Conchological Society of Great Britain & Ireland

Papers for Students

No. 20. Keeping a Marine Aquarium

by

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CONTENTS

INTRODUCTION

There is no need to live close to the sea in order to be able to maintain an aquarium containing marine organisms. This said, the keeping of a marine tank is within the reach of anyone interested in observing our native fauna at close quarters. This paper concerns itself primarily with molluscs, although the addition of a few selected animals from other phyla has the dual benefit of providing some ecological balance to the community as well as more diverse activities and behaviour for observation.

The installation and maintenance of the tank together with the choice of animals to be kept and how to obtain them are dealt with in detail in the following pages. The first step, therefore, is the decision to keep marine molluscs in captivity. In doing so one can discover the fascination of watching at close hand many of our intertidal animals and also some of the infralittoral species.

There are a number of publications available which describe temperate and tropical marine tanks. Some of these books deal with complex and permanent installations which involve specialised lighting, water circulation and cooling systems. The purpose of this paper is to provide the beginner with enough information to set up a functional and attractive marine tank with a length of between 0.6 m and 1.3 m and maintain a community of animals collected for the purpose.

EQUIPMENT

TANK

The size of tank chosen should be as large as space and budget permit, since it will be easier to maintain stable conditions with regard to temperature and salinity. The tank should be constructed of corrosion-resistant materials. A tank consisting of glass glued together with pliable non-toxic silicone adhesive is recommended. Some tanks are supplied with a plastic frame around the edges - this is purely decorative. Metal trimmed tanks should be avoided as salt water is corrosive to most metals. Secondhand aquarium equipment is often offered for sale in the classified advertising section of local newspapers and can represent a considerable saving in initial outlay. Providing the tank is made of suitable materials and is checked for leakage, this is an excellent way of obtaining equipment. Many towns have a pet supplies shop or aquarium retail outlets where the basic items can be bought. In addition, there are aquarist magazines available containing advertisements by dealers in specialist equipment.

The tank will need a lid, hood, or both. A sheet of glass or plastic will prevent splashing and keep evaporation to a minimum. It will also stop inhabitants such as littorinids from escaping and prevent objects falling into the tank. One corner of the glass should be removed to allow for the passage of tubes to the aeration and filtration equipment in the tank. A hood is needed to support lighting equipment and is often sold complete with the tank.

LIGHTING

There are several approaches to the question of lighting for the tank. It is quite satisfactory to use tungsten lighting with angle-poise lamps provided the bulbs are kept at least 0.6 m away from the glass. If the tank also receives some natural light the aquarium will thrive and there will be some growth of algae, of algae particularly on the inner surface of the glass which will be grazed by herbivores. In addition to the simplicity of this method, the play of shadows within the tank can be effective.

It is, however, generally considered necessary to install fluorescent tube lighting if an abundant growth of algae is desired as a supply of food for herbivores. This is relatively inexpensive and will provide even lighting without radiating excessive heat. Many activities within the aquarium are governed by the amount of light available. The minimum number of tubes recommended is one for tanks up to 30 cm deep, and two

for tanks between 30 cm and 40 cm and three or more for a greater depth.

A more expensive option is a mercury vapour lamp known as a Flora-set. One of these lamps sheds as much light as two 150 W reflector lamps but only consumes half the electricity. Although the lamps become hot they radiate very little heat. Flora-sets are usually suspended above, or mounted on the wall, behind the tank.

A switch will need to be installed and can either be a manual or automatic timer device. In deciding upon the length of time to leave the lighting on, it is a good idea to simulate the seasons by lengthening the period of 'daylight' in the summer and reducing it in the winter. The timing of such lighting can be delayed so that the aquarium can be enjoyed during the evening.

AERATION AND WATER CIRCULATION

An air pump is essential to promote a constant supply of oxygen and to remove carbon dioxide from the water. The air from the pump causes the water to circulate and the gaseous exchange takes place at the water surface. The pump may also be used to power several types of filter. The air line from the pump should have a non-return valve to prevent water siphoning back into the air pump during power failure. A diffuser or 'air-stone' should be fitted to the air line if the latter is not connected directly to the filtration equipment. Small electric water pumps which operate whilst submerged in the aquarium are obtainable. Despite their small size and low power consumption such devices can turn over a considerable amount of water and are an alternative to the air pump.

FILTRATION

Filtration is a general term encompassing the various ways in which seawater is maintained in a healthy condition. In a marine tank its purpose is to remove particulate matter from the water and break down and remove dissolved toxic wastes. The latter is referred to as biological filtration and it is recommended that the beginner use a system incorporating an undergravel filter. This is a corrugated plastic sheet fitting over the floor of the aquarium. It is perforated with many tiny slits and there are also one or two plastic tubes that rise up from the plastic sheet. These tubes are called the airlifts and are important in ensuring the circulation of water. It is on top of this undergravel filter that the gravel/rocks, etc. which will form the tank's 'sea-bed' will be placed and this is dealt with later under Installation.

Some form of mechanical filtration for removing particulate matter from the water is a useful adjunct to the main filtering system. This is particularly helpful where a 'corpse' may have caused sudden and rapid deterioration of the seawater in the tank. An internal box filter powered by an air pump and containing filter wool, activated carbon, or both is all that is required. (Activated carbon is charcoal that has been heated to a very high temperature and will remove a number of dissolved organic substances. It also helps prevent water discolouration.) The filter wool is replaced when it becomes clogged. Severe discolouration is an indication that it is time for replacement. Filter foam as an alternative to filter wool is becoming more widely used and has the advantage that it can be cleaned in hot water although it will still need to be renewed periodically. Manufacturer's instructions should be followed for correct procedure.

COOLING UNITS

Cooling units are obtainable but are aimed primarily at the commercial market and are relatively expensive. It is possible for an enterprising aquarist to convert an old beer cooler or refrigerator for the purpose. The subject of overheating of the water and suggestions for bringing about a reduction in temperature are discussed later.

ANCILLARY EQUIPMENT

A hydrometer will be needed to measure the salinity of the water. Waterproof thermometers are obtainable and can be secured to the inside of the tank. Liquid crystal thermometers are now widely used by aquarists

although they do not record temperatures below 20° C. There are also kits with which the nitrite level of the water can be tested. Full instructions come with these kits. Buckets or small vats are needed for collecting water from the sea or mixing up artificial seawater. A second air pump is useful
for aerating seawater in temporary storage or a temporary container of animals awaiting transfer to their permanent quarters.

INSTALLATION

SITING OF THE TANK

In choosing a position for your tank several factors should be borne in mind. The most important consideration with temperate marine aquaria is that they should be able to remain cool in summer - ideally the temperature should not rise above 20°C., since the temperature of the sea around our coast varies between 5°C. in winter and 17°C. in summer. (The subject of cooling units has already been mentioned and further information about cooling systems may be obtained from some of the publications mentioned in the Bibliography.) Therefore the siting of the tank should be away from direct heat sources including sun-light and preferably not in a room that is well heated in winter. A spare bedroom, a seldom-used room, a hallway or a frost-free conservatory that does not overheat in summer would be suitable places.
For example, one of the authors of this paper keeps her tank on the north wall of a small south-facing study. The curtains are drawn on bright sunny days and the window is kept slightly open throughout the year. When the room is in use during the winter, the room is warmed temporarily, then allowed to cool down after use. The temperature of the water in the tank is not greatly affected over a matter of a few hours. The tank has been kept stocked continuously for three years and the temperature has fluctuated between 8°and22^{0}C.

If the tank is to be viewed easily and to feature as part of a living-room then some compromise may have to be made about the range of molluscs kept in the tank. Most hardy intertidal animals will adapt to a higher than normal temperature as will a few sublittoral species; the aquarist will have to experiment. Another factor to bear in mind is the necessity of siting the tank away from all power points and electrical equipment, and also away from metal objects which may corrode if splashed with seawater. Finally, it is important to remember that a tank full of water with sand and rocks is extremely heavy (One litre of water weighs 1 kg). The tank should be placed only on objects of very sturdy construction; a strong piece of timber or length of polystyrene foam underneath the base of the tank is a useful device for spreading the weight over several joints of a piece of furniture, or over floorboards.

ASSEMBLING THE TANK

Once you have acquired all the equipment you need and have decided where the tank is to be kept, the system can be set up. This should be completed in the chosen position as the tank will be very heavy to move and when full excessive strain would be exerted on the joints of the tank.

1. Ensure the tank and all equipment that is to go inside it are clean.

2. Put the undergravel filter in position; if the filter has one airlift it will be central, otherwise two airlifts should be placed at either corner at the back of the tank.

3. A length of clear plastic tubing connected at one end to the air pump should be fed through one of the airlifts and an airstone attached to the end then adjusted in order that it may rest on the floor of the tank at the base of the filter. The length of tubing will depend on the proximity of the pump to the tank but at least 2 m should be allowed.

4. A layer of gravel between 5 and 10 cm deep should be placed on top of the filter. This may consist of grains (2 – 5 mm) of calcareous material such as crushed shells or specially prepared fossil coral that may be bought from a specialist aquarium shop. A substrate for the tank may be collected from the seashore provided

the correct grain size is selected. Grains smaller than 2 mm will tend to clog the filter. Seashore collected material need not be washed provided it has been collected from a clean site. Certain invertebrates may be present in self-collected material – any 'pests' such as shore crabs should be removed. Coral sand or crushed shell bought from an aquarium shop should be washed before use. Larger shells and pebbles can be dispersed over the surface of the 'sand' for effect and as suitable niches for the occupants of the tank.

5. Filling the tank with seawater may be achieved either by transporting the requisite amount of water from the shore or by mixing up artificial seawater. The latter should be supplemented by a small amount of natural seawater after the mix has been tested with a hydrometer to check that the concentration is correct. Specially prepared salts are obtainable from aquarium stockists; these are a finely balanced mix of all the salts and trace elements which are found in natural seawater. Culinary seasalt should not be used. The manufacturer's instructions should be followed and the artificial seasalt may be placed dry into the tank and the requisite amount of tap water added. The air pump should then be switched on to enable the water to circulate through the undergravel filter. If a charcoal filter is to be used this should be put in position. It can be recessed slightly into the substrate and eventually hidden by placing larger rocks in front of it.

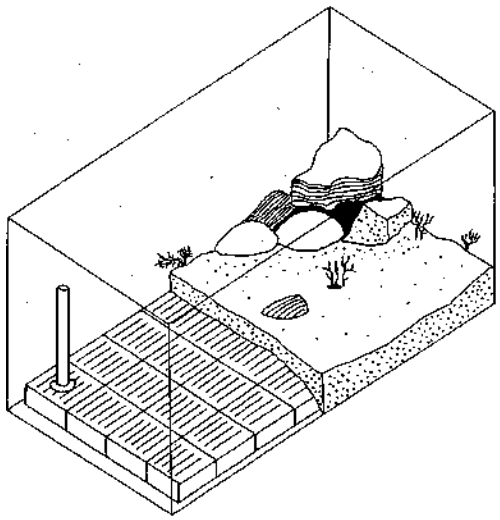


Figure 1. View of tank with part of the gravel removed to illustrate the undergravel filter in position.

6. The tank should be left for at least a week with the pump running continuously. From now on the tank will be a living community of microscopic organisms which will multiply. Beneficial bacteria will also start to accumulate in the substrate if a few pieces of fish or mollusc are allowed to

decay in the tank. The water should be tested at least every other day with a nitrite testing kit (see Appendix 1).

7. It will now be necessary to visit the seashore to collect some rocks and inhabitants for the tank. Rocks should be of a suitable size, without metallic veins running through them. Limestone is ideal as it will act as a natural buffer to the sea water. In excess, algae may rot and foul the water. Finally, it is important to note that brown algae such as *Fucus* spp. are unsuitable as they may emit poisonous chemicals and are subject to decay in the tank environment.

CHOICE OF ANIMALS AND HOW TO OBTAIN THEM

The following molluscs are suggested species for an initial community. (Capital letters in brackets refer to the Feeding Key - see below):

Patella vulgata (A C)
Gibbula cineraria (A C)
G. umbilicalis (A C)
Calliostoma zizyphinum (B C D)
Littorina littorea (A C D)
L. saxatilis (A C)
Nucella lapillus (B)
Ocenabra erinacea (B)
Buccinum undatum (B C)
Hinia reticulata (B C)
H. incrassata (B C)
Mytilus edulis (E)
Cerastoderma edule (E)
Macoma balihica (E)
Angulus (Tellina) tennis (E)

All of the above can be obtained from a suitable shore and have proved tolerant of fluctuating conditions in a tank.

The collecting trip should take place at the time of a good spring tide. A rocky shore with some sand is ideal. Check the tide tables, wear suitable clothing, in particular safe footwear, and preferably do not go alone. It is best to search under rocks and ledges as far down the shore as you can go, being careful to turn all rocks and boulders back to their original position. Collect no more than three or four individuals of a species. Most aquarists have more success with some species than others and experience will show which animals one is best able to keep.

Some opisthobranchs, particularly nudibranchs and bullids prove to be short-lived in a tank of the suggested size range and this may be partly accounted for by their specialised feeding requirements. In the short term they are, however, interesting to observe and photograph.

The following may be obtained by dredging or from fishermen's nets, lobster pots etc., but may prove less resilient in a tank:

Aporrhais pespelicani (C)
Turritella communis (E)
Lunatia [Natica] catena (B F)
Trivia monacha (B F)
Gibbula magus (C)
Chlamys varia (E)
Aequipecten opercularis (E)
Acanthocardia echinata (E)
A. tuberculata (E)
Neptunea antiqua (B C)

Apart from the above-mentioned methods of shore collection and dredging, specimens may be obtained from suppliers such as the Supplies Depot of establishments like the University Marine Biological Station at Millport on the Isle of Cumbrae. This is particularly useful where the aquarist might like to obtain a species not indigenous to conveniently accessible shores.

The following are suggested animals from other phyla which may help to provide a balanced community.

ANEMONES - The beadlet *(Actinia equina)* and dahlia *(Urticina felina)* sea anemones have proved durable in an aquarium and may be fed about once a week with a small piece of fish or mollusc.

CRABS - Only hermit crabs are recommended as the shore crab *(Carcinus maenas)* is excessively predatory and disruptive in its behaviour.

SHRIMPS AND PRAWNS - Two or three individuals are attractive to watch and are useful in scavenging scraps of uneaten food.

STARFISH - Juvenile specimens of *Asterias rubens* may be found on some rocky shores and are interesting to watch as they move about the tank. They do grow rapidly, however, and should be returned to the shore when their size threatens the other occupants of the tank. They appear to have voracious appetites and will not only attack bivalves in the tank but also any gastropods they come across. Some species of brittlestar are fragile and tend to reject limbs when handled but the black species *Ophiocomina nigra* has proved hardy in a marine tank. Another suitable starfish is the cushion-star, *Asterina gibbosa.*

FISH - suggested species for the beginner are the rocky goby *(Gobius paganellus)* and black goby (G. *niger),* and some of the blennies *(Blennius* spp.). Very young flatfish, although spending the majority of their time just below the surface of the substrate with only their eyes visible, can provide a source of amusement in searching for them.

WORMS - One or two small specimens of the ragworm *(Nereis diversicolor)* can be kept in the tank. They remain buried in the sand during the day but emerge from their burrows at night to feed on, for example, opened mussel shells.

The above animals are just a selection of the possible inhabitants of a marine tank. There are many other species that are suitable.

TRANSPORTATION OF THE ANIMALS

The main considerations in the transportation of molluscs and other marine organisms are temperature and oxygen supply. For daytrips during warm weather small animals may be transported in wide-necked vacumn flasks. Some headspace should be left for the turbulence that occurs during transportation to aerate the water. In cold weather transportation is less of a problem; clean plastic containers with lids can be used. Larger animals may have to be carried in scalable polythene bags (or containers) which in warm weather should contain a smaller amount of water and a large volume of air. This bag should be placed inside a larger bag containing ice cubes and transported in a polystyrene box, cool-bag or similar. If any container is overstocked the animals may suffocate.

If collecting is to take place over a period of days a small pump with a length of plastic tube and an air-stone would help to keep the container acting as a temporary tank healthy. Alternatively a wide shallow container where a large surface of water is exposed to the air will suffice.

When packing up one's stock for the journey care should be taken in the choice of animals to travel together as companions. For example, sea anemones should ideally travel alone and certainly not with small fish. These may be trapped by the anemones in the confined space and the movement of transit.

MAINTENANCE

FEEDING KEY

A. Herbivores

Many molluscs are herbivores and in a marine tank will live by scraping off the algae that grows on the inner surfaces of the tank. In a reasonably well lit aquarium a good growth of microalgae will be achieved. Additional weed can be obtained from the rocks in the tank; these rocks can be replaced from time to time as visits to the shore permit. An addition to a herbivore diet consists of a leaf of lettuce (of the 'floppy' rather than the crisp variety) which may be anchored beneath one of the rocks in the tank.

B. Carnivores

Amongst the animals suggested in this paper as suitable inhabitants for a marine tank, many are carnivores including sea anemones, worms, crabs, fish and some of the molluscs. In the wild they may feed collectively on a host of different foods but their needs can be quite simply met in the aquarium. Pieces of fresh boiled prawn, slivers of raw fish or mussel flesh are all easy to obtain. It is sensible to hand-feed anemones to ensure they are adequately nourished! It is recommended that small quantities of food are placed in the tank twice a week. It is preferable to risk underfeeding

since marine animals are more likely to become unhealthy through overfeeding. It should be borne in mind that in a mixed community of predators and prey animals a certain amount of feeding will occur without effort on the part of the aquarist. For example *Ocenebra erinacea* specimens will avail themselves of live *Mytilus edulis. Lunatia* specimens will need a supply of bivalves and it is suggested that a dozen *Angulus tennis* could be easily accommodated in the sand at the bottom of the tank.

C.Detritivores

This group includes certain whelks, crustaceans, worms and brittlestars. They will simply fend for themselves by clearing up the leftovers and waste of other animals and therefore make extremely useful inhabitants of a marine tank.

D.Omnivores

Littorina littorea is an example of a mollusc which will accept a mixed diet, although traditionally considered to be a herbivore. This opportunism in feeding makes it a particularly easy animal to keep in an aquarium.

E.Filter feeders

It must be borne in mind that the filtration system of the aquarium will of necessity remove a good deal of the plankton and suspended particulate matter which would act as food for filter feeders such as bivalves and *Turritella communis.* Some authorities consequently do not recommend the keeping of such animals in the confines of a tank. If you do live near a source of unpolluted seawater then a regular change of a few litres of seawater will ensure a continuous supply of plankton.

As an alternative, however, a combination of mussel, prawn, fish and spinach or lettuce liquidised with a little seawater and frozen will provide a nourishing substitute. A few flakes should be chipped off and allowed to melt directly into the tank. A visit to the seashore will enable one to collect useful ingredients to incorporate into this 'food'; a green seaweed such as *Ulva lactuca* would make the product even more natural. It is also possible to buy proprietary brands of dried filter food such as flaked brine shrimp and plankton tablets.

Brine shrimp may also be hatched from dried egg capsules obtained from a specialist shop and can be offered as newly hatched larvae for filter feeders or as adults to act as a live food for the fish in the tank. Full instructions are provided.

Only a certain number of filter feeders can be kept in a marine tank as they will all compete for the same food; some species are more sensitive than others and will only feed if the conditions are right. Experimentation will enable the aquarist to discover the species he is able to keep.

F. Specialist feeders

Mention should be made of species with very particular food requirements. An example would be the *Trivia* species which feed on compound ascidians such as *Diplosoma listerianum, Botryllus schlosseri* and *Botrylloides leachi.* Clearly such animals would require pebbles bearing their preferred food.

DAY TO DAY CARE

It is advisable to inspect the aquarium every day, preferably in the morning, to check for corpses or moribund animals. These should be removed immediately to prevent contamination of the water. At the same time one should check that the bubbles of air are rising to the surface; if they are not this could indicate that something has died. A film or scum on the surface of the water or change in smell may also indicate unhealthy conditions.

The filter media of the mechanical filtration system should be checked for discolouration regularly and should either be cleaned or renewed. If the water is yellowing then the charcoal (if used) should be replaced, although it should in any case, be renewed every four to eight weeks. If an undergravel filter is being used it is a good idea to stir up small portions of the sediment a day or two before renewing filter foam or wool as this will help to prevent the undergravel filter becoming clogged and obviate the need for a major clean-out.

The inside surface of the front glass should be cleared of algal growth but the sides and back should be left to provide food for the herbivores. Although there is a wide variety of implements offered for this task, a small piece of filter wool wiped from side to side starting at the top and working downwards will remove all but the most stubborn of algal growth. For this a paint scraper that is absolutely clean of paint, chemicals, detergents, etc. can be used. It should be rinsed in clean water afterwards and carefully dried to prevent rusting. Of the range of commercially made aquarium cleaners on the market, a useful and effective one is a magnetic cleaner which enables cleaning to take place without wetting the hands. A glass or plastic lid should be washed regularly to remove algae and salt deposits and all electrical equipment should be checked for salt water splashes or spillage.

WATER CHANGES

The sound practice is to change little and often. This is preferable to 'shocking the system' by a large water change. About 20% to 30% monthly should be substituted for a healthy aquarium but if the tank has been polluted, for example, as a result of the death of one of the inhabitants or decayed uneaten food, a larger proportion of the water in the tank should be replaced. Before changing the water the specific gravity in the aquarium should be checked so that, for example, if the concentration has become too high as a result of evaporation, it may be diluted to its correct value before renewal takes place. In order not to cause undue stress to the occupants of the tank, new water should be added to the aquarium very slowly after the required amount of old water has been removed. This may be achieved by siphoning with narrow diameter airline tubing (4mm).

MAKING OR COLLECTING SEAWATER

For the majority who will not be able to visit the coast regularly, making up artificial sea water will be necessary. As mentioned earlier specialist shops sell seawater mix with full instructions. The correct specific gravity is 1.020 -1.025, the water being at the correct temperature for the hydrometer. Most are calibrated to about 24° C. (See Appendix 2). When mixed the artificial seawater should be aerated for about 24 hours prior to use.

COLLECTING NATURAL SEAWATER

The collection of natural seawater offers two advantages. Firstly, provided it does not necessitate a special journey, it is a cheaper option and secondly, provided care is taken not to collect from polluted shores or estuaries where the salinity may be low, the water will contain planktonic organisms beneficial to the filter feeders of the tank. Seawater should be kept cool in transportation and used immediately and certainly not allowed to stand, unless aerated. It would be sensible to filter seawater with activated carbon if a degree of pollution is suspected or if the water is overloaded with organic debris. Large plastic drums which have not been used for detergent or other potentially harmful agents should be used.

SEAWATER CHEMISTRY

Some publications place heavy emphasis on the subject of the pH value and nitrite levels of the water in the marine tank. The animals and plants, while carrying out their essential functions, produce or use up compounds that affect the chemical balance of the water. Provided the water is being continuously aerated and circulated and general maintenance is carried out, the aquarist should not have problems. There will be a certain amount of fluctuation from the standard pH value of 8.3 for seawater, however this fluctuation should not reach harmful levels. Kits for testing the pH and nitrite levels of the water in the tank are available from specialist shops with full instructions.

SSALINITY AND TEMPERATURE

The salinity of the water should be checked regularly with a hydrometer as mentioned above. Tapwater that has been allowed to stand for 12 hours can be used to top up the tank. A thermometer inside the tank will enable the temperature to be monitored.

TRACE ELEMENTS AND VITAMINS

Shell-bearing molluscs and crustaceans will deplete the water of calcium and magnesium during the course of their growth and most animals and plants will remove varying amounts of other elements from the water. If the tank is well stocked these elements may need replacing with a trace element stock solution; vitamin supplements are also available.

EMERGENCY MEASURES IN THE EVENT OF OVERHEATING OF THE TANK

During the summer months there may be periods during which it is difficult to maintain the temperature of the tank below 20° C. The following are suggested as various improvisations to reduce the temperature:

1. The removal of a portion of the water for storage in the fridge until the water has cooled down, to be replaced after a similar amount has been removed from the tank, will bring about a small reduction in temperature. A rotation system can be operated.

2. Frozen icepacks can be floated in the tank and allowed to thaw. It is important to check that the icepacks are water tight.

3. The placing of polystyrene sheets around the tank before thee heat of the day will help to prevent overheating. This is a preventative measure and should be used after a satisfactory temperature has been achieved. These sheets can be removed in the evening and lighting may be left on to compensate for loss of daylight.

A permanent cooling system may be fitted, as mentioned in Section 2.

POWER CUTS

In the event of a power cut, water may siphon back into the air pump if you do not have a non-return valve fitted in your airline. This should be checked immediately. Battery operated pumps are available and are recommended for cuts longer than two or three hours. Such a pump would also be useful on collecting trips where a source of electricity is unavailable.

MAJOR CLEAN OUT OF THE AQUARIUM

A total evacuation of the tank should be avoided if at all possible because of the stress it may cause to the animals and possible damage to the filtration system. This can be prevented by giving parts of the gravel an occasional stir up so that the undergravel filter does not become clogged. So-called 'dead spots' where anaerobic conditions build up and staining of the grave occurs should also be disturbed.

Occasionally, even in the best regulated aquarium, a major cleanout may be necessary. If you have two or more aquaria this process will be relatively easy as it is possible to move the animals you wish to keep to the second aquarium, clean off with fresh water, sterilise, and set back as new all the equipment, substrate, etc. into the original tank and leave it to stabilise for two weeks before replacing its original occupants. Most beginners, however, will not have this facility and therefore the inhabitants must be kept in buckets, aerated, whilst the rest of the aquarium is emptied and cleaned. If the gravel needs cleaning this should be done with seawater to preserve as much of the nitrifying bacteria as possible. Anything in need of sterilisation can be scalded with hot water. Detergents should only be used if thorough rinsing is possible. The tank can then be reassembled using as much as possible of the original water. Daily water tests are recommended for a week or two after a major clean out. After this time a 10 - 25% water change is recommended.

RECORD-KEEPING

From the moment you begin to stock the tank with animals it is likely that you will make observations relating to anatomy, behaviour, feeding, etc. of the animals in the aquarium. For example, locomotion is easily seen when it takes place across the surface of the glass. Some species may be prompted into a reproductive cycle as a result of being taken into captivity or an increase in temperature of the water. They may commence copulation or egg-laying. In particular, nudibranchs are noted for producing their egg ribbons which are laid on weed, the sides of the tank or on the shells of other molluscs.

Ideally a journal of some kind into which all observations can be noted with a record of the date would be of benefit, not only to the owner of the tank, but as a possible source of information for wider distribution.

Some aquarists like to keep graphs of pH and nitrite levels.

BIBLIOGRAPHT

ANGEL, H. 1983. (2nd impr. 1987). *The Book of Close-up Photography.* Ebury Press.

ANGEL, H. 1988. *Nature in Focus.* Pyramid/Octopus.

EMMENS, C.W. 1985. *The Marine Aquarium in Theory and Practice.* 2ndEd. Revised. T F M Publications, New Jersey.

FREEMAN, M. 1981. *Wildlife and Nature Photography.* Croom Helm.

FRETTER, V. & GRAHAM, A. 1976 - 1986. The Prosobranch Molluscs of Britain and Denmark. *Supplements to The Journal of Molluscan Studies.*

HAWKINS, A.D. 1981. *Aquarium Systems.* Academic Press, London.

JACKMAN, L.J. 1974. *Sea water Aquaria.* David & Charles, London.

MELZAK, M. 1984. *The Marine Aquarium Manual.* B.T. Batsford, London.

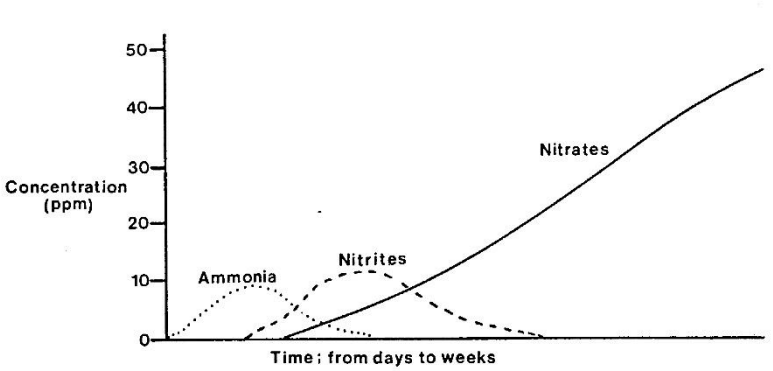
MOE, M.A. 1982. *The Marine Aquarium Handbook, Beginner to Breeder.* Green Turtle Publications, Florida.

SPOTTE, S. 1979. *Seawater Aquariums, the Captive Environment.* John Wiley & Sons, Chichester.

SPOTTE, S. 1979. *Fish & Invertebrate Culture. Water Management in Closed Systems. John* Wiley & Sons, Chichester.

Aquarist and Pondkeeper. Monthly publication by Buckley Press Ltd., London.

APPENDIX 1



Key: Ammonia = dotted line
Nitrite = broken line
Nitrate = solid line

Figure 2. Graph to show levels of Ammonia, Nitrite and Nitrate in a marine tank after initial installation.

The point to note from this graph is that the nitrite in the water is not turned to nitrate until the ammonia falls below a certain level, since it acts as an inhibiter to this chemical reaction.

APPENDIX 2

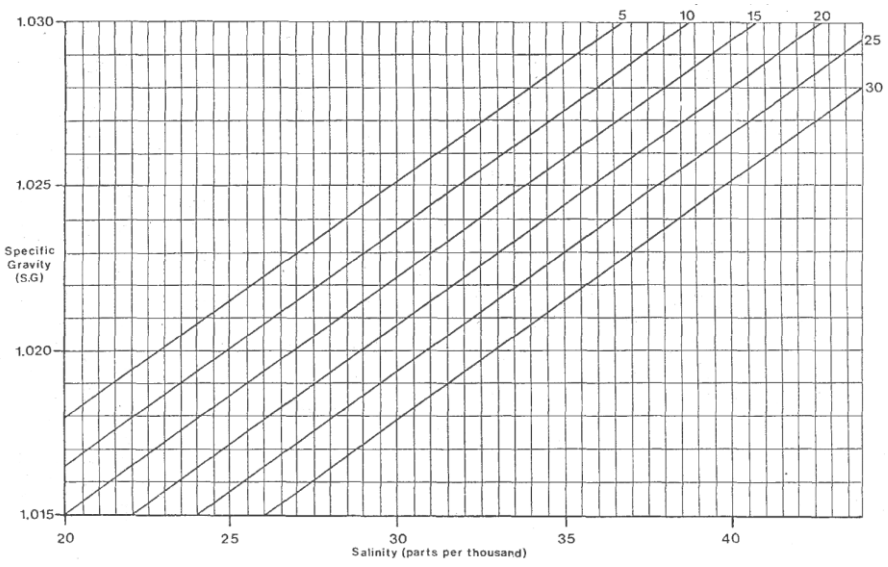


Figure 3. Specific gravity chart.

This chart deals with the relationship between specific gravity and salinity at differing temperatures. This enables conversion of readings where the water in the tank is not at the temperature to which the hygrometer being used is calibrated.

APPENDIX 3

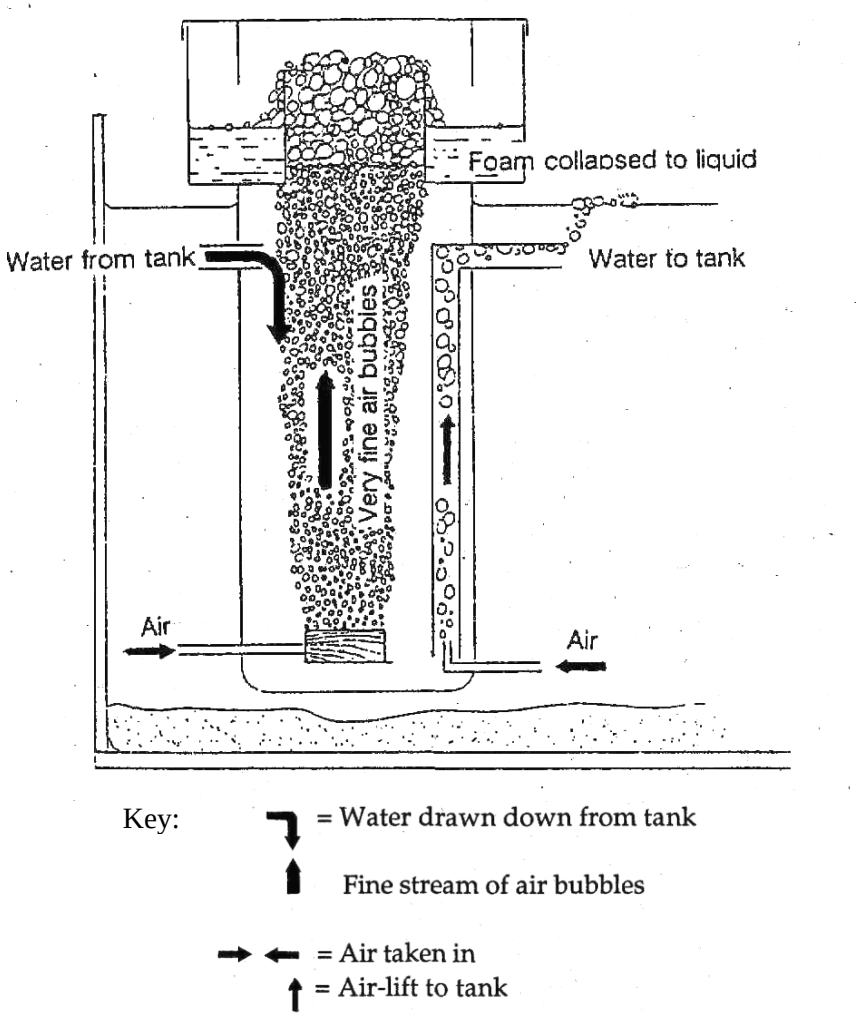


Figure 4. Protein skimmer

A more sophisticated method of removing dissolved organic substances from the aquarium water involves the use of a protein skimmer. This consists of a tube through which a downward flow of water is in contact with an upward stream of fine air bubbles. Dissolved organic substances form a film at the air/water interface and the bubbles of air carry this film up to the top of the tube where it is collected by passing it through a smaller tube at the top. Such a device will also remove excess gases such as carbon dioxide. Protein skimmers may be bought fairly cheaply or can be made from plastic pipe and perspex.