Marine Net Pen Best Management Practices for Finfish Aquaculture[1]

NOTE: These best management practices were provided to the Ad Hoc Aquaculture Advisory Panel prior to the publication of an EPA final rule, 40 CFR Part 451, Effluent Limitation Guidelines and New Source Performance Standards for the Concentrated Aquatic Animal Production Point Source Category, on August 23, 2004. This rule added new aquaculture effluent limitation guidelines and source performance standards for net pen operations to those sections of the Clean Water Act that pertain to the standards imposed in National Pollution Discharge Elimination System (NPDES) permits. Noted within this document are the new operational practices and management requirements that duplicate certain best management practices suggested here.

These Best Management Practices pertain only to the operation of net pens or cages that are anchored or floating in the Gulf of Mexico Exclusive Economic Zone managed by the Gulf of Mexico Fishery Management Council and the National Marine Fisheries Service for the purposes of cultivating marine finfish. Net pens and cages are submerged, suspended, or floating holding systems (hereinafter referred to as "net pens").

Net pen operations must acquire: 1) a Section 10 permit from the U.S. Army Corp of Engineers to establish a facility permanently or temporarily attached to the seabed, 2) a National Pollution Discharge Elimination System (NPDES) permit from the U.S. Environmental Protection Agency if the facility produces more than 100,000 pounds of fish annually, and 3) a permit from the U.S. Coast Guard for conformity with markers and the private aids to navigation. Bivalve molluscs (clams, mussels, scallops or oysters) being produced for sale as edible product can only be cultured within the boundaries of Shellfish Harvesting Areas classified and managed by states bordering the Gulf of Mexico. This limitation is not in effect when shellfish are being polycultured with marine finfish solely for the ecological benefits they provide and the shellfish will not be sold as a food product.

Best Management Practices

These Best Management Practices are to improve the environmentally friendly performance of net pen aquaculture facilities. Practices are provided for site selection, feed management, solids management and disposal, management of escapees, mortality removal and disposal, and facility operation and maintenance. Net pen systems may be used to culture a variety of marine fish species. The diversity of species, stocking density, pen design, numbers of pens, and culture methods used in net pen systems may make the implementation of these Best Management Practices to attain the environmental conservation or preservation goals of the **[Agency]** a very challenging decision making process for the farmer. An effective Practice for one species or facility may be totally

[1] Information and guidance in this chapter was adapted from a document entitled, "Best Management Practices for Flow-Through, Net-Pen, Recirculating, and Pond Aquaculture Systems" prepared during 2003 as part of an interagency agreement between the U.S. Environmental Protection Agency and U.S. Department of Agriculture.

inappropriate for another. Furthermore, Practices may be combined in unique ways to achieve certain environmental conservation goals. The **[Agency]** recommends that the net pen operator consult with the **[Agency]** before implementing any of these Best Management Practices.

SITE SELECTION

Site selection requires balancing of multiple factors. Appropriate site selection for net pens is critical for the minimization of potential environmental impacts, optimal fish health and performance, worker safety and the minimization of production costs. With the exception of site selection, net pen farm operators have little ability to control the environmental conditions their fish may experience. Fish physiology, metabolic performance and health are all highly influenced by the environmental conditions in which they are cultured. Small changes in environmental conditions can cause sublethal stress, suppressed growth rates and elevated food conversion ratios. All of these effects result in elevated production costs to the farmer.

Wise site selection has significant potential to reduce the risk of environmental impacts associated with net pens. Site selection to minimize environmental impacts may have to balance conflicting goals. For example high-energy exposed sites tend to reduce the risk of benthic waste deposition. However, due to their exposure, these same sites may increase the risk of storm damage, fish escape, or compromise worker safety. Appropriate sites combined with careful farm management can result in minimal environmental impact.

Best Management Practices

1) Evaluate each potential farm site to insure that environmental conditions on the farm site are appropriate for the species being considered for culture and the equipment proposed for use.

   Farm Record: A Farm Site Plan with net pen schematic that maps the location of the net pens, anchoring, and feeding systems should be maintained, updated and made available for review by **[Agency]** personnel during site inspections.

2) Select sites with good water exchange that are not depositional environments.

3) Baseline site surveys must be conducted and submitted to the **[Agency]** prior to pen placement in order to characterize the marine habitat, ecosystem and hydrographic conditions that prevail on the site prior to the establishment and operation of a farm.

   At a minimum, water depth, circulation patterns, current speeds, wind-wave fetch, water quality (nitrate, phosphate, and ammonia) and benthos (sediment type and composition, interstitial species identity and number) should be documented or, in the case of fetch, calculated. Predominant seasonal weather patterns should be

considered. Baseline studies should also include a characterization of the seasonal variation in the above characteristics and the potential maximum sea state (wave height and frequency) of the site. These surveys should be used to confirm that site conditions are appropriate for the species being cultured and equipment to be deployed.

Farm Record: A Baseline Site Survey should always be available for review by **[Agency]** personnel during site inspections. Pertinent hydrographic data should be included in the Net, Pen Structure and Mooring System Preventative Maintenance Program.

4) Impacts on worker safety, product quality, and animal welfare should also be considered during the prospective site review.

Sites with frequent, extreme weather or sea-state conditions that would limit the grower's access to the farm site and cultured animals should be reconsidered.

5) Care should be taken during site selection to minimize the risk of negative impacts on farm animals from off-farm human activities such as industrial development (oil or gas exploration and drilling), and oil, chemical or sewage spills.

6) The distribution and prevalence of potential pests and predators should be examined when selecting sites. Where practical, farmers should select farm sites away from high pest and predator concentrations.

7) Sites for polyculture of finfish and filter-feeding shellfish (mussels, clams, oysters or scallops) can only occur in Shellfish Harvesting Areas classified and managed by the states bordering the Gulf of Mexico. This is not a required where shellfish are being cultured solely for the ecological benefits they provide or will not be sold as a food product. Contact the Interstate Shellfish Sanitation Conference to identify the responsible state agency for classifying Shellfish Harvesting Areas and implementing the provisions of the National Shellfish Sanitation Program (http://issc.org/).

8) The number of net pens or their configuration may require the allocation of the capital, labor and time required to move net pens and allow the recovery of a site to avoid benthic degradation (referred to as "fallowing"). Farms that intend to implement a fallowing strategy must inform the **[Agency]** of this intent during the permit application process and identify potential fallowing sites in the Farm Site Plan and mooring management and adjustments in the Net, Pen Structure and Mooring System Preventative Maintenance Program.

FEED MANAGEMENT

NOTE: The EPA NPDES Permit requirements include: 1) employ efficient feed management and feeding strategies to limit feed input to the minimum amount reasonably necessary to achieve production goals and sustain targeted rates of aquatic animal growth (§451.21(a)), 2) minimize the accumulation of uneaten food beneath net pens through the use of active feed monitoring and feed management practices that may include one or more of the following: real-time feed consumption monitoring, monitoring of sediment quality beneath pens, monitoring of benthic communities, capture of waste feed or feces, and other practices approved by the permitting authority (§451.21(a)), 3) the calculation of representative feed conversion ratios, and the maintenance of records documenting feed amounts and estimates of numbers and weight of aquatic animals in culture (§451.21(g)(1)), and 4) training of staff in feed procedures and proper equipment use (§451.21(h)(2)).

Waste feed and fish feces constitute the major portion of the wastes generated by a net pen farm. However, because net pens operate in high-energy environments, the waste management (collection and concentration) can be very difficult. Therefore, the most effective way to reduce the potential environmental impact of net pens is to aggressively and proactively manage the selection, distribution and utilization of feed. Effective feed management is based on two components: waste reduction and optimal feed conversion ratio. Waste reduction focuses on ensuring that feed used by the farm is not lost or discharged prior to intake by the fish. Optimal conversion focuses on ensuring that all feed offered to the fish is actually consumed, optimally digested and utilized.

Fish nutrition and feeding practices are active areas of research, and technology is constantly evolving. An important farm production goal is to improve the efficiency of nutrient utilization by fish, thereby enhancing economic returns and reducing waste production. Because technology is rapidly changing, feed management objectives should be flexible so that newer and better practices and technology can be implemented as they become available.

Best Management Practices:

1) Feed storage, handling, and delivery methods should minimize waste and fine particles of feed.

   Feed storage areas should be secure from contamination, vermin, moisture, and excessive heat. Long-term storage of feed can affect feed quality. As such, feed should be rotated (oldest feed used first) and not stored beyond the manufacturer's recommended use date. Care should be taken during feed handling to minimize pellet damage or crushing and reduce the creation of fine feed particles that cannot be utilized by the fish.

2) Farms should calculate feed conversion ratios by using feed and fish biomass inventory tracking systems.

Calculation of feed conversion ratios is an essential economic function on all net pen farms. Monitoring long- and short-term changes in feed conversion ratios allows farmers to quickly identify significant changes in feed consumption and waste production rates in individual net pens.

Farm Record: Daily Feed Conversion Records and Analysis of the prior 12-month feed conversion trend analysis must be maintained, updated and made available for **[Agency]** personnel review during site inspections.

3) In cooperation with feed manufacturers, farmers should seek to minimize nutrient and solids discharges through optimization of feed formulations.

Feeds should be formulated for optimum feed conversion ratios and retention of protein (nitrogen) and phosphorus. Feed formulations should consider numerous factors including, pellet stability, digestibility, palatability, sinking rates, energy levels, moisture content, ingredient quality and the nutritional requirements of the species being grown. Feeds should be formulated and manufactured using high-quality ingredients. Feed ingredients should have high dry matter and protein apparent digestibility coefficients. Formulations should be designed to enhance nitrogen and phosphorus retention efficiency, and reduce metabolic waste output. Feeds should contain sufficient dietary energy to spare dietary protein (amino acids) for tissue synthesis. Feeds should be water stable for sufficient periods such that pellets remain intact until eaten by fish.

Farm Record: Feed Manufacturer Labels, or copies thereof, should be retained for the prior 24-months of operation for review by **[Agency]** personnel during site inspections.

4) Farmers should use efficient feeding practices.

Feed may be delivered by hand, demand feeders, automatic feeders, or by mechanical feeders. Regardless of the delivery method or system, the amount of feed offered should optimize the balance between maximum growth and maximum feed conversion efficiency. The appropriate quantity and type of feed for a given species is influenced by fish size, water temperature, dissolved oxygen levels, health status, reproductive status, and management goals. Feed particle size should be appropriate for the size of fish being fed. Feeding behavior should be observed to monitor feed utilization and evaluate health status.

5) Feeding equipment should be regularly checked to ensure efficient operation.

Improperly adjusted or malfunctioning feeding equipment can over or under feed a net pen of fish and lower feed and production efficiency.

6) Whenever practical, farmers should grow fish strains that have demonstrated efficient feed conversion ratios.

7) Farmers should make every effort to reduce fish stress and optimize culture conditions to reduce feed conversion ratios.

8) Farms should conduct employee training in fish husbandry and feeding methods to ensure that workers have adequate training to optimize feed conversion ratios.

9) Wherever practical, monitoring technologies such as video, "lift-ups," Doppler, or sonar sensors should be used to monitor feed consumption and reduce feed waste.

   If automated feeding systems are used, fish monitoring systems should, if possible, be actively linked to feeding control systems to provide direct control feedback to reduce feed wastage. Even if monitoring systems are employed, active monitoring by farm operators should also occur to ensure that all systems are functioning properly and fish are behaving and feeding normally.

10) Farmers must annually examine the bottom under their net pens.

    Close attention should be paid to the presence of any waste feed and how the benthic environment appears to be assimilating the nutrient load. Bottom survey analysis should be immediately used to adjust feed and/or farm management practices.

    Farm Record: Bottom Survey Data and Analysis should be retained on file for review by **[Agency]** personnel during site inspections.

SOLID WASTE MANAGEMENT AND DISPOSAL

NOTE: The EPA NPDES Permit will include requirements to: 1) collect and return to shore and properly dispose solid wastes (§451.21(b)), 2) staff training to prevent spills, clean-up spills and spill response (§451.21(h)(1)), and 3) staff training to properly operate and clean equipment (§451.21(h)(2)).

Waste feed and fish feces constitute most of the solid wastes generate by a net pen farm. In many cases, waste feed will be consumed by fauna attracted to the net pen. However, concentration and collection of unconsumed solid wastes is difficult because net pens operate in high-energy, open-waters environments exposed to currents, waves, and storms.

While it is theoretically possible to install secondary net or deflector systems to collect solid wastes, to date experimental trials have demonstrated significant operational and economic problems. For example, the industry trend is towards sites with higher current speeds, and in areas with even moderate currents, pellets that are not consumed by the fish may be swept out of the cage before they are deposited on a collector located on the bottom of the net. Net pen operations in Hawaii and Puerto Rico reported that their operations attract a variety of wild fish that immediately consume pellets exiting the nets.

The most effective and practical way to manage solid wastes associated with feeding fish is aggressive feed management and proper site selection, as described in the Feed Management section of this chapter. Other possible sources of solid waste include biofouling organisms that colonize nets, mortalities, feedbags, packaging materials, scrap rope and netting, worn or broken net pen structural components, and other miscellaneous items.

Best Management Practices:

1) Farmers must conduct a systematic review of their operations and develop a waste management plan. This plan should identify all wastes generated on a site or from a facility.

   Waste management plans should clearly identify all wastes generated on a site and classify them with respect to any risks associated with their collection and appropriate disposal. The waste management plan should be designed to minimize the generation of waste while recognizing the practical challenges associated with marine operations. Whenever possible, waste management plans should encourage recycling of waste except in cases where human or animal health may be compromised. In these cases, a clear containment and disposal method should be outlined. These methods and actions should be designed to minimize any human or fish health risks and benthic impacts associated with the waste. At a minimum, waste management plans should address: human waste, feedbags, scrap rope, scrap netting, fish mortalities, packaging materials and any other solid waste.

   Farm Record: A Solid Waste Management Plan must be created, maintained, implemented, and made available to **[Agency]** personnel during site inspections.

2) Proactive efforts should be taken to minimize the generation of all types of solid waste.

   Farmers should review their operations and consider whether there are alternative practices that help reduce the use of materials that generate solid waste. The use of packaging and materials handling methods that reduce total packaging needs should be strongly considered.

3) Farmers should avoid the discharge of substances associated with in-place pressure washing of nets.

   Every effort should be made to use gear and production strategies that minimize or eliminate the need for on-site wash down and rinsing to reduce biofouling. The use of air-drying, mechanical, biological, and other non-chemical procedures to control net fouling are strongly encouraged. In some areas with high flushing rates or great depth, in-place net washing may be acceptable. In areas with high

fouling rates, treatment of nets with anti-fouling compounds permitted by EPA may represent a lower environmental risk than frequent net washing.

4) All feed bags, packaging materials, waste rope and netting, or worn structural components should be collected, returned to shore and disposed of properly. Recycling is strongly encouraged.

MANAGEMENT OF ESCAPEES

NOTE: The EPA NPDES permit require: 1) routine net pen inspections, repair and maintenance to prevent escape (§451.21(f)), and 2) recordkeeping net changes, inspections and repairs (§451.21(g)(2)).

The escape of cultured species may pose a variety of potential risks to aquatic ecosystems or unrelated economic activities. Potential risks include pathogen transmission, genetic interaction, and competition for resources. For net pen operations in Gulf of Mexico, these outcomes are not anticipated to occur because: 1) a strong economic incentive exists for producers to prevent escape of cultured animals and to recover animals that do escape; 2) most pathogens are naturally occurring and ubiquitous; and, 3) culture is restricted to species native to the Gulf of Mexico or sterile organisms.

There are three principle causes of escapees from net pen farms: equipment failure, operational errors, and predator attacks. While it is theoretically possible to prevent fish escape by the installation of secondary containment nets, these systems have environmental costs. Double netting systems significantly reduce water flow rates through net pens. This flow reduction may negatively impact dissolved oxygen in and around cages, increase sedimentation rates, and alter water circulation patterns on farm sites. The additional stress on fish may predispose fish to diseases and increase feed conversion ratios, resulting in increased waste production per unit of fish biomass. The use of double netting increases the net surface area subject to biofouling, thereby increasing the need for net cleaning and disposal of fouling waste. The heavier physical loads associated with double netting structural, flotation, and mooring requirements will all increase. These increased equipment requirements, in combination with the additional netting required, would significantly increase the consumption of energy and petroleum products used in the manufacture of net pen farming equipment.

The two most effective ways to reduce potential environmental impacts of escapees are prevention and genetic isolation. Prevention involves proactively reducing the potential causes of escape. Genetic isolation is accomplished by using highly domesticated strains that are unlikely to survive in the wild or unable to interbreed with wild fish or sterile organisms. Escape response actions such as net repair and animal recovery plans, may also help mitigate the impact of escapes if they occur. All net pen farms should continuously strive to reduce escape risk.

Best Management Practices:

1) Marine finfish in culture must be derived from Gulf of Mexico species.

Farm Record: Documentation of the source and genetic heritage of broodstock, fry and fingerlings or proof of fry and fingerling sterility for all fish cultured will be maintained and made available to **[Agency]** personnel during site inspections.

2) Before installing net pens on a site, operators should consider how site characteristics might impact the risk of escapes.

Site characteristics that may be relevant include frequency of extreme weather, degree of site exposure, type of bottom, and distribution and prevalence of predators, and navigational considerations. When practical, sites should be selected that minimize the impacts of these aspects.

2) Net pen farms should develop and implement a Loss-Control and Escape Recovery Plan.

Plans should include a site-specific analysis of the potential risks of escapes, their causes, and the specific procedures employed by the farm to reduce the risk. Loss-control plans should be designed to address the three principle causes of escapes (equipment failure, operational errors, and predator attacks) and should include: 1) minimum equipment and operating standards, 2) emergency repair procedures, and 3) escape recovery procedures.

In the event of a significant escape, farmers should make attempts to recapture escaped fish. Recapture procedures should be based on the escape recovery actions the farmer has developed. Plans should allow for continuous improvement and revisions based on innovations in farming methods and technology.

Farm Record: A Loss-Control and Escape Recovery Plan should be created, maintained, implemented and made available to **[Agency]** personnel during site inspections.

4) Fish transfers such as stocking, grading, transfer, or harvest should be conducted in appropriate weather conditions and under constant visual supervision. Equipment appropriate to the weather and net pen or cage designs should be used. Where necessary or appropriate, shields or additional net should be used to prevent stray fish escape during transfer.

5) All holding, transportation, and culture systems should be designed, operated and maintained to prevent escape.

6) Nets should only be obtained from a manufacturer or supplier whose equipment design specifications and manufacturing standards meet generally accepted standards prevalent in the aquaculture industry.

Net design and specification should be commensurate with the prevailing conditions of the site. Stress tests should be preformed on all nets with more than three years of use in the marine environment when the net is pulled out and cleaned. All nets in use should be ultraviolet light (UV) protected.

7) Net pens should only be obtained from a manufacturer or supplier whose equipment design specifications and manufacturing standards meet generally accepted standards prevalent in the aquaculture industry.

Net pen design, specification, and installation should be commensurate with the prevailing conditions and capable of withstanding the normal maximum weather and sea conditions.

Farm Record: A written statement from the net pen manufacturer certifying that net pen(s) have been assembled and moored to their specifications must be available to **[Agency]** personnel during site inspections.

8) Net pens should have jump nets installed to prevent fish from jumping out of the primary containment net.

Jump nets should be an integral part of the primary containment net or joined to it in a fashion that prevents fish escape between the primary net and the jump net. Jump nets should be of a height appropriate to the jumping ability and size of fish they are containing.

9) Nets should be secured to the cage collar such that the collar bears the strain and not the handrail of the net pen or cage.

Net weights, when used, should be installed to prevent chafing. A second layer of net should be added one foot above and below wear points. The use of weight rings should be encouraged at appropriate sites.

10) A preventative maintenance program for nets, net pen structures, and mooring systems should be developed.

The program should have the ability to track individual nets, net pen structures, mooring systems and schedule and document regular maintenance and testing. Nets or net pen structural components that fail testing standards should be retired and disposed of properly. The program should document regular maintenance, the nature of the maintenance, date conducted, any supporting documentation for new materials used, and the identity of the individuals or firms that conducted the maintenance.

Farm Record: A Net, Pen Structure and Mooring System Preventative Maintenance Program should be created, maintained, updated, implemented and made available to **[Agency]** personnel during site inspections.

11) Mooring system designs should be compatible with the net pen system they secure.

Mooring systems should be installed in consultation with the net pen manufacturer or supplier. Mooring system design, specification and installation should be commensurate with the prevailing conditions of the site and be capable of withstanding the normal maximum conditions likely to occur at a site. A mooring system schematic must be included and updated as a component of the Farm Site Plan. Design maximums should be recorded in the Net, Pen Structure and Mooring System Preventative Maintenance Program.

12) Site operators should regularly inspect and adjust mooring systems as needed.

Rigging tension should be maintained to installation standards. New components should undergo their first inspection no later than two years after deployment. A diver or remote camera should regularly visually inspect subsurface mooring components. Special attention should be given to connectors and rope/chain interfaces. Chafe points should be identified and subject to more frequent inspection and removal of marine growth. With the exception of anchors, mooring systems should be hauled out of the water for a visual inspection of all components at least every five years. When considering what inspection method to employ net pen operators should consider the relative risks and benefits associated with the inspection method. On sites frequently exposed to severe weather, or where it is difficult conduct above-water inspection, equipment haul out may represent a greater risk than regular underwater inspections.

13) Shackles used in mooring systems should be either safety shackles, wire-tied, or welded to prevent pin drop-out.

14) Where appropriate, bird nets should be used to cover net pens in order to reduce the risk of escape due to bird predation. Bird nets should be constructed using appropriate materials and mesh sizes designed to reduce the risk of bird entanglement.

15) Site operators should develop a service vessel Standard Operating Procedure (SOP).

Vessel operations around a net pen site can cause escapes. All vessel operators should receive appropriate training in the operation of the vessel. The SOP should minimize the risk of damaging nets and/or mooring system components with the propeller of the vessel.

Farmers must provide a service vessel SOP to the **[Agency]** to assist personnel in completing their inspections in a manner that will avoid damage to net pens, associated structures and moorings, or service vessels.

MORTALITY REMOVAL AND DISPOSAL

NOTE: The EPA NPDES permit requires the: 1) minimization of discharge associated with the transport or harvesting of aquatic animals including blood, viscera, carcasses or water containing blood (§451.21(c)) and 2) the proper removal and disposal of mortalities to prevent discharge (§451.21(d)).

Proper fish health management is the best means for reducing costly mortalities in net pens. Optimizing fish health will reduce the need to deal with dead fish. Even under optimal conditions some mortality will occur naturally. Net pens, by their very design, contain and collect mortalities. This facilitates mortality monitoring and their timely removal.

Best Management Practices:

1) Farmers should proactively manage their fish stocks to optimize animal health.

2) Weather permitting, mortalities should be collected regularly and frequently.

Farmers should use collection and removal methods that do not stress remaining animals, compromise net integrity, or jeopardize worker safety. Mortalities should only be stored and transported in closed containers with tight fitting lids.

FACILITY OPERATIONS AND MAINTENANCE

NOTE: EPA NPDES permits require: 1) recordkeeping that includes feed conversion ratios, feed amounts, number and weight of animals in culture, net changes, net inspections and net repairs (§451.21(g)(1)(2)), 2) the proper storage of drugs, pesticides and feeds in a manner to prevent spills that may discharge (§451.21(e)(1), 3) implementation of procedures for properly containing, cleaning and disposing of spilled material (§451.21(e)(2)), and 4) staff training in the proper equipment operation and cleaning of production systems (§451.21(h)(2)).

Net pen farms are expensive to install and operate. Operators are subject to elevated public scrutiny because they are located and actively utilize public waters. Net pens farms operate in these public waters under the provisions of permits from the U.S. Environmental Protection Agency, U.S. Army Corp of Engineers and U.S. Coast Guard that can be revoked for noncompliance. Net pen operators who do not operate their facilities in compliance with permit conditions and these Best Management Practices risk the revocation of permission to culture marine fish in the Gulf of Mexico and directly jeopardize their investments.

Best Management Practices:

1) Net pen operations that annually produce less than 100,000 pounds of live product are exempt from acquiring the U.S. Environmental Protection Agency's National Pollution Discharge Elimination System (NPDES) permit.

   To appropriately manage net pen operations that are not required to have NPDES permit, the **[Agency]** may require periodic Water Quality Monitoring in addition to the Bottom Survey and Data Analysis requirement.

   Farm Record: Water quality monitoring (nitrate-N) will be periodically completed by the farm operator at locations that will characterize background concentrations and in an array that will adequately detect: 1) farm contribution to the water column and 2) the nitrate-N attenuation point(s) relative to the farm.

   Prior to farm installation the farm operator must submit a Water Quality Monitoring Plan to the **[Agency]** for appraisal. Upon approval by the **[Agency]**, the Water Quality Monitoring Plan must be maintained, updated, implemented and made available to Division personnel upon request.

2) When considering modifications to existing farming practices, procedures or structures, growers should include a review of the type and extent of probable environmental impacts that may occur as a result of the new methods and amend the proposed methods to mitigate potential impacts.

3) Therapeutic drugs and chemicals approved by the U.S. Food and Drug Administration and the U.S. Environmental Protection Agency must be used in accordance with manufacturer's label directions or as prescribed by a licensed veterinarian.

4) When conducting activities such as stocking/seeding, harvesting, feeding, grading, thinning, transfer, cleaning, gear maintenance or fallowing, all standard operating procedures should include diligent efforts to minimize probable environmental impacts.

5) Comprehensive stocking and production strategies that optimize production while minimizing environmental impacts should be used. Production planning should include a systematic review of any probable environmental impacts that would be associated with a particular production plan or method.

6) When installing net pens and their associated mooring systems, careful consideration should be given to their potential impacts on water circulation patterns. Gear deployment should seek to optimize circulation patterns and maximize water exchange through the pens, thereby improving fish health and reducing benthic impacts.

7) Harvest procedures and equipment should be designed and operated in a fashion that reduces any associated discharges. Harvest and post-harvest vessel and equipment clean-up procedures should minimize any wastes discharged overboard.

8) Net pen operators should consider the practicality of polyculture using shellfish and/or marine plants to reduce the contribution of nutrients and particulate matter to waters outside the farm lease.

Where practical, shellfish, marine plant and finfish farms should be co-located in order to maximize production synergies and reduce potential water quality impacts.

9) Farm support vessels should only be fueled at licensed fueling stations.

All fuel or oil spills should be immediately reported to the fueling station operator. All on-board spills and leaks should be immediately reported to the captain of the vessel. Appropriate clean up and repair actions should be initiated as soon as practicably possible. All fuel or oil spills should be reported as required to the appropriate state and federal authorities.

10) Farm support vessels of the appropriate size should have approved Marine Sanitation Devices (MSD) on board. All human wastes should be disposed of according to applicable state and federal regulations.

11) If antifouling paints are used on farm support vessels, nets or structures, only boat-bottom paints approved for use by state or federal regulations should be used.

12) Develop a record-keeping system.

Good record-keeping is the hallmark of a well-operated aquaculture facility. Farm Records identified as components of these Best Management Practices must be updated, maintained and made available to **[Agency]** personnel during site inspections. Farm records that require the collection and analysis of environmental data (physical, chemical or biological) must be documented in a Quality Assurance Project Plan. Farm operators must submit such plans to the **[Agency]** prior to farm construction.

Farmers may keep and analyze additional records related to feeding, chemical use, water quality, serious weather conditions, fish culture operations and inventory to facilitate improvements in the efficiency of farm input use. Such records should be reviewed periodically to determine if they are useful and to provide insight into opportunities for improvement of farm operation.