Chesapeake Bay
National Estuarine Research Reserve
in Virginia

Estuarine Aquarium Keeping for Beginners

By Bob Carroll

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*** The full guide can be found at www.vims.edu/cbnerr/ under the education tab

Introduction

This information was created as an introduction to estuarine, or brackish water, aquarium keeping for the beginner using simple aquarium gear. Estuarine aquarium set-up and maintenance is easy as long as you have access to brackish water and you have time to devote to the tanks. The following information has been obtained from practical experience gained while maintaining estuarine aquariums using basic systems. You can add more sophisticated aquarium gear and keep animals that require more precise water quality, food and care as your 'wet thumb' improves from experience and through information obtained from other sources.

You can learn a tremendous amount about marine biology and estuarine species by keeping an estuarine aquarium so don't be scared to try one even if you have had bad luck keeping fish in the past. It's never to late to develop a 'wet-thumb', especially once you know what to watch out for. The key concepts include:

- 'Age' your aquarium properly before introducing animals.
- Don't overstock your aquarium with animals.
- Stock your aquarium with smaller animals.
- Don't overfeed.
- Watch, watch, watch. A close eye on the aquarium, especially during feeding, will give you invaluable information as to how everything is working.

The author is not professionally trained in aquaculture or aquarium keeping and is not responsible for problems that may occur from the use, or misuse, of this information.

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Estuarine Animals

The Chesapeake Bay and the tidal tributaries is an estuary. An **estuary** is defined as a semi-enclosed body of water where fresh and salt water mix. Fresh water has a salinity of 0 – 0.5 and ocean water is from 30 – 36 parts per thousand salt. Any salinity in between these two can be considered to be **brackish water**, or a mix of fresh and salt water. Animals found in brackish are estuarine animals. Estuarine animals can be broken down into estuarine residents that spend their whole lives in the estuary, or estuarine transients that only spend a portion of their lives in the estuary. Estuarine transients can visit brackish water from both fresh (white perch, catfish, gar) or salt water (striped bass, American shad, pigfish). Both classes of these animals have the ability to osmoregulate their body fluids in the changing salinities found in an estuary. They visit the estuary to feed, escape from predation or during spawning migrations. Of the 267 fish species that have been captured in the Chesapeake Bay in salinities greater than 5 ppt to the Bay mouth, only 32 species can be considered to be *year-round* residents in the brackish water areas of the Chesapeake Bay.

The estuarine resident species are generally the most hardy fish and easiest to keep in your aquarium. They are used to great fluctuations in temperature, salinity, dissolved oxygen (DO) etc. that

occur over the year in the estuary. That means they will be OK with fluctuating conditions in your tank, including low DO for some species.

The table in the appendix lists common species captured in shallow water in the mid to lower Chesapeake Bay and includes brief notes that describe which species have been easy to maintain in a 20-40 gallon estuarine aquarium in my experience. Please keep in mind that these notes are from my experience, and should not deter you from trying to keep any species if you feel you have the right sized tank, food and water quality conditions. The best way to learn which species work and how to make them work is through simple trial and error. Experience is the best teacher.

Aquarium Water Quality Parameters

Salinity

The salinity of the water is one of the most important factors in maintaining estuarine animals. A good rule of thumb is that animals can handle the salinity of the water that they were captured in, so if you're tank is filled with water from the same spot you captured your animals, they should be fine. Caution should be used when catching animals in waters with different salinity than the aquarium you will be transferring to. A difference of 5 or more parts per thousand in salinity could be tough for some species, especially the marine and fresh water transients. For instance, if you captured a pigfish in the lower Bay in 18 ppt water and moved it to a 13 ppt fish tank, it may experience unhappiness. Similarly, a yellow perch captured in 3 ppt water may not find aquarium water with a salinity of 8 ppt to be to it's long term liking.

An interesting aside is that fish body fluid and blood is the equivalent of about 10 ppt in osmotic pressure. Thus the cells of fresh water fish are flooded through osmosis while salt-water fish actually loose water through osmosis from their cells to the surrounding salt water. Fish deal with this problem in very interesting ways that we don't have room to cover in depth here. In general, fresh water fish never drink and excrete copious amount of urine while salt-water fish drink and excrete very small amounts of urine in order to save water.

As water evaporates from your fish tank, the salinity will increase slightly. This should easily be kept in check through proper water changes. If you're salinity is increasing over time, you can dilute the aquarium using tap water. Remember to age tap water in an open container for at least 24 hours to allow any chlorine to diffuse out of the water. You may want to use an aquarium water conditioner just to make sure that any chlorine in your tap water are neutralized.

Temperature

Water temperature is another *major* factor to think about when maintaining an estuarine aquarium. All of the fish, crabs and shrimp that you would be dealing with are cold blooded or 'thermal conforming' animals. The ambient water temperature determines the rate of biochemical reactions at the cellular level, or their metabolic rate. Warmer temperatures cause the metabolism of cold-blooded animals to increase. Cells burn more energy as metabolism increases, and the cells need increased oxygen and food supply which in turn increases animal excretion which can lead to a negative feedback loop of warming water temperature – greater animal metabolism – greater oxygen use and increased excretion as the cells burn more energy – declining water quality. Warmer water temperatures are hard on the fish, and the fish tanks water quality.

All aquatic animals have a range of temperatures in which they can live, and they do best when temperatures are close to the middle of that range. School classrooms are notoriously warm, and this can

be a *major* factor in regards to which species will thrive. Water temperatures can easily climb into the 80's in a school hallway, or during the weekend if they turn the air conditioning off. If you have water that is 75°F and above, you will have the best luck using marsh resident and shallow water species because these animals naturally experience warm water during the summer and their metabolisms can handle it. Most organisms from the Chesapeake will be much easier to care for if you have cooler water. I would not try to keep any animals characterized as 'hard' to keep if the aquarium is not in an air-conditioned room.

The beneficial bacteria and toxic ammonia described later are also affected by temperature. Ammonia becomes more toxic with higher aquarium temperatures and the nitrifying bacteria that comprise the biological filter will likely die if water temperatures rise above 95 degrees F. Again, you will have much better luck if your aquarium is set up in a full-time air-conditioned room.

You do not have to be concerned about cold-water periods. As the water temperature in your aquarium decreases, the critters will simply slow down and may stop eating entirely. It should not be a problem if your water temps decrease to 50°F, or even colder during school vacations. I do not use aquarium heaters in estuarine fish tanks for this reason.

Try to look up where your fish lives in *Life in the Bay* (Lippson and Lippson) or in *Fishes of the Chesapeake Bay* (Murdy, Birdsong and Musick) to figure out what kind of temperature they can handle. Fish found in deeper waters and waters close to the ocean most likely prefer cooler water (65°F or less) and will not do well in water above that temperature. If you put fish in water temperatures that are too high, you may see them breathing rapidly to get enough oxygen and they may loose weight even though you are feeding them. This is because their metabolic rates are so high due to the high water temperature that they simply can't eat enough to balance out their racing metabolism. The only way to make these fish happier is to decrease the water temperature. Ice cubes won't do the job (plus the ice water may have chlorine from the tap water) and water chillers are expensive, so it is very important to think about the room temperature where the aquarium will be and what temperature the animals experience in the wild.

Temperature is also a major factor to address when transferring fish. This will be discussed in the *Fish Transfer* section.

Oxygen

Water can hold a very limited amount of dissolved oxygen, and this is based on the salinity and water temperature. Water can hold less dissolved oxygen as it gets warmer and saltier. Estuarine water usually holds between 5 – 8 parts per million (ppm) oxygen. Considering our atmosphere has roughly 210,000 parts per million free oxygen, it is a wonder that fish don't thank fishermen when they are hauled out of the water. Fish can't breath in the air because their filamentous gill structure becomes 'squashed' when taken from the water, similar to how hair floats freely underwater and falls against the head in a big wet mop when a swimmer gets out of the water.

Fish will begin to get stressed in DO levels of 3 – 5 ppm and will get very stressed in water below 3 ppm. All tanks should have several sources of oxygen including several of the following.

- Aerator: Bubbles are good. Smaller bubbles have more surface area and thus more area for oxygen to diffuse from the bubble into the water than larger bubbles. Aerators are also good because they will come back on when the power is restored during a loss of electricity, while filters may not come back up without assistance. Powerheads used in many undergravel filters or for aeration can be tuned to

produce a great amount of bubbles. Powerheads also restart more reliably than filters after a power outage, however air pumps restart the most reliably and are the easiest to use.

- Filter Outflow: It is good to leave the water level somewhat below your filter outflow level so the outflow falls into the aquarium, creating bubbles and turbulence on the surface.

- Turbulence: Increasing turbulence along the surface will facilitate the diffusion of oxygen across the water surface. The filter outflow or the outflow of a powerhead can enhance turbulence.

- Surface Area: Oxygen diffuses from the atmosphere into the water. The greater the surface area of your aquarium, the more diffusion can occur. There are general rules of thumb about how many fish can be kept based on the surface area of the tank, however the fish carrying capacity can be increased with the use of mechanical aeration.

- Plants: All underwater vegetation, including phytoplankton and algae produce oxygen through photosythesis. The tiny bubbles seen during the day on plants is oxygen that they produce. However all plants USE oxygen through cellular respiration, just like animals. Plants are net oxygen consumers during the night and low light conditions. Therefore, it would be a good bet to aerate your aquarium the same if you have living plants or not.

Fish use more oxygen when they are active and also after eating as they digest food. Active fish (such as fish that don't stop swimming around the tank) use more oxygen than more sedentary species. Fish metabolisms increase with rising water temperatures, so fish also use more oxygen as the temperature increases. It is important to remember that the bacteria in the biological filter (discussed later) also use oxygen. Dead animals and uneaten food left in the tank are colonized by huge numbers of decomposing bacteria, which use oxygen. These bacteria can cause the oxygen in your tank to decrease to a deleterious level for your animals. Therefore you should not have uneaten food or dead animals present in your aquarium.

Aquarium Set-Up

Tank Size

The volume of water in the tank, the surface area of the water/air interface and the surface area of the substrate are all very important components to keep in mind when thinking about how many animals can be put in your aquarium. Most estuarine animals stay close to the bottom of the tank, so you should try to maximize the bottom surface area of an estuarine aquarium. For instance it is better to purchase a 20-gallon *long* aquarium instead of a 20-gallon *tall* model. The long model has more bottom surface area than the 20-gallon tall aquarium model.

The surface area of a tank is important in gas exchange (namely oxygen). Many aquarists use the surface area or volume of the aquaria in a formula to come up with how many fish of what size can be put in that tank. For instance, some recommend that a properly functioning aquarium can handle 2 inches of fish for every 10 gallons of water to be on the safe side, increasing to three 2-inch fish as the tank matures. These calculations are on the cautious side, and more fish can be placed in a well functioning and properly maintained aquarium than the equations tell you. If I had to guess, I would say that a well maintained 10 gallon aquarium could handle 10 small animals (1 inch or less), a 20 gallon aquarium could handle 15 - 20 small animals (1 inch or less) etc. – but don't hold me liable and don't forget that I am talking about stocking hardy estuarine species that can tolerate a wider range of conditions than most fish. It is always far better to understock than overstock your aquarium. *Understocked tanks will be incredibly*

easier to clean and maintain while overstocked tanks will be nothing but trouble, so start slow and don't go over your aquariums ability to process fish waste.

Larger volumes of water experience less fluctuation in temperature and water quality parameters over the normal day, and provide greater areas for fish to swim. Some fish, such as bluefish, require a large amount of swimming room in order to live, and may still experience overall sadness in a confined rectangular tank. Fish that swim constantly in your collection bucket or in the wild will most likely not do all to well in a small aquarium. These include menhaden, shad and herring, and possibly bluefish.

The surface area of the substrate, or bottom of the tank, is also very important. Bacteria grow on the surface of aquarium substrate. These bacteria are part of the biological filter explained below. A larger bottom area will give you more substrate surface area for the bacterial to grow, which increases your biological filter. This is a good thing. Crushed coral and gravel have a lot more surface area for bacteria growth than sand because sand is comprised of such small grains that they compact leaving few 'nooks and crannies'. Thus crushed coral or clean gravel or small stones is a better aquarium substrate than sand.

Materials (prices are approximate)
Tank: 20 gallon long - $35
Aquarium hood with light - $40
Undergravel filter - $20
Air pump and enough airline hose to get from the air pump to the undergravel filters - $25
Hanging filter and extra filter cartridges - $45
Crushed coral substrate - $10
Clean oyster shells for added habitat – find them
Cleaning Supplies: 'Vacuum' siphon, bucket, algae scrubbing pad, test tube cleaner, and towel - $20
Feeding: Frozen brine shrimp, sinking shrimp pellets, flake food = ?

Total for 20 gallon tank = approximately $200 plus feeding supplies

You can purchase all of these materials at most pet stores or you may want to deal through the internet. That Fish Place (www.thatfishplace.com) is one example of an internet dealer that has a large catalogue filled with information and products.

Tank Theme

There are many different aquarium themes that you can use to highlight estuarine habitats, animals and communities. Brief discussions of some of these are below. Most species of estuarine animals will enjoy some cover to hide in. The best aquarium habitat that I know of is scattered oyster shell, no more than 1 or 2 shells high. You can collect them from almost any beach. Avoid piling the oyster shells too high or covering the entire bottom with shells because food will get trapped in places that the animals can't get to it and this will rot. Driftwood can decay in your tank and cause the water to become murky, so I don't advise long-term use of driftwood for habitat or aesthetics.

Marsh Fish – This is one of the easiest themes because marsh fish are so hardy. In order to live in the marsh during the summer time, marsh fish are able to handle very warm water temperatures that are often accompanied by low dissolved oxygen. These fish include the mummichog, striped killifish, sheepshead minnow, rainwater killifish, grass shrimp, mud snails, blue crabs and hermit crabs in saltier places. These species are very interesting to observe and easy to keep.

Oyster Reef Animals (not including oysters) – Many species use oyster shell habitat. These include blenny, goby, skilletfish, mud crabs and blue crab. These species are also very hardy and easy to maintain. Do not put live oysters in the aquarium for longer than you want to observe them because they will add biomass to your aquarium, adding ammonia waste and using oxygen. It is also hard to keep the oysters fed with phytoplankton. You can purchase algae paste and concentrated phytoplankton to feed oysters, or replace water on a daily basis, but this takes significant effort and is beyond the scope of this manual. You could try to make small oyster reefs by gluing oyster shells together with silicone aquarium glue in order to create vertical relief. The shells that I glued together this way fell apart after several months, but they did look good in the tank while they lasted.

Blue Crabs - Blue crabs are very entertaining, but they are cannibals and will likely eat many of the other animals in your estuarine aquaria, however this can be educational and students really enjoy a blue crab tank. I suggest placing either several small crabs in a tank or one mature female crab (sook) in an aquarium. Sooks do not shed again so they can live for a long time in captivity. The vast majority of sooks are carrying sperm packets, so be sure to cycle the lady out and free her so she can have millions of babies after her stay in your aquaria. Smaller crabs are very entertaining in a tank as they are incredibly acrobatic if you provide taller habitat. Their numbers will decrease through cannibalism. Blue crabs will eat one another when they have hard exoskeletons, and are defenseless when they molt in the aquaria and are in the soft crab state. Watching a blue crab shed out of its old shell in an aquarium is an amazing education opportunity. It is well worth the effort to find a peeler crab and keep it in your tank in hopes it will shed.

Mud Tank: A mud tank is one that uses estuarine sand / mud for a substrate. This can provide some really neat observation opportunities of benthic infauna (worms and crustaceans), but be careful when you put fish or crabs in a mud tank because they will stir up the mud and cloud the water. Larval benthic critters usually settle out from the water you filled the tank with, but they will need frequent water changes to bring more food in. These tanks are novel, but very labor intensive and not recommended unless you are working on a project that entails use of a natural estuarine sandy/mud bottom.

Submerged Aquatic Vegetation (SAV): I would suggest not trying to grow brackish water SAV as a beginner. Eelgrass is a cool water SAV species and will have trouble growing above 60°-65°F (it actually prefers around 50°F). While it is possible to put a plug of SAV into a pot and grow it in a tank, the sediment can cloud the water and the vegetative matter can decompose if not healthy, thus adding nutrients to your tank. If you are interested in growing salt water SAV, try it in a tank created solely for that purpose and good luck or go with a fresh water tank and grow fresh water vegetation species in a fresh water tank such as wild celery. Wild celery is easy to grow and looks great.

Macroalgae: This is the generic name for species of plant-like looking matter (green, brown or red) found all over the Chesapeake. These look great in your tank for a while, and the animals will enjoy the habitat structure, however they soon start to break up, potentially clogging filters and decomposing. If you want to add macroalgae, red beard sponge etc., I suggest you keep it in the tank for several days, then take it out before it dies and begins to fall apart. Remember that any living macroalgae cells will use oxygen during the night and bacteria will use oxygen as they decompose dead cells.

Oysters and Filter Feeders: It is very tempting to add oysters, clams, barnacles, sea squirts and other filter feeders to your aquarium. However, your tank does not have enough planktonic food to feed any of these animals to survive. You may be able to use store bought algae paste or concentrated algae to feed filter feeders that eat phytoplankton, but I do not have any experience with this. I would only put in such organisms for a day or two for observation and then move them to natural waters where they can feed.

Substrate

The best substrate that I have found is *crushed coral* for several reasons. It is heavier than sand particles, so it should not rise off the bottom due to fish disturbance and get sucked into the filter. Sand particles are so small that they will frequently get sucked up into the filter. Just one grain of sand can stop the impeller, which stops your filter. Crushed coral also helps buffer the pH in the water. Crushed coral is mostly calcium carbonate, which is a natural seawater buffer. You will not notice the amount of crushed coral changing in your tank because only a very small amount will dissolve over time. Crushed coral also provides a lot of surface area for the biological filtration bacteria to grow on, which is a good thing.

Aquarium gravel can also be used, as can small stones etc. These won't help buffer your pH however, and remember to rinse all types of gravel well before use.

*** Crushed coral needs to be rinsed rinsed rinsed before you use it, even if the package says it was pre-rinsed. Put it in a bucket and keep rinsing it as much as you can, however you'll never clear it all the way up. Don't panic when your aquarium becomes white after you add the crushed coral even after proper rinsing, the water will clear in a day or two.

Aeration

It is a good idea to have an air pump in each aquarium, and I suggest that you use air to power the undergravel filter if you are using an undergravel filter. The bubbles created by an aerator will burst at the surface, leaving a salty residue in areas, but the added benefit of extra aeration overshadows a little extra cleaning. You can also work to position the air stone in a spot where the bursting bubbles at the surface won't create a problem. Air pumps come in different sizes, so make sure you buy an air pump that is strong enough to send air down to the bottom of your tank. Larger tanks need larger air pumps to do this. Air pumps come back on when power is restored after a power outage while your filter may not restart without some manipulation. The aeration provided by the air pump can potentially save a tank when you are away if the filter stops for some reason.

Filtration

There are many different types of filters for your aquaria. Well start with the easiest to use and then get more technical. Filtration rates (gallons per hour) should be between 3 to 6 times the volume of the aquarium

Mechanical Filters: There are many brands and forms of hanging filters. The majority combine mechanical filtration (filter floss), chemical filtration (activated carbon) with a small biological filter (surface area of some sort). The mechanical filter removes particulates, the activated carbon removes dissolved organic matter and the biological filter removes toxic ammonia and nitrite. The filter floss material with is the mechanical filter removes larger particulate material as water passes through, however these particles are still in the aquarium system and continue to break down, releasing ammonia. Cleaning the filter cartridge or replacing them gets rid of accumulated material trapped in the filter floss. Activated charcoal is removes dissolved organic matter, which can cloud the water with a yellow or white tint. Activated charcoal is a very porous and highly adsorptive substance. Activated charcoal removes micro-particulates and dissolved organic matter by chemical attraction of organic molecules to the charcoal surface. Most mechanical filters also have a biological filter included (sponge or biowheel). The surface area provided by the biological filter harbor beneficial denitrifying bacteria described later. It is important to keep these biological filter components (sponge or biowheel) in oxygenated water during filter cleaning so these colonies of aerobic bacteria don't die, and never scrub these items or flush them too heavily.

Mechanical filters suck up water through the operation of a centrifugal pump. The electric motor spins a submerged impeller, which sets up a pressure gradient and water is drawn up the intake siphon. This system works fine until a particle of sand or grit is sucked up into the filter, which can stop the impeller, thus stopping the filter. Not only will your aquarium be unhappy when this happens, but the bacteria in your biological filter part of your mechanical filter will die if they are submerged in stagnant water for too long because this water will quickly become anoxic. The best way to try to avoid this is to keep your intake siphons as high as possible from the substrate (so use the shortest intake pipe option) and use heavy substrate that won't get kicked up into the water by quickly moving fish and crabs. Most filters can be started again simply by pulling the intake tube out and repositioning several times, making sure that there is water in the filter to serve as a prime. If you find that your mechanical filter keeps stopping, unplug and remove the whole filter, take out the intake valve and flush the unit out with water several times and use a test tube cleaner to clean out the area where the impeller goes.

Undergravel Filter: I have used undergravel filters with mixed results. A properly functioning undergravel filter does have many benefits to the aquarium water quality, however I find that they can be difficult at times to keep working at 100% efficiency. Given their low cost however, I still recommend the use of an undergravel filter in combination with a mechanical filter.

The undergravel filter increases the *biological filtration* in your substrate. Water is pulled up the undergravel filter tubes either by air bubbles or by a powerhead. The water going up the tubes with the bubbles is replaced by water that is drawn down through the substrate and through the undergravel filter tray. This increases the biological filtration in the substrate because it brings oxygenated water deeper into the substrate than would normally occur without an undergravel filter, thus increasing the amount of substrate that can be colonized by the beneficial nitrifying bacteria. The bacteria can thus remove more of the toxic ammonia and nitrite from the aquarium water. It is very important to 'vacuum' your substrate (discussed later) when using an undergravel filter because particulates are sucked down into the gravel where they get trapped. Vacuuming your tank will help remove these accumulated particles. I recommend using an air pump to power your undergravel filter. Powerheads move more water through the system, but they can get clogged when pieced of substrate invariably get sucked into the powerhead. Thus powerheads take more maintenance to keep them unclogged and running full speed. Airstones will force pieces of substrate up into the tube as well, but it takes a whole lot more substrate material to clog up an outlet powered by an airstone and it is much easier to fix.

Protein Skimmer: I just purchased a *Skilter Filter*, which is a mechanical filter, an aerator and a protein skimmer all in one. This added protein skimming filtration of this tank has really created remarkable improvements in water quality and ease of maintenance in my aquaria. Protein skimmers work by mixing aquarium water and a torrent of small bubbles in a spinning tube. The surface areas of the bubbles attract organic matter such as proteins that aren't fully decomposed. These organics then rise to the surface of the proteins skimmer and into the collection pan, thus removing them from the aquarium.

Protein skimmers work like a strong wind over the Bay or ocean. *Strong* winds create waves whose associated bubbles attract organic matter from the Bay. These bubbles and organic matter can accumulate in a light bubbly scum under the right conditions either in the water or on the beach.

Sponge Filters: Sponge filters work by pulling aquarium water through the 'sponge' and out the powerhead that provides the energy to move the water. The sponge provides large amounts of surface area for the beneficial bacteria to grow. While these do demand the use of an appropriate sized powerhead (both in terms of flow and fit to the sponge filter), they are incredibly easy to use since it's almost impossible for substrate to get pulled in through the sponge and clog the powerhead. Sponge

filters are also incredibly cheap (10$), however they require a powerhead which are moderate priced ($30). The only down side of a sponge filter is that it takes up space on the bottom of the aquaria and they are not attractive in the tank.

Fluidized Bed Filters: Fluidized bed filters are somewhat more expensive items ($80 for the filter and the filter sand) that require the use of a powerhead to move the water ($30), however they provide a large amount of biological filtration through the surface area provided by the sand particles. As water moves from the tank to the bottom of the fluidized bed filter and out the top, it suspends each sand particle (thus the fluidized bed term). Each sand particle then gets colonized by the good bacteria and is in almost constant contact with new aquarium water. Larger clumps of bacteria get knocked off the sand particles as they hit each other, thus providing constant growing conditions for new bacteria. They are virtually maintenance free, however you need to monitor the bed level to make sure your sand doesn't overflow. I have found it beneficial to wrap the powerhead intake in a thin layer of filter floss (then secure it with plastic twist ties) to keep out large particles (food, fish waste etc) from this filter. This floss will change the desired intake level and require periodic replacement as it traps particles and clogs.

Other Filters: Canister filters, wet-dry filters, diatomaceous earth filters, UV and ozone sterilization filters are advanced filtration methods that you can learn more about as you get further along into aquarium keeping and take on more challenging aquarium projects.

Aging The Aquarium or Cycling the Biological Filter

One of the most critical steps in starting up an aquarium is giving the aquarium enough time for the biological filter bacteria population to build up or 'cycle'. Fish excrete ammonia waste (NH3), which is toxic. Fish feces, uneaten food and dead animals will also add ammonia during decomposition. This ammonia will build up unless you frequently change a lot of water (impractical), or your biological filter converts it first to nitrite (also toxic) and then to nitrate (not toxic) through the nitrogen cycle. It takes time for your bacteria colony to build up, and this time is called *aging or cycling*. The *nitrobacter* and *nitrosomonas* bacteria, which do this important job, are found in all aquatic environments and they are in the river or bay water that you fill your tank with.

Nitrosomonas bacteria convert (oxidize) ammonia to nitrite and will begin growing on the substrate in your tank and the sponge or biowheel in your filter when you set the aquarium up. These bacteria colonies double in size every 15 hours under ideal conditions, but it still takes several weeks for the bacteria populations to reach a level that they can really do their job. It is a good idea to 'seed' these bacteria into your aquarium if you are using store purchased sea salts such as Instant Ocean to create your estuarine water by placing some estuarine water, or gravel from a functioning aquarium into the new aquarium.

Nitrite interferes with oxygen metabolism and destroys hemoglobin. Nitrobacter bacteria use nitrite (NO2 - first breakdown product of ammonia), turning it into less harmless nitrate (NO3). Nitrobacter are inhibited by ammonia and only begin growing as the nitrosomonas bacteria have turned accumulated ammonia into significant quantities of nitrite. Thus the nitrobacter growth curve lags behind the nitrosomonas bacteria, thus adding time for the biological filter to gear up.

Nitrate (NO2) is the end product of nitrification. Nitrate is toxic to aquatic animals, although less so than ammonia or nitrite. Nitrate is a stressor on fish and the fish has to expend more energy on the cellular level to adjust to it, thus decreasing their ability to ward off other stress such as disease, parasites and healing. Nitrate is also a plant fertilizer and it can cause algae blooms in your tank if left to accumulate. Accumulated nitrate can also decrease the pH to dangerous levels in fresh water aquaria in a process known as 'old tank syndrome'. The only way to get rid of accumulated nitrate is if live plants in

your tank use it or through water replacement. Replacing 25% of your aquarium water every two weeks dilutes the nitrate levels in your aquarium and is a key step in proper aquarium maintenance.

Aging your aquarium can take *20 – 40 days* or *longer* and depends on what material you are reading. I like to introduce two or three hardy fish (mummichogs) after a week or so to help speed up the bacteria growth, and then add more fish after 1 or 2 more weeks. Adding too many fish before your biological filter is up to speed can result in fish death from high levels of ammonia, so it is best to go slow off the start. All aquaria have a different amount of biological filtration depending on your filters, gravel, tank size, water temperatures etc. The total amount of biological filtration is a key factor in determining how many organisms you can have in your aquaria. Increasing the amount of biological filtration through the addition of fluidized bed, sponge and other biological filters will allow you to maintain more organisms. It is always better to have fewer fish rather than too many fish, so take your time when adding organisms and add just a few organisms at a time.

You can buy inexpensive and easy to use ammonia test kits from any aquarium store. Ammonia and nitrite results can tell you how your tank is functioning. High levels of ammonia are *any* level detected by the test kits. High levels mean you should replace some water, reduce the number of animals in your tank and most likely feed less. Non-detectable levels mean that you are doing a good job and you *may* be able to add more animals. There are products available that will chemically neutralize nitrite and ammonia in your aquarium, but these products do not take them out of the system, they only 'lock' them up and the nitrogen cycle is still necessary to convert the locked up ammonia into nitrite and subsequently nitrate. These products should be used as a temporary measure if you have high readings, and you should work to bring down the reading by performing a water change, reducing the number of animals in your tank, increasing your biological filtration capacity and making sure the aquarium is aged properly etc.

Collecting Animals and Fish Food

A great way to save money and be connected to your local waterway is to collect your own aquarium animals and food for them. There are several very easy ways to collect live specimens and food.

- Seine Net: This is the best method to collect animals. You can order them from Memphis Net and Twine (1-800-238-6380 or www.memphisnet.net). I suggest a Delta Mesh, ¼ inch or 3/16-inch mesh, 4-foot deep, 12-foot long seine. Longer nets will give you a better chance of catching larger fish, so don't be afraid to try a 15 or 20 foot net, however longer nets are harder to handle and get snagged more often. The custom order nets from Memphis are more expensive, but they last longer and are worth the extra money. I would not get the green dip or net coat treatment. The nets will last a long time if you rinse them off once in a while and dry them before long-term storage.

- Dip Net: A long handled dip net can also be used to catch animals. Try using them around dock pilings and along the edge of the salt marsh and in flooded salt marsh vegetation. Long handled dip nets with a square shape work best. Fish and tackle stores may sell these, but you have to get a net with a fine mesh in order to catch the small grass shrimp and marsh fish that you are looking for. Your best bet is to give a student the net because young people have a nack at catching critters.

- Habitat Cages: I call anything put into the water in order to attract animals a 'habitat cage'. You can put some oyster shell into a milk crate or make a small box with plastic coated wire. Old smushed up crab pots also will do the job. The structure will attract species that are hard to catch using nets such as blennies, gobies, skilletfish, mud crabs, snapping shrimp and spider crabs. It may take several weeks for your artificial habitat to be covered with natural fouling organisms and begin to attract a

host of critters. These work especially well off a dock where you can simply haul them up and shake them over a large tupperware or bucket. The critters will fall out and you can pick out which ones you want. Be careful not to make your habitats too large and heavy. They will become much heavier as algae, mud, sea squirts etc. cover them. I also suggest wearing gloves when dealing with them because the barnacles and oysters often settle on the line and habitat cages and these can be very sharp.

All of these methods for catching aquarium animals. It will be far easier to stock the tank with small animals instead of large ones. One 5-inch fish requires 3-5 times more water than 5 one-inch fish. This is because the small animals weigh incredibly less than larger animals. It should be easier to find acceptable food for the smaller animals as well.

These methods can also be used to gather food for your aquarium animals. Gathering your own food will also save you a lot of money and be an incredible education activity. Fresh food is desirable, but I have found that fish, oysters, clams and grass shrimp can be frozen and used to feed blue crabs and predators like oyster toads during the school year. It is a whole lot easier to go to the freezer everyday to get food than go to the creek. Gather food and freeze before the water cools in the fall and the animals burrow or leave the shallows. Some other ideas about things that can be used as food are below.

- Live grass shrimp and small killifish are great food for predatory aquarium animals such as seatrout, oyster toadfish, stargazer, bluefish etc. I try to keep my tanks filled with a good number of these small baitfish so that the predators can feed when they need to. The smaller the better, because they will put less strain on the water quality and will be easier for the predators to catch.

- Ribbed mussels and oysters can be found along most marsh banks. Try taking a few of these, prying them open and putting cut up chunks into the tank. Most estuarine animals really enjoy eating this. I have found that frozen ribbed mussels loose their appeal after being frozen while oyster and clam meat does not.

- Frozen silversides, minnows and grass shrimp: Stock up on these species and freeze them one layer deep in a zip lock back so you can break off a fish or two at a time. Blue crabs and predators like the oyster toadfish should eat these and everything in the water likes to eat grass shrimp.

- Shrimp: If you are in a bind, try feeding your aquatic animals some uncooked shrimp. You don't need to peel them if you have large enough animals and don't think that your animals won't eat the heads just because humans don't. Try cutting the shrimp up into little bits for your smaller animals. You should have a feeding frenzy on your hands.

Other Food

- Frozen brine shrimp or frozen mysid shrimp (larger than brine shrimp) are a top-notch food for most estuarine aquarium species. I suggest you purchase a large block of them through the internet in order to save money. Chop or cut the block up into small sections (while the entire block is still frozen) when you get it and then you can pull out one chunk at a time from the freezer. Pet stores also sell frozen bring shrimp, but the smaller packs are more expensive. Feed by thawing the small block of brine shrimp in a cup filled with aquarium water and then dole out the shrimp by pouring or using an eyedropper.

- Live brine shrimp are a good food for many estuarine animals. Simply follow the directions on the brine shrimp egg packages and you'll be in business. It would be best if you had three fish bowls

devoted to growing brine shrimp so that you will always have individuals ready for feeding time. The nutritional value of the brine shrimp decreases as the hatched shrimp consume the yolk sac over the first 24 – 36 hours. I have read it is possible to grow brine shrimp to adult size (1/4 inch) which would be a great activity and the larger brine shrimp would make excellent food, however this is more appropriate for the intermediate or experienced aquarists as lighting, heating, aeration and some form of biological filtration are required to do this. Rice bran, or brown rice flour, can be used as food. Several tablespoons of this product, which is reported to be found at health food stores, should be wrapped in cloth and dipped several times into the brine shrimp rearing container like a tea bag. The smallest of the rice flour will get through the cloth, clouding the water slightly. This method is used to ensure that small particle sized food is available to the brine shrimp. Large sizes of the flour cannot be consumed by the small brine shrimp and will only contribute to poor water quality.

- Many estuarine animals will eat flake food and sinking pellets (shrimp pellets are best). This will make your life much easier. Keep an eye on which animals are feeding on what food and you'll soon be an expert in feeding your animals.

Transferring Animals

It is very important to catch, handle and transfer the fish with as little jostling as possible. The more roughly fish are handled and treated during the catch and relocation, the more problems they will have in the aquarium. This is one reason that fish caught in a trawl net do not do so well. They often have much of their protective slime taken off, or are injured in the trawl net. These injuries may allow infections to develop days or weeks after they were caught.

It is important to keep the water that fish are being transferred in well oxygenated. A pack of stressed out fish, crabs and shrimp can deplete the oxygen in a bucket quickly. Either keep a battery powered aerator on hand to provide oxygen to the bucket, or only move a few fish at a time. This second option may be an even better bet, because introducing a few fish at a time would decrease the risk of overstocking your tank.

Care should be taken when moving animals from the collection bucket to the aquarium if there is a large difference in temperature, such as in the wintertime. One way to equilibrate the fish to the new temperature is to place the fish in a plastic bag filled with water that it was transported in and float this bag in the aquarium so the water temperatures can equilibrate. 30 minutes should be sufficient. Another way to equilibrate temperature is to sit the collection bucket next to the aquarium and give the water time to become room temperature, which is the temperature of your aquarium. Most estuarine animals should be able to handle temperature changes of a few degrees without problem. I often directly introduce my fish if the temperatures are 5-10 degrees different between the collection bucket and the aquarium.

Aquarium Operation and Maintenance

Feeding

Feeding is one of the most important steps in successfully keeping estuarine species. Don't feed for a day or two after putting animals in the tank so they can get acclimated and get hungry. Then start experimenting with different foods to see what each species will eat. If your fish aren't feeding at first, give them more time to get over their relocation. Hunger may bring them to eat in several days. If you don't see an animal eating, there is a chance that it is feeding on scraps or predating on other animals in the tank at night. Fish that don't eat will soon be apparent as they will get skinny and become 'all head' meaning that their body shrinks while the head stays the same size. This occurs because all of the bones around the head don't allow the head to shrink much. If such fish don't feed on what you are giving them, keep trying new foods or release the fish.

One of the most important things is DO NOT OVERFEED. Fish will eat until food is coming out of their mouths and gills, but this does not mean they need that much food. Most of the energy consumed during gluttonous feeding will not be converted to body mass, and instead be excreted. A good rule of thumb is to feed them what they can eat in 2-3 minutes once a day. Fish digest food in 16 – 24 hours in 75 degree F water, so one meal a day should be adequate. You want to see the fish, crabs and shrimp quickly consume the food. Leftover food, and excess feeding will lead to water quality problems in your fish tank. It is important to decrease the intake flow into the filter when feeding so that food doesn't get sucked up into the filter where it will rot. There is a valve on top of the intake tube and directions for use should come with the filter. Turn the flow down when feeding and turn it back up to full speed when food is no longer floating around. Another method of feeding is to feed them until you start to see the animals slow down in their feeding rate, at which point you should stop. Again, fish are glutinous feeders and you should not be feeding to complete satiation.

A hungry tank is a happy tank! It is far better to underfeed than overfeed. It is actually pretty hard to starve a fish to death, while it is very easy to overfeed a tank until the water quality gets so bad that fish die. There is a documented case of an American eel living for 5 years in an aquarium without ever being fed. You should never have leftover food lying around in the tank. Most animals, including blue crabs, will not eat old and rotting food. Remove any left over food and cut down on your feeding rates.

It is very important to *watch* the aquarium during feeding to see who is eating what food and how fast the food is being consumed. You may have to find ways to get food to animals that don't seem to be getting any. One way to do this is to use several different foods such as brine shrimp and sinking pellets. Sinking pellets are good for slower mud crabs, hermit crabs and bottom dwelling fish. You can also put pieces of fish food on small skewers, pincers or in long droppers in order to get the food to fish that need it. These are sold in pet stores. Watching your tank during feeding to see who is getting what is invaluable.

The animals do not need to be fed everyday, so don't worry if you are going away for the weekend. The fish should be fine as long as everything is working properly. Fish are very good at taking a break from feeding for a few days here and there as well. I would suggest trying to feed them at least once a week if school is going to be shut down for several weeks during Christmas break etc, but they will often do just fine if you don't feed them over winter and spring break.

Vacuuming and Water Changes

Exchanging old aquarium water with new estuarine water is an integral step in maintaining a healthy aquarium. It is suggested that you change 25% of the water every two weeks. Of course the more water you change the better. Accumulated ammonia, nitrite and nitrate are removed when water is removed from the tank. Take the old water out by **'vacuuming'** the gravel using an aquarium gravel-cleaning siphon that you can purchase in any pet store. Read the instructions for proper use and overturn all the rocks and shells and turn your gravel inside out in order to vacuum correctly. Proper vacuuming will take out accumulating organic matter and detritus from the substrate in your tank and greatly enhance the well being of the aquarium. You will see clouds of dirt being stirred up and sucked into the vacuum. *Vacuuming and water changes are mandatory to maintain water quality.* An added benefit from vacuuming is that you will get a good look at your aquarium substrate and you may find dead animals that were hidden from view, or live animals that you haven't seen in months and have forgotten about. Such 'hands-on' time in your tank is invaluable in understanding how things are going.

The replacement water should be as clean as possible (remove floating debris and pre-filter if you're motivated). It should also be close to the salinity of the aquarium water and the *same temperature*

as the aquarium water. I like to fill buckets and sit them next to the aquarium for a day before performing the water change. This will allow the temperature to equilibrate and most of the dirt / particles will usually settle out in the bucket and you can avoid pouring them in the tank with care.

Algae Removal

A great time to remove algae growing on the tank is while your tank has low water during the water exchange. Use an aquarium scrubber that you keep solely for this purpose. Never use any sponge that had soap on it or other chemicals used to keep sponges bacteria free. It is much easier to remove the algae every time you clean the tank instead of leaving it until it really becomes a problem.

Algae often builds up on oyster shell and other substrate. The easiest thing to do in this case is take the shells out and dry them in the sun, rotating fresh oyster shell in. The algae on the dirty shell will die and flake away. Rinse the shells when they are looking good and they are ready to be rotated back in.

Filter Cleaning

Most hanging filters will need cleaning every 2-4 weeks. Your tank may be overstocked or overfed if your filter is getting extremely dirty before that amount of time.

- Unplug the filter and unplug all of the electrical devices from the aquarium

- Put the biological filter media cartridge from the mechanical filter in the fish tank so that the beneficial bacteria do not die. If you let the biological filter sit in stagnant water in the filter while you are cleaning other parts, the water will quickly go anoxic and the beneficial bacteria will die. If this media is very fouled, you can rinse it out in the old water that you siphoned out of the tank. You do not want to rinse the biological filter in tap water or clean it too well because that will take away or kill the bacteria that you want to be living on the cartridge.

- Clean and rinse the moving parts of the filter and the well that the impeller sits in with a test tube cleaner and fresh water. Inspect the impeller for pieces of hair, algae or other stringy matter that gets spun around the impeller rod and remove using a pair of tweezers. Rinse and dump the filter box several times in order to get rid of any sand or grit which could stop the impeller. Take care not to lose any loose parts of the filter down the drain.

- Throw out the old filter cartridge and install the new.

- Restart the filter as soon as possible and put the biological cartridge back in once flow has started.

Miscellaneous Cleaning

After you have vacuumed out the gravel and removed the amount of water for the exchange, cleaned the algae, cleaned the filter and put it back together and refilled the aquarium, it's a good time to use a small wet towel to wipe off accumulated salts, dust and food on the tank hood etc. Separate the light fixture from the hood and give the hood a good cleaning in a sink or bathtub. Then clean the light with a wet towel.

The outside glass of the aquarium can be cleaned with some glass cleaner wiped off with crumpled up newspaper (nothing works better than old newspaper to clean glass). Take extreme care to not get any glass cleaner in the aquarium as this is toxic, so only use a little.

Operating Tips

- Place the aquarium where it will not receive direct sunlight or very bright natural light. Minimize the amount of time the aquarium light is on and turn the lights out at night and when you are gone. This will help stop algae from growing in your tank. This is very important.
- A hungry tank is a happy tank. Do not overfeed.
- Get several 5-gallon watertight screw top buckets to move water and animals. I got mine at Duluth Trading Company. www.duluthtrading.com, 800-505-8888. They run about $15 for the bucket, the top and shipping.
- You have to be *involved* with your tank to be successful. Watch who is eating what food and if food is falling into spots that animals won't be able to eat it. Don't be afraid to really stir up the gravel when cleaning and take all the habitat or decorations out because you may find dead animals, animals that you haven't seen in months, leftover food or decomposing matter that needs to be siphoned out when you are doing this important hands-on maintenance.
- Animals that shed (crabs and grass shrimp) will usually get eaten when they shed. That is why it is hard to keep small crabs and shrimp. The smaller animals shed so often that they rarely last long, but they are great in the tank while they last. I have kept a large mature blue crab (sook) in a tank for 6 months and she did great. Larger crabs and shrimp shed very rarely and sooks do not shed again (99.9% of the time), so they should do well.
- Small fish are easier on the aquarium filtration system and oxygen supply than big fish. Big organisms need to eat a lot, they excrete a lot and they use a lot of oxygen. Larger fish and crabs weigh much more than smaller ones, and the added biomass simply means more cells to feed and more excretion. A tank that can hold fifteen one-inch long fish may not be large enough to hold even one fifteen-inch fish.

Safety Tips

- Always have a 'drip loop' for every electrical wire and hose or airline tube running from the aquarium. The directions for the use of any aquarium electrical device will have a diagram of a drip loop. Any airline tubing or electrical wire leading from the tank must drop below the level of the electrical outlet and any machinery including air pumps. Any water dripping down the lines will not get to the outlet or the electrical device itself because the water will run down the line and not rise up as the drip loop rises. Failure to maintain drip loops leading to all sockets and electrical aquarium devices could cause a short or electric shock if a drip should occur.
- Make sure the electrical outlets that you are using are GFI (ground fault interrupted). This should serve to cut off the electric should a dangerous electric shock scenario come to play. This is not to say you can't get shocked. Therefore always unplug EVERY electrical device when you are working with the aquarium, dry the area of any water before you plug them back in, read the product labels and use extreme care. Water and electricity is a deadly combination.
- Make sure your stand is strong and the tank is not tipsy. Students have the tendency to 'touch' the glass and it would be bad to have a tank accidentally tip over.
- Do not submerge the light or any of the light fixture during cleaning. This holds true for any of the electrical parts during cleaning and operation.

Trouble Shooting:

All aquaria of the kind we are talking about here should be fully changed over every 6 – 9 months as nutrients invariably accumulate leading to a host of water quality problems. I suggest fully breaking down your estuarine aquaria and starting fresh every semester.

Murky Water: This is a bad sign that often is associated with tank odor. Stop feeding. Change filter, esp. the activated charcoal. Perform an aggressive substrate vacuum and water change. Murky water is

an indication that you are overfeeding, have too many fish in the aquarium, or there are dead animals or organic matter decomposing. All of these need to be addressed.

Odor: Aquarium water should have very little smell and what smell they have should not be at all bad. If your tank has an odor, follow the steps for murky water.

Green Water: The green color comes from phytoplankton, or microscopic free-floating algae, growing in the water. This is likely due to nitrate accumulating in your tank over time. Phytoplankton use these nitrogenous compounds to grow and you can have an 'algae bloom' in your tank under certain conditions. This can be a hard problem to fix. Perform aggressive water changes and clean the filter. Proper water changes several days in a row should dilute the nitrates (phytoplankton food) and decrease your algae bloom. Make sure to turn the fish tank light off at night and try keeping the light off for several days to try to starve the microscopic algae of light. This problem can be hard to fix and may warrant a full tank breakdown and start-over.

Dead Fish: Lots of dead fish mean something bad happened, most likely a build-up of toxic ammonia, temperature shock (mostly from high temperatures or fast temperature changes when introducing fish) or lack of oxygen. Any or all of these causes of dead fish mean you have to work on your 'wet thumb' and go about things differently. If only 1 or 2 fish are dead, it could be due to other reasons, such as starvation, succumbing to infection from rough handling during transfer etc. Take note of which species dies, how many of that species died and what their track record has been in the tank. You may not have lost your fish to water quality problems per se, but you might not have the right environment for that species.

A power outage that lasts for several hours or more will cause death in almost any tank because odds are that the system is stocked to a degree that requires aeration and filtration to maintain water quality. Should a power outage wreak havoc in your tank, don't give up. It was out of your control but you may want to restock your tank with fewer animals in the future.

Crud on your gravel or decorations: A fouling layer of algae and blue green diatoms will grow on most surfaces in your tank over time. Stir up the gravel and 'vacuum' the substrate to remove as much as possible. Also take out the 'fouled' decorations and allow them to dry for several days. The algae and other fouling organisms should dry up and die and your tank decorations or habitat will be ready to put back in with a rinse off. You can also try scrubbing such fouling material off. A thick carpet of algae is an indication that you have a nutrient problem from overfeeding or overstocking and your lights are on too long.

Foul Filter: If your filter cartridges get very dirty very quickly, or very black, it is an indication that your tank is overstocked or you are feeding too heavily. Perform a thorough filter and tank cleaning and change your ways. Decrease the number of animals and/or the amount of feeding.

Inexplicable murky water / algae growth: I have ran across tanks that have been running for 5 or 6 months that I just could not get clean for any duration. My assessment was that waste products had built up in the undergravel filter where I could not get to them with the aquarium 'vacuum' siphon. While these tanks may be brought back to equilibrium with frequent and aggressive cleaning, sometimes it is easier to disassemble the tank, clean and rinse everything and being again with new estuarine water. This can help fix past mistakes in overfeeding or overstocking and give you a clean new start.

Appendix 1: Aquarium Tank Cleaning Order of Operation

Clean every 2-4 weeks depending on your tank conditions.

Bring in new estuarine water (25% of volume of tank) to replace old water a day in advance. Let the temperature of the new water equilibrate to that of the aquarium. * While you may be able to go every 3 or 4 weeks with other steps, do this every 2 weeks.

Unplug everything, take hood off and separate light fixture from hood and move to a save dry spot.

Mechanical hanging filter. First place the biological filter media in the tank or in the replacement water bucket. Clean and rinse the mechanical filter, install new cartridge in and have filter ready to go.

Vacuum the sediment to get old detritus out using your siphon, removing as much water as you have on hand to replace. Remove any floating particles, chunks of dead fish or leftover food with the aquarium dip net. Dispose of this water.

Use aquarium scrubber to remove algae from tank walls.

Mix up the substrate and change out any fouled habitat or structures as necessary.

Add new water, trying not to dump it all in at once in one big glut.

Dry all water from the floors, walls, around the tank etc. Make sure there is no water on electrical devices or plugs. Make sure you have drip loops in all power cords and that no electrical devices will fall into the aquarium.

Start mechanical hanging filter, aerator and undergravel filter

Wipe down outside of tank and clean the hood

Put hood on, dry the sides of the tank with a towel or napkin and clean glass with a bit of glass cleaner and newspaper

Keep light off to let animals recover from the traumatic cleaning event.

Don't feed for a day to let the fish get back to normal.

Change out undergravel aerators occasionally to continue good airflow.

Feeding

Feed once a day, what they can eat in 2-3 minutes. You do not want unused food in the tank after feeding. Fish should appear still hungry at the end of feeding.

Remember, a hungry tank is a happy tank!

Appendix 2. Species List and notes

Species	Care	Notes
American Eel	Easy	Escape artists
Banded Killifish	Easy	Marsh species
Blennies	Easy	Oyster reef species, can become aggressive in tank
Blue Crab	Easy	Eat other animals. Cannibals. Need lots of food
Gobies	Easy	Oyster reef species, very easy to keep
Grass Shrimp	Easy	Get eaten as they shed, but great in a tank while they last
Hermit Crabs	Easy	Need higher salinity water
Hogchoker	Easy	They live but I have never seen one eat
Marsh Killifish	Easy	Marsh species, very hardy and adaptable
Mud Crabs	Easy	Very hardy
Mummichog	Easy	Marsh species, very hardy and adaptable
Oyster Toadfish	Easy	Will eat frozen fish and shrimp.
Rainwater Killifish	Easy	Marsh species, very hardy and adaptable
Sheepshead Minnow	Easy	Marsh species, very hardy and adaptable
Skilletfish	Easy	Oyster reef species, very easy to keep
Spotfin Killifish	Easy	Marsh species
Striped Killifish	Easy	Marsh species, very hardy and adaptable
Summer Flounder	Easy	Will eat frozen brine shrimp
Tonguefish	Easy	Live for a long time in tanks but I have never seen eat
White Perch	Easy	Fresher Water, Live food
Yellow Perch	Easy	Fresher Water, Live food
Crappie	Easy	Fresh Water, Live food
Black Drum	Moderate	May not enjoy warmer water
Black Seabass	Moderate	Cooler water species and eats live food
Croaker	Moderate	Bottom feeders
Kingfish	Moderate	I don't think they enjoy water above 65 F or so.
Lizardfish	Moderate	Piscivore
Mojarra	Moderate	Found in saltier water
Silver Perch	Moderate	
Silverside	Moderate	Need some space, but will eat flake food.
Spadefish	Moderate	
Spotted Seatrout	Moderate	Need live minnows or shrimp in my experience
Stickleback	Moderate	
Striped Bass	Moderate	
Weakfish	Moderate	Predatory fish, may prefer live food.
Bluefish	Hard	Fast swimmers that need lots of space, piscivores
Hake	Hard	I have had bad luck with these. Need cooler water.
Herring species.	Hard	Filter feeding swimmers
Menhaden	Hard	Filter feeding swimmers
Needlefish	Hard	Need large space and likely live food.
Permit	Hard	Fast swimmer
Pigfish	Hard	Need space and good food
Pinfish	Hard	Need space and good food
Pipefish	Hard	Need live brine shrimp
Pompano	Hard	Fast swimmer
Puffer	Hard	Hardy animals but you have to find food that works

Seahorse	Hard	Will liver for a long time, but need live brine shrimp for food
Searobin	Hard	Live well in tanks, but need right food and cooler water
Stargazer	Hard	Need large tanks and live minnows or shrimp
Catfish	?	I never kept, should be easy to keep
Cobia	?	I never kept, my guess is moderately hard to keep
Gizzard shad	?	Constant swimmers, should be difficult
Halfbeak	?	I have never tried. Guess food and space are problems.
Larger Shrimp	?	Should be fairly easy.
Lookdown	?	Never kept, would guess hard due to food, temp and space
Red Drum	?	Never tried - try with small animals
Scup	?	Never tried, cooler water species
Tautog	?	Bottom fish, likely need cooler water.
Threadfin Herring	?	Filter feeding swimmers
White Mullet	?	Never tried to keep this active fish.

* note – Smaller specimens do much better in most aquarium situations (0.5 – 2 inches). You should have much better luck using the smallest animals that you can find, plus you will be able to place a larger total number of animals in your aquariums. An exception may be with seahorse and pipefish, where larger animals may be able to eat either mysid or brine shrimp.