BEST MANAGEMENT PRACTICES
A MANUAL FOR MARYLAND AQUACULTURE

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Developed by the

Maryland Aquaculture Coordinating Council
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INTRODUCTION

Aquaculture, or the production of aquatic plants and animals, has been a part of Maryland's history for over a century. The industry currently consists of a diverse array of products ranging from traditional shellfish such as oysters to aquatic plants for use in water gardens and shoreline stabilization. Several businesses have been developed that raise finfish and shellfish in innovative systems and aimed at non-traditional markets. In addition, the use of aquaculture products for the restoration of depleted or disrupted natural populations has been an area of increasing research and interest in recent years, and is seen as a potential area for increasing opportunity for the future. This would provide enhanced economic activity while assisting in the environmental modification.

Legislation enacted during 2005 created the Maryland Aquaculture Review Board (MARB), which provides regular interagency review of permits and issues across departmental lines. The Maryland Aquaculture Coordinating Council (MACC) was also created, comprising seventeen designated members from industry, academia, regulatory, and political categories. Among the tasks the MACC was charged with was the development of Best Management Practices (BMP) for all forms of aquaculture.

To address this, the MACC created six subcommittees. These were chaired by MACC members, with additional membership provided by council members, as well as knowledgeable individuals able to provide insight into development of the BMPs. During the summer and fall of 2006, these subcommittees met and formulated drafts. Subcommittee meetings were open to the public for input by non-subcommittee members, and to ensure that citizen comments and concerns were heard and considered for incorporation into the BMPs.

These BMPs are formed from existing state and federal laws and regulations, as well as voluntary measures that are recommended. Their purpose is to provide producers with a base of knowledge regarding expectations in the development of their businesses. In all, they comprise a roadmap for those entering the aquaculture industry to follow as they grow businesses in the state. Since another task of the MACC is the regular and periodic review of all laws and regulations pertaining to aquaculture, these BMPs will be reviewed and revised as a part of this process so that they reflect current practice. It is hoped that they will aid the industry in continuing to grow while maintaining a position of environmental compatibility.

SPECIES

The development of BMPs was not driven by production of specific species, except for the section on Shellfish Aquaculture. The reason is that shellfish culture is largely driven by the use of publicly owned waters and bottom. Therefore, there is a reason for adopting practices that take into account the multiple uses of these waters, as well as the social and historical basis of their use in aquaculture.

For all others, the various sections contained in these BMPs will be sufficient to provide guidance for efficient and profitable production while safeguarding the environment and providing for welfare of the animals. It should be clear that aquaculture production is no different than most other forms of animal agriculture. Production and ultimate profitability largely rest upon ensuring that animals are kept healthy and in a suitable environment to promote growth.

The practice of commercial aquaculture contains several inherent objectives for the grower. These are to:

- Increase survival
- Maximize growth rates
- Develop product uniformity
- Protect from predators
- Manage health
- Grow according to market demand
- Develop product continuity

While restoration aquaculture has some differences, it must take into account the basis for all aquaculture production, which is to enhance the survival of young plants and animals in greater numbers than would be found in natural reproduction.

It is clear, therefore, that the use of BMPs can aid in fostering successful aquaculture operations. They represent the results of science, technology, and innovation in many areas - from construction of impoundments to final shipping of the products. If followed, they can aid the aquaculturist in creating and managing a business that will be financially successful while preventing conflicts with neighbors or other users of the waters, and in providing operations that will coexist within the local environment with minimal impact.

DEFINITION

Best Management Practices are defined as methods of operating an aquaculture business to minimize, so far as practicable, pollution or environmental disruption. A key feature of aquaculture production is the reliance on clean water. Whether in the production of shellfish, finfish, or other aquatic life forms, water quality is a key parameter in the economic success of the business. In addition, aquaculture producers recognize the relationship between their production and the natural resources of the state. These BMPs provide a voluntary set of standards and procedures for improving production while helping to preserve the environment. They are a key in the factor that has come to be known as “sustainability” – a desirable state that ensures the long-term efficacy of the business.

These BMPs combine legislative and regulatory mandates, as well as suggested and accepted practices that can help the aquaculture producer become a good neighbor within his area of operation. Through them, the MACC hopes to provide support for the growth of the aquaculture industry in Maryland, as well as its continued economic success.

SECTION I: WATER RESOURCES AND MANAGEMENT

Subcommittee Membership:
Dr. Andrew Lazur, University of Maryland Center for Environmental Science, Chair
Mr. George Harman, Maryland Department of Environment
Mr. Jon Farrington, Industry

The intent of best management practices (BMP's) for the use and management of water resources for aquaculture purposes is to provide operational guidelines to ensure long term environmental and production sustainability. This collection of recommended practices is designed to address specific issues of water use and management covering a variety of aquaculture production systems and species and many are based on experience from other states which have implemented BMP=s as the primary means of regulating the industry. Though this section covers water use issues and practices, there are additional BMP=s within other sections of this manual that producers will need to understand and implement depending on their specific production systems and goals. It is important to note that BMP=s should be considered a continuous work in progress as new species; culture and water use technology is developed, and therefore, require periodic field verification and will be updated as necessary.
Best management practices for water use and management are divided into sub sections as follows:

- **I. Site Development and Wetland/Habitat Protection**
- **II. Water Supply and Management**
- **III. Pond Water Management**
- **IV. Water Quality Enhancement**
- **V. Effluent Management and Treatment**

I. Site Development and Wetland/Habitat Protection

A. Construction of aquaculture facilities

The construction of an aquaculture facility can create significant environmental issues including soil erosion and downstream water quality degradation unless proper practices are implemented at the onset.
Specific best management practices for construction include:

1. Alteration of existing terrain is permissible if no increase in offsite silting or flooding occurs.
2. Stabilize exposed soils as quickly as possible to prevent erosion and use silt barriers around wetlands and other surface waters to prevent sediment intrusion. Refer to MD Critical Area Planting standard 342 and pages 18-19 of MD Pond Standard 378
3. Consider the natural drainage patterns and any offsite impacts during facility design. Maintain existing watersheds and discharge points during pre and post development. Modifications of natural drainage must not affect hydrology of adjacent wetlands.
4. Use construction and erosion control methods as recommended in USDA Natural Resource Conservation Service (NRCS) Conservation Practice Standards, Section IV.
5. Be sure that all required construction permits are obtained prior to site preparation and construction.
6. Any construction in wetlands must meet state and federal laws. Contact local NRCS office for details.
7. Follow recommendations provided in USDA NRCS Agriculture Handbook No. 590, Ponds-Planning, Design and Construction, Maryland NRSC Standard for Ponds, MD-378, and Southern Regional Aquaculture Center (SRAC) factsheets 100-105. All ponds shall be Class A as per MD -378.
8. Submit a facility plan to the MD Department of Agriculture (MDA) for review prior to beginning any construction.
9. During the construction phase, the facility will be subject to unannounced inspections by MDA to verify compliance with all applicable best management practices regarding facility design and construction.
10. Facility construction must comply with local construction and zoning regulations. Obtaining all necessary permits obtained prior to construction is recommended.

B. Wetlands Protection

Wetlands are important aquatic habitats home to diverse flora and fauna populations. They serve a significant environmental function including: natural filtration and storage of storm water, serve as a sink for toxic compounds, provide essential habitat critical for various life stages of fish and wildlife, and provide natural areas of aesthetic and recreational value to the public. Best management practices for aquaculture are designed to protect and prevent negative impacts to these resources including:

1. Any construction in wetlands must meet state and federal laws. Contact local NRCS office for details.
2. Contact the Maryland Dept. of Agriculture Aquaculture Coordinator to assist with determining the presence or absence of onsite and adjacent wetlands during the site evaluation phase and prior to initiating any aquaculture construction activities.
3. Maintaining a natural buffer of at least 50 feet for new construction, including any aquaculture effluent treatment system, from the boundary of all wetlands and/or natural water bodies is recommended. Local requirements may be more restrictive.
4. Natural wetlands can be used for partial effluent treatment in conjunction with a constructed treatment system if approved by NRCS. Approval will depend on several factors including effluent quality, characteristics of the wetland, and whether wetland discharge water quality is negatively affected by aquaculture discharges.
5. Wetlands constructed for aquaculture effluent treatment purposes on land not previously designated as wetlands may be an effective treatment practice and may be exempt from other requirements that apply to natural wetlands.

II. Water Supply and Management

A. Water Supply Considerations

Aquaculture operations are dependent on a supply of water whether from surface or ground sources. Water is used directly for culture systems (ponds, raceways, cages etc…) and associated support facilities (laboratories, processing, etc.) and for periodic replenishment due to evaporation or percolation. Water conservation should be a priority with all aquaculture operations to maintain stream flows, groundwater levels, and reduce production and water treatment costs as well as reducing off site discharges. In the case of specific types of plant or shellfish culture, whether as a component of other species culture or the target crop, improvement of natural water quality can occur and can be considered a form of bioremediation benefiting the environment. Specific best management practices for shellfish are in a separate section within this manual. Regardless of the water source, new aquaculture operations are required to obtain the necessary water appropriation permits. Engineering analysis would be needed in the permitting process to evaluate the availability of the water body or aquifer, supporting the proposed use. In addition to the specific requirements of water use permits applicable to the aquaculture operation, the following best management practices address water supply issues:

1. Contact MDA Aquaculture Coordinator for specific information on necessary water use permits prior to any construction or operation.
2. Minimize water use and implement water conservation by one or more of the following practices:
    i. Water re-use or recirculating systems
    ii. Use of water retention facilities, e.g. ponds
    iii. Maintain proper pond levels and provide for rainfall storage in ponds
    iv. Utilize pond trickle flow devices to store and regulate stormwater discharge (UF Bulletin 985).
3. If surface water is used, intake structures can be designed and located as to not interfere with navigation and to avoid excessive sediment disturbance. Intake structures need to be constructed to prevent floating debris from clogging inflow.
4. Use of surface or open waters such as cage/net pen production or culture leases will require specific review to determine that operation meets any navigational or specific environmental requirements.

B. Water Re-Use

Re-using water is a common practice utilized to reduce production costs and environmental impact. Re-use maybe partial or complete depending on production goals, effluent quality and available resources for treatment of wastes. Because of water re-use, the volume of effluent from a recirculating system is reduced; however the nutrient concentration tends to be significantly higher than other productions systems (See SRAC factsheets 452,454 and 455 for more information on recirculating systems and management).

The effluent resulting from a recirculating aquaculture system can be challenging to treat and requires special management practices as follows:

1. Discharge of production water routed to treatment systems can reduce nutrient concentrations to acceptable levels and improvement of other water quality parameters, e.g. dissolved oxygen, pH, biological oxygen demand, total solids, salinity, and temperature to specified discharge limits.

2. Effluents can be treated and retained on site or discharged to a permitted sanitary sewer system (see section VII. Effluent Management and Treatment for details on treatment practices). Discharging production water to a sanitary sewer system may require a permit from the local municipal wastewater treatment agency.
3. Dispose of waste solids in a legal manner that will not cause environmental degradation. Potential options for solids treatment and disposal include: composting followed by appropriate land application and as a soil amendment or disposal at a sanitary landfill. In some cases, solids can be incinerated or sent to an applicable rendering facility upon approval of MDA.

III. Pond Management

Proper pond management will ensure both healthy water quality for improved aquaculture production and reduce or eliminate any environmental impact due to downstream discharge. Specific practices that effect maintaining adequate water quality include stocking and feeding rates, aeration, using proper water quality enhancements such as aeration or filtration if necessary, harvest or draining procedures, and monitoring of water quality (See Southern Regional Aquaculture Center fact sheets 460-471, and 4600-4603 for water quality management). Recommended best management practices for pond management include:

A. Stocking and Feeding Practices

1. Species stocking rates should take into consideration the carrying capacity of production waters or ability of water treatment systems to mitigate nutrients and other potential pollutants or degraded water quality below water quality standards prior to discharge offsite.
2. Limiting the crop biomass to and feeding rate to within the carrying capacity of the water body to prevent excessive accumulation of nutrients and subsequent impact on water quality is recommended. An alternative is to follow the effluent treatment guidelines found in section V.
3. Addition of feed to stormwater ponds designed and constructed to treat storm induced runoff on aquaculture facilities in not advised.
4. Addition of feed to effluent treatment systems is not recommended.
5. The use of lower nitrogen and phosphorus and higher digestibility feeds are recommended to reduce nutrient concentrations in effluent.
6. Recommended feeds (size and quality) and feeding rates and frequencies for the culture species and its specific life stages should be used to reduce feed waste or overfeeding (See various SRAC fact sheets for feeding practices for a variety of culture species).
7. Overfeeding should be prevented.

B. Aeration

The use of aeration can significantly improve water quality by increasing dissolved oxygen concentrations, mixing waters and destratifying deep ponds. Recommended management practices for aeration of ponds include:

1. Appropriate aeration, surface or diffused air aeration, should be utilized where ponds receive any level of feeding.
2. Commercial ponds should follow aeration rate recommendations for the particular culture species and feeding rates (See SRAC factsheet 3700).
3. Placement of aeration devices is important to maximize oxygenation and water circulation and minimize pond soil erosion, water turbidity, and cost of operation.

C. Harvest or Draining

Harvest or draining ponds can cause significant sediment loading and associated diminished water quality of effluent impacting receiving waters. It is essential to design ponds and conduct these activities to minimize deterioration of water quality. Following best management practices associated with pond harvest and draining will reduce the amount of required treatment (See section VII) necessary prior to discharge offsite:

1. Depending on water temperature, do not add feed 2-4 days prior to pond harvest or draining to reduce nutrient concentrations.
2. Where possible harvest fish without discharging water (see SRAC factsheet 394).
3. Drain ponds only when necessary.
4. Reroute the drained water for use in other production or for irrigation.
5. Use properly constructed harvest basins where possible (See MD-378).

6. Maintain pond/dike facilities to minimize seepage.
7. Use properly designed discharge systems and erosion control prevention at the point of discharge to minimize erosion.
8. Maximize length of draining time for the last 50% of water to allow for settling of solids in pond prior to discharge.

IV. Water Quality Enhancement

A variety of chemical treatments, mechanical, and biological devices are utilized to improve water quality in aquaculture systems. These may include aeration (to increase oxygen concentrations, oxidation of organic matter and volatilization of gases), filtration (for solids capture, ultraviolet light, or ozone for disinfection), biofiltration (for conversion of toxic nitrogen forms to non-toxic forms), and use of chemicals. Chemical treatment may include addition of limestone or other hardness and alkalinity enhancement compounds; salts to increase salinity, aluminum sulfate (alum) to reduce clay turbidity, bacteria amendments to increase breakdown of organic solids; as well as others (see SRAC fact sheets 460-471, and 4600-4603).

Best management practices for use of water quality enhancements, in addition to practices described in this manual and recommendations with referenced SRAC factsheets include:

1. Proper storage of all chemicals is recommended.
2. Follow chemical label recommended for use, rates and application methods.
3. All operators responsible for chemical or bacterial additions are recommended to have the appropriate training and certifications as required by regulatory agencies.

V. Effluent Management and Treatment

Managing and proper treatment of aquaculture effluent is essential to reduce or eliminate any offsite environmental impact. Aquaculture effluent commonly contains organic and inorganic dissolved, suspended and settleable solids as a result of feeding practices. Since the systems (recirculating systems, ponds, cages, raceways) and culture practices (feeds, feeding rates, water treatment), and physical features of the facility vary, several effluent treatment options and management practices are provided to allow for flexibility. It is important to note that the technology for effluent treatment is constantly evolving with field verification often following innovation, and therefore, modifications or updates to these practices may occur or be required by as new knowledge is gained. Also, there is the potential for changes in regulations that may require the implementation of added or enhanced BMPs, or even treatment of the wastewater. In addition, special consideration of the characteristics and water quality of the receiving stream may require further modifications to the BMPs or these treatment practices. Additional management and treatment can be utilized following review with the MDA Aquaculture office. Recommended practices for effluent include:

A. Detention Treatment

Temporary treatment of effluent prior to discharge offsite by use of a pond or ditch system is allowed. Maximum feeding rates during optimal growing season conditions for production units utilizing a detention pond system are: 1) 180 pounds/acre/day for a one-day detention period: and 2) 360 pounds/acre/day for a five day detention period. Systems exceeding these feeding rates will be required to verify that effluent meets water quality standards or use another treatment practice such as water retention.

1. A length to a width ratio of at least 1:1 for single inlet treatment ponds and for multi-inlet detention facilities at least 100 linear feet between the outlet and inlets is recommended.
2. Providing for a perimeter littoral zone in perimeter of ponds to encourage aquatic vegetation can assist in reducing nutrients and trapping solids. System can be baffled to maximize littoral zone or use floating plant systems to maximize nutrient uptake.
3. Proper design of discharge point of the detention system can minimize transport of sediment to the receiving water or erosion of the banks or channel in the receiving waters.

B. Integrated Production System Treatment

Production waters or effluent can be re-used for the purposes of producing a secondary aquaculture crop, agronomic crops or aquatic plants or combination thereof, while providing for effluent treatment. This treatment method allows for numerous design opportunities and innovation while providing water re-use and conservation. Variables of importance in an integrated system include plant and animal species, species biomass, characteristics of water flow, purposes of each species, seasonal effect on growth and other variables. Providing sufficient plant biomass, retention time and photosynthetic surface to adequately remove nutrients and solids is recommended. Depending on the type and degree of integration, additional treatment prior to offsite discharge may be required. Aquaculturists interested in this treatment option should contact the MDA Aquaculture Coordinator.

C. Vegetated Filter Strip Treatment

Treatment of effluent by passing a thin layer through a constructed or natural vegetated filter strip, prior to discharge offsite is an acceptable practice. This strip allows for capture of sediment, organic matter and other pollutants by deposition, infiltration, absorption by vegetation, decomposition and volatilization. See USDA-NRCS Maryland Conservation Practice Standards: MD Code 393 for vegetated filter strips. Specific best management practices include:

1. Use plant species recommended for filter strips to maximize nutrient and solids remediation.
2. Discharges occurring when vegetative growth is actively growing and covers at least 75% of filter strip area will maximize treatment effect.
3. Discharge volume should fall within flow design criteria of filter strip.
4. Design should reduce the potential for discharge from strip.
5. Soil erosion prevention is recommended at the point of discharge from filter strip into receiving waters.

D. Retention or Zero Discharge Treatment

Retention or permanent storage effluent on site is an approved treatment practice. Retention can be accomplished by a variety of methods as follows:

1. Retention or percolation systems: Ponds or ditch/canal system with no discharge point can be used to store all of production effluent. Where soils are porous providing for water percolation into soil, a reservoir may be used to store all discharge. Where stored water will or is designed to percolate to groundwater, the distance to groundwater shall not be less than that required by local stormwater or septic system requirements (e.g., 2 or 3 feet of soil between pond bottom and groundwater). Volume of this reservoir system must be designed to store all discharge and take into account evaporation and percolation rate (Contact NRCS for assistance in soil characteristics). No direct discharge, by any means, to ground water is permissible.

2. Field Application: Applying freshwater effluent to fields during vegetation growing season for irrigation purposes is an acceptable method of discharging production water. At a minimum the effluent must be applied at less than or equal to agronomic nutrient application rates, to a field where there is vegetative cover. Application is not to occur when ground is frozen.

3. Septic System: Where effluent volume is low, an approved septic system may be used for treatment. Appropriate permits must be obtained prior to any discharge.

E. Wetland Treatment

Discharge of effluent from aquaculture production facilities or effluent treatment systems, which incorporate BMPs in this section, can be routed into or through constructed wetlands prior to offsite discharge. Existing facilities previously authorized to discharge into a natural wetland may also utilize this option. See NRCS national practice standard for constructed wetlands 656.

F. Other Treatment Options

Aquaculturists can choose to use other effluent treatment methods provided that they are approved by the Maryland Department of Environment before facility construction.

Supporting Documents:
Natural Resource Conservation Service (NRCS): http://landcare.sc.egov.usda.gov/product.asp?ID=115.

Pond Construction manual AH-590 http://landcare.sc.egov.usda.gov/images/pdf/PondsPlanDesignConstruct.pdf

Southeast Regional Aquaculture Center (SRAC) factsheets 100-105,121,141,181,189,222,223,241,280-282,303-304, 394, 452, 454-455, 484, 460-471, 722, 726, 4600-4603, and 7200-7202: http://www.msstate.edu/dept/srac/ourregio.htm

Smajstrla, A.G., M.E. Griggs and A.M. Lazur. 1998. Storm water detention and discharge from aquaculture ponds in Florida. Univ. of Florida Bulletin BUL 98-5.Bulletin 98-5. http://www.edis.ufl.edu

SECTION II: PRODUCTION SYSTEMS

Subcommittee Membership:
Craig Mask, TFL, Chair
Fred Wheaton, University of Maryland, College Park
Karl Roscher, Maryland Department of Agriculture
Jon Farrington, Industry
Rich Bohn, Maryland Department of Natural Resources

Production systems addressed in this section are land-based as opposed to systems in tidal waters. These production systems may utilize water that is fresh, brackish, or salt. The use of brackish water or saltwater requires special considerations. Design and operation must prevent environmental degradation caused by the salt content of the water or byproducts.

The following provides a framework with references to standards and publications. This should be used as a guideline when planning, designing, constructing, and operating a production system. Other laws and regulations may also apply.

Best management practices for production systems are divided into the following sub sections:

- **I. Ponds**
- **II. Recirculating Systems**
- **III. Flow-through Systems**
- **IV. Species Management**
- **V. Worker Safety**

I. Ponds

A. Site selection

Site selection considerations include: the type of pond embankment-ponds constructed with a dam, excavated- ponds constructed by excavating a pit or dugout, or ponds that are constructed by both methods and are defined by depth of water impounded.

Consider the following:

1. Safety of down stream areas in the case of dam failure
2. Space for future expansion or new conservation measures
3. Production levels requiring a National Pollutant Discharge Elimination System (NPDES) permit
4. Drainage area feeding the pond in relation to water quantity and quality
5. Soil investigation to assure the soil types used for construction are of a type meeting the needs for water retention, structure integrity, and resource protection
6. The potential for earth moving to uncover or redistribute sulfidic soils
7. Water discharge and their effect on receiving areas, including streams, wetlands, tidal waters, and ground water

B. Design and Construction

1. Design considerations should include effects of the water budget including volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability caused by seasonal or climatic changes.
3. Effects on down stream flows or aquifers that could affect other uses and users
4. Effects on the environment caused by the escape of culture species, pathogens, nutrient, saline, chemical, sediment, thermal, or water velocity and volume discharges.
5. The design process should include structures, and procedures that will address these concerns. Possible examples might include water and sediment control basins, wastewater treatment strips, or irrigation system, and tailwater recovery.

All work on permanent structures shall be carried out in areas free from water. Contractors shall construct and maintain all temporary dikes, levees, cofferdams, drainage channels, and stream diversions necessary to protect the areas to be occupied by the permanent works. Contractors shall furnish, install, operate, and maintain all necessary pumping and other equipment required for removal of water from various parts of the work and for maintaining the excavations, foundation, and other parts of the work free from water as required or directed by the engineer for constructing each part of the work.

After having served their purpose, temporary protective works shall be removed or leveled and graded to the extent required to prevent obstruction to the flow of water to the spillway or outlet works and so as not to interfere with operation or maintenance of the structure. Stream diversions shall be maintained until the full flow can be passed through the permanent works. Removal of water from the required excavation and foundation shall be carried out to maintain stability of excavated slopes and bottom and will allow satisfactory performance of construction operations. When placing and compacting material in excavations, the water level being refilled shall be maintained below the bottom of the excavation at such locations which may require draining water sumps from which the water is pumped.

C. Erosion Control

Erosion and Sediment Control

Construction operations will be carried out in such a manner that erosion will be controlled and water and air pollution minimized. State and local laws concerning pollution abatement will be followed. Construction plans shall detail erosion and sediment control measures. All borrow areas shall be graded to provide proper drainage and left in an aesthetically acceptable condition. All exposed surfaces of the embankment, spillway, spoil and borrow areas shall be stabilized by seeding, liming, fertilizing and mulching in accordance with the *Natural Resources Conservation Service Standards and Specifications for Critical Area Planting (MD-342*)

D. Storm Water Management

Reduce excessive storm runoff into ponds that would compromise pond water quality and may result in overflow of pond waters. This can be accomplished by utilizing those practices defined in *USDA-NRCS Maryland Conservation Practice Standards: MD Code 362 & 410* including:

1. Design new ponds with an approved watershed area to pond surface ratio.
2. Use diversions and grade stabilization to divert excess runoff around ponds.
3. Where feasible, construct additional ponds to increase storage capability at the site.
4. Maintain good, dense vegetation on all areas.

E. Fertilization

Fertilization of ponds, usually early in the year, is done to increase production of phytoplankton which serves as food for other organisms that are eaten by fish. A phytoplankton bloom creates a turbid condition that can help to prevent light penetration reducing the growth of rooted aquatic weeds. Care should be taken not to impair down stream waters with high nutrient discharge loads when fertilizing ponds.

1. Check pond water alkalinity, total hardness, and calcium hardness before fertilizing.
2. Use recommended application rates based on site conditions and water quality.
3. Do not use animal manure for fertilizers.
4. Do not apply fertilizers immediately prior to periods of heavy precipitation.

Additional information is available at: *http://srac.tamu.edu/tmppdfs/6177685-471fs.pdf*

F. Feed Management

Feed management should consider feed conversion rates, uneaten feed, feces deposition, pond biomass, and metabolites. Feeding rates should allow water quality to be maintained at a level which promotes culture species growth and minimizes nutrient loading.

1. Use high quality feeds that are prepared for the species being cultured.
2. Apply feed uniformly and do not apply more than the fish will consume.
3. Observe feeding behavior to prevent overfeeding and as an indicator of fish health.
4. Store feed in a dry, rodent free area and use by the manufacturers expiration date.

G. Water Quality

Water quality in the pond is of critical importance in the production of cultured species and as such, water quality parameters including dissolved oxygen, total ammonia, nitrites, nitrates, pH, total alkalinity, temperature, and light penetration should routinely be measured and any corrective action needed should be implemented promptly. Poor water quality affects the health of fish and disease events can occur after stress resulting from impaired water quality. The major water quality problems that occur in culture ponds are related to excessive phytoplankton production, toxic metabolite accumulation and low dissolved oxygen. Weather events may also have dramatic effects on water quality in a very short period of time. Steps should be taken to reduce the risks associated with these situations including:

1. Develop a schedule to regularly take water quality readings from several sites in ponds.
2. Reduce nutrients entering the pond through feed management and runoff control.
3. Maintain dissolved oxygen at or above recommended levels, accounting for daily fluctuations.

H. Therapeutic Agents

Therapeutic agents should only be used if permitted by Federal and State regulatory authorities and only for uses and species allowed under label instructions or otherwise prescribed by a licensed veterinarian. Precautions should be taken to insure that active agents are not to be released where they could damage the environment. Information on aquaculture drugs can be obtained at: *http://www.fda.gov/cvm/aqualibtoc*

I. Effluent

Effluent volume and quality should be managed to ensure that it does not negatively affect receiving waters. Proper design should allow for management options such as controlled discharge, clean water bypass, and treatment areas. Strict effluent management practices must be followed during storm events, therapeutics use, harvest, and pond draining.

1. Construct ponds that can be seined and do not require draining when harvesting.
2. Design new ponds with structures to be drained near the surface instead of at the bottom.
3. Manage ponds to prevent erosion, limit turbidity and maintain good water quality.
4. Utilize settling basins or constructed wetlands to improve effluent quality when possible.
5. When draining ponds completely, reserve 25% of volume to allow solids to settle, then discharge remainder slowly.
6. Maintain adequate dissolved oxygen concentration in effluent.
7. Do not allow livestock access to ponds or embankments.

See also, *USDA-NRCS Maryland Conservation Practice Standards: MD Code 378, 397, 399*

II. Recirculating Systems

Recirculating systems are classified in many ways. Recirculating systems here will be defined as aquatic production systems that reuse at least once at least fifty percent (50%), and usually more, of the water in the system. Typically, recirculating systems reuse as much water as they can as many times as they can before discharge. Optimally, recirculating systems will continually reuse the water, adding enough only to make up for evaporation and/or leakage. Practicality and economics usually dictate a water reuse rate of eighty to nintey-five percent (80-95%). Recirculation of the water requires treatment to remove metabolic products, and in some cases, adjust water quality parameters (e.g. pH) prior to reuse.

A. Site Selection and Development

The primary reasons for use of recirculating systems include:

1. control of the aquatic environment including temperature, oxygen concentration, and other water quality parameters
2. control of diseases, predators, and other outside influences that are detrimental to the crop being produced
3. limitation of land and/ or water volume and/or available water quality.

Although outdoor recirculating systems do exist (raceways using partial water recirculation), achieving the benefits of recirculating systems usually require an indoor installation. Outdoor systems make control of diseases and predators nearly impossible and thus negate many of the system advantages.

Site selection for an indoor installation requires a location that allows construction of a suitable building, access to the site for trucks to bring in feed, remove the crop for marketing, and a suitable water supply.

B. Water Supply

The supply of water is one of the most critical aspects of an aquaculture facility. The water supply must:

1. Provide a continuous (365 days per year and 24 hours per day) flow rate necessary for planned and anticipated expansion of the facility.
2. Water quality must meet needs of the species(s) to be produced (Water acceptable for drinking does not always provide adequate water quality for fish and shellfish. For example, city water often includes chlorine, a compound highly toxic to most aquatic organisms).
3. Water temperature and oxygen concentration in the water can be modified in a recirculating systems but a water supply having close to the needed temperature and adequate oxygen will reduce costs of operation.
4. The water must be free of disease organisms or can be made such by treatment.

C. System Enclosure

The recirculating systems should be designed with the building to cover it designed to optimally house it. The building should contain adequate floor space for components; space to work around components; and must provide adequate sanitation. Sanitation requirements include disposal of sanitizing solutions, construction material for inner building surfaces, waste handling, and other concerns.

The structure must meet construction regulations including zoning, building codes, site preparation, electrical, and sewage. In addition, recirculating system structures contain large open water areas. Humidity is high and proper materials and ventilation must be specified to prevent the buildup of humidity and the potential for mold growth, building rot or rusting. Other problems may occur with insulation becoming saturated with water, and structural, electrical, and related problems. All electrical installations must meet requirements for operation in wet areas.

If ozone is used, adequate care must be taken in material selection for the generation equipment, as well as selection of piping, valves, and connections. Health regulations and safety in the use of ozone must be incorporated into building design.

Ventilation for humidity control usually provides adequate ventilation to prevent carbon dioxide emissions from culture systems building to dangerous levels in the building. However, carbon dioxide generation should be estimated and the ventilation rate checked to assure that dangerous carbon dioxide levels will be prevented. Any increase of carbon dioxide concentration in the building above exterior ambient levels reduces carbon dioxide release from the culture systems and increases the potential for carbon dioxide to become toxic in the culture system.

During and after building construction erosion must be minimized to prevent runoff from polluting water sources and nearby streams. Adequate drainage from the site must be included both during and after construction. Waste handling facilities for bathrooms, waste discharged from the culture facility, if any, and for solid waste, both normal garbage and the waste generated by potential mass morality of the crop, must be considered in design and waste handling in facility design.

D. Management

System management is critical to successful operation. No matter how well a system is designed and constructed, it will fail if poorly managed. Recirculating systems require relatively high densities to be profitable. High densities increase the need for good management. Good management should include:

1. Monitor water quality on a regular basis. Frequency will depend on the variable being monitored with oxygen being most critical. Other parameters include pH, temperature, ammonia, and nitrite. Needs include adequate equipment and backup equipment (in case of malfunction), laboratory space, and trained operators.
2. Train operators for knowledge of system operation, emergency repair, location of spare parts, and procedures and contact information for help in emergencies beyond their ability.
3. Minimize the volume of water used and/or discharged.

4. Monitor feeding rates and equipment and adjust as needed to prevent over or under feeding. Over feeding wastes costly feed and overloads filtration systems which may lead to system failure. Under-feeding reduces growth rates, keeps fish in the system longer and leads to higher production cost.
5. Providing personal attention to fish behavior by experienced culturists who understand the system and its operation on a daily basis (7 days per week) to detect fish stress, determine adequacy of feeding, prevent overfeeding, and check on the operation of system components.
6. Providing regular cleaning of filters, plumbing, waste water treatment systems, and other systems components to prevent plugging and malfunction.
7. Keeping complete and accurate records of all actions in each system including feeding rates, weekly fish weights, adjustments in water quality parameters, additions to the system(s) (e.g. addition of lime), amount of water changed, filter cleaning, and other actions. Records should include date, time, amount of item added, adjustments and other pertinent data. This is useful if there is a problem and the operator wants to trace what happened. Records are a prerequisite to good management and a key to profitability.
8. Developing a maintenance schedule for system components and carry out preventative maintenance to minimize breakdowns.
9. Establishing a stringent biosecurity program and adhering to it. Let no one into the facility except in controlled situations and only after walking through a sterilizing bath to disinfect footwear. Isolate all incoming stock for ten (10) days before permitting them in the production system. Diseases spread rapidly in high density systems. The best protection is to prevent introduction of disease organism.
10. Installing automatic alarm systems for critical parameters (e.g. oxygen) and being certain that when an alarm goes off someone is there to respond quickly.
11. Developing a plan to deal with catastrophic losses before they happen. You may never have catastrophic losses but if you have to get rid of 20,000 pounds of dead fish on a hot summer day, you will be glad you planned ahead and so will your neighbors.
12. Developing a method to deal with odors that may be discharged with your ventilation air.
13. Treating wastewater discharged to meet all discharge regulations.
14. Minimizing noise, truck traffic and other potential sources of irritation to your neighbors. Location and planning of facilities is a major key to minimizing this problem.
15. Not storing pesticides or other chemicals in the culture facility at any time.
16. Providing training to all employees on biosecurity procedures, emergency procedures, system operation and maintenance, water quality monitoring and what are acceptable values for each variable, and related information. Human error is often the cause of fish kills and the high bio-loads in recirculating systems makes mistakes costly.
17. Maintaining an inventory of critical components (e.g. pumps) and people trained to replace malfunctioning equipment.
18. Keeping feed storage compatible with the type of feed used. Most facilities will use pelleted feed that must be kept dry and cannot be stored for excessive time periods. Thus, periodic deliveries of feed must be available and sufficient storage must be provided to store somewhat more than on load of delivered feed.

E. Fish Handling and Harvest

In any recirculating systems it will occasionally be necessary to handle, sort, or in some other way handle the fish. Handling fish is a very stressful process to the fish and if not done carefully can lead to injured or stressed fish or both. Injury or stress can make fish more prone to disease and more sensitive to less than desirable environmental conditions. Stressors can then lead to reduced growth, refusal to eat, or even death. Thus, when handling fish it is imperative that the handling injury and stress be minimized. Good handling practices include:

1. Handle the fish in water (not in the air) if at all possible and have the fish move or perform the desired action without touching the fish where possible. Contact may cause physical injury and almost always damages the fish=s slime coat which allows easier entry by disease organisms.
2. Handle the fish or shellfish gently and do not stack many fish on top of each other in the air (e.g. in a dip net) as this may physically injure the fish due to squashing them.
3. When using crowding gates move the gates slowly to minimize frightening the fish.
4. Keep oxygen concentrations as near as possible to saturation during handling as the oxygen consumption rate of the fish may be several times their normal oxygen consumption rate during handling.
5. Handle fish only when the water temperature is relatively (to what is normal for the fish) cool as this

reduces oxygen consumption and stress.

6. Remove the fish from feed 24 to 48 hours prior to handling or harvest as this reduces feces production and oxygen demand in the water.
7. If fish must be handled in the air, minimize the time they are out of the water.
8. Have a marketing plan and means of getting product to market while maintaining quality before harvest begins.
9. Harvesting and sorting methods should be built into the facility design, especially for larger installations. Whatever the size the facility, harvesting methods need to be clearly thought out before the facility starts up.

F. Discharge

Recirculating systems typically have limited volume wastewater discharges. Discharges should be minimized within the economic practicality of minimizing water exchange rates. Although it maybe technically possible to use 100 percent reuse rates, the economic cost of maintaining water quality rises rapidly at very high reuse rates. Thus, recirculating systems typically have some discharge from the production systems, even though it may only be backwash water from filters. The discharge typically contains solids and nutrients, especially nitrogen and phosphorus. These must be handled with care and in a manner preventing pollution, meeting all local, state and national regulations, and preferably be done without negative reaction by neighbors.

There many ways of disposing of waste from recirculating systems. Choice of method depends on volume, concentration of wastes, waste form, area available for disposal, economics, whether it is an urban or rural area, and other variables. Wastewater can be treated by conventional sewage treatment techniques although many times economics is a severe limitation. Land disposal via irrigation, treatment by a local city sewage treatment system (available in some locations), and other treatment options such as lagoons and settling basins have been used under the correct circumstances.

Disposal of solids from aquaculture facilities also must be fit to the situation. Land spreading, composting, and other options are available. Most of the variables noted above for wastewater will also enter into choice of disposal method for solids. Aquaculturist should contact their local extension office, the Natural Resources Conservation Service (NRCS) office, the local Soil Conservation District, the state Aquaculture Coordinator, and/or state university for information on disposal of liquid and solid wastes.

III. Flow-through Systems

A. Site Selection

Flow through systems may include tidal or non tidal waters. Consider water quality parameters needed with special attention to the variables inherent in natural water bodies i.e. temperature, seasonal droughts or flooding, variable sediment loads, predators, disease and parasites. Consider impacts to source waters including lowered volumes due to withdrawals, increased or reduced velocities and impingement of native species at intakes.

Consider quality of discharges into natural water bodies, oxygen levels, biological oxygen demand, temperature, sediment loads, and other water quality parameters as well as culture species escape, and disease or parasite transmission. All necessary permits must be obtained.

B. Design and Construction

Systems should be designed so that withdraw and discharge of water will not have a negative impact on source or discharge waters. Special attention should be paid to intake and discharge structures to assure locations and constructed items including, pipes and intakes boxes are not a safety hazard for other users of navigable waters.

C. Feed Management

Proper feed management should provide for species health and growth, while minimizing impacts to discharge waters. See above: Ponds (section F)

D. Water Quality
Water quality must be maintained in the production area as well as in any discharge. Improvements to water quality may be needed, including filtering and settling of suspended particles or adding oxygen.

E. Therapeutic Agents
Therapeutic agents should only be used within federal guidelines. The flow through system should be closed during treatment and treated water should only be discharged after the therapeutic agent has degraded to the point that it will not have a negative impact on the receiving waters.

F. Effluent
Effluent must be treated to the point that it does not negatively impact receiving waters.

IV. Species Management
A. Selection
Species selected should meet the needs of the grower to produce a wholesome, good tasting food product at a reasonable cost, or to produce a non-food product with good quality and at a saleable price.

It must be recognized that the more dangerous a species is, either to the environment or to the public, the more restrictive the culture safeguards must be. An example of this would be the culture of stonefish, an exotic non-native species raised for the aquarium trade. The animal has a deadly toxin in its spines and would therefore only be allowed in a secure recirculating system with no water discharge. However, the culture of a native species may have relatively few limitations on culture system design.

It should be recognized that aquaculture is agriculture and, as such, species may be raised that are non-native, and have been bred for selected traits just as cattle (a non-native species) are bred for selected traits such as milk production.

B. Stocking
Stocking rates and stage of development should be managed to produce healthy species in cost effective quantities, without causing environmental degradation.

C. Quarantine and Bio-security
A new group of culture species introduced from an outside source should be quarantined to assure that current animals are not infected with diseases or parasites from the incoming group. Bio-security should include quarantine, disinfection of equipment, restricting access to culture areas, training of employees, signage, etc.

D. Disease Control
Information on disease prevention and control is available in Maryland Best Management Practices Section V, Aquatic Animal Health.

E. Mortality Management
While some mortality in culture systems will occur, large die-offs can be minimized if good aquatic animal health management practices are utilized. The catastrophic loss of culture species should be planned for, and sufficient steps taken to provide for expedient safe disposal of mortalities. This might include land fill disposal or composting on site. All options require pre-mortality planning.

1. Develop and follow a mortality management plan.
2. Do not allow carcasses to exit in outflow or discharge waters.
3. Remove carcasses promptly and dispose of according to your plan.
4. Insure that no offensive odors are produced by decomposing carcasses at your site.

V. Worker Safety

A. General Operations

Refer to Maryland Occupational Safety and Health (MOSH) and the US Department of Labor Occupational Safety and Health Administration (OSHA). Follow the requirements and guidelines established by MOSH (http://www.dllr.state.md.us/labor/mosh) and OSHA (http://www.osha.gov).

B. Chemicals

Chemicals must be secured and used only by authorized personnel with proper personal protective equipment; safety gear and obeying re-entry and product label and use restrictions.

C. Electrical

Extreme care should be taken to assure proper installation of all electrical equipment by a licensed electrician and with particular attention to wet environment requirements.

D. Machinery

Aquaculture is agriculture and as such represents a significant threat to life from mechanical equipment. Tractors used in stationary applications should have wheels chocked as well as brakes set. Only authorized persons should be allowed near the equipment. All guards should be in place and operating properly. Power take-off (PTO) units should never be approached or worked on with the engine running. Extreme care should be taken on steep or wet slopes, and roll over protection system (ROPS) and seat belts should be used.

E. Ozone, Ultra Violet (UV) and Oxygen

Ozone generators and oxygen supplies as well as (UV) sterilizers can represent significant fire and safety hazards. They should only be installed and operated in the manner designed. Signs, monitoring systems and fire suppression should all be used as required. The local fire department should be given a tour of the facilities and requirements from the local Fire Marshall followed.

SECTION III. SHELLFISH CULTURE

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Shellfish have long been a major part of Maryland=s seafood production. While the state had some of the earliest leasing laws, created from an interest in aquaculture and increasing production of the Eastern oyster, socio-political problems have kept the shellfish aquaculture industry from growing significantly. With the drastic decline in the oyster resource due to diseases, and the growth of the hard clam industry in the region, there exists a need to encourage shellfish growers to add to the population of these important shellfish. Growers, and the shellfish they produce, can play a large part in the restoration of the Chesapeake and coastal bays while providing quality seafood to an expanding market.

This section addresses the following areas:

- **I. Site Selection**
- **II. Operations and Management**
- **III. Permitting**
- **IV. Human Health Issues**
- **V. Biological Management**

I. Site Selection and Access

A. Riparian Rights

Selecting a location to cultivate shellfish in Maryland requires many considerations, including legal restrictions and the rights of adjacent landowners. Maryland is one of many states that follow English common law often referred to as a Riparian Right. In *DNR v. Adams*, the Court of Special Appeals defined a riparian property owner as a person who owns property bordering on a body of water. *Code of Maryland Regulation 08.04.01.20* further defines this as a person possessing riparian rights, specifically including the right to gain access to tidal water.

Riparian rights given to a property owner are legal principals that derive from legal cases rather than statute. Applicable cases are discussed under Legal Restrictions to Access. In summary form, a riparian right is the right of the landowner to access the navigable water, but with no right superior to any other water user unless provided by statute.

Ownership of state waters is intertwined with rights of waterfront land owners. By virtue of the state=s succession to the rights of the title of the Lord Proprietor who received the land by grant from the Crown of England, navigable waters and the land beneath these waters are owned by the State. The concept of the APublic Trust Doctrine@ is that these navigable waters are preserved for the benefit of the public. In essence, these areas are owned in common by all the state=s citizens.

In *Caine v. Cantrell*, the Court of Appeals reiterated that the State owned the area between mean high water and mean low water for public benefit. Therefore, individual private property only extends to the mean high water line. However, the right of a riparian owner to access the water past this line is a right of being the owner of that adjacent property.

B. Legal Restrictions to Access

Following is a list of rights provided to landowners that will need to be evaluated when selecting a site:

1. Access to water: A shellfish growing area may not restrict a riparian owner=s right to access the water. *Causey v. Gray* states that a riparian proprietor, whose land is bounded by a navigable river, regardless whether his or her title extends beyond the dry land, has the right of access. In a similar manner, Environment Article 16-201, Annotated Code of Maryland provides that a person who is the owner of land bounding on navigable water is entitled to make improvements into the water in front of the land to preserve that person's access to the navigable water or protect the shore of that person against erosion.
2. Improvement to property: A shellfish growing area may not restrict a riparian owner=s right to improve his or her private property. In *DNR v. Adams* the Court of Special Appeals lays out the rights of the riparian owner including: Athe right of access to the navigable waters; the right to build piers, wharves, docks, and the other improvements to the line of navigation; the right to reclaim land; and the right to accretions to his lands. These rights do not depend upon ownership of the soil under water but upon lateral contact with the water. It is a universal rule that for riparian rights to attach to a tract of land, the water must form a boundary of the tract.@
3. Narrow entrance: Statute does extend riparian rights to the use in any creek, cove, or inlet that is less than 300 feet or less in width at mean low water for the purpose of preserving or depositing oysters or other shellfish. This right of a riparian proprietor, provided by *Natural Resources Article, 4-11A-06, Annotated Code of Maryland*, extends only to the middle of the creek, cove, or inlet. This statute also extends the right to grow and harvest shellfish to the owner of any pier or structure in the water column and as approved by the Army Corps of Engineers with certain restrictions.
4. Aquatic vegetation: A shellfish grower may not impair submerged aquatic vegetation. This provision is part of the lease contract between the State and the shellfish grower. See: Section II. Operations and Management, subsection F, Habitat Protection, for Shellfish Culture Best Management Practices to comply with this restriction.
5. Waterfowl hunting: The shellfish grower may not fish (i.e. work a shellfish growing area) while a duck blind is in use. *Natural Resources Article, 4-512, Annotated Code of Maryland* states that Aduring the open season for migratory waterfowl, a person may not fish by any means within 500 yards of any stationary blind or blind site which is occupied and is being used for hunting migratory waterfowl.@

C. Bottom Leases

As stated, the State owns the waters of the State and the land beneath it. However, the State may grant rights to this land as part of a lease. Tidelands without commercially significant quantities of naturally existing shellfish (i.e. unproductive tidelands) can be leased from the State for oyster cultivation. Productive tidelands with natural beds cannot be purchased or leased and remain part of the public fishery.

If your shellfish growing area involves use of State owned bottom, you must apply for a lease. Statute and Regulation specify criteria for a lease area. Natural Resources Article 4-11A-05 Annotated Code of Maryland states that a lease may not be granted for any of the following submerged areas of the State:

1. areas beneath a creek, cove, bay, or inlet less than 300 feet wide at its mouth at mean low tide
2. any natural oyster or natural clam bar as defined
3. any area within 150 feet of any natural oyster or natural clam bar in any county
4. any area within 600 feet of any natural oyster or clam bar in the Chesapeake Bay
5. any clam bed as defined by the charts of the Oyster Survey of 1906 to 1912 and its amendments

The lease area for production of clams or oysters must be on unproductive tideland. Unproductive is defined by harvesting rates listed in the *Code of Maryland Regulation 08.02.08.11*.

D. Water Column (Off Bottom) Leases

Statutes related to natural clam and oyster bars and their productivity do not apply to a lease of the water column. However, other statutes regarding riparian rights to access the water, navigation, and the hunting blind restriction still apply and should be considered in selecting a site.

Section III, Permitting, subsection C, Off-Bottom Shellfish Aquaculture covers the permits needed for water column leasing and off-bottom aquaculture. Part of the permitting process for off-bottom aquaculture is a Tidal Wetlands License. Approval is required from the Board of Public Works for this license. In selecting your site, it is important to note that the Board of Public Works will consider the public interest in respect to your license application. In particular *Code of Maryland Regulation 23.02.04.01* specifies that the Board will consider:

(a) The preservation of tidal wetlands;
(b) The conservation of natural values and living resources;
(c) Fishing and crabbing;
(d) Navigational needs;
(e) Water access and related recreation; and
(f) Maritime commerce.

E. Water Quality Considerations

A person interested in raising shellfish intended for human consumption must verify the classification of growing waters under the National Shellfish Sanitation Program. It is valuable to research this aspect of your site prior to applying for any permits by contacting the Maryland Department of the Environment, Shellfish Program. Additional management considerations and recommended best management practices are covered under Section IV, Human Health Issues, of this document.

F. Best Management Practices - Being a Good Neighbor

1. An open discussion with neighbors early in the planning stage can minimize conflict later. Try to amend your plan to accommodate comments you receive.
2. According to *Natural Resources Article, 4-11A-10, Annotated Code of Maryland* you must clearly mark the corner boundaries of your bottom lease and navigation hazards. However, markers should be made as visually unobtrusive as possible and the minimum number of markers should be used to protect a neighbor=s view.
3. Recognize that other users have access to the water column above a bottom lease site. Be polite to visitors and look at these visits and a way to educate the public about aquaculture. Inform locals of site markers and their significance.
4. Placement of floating gear must be within the permitted boundaries and the leaseholder should be sensitive to navigation issues.
5. Recognizing that water column aquaculture enterprises affect traditional uses of the water, contact the local County Watermen=s Association regarding site selection. The Maryland Watermen=s Association can direct you to the leader of local county organizations. Understanding boat traffic and commercial use of an area will help minimize protests to your application.
6. Check local city and county ordinances. It is your responsibility to obtain necessary city and county permits. Zoning variances, critical area activity applications, and building permits may be required. Permits may also be required for commercial activities, especially in residential areas.
7. Keep noise to a minimum. *Code of Maryland Regulation 08.18.03.03* requires maximum noise level of any vessel operating on the waters of the State not to exceed 90 decibels.
8. Maintain the gear and appearance of your growing area. See Section II, Operations and Management, for best management practices related to maintenance of shellfish gear.

II. Operations and Management

A. Site Marking and Access Control

The great variety of recreational and commercial opportunities on Maryland waters, along with the proliferation of residential development on waterfront property, may lead to user conflicts with aquaculture operations. Seascape impacts, obstacles to navigation, boating safety, waterfowl hunting, and access to the water column over the shellfish beds are all issues that may raise objections to shellfish farms.

While boundary markers for the shellfish grounds are important for boater safety and protecting the beds, a high density can raise complaints about interference with views and access to the area. State regulations already in place that delineate growing areas, ensure access for others, and reduce conflicts with watermen, along with the judicious application of best management practices, can address the concerns of property owners and the maritime community.

Issues

- Delineating and protecting beds
- Seascape Impacts
- Navigation and boater safety
- Public access
    - Water column access (boating, fishing, crabbing)
    - Waterfowl hunting blinds

Best Management Practices

1. Clearly mark corner boundaries and navigation hazards.
2. Markers should be as visually unobtrusive as is prudent. A minimum number of markers should be used to protect the seascape.
3. Unnecessary, damaged, or heavily fouled markers should be removed and disposed of in a timely manner.
4. Recognize other users have access to the water column above the site. Be polite to visitors and look at these visits as a way to educate the public about aquaculture. Inform locals of site markers and their significance.
5. Use of fencing, water-column netting, close-set stakes or other means that extend from the bottom to the water surface and restrict movement through site is strongly discouraged.
6. Be aware of the 500 yard restriction on any fishing activity around duck blinds when occupied for hunting migratory waterfowl. If site access is necessary during this period, work out a schedule with hunting neighbors.
7. Placement of floating gear must be within the permitted boundaries and should be sensitive to navigation issues.
8. It is recommended to not exceed an 18 inch elevation limit on structures placed on site bottom to minimize interference with watercraft.

B. Vessel and Equipment Use

Boats and engine-powered equipment are an integral part of aquaculture operations. However, care must be taken so that use of vessels and equipment, as well as accidental spills of toxic substances, does not damage the environment. Fuels, lubricants, and other chemicals used in routine operations should be properly stored and handled to minimize risk of spillage. Boat and equipment noise is another issue, particularly in residential and recreational areas, as well as areas occupied by noise-sensitive wildlife.

Issues

- Mechanical damage to marine life and habitat
- Pollution
- Noise

Best Management Practices

1. Avoid damaging marine life and sensitive habitat such as seagrass meadows or salt marshes when operating vessels and equipment.
2. Take precautions to prevent release of contaminants from vessels and equipment into the marine environment.
3. Vessels must be in compliance with Code of Maryland Regulation 08.18.03.03 concerning noise. When operating equipment, be aware of the noise generated and try to reduce its impact on neighbors.
4. Keep vessels and equipment clean and well maintained.

C. Predator Control

Predators are the major cause of shellfish mortality in field-culture operations. Maryland waters contain an abundance of mollusk-eating species. To control loss, growers use nets, mesh bags, cages, or other means to exclude predators. This gear must be routinely inspected for displacement, damage, or burial and cleaned of bio-fouling. Because ice can dislodge or damage nets and other gear, they are sometimes removed in winter when predation is low.

There are environmental, navigation, and aesthetic issues regarding protective gear. Dislodged gear can be transported and serve as an entanglement to wildlife and boat propellers. Derelict gear washed up on shore is unsightly and often malodorous. Lost, abandoned, and improperly disposed of netting also creates a negative image of the industry and builds opposition to it.

It is the grower=s responsibility to be sure gear is securely anchored, old netting is properly disposed of, and to completely remove gear and associated materials when operations end. Beyond caring for their own site, growers should retrieve others= derelict gear. Virginia growers have a Clam Net Hotline with a year-round commitment to cleaning up stray nets. This is an idea Maryland growers should seriously consider. A strong group effort by the shellfish aquaculture community to police themselves as well as educating their fellow growers is crucial in dealing with this problem and fostering good will towards the industry.

Issues

- Abandoned, lost, or improperly discarded nets and associated gear
- Pollutants from culture gear
- Loss of access to water column
- Aesthetic impacts

Best Management Practices

1. Make periodic inspections and repair or replace damaged gear.
2. Assure gear is securely anchored.
3. Police site immediately following a storm event to ensure gear and materials are secure.
4. Remove all old or unnecessary gear and associated materials in a timely manner. Re-use, recycle, or properly dispose of all materials.
5. Fencing, water column nets, and closely set stakes are not considered to be best management practices. If absolutely necessary, additional permits are required.
6. In addition to your own, keep an eye on your neighbors' sites and equipment for vandalism and theft.
7. Prepare for winter conditions.
8. Secure or remove gear and be sure it is in good condition
9. Regularly monitor site
10. Conduct a spring cleanup with other growers
11. Do not use exposed lead to secure gear. Dispose of lead responsibly.
12. Use only durable, long-life materials. Materials that readily deteriorate (e.g. unprotected Styrofoam) are unacceptable.
13. Follow good neighbor practices with regards to noise. Restrict activities to daylight hours.
14. Where possible, try to be consistent in color scheme and design (e.g. uniform flotation, structures, rafts, etc.) to present a neat, orderly appearance.
15. Identify gear with tags.
16. Be on the lookout for abandoned gear from others. Always gather this and dispose of properly. Notify the owner of the problem, if possible.
17. Industry and the bay or river keepers might wish to establish an aquaculture gear hotline, similar to Virginia=s Clam Net Hotline, for the public to report derelict gear. Industry should make a commitment to provide cleanup of any gear reported through this system.
18. All culture materials including cover nets, bags, markers, etc. should be clean and free of pollutants, including petroleum-based products such as creosote, oils, greases, or other contaminants.

D. Biological Fouling Organisms

Marine organisms that accumulate on submerged aquaculture gear are known collectively as biofouling. Among many others, these include tunicates (sea-squirts), mussels, and tube-building worms, as well as macroalgae (seaweeds). Although biofouling usually relates to attached organisms, the definition can be broadened to include drift macroalgae and the sloughed-off leaves of seagrasses that may be trapped by aquaculture structures.

Biofouling can become a problem when it clogs the mesh of grow-out nets, bags, and cages, cutting off water circulation to the shellfish. This can inhibit growth and ultimately kill the shellfish unless measures are taken to control the biofouling. Using a hand brush can usually remove most biofouling, especially macroalgae, on the surface of the structure. High-pressure spraying with water is especially effective for mud and sand tubes, especially if they accumulate inside the container. For more stubborn biofouling, the gear may have to be swapped out and dried in an upland location before cleaning, or perhaps even discarded. Chemical treatment of biofouling in not acceptable except for high-concentration brine dips.

There are environmental and aesthetic issues associated with biofouling control, especially concerning the destination of removed macroalgae. The macroalgae may accumulate downstream from the site, smothering organisms or leading to a buildup of organic detritus, or it may wash up on the shoreline, creating visual and odor problems. These concerns are conditions dependent and may not be an issue on a specific site.

Issues

- Water flow
- Macroalgal growth
- Odors and noise

Best Management Practices

1. Inspect gear and routinely to maintain adequate water flow to shellfish.
2. When practical, cleaning should be confined to the aquaculture site. Otherwise, old, heavily fouled gear should be removed and taken to upland sites for cleaning or disposal.
3. Sweeping with brush can remove most biofouling.
4. Do not allow removed material to accumulate on downstream sites where it may cause local environmental degradation.
5. Take care that removed macroalgae does not pose a nuisance. If so, transport to a more acceptable overboard or upland disposal site.
6. If using internal combustion engine, be aware of noise issues.
7. When drying gear be mindful of adjacent upland owners. Clean heavily fouled gear prior to dry storage.
8. Make sure that all upland cleaning activity is conducted at an approved site. Public access boat ramps and parking lots are not approved sites.
9. Do not use anti-fouling paints on shellfish culture gear.

E. Trash Management

Aside from primary gear such as nets, mesh bags, and stakes, aquaculture operations and workers generate other refuse, including used cable ties, old lines, broken baskets, leaking buckets, cans, bottles, plastic bags, cigarette wrappers, etc. It is essential that trash be managed responsibly, both for the environment and the success of the industry. The sight of garbage floating on the water or washed up on shore creates a negative image in the public=s mind, turning people against aquaculture.

Issues

- Effects of discarded or abandoned ancillary materials (cable ties, bottles, lines, baskets, etc) on the environment.

Best Management Practices

1. Remove trash from your grounds, even if not from your operation, and dispose of in an appropriate upland location.
2. Be conservative in using materials; re-use and recycle when possible. This also makes economic sense.
3. Educate members of the industry and their staff on the importance of waste management.

F. Habitat Protection

Among the important marine habitats are seagrass beds, or rooted vascular submerged aquatic vegetation (SAV), which supports a diverse community of animals. Seagrass often occurs in environments that are conducive to shellfish aquaculture, which potentially can affect each other.

Aquaculture activities, such as placing nets or other gear directly on the grasses, boat and foot traffic within beds, and some harvesting practices, can damage plants. The presence of SAV also makes the task of growing shellfish more difficult as nets are lifted off the bottom by the plants, allowing predators access to the shellfish. Sediment and detritus accretion can foul gear and suffocate animals; dissolved oxygen fluctuation and organic sediment common in seagrass beds can inhibit shellfish growth; and the structure of the plants (roots, rhizomes, and shoots) can make it difficult to harvest the shellfish.

On the other hand, the proximity of cultured shellfish to SAV can be beneficial to seagrass. Bivalves filter the water, improving water clarity, which is a limiting factor for SAV growth since plants need light. Shellfish transfer nutrients from the water column to the sediment, fertilizing the grasses. Seagrass seeds and reproductive shoots get trapped in netting, allowing plants to colonize previously unvegetated areas.

Avoid existing seagrass beds when planning an aquaculture operation. If the site is in shallow water, check with DNR for SAV maps but, more importantly, inspect the site during warm weather when the plants are actively growing to determine location and density. Destruction of seagrass through aquaculture is not acceptable and is prohibited in the bottom lease agreement.

Issues

- Damage to important habitat, especially submerged aquatic vegetation, from gear, traffic, and harvesting associated with aquaculture operations.

Best Management Practices

1. Conduct a site visit to a prospective growing area to ensure that it does not contain significant amounts of submerged aquatic vegetation.
2. Avoid planting shellfish or placing gear in existing seagrass beds.
3. If SAV invades areas of existing aquaculture, growers should avoid unnecessary damage to grasses.
4. Minimize damage to seagrass when operating vessels in SAV beds by running vessels at the lowest possible speed with the prop raised to avoid bottom contact.

III. Permitting

There are three major types of shellfish culture in Maryland: the culture of shellfish or seed in land-based facilities, grow-out on submerged (leased) bottoms, and off-bottom grow-out in containers suspended in the water column. State aquaculture permits are not required for grow-out on leased bottom, but harvesting or leasing laws can vary from county to county. Land-based systems will require an aquaculture permit, and may need to address water appropriation or discharge issues. Off-bottom grow-out requires a state aquaculture permit as well as approval from a joint state/federal program for navigable waters (with final approval from the Maryland Board of Public Works).

A Shellfish Import Permit is required for imports across state lines that are destined for placement in the waters of the state. Harvesting and selling seafood, particularly for human consumption, may require Water Quality Certification and harvesting permits discussed in the section on Human Health Issues.

A. Shellfish Bottom Leasing

There are three ways to obtain control of Shellfish Bottom Leases in Maryland. The typical method for obtaining a lease involves checking charts for Natural Oyster Bottom or designated Clam Bottom, then examining areas outside of these for suitable locations. A number of factors determine what might be a suitable location, and it is the responsibility of the applicant to make these decisions, see section I, Site Selection and Access. Applications returned with the appropriate non-refundable fees are followed by a hydrographic and biological survey of the site (see the *Shellfish Leasing flow chart*). Lease applications are then posted for public comment for four consecutive weeks in that county. Discovering commercial quantities of clams or oysters on the site, as well as evidence of recent harvests there, may result in the denial of a lease application.

Another avenue may be to locate abandoned leases in an area, and apply in the same way as for a new lease. Often areas that have been leased in the past are more easily prepared or used for shellfish culture. There are a number of abandoned leases, but about half of the tidewater Chesapeake Bay counties are Aclosed@ to new leasing, particularly in the upper Bay area. These closures were requested by the affected counties and are legislated. Previous leases are honored, but new leases are prohibited.

A third approach would be to transfer an existing parcel from a current leaseholder. Transfers require only a $5 fee. In all cases the recipient of the lease must also meet the standards required of an applicant or leaseholder, such as full-time residency in Maryland and prompt payment of fees or rents.

Maps of existing leases, charted natural resources and cancelled leases may be obtained from the Hydrographic Operations office at the DNR Matapeake Work Station. This office receives applications and performs the hydrographic survey. It should be noted that a number of statutes affect the size, area controlled, and harvest methods used on leases; these laws are located in the *Natural Resources Article, ''4-11A-01 through 15*.

B. Land-based Shellfish Aquaculture
Shellfish aquaculture facilities on land (without water column or bottom rights) will require a state aquaculture permit. Aquaculture permits are issued by the Department of Natural Resources (as required by *'4-11A-02 (2)(b)*) to protect wild stocks of fish, identify fish as products of aquaculture operations rather than natural resources, and serve as a primary entrance to other required permits.

Applications for an aquaculture permit are available directly from the permit coordinator in the DNR Fisheries Service or on-line at the Department=s website. Applications for an aquaculture permit should include site plans and descriptions, maps to the facility, a solid waste management plan for disposing of processing wastes or mortalities, and (if employing others) a certificate of compliance with state workman=s compensation laws.

The species to be raised and its origin must be detailed. Permit holders must keep production records quarterly, and report yearly production to the Department.

For land-based aquaculture, water appropriation and use permits may be required, as well as discharge and/or NPDES permits, pond construction or mining permits (depending on the extent of proposed activities). Appropriate county zoning and use permits must also be obtained. It is the responsibility of the applicant to obtain appropriate county permits. Zoning variances, critical area activity applications, and building permits may be required. Permits may also be required for conducting commercial activities, especially in residential areas.

On land as well as in state waters, water quality criterion for the harvest of shellfish for human consumption must be met. Contact the Department of Health and Mental Hygiene=s Office of Food Protection and Consumer Health Services to inquire if such standards apply to shellfish grown or held in land-based systems.

C. Off-bottom Shellfish Aquaculture
Shellfish culture (not on leased bottom) in public waters involves areas perceived to be utilized by multiple stakeholders, including recreational and commercial fishers, boaters and adjacent landowners. Permission to raise shellfish in navigable waters includes a state aquaculture permit and a Tidal Wetlands License, which is available from the Department of the Environment=s Water Management Administration (see the Off-Bottom Aquaculture flow chart). A permitted area may not exceed 5 acres per individual. Two persons may jointly obtain a permit for up to 10 acres. A single permit may include more than one location.

Activities may not interfere with ongoing oyster bottom leases or fisheries at the same location, and aquaculture is not permissible over charted natural resources or protected State oyster sanctuaries or reserves. In some designated Oyster Recovery Areas, typically in upper reaches of major tributaries, only oysters free of specified oyster diseases may be stocked.

Following an application for an aquaculture permit, an application for a Tidal Wetlands License (required in navigable waters, and for the alteration of any flood plain, tidal or nontidal wetland in Maryland) is normally the next step in receiving approval to conduct aquaculture in State waters. The Tidal Wetlands License is a joint Federal/State application, submitted to the MDE Water Management Administration, Regulatory Services Coordination Office. This joint permit application receives a tracking number and is distributed by the Water Management Administration to the appropriate agencies.

The U.S. Army Corps of Engineers (ACE) will coordinate efforts with other Federal agencies, such as the Environmental Protection Agency, Fish and Wildlife Service, and National Marine Fisheries Service. The MDE Tidal Wetlands Division will coordinate with other State agencies, including the Chesapeake Bay Critical Areas Commission, the MDNR Environmental Review Unit, Natural Resource Police and Boating and Hydrographic Operations Unit, the Maryland Historical Trust and the MDHMH. MDE will also contact the local Planning and Zoning offices. Upon receipt of the Tidal Wetlands License application, all agencies involved will initiate procedures for issuing any other necessary permits. These permits may include a water use permit, waste water discharge permit and Section 401 Water Quality Certification.

The Tidal Wetlands License application review involves issues of conflicting uses of the waterway, as related to activities in navigable waters and land-based operations. Many of the impacts of aquaculture are reviewed, and may include conflicts with established recreational and commercial boating or fisheries, water quality impacts, the protection of submerged aquatic vegetation, boating safety issues, and the like. These considerations are important with the understanding that any water column aquaculture enterprise will impact public rights and traditional uses of the waters, at least to some degree.

A major consideration is that the use of an area for aquaculture does not unreasonably impair navigation. For example, an aquaculture site may not be within a navigable channel marked or maintained by a State, local, or federal agency, or unreasonably interfere with the exercise of riparian rights by adjoining riparian landowners, including access to navigation channels from piers or other means of access.

For many projects at and above 500 square feet of surface area used, a lease of State real property is required. A lease is required because the structures would occupy State Tidal wetlands or waterways for commercial benefit. Following public review and processing of the application, the MDE Water Management Administration makes a recommendation to the Maryland Board of Public Works Wetlands Administration concerning issuance of a Tidal Wetlands License and the granting of a water column aquaculture lease by the Board. Upon approval by the Board, a prescribed one-time license fee is paid to the Board and a rate-per-acre fee is set. The annual fee is paid through the Department of Natural Resources to the State Treasurer for the term during which a pertinent water column lease is valid.

D. Shellfish Import Permit

To protect the shellfish resources of the state from introduced diseases and parasites, imports of shellfish which are destined for immersion in state waters require prior approval (*'4-743, Quarantine of shellfish*). Diseases of the most concern are developed by the Aquatic Health Management Committee under the Aquaculture Council in cooperation with the Department of Natural Resources, to ensure protection of both natural resources and other aquaculturists who may be affected by disease-causing agents.

An application for a Shellfish Import Permit, and listed diseases, may be found on the DNR website (www.dnr.state.md.us). A Certificate of Health (examining for specific diseases or parasites) may be required from the importer prior to approval. The application should be submitted 30 days before a planned shipment; contact the Permit Coordinator at the Department of Natural Resources in advance of any application to determine the animal health status that is required for a given species.

Best Management Practices

1. Contact the Aquaculture Coordinator prior to applying for permits for shellfish culture other than shellfish leases. Specific limitations to and permits required for different types of aquaculture operations are dependent on the proposed activities.
2. File reports required by permit agencies in a timely manner.
3. Contact the Department of Natural Resources for harvesting or planting restrictions on shellfish bottom leases in specific counties or restrictions on shellfish introductions based on disease status.

IV. Human Health Issues
Molluscan shellfish such as clams, oysters, scallops, and mussels, are filter-feeding organisms. They strain surrounding water through their gills which trap and transfer food particles to their digestive tract. If the water is contaminated with disease-causing bacteria, these bacteria are also trapped and consumed as food. Because shellfish pump large quantities of water through the gills each day, bacterial concentrations in shellfish from polluted waters can accumulate to dangerous levels.

Shellfish can be contaminated either in a growing area before harvest or during activities involved in harvesting, processing, or distribution. Since shellfish are routinely eaten raw or partially cooked, the risk is high that if shellfish contaminated by polluted waters or poor handling practices are consumed, human illness will result. Therefore, to assure that molluscan shellfish are safe for human consumption, it is mandatory that shellfish be harvested from approved harvest waters and be harvested, handled, and processed in a sanitary manner.

The Maryland Department of the Environment (MDE) is responsible for conducting sanitary surveys of all shellfish growing waters. This includes monitoring and assessing shellfish waters and the adjacent shoreline to properly classify shellfish harvest waters. The Maryland Department of Health & Mental Hygiene (MDHMH) is responsible for the inspecting, licensing, and certifying shellfish dealers to control the processing and distribution of shellfish.
Management Consideration
1. Classification of the shellfish growing waters determines if shellfish aquaculture may be conducted at a specific location.
2. License and certification will be required to harvest shellfish for human consumption.

A. Site Selection of Traditional On-bottom and Surface Aquaculture
Select sites that have the least variability in water quality, meaning areas where water classification is consistent or remains unchanged. Classifying shellfish waters is an on-going process because water quality is dependent on many uncontrolled factors and the shellfish water classification for any given area is subject to change. An aquaculture business should be aware of and be able to adapt to the potential change in shellfish water classification.

Contact MDE to determine the classification of the proposed aquaculture site. Four classifications are possible:
1. Approved- direct harvest of product allowed
2. Conditionally Approved- direct harvesting allowed when the conditional area is in the open status
3. Restricted- no direct harvest allowed, relay required
4. Prohibited- growing or harvesting of shellfish not allowed

A site may be turn out to be unclassified because the MDE has not made appropriate investigation through sampling and shoreline survey to determine its classification. If the site is unclassified it will take between 18 months and 3 years to gather suitable data to determine the classification.

It is best to find a site that is classified as approved where direct harvesting is permitted at anytime. Restricted sites require relay, where shellfish are harvested and moved to an approved area for natural cleansing. There are water temperature and seasonal restraints in using relay. See *Procedures for Relay* (Appendix, page__) for relay requirements. It is the responsibility of the aquaculturist to locate a suitable relay site and get written permission for its use.

B. Site Selection of Off-bottom, Near-Shore Aquaculture
Off-bottom aquaculture of shellfish in floats is often conducted in areas that have traditionally had no known shellfish population or harvest. Because shellfish sanitary surveys for classification are conducted in areas that have a known shellfish harvest the near-shore sites are often unclassified.

Established sampling stations for natural oyster bottom and lease bottom shellfish do not capture the water quality on the surface; therefore the sampling data may not be applied to a near-shore off-bottom aquaculture site. In order to classify an area MDE must conduct an appropriate investigation of the site through a thorough assessment of the site to include sufficient water sample results to determine water quality and a shoreline survey. The process can take 10 to 18 months before preliminary classification can be determined. The other licenses issued by MDE, BPW and ACE as outlined in section III, Permitting, of this document will not be issued until the classification is determined. Growers should have an approved relay site available since shellfish water at off-bottom, near-shore aquaculture sites is typically classified as restricted.

C. Land-based Aquaculture

1. Local zoning laws may apply.
2. Tanks, pumps, and lines must be constructed of food-grade materials.
3. Water classification requirements are dependent on the type of operation.
4. Wet storage, which is the storage of shellfish after harvest in tanks for purging or salting, requires a DHMH license.

D. Harvest and sale

Molluscan shellfish are susceptible to contamination during harvest, storage, and transportation. Temperature abuse of harvested shellfish allows bacteria to grow in the shellfish which may cause illness and shorten shelf life. To assure that post-harvest shellfish sanitation is maintained, license / certification is required from the MD Department of Health and Mental Hygiene. To gain this license / certification, an aquaculturist must have:

1. Received the required permits from DNR, MDE, BPW, and ACE to operate the aquaculture site;
2. An approved relay area if site is classified as restricted;
3. Taken Hazard Analysis Critical Control Point (HACCP) training;
4. A written operational plan; and
5. A HACCP plan

It is best to contact DHMH, complete HACCP training, and develop plans before shellfish are of harvest size.

V. Biological Management

Successful shellfish culture depends upon having access to sufficient supplies of high quality water. The parameters that are required depend largely upon the species being cultured and the use of those species. Species destined for human consumption will also be expected to be cultured in water that meets standards developed by government agencies designed to protect human health. Location of an aquaculture operation at a site with poor water quality is usually problematic and should be avoided.

A. Water Quality for Shellfish Growth and Health:

Site selection should result in locations that provide the water quality parameters necessary for good growth and survival of the species being grown. Issues include:

1. Salinity: The amount of salt in the water can be highly variable both seasonally and from year to year. Care should be taken to insure that those variations are not so severe as to cause problems with either growth or survival of the shellfish.
2. Temperature: Water temperatures also vary seasonally and geographically within Maryland. As with salinity, care should be taken to insure that those variations are not so severe as to cause problems.
3. Dissolved Oxygen: Many water sources experience fluctuations in dissolved oxygen with severe cases resulting in hypoxia or anoxia. Either of these events are capable of causing problems during culture either in growth or survival.
4. Suspended Sediments: Heavy sediment loads can cause problems with culture. While usually not as severe as A, B, and C above, extremely heavy sediment loads should be avoided.
5. Algal Blooms: Many shellfish are filter feeders and as such depend upon algae for growth. The presence of sufficient quantities of high quality phytoplankton will largely determine the growth rate and impact the survival of the crop. Where possible, care should be taken to locate shellfish operations where advantageous algal blooms are typical
6. Harmful Algal Blooms: Harmful algal blooms (HAB=s) are common in Maryland and around the world. Their occurrence is increasing and both periodicity and severity. Not all HAB=s are harmful to shellfish

growing operations but many are. HAB=s can cause growth to stop or cause mortality. There may also be human health risks associated with HAB=s. Location of a shellfish growing operation in locations where regular HAB=s occur could result in unmarketable product for at least part of the year.

7. Disease: Shellfish are prone to several diseases and some of these can cause huge mortalities in the crop. Potential growers should become familiar with those diseases likely to effect their crop and the water quality conditions necessary for them to proliferate. It may be possible to locate all or part of an operation away from some water quality parameters to minimize effects of disease.
8. Polluted Waters: There are many types of pollutants possible in any water source. In general, it is recommended that shellfish growing operations be located away from waters that contain toxic pollutants. While impossible to list all potential pollutants in this document, some of the more commonly encountered are:
    - runoff from industrial or urban areas
    - point source discharge from industrial or sewage treatment plants, marinas (which may contain high concentrations of anti-fouling chemicals) and
    - areas subject to episodes where heavily polluted bottom sediment may be stirred up and re-suspended

In summary, BMPs for shellfish culture should incorporate all of these issues. It should be understood that often more than one of these water quality concerns will be an issue at a site. The presence of a single water quality issue may not be a make or break decision but many of them are. Often the presence of several of these issues, while even on a minor basis, may jointly become severe and render the shellfish culture operation ineffective.

B. Restoration Shellfish Aquaculture

A recent emphasis in Maryland has been the production of shellfish for use in restoration programs. While most of the above concerns apply to this specific type of aquaculture there may be instances where some of them are not applicable. For instance, water quality associated with human health issues need not be applicable to shellfish used to restore sites that are not designated for human consumption. Also, production of some stages of the shellfish life cycle may be able to be cultured even in the face of some water quality issues if they will be re-located to other sites sometime during their life cycle. BMP=s for restoration aquaculture may be very different than those recommended for shellfish destined for harvest and subsequent human consumption.

In summary, it is best to locate any aquaculture operation away from water quality problems. The benefits to not only the species under culture but also to the amount of regulatory issues that need to be dealt with in order for the crop to be sold for human consumption.

C. Genetics

Shellfish growers may benefit from recent advances in the field of genetics. Hatchery production of oysters, clams and other shellfish species are generally produced through the use of wild broodstock or from broodstock that have been produced in other hatchery operations. Recently, researchers have successfully produced broodstock that may result in superior performance for farming. Much of this effort has been targeted on the development of oyster stocks that survive to market size in the face of disease and yield (the product of survival and growth). For example, several stocks have been developed by the Mid-Atlantic Shellfish Genetics and Breeding Consortium that have been used to produce market sized oysters in areas impacted by disease. This work is ongoing and some success is evident in the growth of oyster culture especially in Virginia. Further success is anticipated with additional improvements in traits, such as shell growth, meat quality, or shelf life. Selection, particularly by commercial hatcheries themselves, has also begun on hard clams and it is likely that future research could include other economically important species as the need is identified.

Another aspect of genetics is ploidy manipulation. It is possible through hatchery manipulation of the fertilization process or using tetraploids to produce shellfish that are triploids (three sets of chromosomes, like many domesticated plant species). Triploids have been a valuable tool in many shellfish grow-out operations around the world and increasingly in aquaculture in the Bay. Since triploids do not expend much energy producing gametes they may exhibit increased growth. The extent of this growth advantage can only be determined by deploying them in specific grow-out systems and recording their performance over non-triploid animals. Another benefit of triploid animals is that they do not spawn and therefore they do not undergo a dramatic loss of meat quality during the spawning season like their diploid counterparts. This can result in a superior quality product to market during periods of the year when diploid animals are difficult to sell. Finally, a third advantage of triploids, because they are sterile, is that they can be farmed in close proximity to natural populations of shellfish with no effect on the population genetics in wild animals. That is, they can not interbreed with natural populations (or themselves) making it possible to juxtapose farming and restoration.

Despite the use of domesticated stock for farming, hatchery operators should still consider proper fertilization techniques that insure the maximum genetic diversity among the larvae produced. Failure to use reasonable number of parents for larval batches could result in partial or total larval failure. Even in batches of larvae that successfully complete the larval period and result in seed stocks, limiting the number of broodstock can result in genetic bottlenecks that could begin to express themselves in poor performance of the stocks over time.

For restoration aquaculture, genetic considerations may be quite different than for farming. Typically, every effort should be made to insure that the Aeffective population number@ of parents is as high as possible. For one, restoration animals are planted in the environment with the expectation that they will survive, grow, and contribute to the natural recruitment of the species in the region. There have been concerns raised over the potential for creating genetic bottlenecks in the wild populations that could ultimately have deleterious effects on the naturally occurring stocks. Conversely it has also been proposed to use selected stocks (which by design have some degree of bottlenecking) to infuse desirable characteristics into stocks suffering from disease. Neither of these concerns has been adequately proven and it remains to be seen whether shellfish growers will need to be concerned with special genetic practices for restoration in the future. However, there are some simple steps that can help to moderate any ill effects from hatchery planting of oysters for restoration.

Most restoration projects are fairly large in scale involving millions of animals. Additionally, most sites receive seed oysters more than once and in multiple years. One approach to minimizing potentially harmful effects of limited parental contribution is to plant seed oysters from spawns produced from as many parents as possible, to plant sites with seed oysters from multiple spawns, and to plant sites with multiple year classes. Unless broodstock are collected from the population that is being restored B a practice surely to result in population bottlenecks B using multiple spawns over multiple years will increase the number of parents that contribute to the genetic diversity of the population on the restored bar.

SECTION IV: NON-NATIVE SPECIES

Subcommittee Membership:
Chip Crum, Industry, Chair
Rich Bohn, Department of Natural Resources
Harley Speir, Department of Natural Resources

Many species raised by aquaculturists are not native to Maryland. The typical aquatic organisms raised are hardy in captivity, have life-cycles which can be controlled and manipulated, and have good marketability. These species may or may not have a natural range in Maryland, and non-native species warrant special consideration from an environmental and regulatory viewpoint.

Best management practices for Non-Native Species are divided into the following sub-sections:

- **I. Background**
- **II. Definitions**
- **III. Permitting**
- **IV. Best Management Practices**

I. Background

Non-native species raised in aquaculture have three potential ways to impact their surroundings: escapes or releases of cultured stocks may compete with native aquatic organisms, gametic material from fertile adults may enter the gene pool of native organisms, or aquatic diseases or parasites may affect native organisms. The aquaculture of hybrid species and transgenic species are also included in this section for the same reasons. Thus, while culturing methods are similar to those described in other chapters of this manual, containment methods and the fate of effluents must be more tightly controlled for non-native species. These considerations are paramount even if the species is raised indoors.

Non-native species that are considered "nuisance organisms" or "invasive species" demonstrate rapid spread once introduced into a naïve environment, and either displace native species or exhibit characteristics that require expensive mitigation. For example, the zebra mussel can both replace native mussel species and colonize and clog intake pipes for power plants or water supplies. Those species considered invasive may be subject to greater restrictions than other non-native species. Degree of invasiveness or potential for becoming a nuisance species is not always known beforehand and the cultured organism will be evaluated during the application process.

II. Definitions

In Maryland, the following definitions are found in Code of Maryland Regulation 08.02.19, "to control the importation, possession, propagation, transport, purchase, sale or introduction into state waters of certain nonnative aquatic organisms".

(1) "Historically" means commonly accepted to have been in State waters in the year 1500.

(2) "Hybrid" means the offspring of any species of fish of genetically dissimilar parents or stock.

(3) "Introduction into State waters" means the deliberate or accidental release of an aquatic organism into State waters.

(4) "Native" means having historically lived, grown, and reproduced in State waters.

(5) "Naturalized" means documented as having lived, grown, and reproduced in State waters for more than 10 years without known harm to the ecosystem.

(6) "Non-native" means any species other than native or naturalized.

(7) “Nuisance organism” means a nonnative aquatic organism that will foreseeably alter and threaten to harm the ecosystem or the abundance and diversity of native or naturalized aquatic organisms.

(8) “State waters” means tidal and nontidal waters located within the boundaries of the State, including that portion of the Atlantic Ocean within the boundaries of the State, the Chesapeake Bay and its tributaries, and all ponds, lakes, rivers, streams, public ditches, tax ditches, and public drainage systems within the State.

(9) “Transgenic” means an organism into which genetic material from another organism has been experimentally transferred so that the host acquires the genetic traits of the transferred genes.

(10) “Transport” means to move a nonnative aquatic organism from one watershed, as named by Maryland Integrated Watershed Data and Information System to another watershed, as named by Maryland Integrated Watershed Data and Information System.

(11) “Without known harm” means a species has acclimated or adapted to life in Maryland's waters for more than 50 years without diminishing the abundance, diversity, distribution or reproduction of a native species or degrading water quality requirements for a native species

These definitions apply to all activities that may affect the waters of the state, including stocking for recreational fishing or environmental enhancement activities.

III. Permitting

The aquaculturist that is considering raising a non-native, hybrid, or genetically-altered species will not be permitted to raise or sell their products in a manner that result in the release of these stocks into Maryland waters. An inspection of the growing facility is required prior to the issuance of an aquaculture permit for these species. Consideration of the markets is a factor in permitting. Sales that exclusively target the aquarium trade, ornamental ponds or processed food markets will receive different consideration than species that may be used in recreational fish stocking or live-fish markets. The life cycle of the species, its tolerance for local environmental conditions and history of invasiveness in other regions may be factors in the degree of containment required. An applicant for an aquaculture permit in Maryland should seek information about issues raised in other regions where a particular non-native species has been cultured before, and expect similar considerations here.

To identify any possible problems with escapement or health status of stocks imported into Maryland, the source of the stocks is specifically approved during the permit process. Health screening to determine whether specific pathogens or parasites are present may be required for every shipment imported. A list of prohibited pathogens may be found on the DNR website at: *http://dnrweb.dnr.state.md.us/download/fisheries/importpolicy.pdf*

If the stocks are to be imported from outside the United States, approval must also be received from the U.S. Fish and Wildlife Service (USFWS). Some species are banned; typically these display invasive characteristics. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA/APHIS) may prohibit imports of stocks from countries where harmful pathogens are endemic, and imports are restricted until safeguards are in place. Quarantine of imported stocks may be required, and must only enter pre-approved facilities. Check the USFWS and USDA/APHIS websites for more information.

IV. Best Management Practices for Non-Native Species

1. Aquaculturists who raise non-native aquatic species are responsible for preventing their release into the environment, either by the culture system or by purchasers intending release to state waters.
2. Aquaculturists who raise non-native aquatic species are responsible for notifying purchasers that release of these organisms to state waters is prohibited.
3. All holding, culture or transport systems must be designed and operated to prevent the liberation of non-native, hybrid or transgenetic aquatic species, pathogens, or gametic products to the waters of the state.
4. Mortalities of non-native, hybrid and transgenic species should be disposed of in an approved manner that minimizes the chances of environmental contamination.

5. The facilities must have effective measures in place to prevent the theft of non-native, hybrid and transgenic species.
6. Aquaculturists importing stocks from outside the U.S. should receive prior approval and follow all protocols required by the USFWS and USDA/APHIS.
7. Written records of live non-native, hybrid and transgenetic organisms sales and transfers must be maintained and available for inspection for a period of two years.
8. Any non-native species, or species with an origin outside the state, must be approved by the Department of Natural Resources before release into Maryland waters by the aquaculturist or a purchaser.
9. The import of any non-native, hybrid or transgenic species or native species with an origin outside the state, into Maryland must be approved by the DNR.

SECTION V. AQUATIC ANIMAL HEALTH

Subcommittee Membership:
Karl Roscher, Maryland Department of Agriculture, Chair
Larry Pieper, Maryland Department of Natural Resources
Dr. Ana Baya, Maryland Department of Agriculture

The success of aquaculture depends on minimizing the impacts of disease producing organisms. This requires rapid detection and control of pathogens as they appear, anticipation of problems resulting from pathogens before they occur, and managing around pathogens when they become established. The goal is to reduce loss that results in economic harm to the aquafarmer by establishing an infrastructure of support to the aquaculture industry similar to that enjoyed by traditional forms of agriculture. Without support provided by a combination of both public and private assistance, aquaculture within the state could be seriously deterred in its becoming an economic asset to the State of Maryland.

The legal authority for state fish health standards resides in agriculture and resource agencies. Federal health standards apply to international movement of fish and are administered by the U.S. Department of Agriculture or the U.S. Fish & Wildlife Service.

Maryland's Aquatic Animal Health Policy and Implementation Plan has been established to protect the ecological integrity of natural aquatic populations and economic integrity of the aquaculture and fisheries industries. It is the policy of the State of Maryland to control or prevent the introduction and spread of pathogens and other substances that threaten the health of fish, mollusks and crustaceans resident to the State. This document is available on the web at: *www.marylandseafood.org/aquaculture/animal_health.php*

Best management practices for aquatic animal health are divided into the following sub-sections:

- **I. Facility Management**
- **II. Animal Husbandry**
- **III. Disease Prevention and Management**

I. Facility Management

Good aquatic animal health practices are a necessary component of any aquaculture facility's operational plan. Disease prevention is based on good animal husbandry including reducing animal stress and quarantine of animals entering the facility. The following Best Management Practices are intended to provide the basis for developing a sound health management, disease prevention and sanitation program within your facility.

1. Research and educate yourself on fish health and management requirements of all species that you intend to raise.
2. Obtain the proper import and stocking permits prior to receiving any aquatic animals. Applications available from the Department of Natural Resources.
3. Maintain appropriate records and documentation on all shipments of animals in and out of the facility.
4. Inquire with the supplier regarding the health status of all aquatic animals to be stocked at the facility. Request a health certificate to insure that these animals are free of serious disease-causing organisms and have been screened for pathogens of concern in Maryland. Make sure the supplier is registered with the Maryland DNR.
5. Institute effective bio-security measures to reduce the risk of the transfer of disease producing organisms to your farm and between culture systems on your farm. ***Appendix I***
6. Prepare and maintain an aquatic animal health management plan to avoid fish health problems and to respond in the event of a crisis. Recognize when you are beyond the scope of your knowledge and expertise and consult a professional.
7. Keep daily records of animal behavior, feeding activity and mortality to be able to distinguish between normal behavior and the early signs of a problem.
8. Know your state fish health contact person and how to contact him or her. Your contact person may be an aquatic animal health veterinarian, certified fish pathologist, or university extension specialist. ***Appendix II***

II. Animal Husbandry

Changes in management strategies will be necessary as scientific data accumulates on the understanding of disease causative agents, methods of transmission, the development of more precise diagnostic procedures and the description of new pathogens. As management strategies to prevent disease are developed, there is a need to make them sufficiently flexible to accommodate special situations. Continued surveillance and vigilance are necessary to avoid the introduction of infectious diseases.

1. Maintain optimum water quality and oxygen levels.
2. Avoid over-crowding.
3. Use high quality feeds with proper nutritional levels.
4. Avoid over-feeding and remove any uneaten feed.
5. Minimize handling and temperature related stress.
6. Remove organic debris from culture system.
7. Remove dead fish immediately and dispose of properly.
8. Maintain a high level of sanitation throughout the facility.
9. Routinely sanitize nets and other farm equipment.
10. Call for professional assistance early.

III. Disease Prevention and Management

Given the necessity of movements of aquatic animals and the possibility of introducing infectious diseases with them, best management practices to avoid the dissemination of finfish and shellfish pathogens and how to mange the facility during a problem are required. It must be understood that just a few diseased animals may be sufficient to destroy an entire stock of aquatic animals. There should also be a commitment to compliance and enforcement of existing regulations.

1. Establish adequate quarantine practices and procedures.
2. Prevent the introduction of organisms that cause disease into your farm. Sources include infected fish, water, equipment, farm traffic and visitors.
3. Develop a schedule for water quality testing and consistently check for dissolved oxygen, temperature, pH, nitrite, and ammonia. Establish an action plan to correct unhealthy water quality parameters.
4. When fish health problems occur, contact fish health experts. Aquatic animals affected by disease or in an otherwise compromised condition should be sent to a diagnostic laboratory for evaluation. ***Appendix III***
5. Contact the appropriate authority when reportable diseases occur.
6. Carefully consider disease treatment options after a thorough assessment of the culture system, water quality and a review of diagnostic reports. Treatments should begin with improving management and husbandry regardless of other options utilized.
7. Only use chemicals, medications, therapeutic drugs and other remedial agents in accordance with all Federal and State guidelines and laws, label instructions or as directed by a licensed veterinarian. There are restrictions on these applications as they may impact public health and waters of the state.
8. Clean and sanitize the facility, culture system and equipment following disease outbreaks and prior to restocking.

Always be conscious that farm management practices can impact human health and the environment. Aquafarmers are responsible for maintaining good fish health to eliminate any adverse impact to the state’s natural resources, other producers, consumers, and their own facility. Prepare for problems and use these Best Management Practices to prevent the occurrence and reduce the severity of fish health problems on your farm while doing so in a safe and responsible manner.

SECTION VI. SHIPPING, TRANSPORT, AND SALE

Subcommittee Membership:
Bob Parkinson, Industry, Chair
Erin Butler, Department of Health and Mental Hygiene
Kathy Magruder, Department of Business and Economic Development

This section provides operational guidelines for the safe and cooperative movement of aquaculture products from location of aquaculture operations to point of sale. Practices are designed and recommended to address general issues of related to the transport, shipping and sale of the many possible species in Maryland Aquaculture. Many are based on experiences from other states that have implemented BMPs as a primary means of regulating the industry.

Though this section covers shipping, transport and sale, there are additional BMPs in other sections that producers will need to understand and implement depending on their production system and goals. BMPs are a continuous work in progress. As new species, culture systems, and water use technology are developed they require periodic field verification and updating.

Best management practices for shipping, transport and sale are divided into the following sub-sections:

- **I. Transportation prior to post-harvest shipping and sale**
- **II. Considerations for daily motorized transport to and from aquaculture site**
- **III. Prevention of spread of aquaculture farm diseases**
- **IV. Traceability of product**
- **V. Controlling impact of equipment spills and leakage**
- **VI. Detailed shipping considerations**

I. Transportation Prior to Post-Harvest Shipping and Sale

There are conditions in which the optimum site for aquaculture farms may front on an upland owner who will control the access to the farm. Aquaculture farmers are neighbors to many other users of the inter-tidal and shallow sub-tidal environment and, as such, they must be sensitive to the needs and expectations of their neighbors to minimize potential conflicts or detrimental interactions. At times, these realities appear to conflict but in truth they are complementary. Good neighbor policies coupled with high water quality within a healthy environment will make local aquaculture crops more competitive in today's markets.

If these considerations are coupled with practices that increase crop productivity, then everyone wins, including the public, other coastal users, and the shellfish growers. These aspects include the movement of the product overland on the right of ways and that may be unimproved and through and within site of neighbors. The following best management practice is often ignored but always produces good results:

1. Cultivating seafood and other aquatic products includes cultivating good rapport with your neighbors, including those that front or own the land under your right of way to your aquaculture farm.

II. Considerations for Daily Motorized Transport to and from Aquaculture Site

Location and layout of aquaculture farm areas must consider access to the site, including motorized transport, for daily and normal maintenance of the structures and product.

Maintenance of aquaculture farms requires intensive activity during initiation and termination of the growing process as well as constant diligence to ensure optimal growing conditions for the product. These activities may require transport of materials and equipment to and from the site. Routine maintenance may be achieved through the use of low impact equipment left on-site and access may be limited to foot or boat traffic. However during set-up, selected maintenance and harvest, transport of heavier materials to the site may necessitate motorized transport on occasion. If access to the leased site is through a wetlands buffer zone, as defined in the Wetlands Protection Act and is not a pre-existing public access point, the applicant (either individual or county) may be required to submit a Request for Determination of Applicability or a Notice of Intent with the local governmental authorities to permit such activities. Specific BMPs are:

1. Whenever possible or feasible, access to the farm site should be limited to foot or boat traffic.
2. Research your site and plan routes for access and maintenance prior to the initial permit application and development of your site.
3. For farms located in the tidal and non-tidal waters of Maryland there are a number of public access points. Plan to use public access routes whenever possible to minimize transport over private property.
4. If access is direct from a privately owned upland site, you should get written permission from the landowner whose property you are traversing. In any case, establish a rapport with the landowner that will front your farm.

III. Prevention of Spread of Aquaculture Farm Diseases

Aquatic animal diseases can be spread through transport of infected product. As is true of all infectious diseases, the occurrence of the disease requires that the causative agent be present in the environment. When the environmental and host conditions are sufficiently compromised, a pathogen can proliferate and cause the disease. Some pathogens are capable of living outside of their host in the environment while others must reside in the host to survive.

Regardless of the pathogen's requirements, introduction of a pathogen within an unaffected area is necessary to spread disease. Some diseases, such as the oyster disease MSX, can have an intermediate host that may serve to carry the disease from one site to another. Other pathogens are more easily moved from site-to-site because they are capable of living outside of the host and may be moved via sediment or water transport.

Another concern, for aquaculture farmers, is the inadvertent movement of disease through wet storage of imported product. The risk of moving disease through wet storage is exceedingly high and the public must be educated concerning the risk to local product stocks from this practice.

The Maryland Department of Natural Resources has authority to control the interstate movement of aquaculture products as well as transport across town boundaries within the state. During disease situations, DNR may impose shellfish movement restrictions, contingent on health inspections, to manage the movement and reduce the risk of spreading the disease. USDA-APHIS may also impose restrictions on the movement of aquaculture products (http://www.aphis.usda.gov/vs/aqua). To reduce the risk of introducing or spreading disease, follow these best management practices:

1. Purchase aquaculture product seed, fingerlings or saplings that have been produced by a commercial hatchery certified by the DNR for importation into the State.
2. Due to potential disease problems and the possibility of spreading the disease by your actions, do not move product from one water body to another without consulting local and/or state authorities. All aquaculture products being moved require DNR permission.
3. When grading or handling under-size product and replants off-site, keep lots from different sites separate, be aware of the originating source and do not move animals from one water body to another.
4. If grading in a common-use facility, ensure your product culls and replants do not co-mingle with those of other growers. Return only your product to your growing area.
5. When exposing equipment to product from different locations and/or when moving equipment between farm sites, rinse the gear thoroughly with freshwater (and, preferably, biodegradable soap) between uses to minimize the risk of spreading pathogenic organisms.
6. Do not dispose of cull product or its residual waste into the marine environment. Compost the product for an interval until the products have decomposed and the wastes are clear of tissue.
7. It is not legal for unlicensed individuals to hold product in seawater systems that flow into the open environment (wet storage). Be aware of others practicing wet storage of foreign product in your area. When possible, educate the public about the risk of disease introduction associated with wet storage of foreign product and, if necessary, report incidences of illegal wet storage to the appropriate authority.

IV. Traceability of Product

Traceability of product from harvest area to consumer sale is extremely important to prevent and in the event of illness or disease introduction, initiate actions to prevent spread of disease and illness.

Product traceability is a crucial component of the disease prevention and spreading. It interconnects links in the aquaculture product chain and allows each lot to be traced back to the source and inputs of origin. Results of food quality and safety analyses by accredited laboratories can also be included. Traceability ultimately assures the purchaser that all steps in the production process were in compliance with environmental, social and food safety standards.

Aquaculture farmers and product processing plants can maintain paper records of the required data in notebooks or files using the sample Processing Plant Product Traceability Form below. If possible, the information should also be transferred to computer database files, with the original files kept to allow verification of the electronic data. The record-keeping process requires timely, organized, accurate entries ideally performed by a single clerk responsible for collecting the data and transferring it to the database.

In the movement of the product a copy of its previous history should accompany the movement of that product and the receiver of the product should add their processing history to that provided by the farmer. Aquaculture product buyers will then have access to the information for chain-of-custody traceability.

Adequate record keeping is only meaningful when combined with procedures that maintain lot separation. Incoming lots of product from farms shall not be stored, mixed or processed with lots from other farms.

Boxes and masters shall be accurately labeled and primary box or bag containers shall be clearly marked with processor lot identification numbers. Monitoring records for microbial and chemical analysis shall be provided for production lots.

Best Management Practices:

1. To establish product traceability, the following data shall be recorded for each farm lot and each production cycle (as applicable) (see sample form below):
    a. Farm lot identification number
    b. Farm area
    c. Stocking date
    d. Quantity of post larvae stocked
    e. Source of post larvae (hatchery)
    f. Antibiotic and drug use
    g. Herbicide, algaecide and other pesticide use
    h. Manufacturer and lot number for each feed used
    i. Harvest date
    j. Harvest quantity
    k. Sulfite use and protocol
    l. Processing plant or purchaser
    m. Date and time of product reception at plant
    n. Plant lot number
    o. Finished lot weight, if applicable
    p. Product form and count
2. Processing plants shall maintain documentation records from producers that verify sources of post-larvae and feed use, and report chemical treatments. Plants shall also keep records of testing data for the presence of microbes, antibiotics and chemicals in the product.
3. As lots of product from farms are sold or shipped to buyers, the processing plant shall record:
    a. Buyer name
    b. Buyer identification
    c. Lot quantity shipped
    d. Shipping date
    e. Invoice/transfer number
4. The recipient of the product shall maintain all pertinent chain-of-custody records, including those related to shipment and invoicing.

Sample Processing Plant Product Traceability Form

PROCESSING PLANT ACC Plant Number	New Lot Number
Lot Weight	Species
Received From: FARM ACC Farm Number	Farm Lot Number Reception Time/Date
Postlarvae Source Statement Available? Y N	Feed Source Statement Available? Y N
Chemical Treatments Statement Available? Y N	
Antibiotics Testing Statement Available? Y N	Heavy Metals/Pesticides Testing Statement Available? Y N
Product Form/Count 1	Product Weight
Product Form/Count 2	Product Weight
Product Form/Count 3	Product Weight
Product Form/Count 4	Product Weight
	Total Finished Product Weight
Plant Analysis Results for Microorganisms	Results for Chemical/Antibiotic Residues
Analysis Results for Finished Product	Analysis Results for Cooked Shrimp
Sold To: BUYER ACC Buyer Number	Shipping Date
Lot Quantity Shipped	Invoice Number
Container Company/Number	Destination

V. Controlling Impact of Equipment Spills and Leakage

The intensity of operations at a farm and at processing plants often require heavy machinery and the itinerant environmental impacts of spills and leakage from the equipment need to be addressed and mitigated.

Oil leaks and spills from equipment should be prevented through good maintenance. Used oil and contaminated refrigerants should be removed and disposed of properly. Outdated chemicals and wastes collected after spills should be properly confined, labeled and disposed of in a safe place to avoid environmental damage or danger to animals or humans.

Specific BMPs are:

1. Sanitation Control Procedures:
   a. Ensure the safety of water and ice in contact with food and food contact surfaces.
   b. All surfaces and substances in contact with food, or in food production areas that might come in contact with product, must be food grade and/or made of impermeable, easily cleaned and sanitized materials or materials that will not shatter and adulterate product. (Glass is an example of a material that can shatter and create a food hazard.)
   c. Maintain and clean food contact surfaces, equipment and clothing.
   d. Prevent cross-contamination between raw and cooked products and from unsanitary contact surfaces, clothing and equipment.
   e. Maintain hand-washing and toilet facilities.
   f. Protect food, packaging materials and food contact services from adulteration with chemical, biological and physical contaminants.
   g. Properly mark, store and use chemical and toxic compounds.
   h. Control employee health conditions to avoid contamination of food, packaging or contact surfaces.
   i. Exclude and control animal pests.

j. Remove all spoiled, decomposed or adulterated products and materials.
k. Monitor cleaning and sanitizing activities that directly contact food and food contact surfaces.
l. Verify the efficacy of cleaning and sanitation procedures and of food safety through product analysis carried out at a frequency specified by the processor and showing that control is sufficient to prevent adulteration for those hazards the processor has identified as controlled.

VI. Detailed Shipping Considerations

Multiple sections of the National Shellfish Sanitation Program cover the Shipping and Transportation of Shellfish. Many of those considerations are applicable to other aquaculture products grown and shipped for human consumption. This section is a plain language reproduction of the transportation section of the NSSP. They are also suitable for consideration of other kinds of aquaculture but should be refined for non-food shipping and transportation, i.e., aquatic stock, aquatic plants. Utilize the following best management practices as applicable to your product:

A. Shipment Acceptability. Shellfish shipments shall be considered acceptable when:
1. Shipments are properly identified with tags and/or labels and shipping documents;
2. Shellstock is alive and cooled to an internal shellstock body temperature of 50° Fahrenheit (10 ° Centigrade) or less;
3. Shucked or post harvest processed shellfish are cooled to a temperature of 45° Fahrenheit (7.2 ° Centigrade) or less; and
4. The time-temperature indicating device shows that the ambient air temperature has exceeded 45° Fahrenheit (7.2 ° Centigrade) but the shellstock internal body temperature is 50 ° Fahrenheit (l0 ° Centigrade) or less;

B. Shipment Rejection: Shellfish shall be rejected when:
1. Shellfish are not properly identified with tags or shipping documents;
2. Internal shellstock body temperature exceeds 60° Fahrenheit (15.6 Centigrade) unless the harvest initiation time can be documented and indicates that the time from harvest has not exceeded the requirements state elsewhere
3. Shucked shellfish exceeds 50° Fahrenheit (10° Centigrade); or
4. It is determined that the product is unwholesome or unsafe for human consumption.
5. The rejecting party shall notify the shipping dealer, the receiving dealer, and the Authority in the State where the shipment originated of the shipment's rejection.

C. Bacteriological Examination of Shellfish Shipments:
If the State chooses to sample, the following protocol shall be used:
1. Bacteriological samples of any shellfish taken for the purpose of rejection of shipments from out-of-state dealers shall be collected within twenty-four hours of the shellfish entering a State.

D. Bacteriological examination shall be made of the shellfish shipment if:
1. The internal body temperature of the shellstock exceeds 50° Fahrenheit (10° Centigrade) and is less than or equal to 60° Fahrenheit (15.6° Centigrade) unless the harvest initiation time can be documented and indicates that the time from harvest has not exceeded the requirements stated elsewhere;
2. The shucked shellfish temperature exceeds 45° Fahrenheit (7.2° Centigrade) and is less than or equal to 50° Fahrenheit (10° Centigrade);
3. The shipping time exceeds four hours and there is no temperature recording device or the recording
4. device is inoperative; or
5. The Authority determines it is necessary.

E. Requirements for the Harvester/Dealer:
1. Trucks or Other Vehicles Used to Transport Shellstock to the Original Dealer.
   a. The harvester, or dealer who transports shellstock from the harvester to the original dealer, shall assure that all trucks used to transport shellstock are properly constructed, operated, and maintained to prevent contamination, deterioration, and decomposition.
2. Storage bins on trucks or other vehicles used in the transport of shellstock for direct marketing shall be:

    a. Kept clean with potable water or water from an approved area or conditionally approved area in the open status; and
3. Provided with effective drainage.
    a. Shellstock shall be transported in adequately refrigerated trucks when the shellstock have been previously refrigerated or
    b. When ambient air temperature and time of travel are such that unacceptable bacterial growth or deterioration may occur
    c. Pre-chilling trucks or other vehicles shall be required when ambient air temperatures are such that unacceptable bacterial growth or deterioration may occur
4. When mechanical refrigeration units are used, the units shall be:
    a. Equipped with automatic controls; and
    b. Capable of maintaining the ambient air temperature in the storage area at temperatures of 45° Fahrenheit (7.2° Centigrade) or less
5. Ice used to cool shellstock during transport shall meet the requirements of *Chapter XI.02A.(2)*.
6. Cats, dogs, and other animals shall not be allowed in any part of the truck or other vehicle where shellstock is stored.

F. Receiving Shellfish

For the purpose of this section, temperature control is defined as the management of the environmental temperature of the shellstock by means of ice, mechanical refrigeration or other means approved by the Authority.

1. The dealer shall reject or discard any shellfish shipments which:
    a. Do not originate from a licensed harvester or dealer; and/or
    b. Are unwholesome, inadequately protected, or whose source cannot be identified.
2. Transportation agents or common carriers used by a dealer are not required to be certified.
3. The dealer shall:
    a. Inspect incoming shellfish shipments to assure that the shipments are received under the conditions required in this Chapter;
    b. Place shellstock under temperature control within 2 hours after receipt from the harvester, or when the dealer is also the harvester
4. When shellstock reaches the dealer's facility;
    a. Ensure that shellstock are not permitted to remain without ice, mechanical refrigeration, or other approved means of lowering the internal body temperature of the shellstock to, or maintaining it at, 50° Fahrenheit (10° Centigrade) or less for more than 2 hours at points of transfer such as loading docks;
    b. Ensure that shucked shellfish are not permitted to remain without ice, mechanical refrigeration, or other approved means of maintaining shellfish temperature at 45° Fahrenheit (7.2° Centigrade) or less; and
    c. Ensure that frozen shellfish remain frozen.

G. Transportation Containers:

1. All containers used to transport shellstock shall be:
    a. Constructed to allow for easy cleaning; and
    b. Operated and maintained to prevent product contamination.
2. All containers shall be cleaned with:
    a. Potable water; and
    b. Detergents, sanitizers, and other supplies acceptable for food contact surfaces.

H. Cargo Protection From Cross Contamination.

All containers used for storing shellfish shall be clean and fabricated from safe materials.

1. Shellfish Cargo Only:
    a. The entire cargo shall consist of shellfish products only.
    b. Except for bulk shipments, shellstock shipments shall be shipped on pallets.
    c. If the conveyance does not have a channeled floor, pallets shall be used for all shellfish.

2. Mixed Cargo: Shellfish shall be shipped as part of a mixed cargo of seafood or other food product only when:
    a. Shellfish products are protected from contamination by the other cargo;
    b. All cargo is placed on pallets; and
    c. No other cargo is placed on or above the shellfish unless all cargo is packed in sealed, crush resistant, waterproof containers.

I. Ice: ice used to cool shellfish shall meet the requirements of Chapter XI.02A.(2).05

J. Shipping Times:
1. When the shipping time is four hours or less, the dealer shall ship all shellfish:
    a. Well iced; or
    b. Using other acceptable means of refrigeration.
    c. When mechanical refrigeration units are used, the units shall be equipped with automatic controls and shall be capable of maintaining the ambient air in the storage area at temperatures of 45° Fahrenheit (7.2°Centigrade) or less.
    d. The dealer shall not be required to provide thermal recorders during shipment.
    e. Lack of ice or other acceptable types of refrigeration shall be considered an unsatisfactory shipping condition.
    f. Shipping Time is Greater Than Four Hours.
2. When the shipping time is greater than four hours, the dealer shall ship all shellfish in:
    a. Mechanically refrigerated conveyances which are equipped with automatic controls and capable of
    b. maintaining the temperature of ambient air in the storage area at temperatures of 45° Fahrenheit (7.2° Centigrade) or less; or
    c. Containers with an internal ambient air temperature maintained at or below temperatures of 45° Fahrenheit (7.2° Centigrade) or less.
3. Unless the dealer has an approved HACCP plan with an alternate means of monitoring time-temperature, initial dealer shall assure that a suitable time-temperature recording device accompanies each shipment of shellfish.
4. The initial dealer shall note the date and time on the temperature-indicating device, if appropriate.
5. Each receiving dealer shall write the date and time on the temperature-indicating device, if appropriate, when shipment is received and the doors of the conveyance or the containers are opened.
6. The final receiving dealer shall keep the time-temperature recording chart or other record of time and temperature in his files and shall make it available to the Authority upon request.
7. An inoperative temperature-indicating device shall be considered as no recording device.

Appendix 1
Terrapin and Turtle Aquaculture

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(Adopted - July 2007)

BACKGROUND

Legislation was passed during 2007 session in Maryland for enhanced protection of the Diamondback terrapin from commercial and recreational harvest. As part of the legislation, it was recognized that the culture of terrapin and turtle species currently existed with in the state and could expand in the future. The Maryland Aquaculture Coordinating Council (MACC) was directed to develop Best Management Practices for this segment of the industry.

The BMPs adopted by the MACC in November 2006, however, are not species specific, and are differentiated only in the area of shellfish production. Existing information contained in the BMPs does, however, provide strong guidance for producers of terrapins and turtles through the various sections. Humane treatment of animals is one of the principal aspects of aquaculture production. Ensuring that animals are well cared for and kept in an environment conducive to their survival and growth can provide a business with the potential for remaining successful. Poorly designed and operated culture systems, inadequate health management, or shoddy transport methods can lead to low growth and survival through to the ultimate purchaser.

In order to comply with the 2007 legislative mandate, this appendix will serve as a reference point for those involved in the aquaculture of terrapins and turtles. For more information, producers are urged to fully read the Maryland BMPs and to understand the aspects related to their species and production methods. However, the following specific references are recommended to terrapin and turtle producers:

Section I: Water Resources and Management

I. Site Development and Habitat Protection
- A. Construction
  - 8. Facility plan – p. 3
  - 9. Construction inspection – p. 3
  - 10. Construction and zoning regulations – p. 3
- B. Wetlands
  - 4. Wetlands for partial effluent treatment – p. 4
  - 5. Exemption for effluent treatment – p. 4

II. Water Supply and Management
- A. Considerations
  - 1. Water use permits – p. 4
  - 2. Water use and conservation – p. 4

III. Pond Management
- A. Stocking and Feeding Practices
  - 1. Stocking rates – p. 5
  - 2. Carrying capacity – p. 5
  - 6. Feed sizes and rates – p. 5
  - 7. Overfeeding – p.5
- C. Harvest or Draining
  - 1. Reduce feed – p. 5
  - 2. Reroute drained water – p. 5

Section VI: Shipping, Transport, and Sale

Additional Practices

I. Purchase records

A. Terrapins purchased from approved out-of-state sources shall be accompanied by records showing:
1. Date of purchase
2. Number of animals purchased
3. Name and contact information of the person purchased from

B. Records shall be kept for terrapins in culture systems including:
1. Breeding information including number of eggs laid, hatched, and survival
2. Mortality of animals in the system
3. Importation of animals from approved sources
4. Inventory of animals by month and year

C. Sale and transport of terrapins shall be accompanied by records showing:
1. Name and contact information of the seller
2. Name and contact information of the buyer
3. Date of transport
4. Number of animals being shipped

D. Records shall be kept for a period of at least three (3) years and made available for audit by state agencies responsible for aquaculture and natural resource enforcement