LITERATURE CITED AND FURTHER READING

GENERAL


HATCHERY CULTURE


Hartman, M. 1989. Manual for the design and operation of a low budget hatchery for the hard clam Mercenaria mercenaria in Florida. Aquaculture Report Series, Florida Dept of Agriculture and Consumer Services, Division of Marketing. (to get a copy write Aquaculture Program, Room 425, Mayo Building, Tallahassee FL 32399-0800 or call (904) 488-4033 -free or nominal cost)


NURSERY CULTURE


FIELD CULTURE


**GENETICS/BREEDING**


**ALGAL CULTURE AND DIETS**


ECONOMICS

GLOSSARY

**Airlift:**
A device for aerating and circulating water. Usually consists of a vertical cylinder submerged in water into which air is pumped.

**Aliquot:**
A measured quantity; a subsample of known quantity.

**Autoclave:**
A machine which uses steam and high pressure to sterilize.

**Axenic:**
Bacteria-free.

**Batch culture:**
A culture method in which water is not continuously exchanged. In batch culture of larvae, the larvae are grown in standing (not circulating) water which is completely changed on a regular schedule. In batch culture of algae, algae is allowed to bloom and then is completely harvested.

**Broodstock:**
Adult animals retained for reproduction.

**Calibrated:**
Marked in known units of measurement.

**Calipers:**
Precision hand-held measuring tool, useful for measurements of items ranging from 1 mm to 100 mm.

**Ciliates:**
Microscopic, unicellular animals which swim by means of cilia. These may contaminate algal cultures or larval cultures.

**Compound microscope:**
Same as light microscope. A microscope which provides relatively high magnification (usually 40 to 1000 times the actual size). The magnification provided is the product of the magnification provided by the ocular lens and the magnification provided by the objective lens. Used to examine microalgae, gametes and early larvae.

**Coulter® counter:**
A precision instrument which counts particles suspended in liquid. A Coulter® counter can be used for quantifying gametes, microalgae, and larvae.

**Dissecting microscope:**
A microscope used for examining relatively large objects. It can be used for surface examination of adult clams, for examination of late larvae, post-set and seed clams. Magnification is usually in the range of 4 to 40 times actual size.

**Downweller:**
A culture container in which a flow of water is directed down through a layer of clams supported on a mesh screen. Used for pediveligers and early post-set.
**Downwelling unit:**
See downweller.

**Fecundity:**
Reproductive capacity; ability to reproduce.

**Fluorometer:**
An instrument which measures fluorescence. Since chlorophyll and other photosynthetic pigments fluoresce (release energy as light) when stimulated by light, a fluorometer can be used to quantify microalgae.

**Gamete:**
Reproductive cell; egg or sperm.

**Gonad:**
Portion of body containing reproductive cells.

**Hemacytometer:**
A special microscope slide, designed to count blood cells, which is used for counting phytoplankton.

**Heritable:**
Determined by genetic factors, as opposed to environmental ones. Able to be passed on to offspring.

**Intertidal:**
Above the average low tide level. Exposed at low tide.

**Kalwall®:**
A cylindrical container made of clear fiberglass used for algal culture.

**Lugol’s solution:**
An iodine solution which is used for preserving algae. Lugol’s solution is made by mixing 6 g of potassium iodide and 4 g of iodine in 10 ml of seawater.

**Metamorphosis:**
Change from one morphological state to another. Hard clams metamorphose from trophophore to veliger and again from veliger to adult form. Metamorphosis is stressful and high mortalities may occur at these times.

**Micrometer:**
A calibrated device for measuring objects under magnification. An ocular micrometer can be inserted in the eyepiece of a microscope. It is calibrated with a stage micrometer (a special microscope slide).

**Milford method:**
A system for mono-specific algal culture. See description in chapter on algal culture.

**Muriatic acid:**
Dilute hydrochloric acid (HCl) used for cleaning glassware and other non-corroding materials.

**Notata:**
Having distinctive shell markings, often reddish. These may be in the form of bands or chevron-shaped marks.

**Objective lens:**
The lens nearest the sample on a compound microscope. Most compound scopes are equipped with several inter-
changeable objectives, allowing a range of magnification. The magnification is the product of the ocular lens magnification and the objective lens magnification.

**Ocular lens:**
The lens nearest the eye on a compound microscope. Total magnification on a compound microscope is the product of the ocular magnification (usually 10X or 15X) and the objective magnification.

**Pathogenic:**
Disease causing.

**Pediveliger:**
A late larval stage, intermediate between a swimming veliger and a non-swimming post-set. A pediveliger has both a foot and a velum.

**pH:**
A measure of the number of free hydrogen ions in a liquid. pH is measured on a scale of 0 to 14. 7 is neutral, <7 is acidic, >7 is basic or alkaline. Seawater usually has a pH of 7–8. Algal cultures become alkaline (pH increases) as the algae multiplies. Carbon dioxide is added to decrease the pH. pH can be measured with special paper strips which change color in response to pH, or with a variety of meters.

**Phytoplankton:**
Microscopic aquatic plants which are the primary food source for hard clams.

**Pig:**
A special device for cleaning the inside of pipes, such as in a flow-through nursery system.

**Polyspermy:**
A situation which results when more than one sperm penetrates a single egg, resulting in abnormal development.

**Post-set:**
Clams which have metamorphosed to the adult form but are still retained in hatchery culture, usually 1 mm or less in length.

**Pseudo-feces:**
Material which a clam has filtered from the water but not ingested. Copious pseudo-feces production indicates that the concentration of microalgae or other suspended particles is very high. The clams are filtering more particles than they can eat.

**PVC:**
Polyvinyl chloride. A common plastic used to fabricate piping. Commonly used in aquaculture for plumbing because it is non-corrosive and non-toxic.

**Ripe:**
Having mature gametes; ready to spawn.

**Salinity:**
Concentration of dissolved salts in seawater. Usually measured in parts per thousand (ppt), the grams of salt contained in a kilogram of water. Full-strength seawater is 35–36 ppt. Salinity can be measured by refractive index (refractometer), specific gravity (hydrometer) or conductivity.

**Secchi disk:**
A device for measuring turbidity. A white disk is submerged in liquid until the disk disappears from view. The depth at which
the disk disappears can be related to the quantity of suspended particles in the liquid (turbidity). A small Secchi disk can be calibrated for use in determining microalgae densities.

**Sedgewick-Rafter cell:**
A special microscope slide used for counting larvae.

**Seed:**
Any sub-market size (<45 mm) clams.

**Silo:**
Cylindrical culture container used as a downweller or upweller for culture of post-set and juvenile bivalves.

**Sodium thiosulfate:**
Na₂S₂O₃. A compound used to neutralize chlorine.

**Spawning:**
Release of mature gametes (eggs/sperm). Clams release gametes into the water column where fertilization occurs.

**Spectrophotometer:**
An instrument which measures how much light of a given wavelength passes through a liquid.

**Subtidal:**
Below the average low-tide level.

**Trochophore:**
Early non-feeding bivalve larval stage with no shell, resembles a child’s top.

**Upweller:**
A culture container in which continuous water flow is directed up through a layer of clams supported on a mesh screen. Used for late post-set and juveniles.

**Upwelling unit:**
See upweller.

**Veliger:**
Free-swimming larva which uses a “velum” for locomotion and feeding. Veligers have a shell, initially “D” shaped, later rounding out to a shape similar to adult clams.

**Wells-Glancy method:**
A system of algal culture depending on natural phytoplankton populations. Also known as “brown-water” culture.

**Wildstock:**
Animals procured from the wild, as opposed to those which have been produced in a hatchery.

**Zooplankton:**
Very small aquatic animals. Clam larvae are zooplankton. Other zooplankton may contaminate algal and larval cultures.

**Zygote:**
Fertilized egg.
APPENDIX A. AGENCY/TECHNICAL ASSISTANCE CONTACTS

REGULATORY AGENCIES

S.C. Department of Health and Environmental Control

Critical zone activity permits
Office of Ocean and Coastal Resources Management
Ashley Corporate Center
4280 Executive Place, Suite 300
Charleston, SC 29405
(803) 744-5838

Discharge permits
Div.of Industrial and Agricultural Wastewater
2600 Bull St.
Columbia, SC 29201
(803) 734-5300

Water quality and shellfish safety
Bureau of Environmental Sanitation (Columbia)
(803) 734-5071
Div. of Water Quality and Shellfish Sanitation (Columbia)
(803) 734-5232
Environmental Quality Control (Charleston)
(803) 740-1590

Water use
Water Resources Division
1500 Hwy. 17 N, Suite 212
Surfside Beach, SC 29577
(803) 238-4406
or
144 Ribault Square
Beaufort, SC 29902
(803) 524-1995

S.C. Department of Natural Resources
Marine Resources Division
PO Box 12559
Charleston, SC 29422-2559
(803) 762-5000

Warning signs
Boating Safety Division:
(803) 762-5041; 795-6800

Harvest, land and sell, wholesale dealers license
Commercial License Office:
(803) 762-5078; 762-5004; 762-5053

Law enforcement
Charleston: (803) 795-7951
Port Royal: (803) 524-9190
Georgetown: (803) 546-8523.
No answer: 1 (800) 922-5431
Aquaculture regulations; importation regulations
Office of Fisheries Management:
(803) 762-5010

Aquaculture permit
Shellfish Management Program:
(803) 762-5049; 762-5089

U.S. Army Corps of Engineers
Federal permits (Section 10 and Section 404)
District Engineer
PO Box 919
Federal Building
Charleston, SC 29402
(803) 724-4330

U.S. Coast Guard
Navigation hazards; Marking of structures in navigable waters
Marine and Safety Office
196 Tradd St.
Charleston, SC 29401
(803) 724-4393

PERMITTING ASSISTANCE/INFORMATION

S.C. Department of Natural Resources
Office of Fisheries Management
Shellfish Management Program
PO Box 12559
Charleston, SC 29422-2559
(803) 762-5000; 762-5010; 762-5029; 762-5049; 762-5089

S.C. Department of Agriculture
Permit Assistance Office
PO Box 11280
Columbia, SC 29211
(803) 734-2210

S.C. Sea Grant Consortium
287 Meeting St.
Charleston, SC 29401
(803) 727-2078
TECHNICAL ASSISTANCE

S.C. Department of Agriculture
Marketing Section
PO Box 11280
Columbia, SC 29211
(803) 734-2151
Marketing assistance

S.C. Department of Natural Resources
Marine Resources Division
Marine Resources Center
PO Box 12559
Charleston, SC 29412
(803) 762-5000 - Switchboard
Business/economic information:
(803) 762-5040
Culture assistance: (803) 762-5022;
(803) 762-5071
Marketing assistance: (803) 762-5017
Site selection, regulations:
(803) 762-5049; 762-5089; 762-5010

Waddell Mariculture Research and
Development Center
PO Box 809
Sawmill Creek Road
Bluffton, SC 29910
(803) 837-3795
Culture assistance

S.C. Sea Grant Extension Program
Aquaculture Specialist
PO Drawer 1100
Georgetown, SC 29440
(803) 546-4481
Culture/site selection assistance
APPENDIX B. SEED SUPPLIERS

Aquaculture Research Corporation
PO Box 2028
Dennis, MA 02638
(800) 334-1380

Aquarius Inc.
2050 South Dixie Highway
Palm Bay, FL 32905
(407) 725-1829

Atlantic Little Neck Clam Farms, Inc.
PO Box 12139
James Island, SC 29422-2139
(803) 762-0022

Bagwell Enterprises
PO Box 508
Eastville, VA 23347
(804) 678-5806

Bayfarm
586 Dock Rd.
West Creek, NJ 08092
(609) 294-0235

Biosphere, Inc.
1199 South Green St.
Tuckerton, NJ 08087
(609) 296-0945

Blueprints Co., Inc.
PO Box 8
West Sayville
Long Island, NY 11796
(516) 589-0123

Chincoteague Island Oyster Farms
101 Maddox Blvd.
Chincoteague, VA 23336

The Clam Farm, Inc.
Box 402
Fishers Island, NY 06390
(516) 788-7889

Cultured Aquatics
Northport Envir. Res. Ctr.
Eatons Neck Rd.
Northport, NY 11768-1298
(516) 757-8182

Flomax
H.C. Route, Box 207
Westover, MD 21871
(301) 651-9336

Half Shell Farms, Inc.
1260 Plum Avenue
Merritt Island, FL 32952
(407) 453-8906

Harbor Branch Institute
5600 Old Dixie Hwy.
Ft. Pierce, FL 34946
(407) 465-2400 Ext. 400

Joe Huber
Hwy 70 East
PO Box 96
Atlantic, NC 28511
(919) 225-2071
**Intertidal Marine**  
20 Whitehouse Drive  
Poquosin, VA 23662  
(804) 868-6058

**Bob Baldwin**  
Lowcountry Seafood  
PO Box 262  
McClellanville, SC 29548  
(803) 887-3389

**Mercenaria Manufacturing**  
R.D. 1, Box 293 B  
Millsboro, DE 19966  
(302) 945-8755

**Mook Sea Farms**  
HC 64, Box 041  
Damariscotta, ME 04543  
(207) 563-1456

**Nelson Bay Aquafarms**  
Star Rt. Box 22  
Sea Level, NC 28577  
(919) 225-0151

**The Oyster Bed**  
12535 North A1A  
Vero Beach, FL 32963  
(407) 589-6138

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**Oysterrific!!!**  
PO Box 156  
Cape May Court House, NJ 08210  
(609) 465-4878

**Pleasant Bay Shellfish**  
61 Eldredge Parkway  
Orleans, MA 02653  
(617) 255-5750

**Sea-Ag, Inc.**  
2030 SE Old Dixie Hwy. #2  
Vero Beach, FL 32962  
(407) 468-3216

**Sea Breeding Farm, Inc.**  
88 Knox St., A-2  
West Haven, CT 06516

**Sembler & Sembler**  
Sebastian, FL  
(407) 724-0272

**Sloop Point Seafood Co.**  
207 Pelican Walk  
Hampstead, NC 28443  
(919) 270-2438
APPENDIX C. VENDORS AND PRODUCT DIRECTORY

VENDOR DIRECTORY

Many of the supplies you will need are available at local hardware or building supply stores. The following vendors may be useful for obtaining more specialized supplies and equipment. This is undoubtedly not an all-inclusive list of sources. Inclusion does not imply endorsement; omissions are unintentional.

Aquacenter, Inc.
PO Box 4877, Greenville, MS 38704.
(800) 748-8921
Wide variety of aquaculture supplies and equipment.

Aquaculture Supply
5532 Old Saint Joe Road, Dade City, FL 33525. (904) 567-8540
Wide assortment of aquaculture supplies and equipment; algal cultures.

Aquafine Corp.
25230 West Avenue Stanford, Valencia, CA 91355. (800) 423-3015
Ultraviolet sterilizers.

Aquanetics Systems, Inc.
5252 Lovelock, San Diego, CA 92110.
(619) 291-8335
Variety of aquaculture equipment; seawater chillers, heat exchangers; sterilizers; pumps; air blowers; PVC valves and fittings.

Aquatic Ecosystems, Inc.
2056 Apopka Blvd., Apopka, FL 32703.
(407) 866-3939
General aquaculture supplies, air pumps, air blowers.

Aquionics Inc.
Erlanger KY. (606) 341-0710
Ultraviolet Sterilizers

Acry-tec, Inc.
7868 Silverton Ave., Suite J, San Diego, CA 92126. (619) 271-0045
Fiberglass tanks; chillers; heat exchangers.

Adams Mfg. Co.
PO Box 339, Hardeeville, SC 29927.
(803) 784-6756
Custom fiberglass tanks.

ADPI Enterprises, Inc.
3621 B Street, Philadelphia, PA 19134.
(800) 621-0275
Plastic mesh, plastic netting, grow-out bags.

AMETEK-Haveg Div.
523 Fieldstream Way, Lawrenceville, GA 30244. (404) 822-9707
Heat exchangers, chillers.
**AREA Inc.**  
PO Box 1303, Homestead, FL 33090.  
(305) 248-4205  
General aquaculture supplies, submersible heaters, aeration equipment.

**Argent Chemical Laboratories**  
8702 152nd Ave. NE, Redmond, WA 98052. (800) 426-6258  
General aquaculture supplies, chemicals.

**Baxter Scientific Products**  
8350 Arrowridge Clvd., Charlotte, NC 28273. (800) 395-8900  
General scientific and laboratory supplies; submersible pumps.

**Bigelow Lab for Ocean Science**  
McKown Point, West Boothbay Harbor, ME 04575. (207) 633-2173  
Algal cultures.

**Biomarine Aquafauna**  
PO Box 5, Hawthorne, CA 90250.  
(213) 973-5275  
General aquaculture supplies.

**Boatcycle Hmg. and Chemical Co.**  
Box 494, Henderson, TX 75654.  
(800) 333-9154  
General aquaculture & fishing supplies.

**Carolina Biological Supply Co.**  
2700 York Rd., Burlington, NC 27215-3398. (800) 334-5551  
Algal cultures.

**Champlin Net Co., Inc.**  
PO Box 788, Jonesville, LA 71343.  
(318) 339-9623  
General fishing/boating supplies.

**Cole Parmer Instrument Co.**  
7425 N. Oak Park Ave., Chicago, IL 60648. (800) 323-4340  
General scientific and laboratory supplies; peristaltic pumps; metering pumps; air filters.

**Coulter Scientific Instruments.**  
PO Box 2145, Hialeah, FL 33012-0145.  
(800) 526-6932  
Coulter counters.

**C Squared Corporation**  
7900 N. University Dr., Tamarac. FL 33321. (800) 448-3929  
Coulter counters.

**Dolphin Boats & Fiberglass**  
24601Packing House Rd., Princeton, FL 33032. (305) 257-2628  
Fiberglass tanks.

**Engineering Sales Associates, Inc.**  
PO Box 35514, Charlotte, NC 28235.  
(704) 523-8535  
filter bags and filter cartridges

**Fisher Scientific**  
2775 Pacific Dr., PO 4829, Norcross, GA 30091. (800) 282-0578  
General scientific and laboratory supplies.

**Florida Aquafarms**  
See Aquaculture Supply.
Gardeners Supply
128 Intervale Rd., Burlington, VT 05401.
(802) 863-1700
Fluorescent plant-growing lights.

Gilson Co.
PO Box 677, Worthington, OH 43085-0677. (800) 431-5935
Sieves, screening materials.

W.W. Grainger, Inc.
7401 Pepperdam Ave., North Charleston, SC 29418. (803) 552-0633
General industrial supplies; pumps; metal halide lamps; fluorescent bulbs.

Hach Co.
PO Box 389, Loveland, CO 80539.
(800) 227-4224
Water quality test kits.

ICN Biomedicals, Inc.
PO Box 19536, Irvine, CA 92713-9921.
(800) 854-0530.
Chemicals.

Internet, Inc.
2730 Nevada Ave. North, Minneapolis, MN 55427. (800) 328-8456
Plastic netting and mesh.

Jelliff Corp.
354 Pequot Ave., Southport, CT 06490.
(203) 259-1615
Nylon and polyester mesh.

La Motte Co.
PO Box 329, Chestertown, MD 21620.
(800) 344-3100
Water quality test kits.

Memphis Net and Twine Co.
PO Box 8331, Memphis, TN 38108.
(800) 238-6380
General fishing/boating supplies.

Nalle Plastics, Inc.
203 Colorado, Austin, TX 78701.
(800) 531-5112
Plastic mesh and netting.

National Netting Inc.
PO Box 2562, Norcross, GA 30091.
(800) 233-7896
Plastic netting, cages.

Nylon Net Co.
615 E. Bodley Ave., PO Box 592,
Memphis, TN 38101. (901) 774-1500
General fishing/boating supplies.

Package Supply and Equipment Co.
PO Box 19021, Greenville, SC 29602.
(803) 277-0900
Buckets, bottles.

Packaging Products Corp.
198 Melville Blvd., Box 6002, New Bedford, MA 02742. (800) 225-0484
Shipping containers.

Plastic Piping Systems
(PPS) 3603-07 Tryclan Dr., Charlotte, NC 28217. (800) 438-3535
PVC pipe and fittings.

PPS
See Plastic Piping Systems
PVC Supply House
120 Fortenberry Rd., Merritt Island, FL 32952. (407) 452-1540
PVC pipe and fittings.

Rainbow Plastics, Filter Div.
PO Box 4127, El Monte, CA 91734.
(818) 443-6114
Filters, UV sterilizers.

Red Ewald, Inc.
PO Box 519, Karnes City, TX 78118.
(800) 531-3606
Fiberglass tanks.

Riverdale Mills Corp.
130 Riverdale St., PO Box 200,
Northbridge, MA 01534. (800) 762-6374
Vinyl coated wire for field cages; hog-nose rings.

Rowland Fiberglass Inc.
PO Box 971, Ingleside, TX 78362.
(512) 776-7753
Fiberglass tanks.

C.E. Shepherd Co., Inc.
7206 Dallas, PO Box 9445, Houston, TX 77011. (713) 928-3763
Vinyl coated wire; hog nose rings.

Sigma Chemical Co.
PO Box 14508, St. Louis, MO 63178-9916.
(800) 325-3010.
Chemicals.

Solar Components Corp.
88 Pine St., Manchester, NH 03103.
(603) 668-8186
Kalwalls®.

Southeastern Industrial Plastics (SIP)
2740 S. Cobb Industrial Blvd., Smyrna,
GA 30082. (800) 325-0121
PVC pipe and fittings.

Southern Industrial Sales,
Pureflow Division
4958 Hammermill Rd., Tucker, Ga 30084.
(409) 939-7715
Ultraviolet sterilizers.

Techpak, Inc.
2 Fifth St., Peabody, MA 01960.
(800) 225-5019
Styrofoam shipping containers.

Tenax
8291 Patuxent Range Road, Jessup, MD 20794. (800) 356-8495
Plastic netting; plastic mesh.

Tetko Inc.
420 Saw Mill River Road, Elmsford, NY 10523. (914) 941-7767
Nylon and polyester mesh.

Universal Marine Industries (UMI).
1815 Williams St., San Leandro, CA 94577-2389. (415) 352-9856
Seawater heat exchangers and chillers.

SIP
See Southeastern Industrial Plastics
US Plastic Corp.
1390 Neubrecht Rd., Lima, OH 45801.
(800) 537-9724
Wide variety of plastic supplies; pans; tubing; PVC; pumps.

V-J Growers Supply
Charlotte, NC (800) 222-4504;
Apopka, FL (800) 327-5422
Plastic netting, nylon and polyester mesh.

Water Treatment Technology
5332 Selton Ave., Jacksonville, FL 32211.
(904) 744-9393
Water purification systems.

West Coast Aquatics
906 Calle Collado, Thousand Oaks, CA 91360. (805) 499-7866
Seawater chillers.

W.P. Law, Inc.
PO Box 448, Johns Island, SC 29457.
(803) 559-3945
PVC pipe and fittings; pumps.

PRODUCT DIRECTORY

Algal cultures:
See Appendix D.

Algal nutrients (premixed):
Aquacenter; Aquaculture Supply; Argent.

Algal nutrients (chemicals to mix your own):
Argent; Baxter; Fisher; ICN; Sigma.

Airline:
Aquaculture Supply; Aquatic Ecosystems.

Airstones:
Aquaculture Supply; Aquatic Ecosystems; Area; Argent; Boatcycle; Biomarine Aquafaun.

Air pumps/blowers:
Aquacenter; Aquanetics; Aquatic Ecosystems; AREA; Boatcycle.

Air filters:
Baxter; Cole Parmer; Fisher.

Boots:
Argent; Boatcycle; Champlin; Grainger; Memphis Net; Nylon Net.

Buckets:
Package Supply & Equipment.

Calipers:
Aquaculture Supply; Aquatic Ecosystems;
Baxter; Fisher.

Carboys:
Aquaculture Supply; Baxter; Cole Parmer;
Fisher; Package Supply.

Chemicals:
Argent; Baxter; Fisher; Hach; ICN;
LaMotte; Sigma.

Chillers (seawater):
Acry-tec; AMETEK-Haveg Div.;
Aquanetics; UMI; West Coast Aquatics.

Chlorine test kits, test papers:
Aquaculture Supply; Argent; Hach;
LaMotte.
Clothing, foul weather:
Boatcycle; Champlin Net; Memphis Net;
Nylon Net.

Coulter counter:
Coulter Scientific; C Squared Corp.

Crimps (=hog-nose rings):
Riverdale Mills; C.E. Shepherd.

Filter bags:
Aquaculture Supply; Aquatic Ecosystems;
Engineering Sales Associates; Grainger;
Tetko.

Filter cartridges:
Aquaculture Supply; Aquatic Ecosystems;
AREA; Engineering Sales; Rainbow
Plastics.

Fittings (plastic):
Aquacenter; Aquaculture Supply;
Aquanetics; Aquatic Ecosystems; AREA;
Cole Parmer; US Plastics.

Fittings (PVC):
Aquacenter; Aquaculture Supply;
Aquanetics; Aquatic Ecosystems; AREA;
PPS; PVC Supply; SIP; US Plastics; WP
Law.

Fittings (tubing/specialty):
Aquacenter; Aquaculture Supply; Aquatic
Ecosystems; AREA; Cole Parmer; US
Plastics.

Flasks:
Aquacenter; Aquaculture Supply; Baxter;
Cole Parmer; Fisher.

Fluorometer:
Baxter; Fisher.

Foul weather clothing:
Argent; Champlin; Boatcycle; Memphis
Net; Nylon Net.

General aquaculture supplies:
Aquacenter; Aquaculture Supply; Aquatic
Ecosystems; AREA; Argent; Biomarine
Aqua fauna; Boatcycle.

Glassware:
Baxter; Fisher; Package Supply & Equip-
ment.

Gloves (heavy duty):
Champlin; Boatcycle; Memphis Net;
Nylon net.

Heaters (submersible):
Aquacenter; Aquanetics; AREA.

Hemocytometers:
Aquaculture Supply; Baxter; Fisher.

Hog-nose rings (for fastening wire and
mesh on field cages):
Riverdale Mills; C.E. Shepherd.

Hose, hose fittings:
Aquacenter; Aquaculture Supply;
Aquanetics; Aquatic Ecosystems; Cole
Parmer; US Plastics.

Kalwalls*:
Solar Components.

Lab supplies:
Aquacenter; Aquaculture Supply; Aquatic
Ecosystems; Baxter; Cole Parmer; Fisher.
**Lights for algal culture:**
Aquacenter; Aquaculture Supply; Gardeners Supply; Grainger's.

**Mesh, nylon and polyester (for sieves, silos):**
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Argent; Jelliff; Tetko.

**Mesh, plastic (for field cages):**
ADPI; Aquatic Ecosystems; Argent; Internet; Nalle Plastics; Tenax; V-J Growers Supply.

**Mesh, wire (for field cages):**
Aquatic Ecosystems; Boatcycle; Riverdale Mills; C.E. Shepherd.

**Microscopes:**
Aquacenter; Aquaculture Supply; Argent; Baxter; Cole Parmer; Fisher.

**Netting, plastic:**
ADPI; Aquatic Ecosystems; Argent; Champlin; Memphis Net; Nalle Plastics; Nylon net; Tenax; V-J Growers Supply.

**Nylon mesh:**
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Argent; Jelliff; Tetko.

**pH meters, testers:**
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Argent; Baxter; Biomarine Aquafauna; Cole Parmer; Fisher.

**pH strips:**
Aquaculture Supply; Aquatic Ecosystems; Argent; Baxter; Biomarine Aquafauna; Cole Parmer; Fisher.

**Pipe:**
See PVC.

**Pipets:**
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Baxter; Cole Parmer; Fisher.

**Polyester mesh:**
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Argent; Jelliff; Tetko.

**Pumps, air:**
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Aquanetics; AREA; Boatcycle.

**Pumps, gasoline:**
Aquanetics; Grainger.

**Pumps, metering:**
Cole Parmer; Grainger; US Plastics.

**Pumps, peristaltic:**
Cole Parmer; US Plastics.

**Pumps, submersible:**
Aquacenter; Aquaculture Supply; Aquanetics; Aquatic Ecosystems; Baxter; Boatcycle; Cole Parmer; Fisher; US Plastics.

**PVC pipe:**
PPS; PVC Supply; SIP; US Plastics; WP Law.

**Refractometers:**
Argent; Aquacenter; Aquaculture Supply; Aquatic Ecosystems; AREA; Baxter; Fisher.
Rope:
Aquacenter; Champlin; Memphis Net; Nylon net.

Sand filters:
Aquaneics.

Secchi disk (for algal culture):
Aquaculture Supply.

Sedgewick-Rafter cells:
Aquaculture Supply; Baxter; Fisher.

Shipping containers (styrofoam):
Packaging Products; TechPak.

Sieves:
Aquaculture Supply; Gilco.

Sodium thiosulfate:
Aquacenter; Aquatic Ecosystems; Argent.

Spectrophotometer:
Baxter; Fisher.

Tanks, fiberglass:
Acr-tyc; Adams Mfg.; Aquacenter; Aquaneics; Dolphin; Red Ewald; Rowlands.

Tanks, plastic:
Aquacenter; Aquaculture Supply; Grainger; Solar Components; US Plastics.

Test kits:
Aquacenter; Aquaculture Supply; Argent; Hach; LaMotte.

Test tubes:
Aquacenter; Aquaculture Supply; Baxter; Cole Parmer; Fisher.

Tubing:
Aquacenter; Aquaculture Supply; Aquaneics; Aquatic Ecosystems; Cole Parmer; US Plastics.

Tubing fittings:
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; Cole Parmer; US Plastics.

Ultraviolet sterilizer:
Aquacenter; Aquaculture Supply; Aquafine; Aquaneics; Aquionics; Rainbow Plastics, Filter Div.; Southern Industrial Sales, Pureflow Div.

Valves (air):
Aquacenter; Aquaculture Supply; Aquatic Ecosystems.

Valves (water):
Aquacenter; Aquaculture Supply; Aquatic Ecosystems; AREA; PPS; PVC Supply; SIP; US Plastics; W.P. Law.

Wire mesh:
See Mesh, wire.
Appendix D. Commonly Cultured Phytoplankton Species and Sources for Starter Cultures

Commonly Cultured Phytoplankton Species

Class Prymnesiophyceae
(formerly Haptophyceae)
Golden brown flagellates

Isochrysis galbana  Size: 3-7 μm

The most commonly cultured strain is Tahitian Isochrysis (T-Iso). Recently a strain isolated in the Caribbean has become popular (C-Iso). T-Iso is generally considered to be the optimal feed for larvae. It is also utilized for post-set and broodstock. It thrives at relatively high temperatures.

Pavlova (Monochrysis) lutheri  Size: 4-6 μm

A formerly popular flagellate whose use has been largely superceded by T-Iso.

Class Bacillariophyceae
Diatoms

Chaetoceros spp.

Several species of these diatoms are commonly cultured. Slightly large than Isochrysis and non-motile, these are fed to older larvae, post-set and broodstock.

Usually less tolerant to warm temperatures than T-Iso and C-Iso.

Size:  C. gracilis: 7-12 μm
       C. muelleri: 4-6 μm
       C. calcitrans: 3 μm

Skeletonema costatum
Size: 3-22 μm X 3-12 μm

This diatom has been much used in shellfish hatcheries but recently has been largely replaced by Chaetoceros spp., which are often easier to culture. Often the most abundant diatom in natural waters.

Thalassiosira spp.

T. pseudonana (clone 3H) has been used in shellfish hatcheries for years and can be used for all life stages. T. weissflogii (formerly T. fluviatilis) is a large diatom which is an excellent feed for broodstock.

Size:  T. pseudonana: 4 μm
       T. weissflogii: 6-20 μm

Cyclotella spp.  Size: 10-90 μm
These diatoms are very hardy and multiply rapidly. They are a good feed for broodstock.
**Class Chlorophyceae**
Green algae

*Nannochloris* spp.  Size: 4 μm

A small green alga which multiplies rapidly.

**Class Prasinophyceae**
Greenish algae

*Tetraselmis suecica*  Size: 7-13 μm

Widely used in bivalve culture.

**Sources for starter cultures**

Many state universities may maintain algal collections and be able to provide starter cultures. Often your best source for starter cultures may be established hatcheries in your area. Your extension agency may be able to help locate a source for starter cultures. There is also an extensive list of algal culture collections contained in Miyachi et al. (1989). The following vendors sell monospecific phytoplankton cultures:

**Aquaculture Supply**
5532 Old Saint Joe Road, Dade City, FL 33525. (904) 567-8540

**Bigelow Lab for Ocean Science**
Provafoli-Guillard Center for Culture of Marine Phytoplankton. McKown Point, West Boothbay Harbor, ME 04575. (207) 633-2173

**Carolina Biological Supply Co.**
2700 York Rd., Burlington, NC 27215-3398. (800) 334-5551
APPENDIX E. UNITS OF MEASUREMENTS

SCIENTIFIC NOTATION

Scientific notation uses exponents to simplify very large or very small numbers. It is particularly useful when precision is not important; in other words, if you do not care whether the number is 1,000,000 or 1,000,100—1 million is close enough—scientific notation can be used to simplify calculations.

\[ 10^9 = 1 \]
\[ 10^1 = 10 \]
\[ 10^2 = 100 \]
\[ 10^3 = 1000 \]
\[ 10^4 = 10,000 \]
\[ 10^5 = 100,000 \]
\[ 10^6 = 1,000,000 \text{ (million)} \]
\[ 10^9 = 1,000,000,000 \text{ (billion)} \]

Negative exponents indicate fractions:

\[ 10^{-1} = 0.1 = \text{one tenth} \]
\[ 10^{-2} = 0.01 = \text{one hundredth} \]
\[ 10^{-3} = 0.001 = \text{one thousandth} \]
\[ 10^{-6} = 0.000001 = \text{one millionth} \]

Other numbers are represented as multiples of these base units:

3.5 million = 3.5 \times 10^6
1.5 billion = 1.5 \times 10^9

THE METRIC SYSTEM

Scientific measurements are usually made in metric units. The metric system is a decimal system. Basic units are multiplied or divided by ten. The following prefixes are the ones you will most commonly encounter. These prefixes are combined with the basic units (gram, liter, meter) to produce larger or smaller units. For example, "kilo-" + "meter" yields kilometer, meaning 1000 meters.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Abbreviation</th>
<th>Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilo-</td>
<td>k</td>
<td>10^3</td>
</tr>
<tr>
<td>centi-</td>
<td>c</td>
<td>10^-2</td>
</tr>
<tr>
<td>milli-</td>
<td>m</td>
<td>10^-3</td>
</tr>
<tr>
<td>micro-</td>
<td>μ</td>
<td>10^-6</td>
</tr>
</tbody>
</table>

1000 micrograms = 1 milligram
1000 milligrams = 1 gram
1000 grams = 1 kilogram
1000 microliters = 1 milliliter
1000 milliliters = 1 liter
1000 micrometers = 1 millimeter
1000 millimeters = 1 meter
10 millimeters = 1 centimeter
100 centimeters = 1 meter
1000 meters = 1 kilometer
The following approximations can be used to convert between US measurements and the metric system.

<table>
<thead>
<tr>
<th>LENGTH</th>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millimeters</td>
<td>0.04</td>
<td>inches</td>
<td>inches</td>
<td>25.40</td>
<td>millimeters</td>
</tr>
<tr>
<td></td>
<td>centimeters</td>
<td>0.39</td>
<td>inches</td>
<td>inches</td>
<td>2.54</td>
<td>centimeters</td>
</tr>
<tr>
<td></td>
<td>meters</td>
<td>3.28</td>
<td>feet</td>
<td>feet</td>
<td>30.48</td>
<td>meters</td>
</tr>
<tr>
<td></td>
<td>meters</td>
<td>1.09</td>
<td>yards</td>
<td>feet</td>
<td>0.30</td>
<td>meters</td>
</tr>
<tr>
<td></td>
<td>kilometers</td>
<td>0.62</td>
<td>miles</td>
<td>yards</td>
<td>0.91</td>
<td>meters</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>miles</td>
<td>1.61</td>
<td>kilometers</td>
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</table>

<table>
<thead>
<tr>
<th>AREA</th>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sq. centimeters</td>
<td>0.16</td>
<td>sq. inches</td>
<td>sq. inches</td>
<td>6.54</td>
<td>sq. centimeters</td>
</tr>
<tr>
<td></td>
<td>sq. meters</td>
<td>1.20</td>
<td>sq. yards</td>
<td>sq. feet</td>
<td>0.09</td>
<td>sq. meters</td>
</tr>
<tr>
<td></td>
<td>sq. kilometers</td>
<td>0.39</td>
<td>sq. miles</td>
<td>sq. yards</td>
<td>0.84</td>
<td>sq. meters</td>
</tr>
<tr>
<td></td>
<td>hectares</td>
<td>2.47</td>
<td>acres</td>
<td>sq. miles</td>
<td>2.60</td>
<td>sq. kilometers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>acres</td>
<td>0.40</td>
<td>hectares</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VOLUME</th>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>milliliters</td>
<td>0.20</td>
<td>teaspoons</td>
<td>teaspoons</td>
<td>4.93</td>
<td>milliliters</td>
</tr>
<tr>
<td></td>
<td>milliliters</td>
<td>0.06</td>
<td>tablespoons</td>
<td>tablespoons</td>
<td>14.78</td>
<td>milliliters</td>
</tr>
<tr>
<td></td>
<td>milliliters</td>
<td>0.03</td>
<td>fluid ounces</td>
<td>fluid ounces</td>
<td>29.57</td>
<td>milliliters</td>
</tr>
<tr>
<td></td>
<td>liters</td>
<td>4.23</td>
<td>cups</td>
<td>cups</td>
<td>0.24</td>
<td>liters</td>
</tr>
<tr>
<td></td>
<td>liters</td>
<td>2.12</td>
<td>pints</td>
<td>pints</td>
<td>0.47</td>
<td>liters</td>
</tr>
<tr>
<td></td>
<td>liters</td>
<td>1.06</td>
<td>quarts</td>
<td>quarts</td>
<td>0.95</td>
<td>liters</td>
</tr>
<tr>
<td></td>
<td>liters</td>
<td>0.26</td>
<td>gallons</td>
<td>gallons</td>
<td>3.79</td>
<td>liters</td>
</tr>
<tr>
<td></td>
<td>cubic meters</td>
<td>35.32</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td>28.32</td>
<td>liters</td>
</tr>
<tr>
<td></td>
<td>cubic meters</td>
<td>264.21</td>
<td>gallons</td>
<td>cubic feet</td>
<td>0.03</td>
<td>cubic meters</td>
</tr>
<tr>
<td></td>
<td>cubic meters</td>
<td>1.35</td>
<td>cubic yards</td>
<td>cubic yards</td>
<td>0.76</td>
<td>cubic meters</td>
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</table>
### Weight

<table>
<thead>
<tr>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
</tr>
</thead>
<tbody>
<tr>
<td>grams</td>
<td>0.035</td>
<td>ounces</td>
</tr>
<tr>
<td>kilograms</td>
<td>2.21</td>
<td>pounds</td>
</tr>
<tr>
<td>metric ton</td>
<td>1.10</td>
<td>tons</td>
</tr>
<tr>
<td>(1000 kg)</td>
<td></td>
<td>(2000 lbs.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If you know</th>
<th>Multiply by</th>
<th>To find</th>
</tr>
</thead>
<tbody>
<tr>
<td>ounces</td>
<td>28.35</td>
<td>grams</td>
</tr>
<tr>
<td>pounds</td>
<td>0.45</td>
<td>kilograms</td>
</tr>
<tr>
<td>tons</td>
<td>0.91</td>
<td>metric tons</td>
</tr>
</tbody>
</table>

### Temperature

If you know Celsius (= centigrade), multiply by 9/5 and add 32 to get Fahrenheit.

If you know Fahrenheit, subtract 32 and multiply by 5/9 to get Celsius.

<table>
<thead>
<tr>
<th>Fahrenheit</th>
<th>Celsius</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>59</td>
<td>15</td>
</tr>
<tr>
<td>68</td>
<td>20</td>
</tr>
<tr>
<td>77</td>
<td>25</td>
</tr>
<tr>
<td>86</td>
<td>30</td>
</tr>
<tr>
<td>98.6</td>
<td>37</td>
</tr>
<tr>
<td>104</td>
<td>40</td>
</tr>
<tr>
<td>122</td>
<td>50</td>
</tr>
<tr>
<td>140</td>
<td>60</td>
</tr>
<tr>
<td>212</td>
<td>100</td>
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</tbody>
</table>