Swimming and Recessing Behaviour of Scallops Seeded onto a range of Substrates

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The Sea Fish Industry Authority

Marine Farming Unit, Ardtoe

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Summary

The substrate of the seabed is known to affect the recessing behaviour and dispersal behaviour of scallops. The further understanding of the effect of substrate characteristics upon scallop behaviour will improve judgment concerning the suitability of sites for seeding scallops on the seabed.

Frequency of swimming and recessing behaviour of the scallop (*Pecten maximus*) was observed on four substrate types (mud, fine sand, coarse sand and maerl), in laboratory tanks using time-lapse video techniques.

Frequency of swimming varied greatly in different trials. However, scallops swam relatively less on coarse sand substrates. Patterns of recessing behaviour also varied greatly on different days although relatively more scallops tended to recess on coarse sand and fine sand substrates.

The experiment confirmed that substrate was influential upon both the swimming and recessing behaviour of scallops. Coarse sand was determined as the most suitable substrate for the seeding of scallops on the seabed, since scallops swam less and recessed readily when on this substrate. However, the large variability in data, collected on different days, demonstrated that other factors are influential. Field observations which have suggested that scallops prefer to occupy areas of some water movement (in the near proximity of natural currents or tidal races) are supported by these tank experiments; the general direction of swimming was towards the water inlet.

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1. Introduction

The cultivation of the scallop (*Pecten maximus*) in European waters may be undertaken entirely in suspension. However this incurs cost penalties as a result of high capital cost and the need to service culture containers regularly throughout the year (Hardy, 1991, Dare, 1994). There is therefore considerable commercial interest in accommodating at least the later stages of the rearing cycle on the sea bed. However, major stock losses frequently follow transfer to the seabed as a result of the predation of and dispersal of scallops from the seeded site, all of which reduce the density and the efficiency with which the animals can be harvested.

In general, *P. maximus* is found on a range of bottom substrates but typically occurs on gravel and coarse sand. Silt or mud can be tolerated in moderation, high population densities and fast growth rates are normally associated with areas with little mud. The grain distribution of a substrate varies with current; coarser grained sand being associated with strong current and finer grained sand with weaker current. Scallops aggregate in areas of strong flow which is thought to improve efficiency of feeding (Brand, 1991). Sediment can vary within the range of currents suitable for scallop feeding so the distribution of scallops on the seabed may therefore be related to water movement rather than to substrate type. However, substrate type is clearly important since scallops anchor themselves in areas of strong current by recessing in the seabed.

In suitable areas, scallops will recess into the sediment, in areas unsuitable for feeding or recessing, swimming movements are used to move until ground more suitable for recessing is reached (Buestal and Dao, 1979). For example, Baird (1958) reported that scallops would swim more frequently when placed on hard substrates.

The ability to recess in the substrate is also likely to offer some protection against predation (Minchin and Buestal, 1983), a view supported by observations of increased swimming movements of smaller more vulnerable scallops when they are unable to recess (Wilkens, 1991).

The habitat preference of scallops is complex, involving water flow, sediment and predation. The aim of this project was to determine the causal relationship between the substrate and swimming and recessing behaviour of the scallop.

2. Methods

Two plastic partitions were constructed and fixed into a large tank (3000 litre) to enable an equal current to be passed over two sets of four 0.25m^2 trays, each filled to the edge with a test substrate. Each set of trays was fitted into the base of one of the 1m^2 sections, all trays being interchangeable and randomly allocated. Sea water, pumped from Ceann Traigh Bay passed from a header tank (8000 l) and was split between the two partitions, water flow being approximately 10 cm/min. across the substrate. Water entered each section via a spray bar the side of the partition. At the base of the chamber, level with the surface of the trays, an opening (1m x 0.15m) enabled water to pass into the partition at the level of the substrate. A similar opening on the opposite side of the partition enabled the flow to leave the partition at the same level, producing a current across the surface of the substrate. The inlets and outlets of each partition were separated from the main tray area by a mesh (4 cm aperture), to prevent the scallops escaping. (Diagram 1)

Four substrates were used in the trial and were tested in pairs. Coarse sand, was designated as a reference substrate and was used in all trials. The scallops used in the trial (45 - 50 mm), were recovered from longline facilities in the sea and transferred to tanks on shore several days before the trial. Sixteen juvenile scallops, each marked with a plastic tag displaying an identification symbol, were seeded onto each substrate and both substrates in each test were monitored simultaneously for twenty-four hours using time lapse video equipment. Substrates ranged from fine to coarse: Mud, Fine sand, Coarse sand and Maerl (a coarse sand containing fragments of a species of calcareous algae, *Phymatolithon sp.).* At the end of each test, a small jet of seawater was directed at each scallop to display the tag and final position of each scallop to the camera.

A simple security camera (Panasonic BP 102) fitted with a wide angle lens (Panasonic LA4R5C3), sealed into a C-Technics Underwater Camera Housing, was positioned above each of the partitions to provide a complete view of all four trays in the trial, recording scallop positions once every ten minutes. A window at one end of the room was almost completely covered (to prevent reflection from the surface of the water), but enabled a natural photoperiod to influence the room. Light for the cameras was provided by a fluorescent tube covered with a duration of the trial period, this wavelength giving minimal disturbance to the stock.

Analysis of the video footage involved placing an acetate sheet over the screen of a monitor, and marking the initial and subsequent positions of each scallop. The times of movements and of recessing were noted to give movement frequency and time taken to recess. This analysis also enabled tank effects to be investigated.

2.1 Swimming frequency analysis

There are three basic scallop movements: small 'puffs' which can be used to push a predator away, or to excavate a recessing cavity in the substrate, a 'righting move' which enables the scallop to turn itself over if it is upside down, and a 'swim' which is a series of shell adductions and can carry the scallop for up to three metres horizontally (Wilkens, 1991). 'Swims' were further divided into short (less than a shell length) and long 'swims' (more than a shell length). Short 'swims' were usually centred around the site on which the scallop would recess and could be considered as an indication that recessing was imminent. For the purpose of this trial, a count of long 'swims' was used to determine the scallop's propensity for swimming.

The frequency of swimming movements over the first two hours was monitored for the 16 scallops seeded onto each set of trays in each trial. Four pairwise trials being performed for each test substrate.

A swimming frequency index (SFI) was calculated as follows;

$$\text{SFI} = \frac{\text{Frequency of 'swims' on test substrate}}{\text{Frequency of 'swims' on reference substrate (CS)}}$$

An SFI value of < 1 indicating less swimming on the test substrate than on the reference substrate. A value = 1 indicating the same propensity for swimming, or no difference. Values > 1 indicate that swimming occurred more on the test substrate than on the reference substrate.

2.2 Substrate particle size analysis

An analysis of particle size distribution was conducted for each substrate.

2.3 Recess analysis

The time at which scallops recessed and re-recessed was noted for test substrates and the reference substrates for all runs.

2.4 Direction

The beginning and final positions were marked for all scallops to indicate overall directional movement throughout the period. This analysis was conducted without regard to the substrate, but with reference to the tank in which movements occurred.

3. Results

Table 1. shows the tidal state during each trial and indicates weather conditions and water parameters which may have affected the behaviour of scallops during their respective trials.

3.1 Swimming Frequency analysis

Raw data are presented as bar charts in figures 1a - 1c, showing the number of 'swims' which occurred on each substrate during the twenty-four hour period, test substrates being compared directly to the reference substrate. In each case, results for test substrates are represented by white bars while the reference substrates are represented by black bars.

The Swimming Frequency Indices for each trial and the mean SFI for each test substrate are presented in Table 2. The mean SFI was greater than 1 for all substrates compared to the reference (coarse sand). In all cases, the propensity for swimming on each test substrate was almost twice that for the coarse sand substrate.

A two-way Wilcoxon signed-rank pairs test was used to detect any difference in swimming frequency on coarse sand in relation to the tank in which it was being tested. This analysis indicated no significant differences in swimming frequency (in the first two hours after seeding) in coarse sand treatments with respect to the two tanks ($P>0.05$). However, large fluctuations were observed on different days for this substrate.

A one-way Wilcoxon signed-rank pairs test on raw data ($n=4$) was performed to determine whether swimming frequency on test substrates was greater than or equal to the swimming frequency on the reference substrate. In each case the hypothesis was accepted ($P>0.05$). The swimming frequency on all test substrates was significantly greater than on coarse sand.

3.2 Substrate particle size analysis

A comparison of particle size distribution for all substrates is presented in Figure 2. This indicates that while maerl was considered to be the coarsest substrate, due to the large pieces of calcareous algae present, in fact the major fractions of this substrate were much finer (the major proportion of particles being between 500 µm and 63 µm), relating more to the fine sand and mud substrates rather than to the coarse sand. Coarse sand consisted of considerably larger fractions of large particles (The major proportion being between 250 µm and 2.0 mm).

3.3 Recess analysis

Numbers of scallops recessing during the first 24 hours are presented for each tank trial (Figures 3 a-i). Results for test substrates are represented in white while those for reference substrate are represented in black. There was considerable variation in the number of scallops recessing and the number re-emerging when all trials were compared (Figures 3 a and e.), although the behaviour of scallops was more consistent during each run. In most trials there was a trend for numbers recessing to increase between the beginning of the trial and midnight, followed by a trend of re-emergence during the early hours of the morning, after which the numbers recessing increased towards dawn (Figures. 3 b, d, e, f, h and i). In coarse sand/mearl trials (Figures 3 a, b and c) and in coarse sand/mud trials (Figures 3 g, h and I), relatively more scallops were recessed on the reference substrate . In coarse sand/fine sand trials (Figures 3 d, e and f) relatively more scallops were recessed on the fine sand. However the differences between numbers recessing in each trial, were too small to draw statistically valid conclusions.

3.4 Direction

Data presented in Figures 4a - c indicated a tendency of movement toward the side of the tanks where the inlet was positioned. There also appeared to be a slight bias towards southeasterly movements in tank A and the northeasterly movements in tank B.

4. Conclusions

The information collected in this trial indicated that scallops seeded onto the seabed swim less on substrates similar in particle size distribution to the coarse sand substrate used in this trial. Although the Maerl substrate used appeared to be very coarse, large particles made up only a small fraction of the weight of substrate. The main proportion of the weight of the Maerl used had a similar particulate structure to the fine sand and mud substrates used. Although the substrate 'preferred' in this trial (on the basis of lack of mobility) would be associated with a stronger current, which is where scallops are more likely to aggregate in the wild (Wickens 1991), the current used in this trial was the same for all substrates. It is thought that scallops use their tentacles to test substrates before recessing, and therefore these results would suggest that the tendency of scallops to aggregate in areas of stronger current may be a result of their ability to test grain size rather than current.

The trial also indicated that although scallops tended to swim more on fine sand than coarse sand, they recessed to a greater degree in the fine sand. This would suggest that the scallops will search for a better area if seeded onto fine sand, but are either more able to recess in the fine sand, or will recess readily following a short search.

The trials produced some evidence for a period of recessing following seeding, but would often re-emerge during the night (around midnight), and recess again close to dawn. This could be associated with a dusk onslaught of predators and the morning foraging before dawn. The behavioural cycle of recessing displayed by data in the recessing figures is consistent but does not seem to be associated to the tidal movement (see Table 1.). It might have been significant that the trials room was inspected by security personnel in the middle of every night, but it was not possible to clearly relate these visits to behavioural cycles.

Several of the trials also showed no sign of 'midnight re-emergence' (Figures 3a, 3c and 3g.), but it is possible that, through some difference in handling, these scallops were less fit and therefore recessed but did not re-emerge during the night. It would be interesting to investigate the recessing for longer than twenty four hours in order to indicate whether this 're-emergence' was related to recovery time after handling rather than environmental factors.

5. References

Baird, R., H. (1958) On the swimming behaviour of escallops (*Pecten maximus* L.). Proc. Malac. Soc. Lond., 33: 67-71.

Brand, A., R. (1991) Scallop Ecology: Distribution and behaviour. Chapter 11. In Shumway (see below).

Table 1. Recordings of temperature, salinity and tidal cycle during the course of each trial.

Start date	Trial	Start Time	Substrate	Temperature	Salinity(ppt)	Times of low tide	Times of high tide	Tidal range (m)	Cycle	Comments
19/10/95	e	1343	Fine sand	13.3	29	2113, 0848	1439, 0314	1.8-3.2	Neaps	Southwesterly gales (6-7), heavy showers
21/10/95	f	1214	Fine sand	13.4	34	2223, 1016	1555, 0424	1.0-3.7	Springs	Light westerly winds, heavy northwesterly swell (3-4), bright day
28/10/95	g	1037	Mud	13.3	34	1433, 0256	2015, 0848	0.9-3.6	Springs	Westerly gales, rough seas
04/11/95	h	1131	Mud	12.4	34	2208, 1031	1556, 0413	1.0-3.8	Springs	Calm seas, bright day
08/11/95	d	1526	Fine sand	12.5	34	0030, 1301	1808, 0619	1.0-4.1	Springs	Calm seas, bright day
10/11/95	b	1505	Mearl	12.4	34	0143, 1410	1915, 0726	1.2-3.9	Springs	Calm seas, overcast
14/11/95	i	1520	Mud	12.3	34	1628, 0440	2157, 1018	1.9-3.2	Neaps	Calm seas, bright day
21/11/95	c	1702	Mearl	11.5	34	2259, 1110	0502, 1716	0.7-4.2	Springs	Southwesterly gales, showers
11/12/95	j	1600	Mearl	9.4	34	0234, 1506	2011, 0821	1.4-3.7	Spr/neaps	Calm seas, bright day
13/12/95	a	1500	Mearl	9.1	34	1546, 0352	2126, 0904	1.7-3.4	Neaps	Calm seas, bright day

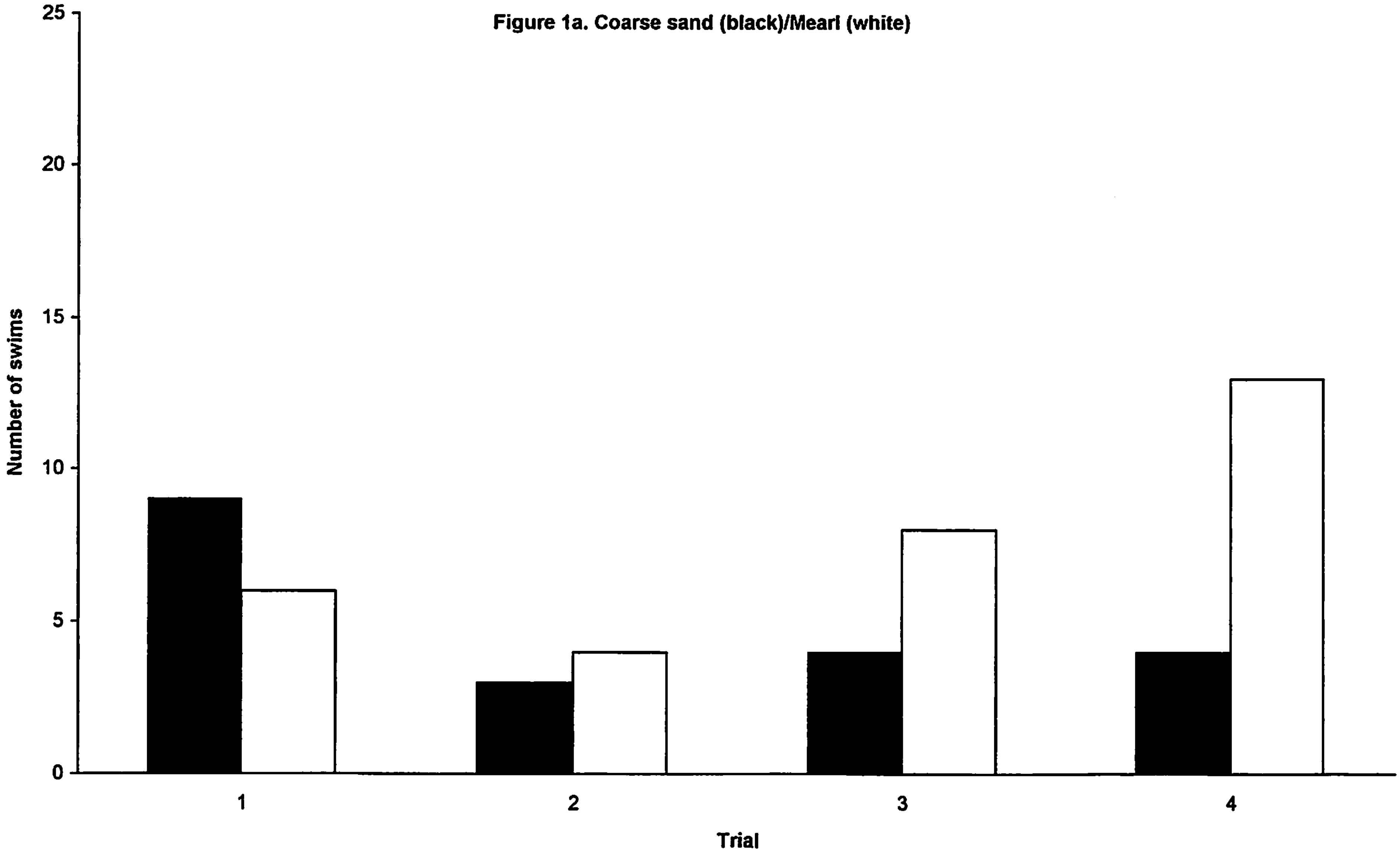


Figure 1a. Coarse sand (black)/Mearl (white)
Number of swims
25
20
15
10
5
0
1
2
3
4
Trial

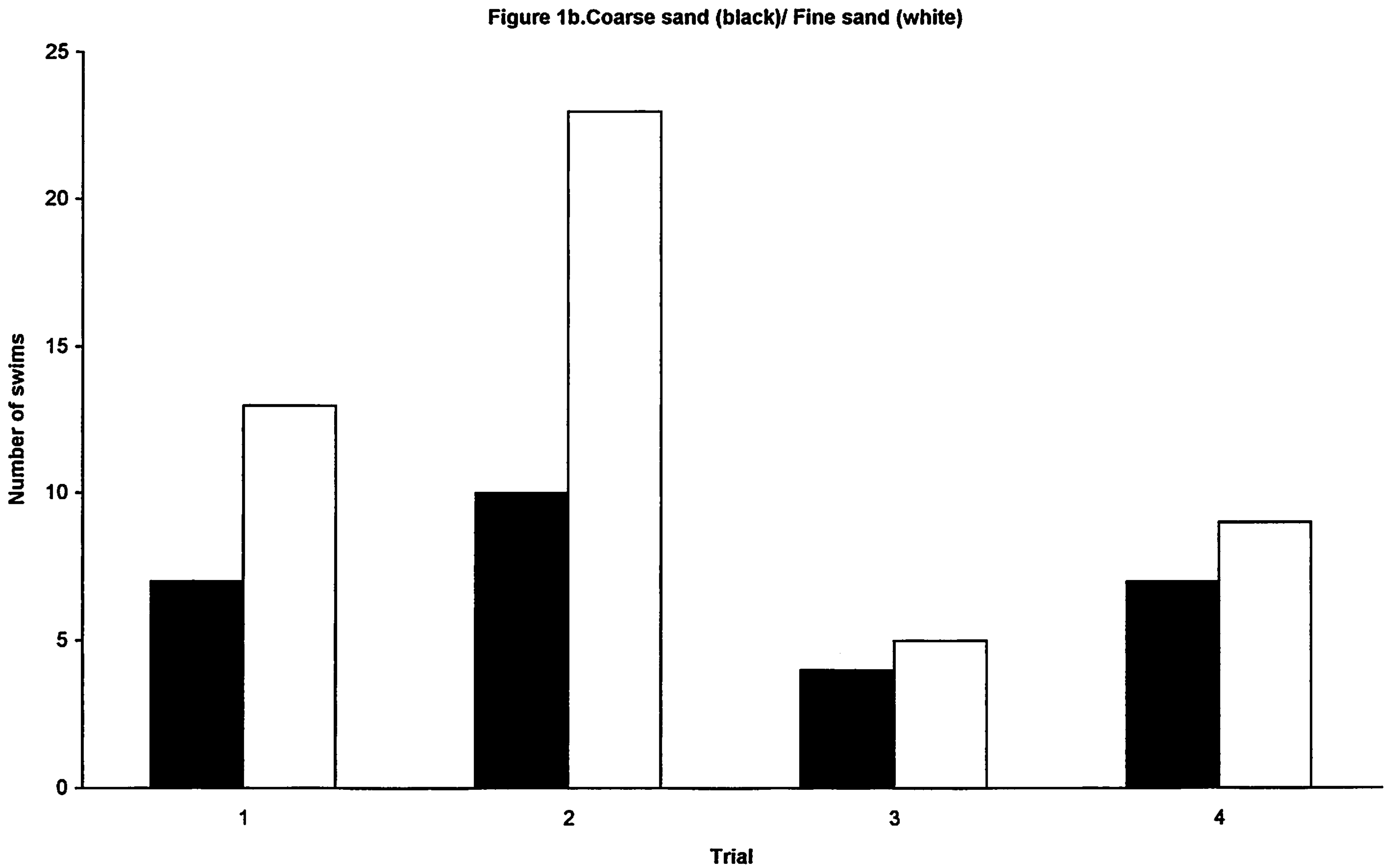


Figure 1b.Coarse sand (black)/ Fine sand (white)
Number of swims
0
5
10
15
20
25
1
2
3
4
Trial

Figure 1c. Coarse sand (black)/ Mud (white).

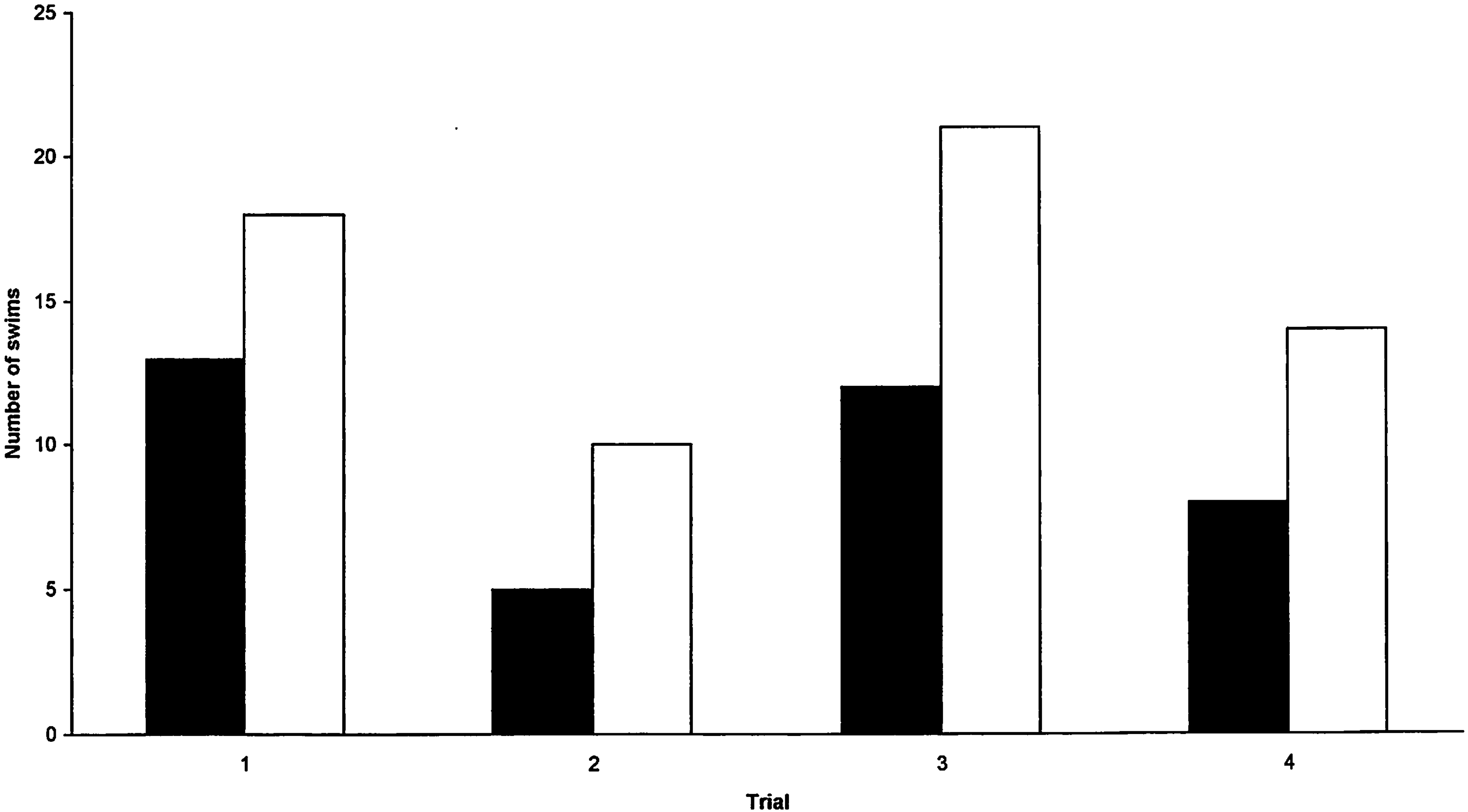


Figure 2. Particle size distribution for substrates.

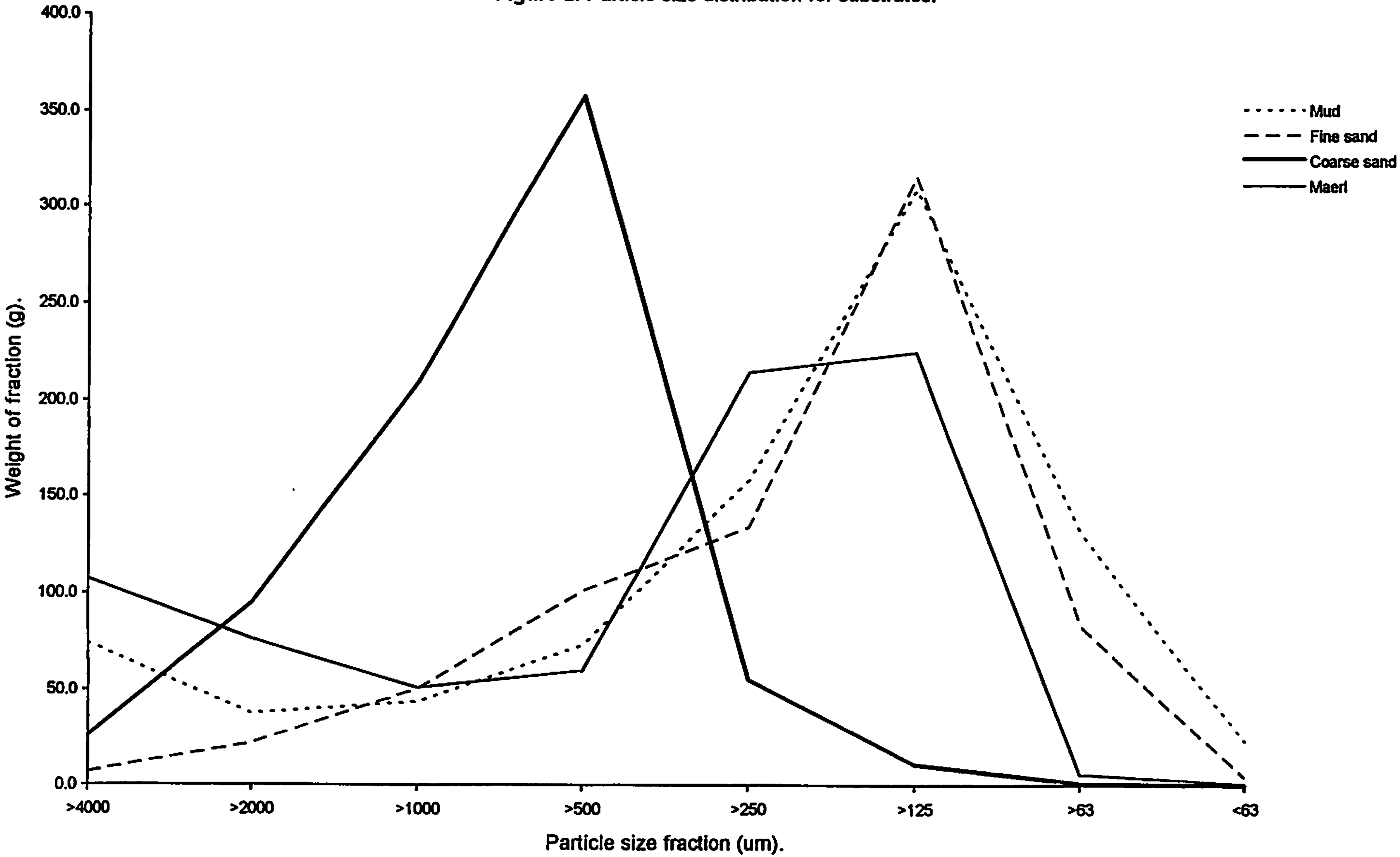


Figure 3a. Mearl\Coarse sand. (10/10/95)

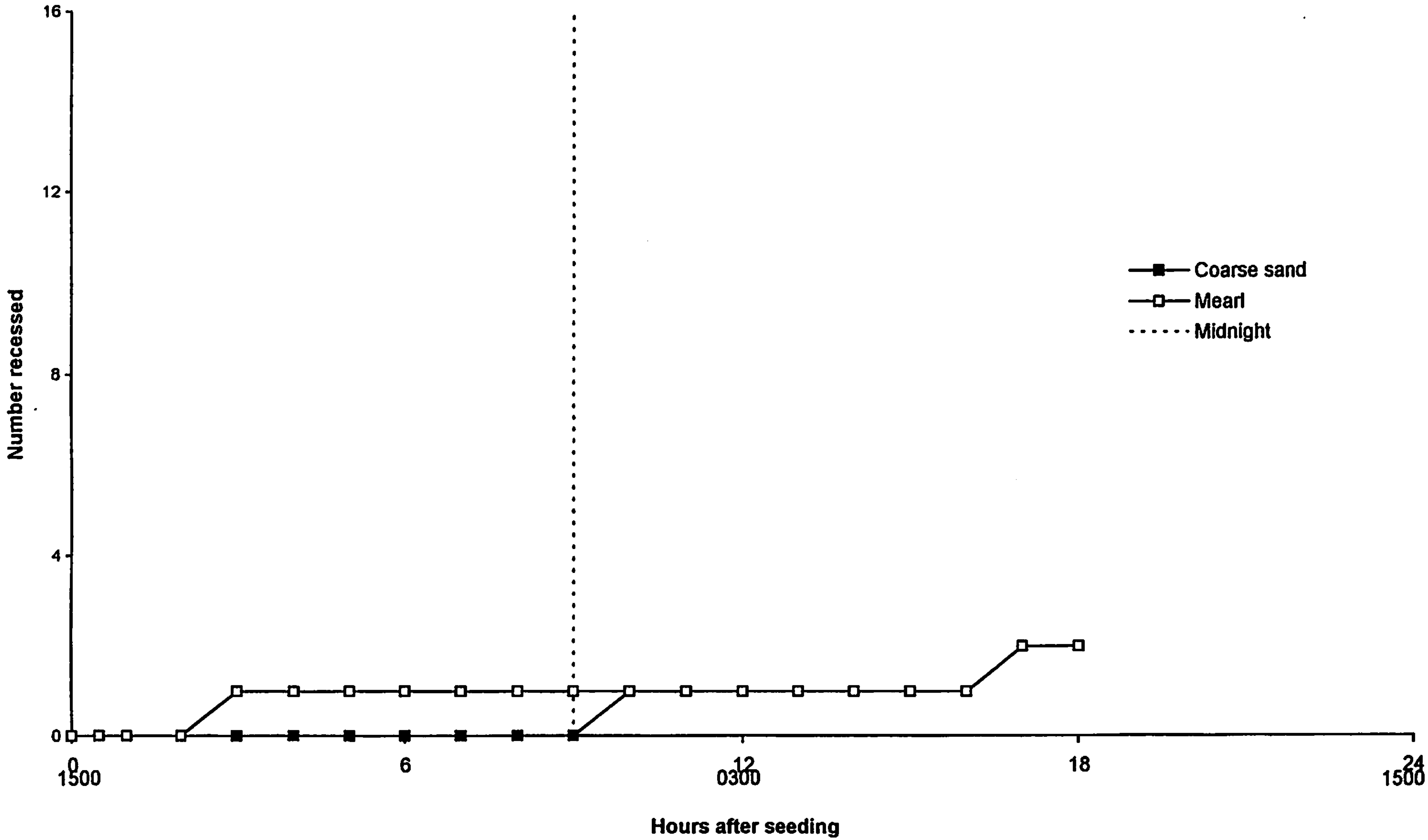


Figure 3b. Mearl\Coarse sand. (10/11/95)

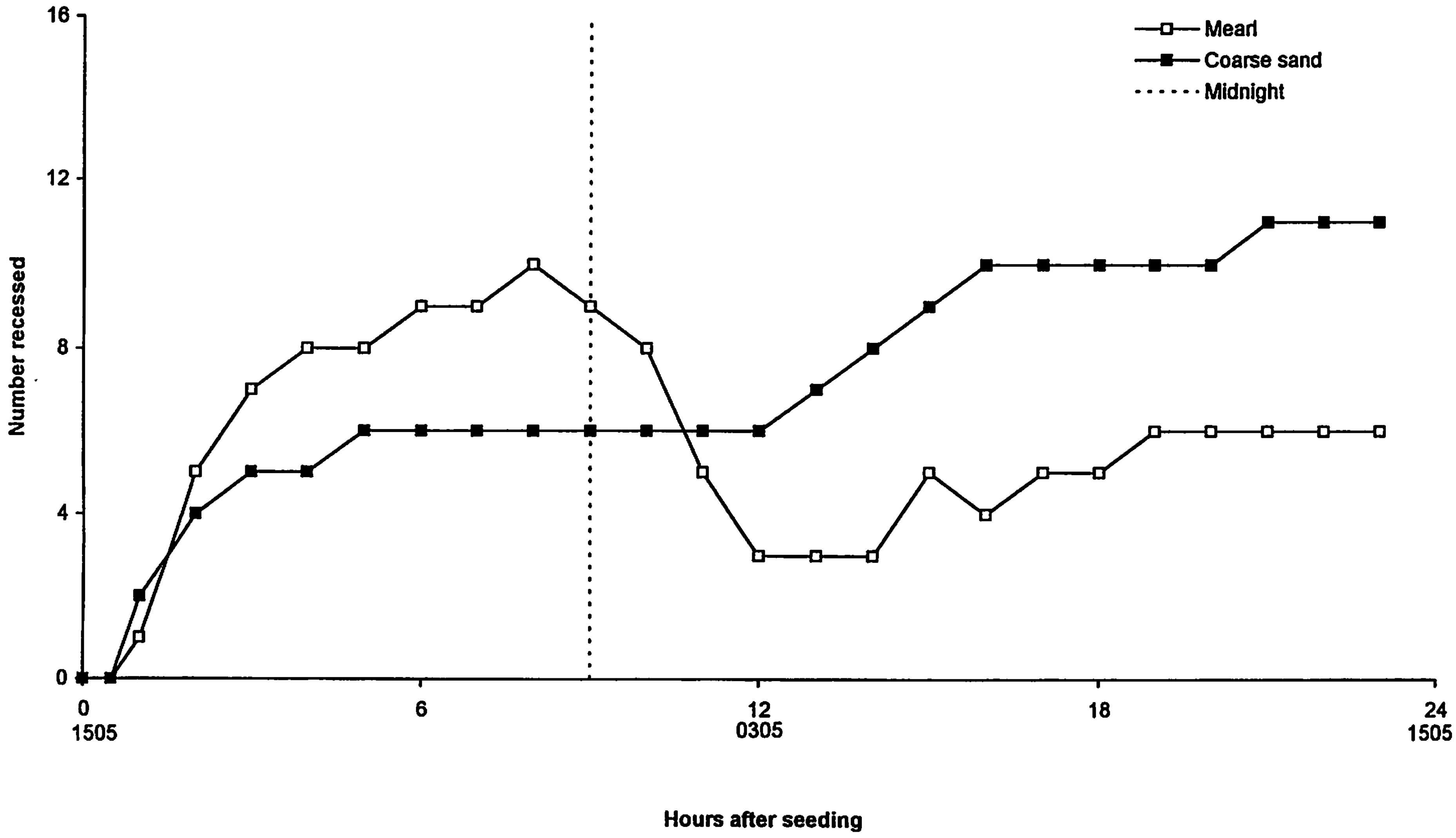


Figure 3c. Mearl\Coarse sand. (21/11/95)

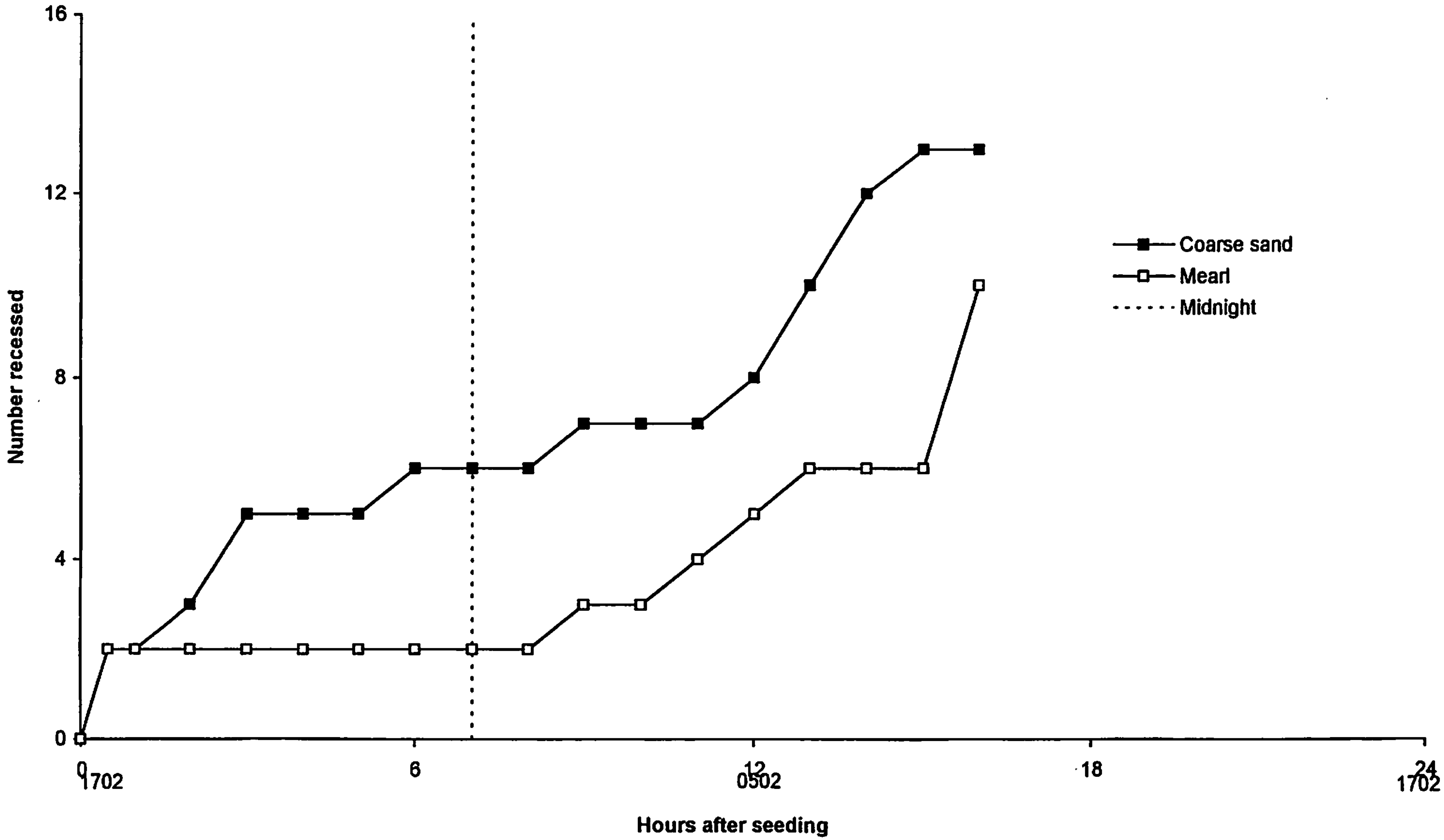
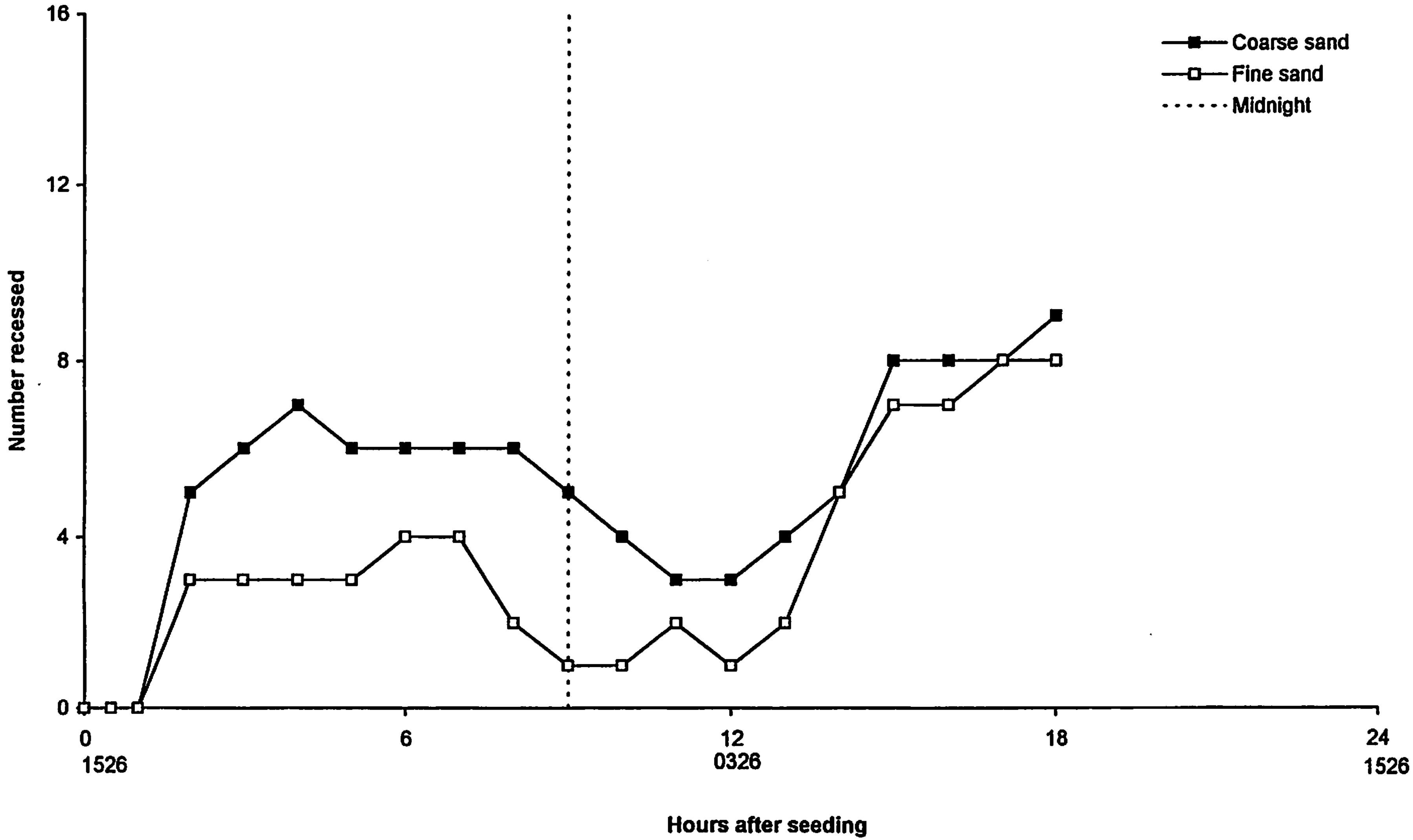


Figure 3d. Fine sand\Coarse sand. (08/11/95)



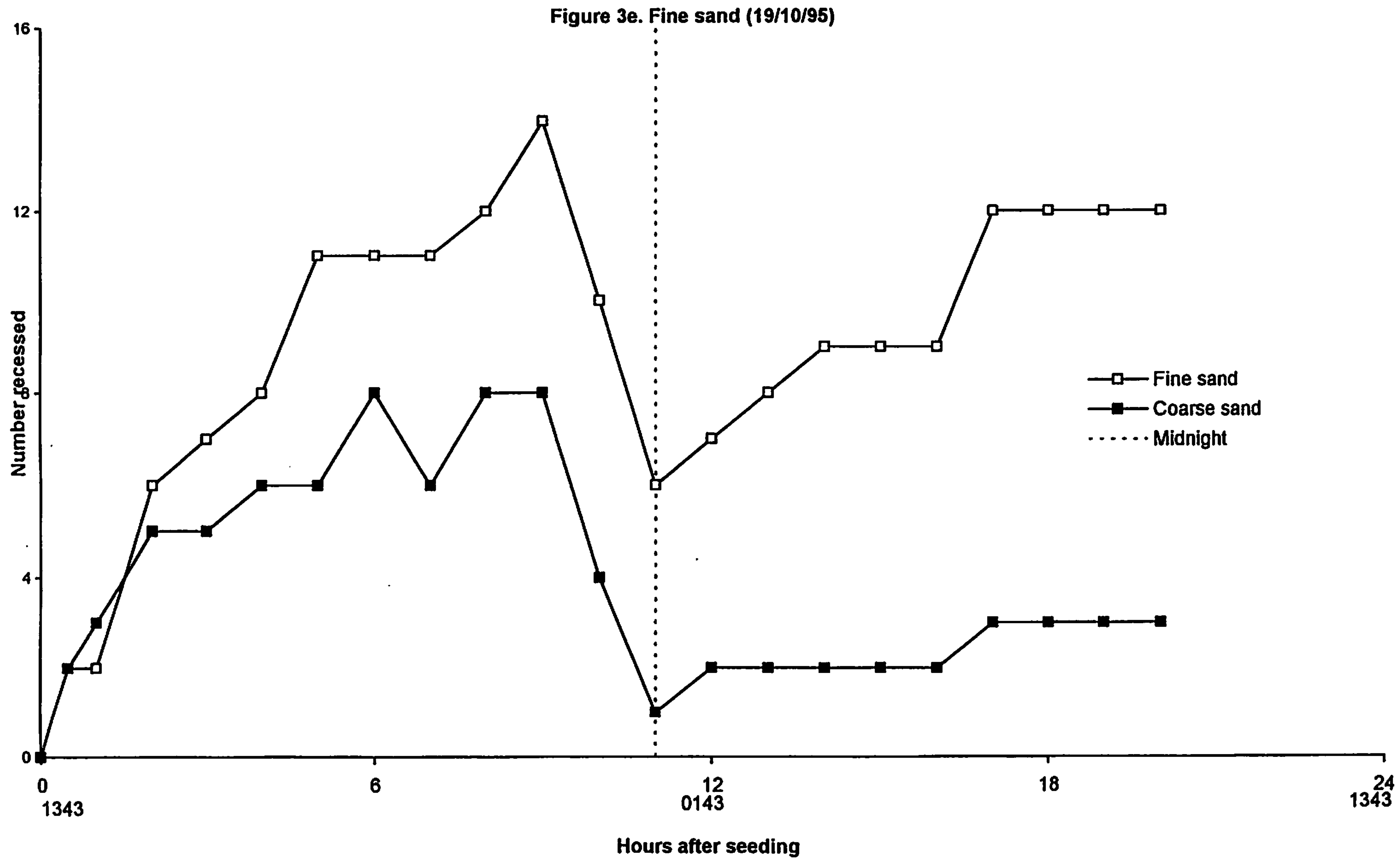


Figure 3e. Fine sand (19/10/95)
Number recessed
16
12
8
4
0
0
1343
6
12
0143
18
24
1343
Hours after seeding
Fine sand
Coarse sand
Midnight

Figure 3f. Fine sand\Coarse sand. (21/10/95)

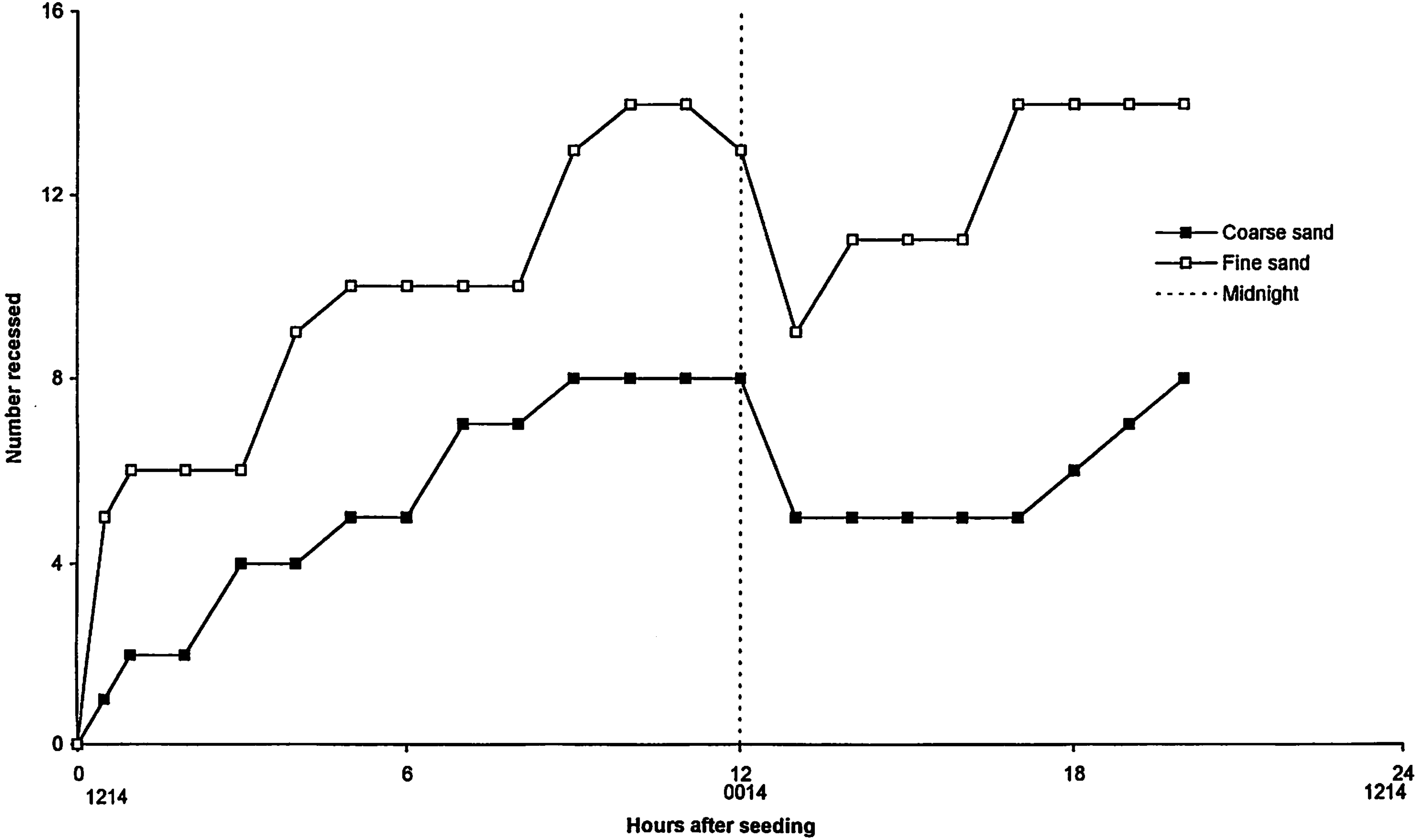


Figure 3g. Mud\Coarse sand. (28/10/95)

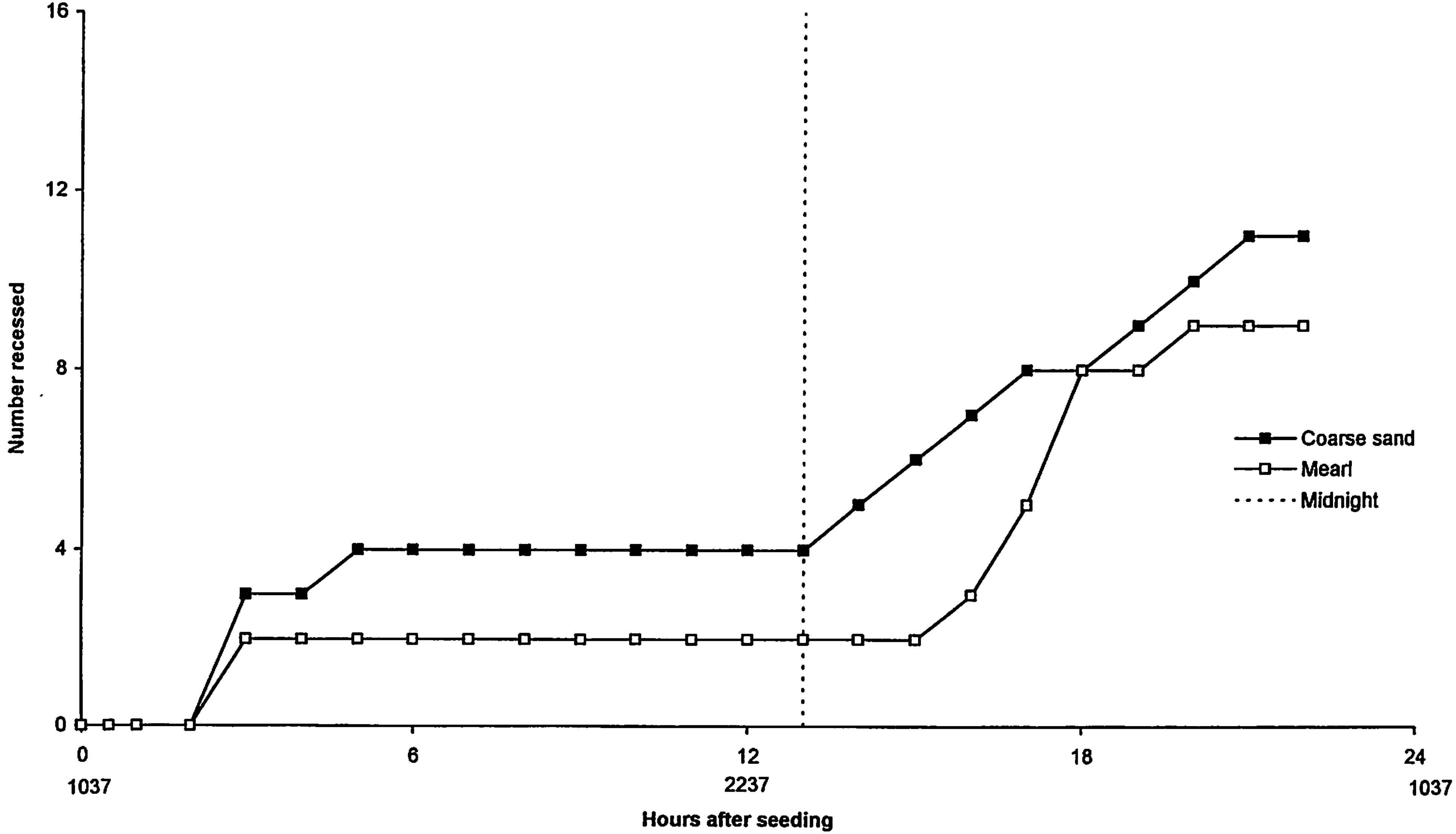


Figure 3h. Mud\Coarse sand. (04/11/95)

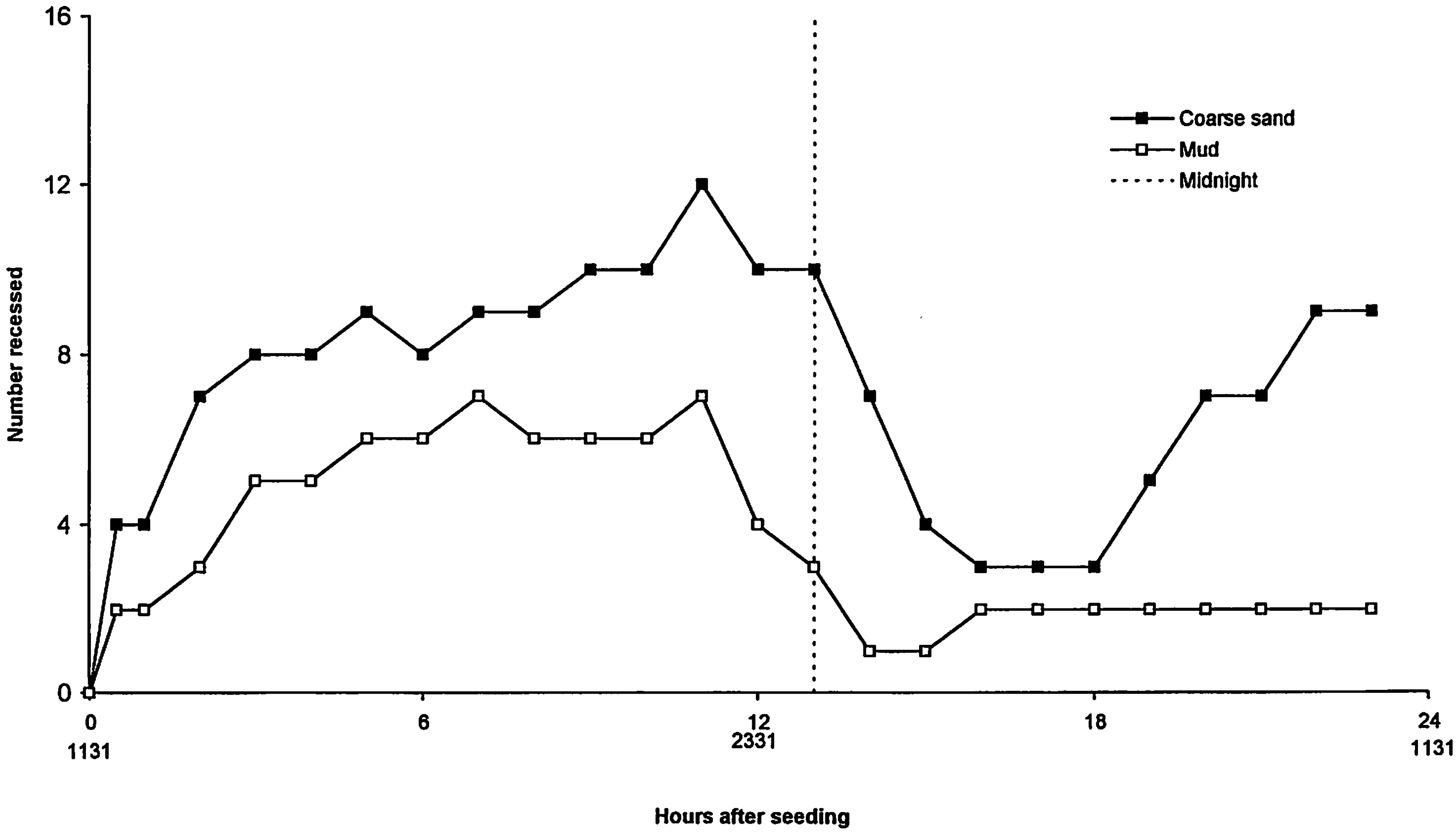


Figure 3i. Mud\Coarse sand. (14/11/95)

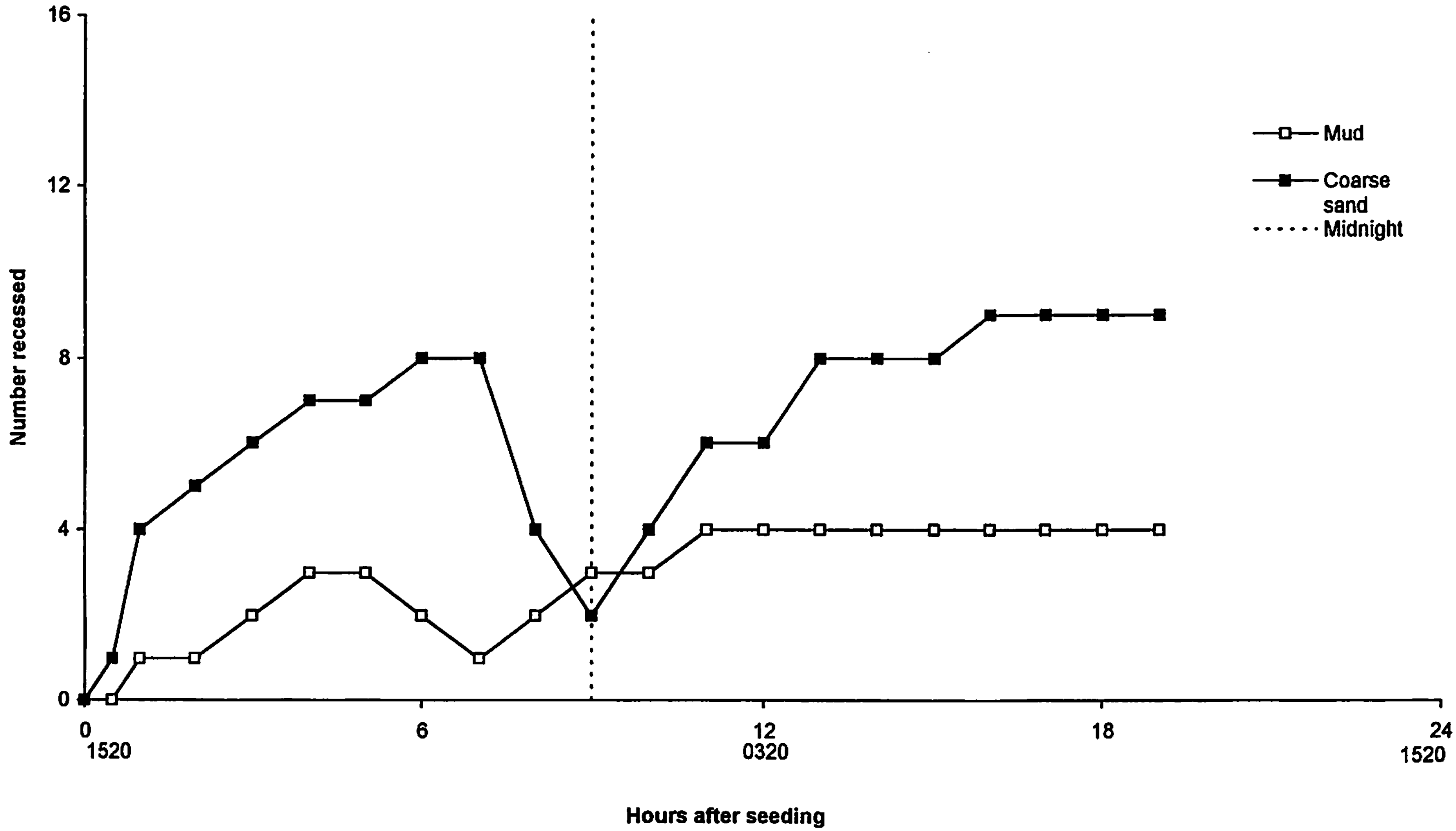


Figure 4a. Total directional movements in Tank A.

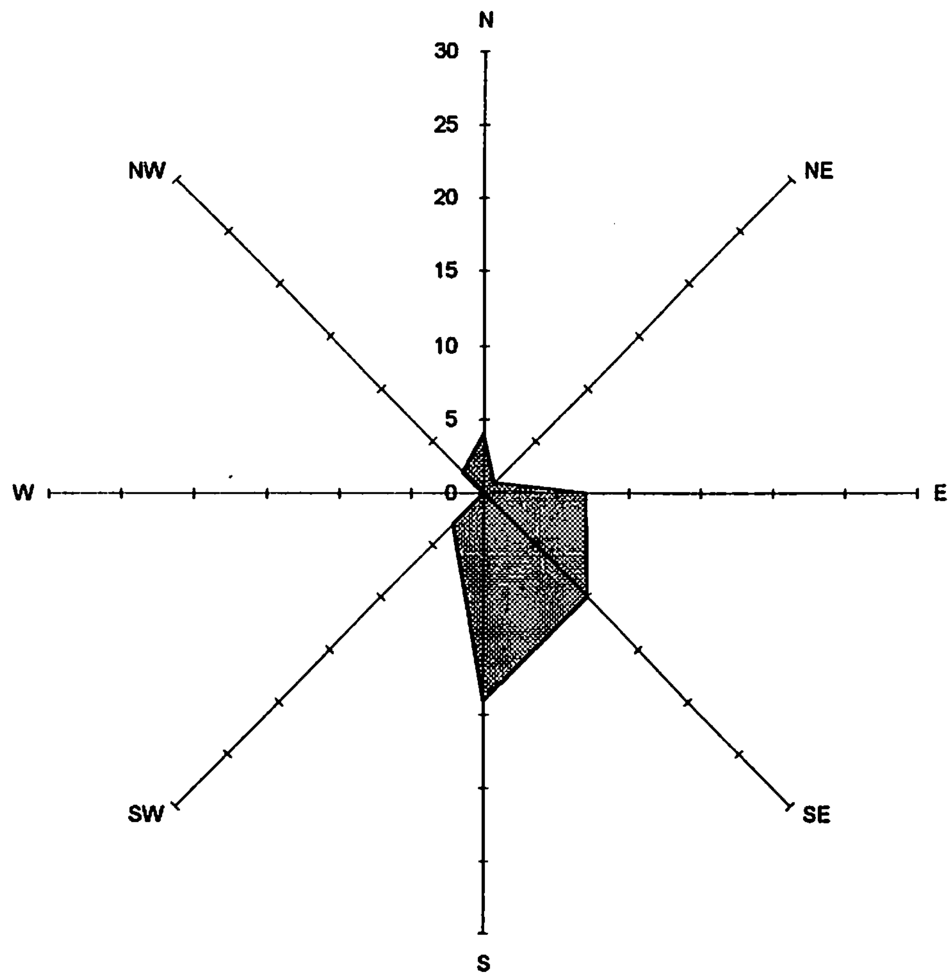


Figure 4b. Total directional movements in Tank B.

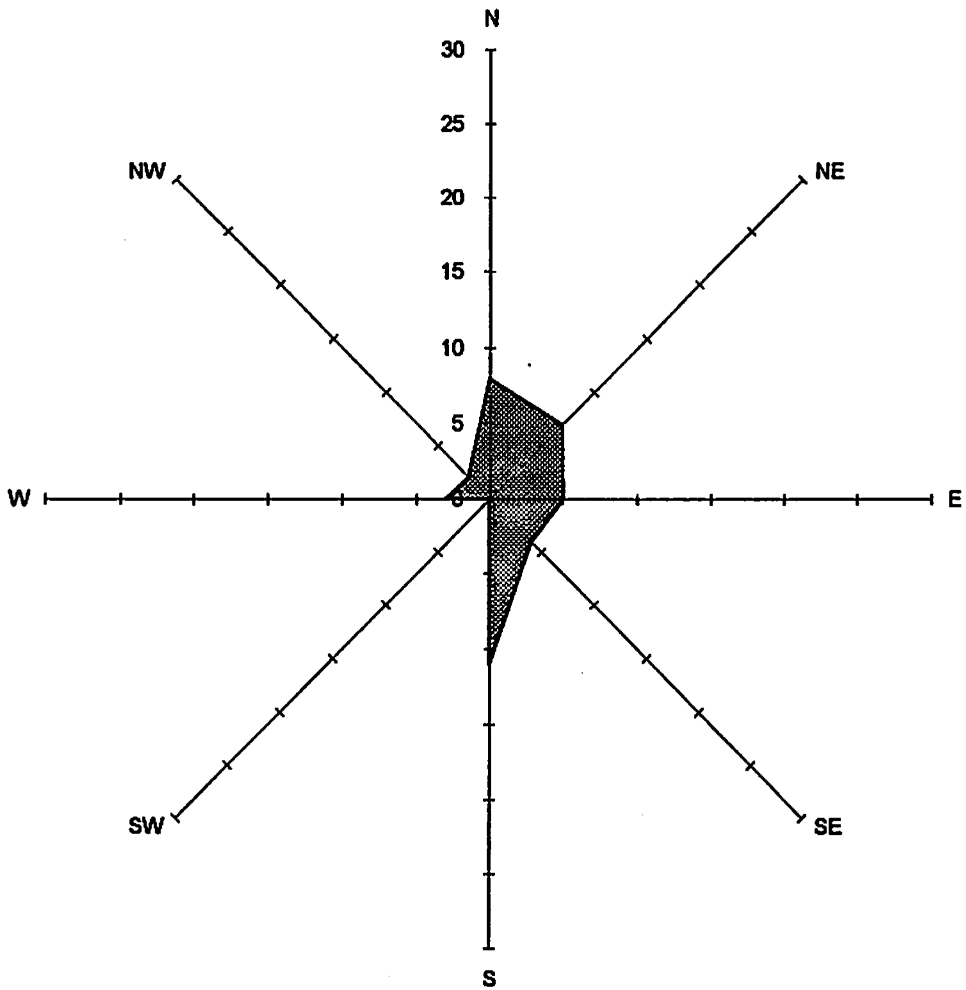


Figure 4c. Total directional movements in both tanks

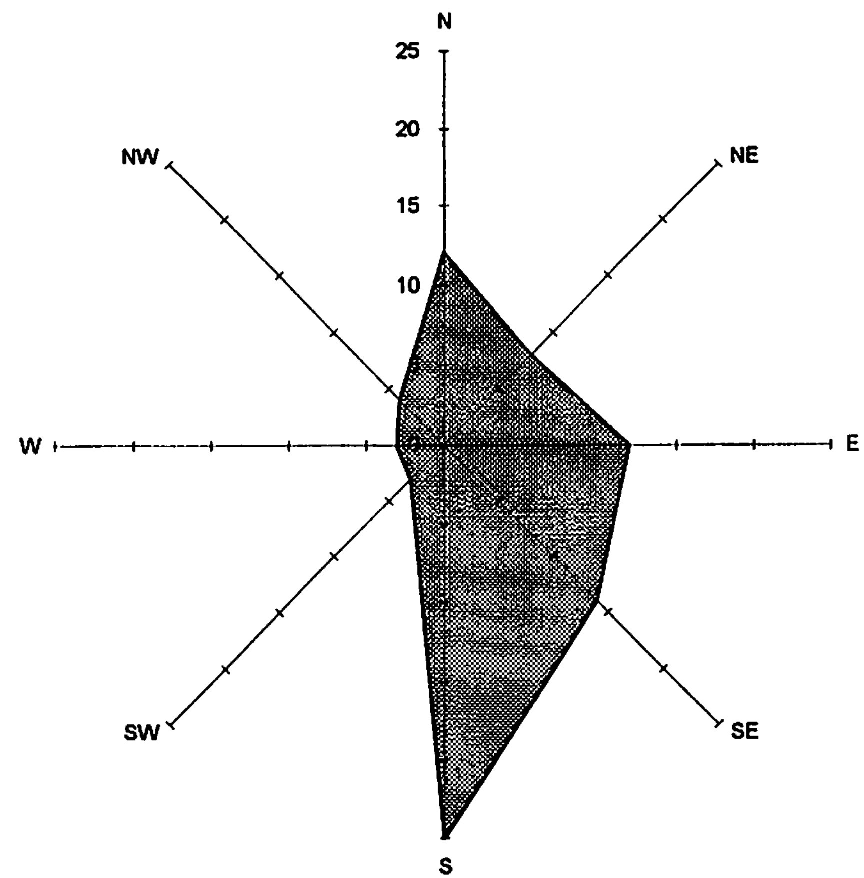


Table 2a. To show the swimming frequency index for each test substrate

	SFI	x	(+/-SE)
Mearl	0.66, 1.33, 2.00, 3.25	1.81	(0.55)
Fine	1.25, 2.30, 1.85, 1.80	1.80	(0.14)
Mud	1.38, 2.00, 1.75, 1.90	1.75	(0.22)

Table 2b. Date and time for each swimming trial

Substrate	Trial	Date	Time
Mearl	a	13-Dec	1500-1700
	c	21-Nov	1702-1902
	b	10-Nov	1505-1705
	j	11-Dec	1600-1800
Fine sand	e	19-Oct	1343-1553
	f	21-Oct	1214-1414
	d	08-Nov	1526-1726
	d	09-Nov	0900-1100
Mud	g	26-Oct	1037-1237
	h	04-Nov	1131-1331
	i	14-Nov	1520-1720
	i	15-Nov	0900-1100