datum	22	
18/7	1	No datum	27	4	29	
1/8	1	-	50	11	48	1
15/8	4	-	77	9	118	1
29/8	2	-	31	6	116	1
12/9	1	-	23	8	65	No datum
26/9	-	-	28	9	61	No datum
10/10	2	1	54	4	133	2
24/10	1	No datum	43	30	76	2
7/11	5	2	64	13	102	3
22/11	5	1	30	3	8	2
5/12	1	1	5	16	28	2
19/12	1	-	14	6	22	4
3/1/74	4	-	27	2	7	4
16/1	-	1	63	14	30	1
31/1	7	-	13	8	13	1
13/2	12	-	52	10	35	2
27/2	4	-	73	24	9	4
13/3	2	-	83	14	28	8
27/3	1	-	105	46	12	6
10/4	10	No datum	172	No datum	53	14
24/4	1	-	77	77	52	6
8/5	2	No datum	41	54	No datum	8
22/5	20	No datum	44	103	No datum	No datum

Appendix 11 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
7/6/74	3	-		
21/6	-	-		
5/7	1	-		
19/7-30/8	-	-		
12/9	1	-		
26/9	2	-		
10/10	-	-		
24/10	3	-		
7/11	1	-		
21/11	3	-		
5/12	2	-		1
19/12	1	-		17
2/1/75	-	No datum		24
16/1	-	No datum	5	3
30/1	-	No datum	No datum	9
13/2	1	No datum	7	2
27/2	-	No datum	4	No datum

Appendix 11 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	1			38		
27/9	-			42		
11/10	1		113	37		
25/10	2		138	72		
8/11	20		14	2		
22/11-6/12	-		-	-		
20/12	-		-	5		
3/1/73	2		34	-		
17/1	No datum		94	13	74	
31/1	No datum		-	32	No datum	
14/2	No datum		23	37	4	
28/2	No datum		79	No datum	28	
14/3		No data				
28/3	-		820	34	155	
11/4	1		127	77	46	
26/4	No datum		13	No datum	93	
10/5		No data				
23/5	20	-	-	68	157	
6/6	11	No datum	77	73	125	
20/6	2	No datum	29	121	205	
4/7	-	No datum	63	No datum	158	
18/7	No datum	No datum	53	16	30	
1/8	2	-	72	9	78	
15/8	2	-	68	23	159	
29/8	3	-	84	12	234	2

Appendix 11 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
12/9/73	1	-	36	4	2	No datum
26/9	2	-	45	8	141	No datum
10/10	1	-	77	3	43	No datum
24/10	-	1	27	4	18	No datum
7/11	-	-	61	2	7	16
22/11	1	-	9	-	22	1
5/12	-	-	4	4	34	1
19/12	2	-	4	3	11	2
3/1/74	5	-	1	-	-	3
16/1	-	-	9	7	No datum	-
31/1	1	-	8	28	-	-
13/2	2	-	-	-	1	12
27/2	-	-	67	154	87	2
13/3	-	-	17	34	154	8
27/3	-	-	237	-	317	13
10/4	-	No datum	725	98	184	37
24/4	13	No datum	138	57	136	78
8/5	7	No datum	423	160	No datum	19
22/5	17	No datum	461	144	No datum	No datum
7/6-5/7	-	-				
19/7	4	-				
2/8-12/9	-	-				
26/9	1	-				
10/10	-	-				
24/10	2	-				
7/11	3	-				

Appendix 11 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
21/11/74	5	-		
5/12	5	-		
19/12	-	-		
2/1/75	-	No datum		47
16/1	-	No datum		163
30/1	-	No datum		92
13/2	-	No datum	48	104

Appendix 12. Presence of the simple ascidian *Microcosmus squamiger* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-20/12/72	-		-	-	-	
3/1/73	-		-	1	-	
17/1	No datum		-	-	-	
31/1	1	1	-	1	-	
14/2	-	-	9	-	-	
28/2	No datum	No datum	2	No datum	-	
14/3-28/3		No data				
11/4	-	-	1	-	-	
26/4-24/10	-	-	-	-	-	-
7/11	-	-	-	11	-	-
22/11	-	-	-	-	-	3
5/12	-	-	-	-	-	-
19/12	-	-	1	2	-	-
3/1/74	-	-	-	-	-	-
16/1	-	-	-	2	-	-
31/1	2	-	10	5	1	-
13/2	-	-	-	-	-	-
27/2	1	-	1	1	-	-
13/3	-	-	-	-	-	-
27/3	-	-	1	-	-	-
10/4-24/4	-	-	-	-	-	-
8/5	1	-	-	-	No datum	-
22/5	-	-	-	-	No data	

Appendix 12 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
7/6/74-5/12/74	-	-		-
19/12	-	-		4
2/1/75-27/2/75	-	-	-	-

Appendix 12 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-25/10/72	-		-	-		
8/11	-		-	4		
22/11	-		-	-		
6/12	-		-	6		
20/12	6		-	-	2	
3/1/73	-		30	26	-	
17/1	No datum		39	48	-	
31/1	No datum		5	31	1	
14/2	2	-	161	39	7	
28/2	No datum	No datum	11	No datum	No datum	
14/3		No data				
28/3	No datum	No datum	11	No datum	3	
11/4		No data				
26/4	3	2	-	1	8	-
10/5	-	-	-	4	2	-
23/5-29/8	-	-	-	-	-	-
12/9	-	-	-	1	-	No datum
26/9	2	-	-	2	5	No datum
10/10	-	-	-	6	-	-
24/10	-	No datum	2	29	1	-
7/11	4	-	27	59	-	1
22/11	-	-	5	14	-	5
5/12	2	-	6	8	3	-
19/12	1	-	3	53	10	2
3/1/74	-	-	4	8	4	2

Appendix 12 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/1/74	5	1	23	76	1	-
31/1	10	18	11	36	-	-
13/2	1	2	76	208	1	-
27/2	2	2	66	179	1	-
13/3	2	-	16	160	3	-
27/3	-	-	2	45	-	-
10/4	-	No datum	39	No datum	-	-
24/4	-	-	-	2	2	-
8/5-22/5	-	-	-	-	-	-
7/6-24/10	-	-				
7/11	5	-				
				Jetty		
21/11	15	-				
5/12	26	-		183		
			Outfall			
19/12	8	-		8		
2/1/75	12	No datum		18		
16/1	-	No datum	48	30		
30/1	-	No datum	No datum	55		
13/2	9	No datum	34	534		
27/2	-	No datum	33	No datum		

Appendix 12 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72	-			7		
27/9	-			2		
11/10	-		2	-		
25/10-8/11	-		-	-		
22/11	3		-	-		
6/12	-		-	1		
3/1/73	21		57	-		
17/1	No datum		73	14	8	
31/1	No datum		37	122	No datum	
14/2	No datum		77	69	-	
28/2	No datum		71	No datum	6	
14/3		No data				
28/3	-		73	78	7	
11/4	1	-	4	40	2	
26/4	No datum		51	No datum	-	
10/5		No data				
23/5	4	-	-	19	5	
6/6	-	No datum	-	1	2	
20/6	-	No datum	-	2	2	
4/7	-	No datum	1	No datum	-	
18/7	No datum	No datum	1	1	1	
1/8	No datum	No datum	1	-	3	
15/8	1	-	1	2	2	
29/8	-	-	-	4	1	9
12/9	-	-	2	6	-	No datum

Appendix 12 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
26/9/73	-	-	2	4	6	No datum
10/10	-	-	2	1	6	No datum
10/10	-	-	2	1	6	No datum
24/10	1	-	24	119	14	No datum
7/11	2	3	38	151	8	8
22/11	1	-	54	118	25	5
5/12	10	-	38	49	17	5
19/12	23	11	70	43	6	5
3/1/74	7	8	9	3	-	1
16/1	41	14	118	59	No datum	23
31/1	5	1	139	35	46	3
13/2	13	12	401	559	21	8
27/2	1	13	428	447	27	23
13/3	3	-	363	587	38	1
27/3	-	-	208	470	18	-
10/4	2	No datum	80	470	14	-
24/4	6	8	32	324	20	4
8/5	1	-	20	130	No datum	-
22/5	8	No datum	1	25	No datum	No datum

			Jetty
7/6-10/10	-	-	
24/10	1	3	
7/11	31	17	
21/11	67	22	
5/12	83	14	
19/12	42	3	
2/1/75	17	No datum	364

Appendix 12 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
16/1/75	6	No datum		407
30/1	19	No datum		451
13/2	20	No datum	103	690

Appendix 13. Presence of an unidentified polychaete (family Sabellidae) on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-8/11/72	-		-	-		
22/11	-		-	1		
6/12	-		-	1	-	
20/12	-		-	-	-	
3/1/73	2		-	1	-	
17/1	No datum		1	-	-	
31/1-14/2	-	-	-	-	-	
28/2	No datum	No datum	2	No datum	-	
14/3-24/10	-	-	-	-	-	-
7/11	-	-	-	1	-	-
22/11/73-22/11/74	-	-	-	-	-	-
5/12	-	-		3		
19/12	-	-		-		
2/1/75	-	-		3		
16/1-27/2	-	-		-		

Appendix 13 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-25/10/72	-		-	-		
8/11	-		1	-		
22/11	2		-	-		
6/12	1		-	2		
20/12	11		24	-	7	
3/1/73	-		8	21	-	
17/1	No datum		10	2	-	
31/1	No datum		3	-	-	
14/2	-	-	7	-	-	
28/2	No datum	No datum	4	No datum	No datum	
14/3-12/9	-	-	-	-	-	-
26/9	1	-	1	-	-	No datum
10/10	1	-	-	2	-	-
24/10	3	No datum	-	15	1	-
7/11	-	-	1	14	-	-
22/11	-	-	-	2	-	2
5/12	-	-	-	21	-	-
19/12	-	-	-	15	-	-
3/1/74	2	-	3	27	3	1
16/1	-	-	9	20	1	-
31/1	2	-	3	11	-	-
13/2	3	-	6	29	-	-
27/2	-	-	6	11	-	-
13/3	-	-	1	6	-	-
27/3	-	-	-	1	-	-

Appendix 13 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/4/74	-	No datum	-	No datum	-	-
24/4-22/5	-	-	-	-	-	-
7/6-7/11	-	-				
				Jetty		
21/11	1	-				
5/12	5	-		175		
19/12	7	-		33		
			Outfall			
2/1/75	8	No datum		58		
16/1	-	No datum	10	8		
30/1	-	No datum	No datum	4		
13/2	-	No datum	2	29		
27/2	-	No datum	-	No datum		

Appendix 13 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72-27/9/72	-			-		
11/10	-		1	-		
25/10	1		1	-		
8/11	-		1	2		
22/11	1		-	1		
6/12	-		-	-		
20/12	8		-	-		
3/1/73	10		9	1		
17/1	No datum		29	12	-	
31/1	No datum		40	13	No datum	
14/2	No datum		20	-	-	
28/2	No datum		1	No datum	-	
14/3		No data				
28/3	-		1	-	-	
11/4	-		-	-	-	
26/4	No datum		2	No datum	-	
10/5-29/8	-	-	-	-	-	-
12/9	-	-	-	5	-	No datum
26/9	2	-	-	1	-	No datum
10/10	3	-	4	17	-	No datum
24/10	3	-	9	46	6	No datum
7/11	14	2	9	38	3	-
22/11	21	-	4	82	-	-
5/12	-	-	13	50	-	-
19/12	11	3	17	48	1	2

Appendix 13 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
3/1/74	8	-	-	55	-	-
16/1	25	-	30	35	No datum	11
31/1	58	17	34	106	37	6
13/2	7	-	88	135	4	14
27/2	10	-	36	154	2	8
13/3	2	-	15	82	-	-
27/3	-	-	9	65	-	-
10/4	-	No datum	3	3	-	-
24/4	-	-	-	-	-	-
8/5	1	No datum	-	-	No datum	-
22/5	-	No datum	-	-	No datum	No datum
7/6-24/10	-	-				
7/11	1	-				
21/11	3	-				
5/12	8	1				
				Jetty		
19/12	-	-				
2/1/75	-	No datum		9		
16/1	-	No datum		21		
			Outfall			
30/1	-	No datum		17		
13/2	-	No datum	46	106		

Appendix 14. Presence of the serpulid *Hydroides norvegica* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-25/10/72	-		-	-		
8/11	2		-	2		
22/11	3		-	-		
6/12	-		1	2	6	
20/12	-		-	-	2	
3/1/73	1		-	1	-	
17/1	No datum		-	-	-	
31/1	21	28	8	26	10	
14/2	19 (12)	6 (4)	11	1	-	
28/2	No datum	No datum	35	No datum	8	
14/3-28/3		No	data			
11/4	73	46	23	16	10	
26/4	56	17	84	67	50	
10/5	-	-	1	-	1	
23/5	-	-	-	-	-	
6/6	-	1	2	2	1	
20/6	1	No datum	1	-	-	
4/7	-	-	3	-	1	
18/7	-	-	-	-	-	-
1/8	-	-	5	4	5	2

Appendix 14 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
15/8/73	2	1	5	8	12	2
29/8	-	-	1	1	5	-
12/9	16	30	45	45	29	18
26/9	107	85	188	310	266 (263)	42
10/10	92	118	294 (291)	383	447 (443)	102
24/10	86	61	114 (113)	97	105 (103)	33
7/11	80	140	46 (43)	84 (82)	43 (42)	17
22/11	47	42	90 (69)	70 (46)	33 (30)	20
5/12	-	1	-	-	-	-
19/12	10	8	18 (15)	17 (15)	8	8
3/1/74	96 (87)	184	89 (83)	58	71	67
16/1	63 (43)	36	29	29	16 (15)	11
31/1	411 (395)	482	182	162	235	207
13/2	221 (186)	238	121	86	43	41
27/2	740 (540)	207	324	306	137	227
13/3	1030	417	179	334	92	147
27/3	477	698	248	306	141	157
10/4	286	No datum	153	85	58	49
24/4	21	No datum	7	25	9	-
8/5	10	7	14	11	No datum	2
22/5	16	14	25	41	No datum	No datum

		Jetty
7/6-10/10	-	
24/10	1	
7/11	11	
21/11	1	1
5/12	54	64

Appendix 14 (a) (cont.)

Date of examination	CW(OS)	Outfall	Jetty
19/12	60		45 (43)
2/1/75	28		13
16/1	212 (204)	108	126 (123)
30/1	89 (87)	54	82
13/2	724	188	201
27/2	194 (188)	27	No datum

Appendix 14 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-10/8/72	-			-		
23/8	1			-		
30/8	-			1		
13/9-25/10	-		-	-		
8/11	3		-	-		
22/11	3		-	-		
6/12	2		-	-		
20/12	1		2	2	7	
3/1/73	-		1	2	-	
17/1	No datum		-	2	-	
31/1	No datum		7	23	-	
14/2	11	9	26	40	16	
28/2	No datum	No datum	73	No datum	No datum	
14/3		No data				
28/3	No datum		74	No datum	21	
11/4		No data				
26/4	211	239	76	66	118	
10/5	36	23	100	70	34	
23/5	4	-	-	6	1	
6/6	-	1	1	2	1	
20/6	3	No datum	1	4	2	
4/7	1	No datum	3	No datum	1	
18/7	-	-	4	4	-	
1/8	3	3	13	13	7	5
15/8	3	3	19	27	25	12

Appendix 14 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
29/8/73	2	-	4	10	19	-
12/9	25	19	31	63	29	No datum
26/9	180	106	370	557	343	No datum
10/10	187	250	452	710	504	291
24/10	141	303	369	462	322	188
7/11	239	201	149	221	93	69
22/11	187	236	45	99	32	123
5/12	26	31	58	52	87	20
19/12	28	15	1	4	11	3
3/1/74	39	231	18	13	40	36
16/1	93	203	94	72	79	34
31/1	238	550	120	71	205	269
13/2	485	478	251	342	242	291
27/2	336	Not scored	361	373	79	246
13/3	537	Not scored	379	273	300	457
27/3	658	Not scored	355	294	161	359
10/4	741	Not scored	441	No datum	229	228
24/4	328	Not scored	184	144	88	41
8/5	44	Not scored	8	33	No datum	14
22/5	67	Not scored	44	55	No datum	No datum

			Jetty
7/6	15	Not scored	
21/6-24/10	-	-	
7/11	15	Not scored	
21/11	6	Not scored	
5/12	150	Not scored	43
19/12	199	Not scored	82

Appendix 14 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
2/1/75	56	Not scored		21
16/1	87	Not scored	43	77
30/1	368	Not scored	No datum	137
13/2	631	Not scored	107	206
27/2	750	Not scored	162	171

Appendix 14 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72-25/10/72	-		-	-		
8/11	1		-	3		
22/11-6/12	-		-	-		
20/12	3		-	-		
3/1/73	1		1	-		
17/1	No datum		1	5	7	
31/1	No datum		2	7	No datum	
14/2	No datum		3	2	5	
28/2	No datum		12	No datum	11	
14/3		No data				
28/3	291		75	39	70	
11/4	181		47	43	47	
26/4	No datum		29	No datum	41	
10/5		No data				
23/5	83	80	-	218	101	
6/6	42	No datum	64	73	25	
20/6	4	No datum	12	4	2	
4/7	4	No datum	4	No datum	3	
18/7	No datum	No datum	14	10	3	
1/8	2	-	19	24	7	
15/8	4	4	24	58	8	
29/8	11	8	30	56	25	11
12/9	15	4	45	60	1	No datum
26/9	79	86	294	248	278	No datum
10/10	491	50	534	641	381	No datum

Appendix (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
24/10/73	506	162	570	607	372	No datum
7/11	324	324	446	492	196	434
22/11	340	238	264	268	115	182
5/12	196	85	69	153	62	84
19/12	219	120	60	69	37	10
3/1/74	113	24	9	18	-	35
16/1	50	86	6	2	No datum	5
31/1	297	224	5	4	46	1
13/2	291	342	156	128	237	108
27/2	484	Not scored	134	212	917	543
13/3	567	Not scored	164	276	432	137
27/3	656	Not scored	369	343	379	212
10/4	543	Not scored	875	347	561	154
24/4	760	Not scored	437	517	219	141
8/5	463	Not scored	385	308	No datum	178
22/5	414	Not scored	227	147	No datum	No datum
7/6	25	Not scored				
21/6-19/7	-	Not scored				
2/8	1	Not scored				
16/8-24/10	-	Not scored				
7/11	12	Not scored				
21/11	8	Not scored				
5/12	36	Not scored				
19/12	63	Not scored		Jetty		
2/1/75	17	Not scored		8		
16/1	19	Not scored		14		

Appendix 14 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
30/1	243	Not scored		18
13/2	24	Not scored	77	162

Appendix 15. Presence of the barnacle *Balanus amphitrite* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-27/7/72	-			-		
10/8	-			1		
16/8-27/9	-		-	-		
11/10	-		-	1		
25/10	-		-	-		
8/11	2		-	33 (31)		
22/11	8		25 (20)	38 (32)		
6/12	23		179 (156)	122 (50)	86 (84)	
20/12	55 (54)		35 (33)	51 (46)	55 (43)	
3/1/73	11 (10)		24	29 (24)	12 (2)	
17/1	No datum		1	1	-	
31/1	5	74	8	15	8 (3)	
14/2	2	10 (7)	5	2	4	
28/2	No datum	No datum	1	No datum	1	
14/3-28/3		No data				
11/4	-	-	2	-	1	
26/4-10/5	-	-	-	-	-	
23/5	-	-	1	-	-	
6/6-29/8	-	-	-	-	-	
12/9	-	-	1	-	-	-

Appendix 15 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
26/9/73-10/10/73	-	-	-	-	-	-
24/10	-	-	1	-	-	-
7/11	-	1	-	17	3	8
22/11	16	6	5 (4)	14 (9)	15 (14)	20
5/12	2	-	2	9 (7)	16 (12)	36
19/12	1	-	2	4	4	7
3/1/74	11 (10)	6	5	7	14	14
16/1	6 (4)	-	2	6	8	1
31/1	6	1	14	7	4	11
13/2	-	-	1	1	-	-
27/2	12 (9)	-	6	4	1	-
13/3	5	-	8	5	1	5
27/3	-	4	9	1	1	1
10/4	6	No datum	3	-	-	3
24/4	-	No datum	1	-	-	-
8/5	-	2	-	-	No datum	-
22/5	-	-	-	-	No datum	No datum

	CW(OS)	CW(NS)	Jetty
7/6-24/10	-	-	
7/11	14	-	
21/11	2	1	16
5/12	33	20	141
19/12	189	Not scored	160
2/1/75	50	No datum	39
16/1/75	4	-	-
30/1	7	2	2
13/2	168	25	70
27/2	11	12	No datum

Appendix 15 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-13/9/72	-		-	-		
27/9	-		3	-		
11/10	-		1	-		
25/10	-		-	-		
8/11	3		-	2		
22/11	13		-	-		
6/12	26		8	3		
20/12	58		131	1	151	
3/1/73	29		79	21	-	
17/1	No datum		23	5	-	
31/1	No datum		11	6	-	
14/2	2	34	17	5	30	
28/2	No datum	No datum	5	No datum	No datum	
14/3		No data				
28/3	No datum	No datum	8	No datum	-	
11/4		No data				
26/4	-	2	1	1	1	
10/5	-	-	-	-	1	
23/5-20/6	-	-	-	-	-	
4/7	-	No datum	1	No datum	-	
18/7-10/10	-	-	-	-	-	-
24/10	-	-	1	6	-	6
7/11	1	3	9	15	8	28
22/11	17	6	12	25	7	83
5/12	1	1	15	17	76	54
19/12	11	-	3	1	31	33

Appendix 15 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
3/1/74	12	4	8	4	33	5
16/1	14	-	20	10	54	8
31/1	6	11	4	4	8	47
13/2	4	-	11	13	2	2
27/2	12	-	8	8	-	2
13/3	15	-	19	17	8	15
27/3	-	-	34	11	-	5
10/4	2	No datum	20	No datum	-	3
24/4	3	No datum	4	1	1	5
8/5	-	No datum	1	-	No datum	1
22/5	-	No datum	1	-	No datum	No datum
7/6	1	-				
21/6-24/10	-	-				
7/11	7	Not scored				
21/11	71	Not scored				
5/12	272	Not scored		86		
19/2	344	Not scored		89		
2/1/75	297	Not scored		147		
16/1	25	Not scored	19	19		
30/1	11	Not scored	No datum	3		
13/2	97	Not scored	19	53		
27/2	82	Not scored	23	No datum		

Appendix 15 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
7/9/72-27/9/72	-			-		
11/10	-		1	1		
25/10	-		-	5		
8/11	2		-	-		
22/11	2		-	-		
6/12	-		-	-		
20/12	17		-	1		
3/1/73	5		172	-		
17/1	No datum		46	6	54	
31/1	No datum		96	15	No datum	
14/2	No datum		19	19	1	
28/2	No datum		8	No datum	1	
14/3		No data				
28/3	-		9	2	2	
11/4	1		3	2	-	
26/4	No datum		8	No datum	-	
10/5		No data				
23/5	-	-	-	-	2	
6/6-18/7	-	No data	-	-	-	
1/8	-	No datum	-	-	1	
15/8	-	-	-	-	-	
29/8	-	-	-	-	-	1
12/9	-	-	2	-	-	No datum
26/9	-	-	-	-	-	No datum
10/10	-	-	4	4	2	No datum

Appendix 15 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
24/10/73	3	-	4	6	2	No datum
7/11	4	-	5	13	3	25
22/11	3	2	16	9	15	84
5/12	9	-	20	23	37	52
19/12	14	2	29	34	41	57
3/1/74	49	4	15	9	57	65
16/1	33	3	9	2	No datum	-
31/1	45	6	17	9	32	20
13/2	22	6	11	17	22	17
27/2	6	3	11	7	68	35
13/3	1	-	15	18	14	11
27/3	11	1	13	6	6	3
10/4	16	No datum	37	31	32	5
24/4	5	-	54	19	13	6
8/5	3	-	27	5	No datum	10
22/5	1	No datum	9	3	No datum	No datum

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
7/6-24/10	-	-		
7/11	27	Not scored		
21/11	57	Not scored		
5/12	103	Not scored		
19/12	62	Not scored		
2/1/75	207			92
16/1	192			163
13/2	152		103	164

Appendix 16. Presence of the oyster *Ostrea angasi* on plates from six locations, two in North Arm and four in Angas Inlet.

(a) Two-week plates. On those occasions when the data were corrected to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-11/10/72	-		-	-		
25/10	-		-	1		
8/11	1		1	2		
22/11	1		12 (10)	5 (4)		
6/12	9		46 (40)	4 (2)	14	
20/12	58		7	18 (16)	23 (18)	
3/1/73	29 (27)		19	6 (5)	6 (1)	
17/1	No datum		1	1	-	
31/1	5	-	8	8	5 (2)	
14/2	-	-	2	-	-	
28/2	No datum	No datum	-	No datum	-	
14/3-24/10	-	-	-	-	-	-
7/11	-	-	-	1	1	-
22/11	-	-	1	-	-	-
5/12	-	-	3	1	4	-
19/12	-	-	21 (26)	2	10	-
3/1/74	1	1	7	4	5	2
16/1	1	-	1	1	2	2
31/1	-	1	6	3	17	7
13/2	-	-	2	-	-	-

Appendix 16 (a) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
27/2/74	-	-	-	-	1	-
13/3	4	-	1	2	16	3
27/3	-	-	-	-	-	-
10/4	-	No datum	1	-	-	-
24/4-22/5	-	-	-	-	-	-
7/6-5/12	-	-		-		
19/12	1	-		-		
			Outfall			
2/1/75	2	No datum		1		
16/1	-	No datum	-	-		
30/1	-	No datum	-	1		
13/2	15	No datum	30	8		
27/2	-	No datum	-	No datum		

Appendix 16 (cont.)

(b) Four-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-25/20/72	-		-	-		
8/11	-		2	-		
22/11	4		-	-		
6/12	7		-	-		
20/12	40		11	-	18	
3/1/73	68		45	38	-	
17/1	No datum		26	16	-	
31/1	No datum		4	2	-	
14/2	4	-	2	5	26	
28/2-24/10	-	-	-	-	-	-
7/11	-	-	-	-	1	-
22/11	-	-	2	-	-	-
5/12	-	-	-	2	2	1
19/12	-	-	3	-	4	2
3/1/74	-	2	13	11	20	13
16/1	-	-	13	6	31	2
31/1	1	3	5	2	31	2
13/2	5	-	7	8	28	1
27/2	-	-	1	1	-	-
13/3	2	-	4	1	1	1
27/3	1	-	3	2	1	3
10/4	1	No datum	-	No datum	-	1
24/4	-	-	-	1	-	-
8/5-22/5	-	No data	-	-	No data	-
7/6-21/11	-	-				
5/12	1	-				

Appendix 16 (b) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
19/12	1	-		
2/1/75	4	No datum		-
16/1	1	No datum	-	-
30/1	3	No datum	No datum	-
13/2	14	No datum	8	3
27/2	-	No datum	-	No datum

Appendix 16 (cont.)

(c) Eight-week plates.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
16/6/72-8/11/72	-		-	-		
22/11	1		-	-		
6/12	-		-	-		
20/12	1		-	-		
3/1/73	19		31	-		
17/1	No datum		20	4	59	
31/1	No datum		25	29	No datum	
14/2	No datum		18	11	-	
28/2	No datum		1	No datum	12	
14/3	No data					
28/3	-		1	3	4	
11/4	-		-	1	-	
26/4-8/11	-	-	-	-	-	-
22/11	-	-	-	-	1	-
5/12-19/12	-	-	-	-	-	-
3/1/74	-	-	1	-	-	15
16/1	-	-	15	-	No datum	2
31/1	1	-	10	2	41	-
13/2	-	-	1	6	15	-
27/2	1	-	-	5	22	2
13/3	-	-	3	2	12	2
27/3	-	-	3	-	8	-
10/4	-	No datum	10	1	15	1
24/4	2	1	8	-	5	-
8/5	-	-	1	-	No datum	-

Appendix 16 (c) (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
22/5/74	-	No datum	1	-	No datum	No datum
7/6-19/12	-	-				
2/1/75	-	No datum		-		
16/1	1	No datum		-		
			Outfall			
30/1	3	No datum		2		
13/2	-	No datum	2	-		

Appendix 17. Presence of the tube-dwelling amphipod *Corophium* sp. on two-week plates from six locations, two in North Arm and four in Angas Inlet. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72	-			-	
16/6	1			1	
30/6	-			1	
13/7-16/8	-			-	
30/8	3		1	2	
13/9	3		-	1	
27/9	10		2	22	
11/10	19		6	39	
25/10	4		1	21	
8/11	5		-	58 (55)	
22/11	7		23 (19)	2	
6/12	30		28 (24)	22 (9)	26
20/12	5		12 (11)	1	7 (6)
3/1/73	-		2	-	12 (2)
17/1	No datum		1	-	-
31/1	-	-	-	-	-
14/2	-	6 (5)	-	-	-
28/2	No datum	No datum	-	No datum	-
14/3-28/3	No data				
11/4	2	-	-	-	-
26/4	1	2	-	1	3

Appendix 17 (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
10/5/73	-	-	-	-	-	
23/5	-	2	-	-	-	
6/6	-	1	-	-	1	
20/6	-	-	-	-	4	
4/7	1	-	1	1	2	
18/7	-	-	10	-	1	1
1/8	-	2	5	1	1	6
15/8	-	-	7	-	5	1
29/8	2	1	12	1	11	18
12/9	1	2	-	-	4	1
26/9	13	30	2	5	7	12
10/10	43	12	18	13	15	21
24/10	36	10	21	25	55	33
7/11	71	27	47 (46)	52 (51)	40 (39)	29
22/11	51	43	25 (21)	12 (8)	1500	121
5/12	265	60	68 (57)	5 (4)	58	90
19/12	273 (257)	75	5	5	22	58
3/1/74	85 (78)	71	-	-	4	12
16/1	12 (9)	75	15	10	8	4
31/1	-	16	2	-	-	-
13/2	-	-	2	-	-	-
27/2	-	-	2	-	1	-
13/3	1	-	6	-	2	-
27/3	-	1	2	-	1	-
10/4	-	No datum	1	1	1	2
24/4	-	No datum	-	1	2	-
8/5	-	-	-	-	No datum	-

Appendix 17 (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
22/5/73	-	1	-	1	No datum	No datum
7/6	1	3				
21/6	-	-				
5/7	-	1				
19/7	5	2				
2/8	-	-				
16/8	15	4				
30/8	3	-				
12/9	5	-				
26/9	6	4				
10/10	79	6				
24/10	28	-				
				Jetty		
7/11	6	-				
21/11	14	2		54		
5/12	50	9		211		
19/12	-	-		-		
			Outfall			
2/1/75	11	No datum		-		
16/1	2	No datum	-	-		
30/1	-	No datum	3	-		
13/2	-	No datum	4	-		

Appendix 18. Presence of an unidentified tube-dwelling amphipod (family Corophiidae) on two-week plates from six locations, two in North Arm and four in Angas Inlet. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

* Indicates an estimate of the number present.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R
2/6/72-13/7/72	-			-	
27/7	-			1	
10/8-13/9	-		-	-	
27/9	2		-	2	
11/10	-		17	6	
25/10	1		47 (45)	-	
8/11	1		26 (9)	59 (51)	
22/11	-		5 (4)	63 (26)	
6/12	3		15 (13)	2	8
20/12	1		4	1	-
3/1/73	-		1	2	6 (1)
17/1	No datum		-	-	-
31/1	1	1	-	-	-
14/2	-	121 (91)	-	-	-
28/2-11/4	-	-	-	-	-
26/4	-	14	-	-	-
10/5	-	-	-	-	-
23/5	-	71	-	-	-
6/6	-	79	-	-	-
20/6	1	No datum	2	-	-

Appendix 18 (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
4/7/73-18/7/73	-	-	-	-	-	-
1/8	-	1	-	-	-	-
15/8	-	3	-	-	-	1
29/8	-	41	2	-	-	-
12/9	-	6	-	-	-	2
26/9	13	29	2	-	-	3
10/10	3	217	3	-	1	18
24/10	8	352	55	-	36	94
7/11	27	82	43 (40)	23	10	60
22/11	35	112	118 (92)	26 (17)	23 (21)	315
5/12	265	1000 *	47 (37)	-	2	323
19/12	85 (80)	2000 *	3	2	3	182
3/1/74	29 (27)	500 *	-	-	6	58
16/1	7 (5)	750 *	12	25	12 (11)	96 (94)
31/1	-	37	5	1	-	17
13/2	34 (31)	-	26	-	-	1
27/2	121 (99)	17	71	-	1	9
13/3	8	-	3	-	1	25
27/3	-	17	85	-	-	1
10/4	5	-	-	-	1	-
24/4	1	-	17	-	3	1
8/5	2	1	1	-	No datum	1
22/5	-	53	9	-	No datum	No datum
7/6	-	80				
21/6-12/9	-	-				
26/9	1	-				
10/10	5	16				

Appendix 18 (cont.)

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty
24/10/74	5	-		
7/11	1	7		
21/11	-	3		6
5/12	43	40		15
19/12/74-2/1/75	-	-		-
16/1	1	No datum	-	-
30/1	-	No datum	7	-
13/2	-	No datum	1	1

Appendix 19. Presence of a tanaid crustacean (Tanaidacea : Tanaidae), possibly *Paratanais ignotus*, on two-week plates from six locations, two in North Arm and four in Angas Inlet. On those occasions when the data were adjusted to allow for the presence of *Leptoclinum rayneri*, the actual numbers present are shown in brackets.

Date of examination	CW(OS)	CW(NS)	Outfall	Jetty	30R	28R
2/6/72-13/9/72	-		-	-		
27/9	-		5	1		
11/10	-		64	3		
25/10	-		34 (32)	4		
8/11	-		27 (9)	27 (25)		
22/11	-		22 (18)	8 (7)		
6/12	2		4	-	1	
20/12	1		7	1	1	
3/1/73	1		-	1	-	
17/1-30/8	-	-	-	-	-	-
12/9	-	-	-	-	-	1
26/9-27/2/74	-	-	-	-	-	-
13/3	-	-	1	-	-	-
27/3/74-27/2/75			Not present			