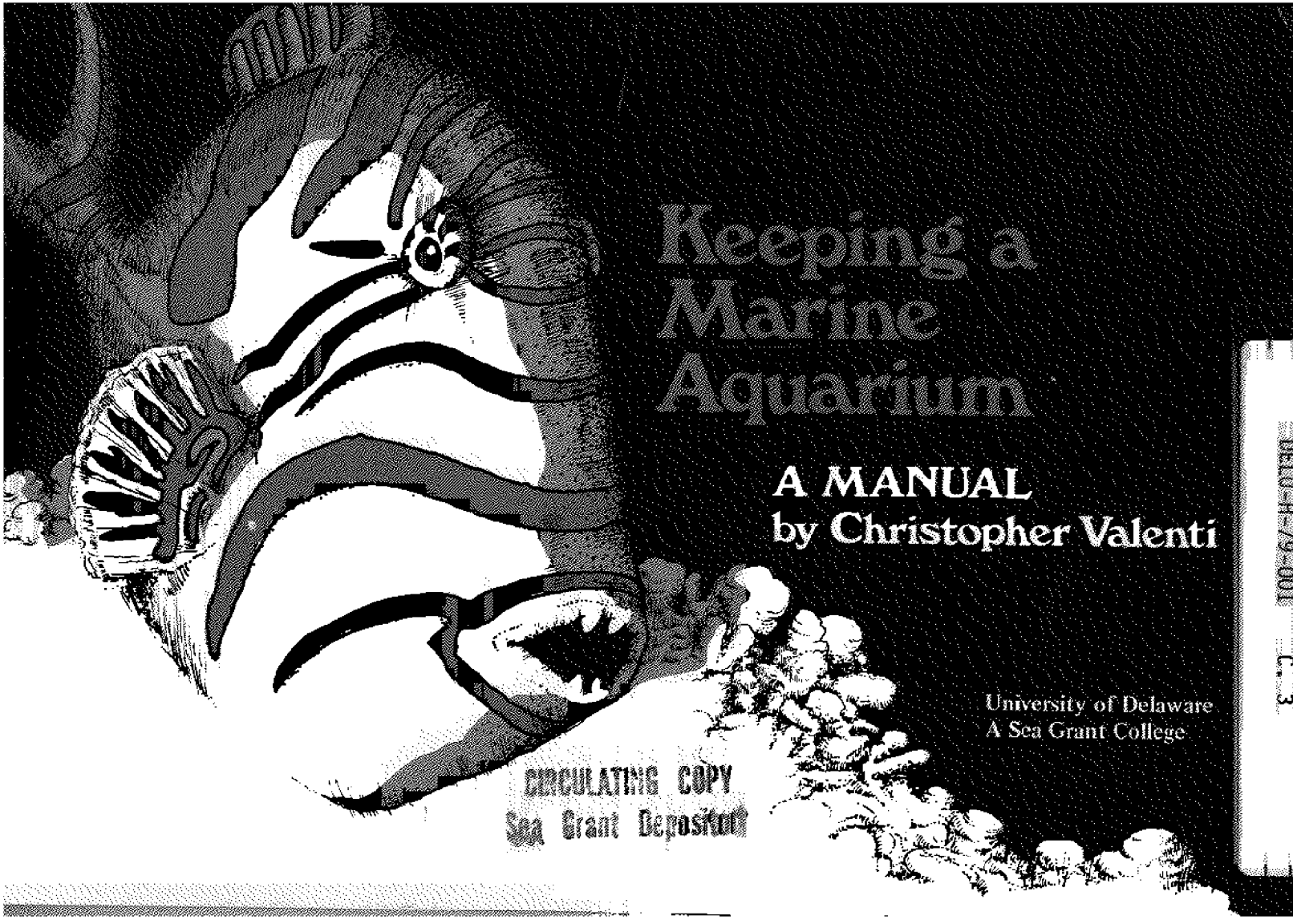

Keeping a Marine Aquarium

A MANUAL

by Christopher Valenti

University of Delaware
A Sea Grant College

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Contents

Introduction

If you're one of the many people out there who have said **no** to a saltwater aquarium because you thought it was too much work and required a scientist's expertise, keep reading. You're about to find out otherwise.

To get one going successfully, you **will** need to be acquainted with some basic theories and techniques. But once you get one started, a saltwater or marine aquarium demands no more time than its freshwater counterpart. If you follow the steps outlined here, you should have little difficulty culturing many of the ocean's fascinating animals. In the microcosm you create, you may spend hours watching a sea skate emerge from its protective egg case, a hermit crab molt, or a swimming scallop make a daring escape from a predatory starfish.

The first responsibility of the aquarist (that's you) is to make sure the animals have clean, adequate living quarters. Human beings appreciate clean, unpolluted air, and it's reasonable to assume that marine animals prefer their water the same way. Marine animals produce wastes that include ammonia and urea. Although these wastes rarely reach toxic levels in the natural environment, in the confined space of an aquarium they can accumulate enough to seriously harm or even kill the animals. Ammonia and urea must be removed from the aquarium water quickly--at a rate about equal to the rate they are produced. In the sea, these wastes are taken care of naturally by **bacteria** and **algae** (bacteria use animal wastes for food or energy; algae use wastes as fertilizer). In the aquarium, the same thing happens. With a little help from you, these two garbage disposers will keep the water clean. In fact, scientists have not devised a faster, more economical, or more efficient way to purify water than by natural methods. In addition to removing wastes from the water, algae are eaten by the fish and other aquarium animals, thus making the system somewhat "recycling."

The ever-present single-celled algae will grow on their own, with practically no help. In fact, it's hard to discourage algae growth, as you'll see later. To help nature along in the waste removal plan, the aquarist must cultivate a dense colony of bacteria in the aquarium. The bacteria require three things: a material such as gravel on which to live; food, in the form of animal wastes; and oxygen.

In the sections that follow you'll find out more about those bacterial requirements, the basics necessary for a saltwater aquarium, and the techniques of setting up and maintaining one.

What do I need and how much is it going to cost?

Here's a rundown of the necessary equipment (other than animals) and approximate costs for setting up a 10- or 20-gallon aquarium. Each item is further explained elsewhere in the text. Mention of brand names does not imply endorsement of those products.

ITEM	BRAND/TRADE NAME	10 GAL (38 l)	20 GAL (76 l)
All-glass aquarium	Living World[1]	$ 8.99	$ 17.94
Undergravel filter	Nektonics[2] or	9.95	12.95
	HiFi[1]	5.00	6.00
Air pump	Silent Giant[3]	19.95	19.95
Carbonate gravel dolomite, aragonite, calcite or crushed coral		5.00	8.00
Accessory filters			
inside filter	Bubble-up[1]	1.98	2.98
outside filter	Turbo-Flo II[1]	8.98	8.98
power filter	Dynaflo[1]	(too large)	15.00
Activated carbon (per month)		.50	1.00
Seawater			
natural		free	free
artificial	Instant Ocean[4]	3.00	6.00
Hydrometer	many brands	from 2.00 to 6.00	
Thermometer	many brands	1.00 and up	
Heater	Metaframe[1]	10.00	10.00
Cover and light fixture	Metaframe[1]	22.24	25.20
APPROXIMATE TOTAL		$ 95.00 ($9.50/gal)	$ 125.00 ($6.25/gal)

[1] Metaframe Corp., Elmwood Park, NJ 07407
[2] Nektonics, 1015 E. 35th St., Brooklyn, NY 11210
[3] Aquarium Pump Supply, Inc., 314 Whipple St., Prescott, AZ 86301
[4] Aquarium Systems, Inc., 33208 Lakeland Blvd., Eastlake, OH 44094

Prices quoted courtesy of Burns Tropical Fish and Pet Shop, Rt. 9, Gravel Hill, DE

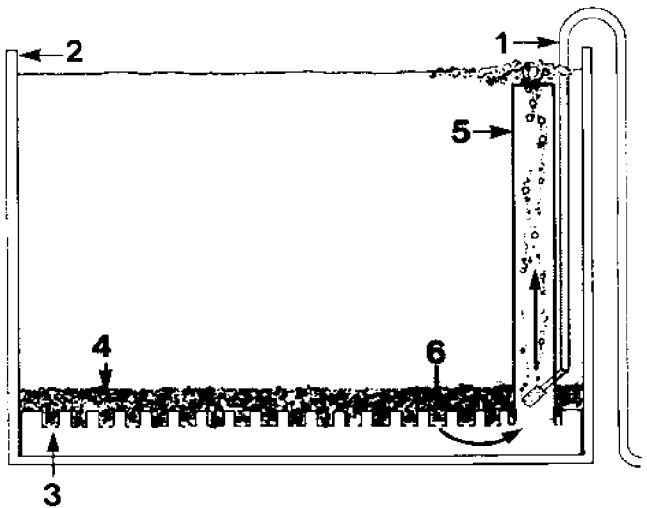
The Basics

An **all-glass aquarium** is a **must.** Metal edges are not suitable for salt water because they will rust quickly, producing chemical compounds that are toxic to the marine animals. An important rule to remember is **never allow metal to come into contact with aquarium water.**

The **undergravel filter** is the single most important item aside from the aquarium itself. It is this filter that, when covered with the proper gravel, is responsible for keeping the water clean. This is where the waste-removing bacteria live. Of the two brands listed, HiFi is considerably less expensive, but less efficient, too. You can make your own low cost undergravel filter by following the instructions on page 10.

A perforated plastic grid that completely covers the bottom of the aquarium is the primary component of the undergravel filter system. Attached to the grid are several **air-lift tubes*** that open into the water-filled space underneath the filter. Air from the **air pump** bubbles into the air-lifts, producing an air/water mixture that is lighter than the surrounding water. This creates an updraft in the air-lifts, pulling water upward from below the filter and replacing it with water that is

*Words identified by an asterisk (*) are defined in the glossary, p. 37.



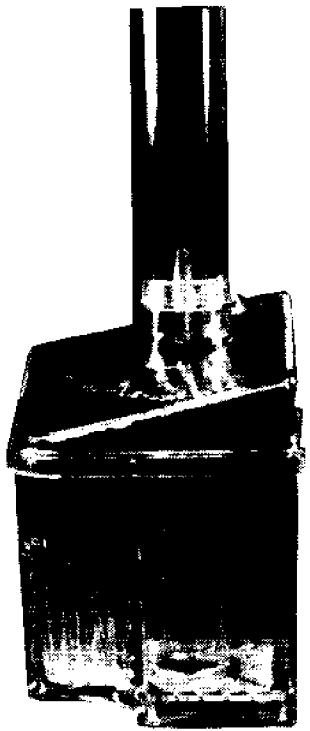
UNDERGRAVEL FILTRATION SYSTEM. Air line tubing **(1)**; all glass aquarium **(2)**; filter grid **(3)**; gravel **(4)**; air-lift tube **(5)**; and direction of water flow **(6)**.

pulled downward through the gravel. The result is a continuous current passing through the gravel. Make sure you get a reliable air pump, since it is an integral part of the undergravel filter.

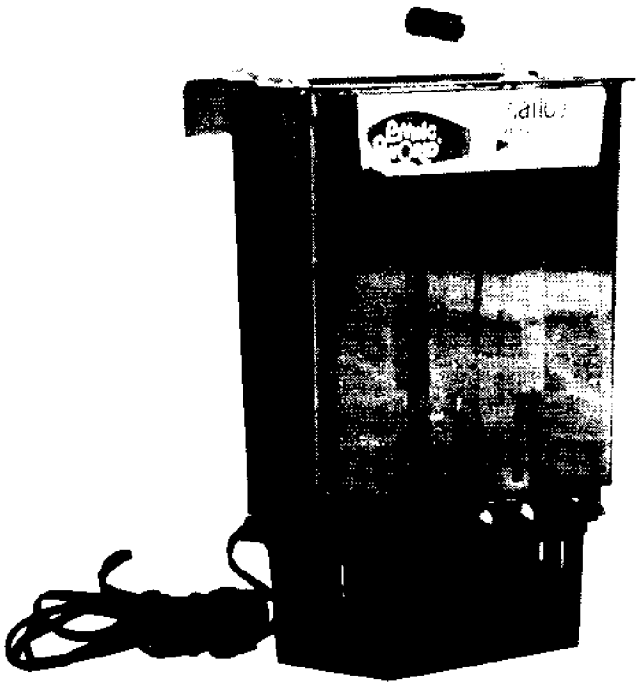
Accessory filters are used to augment the undergravel filter. The simplest of these are powered by compressed air from an aquarium pump and are either submerged in the aquarium or hung on the outside. The most efficient accessory filters are powered by their own motor and have a greater capacity than non-motor driven ones. The Dynaflo is an example. All of these filters use two filtering media: **activated carbon** and **filter floss**.

Activated carbon is a high grade charcoal that will adsorb organic wastes (they can turn aquarium water yellow). Low grade, less expensive aquarium charcoal should be avoided since it can cause a lowering of **pH*** (degree of acidity or basicity of the water). You should replace the activated carbon monthly because its waste removal capacity diminishes in about a month, depending on the amount of organic particles in the water.

Filter floss (spun polyster) traps suspended particles like leftover food and feces, removing them from suspension. Spun glass, used in freshwater aquaria, must **not** be used in saltwater aquaria since it disintegrates in seawater.



BUBBLE-UP CORNER FILTER



DYNAFLO POWER FILTER

TURBO-FLO II ACCESSORY FILTER

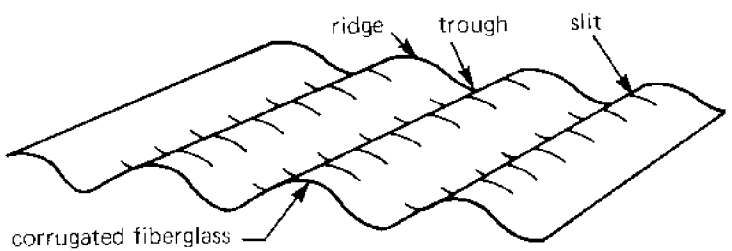
Constructing an undergravel filter

You'll need these materials (available at hardware and pet stores):

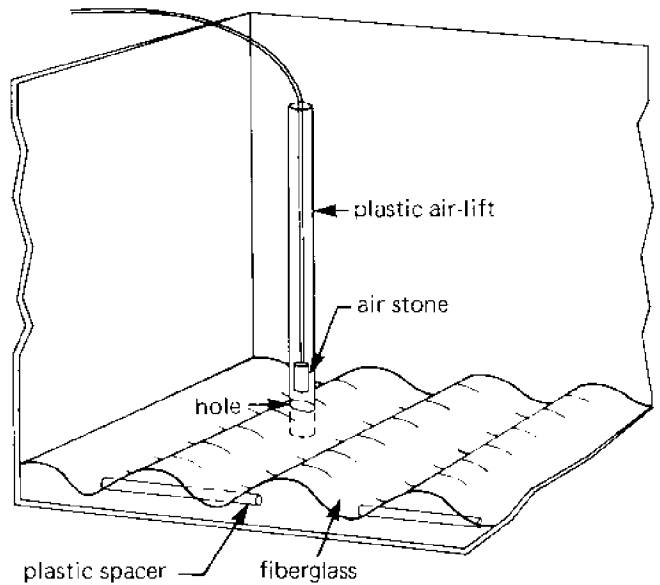
- corrugated fiberglass
- plastic (PVC) pipe
- silicone sealer
- plexiglass (optional)
- circular saw

The basic component of the filter is a perforated grid. Corrugated fiberglass is a good choice for a grid because it is inexpensive and easy to perforate. The fiberglass should fit the inside dimensions of the aquarium exactly. With a circular saw, cut slits across the ridges and troughs of the fiberglass every two inches (five centimeters). Then place it on plastic spacers, raising it about an inch off the bottom. Use short pieces of plastic (PVC) pipe for the spacers. Two types of air-lifts can be used. For a **pipe air-lift**, insert into the grid a piece of two-inch (five cm) inner diameter plastic pipe. The pipe should reach to within two inches of the surface of the water. Cement the pipe to the fiberglass with silicone aquarium sealer. Be prepared--there will be an acrid odor for about 24 hours, until the sealer cures. A **corner air-lift** uses pieces of plexiglass that are glued to both back corners of the aquarium.

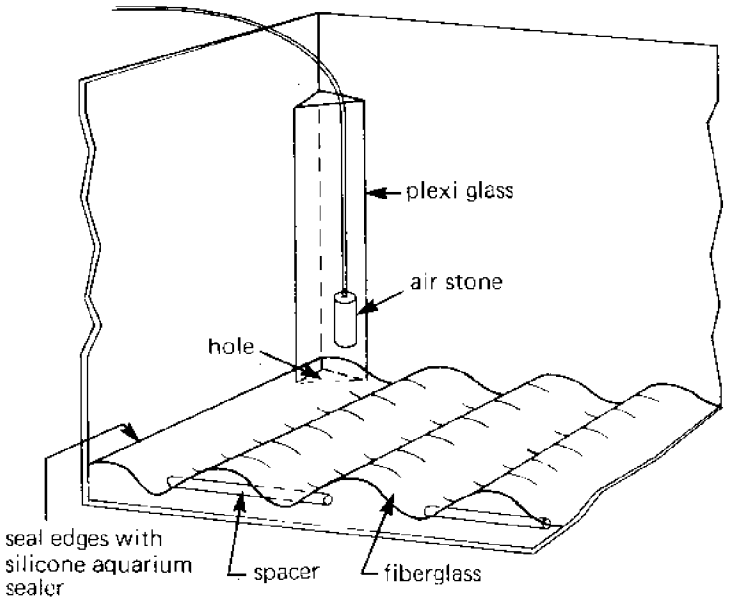
If your filter grid fits snugly into the aquarium, you won't need to seal it in place. If it doesn't, you'll have to glue the filter around the edges to the aquarium glass. The only disadvantage to this is that the filter becomes permanent. After the filter is in place, let the glue cure for 24 hours, then fill the aquarium with tap water and let it stand overnight to leach out any glue residues. Drain, add clean gravel and fill with seawater.



SLITTING THE FIBERGLASS



PIPE AIR LIFT



CORNER AIR LIFT

The type and size of **gravel** are very important. Don't use just any kind of sand or pebbles. Fine gravel or sand tends to clog with particles of waste and food because the spaces between sand grains are so small. And larger gravel or broken shells don't trap particles like food, because water flows through so easily. Proper filtration, meaning adequate movement of water that is filtered free of particles, is achieved by using grains of gravel about the size of a pea.

To insure the proper pH of the aquarium water, the gravel must be one of the four kinds listed on page 6. These all contain calcium and/or magnesium, depending on whether they are biological (like crushed coral) or geological (like calcite rock). How the gravel reacts with the water to maintain a satisfactory pH is explained in more detail on page 15.

A **heater** is only necessary if you have tropical animals in your aquarium. A **cover** for the tank will decrease the evaporation rate and a **light source** will not only enhance the appearance of the display, but also encourage algal growth, needed for clean water and fish food. You'll need a supply of **fresh water** to replace the water lost through evaporation (the salts remain). The fresh water must be rust- and copper-free. Your best bet is distilled or metal-free well water. Rain water often contains pollutants.

Seawater

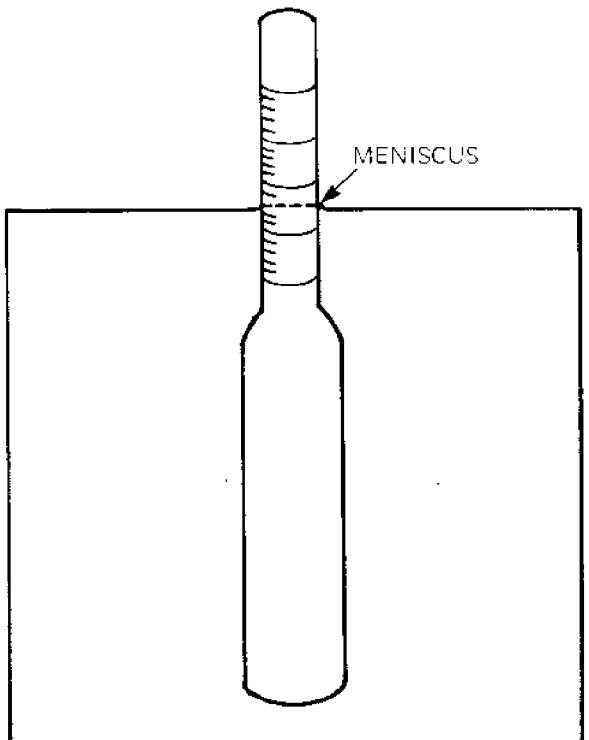
Seawater is a complex mixture--much more than just table salt dissolved in water. It contains most known chemical elements. Some elements such as sodium and chlorine are present in high quantities and others, such as uranium and mercury, are only detectable through delicate analytical procedures. One amazing aspect of seawater is its constant composition. If you compare a water sample taken from the Indian Ocean with one from the Atlantic Ocean, you'll find that the primary ingredients, i.e., sodium, and chloride, are almost always in the same proportion. This is true for seawater everywhere, and it's why many marine animals cannot tolerate fluctuations in their environment.

One aspect of seawater that does vary is the amount of salt dissolved in the water. It can vary with tidal cycle and locale. Oceanic and marine shoreline animals are accustomed to and will tolerate only small variations in salinity. **Estuarine*** animals (as their habitat indicates) will tolerate greater fluctuations.

If you're going to use natural seawater, remember these two points: **seawater should be collected from non-polluted areas only;** and **ocean water is much better than bay water because it is cleaner and has a more constant salinity.** Containers used for transporting and storing seawater must be non-metallic, since, as mentioned before, the interaction of seawater and metals produces toxins dangerous to marine animals. The water can be stored in non-sealed containers after being filtered through several layers of clean cloth to remove animals and silt.

If natural seawater is **not** available, you do have an alternative--synthetic salts. These salts correspond closely to the real thing and are suitable for even the most fastidious marine animals. You can buy synthetic salts in most pet stores.

Whether you start with natural or synthetic seawater, the simplest way to keep track of the salt content in your aquarium is to measure the specific gravity (density) of the water. To do this you need a **hydrometer.** It floats in the aquarium and its height indicates the water's density. Not surprisingly, salt water weighs more than fresh water, therefore it's more dense. A hydrometer reading of 1.020 means that particular water is 1.020 times heavier than the same volume of distilled water. The specific gravity in a properly functioning aquarium should be around 1.0252--the specific gravity of normal seawater. This corresponds to



HYDROMETER. Place it in the aquarium and allow it to stabilize. Then read the numbers at the meniscus (where the water touches the hydrometer). That number is the specific gravity of the seawater.

about 34 ppt (parts of salt per thousand parts of water).

Another characteristic that must be monitored is the degree of acidity or basicity of the water--the pH level. It gives you an important clue to what's really happening with waste removal. You can conveniently measure pH with a kit or pH paper, both available at pet stores.

pH is measured on a scale of 0 to 14. A reading below 7.00 indicates acidity; 7.00 indicates neutrality; above 7.00 indicates basicity. In a properly functioning aquarium, the water will be basic and pH will not fluctuate much, remaining between 7.5 and 8.3. When problems develop, it's very likely that the water is too acidic. If low pH (7.5 or lower) is measured, then animal wastes (they lower pH) are probably accumulating faster than the carbonate in the gravel (it stabilizes pH) can dissolve. To raise the pH, half of the aquarium water should be replaced with new seawater.

Just as humans do, marine animals require small amounts of certain minerals to stay healthy. In the ocean these minerals are never depleted but in the confines of an aquarium, with no turnover of seawater, growing animals and plants will use up necessary nutrients. When this happens,

healthy animals start to look not-so-healthy. To avoid problems, you should remove 10% of the aquarium water every month and replace it with new seawater. This has two benefits: necessary minerals are restored; and some of the concentrated wastes are removed.

You'll also have to add water to compensate for evaporation. When seawater evaporates, pure water is lost and salts remain behind. To replenish this loss, use fresh water that is free of dissolved metals. Tap water is usually contaminated from copper piping, so it is not suitable. Distilled and well water are safe as long as they don't contain traces of metals.

If you continued to fill an aquarium with metal-contaminated fresh water, you would be slowly poisoning the animals. First, **invertebrates*** such as crabs and sea anemones would die. At higher concentrations, fish (less susceptible to metal toxicity) would become pale and lethargic, then die. Of course, metal poisoning is not the only cause of animal deaths, but it is one you should be able to prevent by using clean replacement water.

Why is the pH level of the water important?

Several factors affect the pH level in marine aquaria. When carbon dioxide (a product of respiration) reacts with seawater, it forms carbonic acid, lowering the pH of the water. Carbonic acid, since it's relatively weak, can be neutralized by the seawater itself, which has a kind of "built-in" resistance to changes in pH (known as buffering). But seawater can't single-handedly take care of the acid accumulation. Its buffering system is dependent on the carbonate gravel you placed in the bottom of the aquarium. Here's how the gravel works: as the water becomes more acidic, the carbonate gravel starts to dissolve, releasing its chemical components i.e., calcium or magnesium ions (depending on the type of gravel) and bicarbonate ions. It is the bicarbonate ions that react with hydrogen ions in the water and stabilize pH. This is why it's important to select the right kind of gravel. The dissolution of the gravel happens so slowly that you won't notice any loss. This equation shows the chemical reaction:

$$\text{Water} + CO_2 \rightleftharpoons \underset{H_2CO_3}{\text{Carbonic acid}} \rightleftharpoons \underset{H^+ + 2HCO^-}{\text{Bicarbonate}} \rightleftharpoons \underset{2H^+ + 2CO_3^=}{\text{Carbonate}}$$

Setting Up and Conditioning

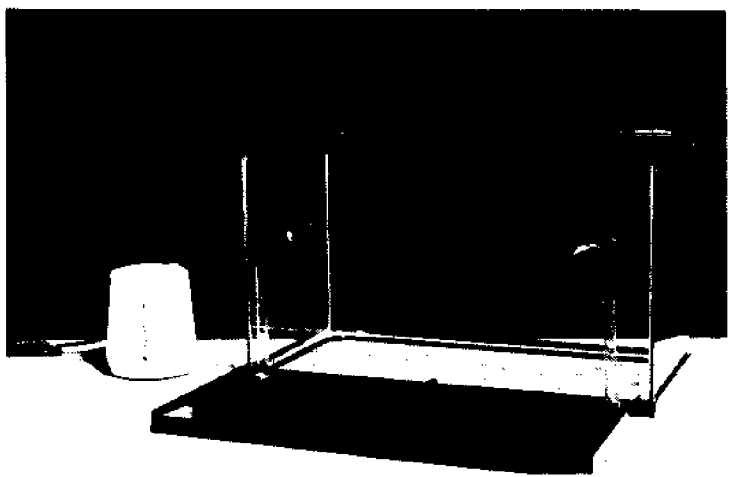
Don't buy a tank smaller than 10 gallons. One less than that could lead to overcrowding problems--waste production would outpace waste removal. It's easy to become enthusiastic about adding animals to your miniature undersea world, and even a 10-gallon aquarium gets filled up quite fast.

You can see from page 6 that the cost per gallon for equipping a 10-gallon aquarium is $9/gallon, while a 20-gallon one costs only $6/gallon. So it really makes sense to purchase the largest aquarium that you can afford and easily maintain.

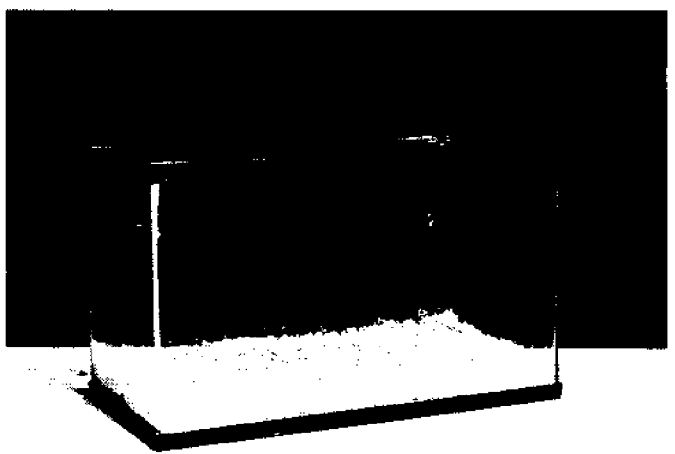
Place the aquarium on a stand that can adequately support the weight: a functioning aquarium weighs about 10 pounds (3.75 kg) per gallon (3.81 l). Then locate the aquarium in an area of the room away from direct sunlight to avoid overheating and too much algal growth. Next, follow these six steps to get your aquarium ready for conditioning:

1. Rinse the new aquarium with tap water to remove glue residues.
2. Test for possible leaks by filling the aquarium to the top with tap water and allowing it to stand for 24 hours. Often a new aquarium will develop a leak because of improper construction. It's a good practice to test for leaks before setting up the aquarium.
3. Install a purchased undergravel filter according to the manufacturer's directions; or construct your own, following instructions on page 10.
4. Rinse gravel to remove any fine silt and place two to three inches of gravel on the filter.
5. Now you're ready to add the water. If you're using natural seawater, fill the aquarium to within one inch of the top. If you're using synthetic salts, dissolve them in metal-free tap, or distilled water (use a plastic bucket), and aerate for 24 hours to assure a complete dissolution of the salts. Then transfer to the aquarium. Mark the water level on the aquarium for reference, and when adding fresh water, fill to this line.

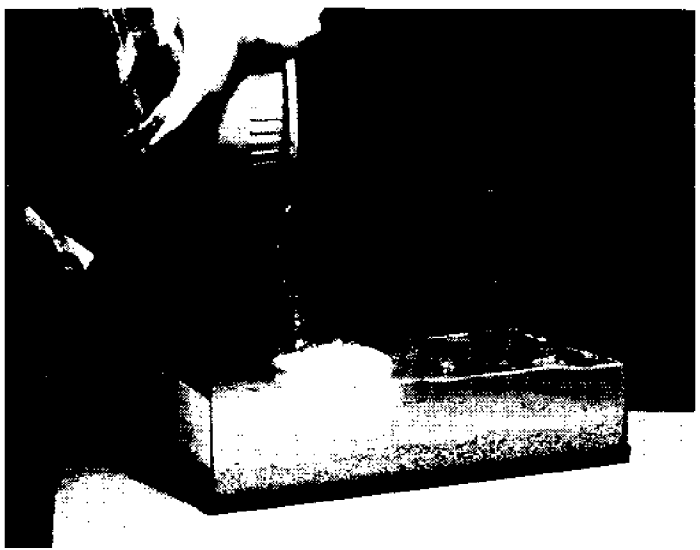
6. When the aquarium is filled with seawater, start the air in the airlifts. Any cloudiness will be removed by the filter within several hours.



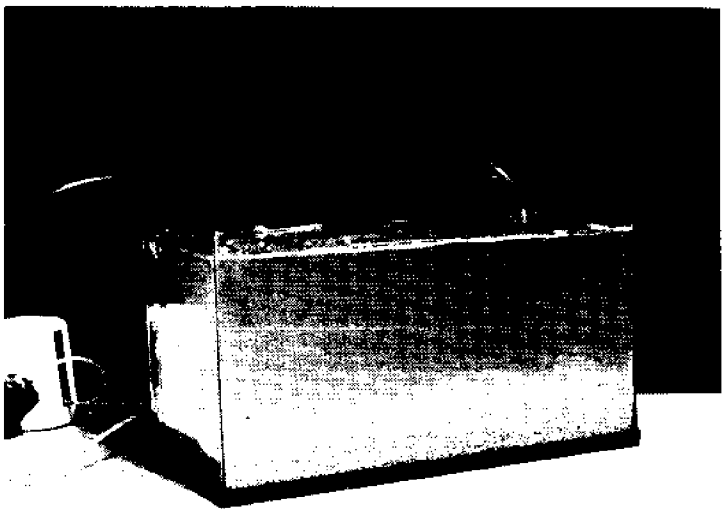
(1) Have your glass aquarium, undergravel filter and washed gravel ready.



(2) Install the undergravel filter system.



(3) After checking for leaks, add either natural or artificial seawater. Use a small bowl to break the force of water stream.



(4) Start the air in the air lifts and in several hours, the cloudiness will disappear and you'll be ready to add your animals.

THE CONDITIONED AQUARIUM

A conditioned aquarium is one in which the bacteria in the undergravel filter are converting toxic animal wastes to harmless compounds at about the same rate as wastes are being produced. During the conditioning period, colonies of bacteria multiply in the gravel in response to waste produced by a few fish that you've put in the aquarium. Because bacteria are everywhere, the fish introduced into the tank actually inoculate the filter bed with the bacteria on their bodies. Conditioning, or acquiring a dense population of bacteria, is of utmost importance in assuring a stable aquarium environment.

You should first know the approximate carrying capacity of your aquarium. What that means is the number of animals (both fish and invertebrates) that can safely live in the aquarium, given its filtering capability. Generally, a maximum carrying capacity is three inches (7.6 cm) of animal per square foot (929 sq. cm) of filter bed. As a rule of thumb, about five small fish (the size of a silverside) per 10 gallons is safe.

Before you reach the maximum carrying capacity, the undergravel filter has to be able to manage the load of wastes produced by that many animals. There are two ways of successfully conditioning the filter, and unfortunately they're both time-consuming. The idea in each case is to get the colonies of bacteria started.

Overloading

In the aquarium, place animals that can tolerate high levels of ammonia. What you're doing is building up the wastes so the first group of bacteria will start to function, followed in succession by the others. During this period (about three weeks) be sure to use more animals than you'd normally keep, so the aquarium will develop a reserve capability for handling wastes. Crabs, tautogs (black fish), minnows, eels, terrapins (marine turtles), or black mollies are good for this method. After the conditioning, these animals can be removed if more delicate ones are preferred.

Gradual Loading

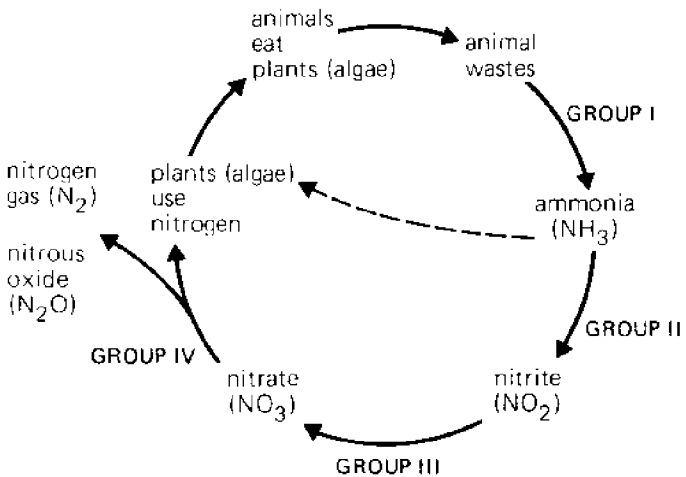
In this method, add delicate animals initially, though slowly. For example, add one fish per week for a 10-gallon aquarium. Conditioning will take four weeks.

You can speed up both processes by adding several handfuls of gravel from a healthy, already-conditioned aquarium to the surface of the new filter bed. The large numbers of bacteria will

condition the filter rapidly. Using this "yogurt method" with the overloading and gradual loading techniques, you can cut the conditioning time in half.

There are many types of marine bacteria with varied nutritional requirements. One way of classifying bacteria is by their oxygen preference. In the aquarium, aerobic bacteria (they need oxygen to live) are the powerhouses because they're the ones responsible for converting toxic animal wastes into harmless compounds. Anaerobic bacteria (they don't need oxygen to live) are the culprits that cause the foul "rotten egg" smell usually associated with tidal marshes. The odor is a result of hydrogen sulfide gas produced by the bacteria. Anaerobic bacteria are also found in the aquarium, although they are suppressed (but not killed) by the oxygen-containing water that is continually forced through the gravel.

If the air in the airlifts were to stop, the flow through the gravel would stop too, and within hours aerobic bacteria would consume much of the oxygen there and die. The anaerobic bacteria, which had been inhibited by the high oxygen levels, would immediately become active, producing hydrogen sulfide gas. Within a day, all of the animals would succumb to the toxic gas and you would have the unpleasant task of cleaning up. The rule? Never allow the filter to stop functioning!



THE NITROGEN CYCLE

What happens during conditioning?

The conditioning period allows bacterial groups to sequentially transform animal wastes into non-toxic substances. Actually, several colonies of bacteria live together on the filter gravel, each requiring a different food substrate and producing a different waste. Animal wastes stimulate Group I bacteria, which in turn produce ammonia as waste. The ammonia is toxic to the animals, but usable by the algae. When ammonia accumulates, Group II bacteria are stimulated. They transform ammonia into nitrites (still toxic to the animals). The Group III bacteria change nitrites to nitrates, and Group IV bacteria make the final transformation to nitrogen gas. This whole process is really only recognizable in a new filter bed, because once it gets underway, the reactions happen concurrently. The conditioning takes several weeks because all the bacterial groups need time to reach their full potential and density.

The Animals and Plants

THE ANIMALS

The collection of animals you keep in your aquarium really depends on you. However, there is something to say for simulating Nature by including a variety of organisms. Stable marine ecosystems include a diversity of plant and animal life. Your objective should be to successfully maintain such an ecosystem.

First, a word about temperature. The aquarium temperature should closely resemble the natural habitat. If you decide to keep tropical animals, the aquarium must be kept at 70-74° F (21-26° C). Heaters are available for any size aquarium and are sold in pet stores. If you're going to keep temperate animals, normal room temperature will do, but no lower than 60° F (15° C).

The ocean offers countless animals that would do well in an aquarium. Tropical coral reefs possess more species than any other habitat on earth. In fact hundreds of varieties of fish and thousands of invertebrates can be found living together on coral reefs.

Similar habitats, but on a much reduced scale, occur in northern latitudes. Various animals are found in reefs built by industrious worms that either secrete a hard calcium shell (*Hydroides* sp.), or bind together sand grains around themselves (*Sabellaria* sp.). In the crevices between the irregularly woven worm tubes, you can find an assortment of crabs (mud, blue, calico, lady, and cancer), shrimp, sea anemones, snails, starfish, mussels, clams, barnacles, eels, and small sea bass. All of these animals depend on each other to some extent. The clams and mussels feed by filtering microscopic algae from the water. Starfish and predatory snails pry open or drill through the clams and mussels to eat the soft flesh. Any remaining food is consumed by scavenging crabs.

A portion of a worm community can be successfully introduced into an aquarium. Since these animals live together in nature, they have similar temperature and salinity requirements. Add some fish to this group and you'll have an interesting exhibit.

If an aquarium were stocked only with fish, you would have to be constantly on the lookout for any uneaten food, because if it's not removed right away, it can foul the water. But this is really unnecessary work for you—let some crabs do it instead. Just add a few small ones, and all the leftover food will be devoured.

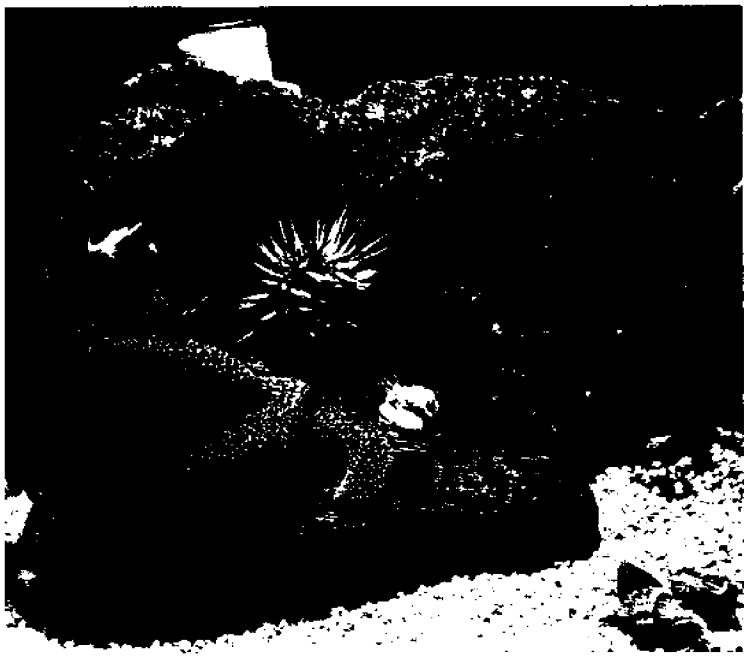
You might have to experiment with some animals in the beginning to determine their disposition and food requirements, but this is part of the challenge! Following are brief descriptions of some of the animals suitable for culturing in an aquarium.

Invertebrates

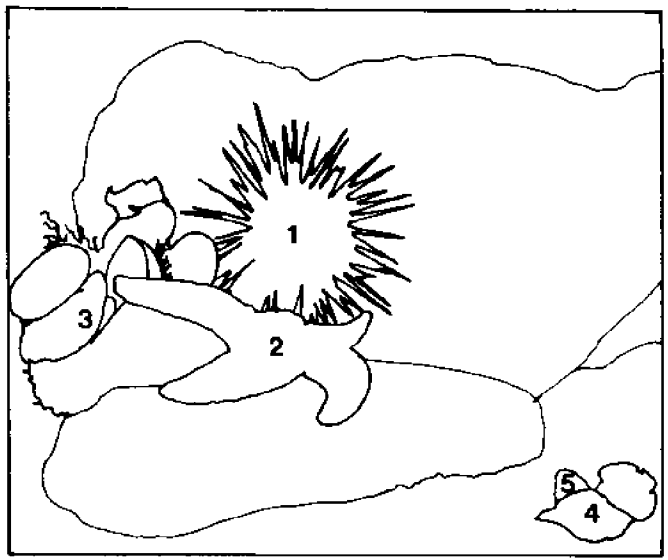
Molluscs: snails, clams, squid, octopuses and nudibranches. Certain snails, like periwinkles and mud snails, eat algae and **detritus***, while other, predatory snails bore through clam and oyster shells and eat the soft insides. Bivalves (clams, oysters, and mussels) filter out single-celled algae from the water using it as food. If you don't have a lot of algae in the aquarium, it is best to keep only several small bivalves. Squid and octopuses are cephalopods and are considered by some to be the most intelligent of invertebrates. Octopuses can only be kept in an aquarium with a tight-fitting lid to prevent them from escaping. They feed on live crabs and chunks of fish. Squid will not do well in an aquarium. Nudibranches are shell-less molluscs and can be extremely beautiful in color and shape. Some feed on hydroids, which are described on page 28.

Echinoderms: starfish, sea urchins, and sea cucumbers. All three of these are good choices. They're easy to keep. Starfish are notorious predators of oysters and clams, but can be coaxed to eat small pieces of chopped clam or fish. Sea cucumbers are shaped as their name implies. They feed by burrowing through sediment like an earthworm, taking out nutrients. Sea urchins resemble pincushions and eat algae and detritus.

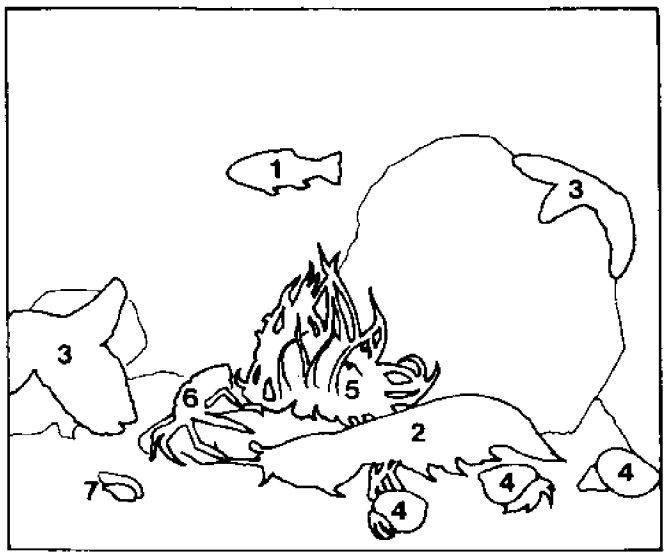
SEA CUCUMBER



TEMPERATE ANIMALS

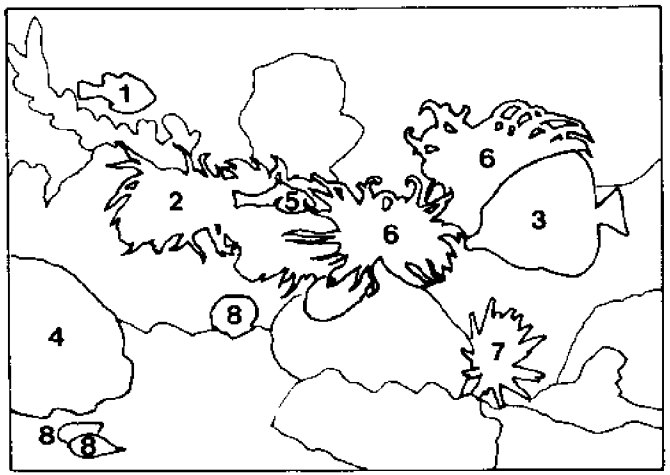


1. Sea urchin
   Arbacia punctulata
2. Starfish
   Asterias forbesii
3. Blue mussels
   Mytilus edulis
4. Oyster drill
   Urosalpinx cinerea
5. Hard shell clam
   Mercenaria mercenaria

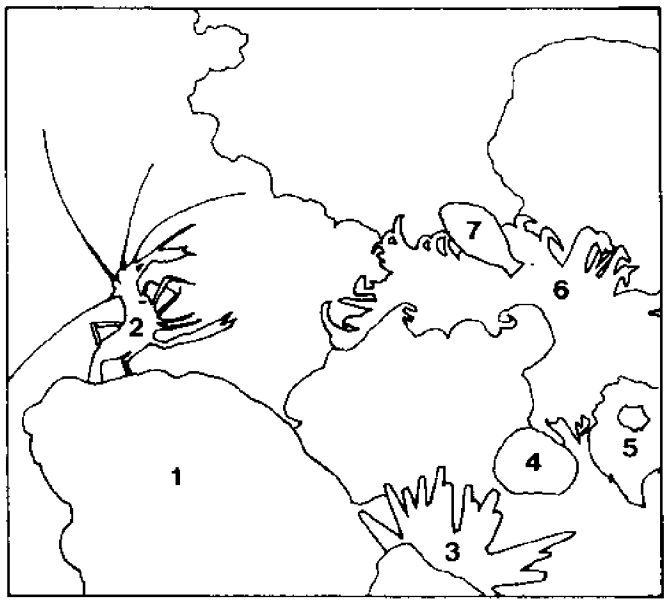


1. Sheeps head minnow
   Cyprinadon variegatus
2. Mantis shrimp
   Squilla sp.
3. Starfish
   Asterias forbesii
4. Hermit crabs
   Pagurus sp.
5. Atlantic anemones
6. Spider crab
   Libinia sp.
7. Periwinkle snail
   Ilyanassa obseleta

TROPICAL ANIMALS



1. Sebae clown
   Amphiprion xanthurus
2. Pacific anemone
   Stoicactis sp.
3. Yellow tang
   Zebrasoma flavescens
4. Live coral
5. Skunk clown
   Amphiprion perideraion
6. Florida anemones
7. Pencil sea urchin
   Cidaris sp.
8. Hermit crab
   Pagurus sp.



1. Live coral
2. Banded coral shrimp
   Stenopus hispidus
3. Pencil sea urchin
   Cidaris sp.
4. Hermit crab
   Pagurus sp.
5. Barnacle
   Balanus balanoides
6. Pacific anemone
   Stoicactis sp.
7. Skunk clown
   Amphiprion perideraion

Cnidarians: jellyfish, corals, sea anemones and hydroids. The most suitable members of this group are the sea anemones. These primitive animals are remarkably diverse in color and form. Most types capture their prey (usually unlucky fish) by stinging when the animal touches their tentacles (human skin is usually too tough to be affected). Most fish seem to be aware of the danger and keep a safe distance. But several tropical fish have evolved an as yet unknown immunity to the sting of sea anemones' tentacles. An example is the clown fish that lives among the tentacles of large Pacific anemones. This interesting combination makes a spectacular and easily maintained aquarium exhibit. Hydroids are stalked animals that live attached to rocks, shells and pilings. They are quite numerous in the mid-Atlantic area during the summer. Some hydroids do well in an aquarium when fed freshly hatched brine shrimp.

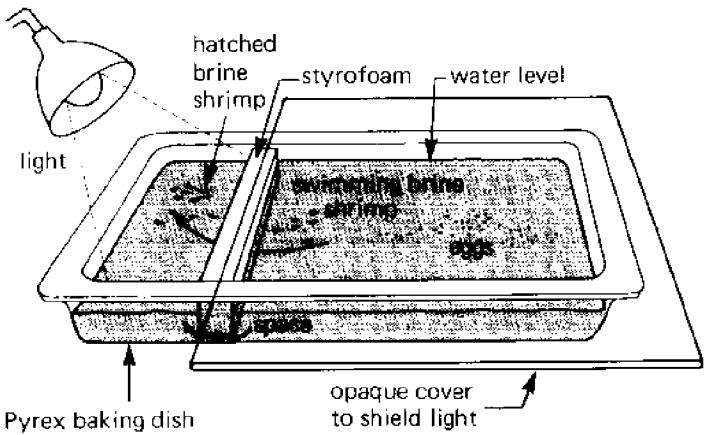
Polychetes: worm rock, tube worms. These are often inappropriately termed "worm coral." They feed by filtering algae and microscopic animals from the water. Brine shrimp are a good food.

Crustaceans; crabs, shrimp, lobsters, and barnacles. Crabs are known to be efficient scavengers and are essential to maintaining a clean aquarium. But some, like the blue crab, are quite adept at predation. To avoid problems, don't keep any of these, unless they are very small. Hermit crabs are relatively docile and well-suited to confinement. If there are no large fish and an adequate algal growth, shrimp will do well. Although it's not as obvious, barnacles are crustaceans, too. They feed by extending a feathery whip, the **cirri**, through the water, removing small particles. Large Maine lobsters, because of their aggressive behavior, are not good company for other animals. Small spiny lobsters from Florida are better at making friends in close quarters.

Hatching brine shrimp

Brine shrimp *(Artemia salina)* are crustaceans that live in very salty water. Frozen adult brine shrimp are sold in pet stores, but you can hatch your own by rigging up a simple hatchery. As dried eggs, brine shrimp are in a dormant or resting period but still viable. They can stay in this stage for many years, yet they remain capable of further development, and can be forced to hatch under the right conditions.

A rectangular Pyrex cake pan makes a good hatchery. Fill the pan with seawater (make sure the density is greater than 1.020). About one-third of the distance from the end of the pan, lay a piece of styrofoam (about one inch wide) across the width, leaving a space underneath the styrofoam. Pour some brine shrimp eggs (you can get them at a pet store) into the larger section and shine a bright light on the small section. In about 24 hours the shrimp will hatch, be attracted to the light, and swim under the styrofoam to the other side. You can then siphon out the baby brine shrimp and add them to the aquarium. The newly hatched shrimp leave their egg cases behind when they swim toward the light. Be careful not to put any of the cases in the aquarium since they may cause digestion problems if eaten by fish. It's best to hatch only the amount you'll use at one feeding, rather than try to keep the shrimp for a longer time.



Vertebrates*

Non-fish. The only "non-fish" suitable for an aquarium are marine terrapins. (Don't confuse these with box turtles or freshwater turtles.) The marine species can be fed chunks of fish, clams and shrimp.

Tropical Fish. Tropical fish are the most colorful and active animals you can have in a marine aquarium. Damsel fish (blue devils, clown fish, beaugregories, and three-spots) are probably the hardiest. Butterfly fish can be tempermental eaters.

Temperate Fish. There is not as much variety among temperate fish as among their tropical cousins. You might consider many Delaware Bay fish drab, but they blend well into the natural habitat. Killifish become brightly colored and attractive in the spring during their breeding season. These are good aquarium candidates because they easily acclimate to aquarium conditions and may even spawn. However, they may prefer salinity a little less than full-strength seawater. Certain other fish, for instance the silversides, are delicate and rarely make the trip home from the shore alive. Eels are interesting and can be easily kept except for one thing – they'll eat any small fish that swims within reach! Small sea bass are fine for awhile, but they quickly become large sea bass requiring larger quarters. Occasionally you can catch puffer fish in the warm bay waters during the summer. These make unusual specimens for the aquarium and can be trained to accept food from your hand.

In their natural environment fish feed continuously, so in an aquarium they should be fed about twice daily. The algae that spontaneously grow in the aquarium provide excellent in-between-meal snacks. Many fish, tropical and temperate, will thrive on dried flake food. Adult brine shrimp (frozen ones are available in pet stores, or you can buy eggs and hatch your own) are very similar to a natural diet and can be used as the main source of nutrition for many marine species. Occasional supplements of finely shredded raw chicken livers or clam will help to keep the fish healthy.

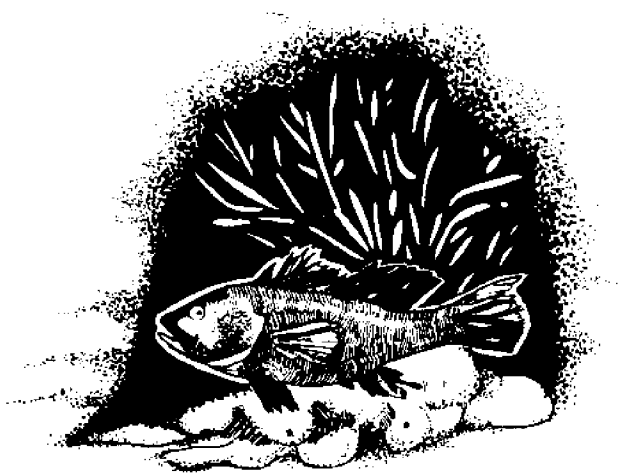
THE PLANTS (ALGAE)

Most people are accustomed to seeing a lot of plant life in freshwater aquaria. Plants thrive in marine aquaria too, but they are seen only as green (or red or brown or purple) films, called **algae**. Algae can be either **macroscopic** or **microscopic**.

The films you see are microscopic algae clumped together. Macroscopic algae are those that can be seen with the naked eye – the familiar seaweeds. Giant kelp in California, the green sea lettuce in the mid-Atlantic region, and the merman's shave brush of the Florida Keys are all examples of macroscopic, or multicellular algae. They are beautiful in their original locales and should remain there because in an aquarium they are difficult to keep alive, even for a brief time. It's virtually impossible to keep them for an extended period. They are not recommended for the novice aquarist.

Just like freshwater plants, the microscopic algae in marine aquaria play the important role of water purifier, by removing animal wastes. In using the waste nitrogen compounds as fertilizer, they supplement the work of the undergravel filter bacteria. Therefore, you should encourage the growth of algae in your aquarium by providing adequate, though not intense, artificial lighting. You'll find it's hard to discourage algae growth, so for an appealing display, the inside surface of the front and side panes should be wiped clean every week; leave the back pane as a growth surface for the algae.

Besides helping with water purification, the algae serve as a food source. As the algae multiply, the shells and coral used for decoration will become coated with algae, changing color from sterile white to warm sea tones. Then sea urchins will eat by scraping the coral and shells; fish will nibble on it.



Adventures in Collecting

If you like the idea of populating your aquarium with animals that are living reminders of your trip to the sea, then this section is for you. Of course you can purchase marine fish and animals in a pet store, too, but it's much more fun to collect them yourself!

To the budding naturalist, a field trip to the sea can open up a new world of interests. At low tide, you can see hundreds of animals on the sand flats and rock piles. Taking along the right equipment, some of it specialized and some of it ordinary, can help you successfully collect and transport the animals (that means getting them home alive).

WHAT DO YOU NEED?

Plastic buckets and styrofoam coolers. For conveniently transporting animals, containers with lids will help prevent spilling. If a lid is used, make sure air holes are provided. Styrofoam helps to minimize temperature fluctuations.

Battery powered air pumps. These are available in most bait shops and are necessary when transporting animals for several hours or more. Batteries are most efficiently used by turning the pump on, then off, for 15-minute intervals.

Nets. Various sizes are useful. In sandy areas, a **seine net*** can be pulled through the water to capture many fish at once. In the summer, a few tropical species from the Caribbean thrive in the Delaware Bay region and can be collected this way.

Large clear plastic bag. In tropical areas, this is a good idea. It is a favorite collecting tool of many Floridians. Open the plastic bag underwater and place a rock inside to keep it still. Then place inside either broken worm rock or sea urchin. Within seconds, fish will begin to swarm; some will find the opening and enter the bag. Needless to say, you must be snorkeling to make this technique succeed!

Collecting bag. Also in tropical areas, if you are swimming and collecting at the same time, you'll need a container to hold the animals. Either a plastic bag or a mesh diver's bag is sufficient.

A word of warning is necessary. Wherever you're collecting, **gather only enough animals to cover the bottom of the transporting bucket and no more.** On a good day, you may be tempted to keep most of the animals you find, especially if they are unusual. Making the mistake of placing too many animals in the transporting container has resulted in many people losing all of their animals before arriving home. Animal respiration quickly depletes oxygen in seawater and when one animal dies the rest will start dying, too. It's better to arrive home with a few interesting **live** specimens than a large collection of corpses.

In temperate areas like Delaware, when should you collect and what laws apply? The best time for collecting is the summer when animals are growing and are already acclimated to a temperature that you can easily achieve in an aquarium. If you were to collect animals during the cold winter months they would not adapt well to the warmer water of the aquarium. Also, in late summer in the Delaware Bay region, you might find some tropical fish such as look-downs and butterfly fish that have survived a trip from warm tropical waters.

Don't collect shellfish in areas clearly designated as closed to shellfishing. Don't take more animals than you can successfully raise in your aquarium. State laws provide protection for all plants and animals, so remember--the preservation of species is your responsibility as well. For specific details of regulations, booklets on fishing and shellfishing are available from the Division of Fish and Wildlife in most states. In Delaware write: Division of Fish and Wildlife, Tatnall Building, Dover, Delaware 19901.

Maintenance Requirements and Troubleshooting

PERIODIC MAINTENANCE

To keep the aquarium functioning well, you should be aware of some of the tasks that must be done regularly.

- Feed the fish about twice **daily,** providing as much food as they will consume in five minutes.
- Feed invertebrates, like sea anemones, once or twice **weekly.**
- Change 10% of the water **monthly** to replace lost nutrients and remove some wastes. Before siphoning water, stir the gravel so that waste particles will be suspended in the water for easier removal.
- Wipe the inside of the aquarium **once a week** to remove excess algal growth. Use a clean sponge that has never been used in soap.

This kind of periodic checklist gives a record of aquarium conditions and can be used as a home or school project for children.

DISEASE

Occasionally a fish will get sick (invertebrates rarely do). Treatment and even diagnosis are experimental and subject to re-evaluation. The best advice is to not stress the fish with irregular feeding, temperature and salinity changes, or poor water quality. Under good conditions, it's rare for a disease to crop up. But if it does, the sick fish should be removed to prevent contamination of the others.

There's always a chance of introducing a disease organism when you add a new fish to the aquarium. This is a double threat. A newly collected fish is subjected to conditions like temperature and salinity changes that can weaken it and make it a target for **Oödinium,** a parasite that can kill apparently healthy fish. In a weakened state, a fish can easily become susceptible to **Oödinium,** which clogs the gills and blocks oxygen uptake, causing suffocation. **Oödinium** is usually always present on a fish's body, but in a dormant stage.

SAMPLE MAINTENANCE CHECKLIST

	DAILY			WEEKLY		MONTHLY		COMMENTS
DATE	DEATHS	ADDITIONS	FEEDER	WATER DENSITY	INVERTE-BRATE FEEDING	WATER CHANGE	FRESH WATER	
JAN. 1			Ann	1.020	Anemones	2 gal.	1 gal.	
2			Sue					
3			Chris					Went to Cape Henlopen
4			Andy					
5	crab		Gisele					
6			Graham					
7		crab	Kent		Anemones			Went to Indian R.
8		fish	Chuck	1.021				

Temperature and salinity changes seem to excite **Oödinium**, and cause it to start multiplying. Then this microorganism proliferates in the aquarium water and within three days, overwhelms the fish. You can't easily detect if the fish is infected until it is in the terminal stages of the disease, with little chance of cure. Symptoms are rapid ventilation of the gills, erratic swimming, and scratching of the body on shells and coral.

You can minimize the chances of disease in your aquarium by following some basic guidelines when adding fish. If you purchase a fish from a pet store, make sure it was not a recent arrival because it may still be harboring a developing plague. When you arrive home, whether the fish was store-bought or collected, put the fish and water into a plastic container and float the container in the aquarium. Slowly begin adding water from the aquarium to the container. The result is a balancing of temperature and salinity. After a half and half mixture is achieved, use a net to scoop the fish and add it to the aquarium. Do not add any of the container water, since it might contain **Oödinium**.

Further Reading

Axelrod, Herbert R. and Will Vorderwinkler. **Salt-Water Aquarium Fish.** T.F.H. Publications, Jersey City, New Jersey. 1967.

Spotte, Stephen H. **Fish and Invertebrate Culture: Water Management in Enclosed Systems.** Wiley-Interscience, New York. 1970.

Straughan, Robert P. L. 4th rev. ed. **The Salt-Water Aquarium in the Home.** A.S. Barnes and Company, Cranbury, New Jersey. 1975.

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Glossary

Air lift tube: the tube attached to the undergravel filter through which water is pulled from beneath the filter.

Detritus: partially disintegrated particles of animal wastes that settle to the bottom from suspension in the water.

Estuarine: pertaining to an estuary, which is a semi-enclosed body of water that is open at one end to the ocean and at the other to a river, and which is diluted by the freshwater inflow from the river. The Chesapeake and Delaware Bays are estuaries.

Invertebrate: animal lacking a backbone.

pH: a value used to express whether a solution is acidic, neutral, or basic. This number (ranging from 0 to 14) is the logarithm of the reciprocal of the hydrogen ion concentration (H^+).

Seine net: large rectangular net having sinkers on one edge and floats on the other, hanging vertically in the water and enclosing fish when either its ends are brought up or it is pulled ashore.

Vertebrate: animal with a backbone.