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## POLICY CONSIDERATIONS FOR THE INTERACTIONS BETWEEN ESSENTIAL FISH HABITATS AND MARINE AQUACULTURE (June 2014)

### Introduction

This document provides the South Atlantic Fishery Management Council (SAFMC) guidance regarding interactions of marine aquaculture with Essential Fish Habitat (EFH) and Essential Fish Habitat - Habitat Areas of Particular Concern (EFH-HAPCs). This guidance is consistent with the overall habitat protection policies of the SAFMC as formulated in the Habitat Plan (SAFMC 1998a) and adopted in the Comprehensive EFH Amendment (SAFMC 1998b), Fishery Ecosystem Plan for the South Atlantic Region (SAFMC 2009a), Comprehensive Ecosystem-Based Management Amendment 1(SAFMC 2009b),Comprehensive Ecosystem-Based Amendment 2 (SAFMC 2011) and the various Fishery Management Plans (FMPs) of the Council.

For the purposes of policy development, aquaculture is defined as the propagation and rearing of aquatic marine organisms for commercial, recreational, or public purposes. This definition covers all authorized production of marine finfish, shellfish, plants, algae, and other aquatic organisms for 1) food and other commercial products; 2) wild stock replenishment and enhancement for commercial and recreational fisheries; 3) rebuilding populations of threatened or endangered species under species recovery and conservation plans; and 4) restoration and conservation of aquatic habitat (DOC Aquaculture Policy 2011; NOAA Aquaculture Policy 2011). This guidance addresses concerns related to the production of seafood and other non-seafood related products (*e.g.*, biofuels, ornamentals, bait, pharmaceuticals, and gemstones) by aquaculture, but does not specifically address issues related to stock enhancement. The findings assess potential impacts, negative and positive, to EFH and EFH- HAPCs posed by activities related to marine aquaculture in offshore and coastal waters, riverine systems and adjacent wetland habitats, and the processes that could improve or place those resources at risk. The policies and recommendations established in this document are designed to avoid and minimize impacts and optimize benefits from these activities, in accordance with the general habitat policies of the SAFMC as mandated by law. The SAFMC may revise this guidance in response to changes in the types and locations of marine aquaculture projects in the South Atlantic region, applicable laws and regulatory guidelines, and knowledge about the impacts of aquaculture on habitat.

The recommendations presented apply to aquaculture activities that may impact EFH and EFH-HAPCs. Aquaculture activities have the potential to interact both positively and negatively with EFH and EFH-HAPCs when conducted in onshore, nearshore, and offshore environments. Current federal and state laws, regulations and policies differ for each of these environments. Additionally, aquaculture activities in nearshore and onshore environments may fall under multiple jurisdictions.

These recommendations should be factored into the FMPs in the region, either newly developed or amended to address offshore aquaculture as "fishing" under the Magnuson-Stevens Fishery and Conservation Management Act (MSFCMA).[1] In those cases where aquaculture activities remain outside of the jurisdiction of federal management, EFH protection mechanisms for "non-fishing" activities should be used to protect EFH, wherever possible.[2,3]

Habitats and species that could be impacted by marine aquaculture activities include those managed by state-level as well as interstate (*e.g.*, ASMFC) FMPs (see Appendices A and B). Examples of affected habitats could include state-designated Critical Habitat Areas (CHAs) or Strategic Habitat Areas (SHAs) such as those established by the State Marine Fisheries Commissions via FMPs, coastal habitat protection plans, or other management provisions.

## Overview of Marine Aquaculture and EFH Interactions

The environmental effects of marine aquaculture can vary widely depending on the species and genetic stock selected for culture, the location and scale of the aquaculture operation, the experience level of the operators, the culture system and facility design, biosecurity procedures, and the production methods. The use of modern production technologies, proper siting protocols, standardized operating procedures, and best management practices (BMPs) can help reduce or eliminate the risk of environmental degradation from aquaculture activities. In recent years, marine aquaculture has been used to bolster EFH (*e.g.*, oyster cultch planting to rebuild oyster reefs) and in some instances, aquaculture has been used to mitigate eutrophication by sequestering nutrients in coastal waters (*e.g.*, shellfish and algae culture).

The following summary provides information on the types of environmental effects resulting from marine aquaculture activities that have been documented and includes references to various BMPs and other existing regulatory frameworks used to safeguard coastal resources. This summary is not an exhaustive literature review of scientific information on this complex topic, rather it is a synthesis of relevant information intended to provide managers with a better understanding of the environmental

[1] Based on a legal opinion by NOAA General Counsel, landings or possession of fish in the exclusive economic zone from commercial marine aquaculture production of species managed under FMPs constitutes "fishing" as defined in the MSFCMA [Sec. 3(16)]. Fishing includes activities and operations related to the taking, catching, or harvesting of fish.
[2] The reference to non-fishing activities is meant to clarify SAFMC's role to comment on aquaculture activities similar to the process that the SAFMC uses for "non-fishing" activities.
[3] While the MSFCMA currently defines aquaculture as "fishing", the Council applies the same EFH standards to both "fishing" and "non-fishing" activities.

impacts of marine aquaculture.

The SAFMC recognizes that there are several types of environmental risks associated with marine aquaculture both in terms of probability of occurrence and magnitude of effects. Federal, state, and local regulatory agencies should evaluate these risks as they develop and implement permitting and monitoring processes for the aquaculture industry. The SAFMC specifically recognizes the following potential interactions between marine aquaculture and EFH:

**Escapement**

Unintentional introductions and accidental releases of cultured organisms may have wide ranging positive or negative effects on EFH. Ecological damage caused by organisms that have escaped or been displaced, in the case of shellfish or algae, from aquaculture may occur in riverine, estuarine, and marine habitats (Waples et al. 2012). The potential for adverse effects on the biological and physical properties of EFH include: (1) introduction of invasive species, (2) habitat alteration, (3) trophic alteration, (4) gene pool alteration, (5) spatial alteration, and (6) introduction of pathogens and parasites that cause disease.

Aquaculture is recognized as a pathway for both purposeful and inadvertent introduction of non-native species in aquatic ecosystems. Most introduced species do not become invasive; however, naturalization of introduced non-native species that results in invasion and competition with native fauna and flora has emerged as one of the major threats to natural biodiversity (Wilcove et al. 1998; Bax et al. 2001; D'Antonio et al. 2001; Olenin et al. 2007). Some non-native species alter the physical characteristics of coastal habitats and constitute a force of change affecting population, community, and ecosystem processes (Grosholz 2002). In the southeast United States, the culture of non-native species is primarily confined to ornamental plant and fish species grown in inland productions systems such as ponds, greenhouses, and indoor facilities. There is limited culture of non-native species for food with notable exceptions including inland production of tilapia (Ciclidae) and shrimp (*Litopenaeus vannamei*).

Even through use of native species, escapees have the potential to alter community structure, disrupt important ecosystem processes, and affect biodiversity. Environmental impacts are augmented by competition for food and space, introduction or spread of pathogens and parasites, and breeding or interbreeding with wild populations. Excessive colonization by shellfish or other sessile organisms may lead to alterations of physical habitat and preclude the growth of less abundant species with ecological significance. Similarly, escapees that colonize specific habitats and exhibit territorial behavior may compete with and displace local species to segregated habitats.

Culture of native species presents genetic risk from escapees interbreeding with individuals in the wild. The magnitude of the genetic impact on the fitness of wild stock is somewhat unclear. Genetic introgression of cultured escapees into wild populations is strongly density-dependent and appears linked to the population size and health of native populations relative to the magnitude of the escapes. To make a genetic impact, escapees must survive and reproduce successfully in the wild and contribute offspring with sufficient reproductive fitness to contribute to the gene pool. The capability of escaped fish to do so can vary widely based on a multitude of environmental and biological factors (*e.g.*, predation, competition, disease). In general, fitness of captive-reared individuals in the wild decreases with domestication (*i.e.*, the number of generations in captivity). Some genetic risks are inversely correlated, such that reducing one risk simultaneously increases another. For example, creating an aquaculture population that is genetically divergent from the wild stock may reduce the chances that escapees can survive and reproduce. Still, under this scenario aquacultured organisms that do survive could potentially pass on maladapted genes to the wild population.

The likelihood of escapes from aquaculture operations will vary depending on the species being cultured, siting guidelines, structural engineering and operational design, management practices (including probability for human error), adequacy of biosecurity and contingency plans, frequency of extreme weather events, and direct interactions with predators such as sharks, marine mammals, and birds. While a certain level of escape may not be avoidable in all cases, risk assessments should be used to make informed regulatory decisions in an effort to account for potential impacts on EFH. Risk assessment tools are available and have been used to identify and evaluate risks of farmed escapes on wild populations (Waples et al. 2012). Many empirical models have been used to inform policy (ICF 2012; RIST 2009), and are readily available for use in permitting and project planning.

Good practices for monitoring, surveillance, and maintenance of the aquaculture operation are critical to minimizing the likelihood of escapes. An escape prevention and mitigation plan should be developed for each farm. Plans should contain a rationale for approaches taken and any recapture or mitigation activities that should be initiated when an escape occurs.

**Disease in aquaculture**

As with all animal production systems, disease is a considerable risk for production, development, and expansion of the aquaculture industry. The industry has experienced diseases caused by both infectious (bacteria, virus, fungi, parasites) and non-infectious (nutritional, environmental, pollution, stress) agents. In addition to mortality and morbidity, disease causes reduction in market value, growth performance, reproductive capacity, and feed conversion. An accredited health professional should regularly inspect stocks and perform detailed diagnostic procedures to determine if disease is present, to identify risks, and to assess the overall health of the aquacultured species. Veterinarians with expertise in fish culture, or qualified aquatic animal health experts, can assist with development of a biosecurity plan to minimize, prevent, or control the spread of pathogens within a farm site, between aquaculture operations, or to wild populations. Culture facilities should be required to report disease and mortality incidents to the proper state and federal agencies so that authorities can assess risk to wild stocks and habitats and determine if control or other management measures should be put in place.

The spread of pathogens from cultured organisms to wild populations is a risk to fisheries, natural resources, and EFH. There are documented cases of mortality in wild populations caused by both endemic and exotic diseases transferred from aquaculture stocks (Glibert et al. 2002, NAAHP 2008). The prevalence of disease in intensive aquaculture operations is influenced by many factors, including immune status, stress level, pathogen load, environmental conditions, water quality, nutritional health, life history stage, and feeding management. The type and level of husbandry practices and disease surveillance will also influence the potential spread of pathogens to wild stocks. International trade in live fish and shellfish and aquaculture products (e.g., discard of seafood processing waste) has led to the introduction of diseases to new areas. Once a pathogen or disease is introduced and becomes established in the natural environment, there is little possibility of eradication. However, increased awareness of disease risks, health control legislation, and better diagnostic methods, which have increased the ability to detect diseases and pathogens, are helping to reduce the frequency of introduction and the spread of diseases (NAAHP 2008). Improved facility design engineering and buffer zones between aquaculture facilities and natural stocks could also reduce the risk of disease transfer.

In some cases, the expansion and diversification of the marine aquaculture industry has resulted in parasite translocations (Shumway 2011). Because of this, many countries and regions have created compacts and agreements to include pathogen screening guidelines and certification programs for movement of germplasm, embryos, larvae, juveniles, and broodstock associated with marine aquaculture operations. In the United States, import and export certifications and testing for certain types of diseases falls under the jurisdiction of the USDA Animal and Plant and Health Inspection Service (APHIS). Most states have specific protocols that must be followed when transplanting cultured species into wild environments to minimize the incidence of disease transfer. In the case of aquaculture operations in federal waters, the Gulf of Mexico Fishery Management Council specified in their Fishery Management Plan for Regulating Offshore Marine Aquaculture that prior to stocking animals in an aquaculture system in federal waters of the Gulf, the permittee must provide NOAA Fisheries a copy of a health certificate signed by an aquatic animal health expert certifying cultured animals were inspected and determined to be free of World Organization of Animal Health reportable pathogens (OIE 2003,) or additional pathogens that are identified as reportable pathogens in the National Aquatic Animal Health Plan (GMFMC 2012).

The dynamics of communicable disease in aquaculture and the level of risk to the environment vary substantially with hydrography and the presence, concentration, and proximity of wild organisms susceptible to infection by introduced pathogens or that may serve as vectors or reservoir hosts. The operational categories onshore, nearshore, and offshore are useful in discussion of this topic:

1) Closed onshore systems: These systems have the least potential for transfer of pathogens between cultured and wild organisms and generally pose low risk to the environment. However, they may internally super-concentrate parasites or pathogens with direct life cycles and as such, can be a human health concern and management challenge. Generally effluent volume is minimal but periodic draining for maintenance or pathogen control may be expected and should be considered for development of regulations and BMPs.

2) Flow-through onshore systems: Effluent from such systems has the potential to contain exotic pathogens or high concentrations of native parasites or pathogens with direct life cycles. So these facilities pose at least some environmental risk. Of greatest concern is the introduction of non-native pathogens, which could have catastrophic effects on regional fisheries and aquaculture operations. Increased prevalence and intensity of infection by native pathogens near the facility is also a concern, particularly if the water body is poorly mixed with little flushing. However, high concentrations of wild pathogens are not likely present in influent water and parasites or pathogens with indirect life cycles are generally not able to proliferate inside the facility.
3) Inshore and nearshore cages and net pens: These operations have the greatest potential for exchange of pathogens between cultured and wild organisms. They bring cultured organisms into close contact with their wild cohorts, predators, prey, and a diverse community of potential intermediate hosts to parasites or pathogens, most importantly benthic invertebrates such as mollusks and polychaetes. These conditions provide an opportunity for parasites or pathogens with direct and indirect life cycles to proliferate in and near the pen where they may become major causes of disease in both wild and cultured hosts. Water depth and rate of flushing will vary greatly by location, but shallow embayments with poor mixing are generally the least suitable areas.
4) Offshore cages and net pens: Open ocean aquaculture operations benefit from high rates of water exchange and by extension rapid dilution of pathogens. Another hypothetical advantage, at least for fish culture, is that wild nektonic organisms and their pathogens are generally widely dispersed in offshore environments. However, wild fish and marine mammals congregate around cages and nets where they find refuge, graze on fouling organisms, consume uneaten culture food, or sometimes successfully prey on cultured stock. So, although the benthos is far removed and dilution is rapid, there is still some opportunity for pathogen exchange, particularly of those infectious agents with direct life cycles.

Climate change has been implicated in increasing the prevalence and severity of infectious pathogens that may cause disease originating from cultured or transplanted aquaculture stocks (Hoegu-Guldberg and Bruno 2010). The emergence of these diseases is likely a consequence of several factors, including shifting of pathogen ranges in response to warming, changes to host susceptibility as a result of increasing environmental stress, and the expansion of potential vectors. Classical examples are outbreaks of oysters infected with MSX (*Haplosporidium nelsoni*), Dermo (*Perkinsus marinus*), and *Bonamia* spp. (Ford and Smolowitz 2007, Soniat et al. 2009, Shumway 2011). In most cases, pathogens have undergone rapid ecological and genetic adaptation in response to climate change. Guidelines for management of these diseases are well-developed for shellfish and other aquatic species. Managing for disease outbreaks is a key aspect of climate adaptation to prevent adverse impact to EFH. Management guidelines include record keeping, isolation and quarantine, and strict regulations on stocking or transplanting species from infected areas. Following these management recommendations should yield protection and conservation benefits for EFH.

**Use of drugs, biologics, and other chemicals**

Disease control by prevention is preferable to prophylactic measures and curative medical treatment. However, aquaculture drugs, biologics, and other chemicals play an important role in the integrated management of aquatic species health. Aquaculture operations in the United States use these products for: (1) disinfectants as part of biosecurity protocols, (2) herbicides and pesticides used in pond maintenance, (3) spawning aids, (4) vaccines used in disease prevention, or (5) marking agents used in resource management (AFS 2011). Additionally, some chemicals may be used as antifouling biocides for nets, cages, and platforms. Despite the best efforts of aquaculture producers to avoid pathogen introductions, therapeutic drugs are occasionally needed to control mortality, infestations, or infections. The availability and use of legally approved pharmaceutical drugs, biologics and other chemicals is quite limited in marine aquaculture (FDA 2012). A list of FDA approved drugs for use in marine aquaculture is provided in Appendix C.

Just as in the case of biological pathogens, the potential environmental impact of chemicals used in aquaculture, and those occurring as normal byproducts of stock physiology, varies greatly with hydrology and the proximity of other susceptible organisms:

1) Closed onshore systems: Water is infrequently discharged from these systems, so they generally pose low risk to the environment. However, improper application of chemicals and failure to comply with requirements for withdrawal periods can more easily harm stock and in the case of food fish may pose some risk to human health.
2) Flow-through onshore systems: Discharge of chemicals from these systems will typically occur in shallow coastal waters or wetlands. The potential for downstream concentration of anthropogenic contaminants, nitrogenous waste products, therapeutics, etc. is relatively high. Further such coastal areas are frequently sensitive to insult and of high conservation priority.
3) Inshore and nearshore cages and net pens: These operations share most attributes of concern with Flow-through onshore systems but add the possibility of wild organisms coming into direct contact with medicated feed. Further, some mitigating practices such as detention ponds and effluent treatment are not options. Antifouling biocides may be employed. Shallow, low energy areas with poor mixing represent the least desirable locations.
4) Offshore cages and net pens: Rapid dilution of chemicals in these operations is a major advantage and concentrated aquaculture byproducts are unlikely to reach the benthos. One caveat is that external therapeutics may need to be administered in greater concentration and volume to be effective. Wild, nektonic organisms congregate around cages and so can come into direct contact with medicated feed. Additionally, antifouling biocides are likely to be needed to maintain functionality of offshore nets and cages.

While antibiotics are a commonly cited chemical therapeutant, the use of antibiotics in U.S. aquaculture is not common and strictly limited, and global use in aquaculture of antibiotics has declined in recent years, up to 95% in the culture of salmon and other species. This decline is largely attributed to improved husbandry and use of vaccines (Asche and Bjorndal 2011; Forster 2010; Rico et al. 2012). Antibiotics are characterized by low toxicity to nonbacterial organisms. The environmental risks of antibiotic use are minimal, especially with regards to impacts to fisheries and EFH. The transference of antimicrobial drug resistance among marine fish and shellfish pathogens is theoretically possible but has not yet been demonstrated. In a comprehensive review of the salmon aquaculture industry, no direct evidence of negative impact to wild fish health resulting from antibiotic use in salmon farming has been found (Burridge et al. 2010). With farms that use medicated feeds, some antibiotic compounds can persist in sediments around fish farms and therefore affect the microbial community. Laboratory and field studies have found that antibiotic persistence in sediment ranges from a few days to years depending on the drug in question and the geophysical properties of the water or sediment (Scott 2004, Armstrong et al. 2005, Rigos and Troisi 2005). At present, there are no approved antibiotics for use with marine aquatic species in the South Atlantic. A limited number of broad spectrum antibiotics and feed additives (*i.e.*, florfenicol and oxytetracycline) are allowed as part of the National Investigational New Animal Drug Program, which is regulated by FDA and managed through partnership with the U.S. Fish and Wildlife Service. Antibiotics like other medicines should be used sparingly with prescription and in accordance with approved protocol to minimize environmental interactions.

Cultured fish are susceptible to parasitic diseases. For example, protozoa, monogenetic trematodes and arthropod parasites such as copepods, caligids, and isopods are naturally present and relatively harmless in wild fish populations, but under culture conditions they may dramatically proliferate and cause major stock losses with the potential for more frequent and intense infections in wild fish populations. Effective mitigation, management, and control of parasitic infections requires good husbandry. Chemicals used in the treatment of most parasitic infections in netpen operations are subsequently released to the aquatic environment. These compounds have varying degrees of environmental impact, but many are lethal to non-targeted aquatic invertebrates. The use of large quantities of drugs and chemicals for parasite control has the potential to be detrimental to fish health and EFH. Also there is evidence that repeated use of chemotherapeutants has led to resistant strain of ectoparasites such as “sea lice” (*Lepeophtheirus*). Excessive use of parasiticides is of concern to the aquaculture industry and its regulators.

The most common biologics used for aquatic organisms are vaccines. A vaccine is any biologically based preparation intended to establish or improve immunity to a particular pathogen or group of pathogens. Vaccines have been used for many years in humans and agricultural livestock. They are considered the safest prophylactic approach to management of aquatic animal health and pose no risk to the environment or EFH. In aquaculture, the use of vaccines for disease prevention has expanded both with regard to the number of aquatic species and number of targeted pathogens. Vaccination has become a basis for good health for most finfish operations. Commercial vaccines can be administered by injection or immersion. Oral vaccines remain experimental. Vaccines have been successfully used to prevent a variety of bacterial diseases in finfish. Few viral vaccines are commercially available and vaccines for fungal and parasitic diseases do not exist. All vaccines for use on fish destined for human consumption must be approved by the USDA APHIS, the federal agency responsible for regulating all veterinary biologics, including vaccines, bacterins, antisera, and other products of biological origin.

**Water quality impacts**

Water quality is a key factor in any aquaculture operation, affecting both success and environmental sustainability. Extensive aquaculture operations should be sited in areas with an abundant and reliable supply of good water quality, and intensive operations face logistical husbandry and engineering challenges. The primary risks to water quality from marine aquaculture operations are increased organic loading, nutrient enrichment, and harmful algal blooms. Excess nitrogenous waste products and suspended organic solids in finfish aquaculture effluents can cause eutrophication in receiving water bodies when nutrient inputs exceed the capacity of natural dispersal and assimilative processes. Elevated nutrients and declines in dissolved oxygen are sometimes observed in areas near the discharge of high-density operations. These conditions rarely persist or present long-term risk to water quality; however acute damage to sensitive ecosystems may be dramatic and in the worst cases irreparable.

At some farm sites, a phytoplankton response to nutrient loading has been reported (Anderson et al. 2002) but generally this is a low risk. Because a change in primary productivity linked to fish farm effluents would have to be detected against the background of natural variability, it is difficult to discern effects unless they are of great magnitude and duration. Small, dispersed operations are probably of less consequence, but where large scale established aquaculture industry is concentrated in an area, anthropogenically derived nutrients could be of concern.  However, contingency planning for harmful algal blooms and other natural perturbations should be considered, particularly in areas with known and frequent bloom events. Examples of mitigating practices include contingency planning for net pen relocation and development of a coordinated early warning system designed to detect early blooms, minimize economic loss and environmental impact.

Environmental impacts will vary by location (*i.e.*, on-shore, near-shore, and offshore); therefore, careful selection of sites is the most important tool for risk management. Operations appropriately sited in well-flushed, non-depositional areas may have little to no impact on water quality. The approach to limiting impacts to water quality will also vary by production format. For example, closed systems located onshore are able to directly control their discharges while production systems located offshore rely on best management practices, including siting aquaculture operations outside of nutrient sensitive habitats (*e.g.*, EFH), using responsible cleaning practices, integrating feed management strategies, using optimally formulated diets.

Aquaculture operations are regulated under the Clean Water Act, by the National Pollutant Discharge Elimination System (NPDES), a permitting system administered by the EPA for wastewater discharges into navigable waters.[4]  NPDES permits contain industry-specific,

[4] Pursuant to the provisions of Section 402(a)(1); 40 CFR 122.44(k) of the Federal Water Pollution Control Act (Clean Water Act).

technology and water-quality-based limits, and establish pollutant monitoring and reporting requirements.[5] Aquaculture operations that qualify as concentrated aquatic animal production facilities (*i.e.*, produce more than 45,454 harvest weight kilograms of fish and feed) must obtain a permit before discharging wastes. A permit applicant must provide quantitative analytical data identifying the types of pollutants present in wastewater effluents. The permit will set forth the conditions and effluent limitations under which an aquaculture operation may make a discharge. NPDES permit limitations are based on best professional judgment when national effluent limitations guidelines have not been issued pertaining to an industrial category or process.

**Benthic sediment and community impacts**

Benthic impacts can result from deposition of organic wastes, chemicals, therapeutics, and biocides from aquaculture operations. These impacts can affect EFH if aquaculture operations are not properly sited or managed. Excess feed and feces are the predominant sources of particulate wastes from fish farms. Shellfish operations release pseudofeces, a byproduct of mollusks filtering food from the water column. If allowed to accumulate, particulate waste products may alter biogeochemical processes of decomposition and nutrient assimilation. At sites with poor circulation, waste accumulation can alter the bottom sediment and perturbate infaunal communities if wastes are released in excess of the aerobic assimilative capacity of the bottom. Under such conditions, sediments will turn anoxic and the benthic community will decline in species diversity.

Common indicators used to assess benthic condition include total organic carbon, redox potential, total sulfides, and abundance and diversity of marine life. Electro-chemical and image analysis methods are used to quantify video-recorded observations of benthic condition. These indicators guide BMPs for grading and stocking fish, fallowing, or adjusting feed rates. Fallowing is the practice of temporarily relocating or suspending aquaculture operations to allow the benthic community and sediments to undergo natural recovery from the impacts of nutrient loading. Under ideal conditions, farms should not require a fallowing period for the purpose of sediment recovery; however, this practice is widely and successfully implemented around the world as a management practice for preventing damage to the benthic environment and EFH (Tucker and Hargreaves 2008). Fallowing times range from a few months to several years depending on local hydrology and the level of accumulation (Brooks et al. 2003, Brooks et al. 2004, Lin and Bailey-Brock 2008).

Benthic accumulation of organic wastes can be reduced by siting aquaculture operations in well-flushed areas, or in areas where net erosional sediments can decrease or eliminate accumulation of wastes, thereby minimizing benthic effects. Benthic monitoring plans should be designed to allow for early detection of enrichment and deterioration of benthic community structure. Additionally, nearby control sites should be established in order to collect baseline data for natural variability.

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[5] EPA issues effluent guidelines for categories of existing sources and sources under Title III of the Clean Water Act. The standards are technology-based (*i.e.*, they are based on the performance of treatment and control technologies); they are not based on risk or impacts upon receiving waters.

## Location Specific Interactions with EFH

### Onshore Aquaculture

Onshore aquaculture activities occur on-land in ponds, raceways, and tank-based systems. These systems can be used for multiple phases of aquaculture including broodstock holding, hatchery production, nursery production, grow-out, and quarantine. Water demand and usage varies from conventional pond systems to intensive recirculating aquaculture systems, which may employ sophisticated filtration components for water reuse. Onshore marine aquaculture operations have the potential to impact a variety of EFHs including:

a) waters and benthic habitats in or near marine aquaculture sites
b) exposed hard bottom (*e.g.*, reefs and live bottom) in shallow waters
c) submerged aquatic vegetation beds
d) shellfish beds
e) spawning and nursery areas
f) coastal wetlands
g) riverine systems and associated wetlands

The greatest impacts to EFH by onshore aquaculture involve escape of non-native species and nutrient discharge and its impact on water quality and bottom sediments. Onshore aquaculture activities affecting EFH are regulated by existing state and federal laws and requirements specified by EPA's National Pollutant Discharge Elimination System and coastal habitat protection plans.

### Nearshore Aquaculture

Nearshore aquaculture activities are those that occur in rivers, sounds, estuaries and other areas that extend through the coastal zone.[6] Currently in the South Atlantic region, nearshore aquaculture is characterized primarily as shellfish aquaculture with hard clams *Mercenaria mercenaria* and oysters *Crassostrea virginica* comprising the most commonly cultured species.

While the relative risk of nearshore shellfish aquaculture to various EFHs is uncertain, the ranges of possible interactions include:

a) coral, coral reef and live/hard bottom habitat
b) marine and estuarine waters
c) estuarine wetlands, including mangroves and marshes
d) submerged aquatic vegetation
e) waters that support diadromous fishes, and their spawning and nursery habitats
f) waters hydrologically and ecologically connected to waters that support EFH

The environmental effects of shellfish and finfish aquaculture in coastal waters are well-

[6] The term "coastal zone" means the coastal waters strongly influenced by each other and in proximity to the shorelines of several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends seaward to the outer limit of State title and ownership under the Submerged Lands Act (43 U.S.C. 1301 et seq.).

documented (Naylor et al. 2006; Nash 2005; Tucker and Hargreaves 2008). Poorly sited and managed aquaculture activities can have significant impact on benthic communities, water quality, and associated marine life. While there are case studies documenting environmental impacts of practices used several decades ago, regulatory and management practices are reducing the likelihood of negative environmental effects (Price and Morris 2013).

In the case of cage culture, water quality and benthic effects are sometimes observed; however, these are typically episodic and restricted to within 30 m of the cages (Nash 2003). Long-term risks to water quality from offshore aquaculture activities are unlikely when operations are sited in well-flushed waters.

The most studied environmental benefit from marine aquaculture operations is as fish attractants. Wild fish use aquaculture cages for refuge and for foraging on biofouling organisms and uneaten feed. Wild fish can help distribute organic waste away from the cages and re-suspend organic compounds in sediments. As a result, overall fish abundance may increase in areas with aquaculture operations. Recreational and commercial fishers may benefit from increased fishing opportunities around marine aquaculture operations. Conversely, interactions with marine mammals that are attracted to the forage fish around cages are identified as potential long-term concern for management of protected species.

Potential interactions of nearshore shellfish aquaculture with EFH are changes to benthic habitat as a result of pseudofeces, the effects of mechanical harvesting, conversion of soft sediment habitat to hard bottom shellfish reef, displacement of cultured organisms, potential genetic transfer, sedimentation and loading of organic waste to the water column and benthic sediments, and disruption of the benthic community. Some changes could potentially impact SAV located near shellfish aquaculture operations, although this impact likely varies with species and production type.

In general, shellfish and algae aquaculture has positive impacts on EFH, providing ecosystem services and habitat related benefits in the estuary including mitigation of land-based nutrients and increased habitat for fish, shellfish, and crustaceans (Shumway 2011). Therefore, the positive and negative effects of shellfish culture activities to EFH need to be considered. The risk of nearshore aquaculture impacts to EFH can be minimized by including terms and conditions designed to protect sensitive habitats in permits issued under state and federal laws and regulations. Best management practices are now in place for shellfish aquaculture along the U.S. East Coast (Flimlin 2010).

**Offshore Aquaculture**

Offshore aquaculture activities occur in areas of the open ocean that extend from the seaward edge of the coastal zone through the exclusive economic zone.[7] In the South Atlantic region, offshore aquaculture may include the cultivation of macrophytic algae, molluscan shellfish, shrimp, or finfish. With exception of a few live rock aquaculture operations, there are currently no offshore aquaculture activities occurring in the South Atlantic region. It is feasible that co-siting aquaculture facilities with other offshore industries such as wind energy could facilitate

[7] The term 'offshore aquaculture' is often used to refer to aquaculture in waters under federal jurisdiction, which typically extend from 3-200 nautical miles from the shoreline.

offshore aquaculture development.[8] Over 25 laws exist to provide regulatory oversight of aquaculture in federal waters. Some examples include the Clean Water Act and the Coastal Zone Management Act.

While the relative threat of offshore aquaculture to EFHs varies widely depending on siting and management considerations, the ranges of possible interactions include:

a) coral, coral reef and live/hardbottom habitat, including deepwater coral communities
b) marine and estuarine waters
c) waters that support diadromous fishes and their spawning and nursery habitats
d) waters hydrologically and ecologically connected to waters that support EFH

The environmental effects of offshore shellfish and finfish aquaculture are not as well-documented for inshore waters. The information gleaned from coastal production sites, especially those with conditions similar to federal waters, provide some indications as to the potential effects of offshore aquaculture (see section on nearshore aquaculture).

**Live Rock Aquaculture**
Live rock is defined as living marine organisms or an assemblage thereof attached to a hard calcareous substrate, including dead coral or rock. In 1994, the SAFMC and GMFMC established a live rock aquaculture permitting system for state and federal waters off the coast of Florida under Amendment 2 to the Fishery Management Plan for Coral and Coral Reefs of the Gulf of Mexico and South Atlantic. The SAFMC further amended this program under Amendment 3 to the Coral FMP (1995), during which time the SAFMC received extensive public comment. This permitting system allows deposition and harvest of material for purposes of live rock aquaculture while maximizing protection of bottom habitat, EFH, and HAPC in federal waters of the South Atlantic.

## SAFMC Policy for Marine Aquaculture in Federal Waters

The SAFMC supports the establishment and enforcement of the following general requirements for marine aquaculture projects authorized under the Magnuson-Steven Fishery Conservation Act (MSA) or other federal authorities, to clarify and augment the general policies already adopted in the Habitat Plan and Comprehensive Habitat Amendment (SAFMC 1998a; SAFMC 1998b):

1. Marine aquaculture activities in federal waters of the South Atlantic require thorough public review and effective regulation under MSA and other applicable federal statutes.

2. Aquaculture permits should be for at least a 10-year duration (or the maximum allowed if the applicable law or regulation sets a maximum less than 10 years) with annual reporting requirements (activity reports). Permits of 10 years or more should undergo a 5-year comprehensive operational review with the option for revocation at any time in the event there is no prolonged activity or there are documented adverse impacts that pose a substantial threat to marine resources.

[8] A notable exception is Live Rock Aquaculture, managed under Amendement 3 to the Coral Fishery Management Plan (1995).

3. Only drugs, biologics, and other chemicals approved for aquaculture by the FDA, EPA, or USDA should be used, in compliance with applicable laws and regulations (see Appendix for current list of approvals).

4. Only native (populations) species should be used for aquaculture in federal waters of the South Atlantic.

5. Genetically modified organisms should only be used for aquaculture in federal waters of the South Atlantic, pending FDA and/or other Federal approval, following a rigorous and documented biological assessment which concludes there is no reasonable possibility for genetic exchange with natural organisms or other irreversible form of ecological impact. Further, aquaculture of genetically modified organisms should be prohibited in federal waters of the South Atlantic when there exists a reasonable opportunity for escapement and dispersal into waters of any state in which their culture and/or commerce are prohibited by state rule or policy.

6. Given the critical nature of proper siting, the permitting agency should require the applicant to provide all information necessary to thoroughly evaluate the suitability of potential aquaculture sites. If sufficient information is not provided in the time allotted by existing application review processes, the permitting agency should either deny the permit or hold the permit in abeyance until the required information is available.

7. Environmental monitoring plans for projects authorized under MSA should be developed by the applicant/permit holder and approved by NOAA Fisheries with input from the Council.

8. Fishery management plans for aquaculture should require permittees to have adequate funds (*e.g.*, assurance bond) committed to ensure removal of organisms and decommissioning of facilities that are abandoned, obsolete, or storm-damaged or have had their permit revoked. The plans should also require that the amount of these funds be determined by NOAA Fisheries with input from the Council and that the funds be held in trust.

9. When issuing permits for aquaculture in federal waters, NOAA Fisheries should specify conditions of use and outline the process to repeal permits in order to prevent negative impacts to EFH. NOAA should take the appropriate steps to modify or revoke permits using its authority if permit conditions are not being met.

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## Appendix A.

### List of Potentially Affected Species Currently Identified by SAFMC and their EFH in the South Atlantic

Sections of South Atlantic waters potentially affected by these projects, both individually and collectively, have been identified as EFH or EFH-HAPC by the SAFMC. Potentially affected species and their EFH under federal management include (SAFMC, 1998b):

a) Summer flounder (various nearshore waters; certain offshore waters);
b) Bluefish (various nearshore waters);
c) Many snapper and grouper species (live hardbottom from shore to 600 feet, and – for estuarine-dependent species (*e.g.*, gag grouper and gray snapper) – unconsolidated bottoms and live hardbottoms to the 100 foot contour);
d) Black sea bass (various nearshore waters, including unconsolidated bottom and live hardbottom to 100 feet, and hardbottoms to 600 feet);
e) Penaeid shrimp (offshore habitats used for spawning and growth to maturity, and waters connecting to inshore nursery areas);
f) Coastal migratory pelagics (*e.g.*, king mackerel, Spanish mackerel; sandy shoals of capes and bars, barrier island ocean-side waters from the surf zone to the shelf break inshore of the Gulf Stream);
g) Corals of various types and associated organisms (on hard substrates in shallow, mid-shelf, and deep water);
h) Muddy, silt bottoms from the subtidal to the shelf break, deep water corals and associated communities;
i) Areas identified as EFH for Highly Migratory Species managed by the Secretary of Commerce (*e.g.*, for sharks this includes inlets and nearshore waters, including pupping and nursery grounds), and
j) Federal or state protected species.

**Appendix B.**

**List of Potentially Affected Habitats Currently Identified by the SAFMC**

Many of the habitats potentially affected by these activities have been identified as EFH- HAPCs by the SAFMC. Each habitat and FMP is provided as follows:

a) All hardbottom areas (SAFMC snapper grouper);
b) Nearshore spawning and nursery sites (SAFMC penaeid shrimps);
c) Benthic Sargassum (SAFMC snapper grouper);
d) From shore to the ends of the sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras, North Carolina; Hurl Rocks, South Carolina; and Phragmatopoma (worm reefs) reefs off the central coast of Florida and near shore hardbottom south of Cape Canaveral (SAFMC coastal migratory pelagics);
e) Hurl Rocks (South Carolina); the Phragmatopoma (worm reefs) off central east coast of Florida; nearshore (0-4 meters; 0-12 feet) hardbottom off the east coast of Florida from Cape Canaveral to Broward County; offshore (5-30 meters; 15-90 feet) hardbottom off the east coast of Florida from Palm Beach County to Fowey Rocks; Biscayne Bay, Florida; Biscayne National Park, Florida; and the Florida Keys National Marine Sanctuary (SAFMC coral, coral reefs and live hardbottom Habitat);
f) EFH-HAPCs designated for HMS species (e.g., sharks) in the South Atlantic region (NMFS Highly Migratory Species);
g) Oculina Bank HAPC and proposed deepwater coral HAPCs (SAFMC coral, coral reefs, and live hardbottom habitat), and
h) HAPCs for diadromous species adopted by the Atlantic States Marine Fisheries Commission (ASMFC).

**Appendix C.**

**Regulation of Drugs, Biologics, and Other Chemicals**

Several federal agencies are involved in regulating drugs, biologics, and chemicals used in aquaculture. Each federal agency has specific, congressionally mandated responsibilities to regulate the products under their jurisdictions. In the case of aquaculture, there is some overlap between these federal agencies, as well as with state and local regulatory bodies.

The U.S. Food and Drug Administration (FDA) regulates the use of animal drugs and animal feed in aquaculture, ensuring their safety and efficacy. The FDA is responsible for ensuring that drugs used in food-producing animals, including cultured seafood, are safe and effective and that foods derived from treated animals are free from potentially harmful drug residues.

The EPA regulates disinfectants, sanitizers, and aquatic treatments used solely for control of algae, biofilm or pest control (excluding pathogens in or on fish). As authorized by the Clean Water Act, EPA also administers NPDES permits, which regulates discharge of pollutants that include drugs and chemicals from aquaculture operations into U.S. waters.

The USDA Animal and Plant Health Inspection Service (APHIS) regulates all veterinary biologics, including vaccines, bacterins, antisera, diagnostic kits, and other products of biological origin. APHIS is responsible for testing, licensing, and monitoring of vaccines used in aquaculture. They insure that all veterinary biologics used for diagnosis, prevention, and treatment of aquatic diseases are pure, safe, potent, and effective.

The Federal Food, Drug, and Cosmetic Act (FFDCA) defines the term "drug" broadly to include articles intended for use in the diagnosis, cure, mitigation, and treatment or prevention of disease. In aquaculture, this includes compounds such as antibiotics, sedatives and anesthetics, gender manipulators, and spawning aids. Common household compounds are also considered drugs (*e.g.*, hydrogen peroxide, salt, ice). These products cannot be used on aquatic species unless they have been approved by FDA for the intended purpose.

- Disinfectants are compounds, which have antimicrobial properties that are generally applied to equipment and structures and are not intended to have a therapeutic effect on cultured animals.
- Pesticides are not widely used in aquaculture; however, herbicides can be an important part of aquatic weed management in pond production.
- Biologics include a range of products of biologic origin used in the diagnosis, prevention, and treatment of diseases. In aquaculture, the most commonly used biologics are vaccines used to immunize animals and prevent infections from occurring.

It is illegal to use (1) unapproved drugs for any purpose or (2) approved drugs in a manner other than that specified on the product label unless the drugs are being used under the strict conditions of an investigational new animal drug (INAD) exemption or an extra-label prescription issued by a licensed veterinarian. Some aquaculture producers may use drugs that are not approved for aquaculture, but considered to be of low regulatory priority (LRP) for purposes of enforcement. Examples include acetic acid, carbon dioxide, sodium bicarbonate, sodium chloride, and ice.

For more information visit:

1. **US FDA Animal and Veterinary Drugs for Aquaculture**

http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/Aquaculture/ucm132954.htm

2. **A Quick Reference Guide to: Approved Drugs for Use in Aquaculture**

http://www.fda.gov/downloads/AnimalVeterinary/ResourcesforYou/AnimalHealthLiteracy/UCM109808.pdf

3. **Guide to Using Drugs, Biologics, and Other Chemicals in Aquaculture**

http://www.fws.gov/fisheries/aadap/AFS-FCS%20documents/GUIDE_OCT_2011.pdf

**Table 1. Approved and conditionally approved drugs for use in marine aquaculture.**

| Active Ingredient | Tradename | Indication(s) |
|---|---|---|
| Chorionic gonadotropin | Chorulon® | Aid to improve spawning function in broodstock |
| Formalin | Parasite-S®, Formalin-F®, Formacide-B®, Paracide-F® | Control of fungi and external parasites in all finfish and penaeid shrimp |
| Oxytetracycline hydrochloride | Pennox® 343, Tetroxy® | Mark skeletal tissues for tagging finfish |
| Oxytetracycline dihydrate | Terramycin® 200 | Broad spectrum antibiotic to control ulcer disease, furunculosis, bacterial hemorrhagic septicemia, enteric redmouth, pseudomonas disease, and other gram negative systemic bacteria in marine fish, Mark skeletal tissues for tagging finfish |
| Tricaine methanesulfonate | Finquel®, Tricaine-S® | Anesthesia and immobilization of finfish and other aquatic poikilotherms |

**Table 2. Low regulatory priority aquaculture drugs for use in marine aquaculture.**

| Active Ingredient | Indication(s) |
|---|---|
| Acetic acid | Parasiticide for finfish |
| Calcium chloride | Used to aid in egg hardening, Used to aid in maintaining osmotic balance during holding and transport of aquatic animals |
| Calcium oxide | External protozoacide for finfish |
| Carbon dioxide gas | Anesthesia and immobilization of finfish and other aquatic poikilotherms |
| Fuller's Earth | Use to reduce the adhesiveness of fish eggs |
| Garlic (whole form) | Use to control heminth and sea lice infestations of marine finfish |
| Ice | Use to reduce the metabolic rate of aquatic poikilotherms during transport |
| Magnesium sufate | Used to treat external parasites (monogenic trematodes and crustaceans) in finfish |
| Onion (whole form) | Used to treat external parasites (sea lice and other crustaceans) in finfish |
| Papain | Used to reduce the adhesiveness of fish eggs |
| Potassium chloride | Used to aid in maintaining osmotic balance during holding and transport of aquatic animals |
| Providone iodine | Used to disinfect fish eggs |
| Sodium bicarbonate | Used to introduce carbon dioxide into water for anesthetizing aquatic animals |
| Sodium chloride (salt) | Used to aid in maintaining osmotic balance during holding and transport of aquatic animals; Parasiticide for aquatic animals |
| Sodium sulfite | Used to reduce the adhesiveness of fish eggs |
| Thiamine hydrochloride | Used to prevent or treat thiamine deficeincy in finfish |
| Urea and tannic acid | Used to reduce the adhesiveness of fish eggs |

**Table 3. Investigational new animal drug exemptions for use in marine aquaculture. Permits held by the U.S. Fish and Wildlife Service as part of the National INAD Program.**

| Active Ingredient | Tradename | Indication(s) |
|---|---|---|
| Common carp pituitary | - | Aid to improve spawning function in broodstock |
| Catfish pituitary | - | Aid to improve spawning function in broodstock |
| Chloromine-T | Halamid®, Actamide® | Control of bacterial gill disease and external flavobacteriosis in certain species of marine finfish |
| Florfenicol | Aquaflor® | Broad spectrum antibiotic to control ulcer disease, furunculosis, bacterial hemorrhagic septicemia, and pseudomonas disease in marine aquatic animals |
| Hydrogen peroxide | Perox-Aid® | Use to treat external parasites in marine finfish |
| Luteinizing hormone releasing hormone analogue (LHRHa) | - | Aid to improve spawning function in broodstock |
| Oxytetracycline hydrochloride | Pennox® 343 | Broad spectrum antibiotic to control ulcer disease, furunculosis, bacterial hemorrhagic septicemia, enteric redmouth, pseudomonas disease, and other gram negative systemic bacteria in marine fish, Mark skeletal tissues for tagging finfish |
| Oxytetracycline dihydrate | Terramycin® 200 | Broad spectrum antibiotic to control ulcer disease, furunculosis, bacterial hemorrhagic septicemia, enteric redmouth, pseudomonas disease, and other gram negative systemic bacteria in marine fish, Mark skeletal tissues for tagging finfish |
| Calcein | Se-Mark® | Mark skeletal tissues for tagging finfish |

**Table 3 continued. Investigational new animal drug exemptions for use in marine aquaculture. Permits held by the U.S. Fish and Wildlife Service as part of the National INAD Program.**

| Active Ingredient | Tradename | Indication(s) |
|---|---|---|
| Salmon ganadotropin releasing hormone analogue (sGnRHa) | Ovaprim®, Ovaplant® | Aid to improve spawning function in broodstock |
| Benzocaine | Benzoak® | Anesthesia and immobilization of finfish and other aquatic poikilotherms |
| Eugenol | Aqui-S® 20E | Anesthesia and immobilization of finfish and other aquatic poikilotherms |
| Emamectin benzoate | Slice® | Use to control sea lice and other external parasite infestations of marine finfish |
| Methyl testosterone | - | Use to produce populations comprising over 90% phenotypically male finfish |

## Appendix D.

**Examples of Existing Federal Laws Designed to Minimize Environmental Risks Associated with Marine Aquaculture.**

Coastal Zone Management Act
Endangered Species Act
Rivers and Harbors Act of 1899
Clean Water Act
National Marine Sanctuaries Act
National Invasive Species Act
National Aquaculture Act
Outer Continental Shelf Lands Act
National Sea Grant College and Program Act
Fish and Wildlife Coordination Act
E.O. 11987: Exotic Organisms
E.O. 12630: Takings
E.O. 13089: Coral Reef Protection
E.O. 13112: Invasive Species
E.O. 13158: Marine Protected Areas
Marine Mammal Protection Act
Magnuson-Stevens Fishery Conservation and Management Act
Animal Health Act of 2002