FIRTA 79/70

FEASIBILITY STUDY FOR A COMMERCIAL OYSTER HATCHERY

IN TASMANIA

TASMANIAN FISHERIES DEVELOPMENT AUTHORITY

FEBRUARY 1979

As part of its development programme the Tasmanian Fisheries Development Authority has assisted persons interested in marine aquaculture. Oysters and mussels are already farmed on a commercial basis in Tasmania but oyster growers have been severely limited by the irregular availability of natural seed oysters called "spat". The cause of this irregularity is the dependence of the industry on a single spat collecting area, the Tamar estuary. Spat production is very susceptible to changes in the physical and chemical properties of the water in which the oysters spawn and therefore the permanent solution to the problem is artificial production of seed oysters under controlled conditions.

The Research Section of the Authority's Fisheries Division has been operating a pilot scale hatchery for some six (6) months and has demonstrated the technique and can provide specialist advice and training for technicians. The seed oysters produced in the pilot hatchery have proved ideal for commercial culture and almost 200,000 of these seeds are now being grown on commercial farms.

This Study, prepared by Mr. R.H. Watson an engineer with practical experience in operating oyster hatcheries, is based on proven techniques and available technology. It was partially funded with a grant from the Australian Fishing Industry Research Trust Account.

Whilst the Study comprises the design and projection of the economics of an operation to produce thirty million Crassostrea gigas, or Pacific Oyster, spat per year of size 3 to 4 mm. such a hatchery could also produce spat of a range of other commercially valuable shellfish with minimal alterations.

The economics of the feasibility study have been checked by the Tasmanian Department of Planning and Development who have supplied the table of cash flow and projected operational figures appearing at the end of the report.

A crucial factor to be considered in the establishment of a hatchery is the selection of a suitable site. As well as the availability of suitable water, the site must be reasonably close to a wide range of services specified in the Study. Thought should also be given to a ready availability of other specialist services such as chemical analysis and micro-biology which would not normally be available within the hatchery itself. Fisheries Development Authority will be available to advise respective operators of a hatchery on the details of site selection.

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MANAGER
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SUMMARY

The following report has been prepared for the Tasmanian Fisheries Development Authority to indicate the economic feasibility of a hatchery to produce 30,000,000/a Crassostrea gigas spat at a size of 3-4 mm.

As a site has not been specified, it has been assumed that a new building would be required; floor plans and equipment lists have been prepared accordingly.

The initial cost has been estimated as $325,000 (which includes $150,000 for the building and land) and the operating costs have been estimated as $190,000/a. Based on these figures, it would be necessary to charge $8.40/1000 spat to give a payback time of 12 years.

Four full-time staff are required for production with part-time assistance from two others for maintenance and book keeping.

CONTENTS

1 INTRODUCTION

Since commercial farming of the pacific oyster (Crassostrea gigas) began in Tasmania some ten to twelve years ago, the centre of natural spat collection has been the Tamar River. Unfortunately the natural catches have not been consistant and, after a promising beginning, the oyster industry is now facing severe difficulties because of shortages of spat. To alleviate this problem, a number of alternative sources of seed have been considered and the purpose of this report is to indicate whether a hatchery operating on a commercial basis could be successfully established in Tasmania.

Some ten years ago (c. 1970) the concept of commercial hatchery production of oyster spat seemed attractive and many hatcheries, both large and small, were built in a number of countries around the World. Unfortunately, all suffered severe 'teething' problems and most of them have now stopped production. The remainder have been transformed - sometimes drastically - and are now successfully producing spat on a regular basis. The superficial reasons for the difficulties were probably different in each case but it is most likely that almost all could be attributed to the lack of biological knowledge available and to lack of commercial experience by both staff and management. A hatchery built now would have the advantage to be gained from hindsight but it is obviously important that full use is made of our improved knowledge of larvae biology and associated subjects.

An important point that should be appreciated in considering the establishment of a commercial hatchery is that there are significant differences between an oyster industry based on hatchery produced seed and one based on natural set; whereas the overall economics of the two systems may be comparable, the equipment, handling techniques, and general management are different and it is not easy to switch from one to the other and back again. In Tasmania, some of the farmers have been able to do trials with spat produced at the Taroona Laboratory of the TFDA and they will recognise this.

The major differences between the two systems are summarised below:

	Hatchery Seed	Natural Seed
Cultch	Hatchery seed is best produced as singles - not on a cultch	Whatever is most suitable. Cultchless seed is not generally available.
Size	Seed cannot be kept in the hatchery past 4 mm and it is preferable to sell at 2 mm.	Any size - 10-15 mm average is typical.
Availability	All year round - a hatchery must despatch seed every week for ten months of the year.	Once a year.
Reliability	Success or failure depends on the designers and operators of the hatchery.	Success or failure depends on luck with some help from the farmer.
Price of Seed	High (c. $15-20 for 1000 adults for sale).	Variable - depending on the catch (c. $2-20/1000 adults).
Method of Cultivation	In trays, either hung from rafts or long-lines, or on intertidal racks	Depends on the cultch: spat on shell can be hung from rafts or long-lines; sticks for intertidal culture.
Attention	Trays and young spat must be cleaned frequently; older spat slightly less so.	After the initial laying out, very little until harvest.
Growth and Mortality	With good care, growth is fast and even; with poor care growth is slow and there is high mortality.	Depends on density on the cultch, but generally variable; some fast and some slow.

2 BASIS OF DESIGN

The specifications and design that follow are for a hatchery that will produce 30,000,000 spat of Crassostrea gigas per year of between three and four millimetres maximum shell length. To make the best use of all the facilities, production is to be spread evenly over a period of ten months with two months each year being set aside for maintenance, cleaning and staff holidays. Each week during the 10 month 'production year' a spawning is carried out and spat is despatched to on-growers.

Whereas the facilities required for raising other species of bivalve have not been considered, with few exceptions these would be much the same as those described here for C. gigas. Most bivalves have similar food requirements and larvae lifespans (2-3 weeks) when cultured at their optimum temperature. The major differences would likely be the setting and on-growing facilities required - the most obvious exception being Ostrea sp. which require different conditioning/ spawning facilities though otherwise they may be treated in the same way as C. gigas.

The hatchery has been designed to operate with a production staff of four (one each for: larvae/stock; spat; algae; algae/microbiology). For these operators to work efficiently it has proved necessary to duplicate some facilities so that one department's routine has a minimum effect on the others.

All equipment has been designed to be as simple as possible using standard techniques that have been proved to work in hatcheries elsewhere. Consideration has been given to the possibility of future expansion and, with minor changes in equipment, it is likely that considerably increased production could be achieved. However this would involve increased complexity of operation and it would not be appropriate to introduce such systems before the operators had experience with the 'basic' equipment described under the particular conditions of the selected site.

A site for this hatchery has not been specified and the characteristics of this will affect many details of the design - especially the primary seawater supply system. Where possible, the effects of site on the basic operations have been indicated in the appropriate sections.

The operations within the hatchery can be summarised by the flow diagram in Fig. I (below). Each stage is largely independent of the others and the factors considered in their design are discussed in the following sections.

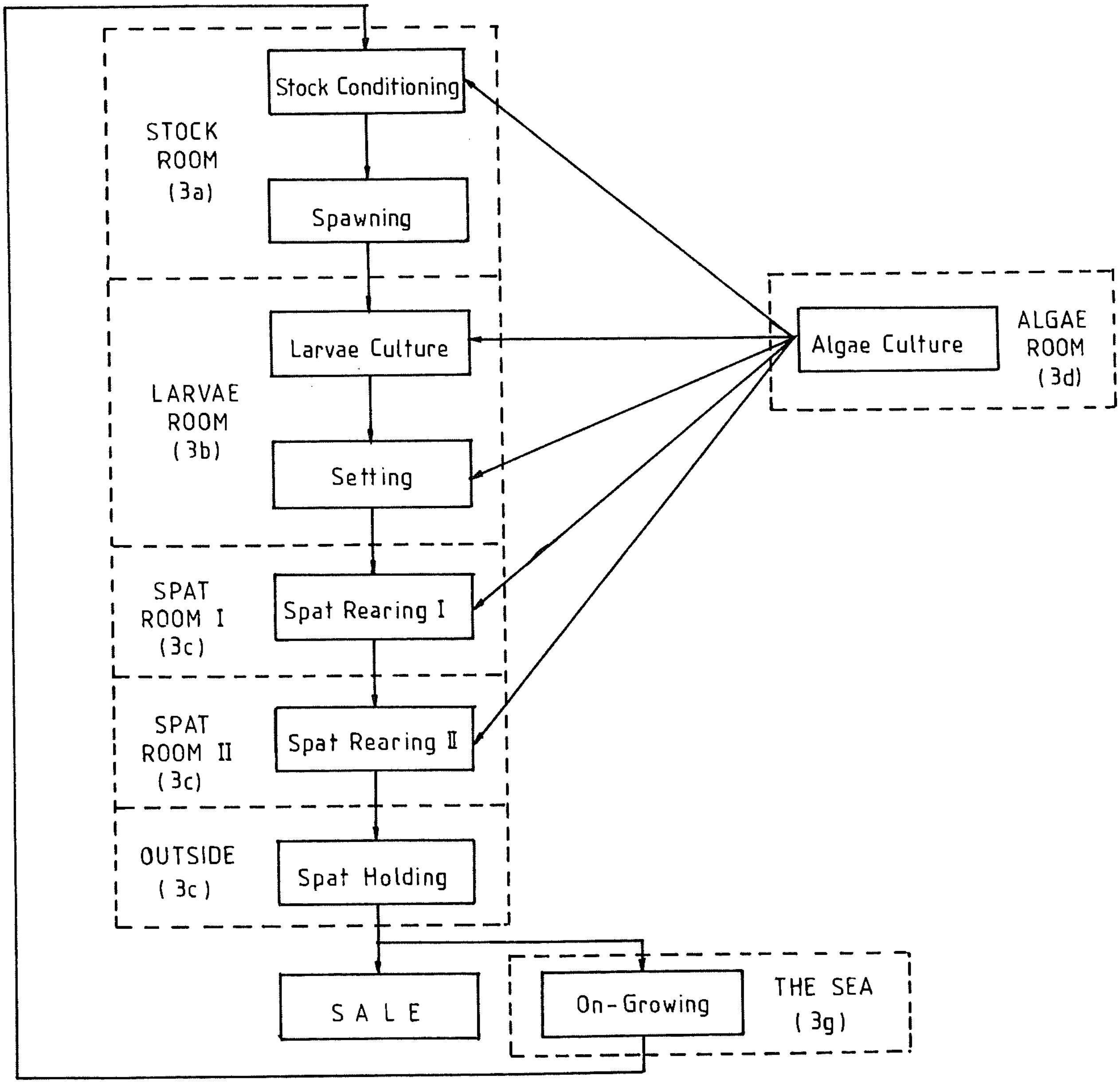

Fig. I - Hatchery Operations.

Data published by CSIRO indicates that the minimum winter temperature of the sea around southern Tasmania is about 6^{o} and this has been used in the design of heaters for the stock conditioning system where the demands are greatest in winter. Elsewhere, a base temperature of 10^{o} has been assumed as a typical winter seawater temperature. Should the actual temperature fall below this, and the heating systems for larvae and spat prove to be underrated, it would be necessary to reduce the water flow rate below that specified; it would take longer to fill the larvae and spat tanks than is generally considered desirable but the alternative is to have a considerably overrated heating system for most of the year.

TABLE I - Basic Design Data

Larvae/Spat size		Age		Density	No/batch	Culture vol. l
Screen u	Length mm	Days	Weeks			
25		0		50/ml	50 000 000	1 000
45		1		15	30 000 000	2 000
60		3		10	25 000 000	2 500
80		6	1	7.5	20 000 000	2 700
100		9		5	15 000 000	3 000
130		12		3	12 000 000	4 000
160		15	2	2	10 000 000	5 000
200		18		1	8 000 000	8 000
250		21	3	1	6 000 000	2 000
Settlement						
250		22		500/l	3 000 000	6 000
350		26		350	2 500 000	7 000
500		32	4	200	2 000 000	10 000
750		37	5	150	1 500 000	10 000
1000	1.0-1.5	42	6	100	1 250 000	12 500
1400	1.5-2.0	46		70	1 000 000	15 000
1800	2-3	51	7	40	850 000	20 000
2200	3-4	56	8	25	750 000	(36 000)

Notes:

Growth rates and densities are based on experience with cultures of C. gigas at 26^{0} but these figures are intended as a guide only as actual numbers will vary considerably from one batch to another.

The 'No/batch' assumes that 30 000 000 spat at 3-4 mm are to be produced annually in 40 weekly batches. The figures assume that c.5% of the larvae are discarded as bottom deposits each day and that the slowest 10% or so of each size group are discarded as 'slow growers'.

3a THE STOCK ROOM

SPAWNING STOCK CONDITIONING

In southern Tasmania, the water temperature seldom reaches that at which C. gigas will spawn, although the gonads will develop quite normally during the spring and summer months. During autumn, if the necessary spawning stimuli (of which a high temperature is the most important) are lacking, the ripe sperm/ova are broken down and converted into glycogen. The following spring the cycle repeats.

To 'condition' oysters so that they may be spawned throughout the year, the metabolic changes associated with spring are induced by holding the oysters at elevated temperatures with a plentiful supply of food. Because the oysters are never 'thin', as they would be had they spawned, it is relatively easy to condition them in the hatchery at any time of the year.

The time required for conditioning will depend on the holding temperature and the state of the oyster gonads when the adults are first brought into the hatchery. In summer the oysters may well be naturally ripe and need little, if any, artificial conditioning, whereas in winter up to ten weeks may be necessary for stock being held at 21°. This time may be reduced to as little as two weeks if the temperature is raised to 30° but then there is a considerable risk of spontaneous spawnings. At 21° this risk is negligible and so can be considered the maximum 'safe' temperature.

To produce a batch of 750 000 spat it is necessary to start with some 50 000 000 fertilized eggs (see Table I, p.6). Three or four females and one male will usually give at least this number, so allowing for only half of any batch to spawn readily, and for a 1:1 male/female ratio, some 15 oysters should be prepared for spawning each week. As the longest time required for conditioning is likely to be 10 weeks, the proposed stockroom has facilities for holding 150 adults in 20 tanks. Several small tanks are preferable to one large one because they are easier to manage and even at 21° there is the possibility of an uncontrolled spawning of ripe oysters.

There are indications that the physical environment of the stock oysters has an effect on the ease with which they will spawn and on the health of the offspring. The main requirement seems to be for as little disturbance as possible - especially with regard to water supply which should be continuous and the temperature should not fluctuate by more than a degree or so about the mean. As the tanks are small and hence prone to rapid heat loss, the air temperature in the room should be maintained at 21°.

Water Requirements:

For simplicity, a flow-through water system with electric heating has been proposed. Such a system allows the use of small tanks and requires less food than a recirculating system although the water heating costs will be greater.

The flowrate of water required for the stock tanks depends primarily on the number of oysters being held and their pumping rates. In turn, the pumping rate of an oyster will depend on its size, the concentration of food in the water and water temperature and flowrate. In fact there is little experimental data published to give guidance on choosing the optimum flowrate for conditioning bivalves and the flows used in different hatcheries vary widely - probably being governed more by the facilities available than anything else. At 21° a flowrate of 2 l/oyster/hr has been found to be suitable under conditions similar to those to be expected in southern Tasmania. On this basis, the maximum number of oysters to be held at any time (150) will require a total flowrate of 300 l/hr.

An alternative to electric heating would be to use a titanium heating panel connected to the hot water boiler. If the boiler is to be operated continuously for space heating, such a system would be more economical to operate than electrical heaters, but the capital cost would be greater. It is possible that there could be a problem with temperature control when the high loads imposed by the larvae and spat heat exchangers were adjusted and this would have to be assessed by experiementation.

Feeding:

During the conditioning process, the oysters require only sufficient food to maintain themselves while their glycogen reserves are being converted to eggs or sperm. Part of this food will come in with the unfiltered water but at most times of the year a supplement of cultured algae will be required also. This supplement is continuously to the water at a rate of about 50 cells/ul*. Thus, with a water flowrate of 2 l/oyster/hr, each oyster will require 0.25 l/day of algae (at 10 000 cells/ul), and when the maximum number of oysters are being held (150), a total of 37.5 (say 40) l/day will be needed.

The food should be of the same quality as that given to the larvae and spat - any poor quality food is better thrown out than given as an 'extra' for the stock.

Oysters can be conditioned without food, but then the energy required for metabolism is drawn from the glycogen which will thus reduce the number of eggs produced. There is also a possibility that the quality of the eggs and viability of the subsequent larvae is less from starved than well nourished oyster.

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*of Isochrysis, or equivalent of other algae species - see p. 53.

SPAWNING

When their gonads are fully ripe, C. gigas readily spawn when stimulated by putting them into warm seawater (26-28^{o}) with, perhaps, some sperm suspension from a stripped male. If the oysters do not spawn after an hour or so when thus treated, it is usually because they are not completely ripe and more time in the conditioning tanks is required.

The number of eggs produced by a feamle will depend on her size and on how complete a spawning is achieved. However, a well developed one to two year old gigas should give at least 10 000 000, and perhaps as many as 40 000 000, eggs so a typical spawning intended to give 50 000 000 fertilized eggs should require no more than three or four females. One male will give more than enough sperm to fertilize these eggs.

The water required for the spawning should be at 28^{o} and filtered. The amount required may be anything up to 500 l so it is convenient to fill a header tank shortly before the spawning is to take place so that water is available as required. The simplest way to do this is to use the water supply system provided for the larvae room as the treatment on the water is similar. The header tank can be of the same design as the stock conditioning header tank and a small heater (1KW) may be required to maintain the temperature of the water if some time elapses between filling and using.

ROUTINE LABOUR REQUIREMENTS

The stock require little regular attention. Every day the food supply must be replenished and the water line from the header tank to the stock tanks should be flushed through momentarily to remove any accumulated debris. The conditioning tanks can be cleaned weekly - perhaps while waiting for action in the spawning tanks.

The time necessary for a spawning can vary from two to four hours depending on how ripe and co-operative are the oysters.

EQUIPMENT LIST

No	Item	Cost $
2	Header Tanks - 1000 l - insulated with lids @ $500	1000
3	Immersion Heaters - 3 KW - with controls @ $130	400
1	Immersion Heater - 1 KW - with controls	150
1	Seawater Pump - 450 l/h - 0.2 KW - with controls	350
1	Food Storage Tank - 100 l	50
1	Dosing Pump - 100 l/h	250
20	Stock Conditioning Tanks - 300 by 200 by 150 mm	200
1	Spawning Tank - 500 by 250 by 100 mm - black	50
10	Buckets	100
	Pipe fittings for conditioning tanks	100
	Timber for racks, sink, etc.	100
	Other	250
	TOTAL	$3000

OPERATING COSTS

Power:

Item	Rating	Hrs/a	Consumption
Seawater pump	0.2 KW	3000	600 KWh/a
Dosing Pump	0.1 KW	8000	800
Stock header tank heaters	9 KW	4000	36 000
Spawning tank Heater	1 KW	200	200
Other			2 400
Total	10.3 KW		40 000 KWh/a @ $0.04/KWh: $1600/a

Maintenance and Repair : $ 400/a

TOTAL $2000/a

EQUIPMENT SPECIFICATIONS

For the stock conditioning a maximum water flowrate of 300 l/h at 21° is required. The water is pumped from the main storage/settling tank into a header tank where it is heated using three 3 KW immersion heaters. The water flows from the header tank into a manifold in the stock room below. The manifold feeds 20 stock conditioning tanks which are arranged on a two tier rack. The overflow from the tanks runs into guttering which takes the waste to a floor drain. Food is added to the stock header tank by a peristaltic dosing pump at a rate of 50 cells/ul (Isochrysis equivalent).

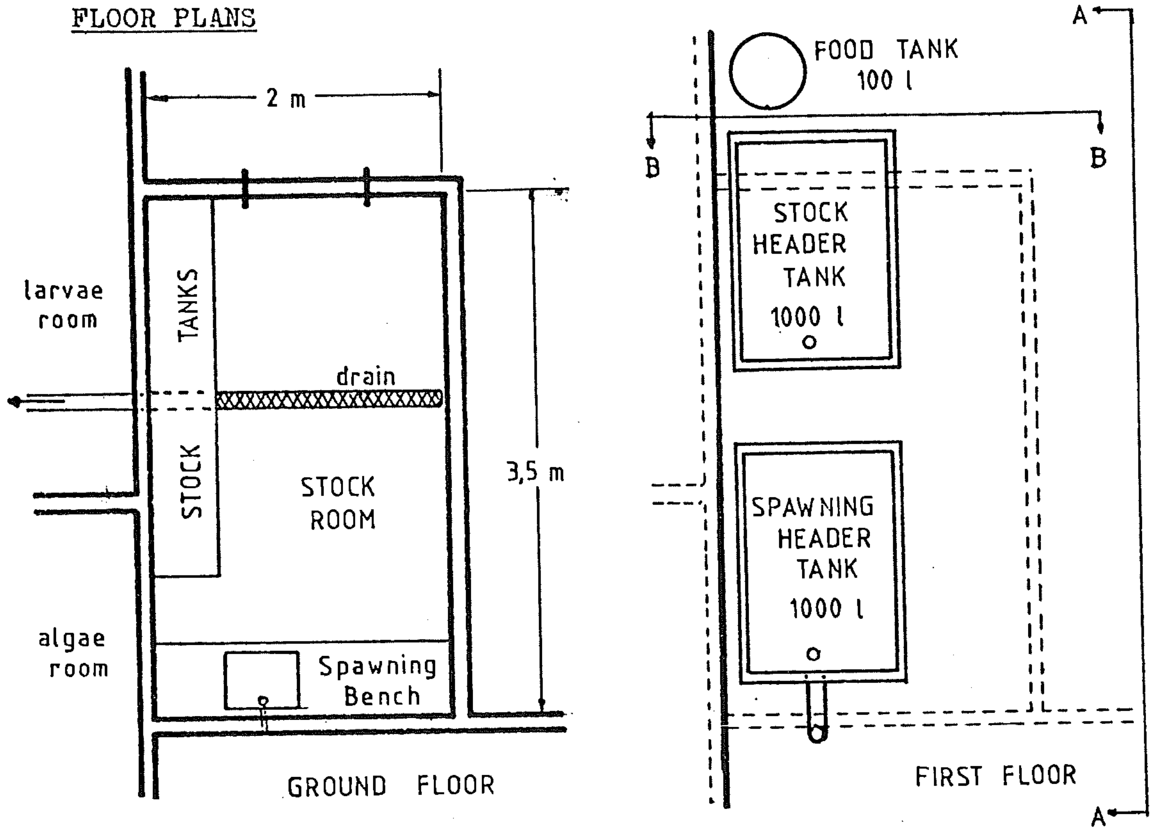
Shortly before a spawning is to be carried out, the spawning header tank is filled with filtered water at 28° using the larvae water supply system. This water is piped to the spawning bench in the stock room and can be used as required.

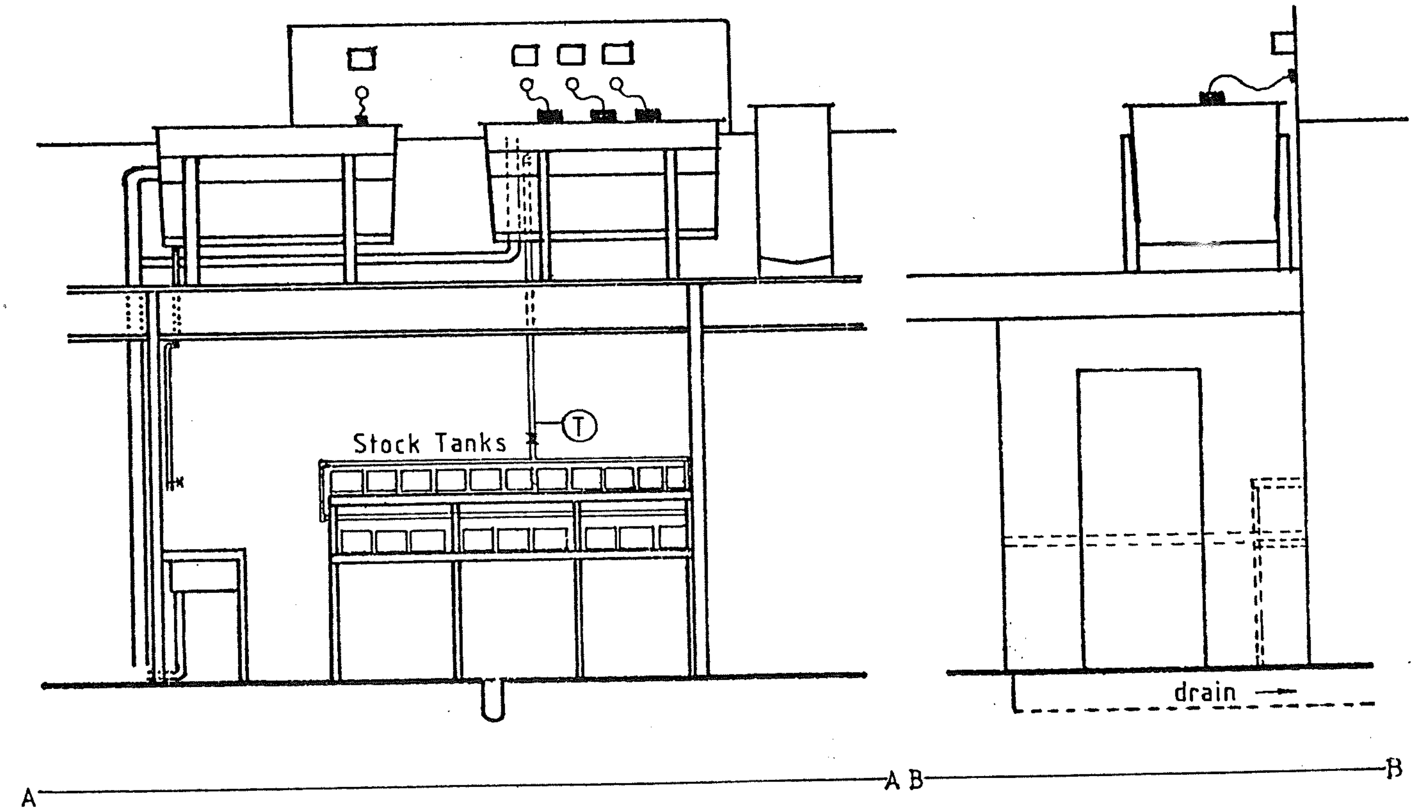
THE SEAWATER PUMP

The seawater pump should deliver between 350 and 600 l/h to the stock header tank and is controlled by a float switch there. If the main seawater holding/settling tank is above the level of the header tank, this pump is not necessary and the feed would be by gravity controlled by a ball cock in the header tank.

3a The Stock Room – Equipment Specifications (cont.)

FLOOR PLANS





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THE STOCK HEADER TANK

As flow is continuous from the tank and intermittent into it, the size of the tank is governed by:
The depth, which should be sufficient to keep the heaters immersed. For 3 KW Vitreosil heaters this would be 0.7 m (minimum).
The surface area, which should be sufficient to allow reasonable control for the filling pump. Say that the pump is not to be switched on more frequently than once in ten minutes, and allow a maximum level differential in the tank of 0.1 m. In ten minutes the maximum flow from the tank will be 50 l, so the tank surface area must not be less than 0.5 m^2.
The volume, which should be sufficient to ensure that the water can be well mixed and of even temperature. The addition of 50 l of seawater at 6^o should not alter the tank temperature by more than one degree.

$$\text{Thus} : V . 20 = (V - 50).21 + 50 . 6$$
$$\text{ie.} \quad V = 750 \text{ l}$$

It is convenient to use a 1000 l tank of the same design as the larvae set tanks. These tanks have an effective volume of 900 l and a surface area of 1.35 m^2, so the pump float switch differential should be about 50 mm. The outlet from the tank should be arranged such that in the case of a pump failure the heaters remain immersed - ie. 0.35 m from the top of the tank.

There should be a drain/overflow so that the tank can be emptied for cleaning and so that the tank cannot overflow should the pump fail to switch off for any reason. The size of overflow pipe required will depend on the maximum flow of the pump, but 50 mm diameter is likely to be sufficient. The drain joins with that from the spawning tank and leads into the washroom (or the floor drain in the stock room).

The water is mixed within the tank by air from a line along the bottom.

The tank should have a lid and be well lagged to reduce the heat losses to a minimum.

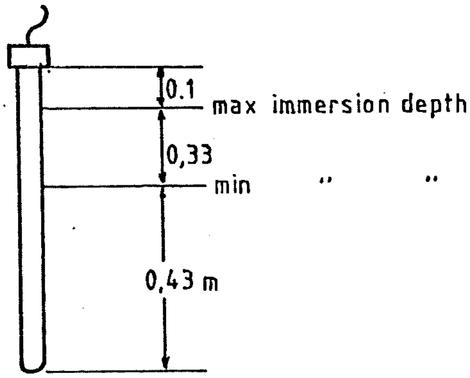
The Heaters:

Say minimum inlet temperature (raw seawater) is 6^{o}
maximum outlet temperature is 21^{o}
and maximum flowrate is 300 l/h (0.1 l/s)

Then maximum heating required is : 0.1 . (21 - 6) = 1.5 Kcal/s
\- 6.3 KW

Allowing for heat losses, three 3 KW heaters are required.

eg. Vitreosil immersion heaters:



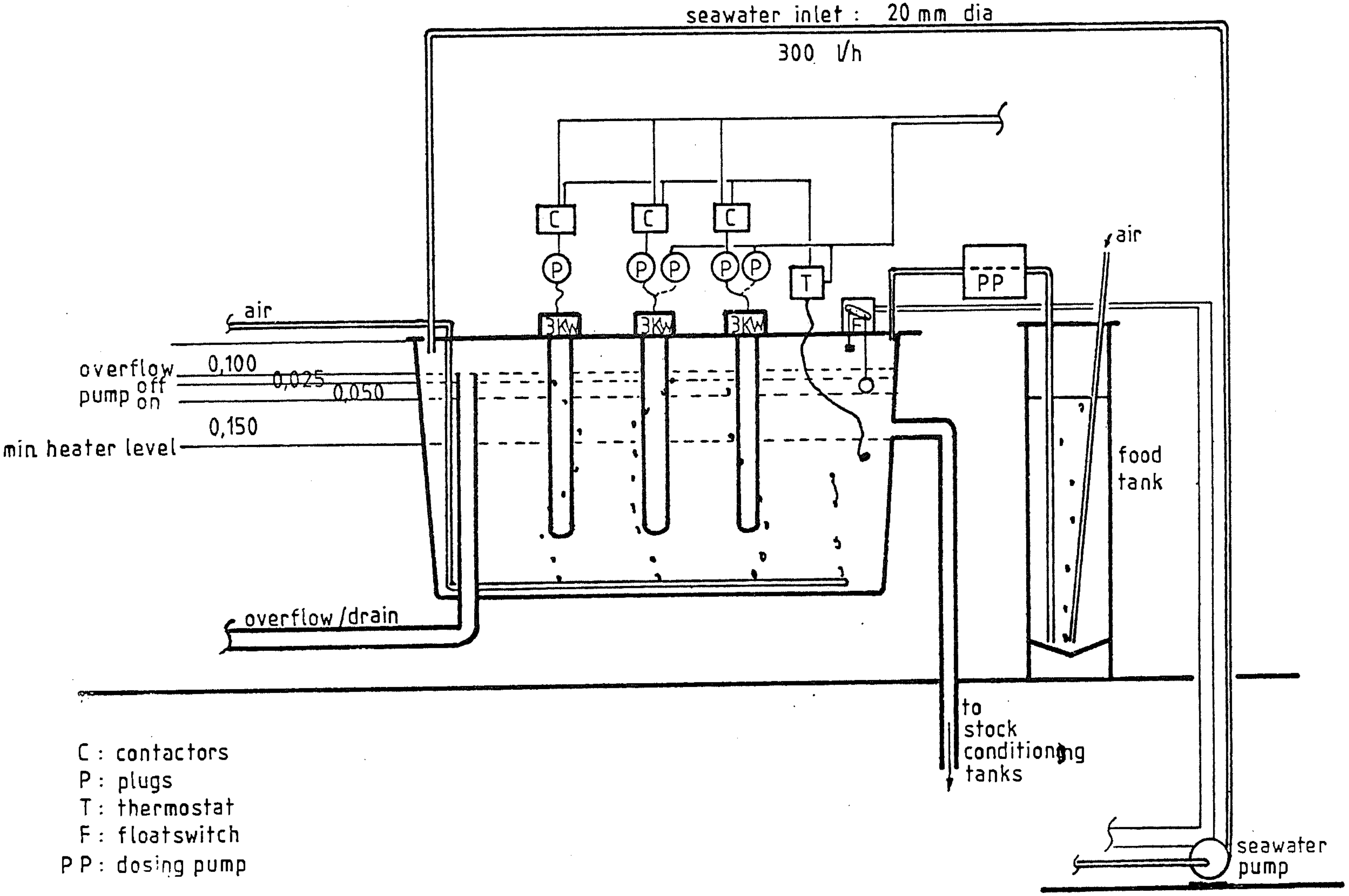
The heaters are controlled by a thermostat which has its sensing probe near the tank outlet. It may be possible to obtain more even temperature control by either completely disconnecting, or by leaving permanently switched on, one or two to the heaters and allowing the thermostat to control the remaining one or two. The effectiveness of such a procedure will depend on the flowrate out of the tank and the temperature of the incoming water.

THE FOOD TANK

The food is kept in a 100 l tank of a design similar to that of the tanks used in the algae room (see p.64) though it need not be transparent.

A peristaltic dosing pump is used to transfer the algae into the header tank over a 24 hour period. A drip feed system is not satisfactory because the fine aperture tubing necessary to control the flowrate becomes blocked too easily.

The Stock Header Tank:

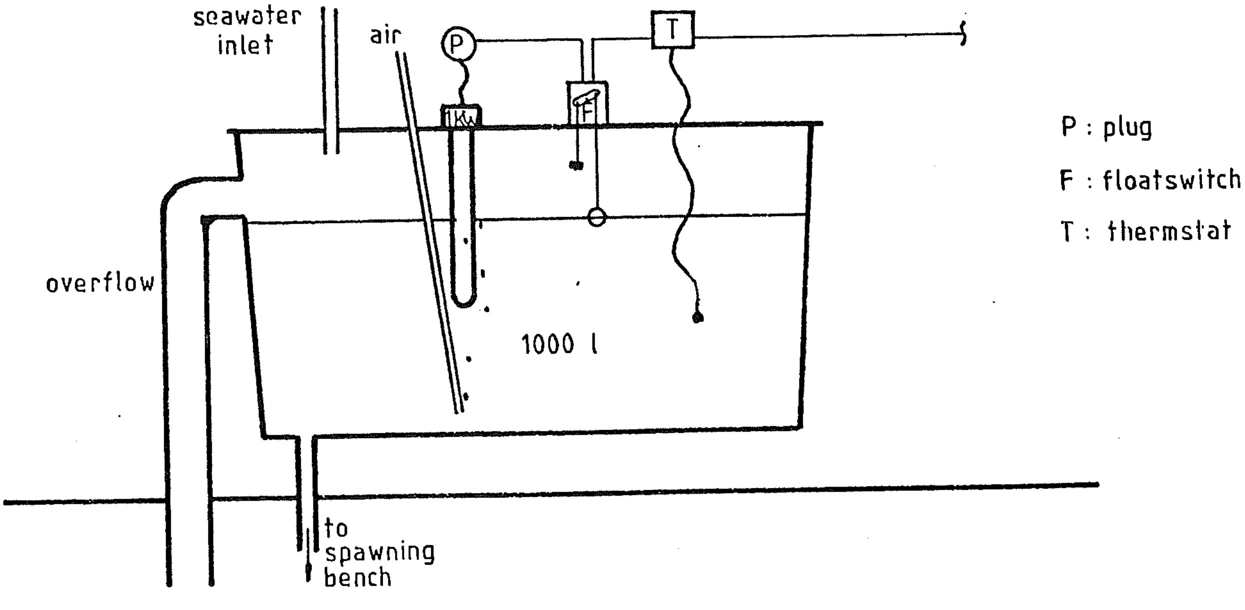


C : contactors
P : plugs
T : thermostat
F : floatswitch
PP : dosing pump

THE SPAWNING HEADER TANK

The volume of water used during a spawning can vary from 200 l to perhaps 750 l depending on the ease with which the oysters are stimulated. It would be convenient to use a 1000 l tank of the same design as the stock header tank and larvae set tanks (see p.33 for dimensions) and this is mounted above the stock room adjacent to the stock header tank. As the tank is to be filled quite rapidly (c. 5000 l/h) using the larvae water system, it is necessary to have a large diameter overflow pipe in case of accident.

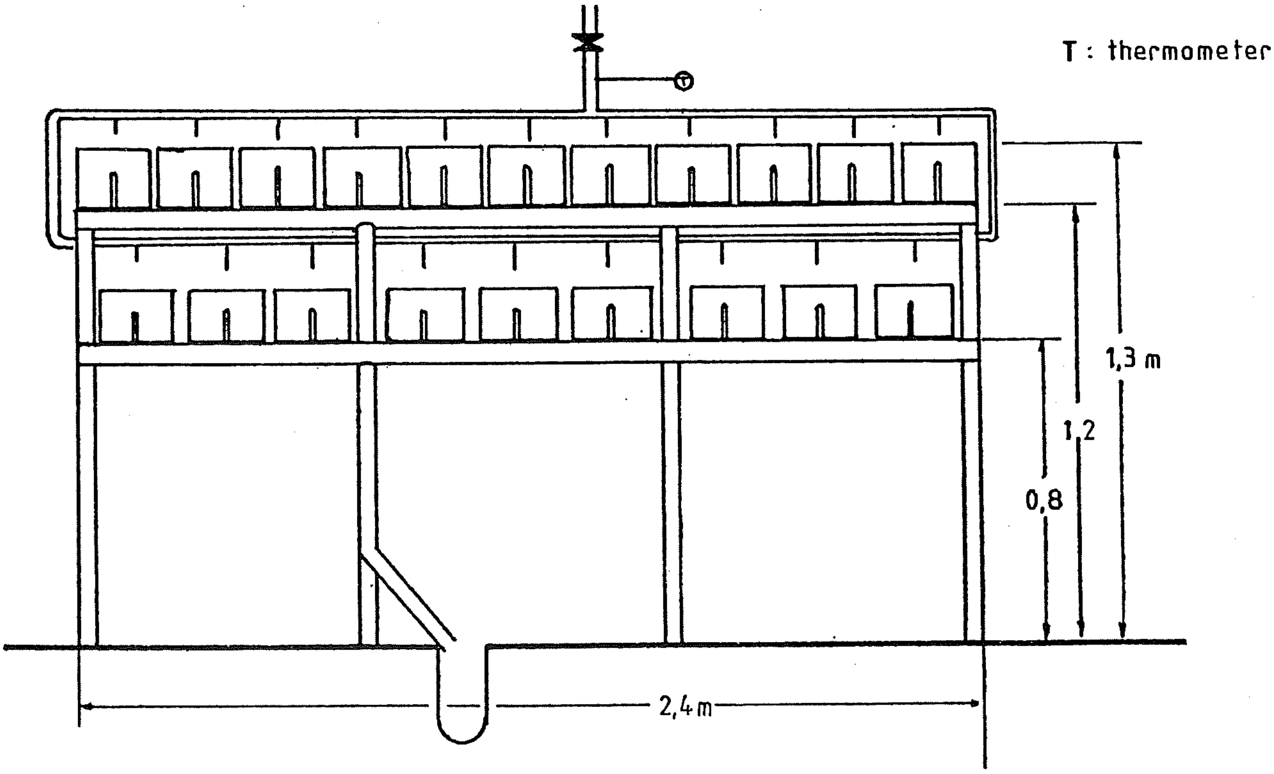
The tank should have a lid and be well lagged to reduce heat loss to a minimum and in winter it may be necessary to use an auxiliary 1 KW heater to maintain the required temperature. If so this heater must be controlled by a thermostat and float switch so that it is automatically switched off when the water level drops below the minimum immersion depth for the heater.



STOCK CONDITIONING TANKS

The heated seawater flows from the header tank to the stock room below where it is distributed to the 20 stock tanks via a manifold. The pipework in this section should be 25 mm dia. so that flow into any of the stock tanks can be adjusted without affecting the flow to the others. As this line contains warm unfiltered water, it will quickly become heavily fouled and should be designed to be easily taken apart for cleaning.

The stock tanks need be of sufficient size to hold 7-8 oysters in about 100mm of water. Suggested dimentions are: 300 by 200 by 150mm. The flow to each tank is controlled by a pinch valve on a short length of soft airline tubing and the tank overflows are led into the floor drain.



SPAWNING TANK

The spawning tank should measure about 500 by 250 by 100 mm and be made of black plastic so that eggs and sperm are readily distinguishable by eye.

3b THE LARVAE ROOM

LARVAE CULTURE

The fertilized ova and larvae are cultured in tanks of filtered seawater at 26-27^{o} and the density at which larvae of different sizes should be cultured is indicated in Table I (p.6). Where possible, larvae of different sizes within a batch should be cultured separately, as it is found that in a culture containing a wide size range, the larger larvae will grow at the expense of the smaller.

The figures suggested in the No/batch column of Table I allow for the slowest 10% or so of each batch to be discarded each time the bulk of the batch moves from one screen to the next. Allowance has also been made for a small percentage of the larvae remaining in the tank after the water has drained out; whilst these bottom deposits will usually contain many healthy larvae, any sick or dead will also be there and it is usually best to discard them to help control the bacterial population in the cultures.

The cultures should be aerated to encourage even distribution of the larvae and algae within the tanks. An air flowrate of 4-6 l/m is sufficient for each tank.

The Larvae Tanks:

Table I gives a guide as to the water volume required for a batch of larvae which will eventually yield 750 000 spat. On the basis of a spawning each week, a total larvae tank capacity of 13 000 l is required at any one time and this is best provided by 13 tanks of 1000 l. An additional tank - bringing the total to fourteen - allows some extra flexibility.

The ideal shape for a larvae tank from a bacteriological point of view is hemispherical as this has a minimum surface area to volume ratio. However, such a shape is not easy to handle and requires a large floor area for a given volume. A compromise of a cylindrical tank (with height = diameter) with a hemispherical bottom has a surface area 11% greater but the floor space required is just slightly more than half that required for a pure hemisphere and is, overall, more satisfactory.

Water Requirements:

The water in the larvae tanks should be changed daily and this should be done as quickly as possible so that the larvae spend a minimum time out of their growing medium. With practice, the cleaning of the tanks and the screening of the larvae can be comfortably achieved within ten minutes for each tank. The time taken to fill the tanks should also be about ten minutes so that a smooth routine can be developed. Thus the water flowrate required will be some 5000 l/h.

The water must be heated from the ambient temperature to 26^{o}. To heat the quantities of water needed each day will require 65 KW in summer and 100 KW in winter. For this duty it is necessary to use indirect heating via a hot water heat exchanger - a titanium plate type being most suitable as they are thermally efficient and compact. As neither the temperature nor the flow of seawater through the exchanger would fluctuate greatly over the three hours of normal operation per day, temperature control could be by either electric or pneumatic controller - the former acting less rapidly, but perhaps being more appropriate in this situation. The primary fluid in the exchanger - hot water - is heated in a hot water boiler (see 'Services' p.90).

Filtration of the water is an important factor in the control of bacteria in the cultures as this will remove a large part of the substrate to which marine bacteria adhere. A diatomaceous earth filter is most suitable and will remove c.95% of the particles present with a diameter greater than 2u. It may prove necessary to remove dissolved organic matter (which acts as nutrients for bacteria) using an activated carbon filter. The sizing and type of filters required can only be specified exactly when the characteristics of the seawater supply is known.

The optimum salinity for raising the larvae of C. gigas depends on the strain of animal involved, but is typically between 25 and 35 %. If it should be found that there is a definite optimum within this range, it is easy to reduce that of the ambient seawater by adding freshwater - it is more difficult to increase it. It is thus preferable to use seawater at (or near) oceanic salinity and which is not subject to great fluctuations.

Feeding:

At the larvae densities and temperatures specified, the larvae should be fed a daily ration of unicellular algae at a concentration of 100 cells/ul (of Isochrysis, or equivalent - see p.53).

Larvae will develop satisfactorily on a diet of Isochrysis or Monochrysis alone, but growth rate is almost always better if a mixture of several algal species is used. For the first week or so only the smallest of the diatoms and flagellates can be utilized by the larvae but as they grow the larger flagellates may be used to advantage.

SETTING

There are a number of ways in which larvae can be set so as to yield single spat, and the actual system finally chosen should depend very much on the one with which the operator concerned has had most experience.

Three systems are applicable in this case and in each the design of the set tanks is similar though different ancilliary equipment is needed:

1. Setting on a flexible cultch and removing the spat after they have grown for a week or so;
2. Setting on a smooth rigid material and removing within 24 hours;
3. Setting on particulate material such as crushed oyster shell.

The first system does seem to give the fastest growth but handling the cultch on a large scale is most awkward and it is possible to lose significant numbers of spat because of overcrowding. Polythene sheet and masking tape have both been successfully used as a cultch material but further information is required on this method before it can be specified as 'trouble-free'.

Removing the spat within 24 hours of settlement overcomes the problem of mortality caused by overcrowding, but requires the use of a special knife to remove the very small spat from the cultch without damage. The best marerial for the cultch is thin sheets of smooth black unplasticised pvc which can be supported in a wire frame.

Using crushed shell as a cultch material has been the standard method in French hatcheries and some experience with this has been obtained in the TFDA hatchery at Taroona. In this system the larvae are encouraged to settle on fine particles of shell and it is hoped that not more than one larvae sets on each particle. As the spat grow, unused shell is removed by screening. (As the spat are not removed from the cultch it would be more accurate to call them 'singles' rather than 'cultchless'). A mill to grind shell to a particle size of 250-350u and a mesh bottom tray with an airlift recirculating pump is required for this system. A disadvantage of using crushed shell is that there is a vast surface area on which bacterial populations

ACCOMMODATION

The larvae culture room should be maintained at 25^{0} so that the temperature of the cultures fluctuate minimally.

Because of the large volumes of aerated water above ambient temperatures, it should be assumed that the atmosphere will be saturated with water vapour. Under such conditions moulds tend to proliferate rapidly and these can be harmful to the larvae. To reduce this problem there should be an absolute minimum of inessential equipment within the room and all surfaces should be non-porous and easy to clean.

ROUTINE LABOUR REQUIREMENTS

Each day the larvae tanks must be drained, cleaned and refilled while the larvae are washed, measured and inspected to assess their health; similarly, the water in the set tanks should be changed daily, and the spat obtained passed on to the Spat Department.

One person should be able to complete this work in four to five hours leaving some time each day for routine maintenance, experimentation, etc.

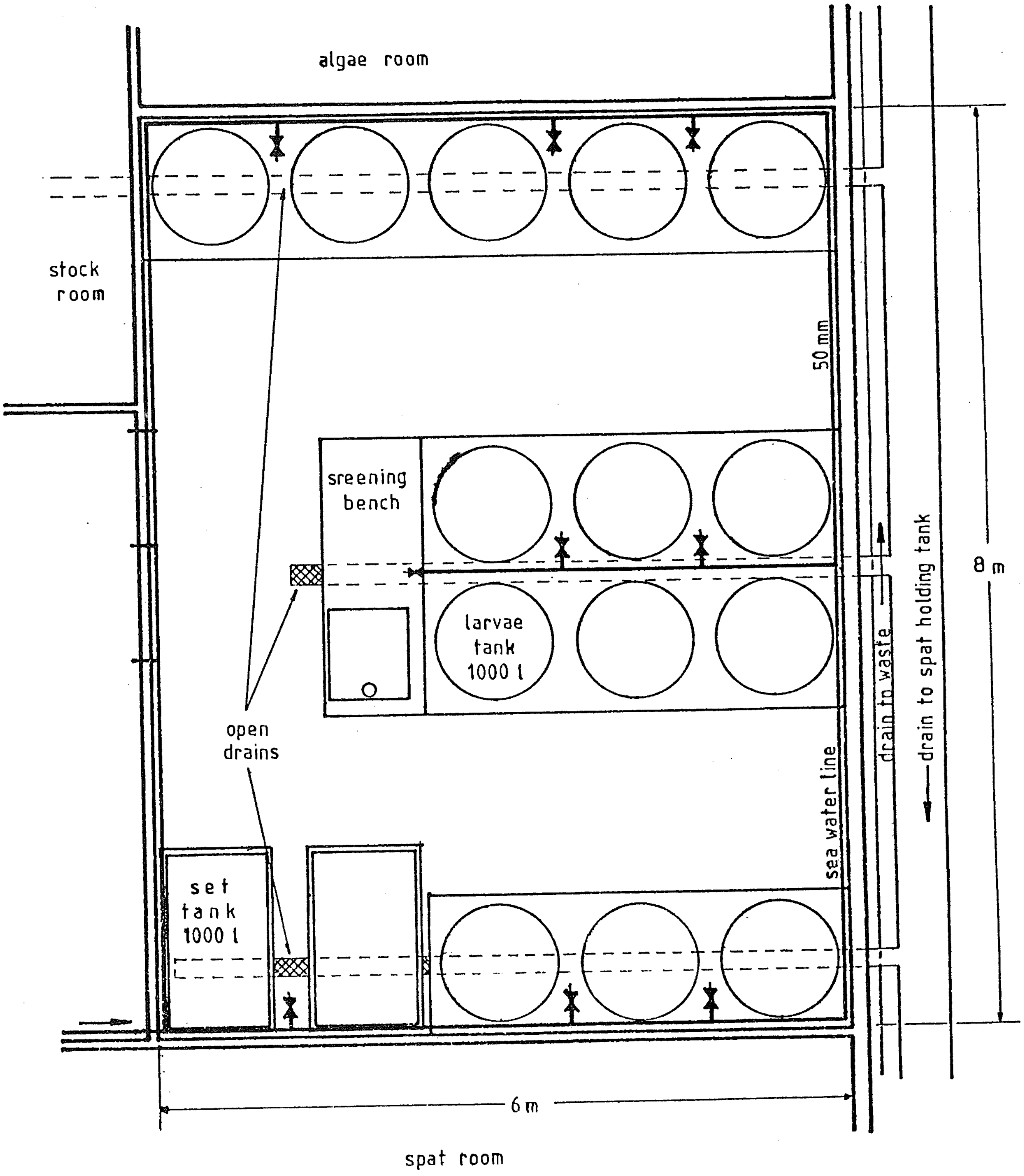
EQUIPMENT LIST

No	Item	Cost
14	Larvae Tanks - 1000 l @ $300	4 200
2	Set Tanks - 1000 l @ $450	900
1	Spat Stripping Knife or Shell Grinder	1 000
1	Diatomaceous Filter and associated equipment	1 500
1	Titanium Plate Heat Exchanger	1 500
	Temperature Controls for heat exchanger	500
1	Pump - 5000 l/h - 2.5 KW - with controls	450
1	Flowmeter - 0-7500 l/h	100
	Cultch - rigid pvc or polythene	250
5	Collecting Screens @ $15	75
10	Sieving Screens @ $12.50	125
10	Buckets	100
5	Counting Slides @ $5	25
	Furniture, Sink, etc.	500
	Other	775
	TOTAL	12 000

OPERATING COSTS

Power:	
1 Pump (2.5KW) operating 1000 hrs/a:	
Consumption : 2500 KWh/a @ $0.04/KWh	$ 100/a
Oil:	
To provide 100 000 KWh/a @ 0.115 l/KWh	
Consumption : 11 500 l/a @ $0.155/l	$ 1 800/a
Maintenance and Repair:	$ 1 000/a
Consumables:	
Diatomaceous earth (1.5 Kg/day, 300 days) @ $1/Kg	$ 600/a
TOTAL	$ 3 500/a

FLOOR PLAN



⧗ : tank filling valve (40 mm)

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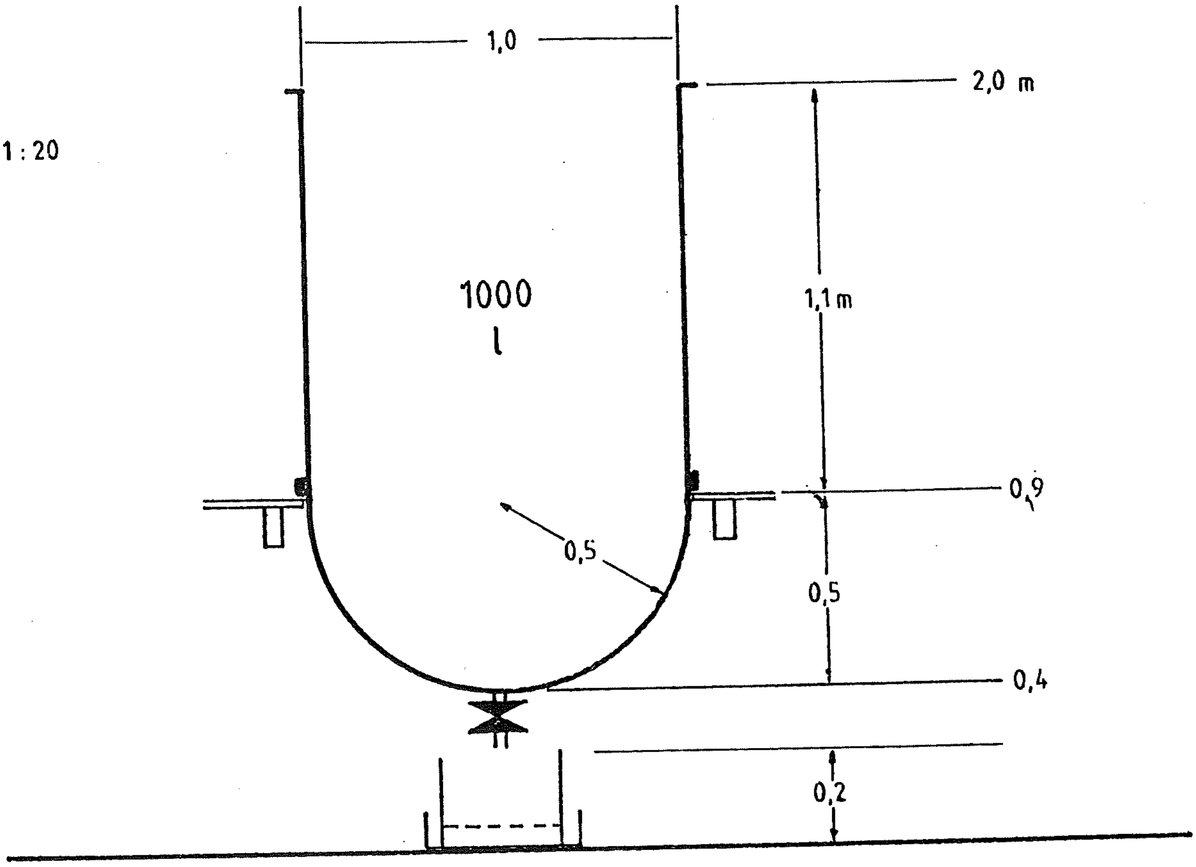
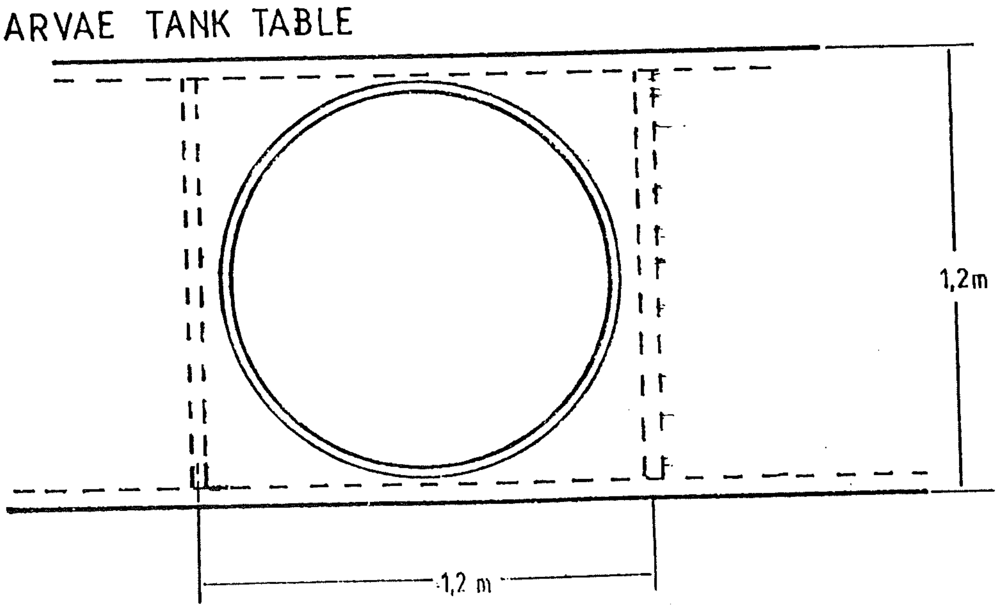
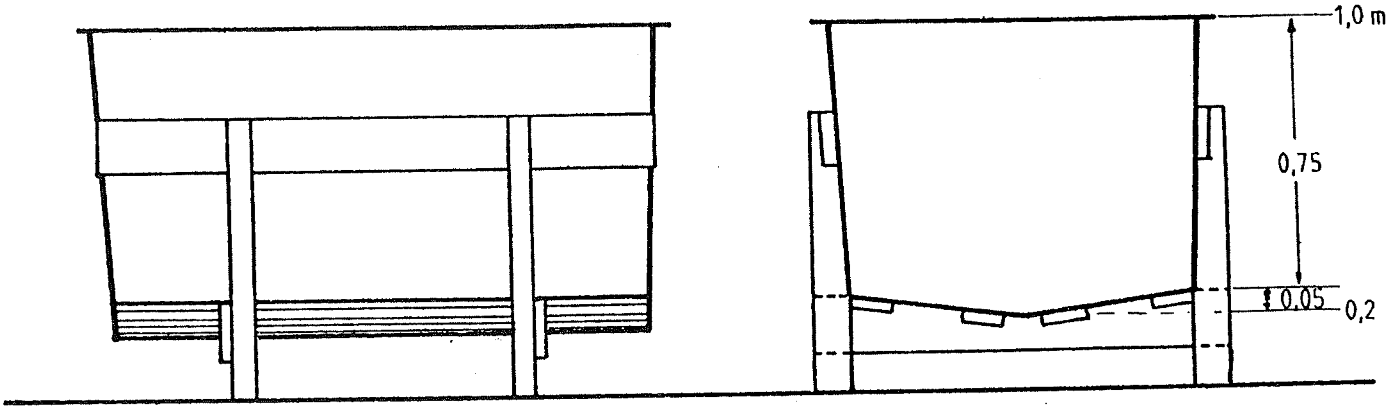
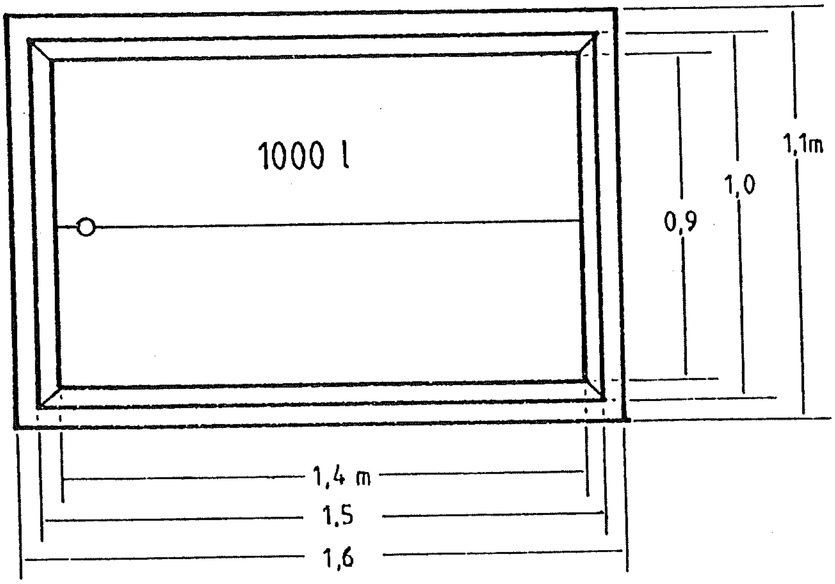
LARVAE TANK DIMENSIONS





SET TANK DIMENSIONS





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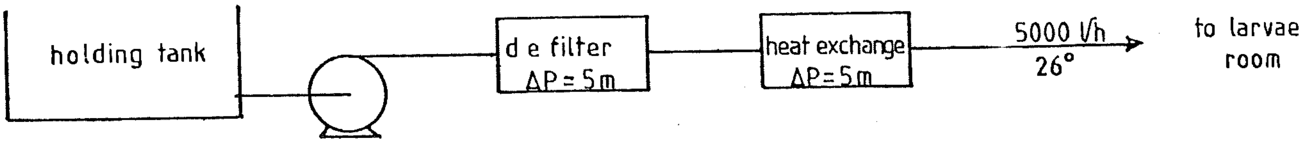
THE LARVAE WATER SUPPLY

Daily Requirements:

16,000 l at a flow rate of 5000 l/h of filtered water at 26°.



THE HEAT EXCHANGER

Sizing:

Minimum seawater temperature (p.5) : 10°

Seawater temperature required : 26°

Water flowrate : 5000 l/h

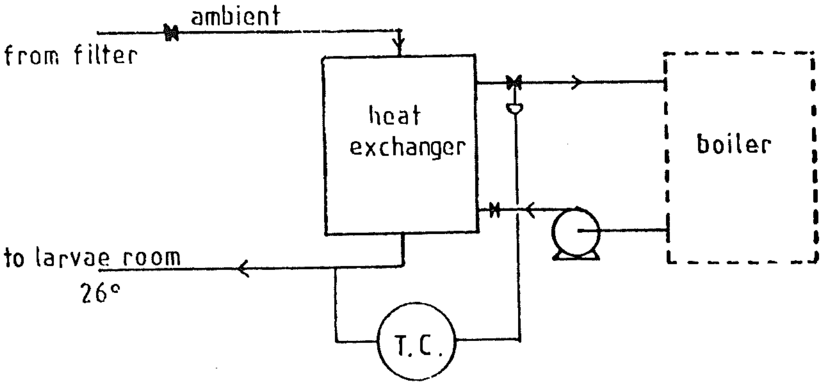
Heat required = 5000 . (26 - 10) = 80,000 Kcal/h
= 96 KW (say 100 KW)

(In summer, seawater temperature is 15°, and heat required is 65 KW)

Type:

Titanium plate heat exchanger - eg Alfa Laval Type P01

Control:



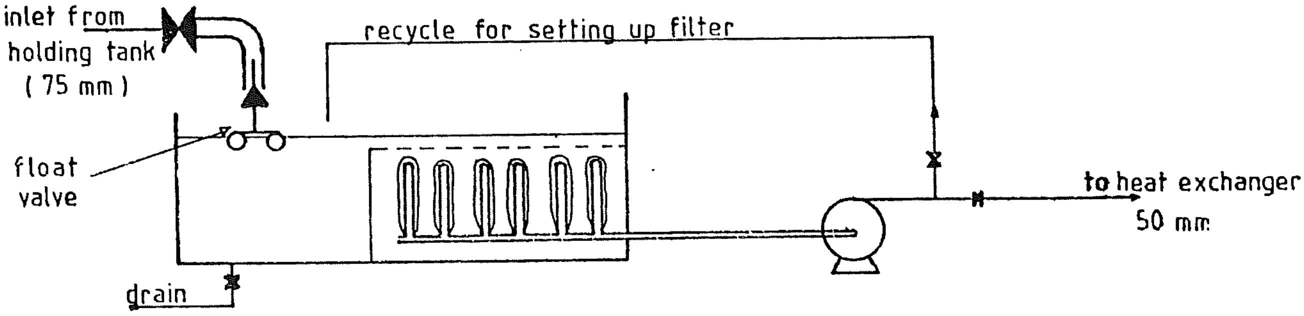
THE FILTER

The diatomaceous earth filter can be either a pressure or vacuum type, and under the circumstances in which it would operate here, there is little to choose between the two types in terms of efficiency. A pressure type is more flexible with regard to location within the hatchery but it is possible to inspect the cake of a vacuum type while it is operating. The final choice will depend on cost and availability.

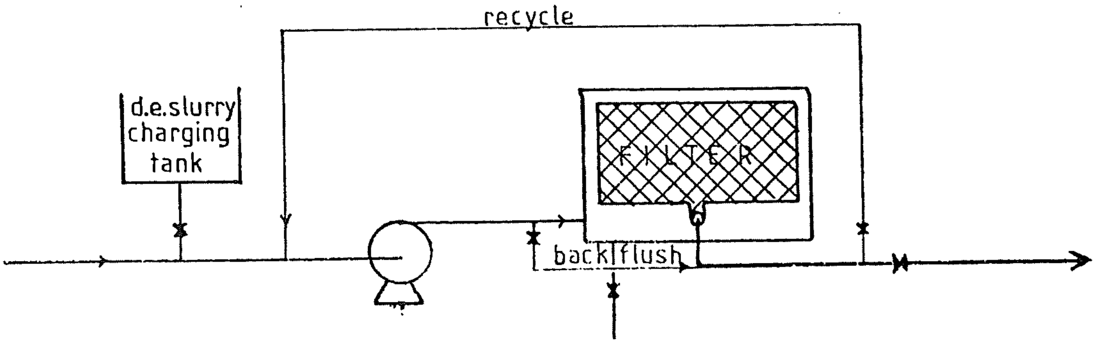
As it would be necessary to set up the filter each day, it is unlikely that it would be necessary to add diatomaceous earth as a filter aid during the filtering process - though this would depend on the amount of algae etc. in the water.

Although the specification will depend on the amount of suspended matter in the water, a filtration area of 1500 to 2000 l/h/m^2 (ie. a total area of 2.5 to 3.5 m^2) is likely to be sufficient.

Vacuum Filter Layout:



Pressure Filter Layout:



3c THE SPAT DEPARTMENT

SPAT REARING

The way in which newly settled spat are handled will depend somewhat on the system used for settlement (but the water, food, and tanks required will be similar):

If the spat are removed from the collectors within 24 hours of settlement, or if they are collected on particulate cultch, the simplest system of culture is to use mesh bottom trays floating in the tanks;

If the spat has been collected on flexible cultch to be stripped later, then the cultch needs to be supported in the tanks on some kind of frame - the exact design of which will depend on the nature of the cultch used.

The Spat Department has been divided into three sections:

Spat Room I, in which the spat are grown from settlement to 1 mm or so. The water temperature is maintained at 23-24^{0}, and the tanks have a capacity of 2000 l. Feeding is at a rate of 100 cells/ul/day.

Spat Room II, in which the spat grow from 1 mm to 3-4 mm. The water temperature is lowered to 21^{0} and larger tanks of 5000 l are used. The food supply should be increased to 150 cells/ul/day.

The water in the tanks in Rooms I and II is recirculated over the spat using small submersible pumps and spray tubes. As spat growth is not adversely affected if the water is changed every two or three days rather than every day, it is recommended that water changes are made three times a week.

The Spat Holding Tank, in which the 3-4 mm spat are held whilst awaiting despatch to on-growers. This tank is sited outside the main building and operates on a 'flow through' basis using unfiltered water at ambient temperature. The spat feed on what algae is present in the untreated water. Should the conditions at the selected site allow, it would be most useful to channel the waste water from the larvae and spat tanks through the holding tank as this waste water will contain considerable amounts of unused food which can be utilized by the large spat.

The Tanks:

As with the larvae, spat of different sizes should be kept in separate tanks so that the growth of the smaller is not inhibited by the larger. The choice of screen sizes is made so that 90% of the spat can be expected to grow onto the next screen in 4-5 days. The slowest 10% are discarded (along with any dead present).

For the smaller spat (in Room I), a tank volume of 2000 l is suggested as this would allow flexibility in handling spat of different sizes and is about the largest size that can be cleaned thoroughly from the outside. The tanks themselves should be fibreglass and can be made quite lightly if well supported in a wooden frame (see p.45).

For the larger spat (in Room II) the tank volume can be increased to 5000 l. This will still give adequate flexibility, whilst saving a signficiant amount of operator time. The tanks will have to be cleaned from the inside, and water change time will obviously be more than for the 2000 l tanks but the larger spat will be well able to tolerate this without problems. The construction of such tanks needs to be robust and hence more expensive than the smaller ones. Whereas fibreglass reinforced with timber undoubtedly makes a better tank, it would be possible to use braced plywood with a thin fibreglass coating - such construction would require more maintenance but be much cheaper. (See p.47).

The holding tank operates on a flow through basis and so the volume is not important and the prime requirement is to have sufficient surface area to accommodate trays containing the weekly production of spat. For this kind of tank the density of the spat on the trays can be increased to about 50 000/m^2 so 15 trays are required to hold the 750 000 spat produced each week. Such a tank is most cheaply made of concrete and constructed in situ. (See p.48).

Water Requirements:

For the smallest spat, the incoming water may or may not need to be filtered depending on its characteristics. Whilst small amounts of silt may be tolerated, and indeed may even be beneficial, large amounts will be unacceptable because of the potential for bacterial build up. However, at the most, only coarse filtration would be required - perhaps through a swimming pool type of sand filter.

The larger spat do not require filtered water.

The water change cycle should be completed in as little time as possible - half an hour for the small spat and an hour for the larger would be acceptable. The 2000 l tanks will take about fifteen minutes to drain and clean and so the filling time should also be fifteen minutes or so requiring a flowrate of 8000 l/h. The 5000 l tanks might take a similar time to drain and clean and so should be filled in forty to fifty minutes.

The water used for the growing spat is heated using a titanium plate heat exchanger of the same type as used for the larvae water.

For the spat in the holding tank the water must obviously be unfiltered as the natural plankton is the sole source of food (unless the waste from the other departments can be used). Up to a point it is safe to say that the greater the flow of water available for these spat the better. As the number of spat being held will vary from day to day, and the food available in the water will vary from season to season, it is impossible to give definite water requirements for this stage. It would be convenient to use the pump used for stages I and II whenever it was not required there or, better, direct gravity feed from the main seawater storage tank, should that be possible.

SPAT PACKAGING

If kept cool, three millimetre spat will survive out of the water for 24 hours or more without ill effect. The packaging of spat for despatch to on-growers can thus be quite simple. The containers should be insulated and preferably contain 'freezing packs' as used in picnic baskets. The spat themselves should be moist and tied up in a mesh bag within a polythene bag.

As a typical order will be worth some thousands of dollars, it is worth taking some trouble over packaging to ensure the product reaches its destination in as good a condition as possible.

ROUTINE LABOUR REQUIREMENTS

Three times a week the water in the spat tanks in Rooms I and II should be changed and the tanks cleaned. At the same time the spat should be washed and screened to separate the faster and slower growers. The trays will also need to be cleaned of algae and faeces.

A time of three to four hours should be sufficient to service the ten 2000 l tanks, and a similar period would be required for the six 5000 l tanks - ie. a total of about 20 hours/week.

The time taken to count, pack, invoice, etc. each order will be about 2 hours plus whatever is needed for delivery. This would be irrespective of the size of the order.

EQUIPMENT LIST

No	Item	Cost
10	Tanks - 2000 1 - with frames @ $750	7 500
6	Tanks - 5000 1 - timber reinforced grp @ $2000	12 000
1	Tank - 8 by 2.5 by 0.5 m - concrete	1 000
25	Submersible Pumps (+ spares) - 0.090 KW @ $70	1 750
22	Spray Tubes - 3 m by 15 mm dia. @ $1	25
2	Spray Tubes - 8 m by 40 mm dia. @ $12	25
60	Trays - 0.4 by 0.6 m (mesh + timber) @ $5	300
50	Trays - 0.8 by 1.2 m (mesh + timber) @ $20	1 000
1	Heat Exchanger	1 500
	Temperature controls for heat exchanger	500
1	Seawater Pump - 10 000 l/h - 3.5 KW - with controls	550
1	Flowmeter - 0-15 000 l/h	100
	Furniture	250
	Other	500
	TOTAL	27 000

OPERATING COSTS

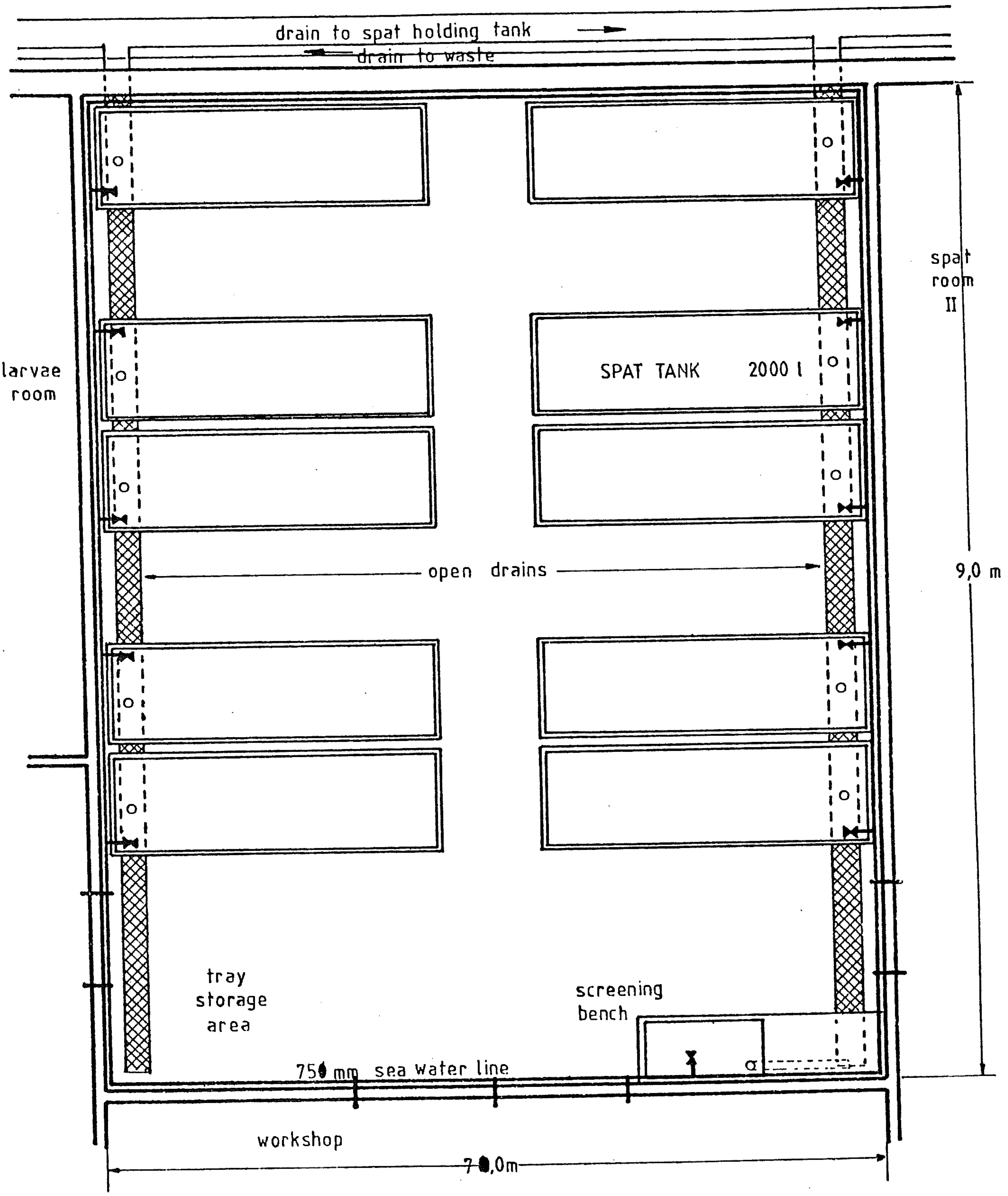
Power:

Item	Rating	Hrs/a	Consumption	
22 Submersible Pumps	2.2 KW	8000	17 000 KWh/a	
Seawater Pump	3 KW	1000	3 000 KWh/a	
TOTAL	5.2 KW		20 000 KWh/a @ $0.04/KWh	$ 800/a

Oil:

To provide 110 000 KWh/a @ 0.115 l/KWh Consumption: 12 500 l/a @ $0.155/l	$ 2000/a
Consumables: Packaging: 100 @ $15	$ 1500/a
Maintenance and Repair:	$ 1200/a
TOTAL	$ 5500/a

FLOOR PLAN – SPAT ROOM I



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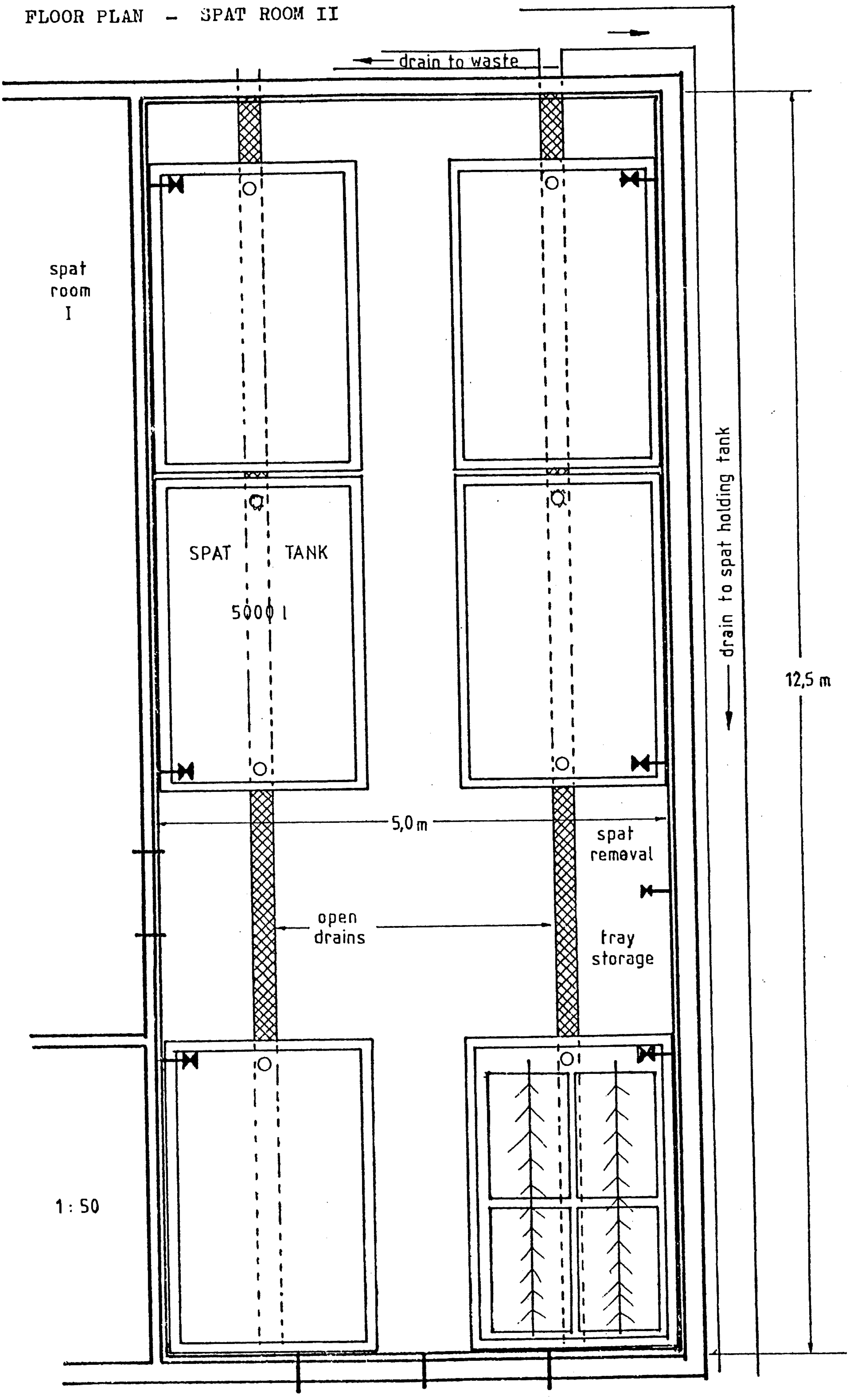
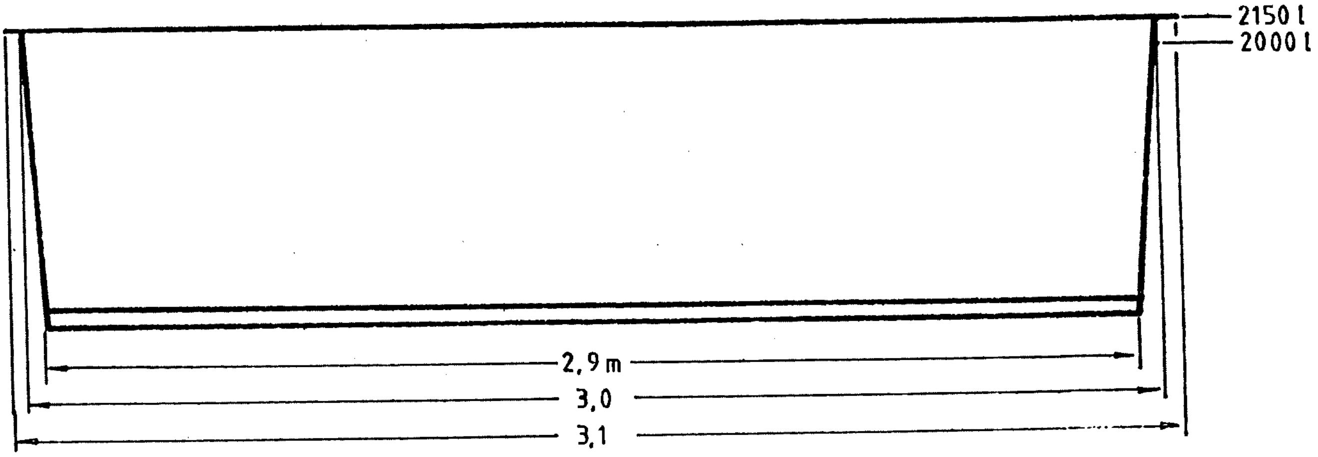
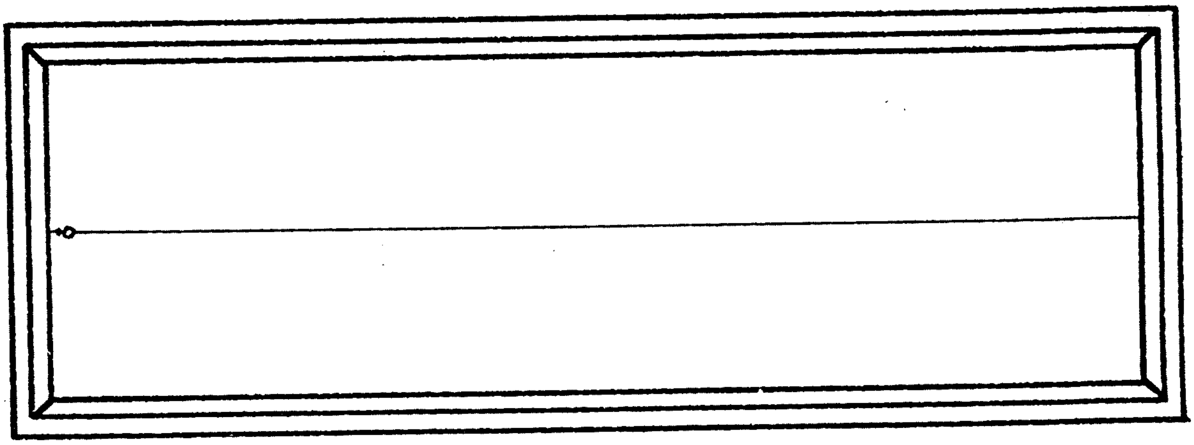
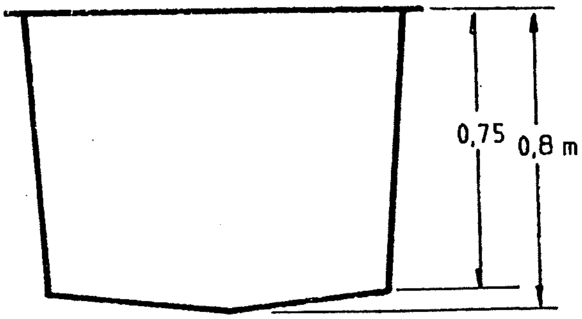
FLOOR PLAN - SPAT ROOM II



SPAT TANK DIMENSIONS - 2000 l







SPAT TANK - 2000 l

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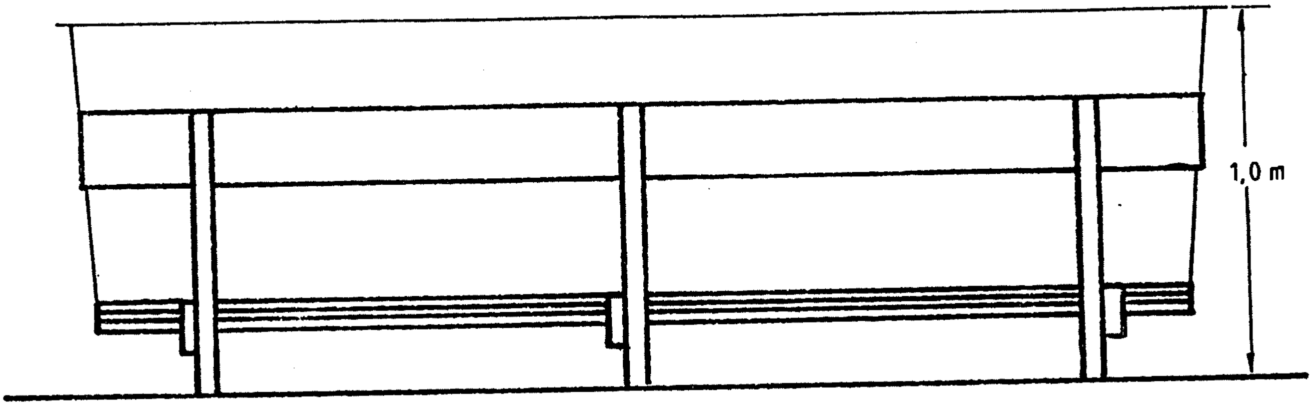
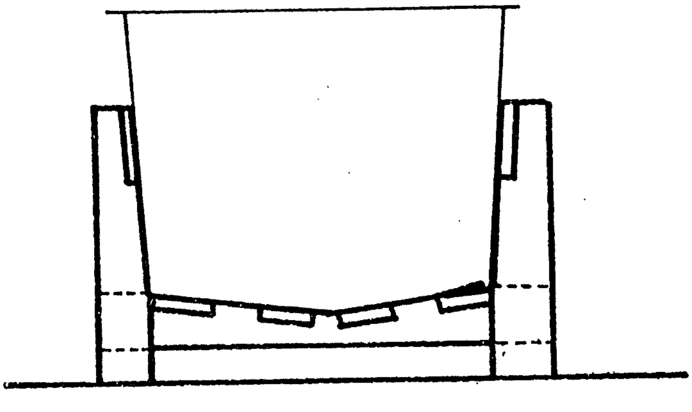
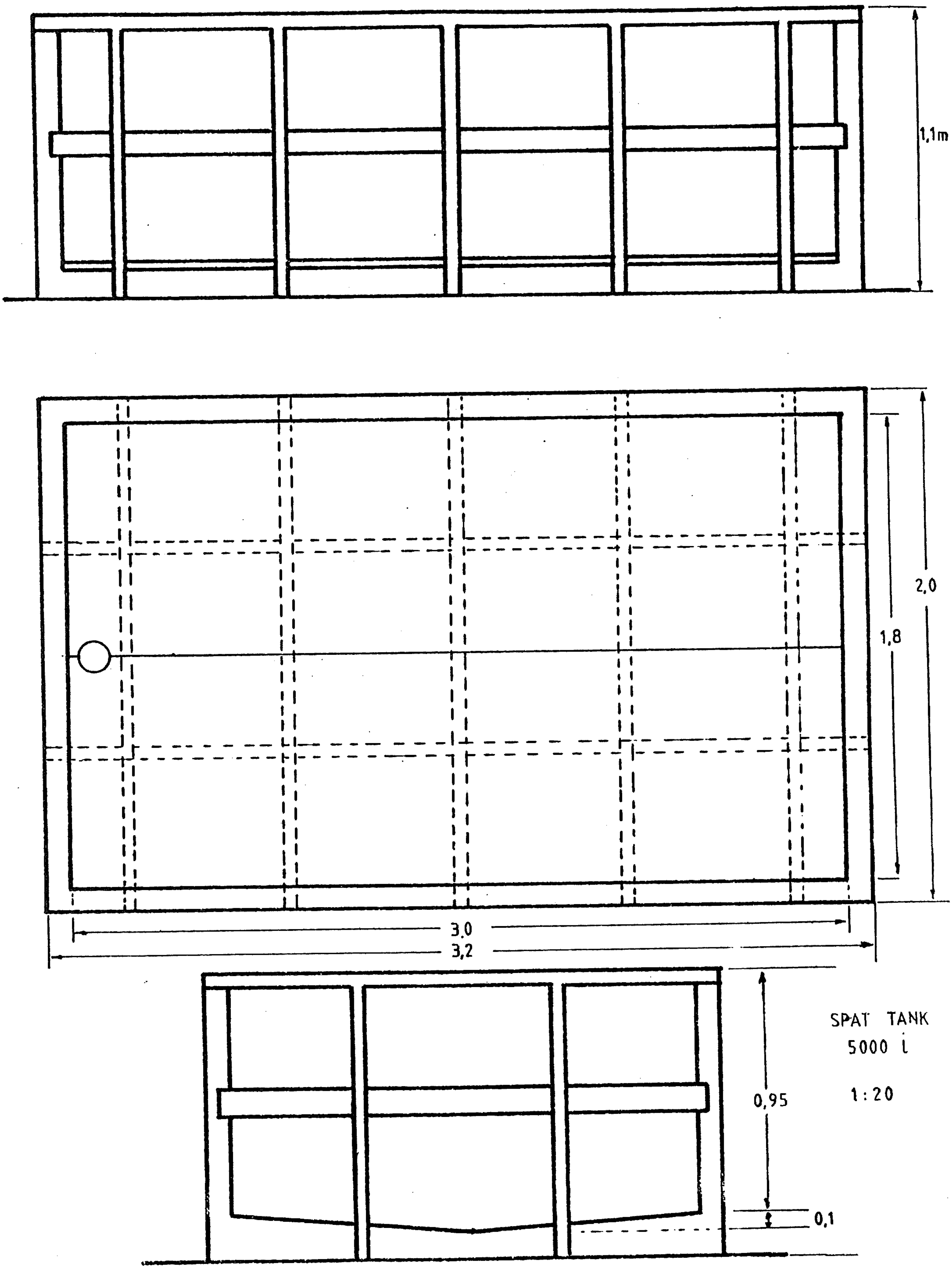
SPAT TANK SUPPORTING FRAME





SPAT TANK DIMENSIONS - 5000 l



SPAT TANK
5000 l

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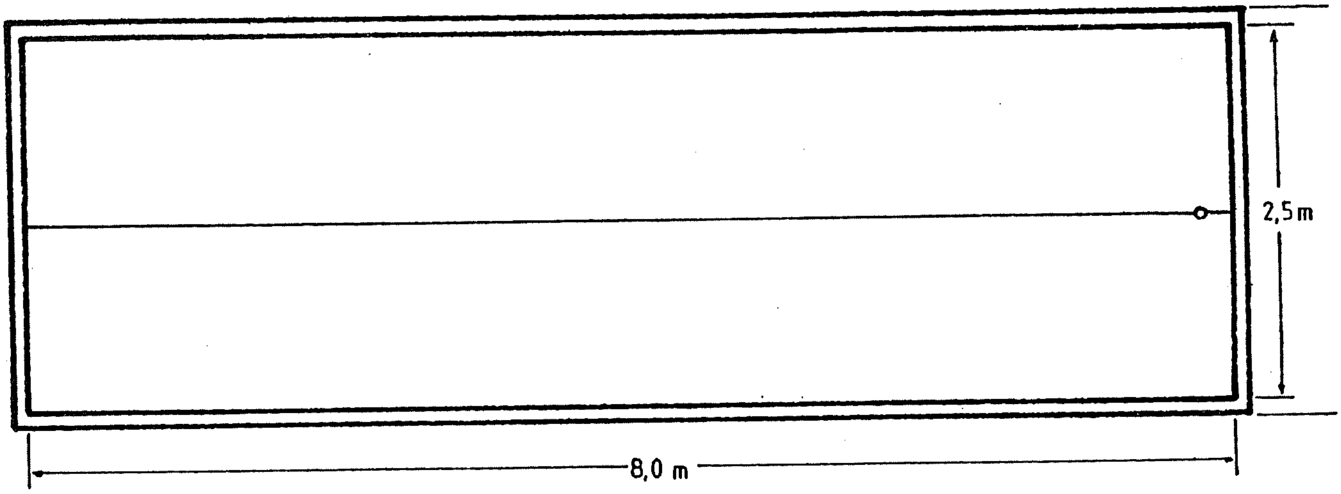
SPAT HOLDING TANK DIMENSIONS



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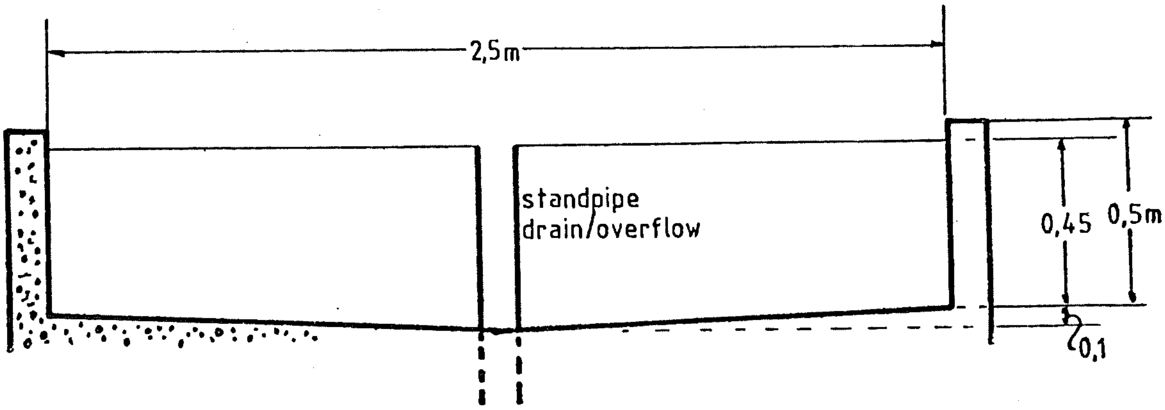

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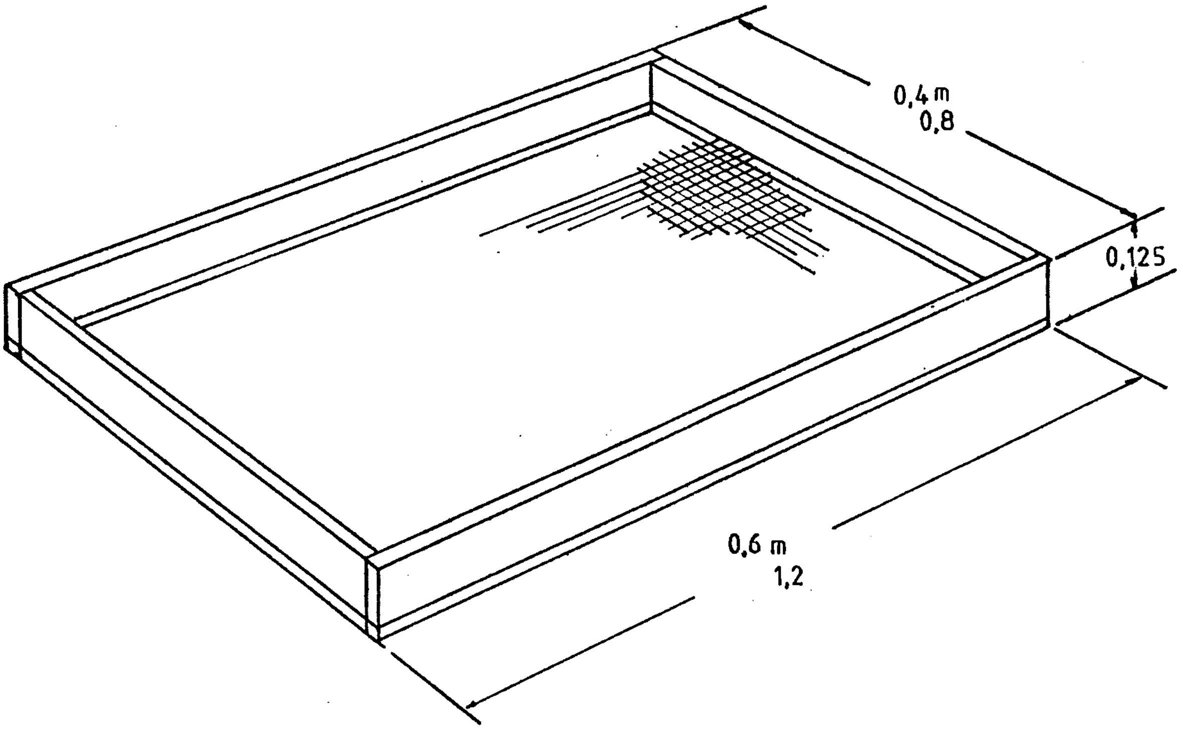
SPAT TRAY DIMENSIONS

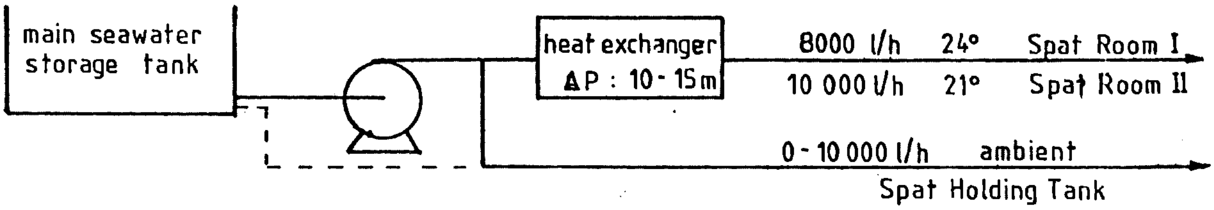


WATER SUPPLY

For small spat (Spat Room I):
20,000 l at 8000 l/h of seawater at 24° - three times per week;

For larger spat (Spat Room II):
30,000 l at 10,000 l/h of seawater at 21° - three times a week;

For 3-4 mm spat in the holding tank:
0 to 10,000 l/h (as required) continuously at ambient temperature.



The Heat Exchanger:

Minimum ambient seawater temperature : 10° (see p.5)
Temperature required : Room I : 24° : Room II : 21°
Water flowrate : " 8000 l/h; 10,000 l/h

Heating required (Room I) : 11,000 Kcal/h = 135 KW
(Room II) : 11,000 Kcal/h = 135 KW

In summer the ambient water temperature is c.15° and the heating required will be 85 KW in Room I and 72 KW in Room II.

The heat exchanger required would be similar to that specified for heating the larvae water (ie. a titanium plate exchanger such as the Alfa Laval Type P01) and the control system would also be the same. (See p.34).

3d THE ALGAE DEPARTMENT (& LABORATORY)

The Algae Department is divided into three rooms:

The Algae Culture Room:

Used solely for growing the algae. The facilities required include: the culture vessels; racks for these; lighting and CO_2 enriched air for the promotion of photosynthesis. Air conditioning is required to control the temperature of the cultures.

The Washroom:

Used for making transfers and washing the tanks and flasks. Facilities required here include: filters for the seawater supply; a steam generator to provide steam for sterilizing the flasks and tanks; general furniture (sinks and benches). For convenience, the autoclave is in this room rather than the laboratory, and it might be possible to use this as a steam generator - depending on its design.

The Laboratory:

Used for preparing enrichment media, microbiological work and it is here that the microscopes and balances would be kept. Whereas the laboratory would be used primarily by the algae department, the larvae department would use it regularly to inspect the larvae and set, and it would also be used when counting spat.

ALGAE CULTURE

The successful rearing of good quality food for the stock, larvae and spat is vital for consistent production and is the activity requiring the most skill within the hatchery.

For this reason, and because the algae culture unit as a whole makes up a large part of the total capital and operating costs of a hatchery, there have been many attempts to develop a 'non-living' food for oysters but, so far, none of these has been successful. Until such an alternative is developed it is necessary to culture large quantities of unicellular flagellates and diatoms under carefully controlled conditions.

Some twenty or thirty species of algae have been tested to assess their food value for C. gigas and those listed in Table III (p.58) have repeatedly been found to be 'good'. The food value of each species compared with Isochrysis galbana is also listed.

All the species listed are readily grown in culture under the same conditions and all cultures also tend to reach a maximum cell density in excess of 10 000 cells/ul (Isochrysis equivalent) when grown under the conditions described in this section. Thus it is convenient to use 'litres of algae at 10 000 cells/ul (Isochrysis equivalent)' as a measure of algae production.

Lighting:

The intensity and quality of lighting required to promote photosynthesis in intensive algae culture has been the subject of much research and considerable differences of opinion. Until these are resolved, most algae culture units are content to use 'cool white' and/or 'daylight' fluorescent lamps. The amount of lighting required depends on many factors, but for the type of unit described here a rule of thumb suggests 200 watts (tube rating) per m^2 of exposed culture vessel surface. Such lighting is certainly adequate.

Air:

Air is required in the larger cultures (5 l and more) to provide agitation and to deliver the carbon dioxide necessary for photosynthesis.

The air is probably efficiently sterilized by the action of the compressor, but a submicron filter is necessary to remove the dead bacteria and any other solid material. The air supply must be oil-free.

The amount of air required is about 4-5 l/m irrespective of the vessel volume (for the design of vessels described) and carbon dioxide is added at the rate of 2% by volume.

Culture Temperature Control:

For the algae species listed (Table III, p.58), the optimum culture temperature is 18-20^{0} and the most common cause of culture collapse is excessive temperature - especially in summer. The only practicable way of controlling this is by control of the room temperature using an air cooler.

Even where temperature rises do not cause cultures to collapse, any contaminants present seem to multiply much faster than the algae and these can adversely affect the larvae.

As the major source of heat in the algae room is the lighting, this should be switched off automatically should the room temperature ever exceed 22-23^{0}.

OPERATING PROCEDURE

For each species of alga in culture:

Master Stock cultures are maintained in test tubes and are used to inoculate the Working Stock cultures when the hatchery starts up. After that the Master Stocks are regularly subcultured but are kept apart from all the other cultures and are only used again if there is a disaster such as serious contamination or total collapse of the Working Cultures.

Working Stocks are maintained as unaerated 200 ml cultures in sixteen 500 ml flasks and, each day, four of these are inspected (when they are four days old). The best three of the four are used to inoculate three 5 l cultures and four more 200 ml Working Stocks.

The three 5 l cultures are aerated with filtered air enriched with CO_2. They are allowed to grow for 6 days when the best two are used to inoculate two 100 l tanks.

The 100 l tanks are similarly supplied with CO_2 enriched air and are harvested after 6 days.

The procedure outlined above uses smaller inocula and longer culture times than is usual current practice. This means that there is more chance of slightly contaminated cultures becoming seriously so, but greatly reduces the amount of handling required; hopefully this will allow more time to ensure that cultures do not become contaminated in the first place.

ROUTINE LABOUR REQUIREMENTS

Each day, samples from the tanks to be harvested should be taken and checked to assess their suitability as food; a cell count should be made to determine the amount to be used for each tank of larvae, spat etc. The food to be used is then pumped into the header tank on the first floor from where it is piped to the relevant departments. Samples from the 5 l cultures and working stocks are also taken and inspected to assess their suitability as inocula for new cultures. After harvesting, the vessels must be washed, sterilized and refilled before inoculation with new culture and nutrients.

This work will normally take some 5-6 hours/day.

Other work includes: the preparation of media; the axenisation of stocks and maintaining them axenic; subculture of stocks; selection of the fastest growing cultures; and the testing of new algal species that could be suitable as food. The time required for this is open ended and, along with routine maintenance, will take all the remaining time of the two people needed in this department.

TABLE II - Algae Production Required:

For Stock	40	1/day @ 10 000 cells/ul*
Larvae	150	
Set	20	
Spat (1)	220	
Spat (2)	450	
TOTAL	880	

*See p.53

TABLE III - Species for unicellular algae found to be good for C. gigas

		Food value
Isochrysis galbana*	small flagellate	1
Monochrysis lutheri*	" "	1
Chaetoceros calcitrans*	" diatom	1
Thalassiosira pseudonana	"	1
Skelotonema costatum	"	1
Chlamydomonas coccoides	medium size flagellate	5
Pyranymonas sp.	" " "	5
Tetraselmis chui	larger flagellate	10
Tetraselmis suecica	" "	10
Rhodomonas sp.	" "	10

*Only these species should be used for larvae less than one week old.
'Food value' is an approximate value compared with Isochrysis.

3d Algae department (cont.)

EQUIPMENT LIST

Algae Room:

No	Item	Cost
60	Tanks - 100 l - polycarbonate (fabricated) @ $100	6 000
100	Flasks - 5l - Pyrex conical @ $15	1 500
100	Flasks - 500 ml - Pyrex conical @ $1.50	150
1	Food Storage Header Tank - 1000 l	450
50	Fluorescent Lights and associated controls - 8' @ $30	1 500
2	Air Conditioning Units @ $750	1 500
1	CO_2 Regulator	50
2	Gas Flowmeters @ $75	150
1	Food Transfer Pump + controls - 1000 l/h - 0.5 KW	250
	Furniture	500
	Other	450
	Total	12 500

Washroom:

1	Autoclave	1 500
1	Steamer	1 000
1	Seawater Pump - 350 l/h - 0.2 KW	200
3	Filter Housings (for 5u,1u, and activated carbon) @ $75	250
1	Filter Housing (for 0.45u filter)	1 000
	Furniture	250
	Other	300
	Total	4 500

Laboratory:

Microscope - compound	1 000
Microscope - stereo	500
Balance - 0 to 150 g by 0.001g	1 000
Balance - 0 to 2.5 KG by 0.1 g	100
pH meter	350
Still	350
General glassware (see p.68)	1 200
Refrigerator	250
Incubator	250
Electric hotplate/gas stove	100
Bunsen burner (+ gas)	100
Membrane filter holders and associated equipment for microbiological work	1 000
Other	800
Total	7 000
TOTAL (for complete Algae Department)	24 000

3d Algae Department (cont.)

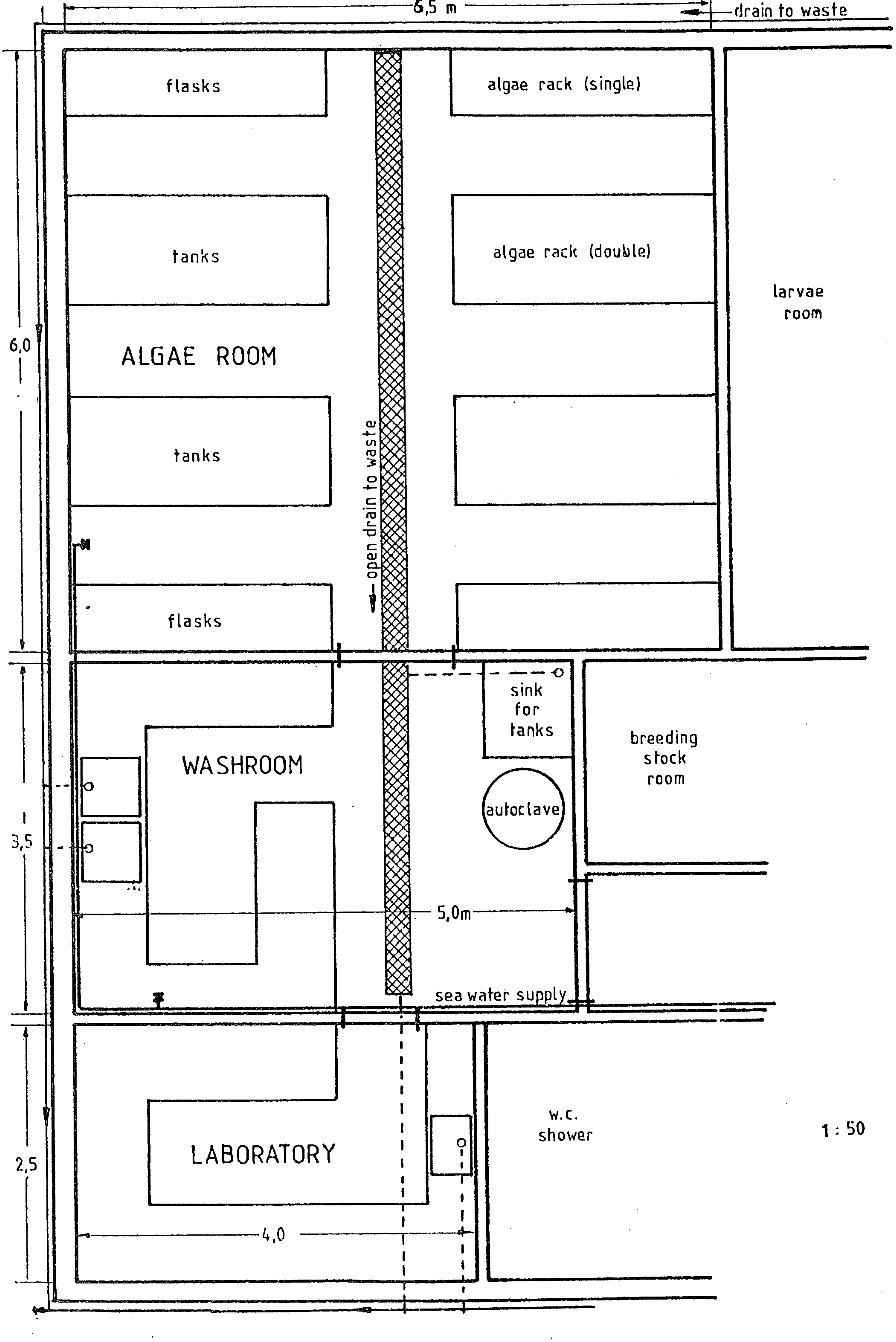
OPERATING COSTS

Power:				$
Item	Rating	Hrs/a	Consumption	
Seawater Pump	0.2 KW	1400	280 KWh/a	
Food Transfer Pump	0.2 KW	700	140	
50 Lights (125w)	6.25 KW	7500	47 000	
2 Air Conditioners	6 KW	3500	21 000	
Steamer	2 KW	1400	2 800	
Autoclave	3 KW	500	1 500	
Hotplate	1 KW	250	250	
Other			2 030	
TOTAL	18.65		75 000 KWh/a @ $0.04 :	3 000

		$	
Consumables:	Carbon dioxide (5 000 000 1/a)	5000	
	Chemicals (see p.69)	1500	
	Filters - 0.45u @ $30	3000	
	Other @ $10	1000	
	Total		10 500
Maintenance and Replacements:			1 500
TOTAL			$15 000/a

3d Algae Department

FLOOR PLAN



EQUIPMENT SPECIFICATIONS

The Culture Vessels:
For a total algae production of 880 l/day (see Table II, p.58) using the procedures outlined on p.56, the following vessels are required:

	No/day	Total
100 l tanks	9	54
5 l flasks	15	90
500 ml flasks	16	64

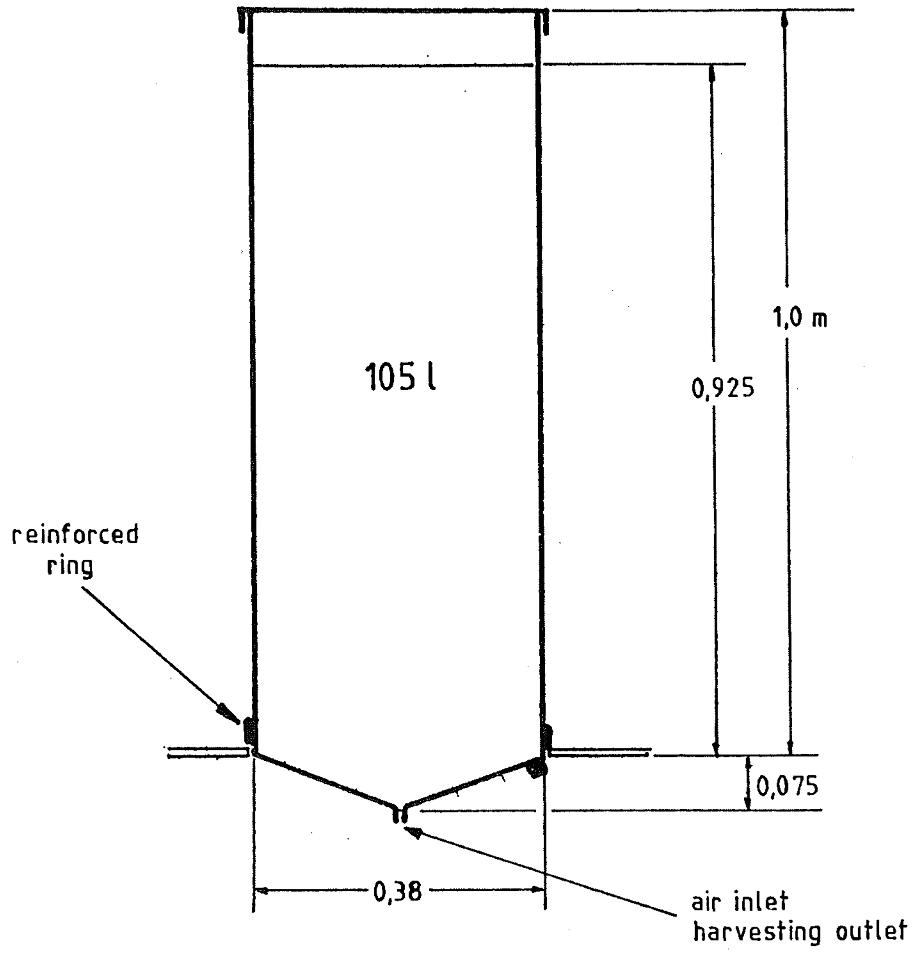
500 ml Flasks: Standard Pyrex conical flasks.

5 l Flasks: If the flasks are to be sterilized by steaming and then filled with filtered seawater (the prefered system) then Pyrex flasks - conical or boiling type - are essential; if sterilization is to be by chlorination followed by dechlorination, then much cheaper glassware (e.g. wine bottles) can be used.

100 l Tanks: The tanks should be vertical cylinders with conical bottoms and made from transparent plastic sheet. Undoubtedly the best material for this is polycarbonate as this can be steam sterilized and is highly transparent. Acrylic would be suitable if 'thorough washing' with hot water and soap were considered adequate for cleaning but it cannot be steamed and seems to be attacked by chlorine; it is about half the price of polycarbonate. Thin fibreglass sheeting is suitable (if available) and is cheap, can be steamed and used with chlorine; it is not as transparent as the other materials, however, and it is not easy to make the tanks completely smooth inside.

The diameter of the tanks is governed by the penetration of light through a thick culture and in practice it has been found that 0.4m is about the maximum useful diameter for tanks of this type. A height of 1m allows the tanks to be cleaned and handled (when empty) with relative ease. The conical bottom is required for strength.

ALGAE TANK DIMENSIONS.



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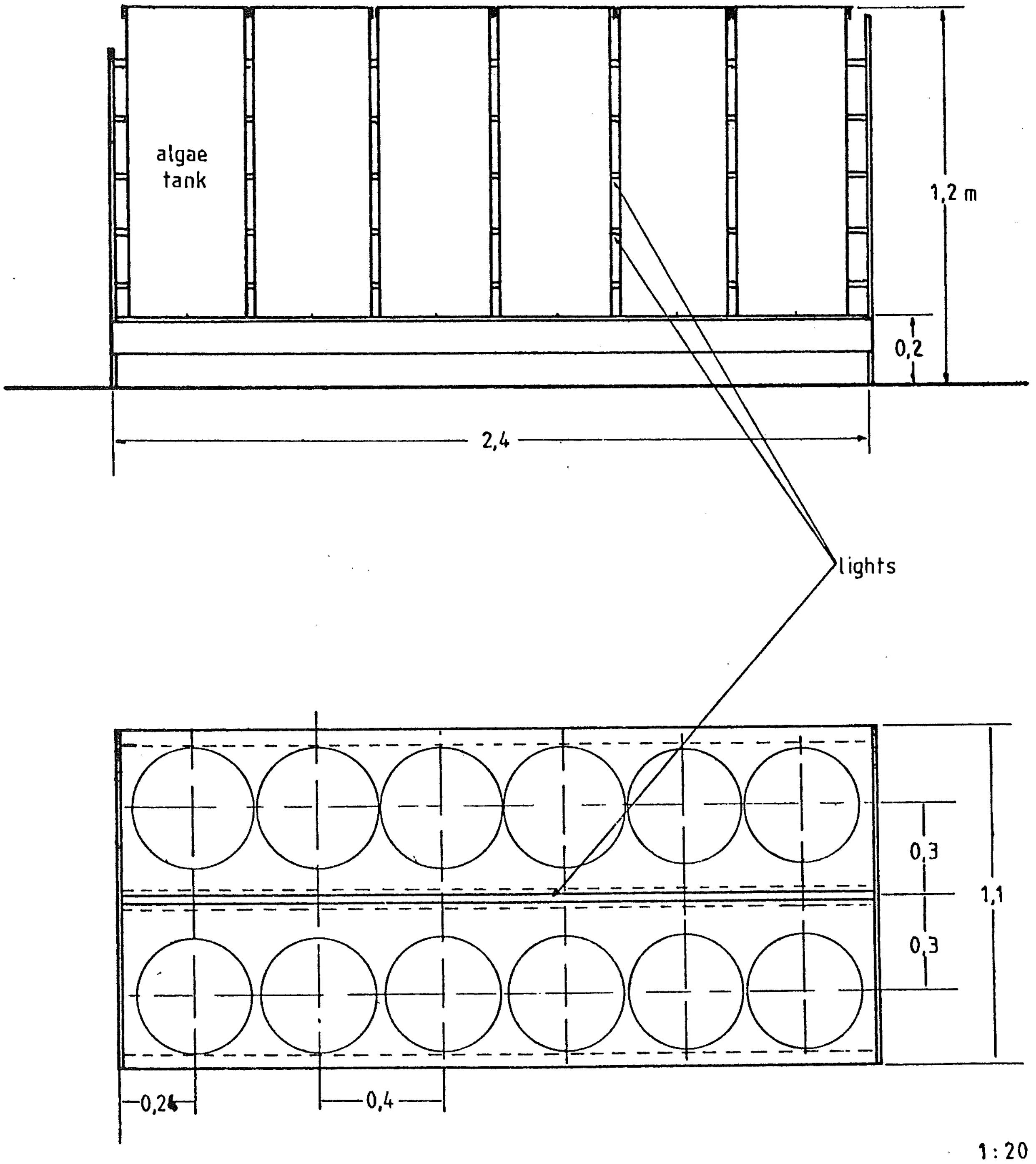
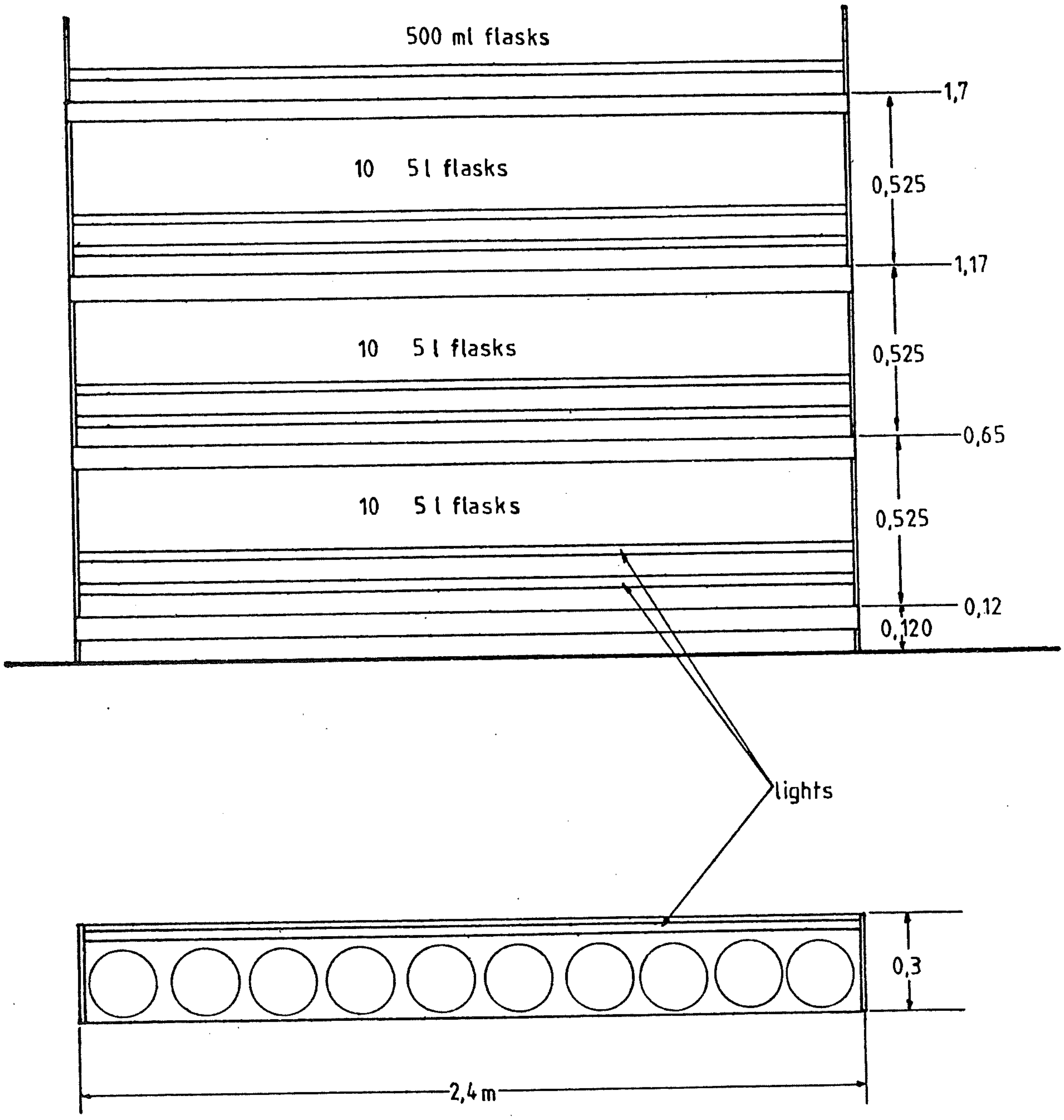
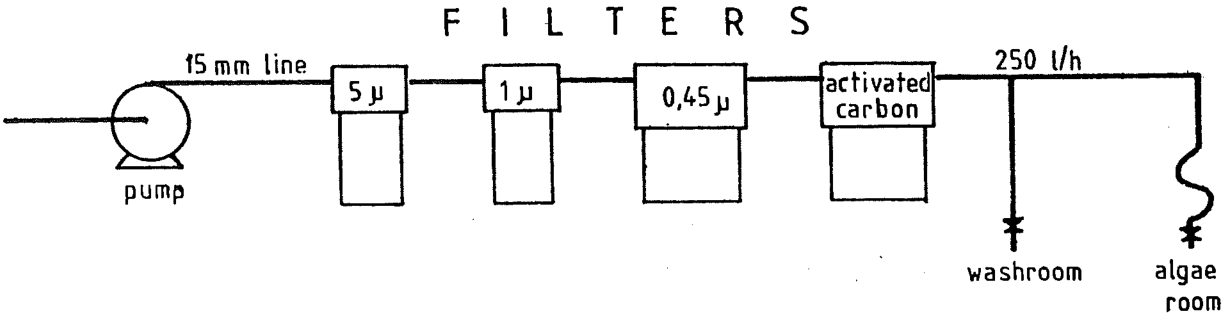
ALGAE RACK DIMENSIONS (100 l TANKS)



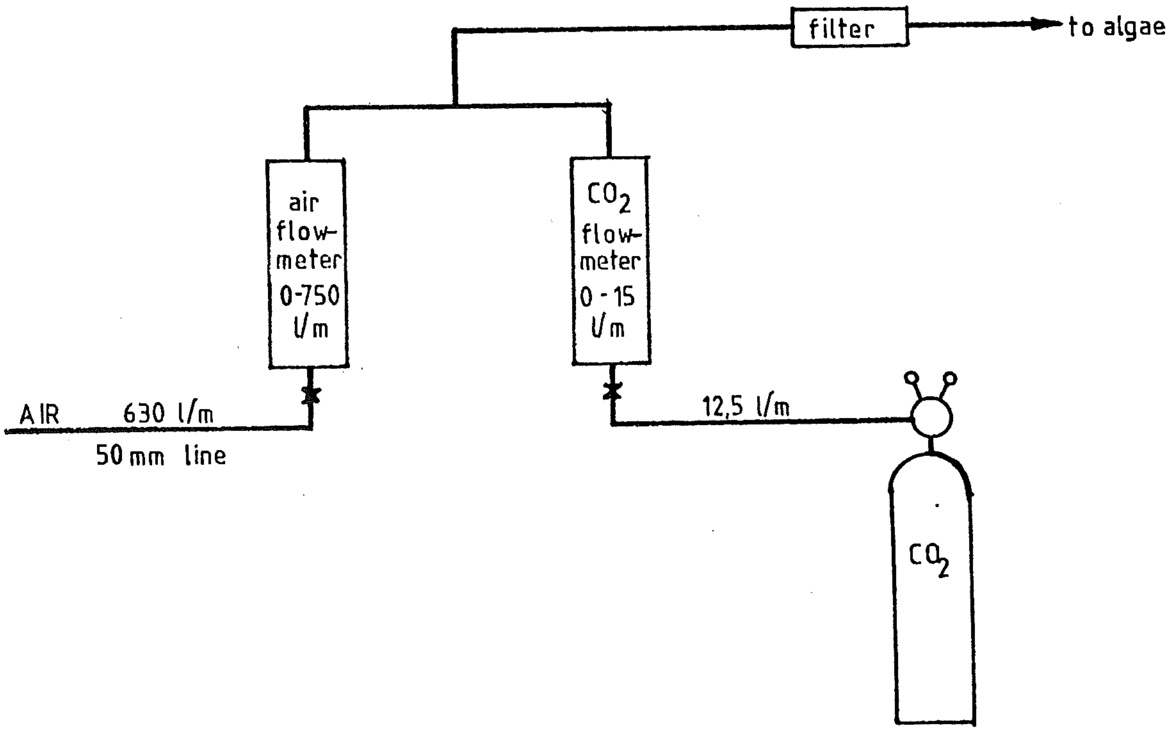
ALGAE RACK DIMENSIONS (5 l FLASKS)



WATER SUPPLY



AIR SUPPLY



Glassware for General Laboratory Use:

Item	Size	Number	$ ea	$
Conical Flasks	2 l	6	5.50	33
	1 l	6	3.50	21
	250 ml	12	1.50	18
Beakers	2 l*	10	4.00	40
	1 l*	10	2.00	20
	600 ml	6	2.35	15
	250 ml	12	1.40	17
Measuring Cylinders	1 l*	2	10.00	20
	500 ml	2	7.50	15
	250 ml	4	7.50	30
	100 ml	6	12.50	75
	50 ml	6	10.00	60
Calibrated pipettes	25 ml	6	8.00	50
	10 ml	6	5.00	30
	5 ml	6	5.00	30
	1 ml	6	5.00	30
	0.2 ml	6	4.00	25
Reagent Bottles	2 l*	5	5.00	25
	1 l*	10	2.00	20
	500 ml*	10	2.00	20
Test Tubes	100 by 12	144		25
Haemocytomers		2	40.00	80
Microscope slides		box		10
Thermometers		10	5.00	50
Hydrometer		1		5
Pasteur pipettes		box		10
Bottle brushes				20
Other				350
TOTAL				1200

* plastic

Chemicals Required for Algae Nutrients and General Use:

Nutrients:	Qty/batch	Ordered Qty (for 6 mon.)	$
Ferric chloride: $FeCl_3.6H_2O$	13 g	250 g	10
Manganese chloride: $MnCl_2.4H_2O$	3.5 g	250 g	10
Boric Acid Crystals: H_3BO_3	350 g	10 kg	50
EDTA (Sodium salt	450 g	10 kg	250
Disodiumhydrogen phosphate: $Na_2HPO_4.2H_2O$	200 g	5 kg	100
Sodium Nitrate: $NaNO_3$	1 kg	20 kg	50
Zinc chloride: $ZnCl_2$	2 g	500 g	10
Cobalt chloride: $CoCl_2.6H_2O$	2 g	100 g	10
Ammonium molybdate: $(NH_4)_6Mo_7O_{24}.4H_2O$	1 g	100 g	10
Cupric sulphate: $CuSO_4.5H_2O$	2 g	500 g	10
Vitamin B_{12}: Cyanobalamine	0.05 g	1 g	100
Vitamin B_1: Thiamine	1 g	20 g	60
General Use:			
Hydrochloric acid		5 l	20
Formalin		500 ml	10
Sodium or Potassium hypochlorite		50 l	50
TOTAL (for 6 months)			750

3e THE SEA WATER SUPPLY SYSTEM

GENERAL

The design of the seawater supply system to the hatchery is totally dependent on the location chosen because of the influence of both the site topography and the nature of the available seawater.

The 'quality' of the seawater will determine the treatment that is required before it is suitable for use in the hatchery and this can vary from nothing to extensive mechanical and biological filtration. From a hatchery point of view, the ideal water should contain a minimum of suspended silt and organic matter and it should have a low total bacteria count. It should also, obviously, not contain significant quantities of heavy metals or other pollutants.

The term 'seawater quality', with respect to hatcheries, can be defined rather better than was possible a few years ago and, after conducting some tests to determine turbidity, dissolved organic matter, bacteria counts, etc. at the selected site, suitable treatment can be specified with some confidence.

The facilities included in this design are based on the assumption that the water is generally 'oceanic' rather than 'esturine' and does not contain excessive silt or organic matter. Under such conditions treatment is confined to a primary settling tank with secondary filters and heating where required. The settling tank also provides storage capacity to allow increased flexibility of water use within the hatchery.

The site topography will govern the arrangement of the facilities required which will in turn influence both capital and operating costs as well as operating procedures.

In this case it has been assumed that the seawater intake lines will be 100 m long, that the settling/storage tank will have a capacity equivalent to 4 hours use at the maximum consumption rate, and that this tank and the hatchery will be at the same level - some 5 m above maximum high water. However, should it be possible to place the tank some way above the hatchery, larger main pumps may be required but the number of pumps within the hatchery is reduced - saving on capital and maintenance costs as well as making the system more reliable.

The Intake Lines and Pumps:

A dual system is necessary to permit routine cleaning of the pipelines and to provide a reserve in case of pump failure.

A number of procedures have been tried in order to control fouling within the lines and the most effective seems to be to fill them with freshwater when they are not in use. If the lines are used on an alternate weekly basis, such treatment seems to work well. As the most serious fouling is likely to occur near the inlet of the lines, the first 5m or so of the pipes should be easy to remove to permit cleaning and/or replacement by a diver.

Whereas submersible pumps at the intake point are generally superior to land based pumps in terms of reliability and flexibility, they are expensive, difficult to maintain, and vulnerable to expensive damage (i.e. burnt out motors). In the model situation considered here, therefore, shore based pumps have been specified; however, if the actual suction head is found to be too great for normal centrifugal pumps, then positive displacement (e.g. Mono) or submersible pumps must be considered.

The pipelines must be well anchored to the beach and seabed - how this is done will depend on the terrain and wave conditions to be expected. In a sheltered sand/hard mud area where maximum wave heights are seldom more than 0.5 m or so, the pipes can be stapled to the ground very cheaply; if the shore is rocky and large waves are common, the cost of fixing the lines may be considerable.

The Settling/Holding Tank:

The efficiency of a settling tank depends on the horizontal surface area and the residence time. A residence time of 4-12 hours/m depth should be suitable in a typical coastal situation though experimentation would be required to determine the optimum once the site has been selected. In this case a four hour residence time has been assumed for a tank 1m deep, which gives a tank volume of 100 000 l. A tank of this size would have sufficient capacity to permit the main functions of the hatchery to proceed for a day (or even two) should the main pumps not be operating for any reason.

Distribution Within the Hatchery:

Water is drawn from the holding tank for a number of destinations within the hatchery and, if practicable, separate lines should be used for each so that there is no interaction between flows as they are switched on and off during the day. This applies whether gravity or pumps provide the motive power for the water.

The systems providing water for the various departments in the hatchery have been considered elsewhere: p.9 for the stock conditioning; p.24 for the larvae; p.39 for the spat; and p.55 for the algae.

TABLE IV : Water Requirements

Destination	Max. Flowrate	Max. Volumes required: in 4hours	in 24 hours	in year
Algae	350 l/h	1 000 l	1 000 l	300 000 l
Stock	300 l/h	1 200 l	7 000 l	1 600 000 l
Larvae	5 000 l/h	16 000 l	16 000 l	5 000 000 l
Spat (I & II)	10 000 l/h	40 000 l	50 000 l	6 000 000 l
Spat Holding	10 000 l/h	40 000 l	250 000 l	50 000 000 l
TOTAL	26 000 l/h	100 000 l	325 000 l	65 000 000 l

Maximum average flowrate over 24 hours : 13 500 l/h

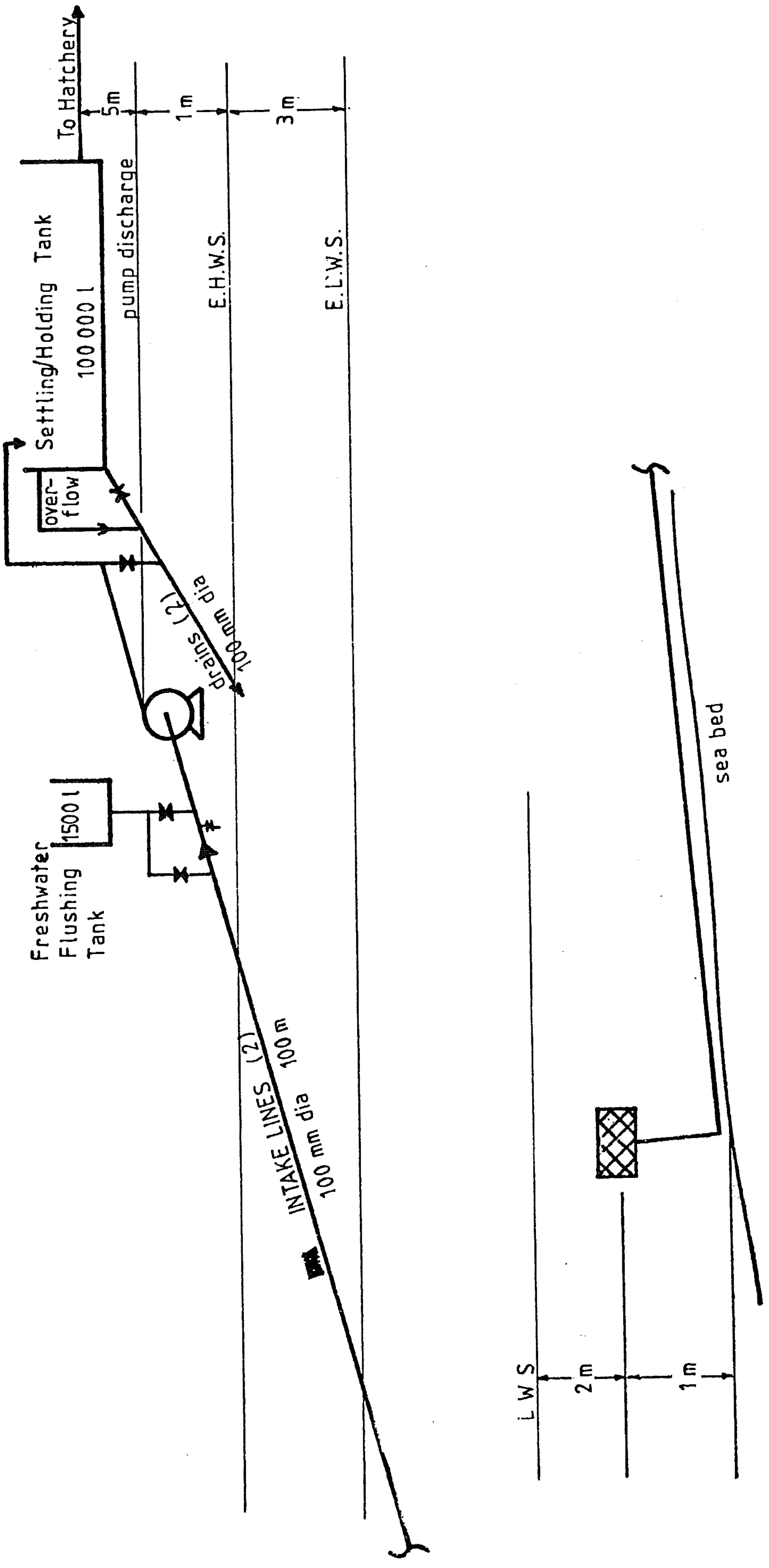
EQUIPMENT LIST

No	Item	Cost
300 m	PVC Pipe - 100 mm dia. @ $8/m	2 400
50	Pipeline supports (fabricated) @ $10	500
2	Check Valves - 100mm dia @ $150	300
4	Stop Valves - 100 mm @ $100	400
1	Flushing Tank - 1500 l - with associated pipework	400
1	Settling/Holding Tank - 100 000 l - concrete	3 500
2	Seawater Pumps - 15 000 l/h - 5 KW (+ controls) @ $750	1 500
	Pipework inside the hatchery	5 000
	Other	1 000
	TOTAL	15 000

OPERATING COSTS

Power:	
2 Pumps (5 KW each) working alternately:	
Total Operating time : 5000 hrs/a	
Annual consumption : 25 000 KWh/a @ $0.04/KWh	$1 000/a
Maintenance and Repair:	1 000
TOTAL	$2 000/a

EQUIPMENT ARRANGEMENT



EQUIPMENT SPECIFICATION

The Pumps:

Each pump should deliver about 15,000 l/h which is slightly more than the maximum average flow over 24 hours. Whereas this is less than the maximum demand during the day, the holding tank has sufficient capacity to cater for the fluctuations in demand.

Assuming the pipes are 'rough' due to fouling, then the maximum pressure drop to be expected in the suction lines is 1m of water for the pipe itself (for a pipe 100mm dia., 100m long, and a flow of 15,000 l/h), and 1m for the fittings. In addition there will be drawing against a total of 6m of water. In the discharge line the pressure drop caused by pipe and fittings is unlikely to exceed 1m and the main effort will be to raise the water to the level of the surface of the Holding Tank - say 5m.

The total pressure head against which the pump must operate is thus 6m suction + 6m discharge = 12m total.

An epoxy coated cast iron centrifugal pump with a 5KW motor would probably be suitable for this duty but if this could not handle the maximum suction head a more expensive positive displacement pump may be necessary; the final specification has to be made after the site has been chosen.

The Pipeline Flushing System:

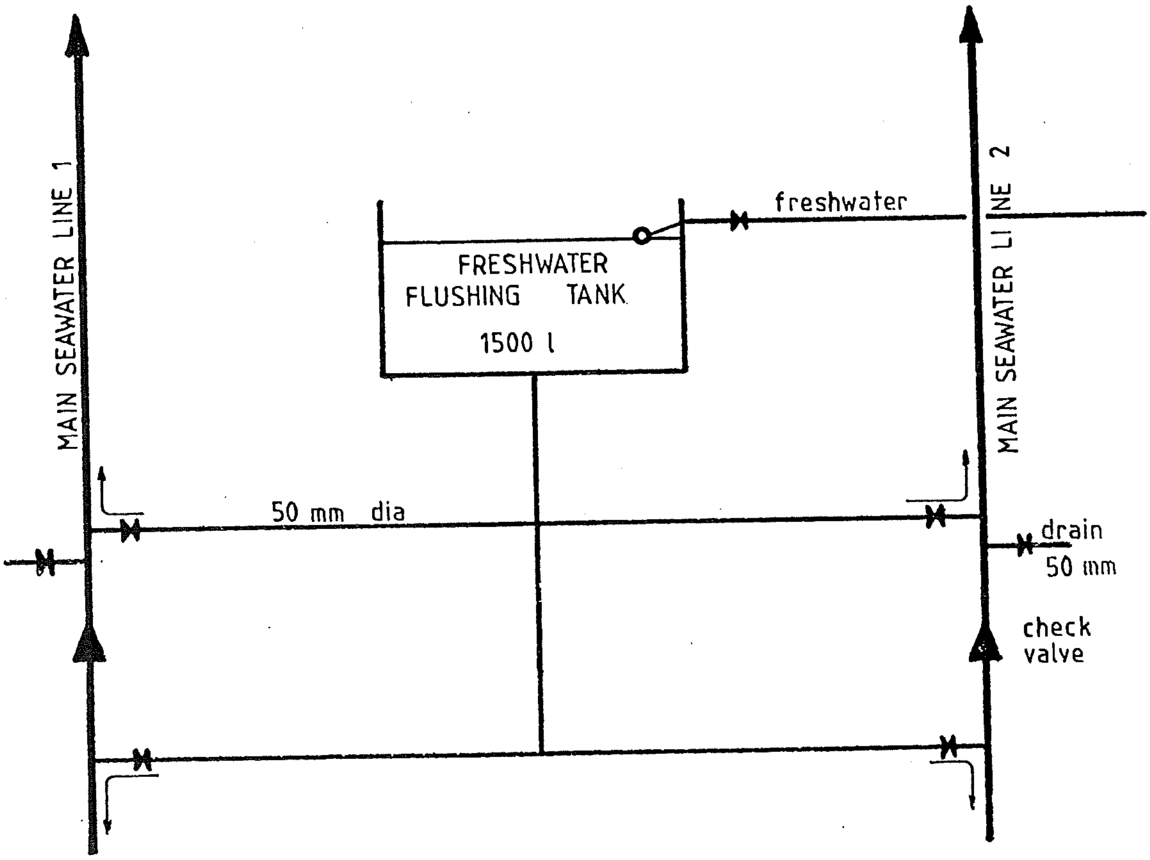
To fill the pipelines with fresh water when they are not being used, a header tank is utilized with connections into the main lines both above and below the check valves. This can also be used to prime the main pumps when necessary.

The capacity of the tank should be a little more than the volume of one pipeline. In this case the pipelines have a volume of about

1000 l. A concrete or polythene tank of 1500 l would thus provide ample capacity and ensure the line was completely filled with freshwater. If it was considered necessary, this tank could be dosed with chlorine to allow the lines to be sterilised.

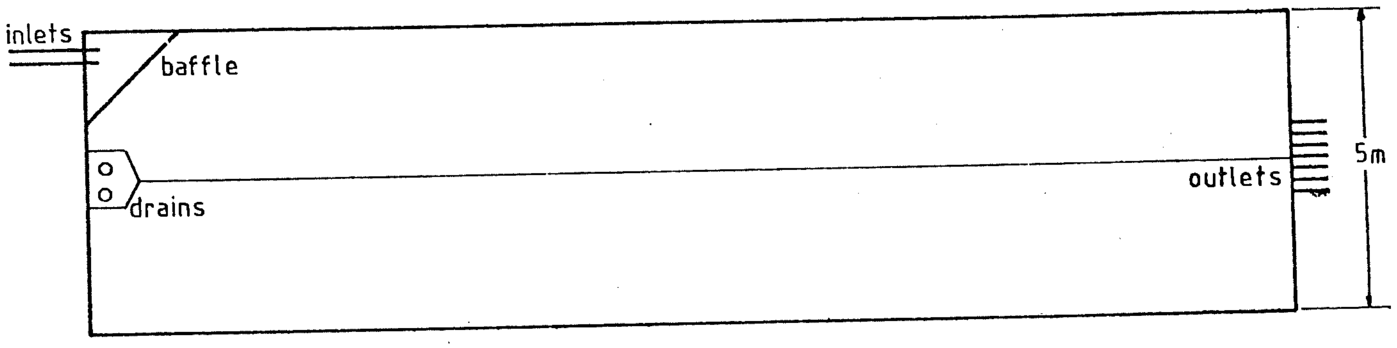
When brought into use, the freshwater, with or without chlorine, is pumped to waste and the line thoroughly flushed.

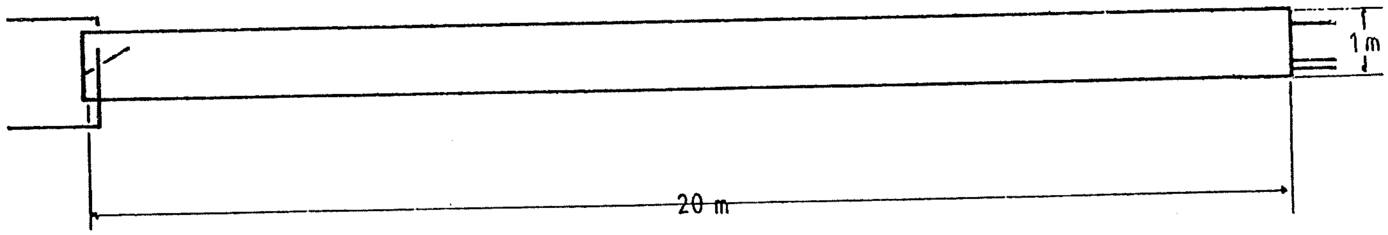
PIPING ARRANGEMENTS FOR FRESHWATER FLUSHING TANK



THE SETTLING/HOLDING TANK

For a 100,000 l tank measuring 20m by 5m by 1m deep, the cheapest form of construction is reinforced concrete. An estimate for the cost of such a tank may be obtained by using the factor of $150/m^3 of concrete used; Assuming a wall and floor thickness of 0.15m, the cost of this tank would be $3500.





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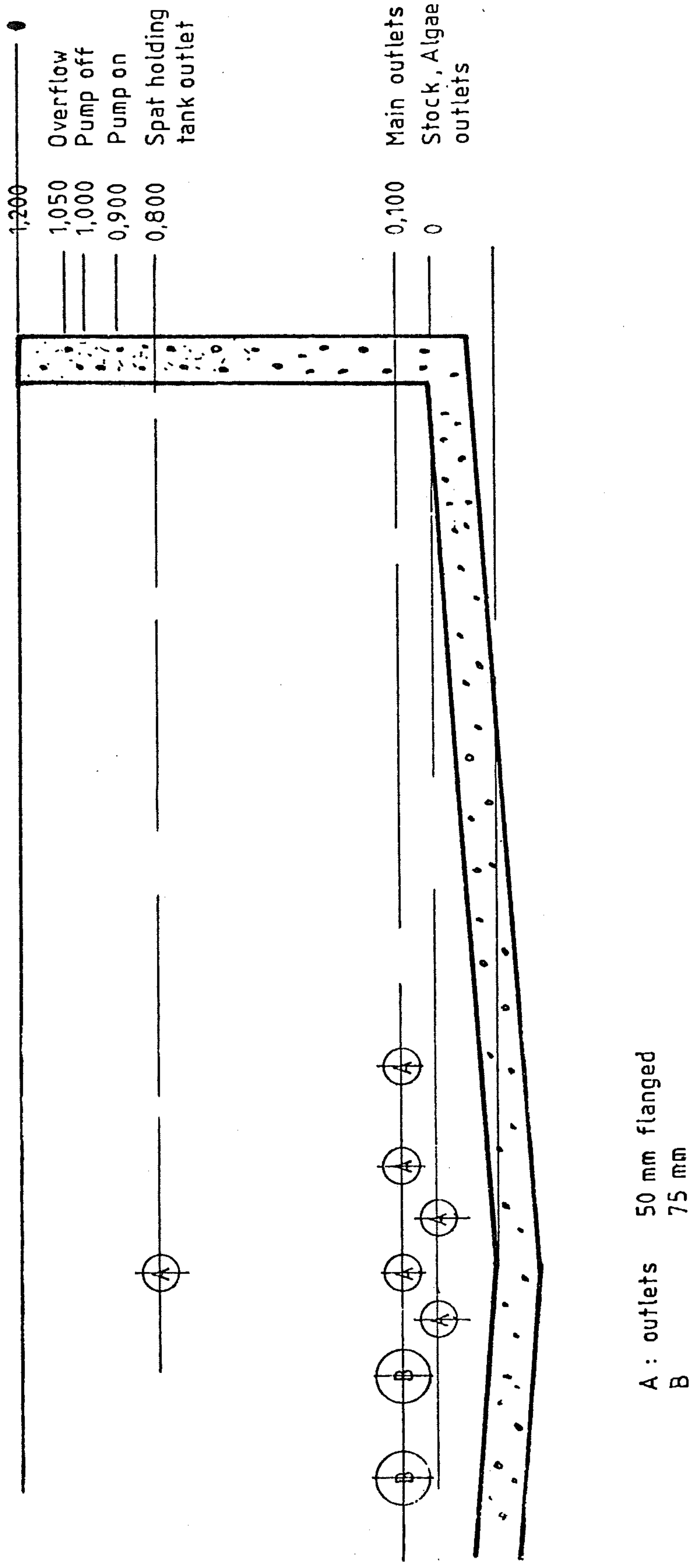
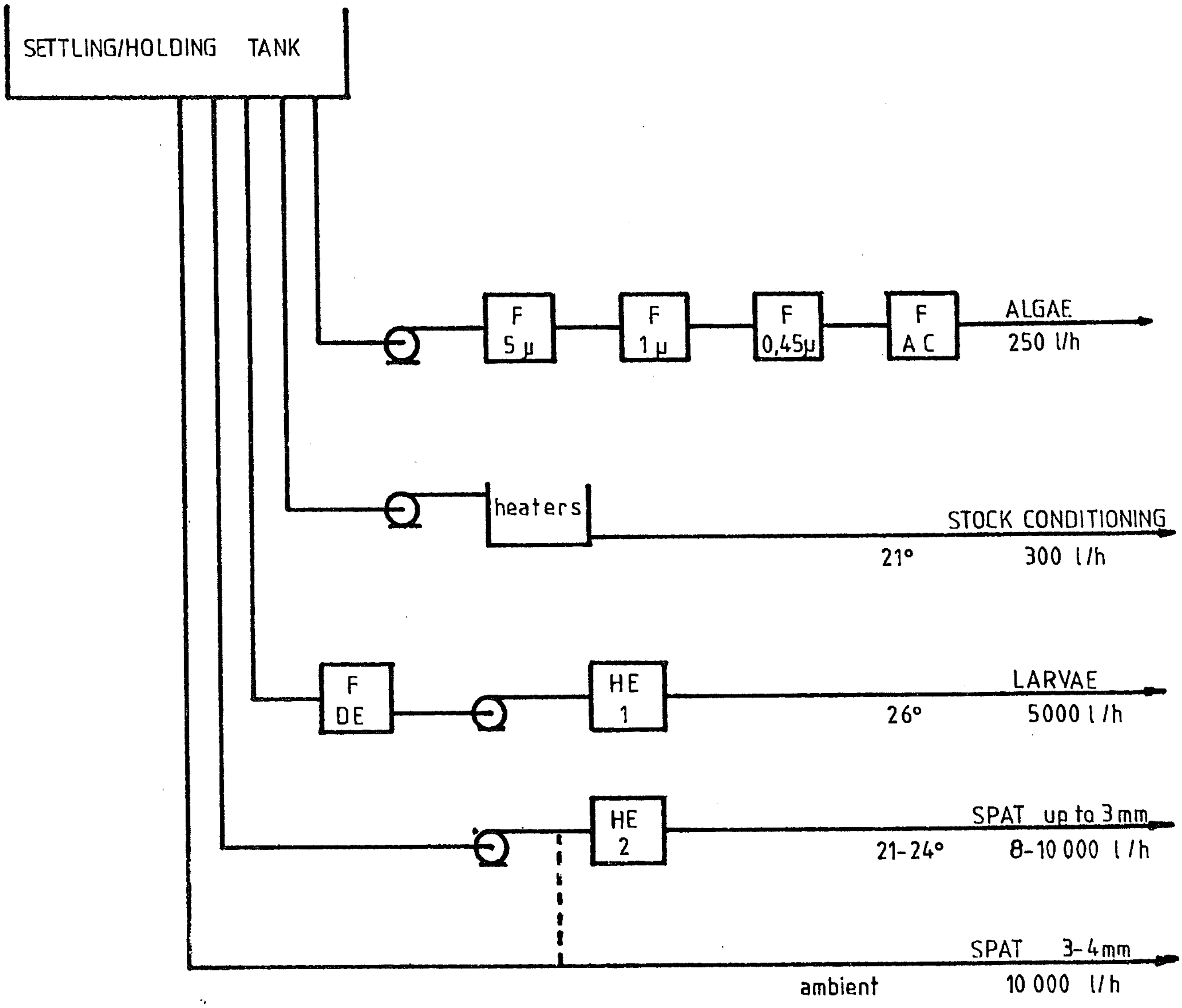
SETTLING/HOLDING TANK - TANK OUTLETS AND LEVELS



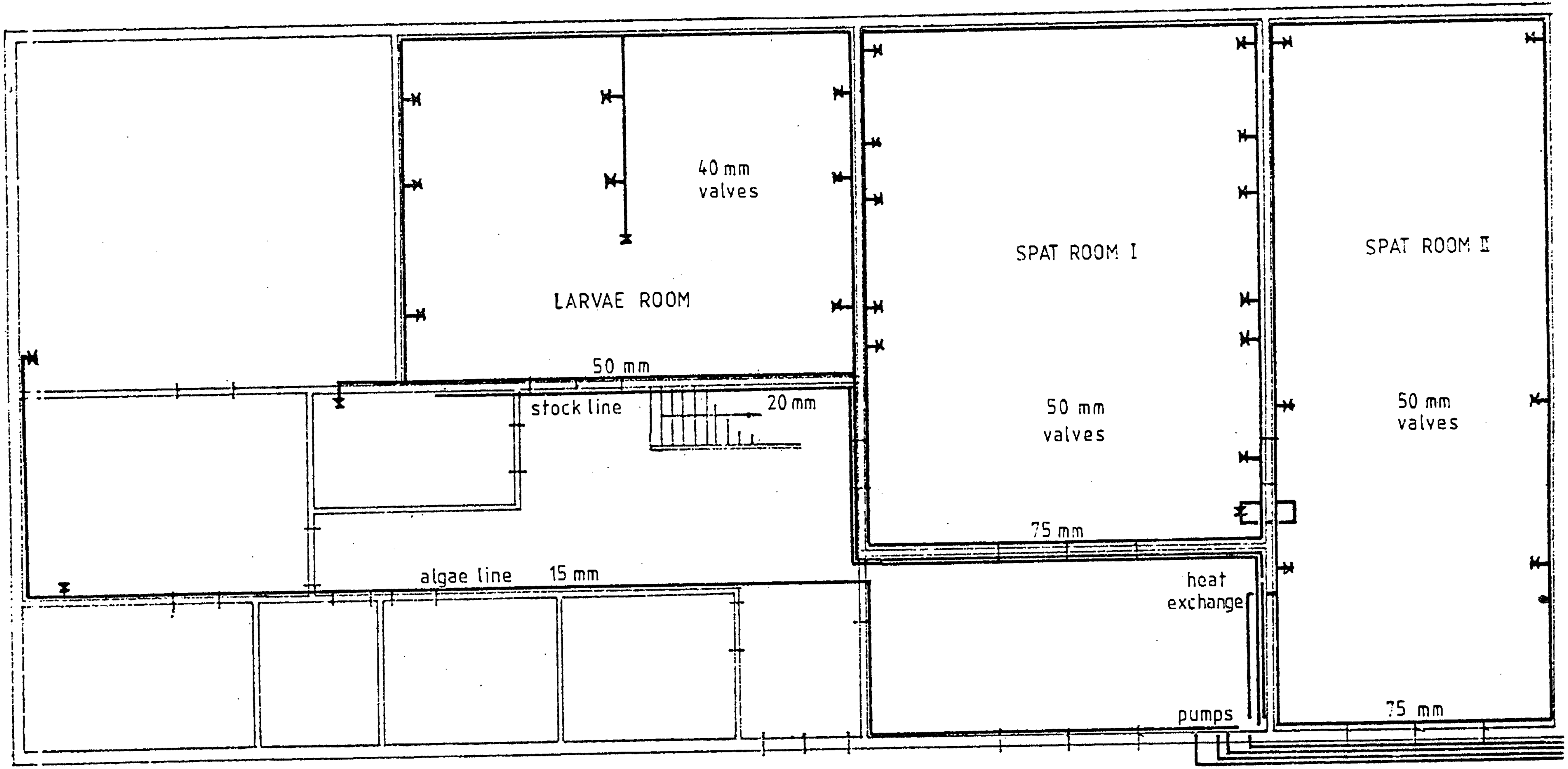
DISTRIBUTION WITHIN THE HATCHERY



F : Filter
AC : Activated Carbon
DE Diatomaceous Earth

HE : Heat Exchanger

SEA WATER DISTRIBUTION



3f THE BUILDING AND SERVICES

THE BUILDING

As the building is the most expensive single item of capital expenditure in this kind of venture, two conclusions are obvious:

If a suitable building is available for use as a hatchery, it would be well worthwhile using this and modifying the floor plans presented here accordingly;

If a new building is necessary, it should be as compact as possible because the cost is highly dependent on floor area.

The proposed floor plan has been prepared on the assumption that a new building would be required and, as such, may be considered a model which is open to modification to suit an existing building - should something suitable be available. However, in changing the design, it is almost inevitable that the total floor area required will be increased and there is likely to be some increases in equipment costs (especially piping) and operating expenses. The extent of these increases will obviously depend on the changes necessary.

Professional advice from a structural engineer was sought to suggest the most appropriate type of building to house the proposed floor plan. A simple timber framed brick/concrete block structure was thought likely to be the most suitable. The floor would be a reinforced concrete slab and the internal walls and ceilings would be clad with asbestos sheeting (which is waterproof and easy to clean).

BUILDING COSTS

The cost of a building as described is estimated to be between \$280 and \$320/m^2 of ground floor area with \$200/m^2 extra for the load bearing storage area on the upper floor.

Thus:

Ground Floor - (340 m^2)	@ \$300/m^2	:	\$102 000
Upper Floor - (90 m^2)	@ \$200/m^2	:	\$ 18 000
TOTAL			\$120 000

This estimate includes the cost of :
Materials and construction of the internal and external walls, floor, ceiling, roof, window, doors etc.
Non process lighting, wiring, painting, etc.
Freshwater supply and sewage.
Limited site preparation, and provision of access.

RUNNING COSTS

'Domestic' power: 10 000 KWh @ \$0.10/KW \$1000/a

Oil for Space heating:

Location	Rating	Hrs/a	Energy/a
Larvae Room	10 KW	4000	40 000 KWh
Spat Dept	10 KW	3000	30 000 KWh
General	10 KW	1500	15 000 KWh
Total			85 000 KWh/a

85000 KWh/a @ 0.115 l/KWh : 10 000 l/a @ \$0.155/l: \$1600/a

Maintenance and Repair	: \$1000/a
Consumables - various	: \$1400/a
TOTAL	\$5000/a

THE FLOOR PLAN

The floor plan suggested has been drawn up on the following principles:

1. The equipment and facilities required should be arranged so that they can be used as efficiently as possible.

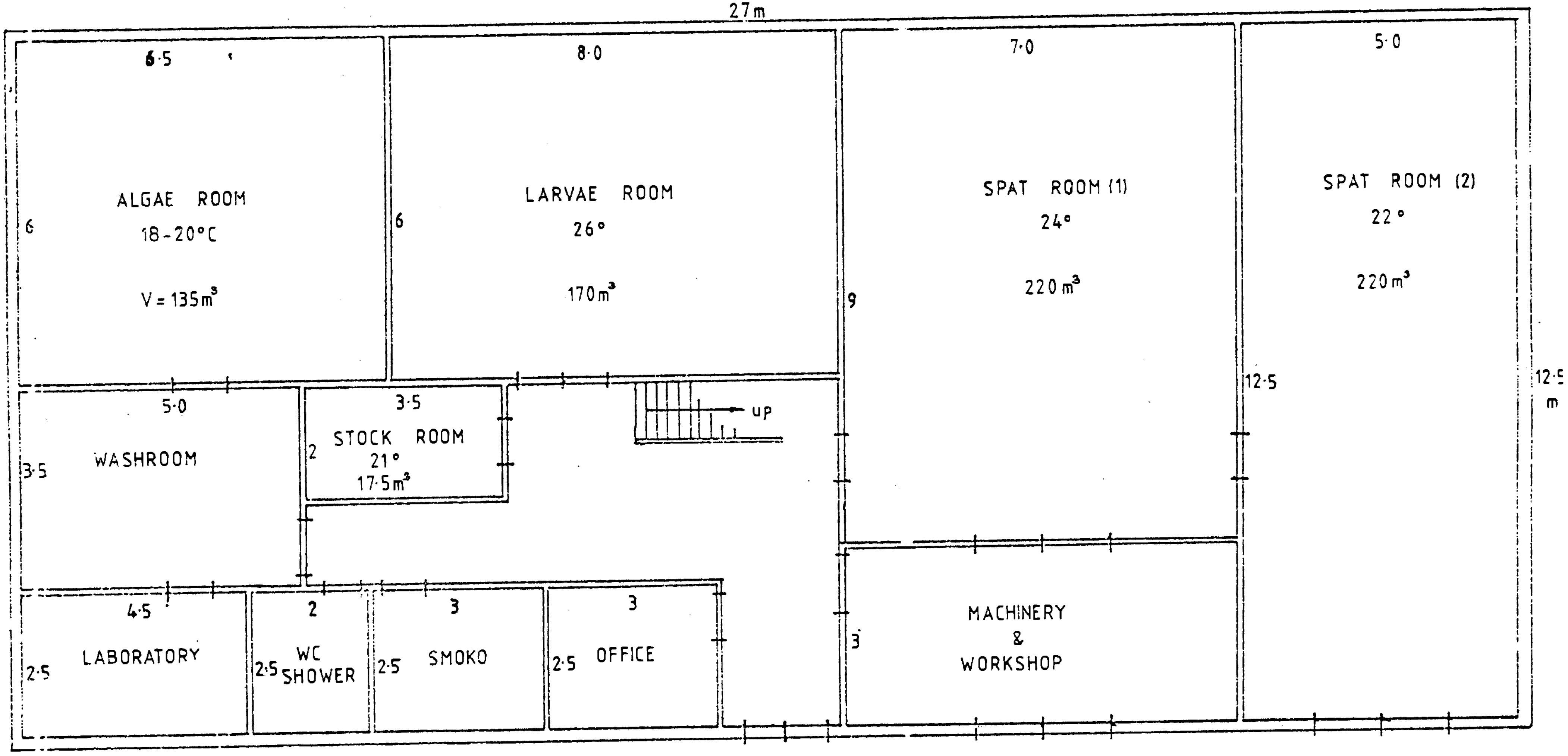
2. Process areas should not serve as passageways.

3. The water supply from the main storage tank should be as direct as possible.

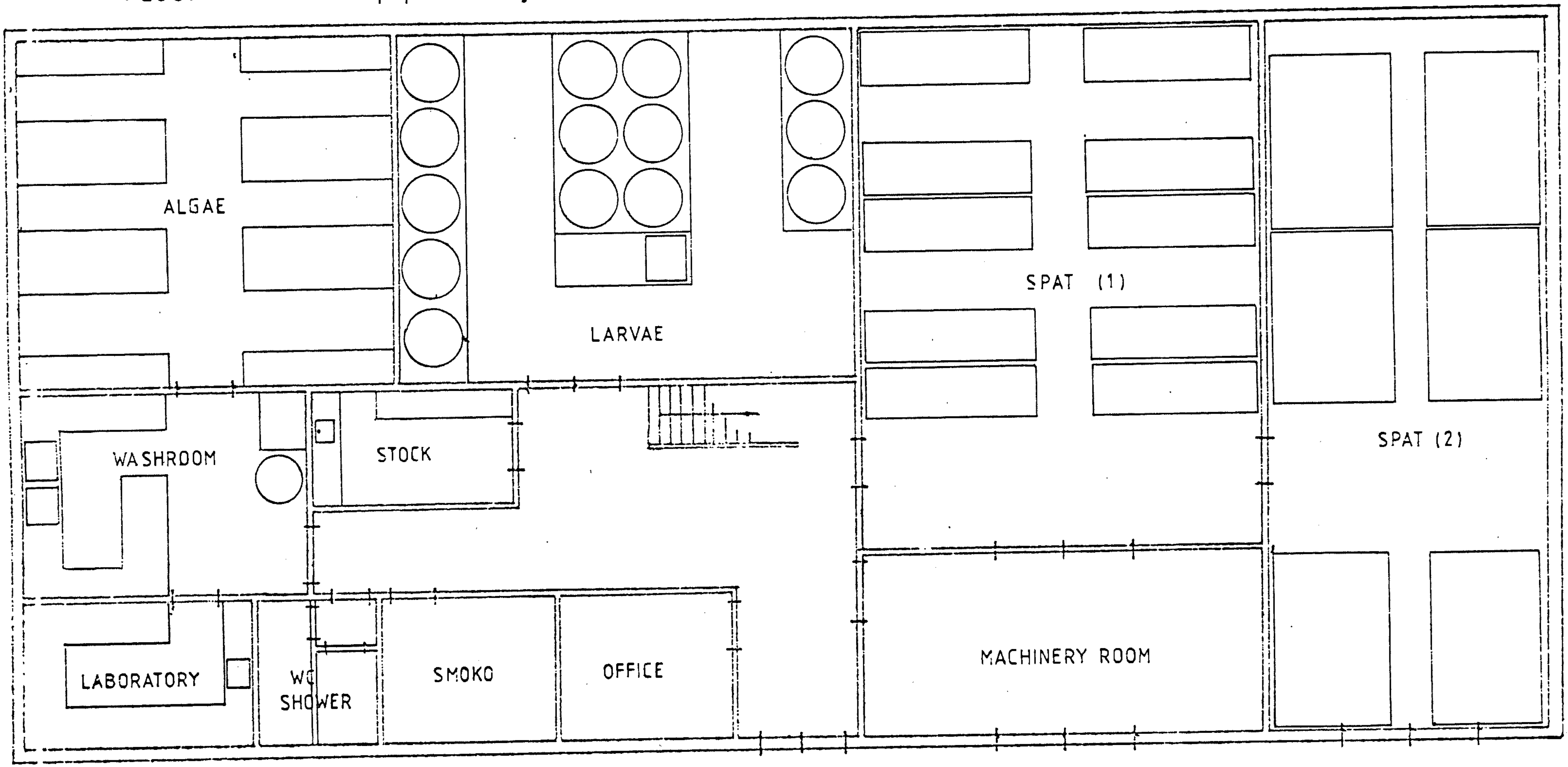
4. The temperature differences across walls should be a minimum to reduce the necessity for insulation.

5. The complete floor plan should occupy as small an area as possible.

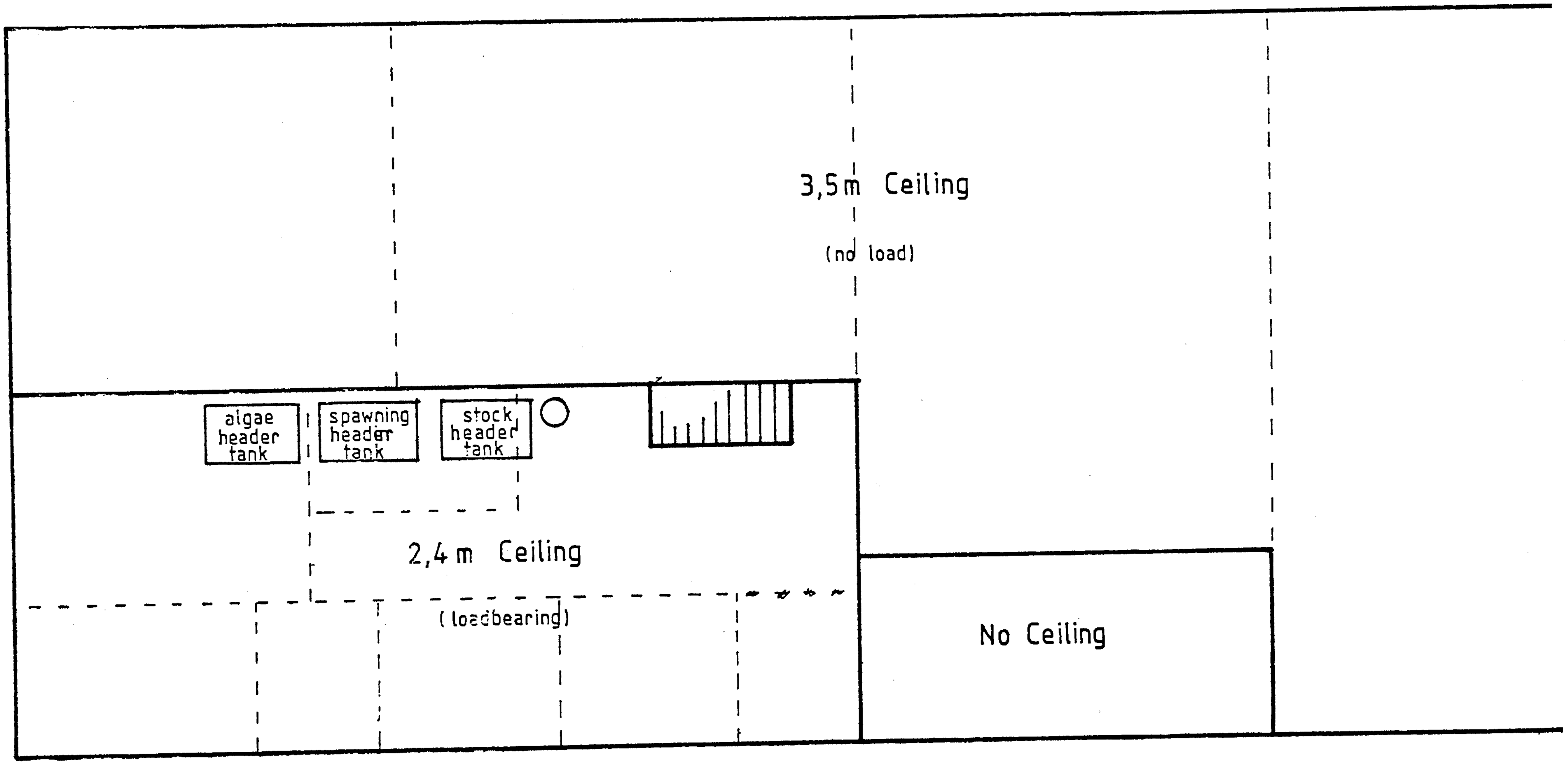
FLOOR PLAN : Room Dimensions



FLOOR PLAN : Equipment Layout - Ground Floor



FLOOR PLAN : Upper Floor



BOILER

The boiler is required to heat the seawater used in the larvae and spat departments. It can also be used to provide space heating in the stock, larvae, spat, and general areas when it is not being used for its primary purpose.

The fuel used will depend on the economics pertaining to the site chosen, but for this study oil firing has been assumed because of its general availability.

The oil storage tank should have a capacity of 5000 l or so which would be sufficient for 6 weeks operation in winter.

EQUIPMENT LIST

Boiler - 250 KW	8 000
Fuel Storage Tank and pipework (+ installation)	1 000
Hot Water Recirculating Pump - 3.5 KW	500
Radiators and Controls in process and general areas	2 000
Fresh Water Make-up Tank	500
Installation	1 000
Other	500
TOTAL	13 500

OPERATING COSTS

Power:

Recirculating Pump (3.5 KW) operating 6500 hrs/a Consumption : 22 500 KWh/a @ $0.04 KW/h	$ 900/a
Oil: For oil consumption see: p.34 (larvae); p.50 (spat); and p.85 (building)	
Maintenance and Repair:	$ 600/a
TOTAL	$1500/a

AIR SUPPLY

Air is required to provide agitation in both larvae and algae cultures. The air supply should be oil free and sterile and distributed at c.20 psi. To meet these conditions, the compressor can be either a high pressure reciprocating type (with a pressure reducing valve), or a low pressure rotary type. The latter is much the less expensive and more compact but has to operate continuously whatever the load because it has no storage tank. As the air consumption will be fairly constant over the year, the rotary type is quite suitable even if some air is constantly vented to waste.

Should air be required at higher pressures (eg. for instruments) it would be possible to use air cylinders.

TABLE V Air requirements:

Algae Room	660 l/m
Larvae Room	120 l/m
Other	20 l/m
TOTAL (at 20 psi)	800 l/m (50 000 l/h)

For the air requirements listed, a low pressure rotary compressor with 3.5 KW motor would be suitable. Ancilliary equipment would include a pressure relief valve, line filter, and silencer.

The piping from the compressor to the distribution manifolds in the larvae and algae rooms should be 50mm dia. to reduce pipeline pressure drop to a minimum.

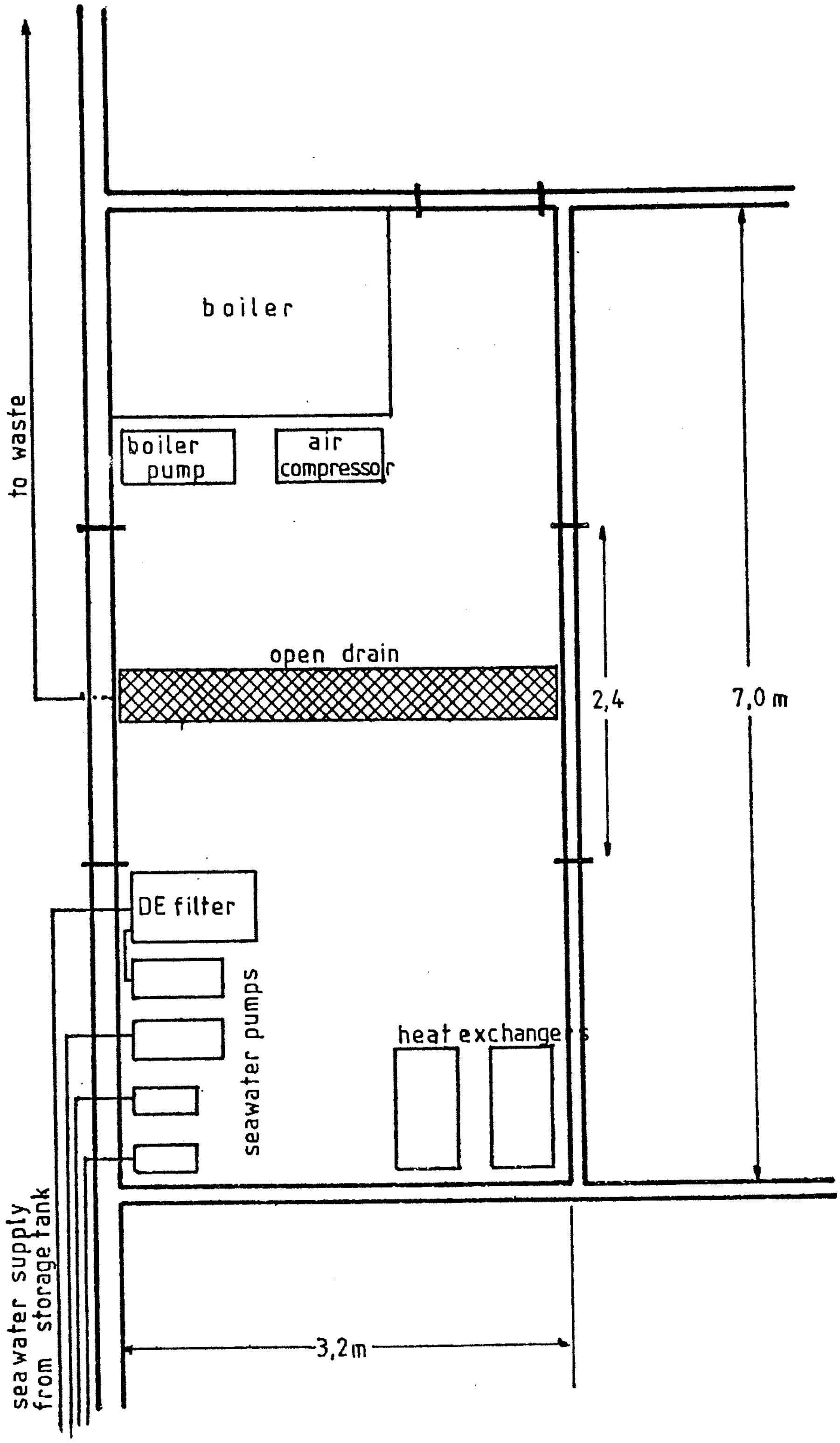
EQUIPMENT LIST

		$
Compressor with motor (3.5 KW), and controls 55 000 l/h	:	1400
Air Filter - submicron rating	:	200
Pressure relief valve and silencer	:	100
Spares	:	300
TOTAL		$ 2000

OPERATING COSTS

3.5 KW for 8000 hrs/a (30 000 KWh/a) @ $0.04/KWh	1200
Maintenance	300
TOTAL	$ 1500/a

MACHINERY ROOM FLOOR PLAN



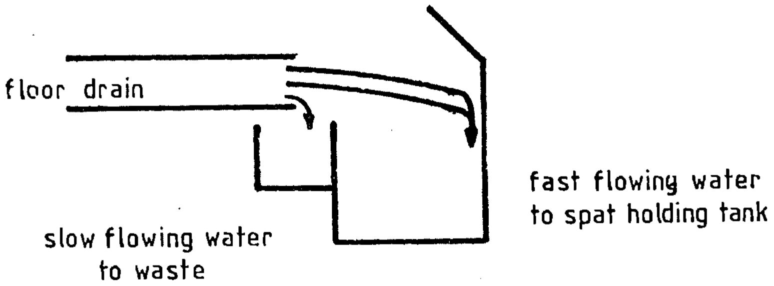
DRAINAGE WITHIN THE HATCHERY

Two drainage systems are required:

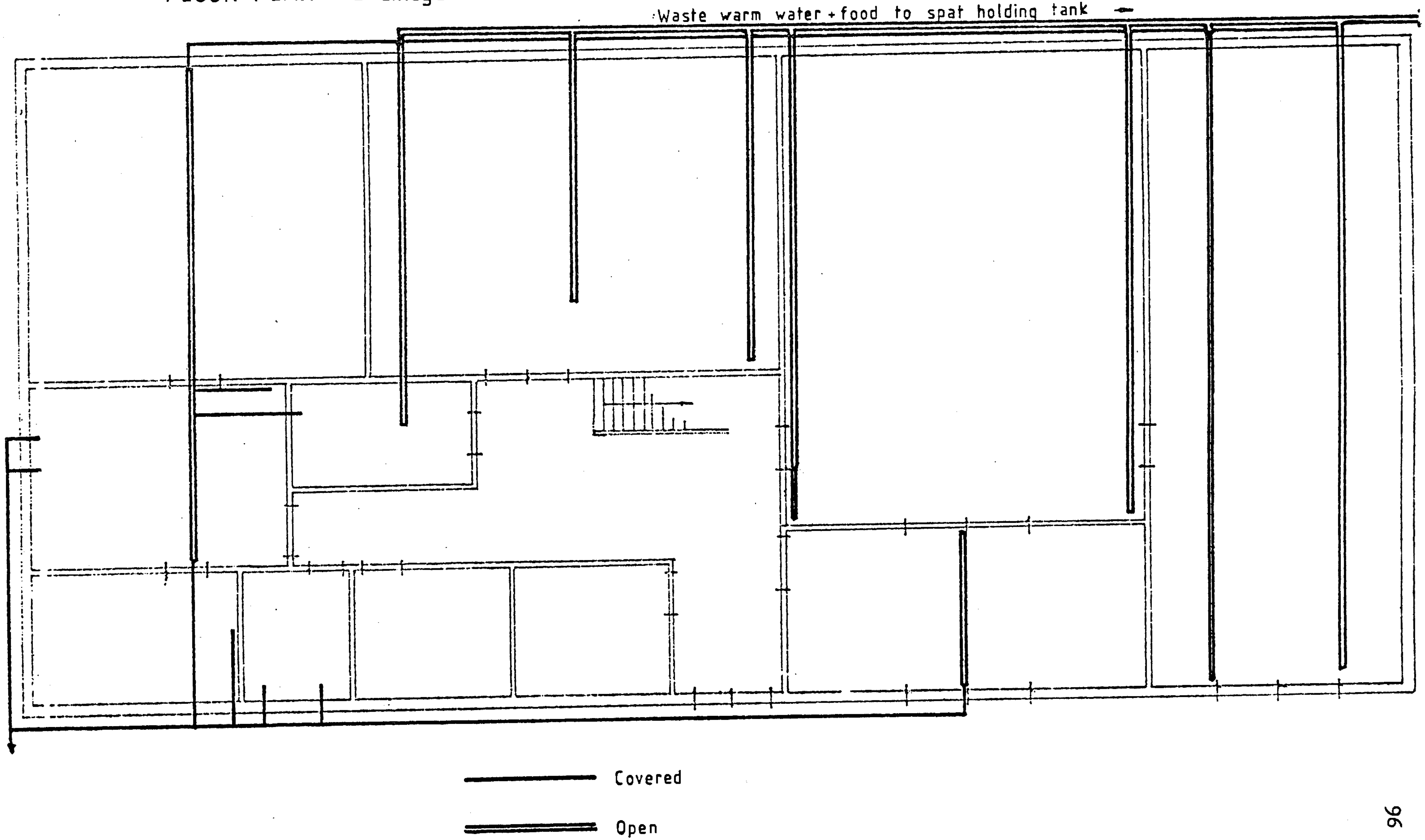
1. to remove the water from the larvae and spat tanks when these are emptied. This water will be warm and contain significant quantities of algae; should the topography of the site allow, this water should be piped to the spat holding tank;

2. to remove other liquid waste including the water used for washing the tanks and floors, and which cannot be utilized by spat - indeed which may be harmful.

Although it would be desirable to have 'dry floors' in all the rooms, on the scale of operation envisaged, this would not be practicable; instead open drains in the process areas are used to carry away the wastewater. To separate useful water from the washwater, a double drain is required which works on the principle that the flow of the former will be much greater than the latter.



FLOOR PLAN : Drainage



POWER

Total Power Requirements:

Department	Total Rating
Stock Room	10.3 KW
Larvae Department	2.5 KW
Spat Department	5.2 KW
Algae Department	18.7 KW
Sea Water Supply	10 KW
(Building	15 KW)
Boiler	3.5 KW
Air Compressor	3.5 KW
Other	11.3 KW
TOTAL	80 KW

Cost of installation and materials (wire, fuse boxes etc): $5000

The cost of materials and installation of 'domestic' power supplies (such as room lighting, wall sockets, etc.) is included in the costing given for the building as a whole.

FRESHWATER

Freshwater is used in the process areas of the hatchery for washing the tanks, screens, pipelines etc. If mains supply is not available, rainwater collection or a well would be required. The cost of installing freshwater supply is included in the 'Building Costs'.

WORKSHOP AND STORES

It is envisaged that much of the construction and maintenance within the hatchery will be carried out by the employed staff and so a reasonably equipped workshop will be required.

COSTS

Tools and equipment for carpentry and mechanical work:	3500
Basic Stock of Fastenings	500
Storage facilities for 'consumables'	1000
TOTAL	5000

ANNUAL COSTS

Tool replacements and additions	500
Fastenings	250
Other consumables	250
TOTAL	1000

VEHICLE

A small ute would be required to carry equipment and supplies to the site and to take spat to the customers.

Cost:

1000 KG Utility Vehicle	5000

Operating Costs:

Fuel	600/a	
Maintenance	500/a	
Other	400/a	
TOTAL		1500/a

3g ON-GROWING FACILITIES

The hatchery should have at its disposal some facilities for rearing 3-4 mm spat to adult size for future spawning stock. Only small numbers are required and provision to rear 1000 adults per year would be sufficient.

A secondary use for the on-growing facilities is to prove that samples from the batches sold will grow if properly looked after. This can prove helpful in settling disputes concerning the quality of spat if a grower suffers heavy mortalities with seed from the hatchery.

The on-growing operation is non-economic and solely to find the oysters with the highest growth potential for breeding purposes and to assess the quality of samples from the batches sold. The system used should thus be optimal from the biological rather than economic point of view. On the other hand, the time available for maintenance of the on-growing system will be strictly limited and this will also influence the design of the system used.

The nature of the site chosen will determine the detailed equipment requirements, but a typical system would use stacks of trays hung from a long-line supported by buoys.

EQUIPMENT LIST

No.	Item			Cost
100	Trays for spat	3-8 mm	- wire or plastic mesh	1000
100	"	8-15 mm	"	500
100	"	15-25 mm	"	500
100	"	25-75 mm	"	500
60	Buoys, cordage, mooring blocks, etc.			500
	Other			1000
	TOTAL			5000

OPERATING COSTS

Maintenance and Replacement	500/a

4 STAFFING REQUIREMENTS

It is envisaged that the hatchery would operate with a production staff of four with part time assistance for book keeping and maintenance.

Production Staff (full time):

One:	Culture of larvae and maintenance of breeding stock:	$ 10-15 000/a
One:	Rearing of spat, organising its sale, and care of the on-growing facilities:	$ 10-15 000/a
One:	Culture of algae and general microbiology within the hatchery:	$ 10-15 000/a
One:	General assistant/trainee (primarily associated with algae culture):	$ 8-10 000/a

Ancillary Staff (part time);

One:	Maintenance and repair of machinery and electrical apparatus requiring special skills not held by the production staff:	$ 5000/a
One:	Book keeping and filing of business transactions, preparation of invoices, payment of bills, etc.	$ 5000/a

It would be necessary to select the most appropriate of the above persons to carry out the ceremonial and legal duties of Manager.

Under normal conditions the duties of the staff as listed will require about 6-7 hours/day, leaving a little time spare to carry out minor repairs and improvements in their particular areas. Weekend working will be necessary, but essential duties will require only two people for 4-5 hours/day.

In a project of this type there will inevitably be batch failures and technical problems during the start-up period, and to be commercially successful it is vital that the production of good quality spat begins as soon as possible. It would therefore be necessary to employ three people (for the larvae, spat and algae departments) who have had previous commercial hatchery experience, and who can (hopefully) quickly overcome any problems that arise. These people should be recruited during the detailed planning stage so that their experience and knowledge can be used to the best advantage.

As such people are unlikely to be available in Tasmania (or even Australia), substantial inducement would be needed to attract them and the cost of recruitment will be high; however, as salaries comprise a large part of the hatchery running costs, it should be part of the work of such experts to train local (and cheaper) personnel to take over within two years or so.

The extra cost of employing foreign rather than local staff might be around $50 000 over two years, but this would be recovered if they can reduce the time to achieve full production by six months or more - this is likely.

EMPLOYMENT COSTS

Salaries	$ 65 000/a
Associated costs	$ 5 000/a
TOTAL	$ 70 000/a
Recruitment Costs	$ 15 000

5. ECONOMICS

GENERAL COMMENTS:

All prices and costs are based on figures obtained in January 1979. It has been assumed that increases in operating costs and salaries will be compensated for by increases in the price of spat.

CAPITAL COSTS

Equipment Costs:	Stock Room (p.13)		$ 3 000	
	Larvae Room (p.29)		12 000	
	Spat Department (p.41)		27 000	
	Algae Department (p.59)		24 000	
	Sea Water Supply (p.74)		15 000	
	Services: Boiler (p.90)	$13 500		
	Air (p.93)	2 000		
	Power (p.97)	5 000		
	Workshop (p.98)	5 000		
	Vehicle (p.99)	5 000		
	Other	4 500		
	Total		35 000	
	On-Growing		4 ~~5~~ 000	
	Other		4 000	
	Total			$12~~5~~4 000
Other Capital Expenditure:				
	Building (p.85)			120 000
	Site			30 000
	Staff Recruitment			15 000
	Contingencies			35 000
TOTAL				$325 000

RUNNING EXPENSES

Depreciation:	Building (20 years)	$ 6 000	
	Equipment (7 years)	23 000	
	Vehicle (5 years)	1 000	
	Total		$ 30 000/a
Interest on Capital (@ 10%)			32 500
Operating Costs (see p.108)			45 000
Salaries (see p.102)			70 000
Other (Insurance, rates, etc.)			12 500
TOTAL			$ 190 000/a

OPERATING COSTS

Department	Power $/a	Fuel $/a	Consumables $/a	Maintenance $/a	TOTAL $/a
Stock	1 600	-	-	400	2 000
Larvae	100	1 800	600	1 000	3 500
Spat	800	2 000	1 500	1 200	5 500
Algae	3 000	-	10 500	1 500	15 000
Seawater	1 000	-	-	1 000	2 000
Building	1 000	1 600	1 400	1 000	5 000
Services:					
Boiler	900	-	-	600	1 500
Air	1 200	-	-	300	1 500
Workshop	-	-	1 000	-	1 000
Vehicle	-	-	1 000	500	1 500
On-Growing	-	-	-	500	500
Other	1 900	600	1 500	2 000	6 000
TOTAL	11 500	6 000	17 500	10 000	$45 000/a

Notes:

Power Charges:	for heating and motors:	$0.056 for first 500 KWh $0.04 for others
	for 'domestic' lighting:	$0.15 for first 500 KWh $0.125 for other.

Oil cost: $0.154/1

START-UP TIMETABLE

1st year: Detailed consideration of plans;
Find sponsors; Find site;
Obtain planning permission;
Obtain firm commitments on finance;
Purchase site; Recruit staff;
Start building.

Expenditure:	Salaries:	$ 35 000	
	Recruitment:	15 000	
	Site:	30 000	
	Other:	20 000	
	Total		$ 100 000

2nd Year: Complete building;
Purchase and install equipment;
Prepare and production;

Expenditure:	Building	$120 000	
	Equipment:	130 000	
	Running costs:	150 000	
	Total		$ 400 000

3rd year: Start production;

Expenditure:	Equipment:	$ 30 000	
	Running costs:	190 000	
	Total		$ 220 000

Production: 20 000 000 spat

4th and subsequent years: Full production.

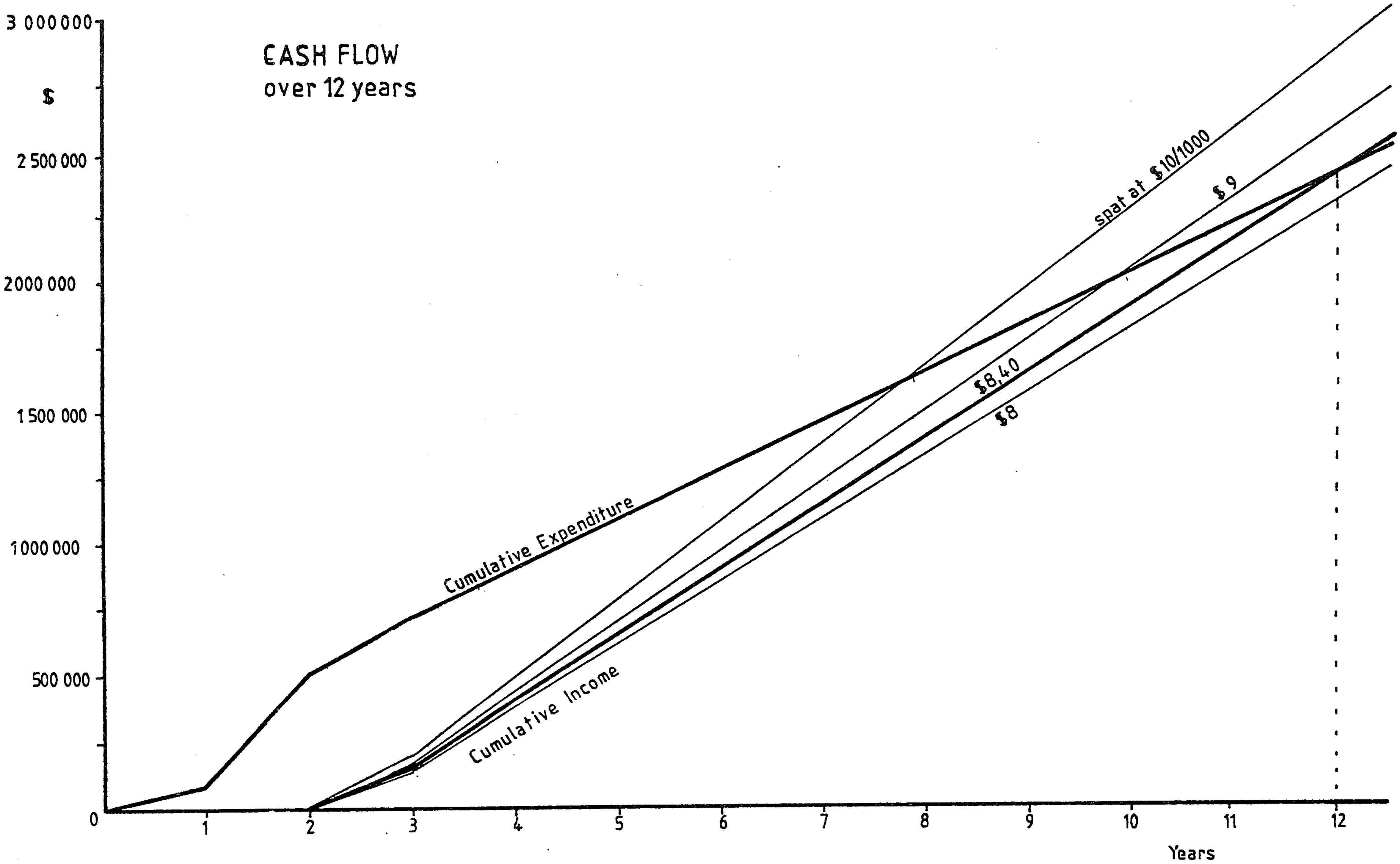
Expenditure:	Running costs	$ 190 000

Production: 30 000 000 spat

CUMULATIVE EXPENDITURE AND SALES

Year	Expenditure ($)		Spat Sales (1 000 000)	
	Annual	Cumulative	Annual	Cumulative
1	100 000	100 000	0	0
2	400 000	500 000	0	0
3	220 000	720 000	20	20
4	190 000	910 000	30	50
5	190 000	1 100 000	30	80
6	190 000	1 290 000	30	110
7	190 000	1 480 000	30	140
8	190 000	1 670 000	30	170
9	190 000	1 860 000	30	200
10	190 000	2 050 000	30	230
11	190 000	2 240 000	30	260
12	190 000	2 430 000	30	290

Thus for a payback time of 12 years, the breakeven price for spat would be : $8.40/1000

CASH FLOW
over 12 years
$
3 000 000
2 500 000
2000 000
1 500 000
1000 000
500 000
0
1
2
3
4
5
6
7
8
9
10
11
12
Years
Cumulative Expenditure
Cumulative Income
spat at $10/1000
$ 9
$8,40
$8

ESTIMATE OF RISKS AND ACCURACY OF ESTIMATES

Capital Costs:

Equipment Costs: Apart from the seawater supply system, the design of which will depend very much on the site chosen, the equipment specified is fairly 'standard' and the cost should be within 20% of the estimates.

Building Costs: These will depend on the site, detailed design, and the distance from the contractor's base, but should be within 20% of the estimate.

Site: The price of a suitable site is difficult to estimate and will depend on location, availability, etc. The figure quoted ($ 30 000) can best be described as a thoughtful guess.

Contingencies: A contingency fund has been included to allow for any unforseen capital expenditure required - in particular if it is necessary to use a 'difficult' site.

As a whole, the capital cost should be within 20% of the estimates. The effect of errors in capital cost estimation on spat prices and overall profitability is moderate: a 10% error (c. $30 000) would alter the cost of production of the spat by about $0.60/1000(c. 7%).

Running Expenses:

Depreciation, Interest on Capital, and Payback Time: The figures used for these are largely a matter of convention and will vary from one investor to another. For this case the percentages used were given by the TFDA.

Operating Costs: These will be highly susceptable to inflation, but based on present day costs they should be within 20% of the estimates.

Salaries: These depend on both inflation and market forces, but should be within 20% of the estimates.

The effect of errors in operating expenditure estimates will have a moderate effect on spat prices: an error of 10% (c.$20 000/a) will change the cost of spat production by about $0.75/1000 (c.9%).

Start-up Programme:

Delays in the start-up programme will affect the cost of spat production variously - depending on when they occur. A delay in the first 6 months or so - before any major expenditure has been incurred - will affect the costs minimally. However, if there are problems in production, the effects will be serious: a delay of 1 year in reaching full production will increase the cost by about $1/1000 (c.12%), and for a second year the cost would rise by a further $1.20/100 (c.26%).

The risk of delays in start-up is hard to assess because it will depend almost entirely on the ability of the staff employed to overcome the problems that are certain to arise.

	Risk of 1 yr. delay	of 2 years
3 experience staff + 1 other:	Low to moderate	Low
1 experienced staff + 3 others:	Moderate	Low to moderate
Inexperienced staff (with advice):	High	High to moderate

Production Rate:

The annual production rate has a significant effect on the cost of spat production:

24 000 000 spat/a	(-20%)	$10.55/1000	(+25%)
27 000 000	(-10%)	9.35/1000	(+11%)
30 000 000	(estimated production)	8.40/1000	
33 000 000	(+10%)	7.60/1000	(-9.5%)
36 000 000	(+20%)	6.95/1000	(-17%)

With competent staff the risk of production less than estimated is low <u>if</u> spat can be despatched at weekly intervals. However, the problems of co-ordinating production with sales has caused considerable problems in many hatcheries; avoiding these problems is important to the commercial viability of the project (and to staff morale).

INFLUENCE OF ESTIMATE ERRORS ON SPAT COST

Capital Cost ($)	Running Expenses ($)	Cumulative Cost over 12 years ($1000)	Cumulative Sales over 12 years (1 000 000)	Spat cost ($/1000)
300 000	180 000	2 300	290*	7.90
	175 000	2 225	290*	7.75
			260	9.35
325 000*	190 000*	2 430*	290*	8.40*
			310	7.85
	210 000	2 650	290*	9.15
350 000	195 000	2 600	290*	9.00

* The estimated figures

Enclosed please find Cash Flow Statement and projected operational figures for the above proposal. It is understood that Mr. Carrington Smith will supply further information to you regarding market prospects in this matter.

In addition to the preparation of the enclosed Cash Flow Statement, where possible costs given in the study were verified with outside authorities, for example, power costs with the Hydro-Electric Commission.

It was noted that oil costs were shown at 15.5 cents per litre where, in fact, the current cost for heating oil is 16.5 cents per litre, and diesel fuel 15.3 cents per litre.

The building is the most expensive single item of capital expenditure and is estimated to cost $120,000. A simple timber framed brick/concrete block structure is thought to be most suitable; the floor to be of reinforced concrete and the internal walls and ceilings clad with asbestos sheeting. The cost of the building is estimated to be approximately $300 per square metre for the ground floor area and $200 per square metre for the load bearing storage area on the upper floor. The costs seem in order for a building of this nature.

As stated in the study the price of a suitable site is difficult to estimate and will depend on location, availability, etc. As no indication was given as to the area of land required, the figure of $30,000 used in the study is incapable of verification.

Another large item of capital expenditure is the building of a settling/holding tank estimated to cost $3,500. This 100,000 litre tank is to be built of reinforced concrete and should require approximately 22.5m^3 of concrete at a total cost of around $1,100. Boxing, labour and steel costs should allow this tank to be built within the budgeted amount.

In compiling this statement, certain assumptions have been made:

1. The Capital has been borrowed in the same year as the capital expenditure has been incurred.

2. Borrowed capital to be repaid by ten equal annual instalments commencing year three, the first year when spat sales will occur.

...2/

3. The interest charged on borrowed capital to be ten per cent. per annum.

4. The vehicle will be replaced after five years and the equipment after seven years.

5. Spat production will commence at 20 million units per annum in year three, increasing to 30 million units per annum year four and thereafter.

6. No allowance has been made for inflation. It has been assumed that increases in operating costs and salaries will be compensated for by increases in the price of spat.

7. No mention was made in the study regarding provision of funds to cover the initial running costs of the project. It has been assumed that these funds are to be provided by the T.F.D.A.

8. Within twelve years, the initial capital cost and running costs of the project will be recovered.

Based on the figures supplied there will be a cash surplus at the end of the period in excess of $200,000, working on a sale price of $7.98 per 1,000 spat.

B. J. KELLY,
EXECUTIVE OFFICER, FINANCE.

FEASIBILITY STUDY FOR A COMMERCIAL OYSTER HATCHERY IN TASMANIA

CASH FLOWS AND PROJECTED OPERATIONAL FIGURES

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Borrow	45000	250000	30000										325000
Capital Cost Expenditure	45000	250000	30000										325000
	-	-	-										-
Capital Repayments			32500	32500	32500	32500	32500	32500	32500	32500	32500	32500	325000
Replacement Vehicles and Equipment						5000			130000	30000	5000		170000
			32500	32500	32500	37500	32500	32500	162500	62500	37500	32500	495000
Spat Production in Units			20000000	30000000	30000000	30000000	30000000	30000000	30000000	30000000	30000000	30000000	290,000,000
Running Costs													
Depreciation-Building		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	66,000
Equipment		18600	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	248,600
Vehicles	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12,000
Interest on Capital	4,500	29500	32500	29250	25000	21750	18500	15250	12000	8750	5500	2250	204,750
Operating Costs		45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000	495,000
Salaries	35,000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	70000	805,000
Other	20,000	12500	12500	12500	12500	12500	12500	12500	12500	12500	12500	12500	157,500
Total Running Costs	60,500	182600	190000	186750	182500	179250	176000	172750	169500	166250	163900	159750	1,988,850
*Total Cash Outflow	59,500	157000	192500	189250	185000	186750	178500	175250	302000	198750	103250	162250	2,090,000
** Cash Inflow (Spat Sales)	-	-	159600	239400	239400	239400	239400	239400	239400	239400	239400	239400	2,314,200
Net Cash Flow	(59,500)	(157000)	(32900)	50150	54400	52650	60900	64150	(62600)	40650	136150	77150	224,200
Profit or (Loss)	(60,500)	(182600)	(30400)	52650	56900	60150	63400	66650	69900	73150	76500	79650	325,450

*Total Cash Outflow= Total Running Costs Less Depreciation Plus Capital Repayments and Replacements

** Calculated as follows:- $\dfrac{\text{Total Running Costs + Capital Repayments}}{\text{Total Spat Produced}}$ = \$Cost Per 1,000 Spat

$$= \frac{1,988,850 + 325,000}{290,000,000}$$

= \$7.98 per 1,000 Spat

le 3: Five-year cash flow projections for hatchery operation with sales of 60 million seed/year.[5]

	Year				
	1	2	3	4	5
Capital Costs					
Hatchery facilities and equipment	200,000	-	-	-	-
Operating Costs					
Depreciation (repayment of capital)	20,000	20,000	20,000	20,000	20,000
Capital service (12% on undepreciated capital)	21,600	19,200	16,800	14,400	12,000
Salaries	80,000	86,400	93,312	100,777	108,839
Utilities and misc.	25,200	27,216	29,393	31,744	34,284
Repairs and maintenance	9,600	10,368	11,197	12,093	13,060
Materials and supplies	24,000	25,920	27,994	30,234	32,653
Total Operating Costs	180,400	189,104	198,696	209,248	220,836
Revenues	300,000	324,000	349,920	377,914	408,147
Annual profit (loss)	119,600	134,896	151,224	168,666	187,311
Cumulative profit (loss)	119,600	254,496	405,720	574,386	761,697
Discounted (8% rate) present value of earnings for years 1-5	119,600	124,904	129,650	133,893	137,679
Sum	645,726				

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[5] Assuming all costs increase 8% per year and price of seed oysters increases 8% per year.

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FISHING INDUSTRY RESEARCH TRUST ACCOUNT

REPORT ON PROJECT

1978/1979

1. Title of proposal - Feasibility study of a commercial shellfish hatchery.

2. Name of applicant - Tasmanian Fisheries Development Authority.

3. Division, Department or Section - Research and Resource Section.

4. Proposal - To assess and report on the economic feasibility of a commercial shellfish hatchery in Tasmania.

5. Name of person responsible for programme - Chairman, T [illegible]., A.J. Harrison, Fisheries [illegible]

6. Qualifications of staff to be employed on the programme - R. Watson, B.Sc (Hons), Shellfish Culture Pty Ltd., Bicheno, Tasmania. A graduate chemical engineer with commercial shellfish hatchery experience in Scottish Sea Farms (4 years), 2 years in New Zealand including work at the hatchery of Ministry of Agriculture and Fisheries and as consultant to New Zealand oyster growers. Four months in Chile helping to establish the hatchery of Fundacion Chile.

7. Location of Operation - Research and Resource Laboratory, T.F.D.A., and Wellington, New Zealand.

8. Date project commenced - 30th November, 1978.

9. Completion date - 6th March, 1979.

10. Report on project

    (a) Research

    The project was completed to the specification proposed and in the allocated time. Watson's 115 page report was received by the T.F.D on 6th March, 1979.

A summary of the report is as follows:-

"The following report has been prepared for the Tasmanian Fisheries Development Authority to indicate the economic feasibility of a hatchery to produce 30,000,000/a *Crassostrea gigas* spat at a size of 3-4 mm.

As a site has not been specified, it has been assumed that a new building would be required; floor plans and equipment lists have been prepared accordingly.

The initial cost has been estimated as $325,000 (which includes $150,000 for the building and land) and the operating costs have been estimated as $190,000/a. Based on these figures, it would be necessary to charge $8.40/1,000 spat to give a payback time of 12 years.

Four full-time staff are required for production with part-time assistance from two others for maintenance and book-keeping."

T.F.D.A. arranged an independent assessment of the cash flow projections contained in the report and decided that establishment of a commercial hatchery should be pursued.

The report was made available to the State's oyster industry and subsequently advertised (4th June, 1979) in the "Mercury", "Australian" and Financial Review".

After consultation with oyster growers and interested investors the original hatchery proposal was scaled down from a production capacity of 30 to 10 million spat per annum.

This necessitated a revision of the feasibility study which was done by T.F.D.A. staff in consultation with Mr. Watson.

Stemming from this a group of Tasmanian oyster growers and investors established a company, Shellfish Culture Pty Ltd., to build and operate a hatchery managed by R. Watson at Bicheno, Tasmania.

The hatchery is nearing completion and should begin production early in 1980.

Copies of the completed feasibility study have been made available to the FIRTA committee.

(b) Expenditure

The allocated funds, $4,500 were expended as follows:-

Initial visit R. Watson, Wellington - Hobart and *per diem*	-	$750.00
Progress payment after 1 month	-	1,000.00
Progress payment after 2 months	-	1,000.00
Final visit and *per diem*	-	750.00
Payment on delivery of report	-	1,000.00
		$4,500.00

Dean.
will you place attached document on folder for 1979 Reports please.

I have a copy on file + will post copy to Ms. Donlevy of Allied Fisheries P/L on 7/11/83.

Judith L.