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Chairwoman Bordallo and Members of the Committee, thank you for inviting me to testify before you today on the development of offshore aquaculture in the United States. My name is Michael Sutton and I serve as Vice President of the Monterey Bay Aquarium where I direct the Aquarium's Center for the Future of the Oceans. In 2007, Governor Schwarzenegger appointed me to the California Fish and Game Commission, where I participate in regulatory decisions related to the management and sustainable use of the state's fish and wildlife resources. I am testifying today regarding what we can learn from California's experience in the governance of marine aquaculture to help inform the development of a federal aquaculture program.

Aquaculture: A Worldwide Phenomenon

Marine fish farming, or aquaculture, is a global "megatrend"; it is now the fastest growing segment of the international food system. Today, nearly half of the fish consumed worldwide are raised on farms rather than caught in the wild. The contribution of aquaculture to global seafood supply has grown dramatically in the last 50 years—from a production of less than 1 million tons in the early 1950s to 51.7 million tons in 2006. The growth rate of seafood production from aquaculture is outpacing production from capture fisheries, which leveled out in the mid-1980s. Just as we replaced hunting with farming on land, we are in the process of replacing fishing with farming in our oceans. But the environmental damage caused by the "Green Revolution" to terrestrial ecosystems is now well understood, and its lessons are sobering as we contemplate a "Blue Revolution" in our oceans. As we develop the U.S. aquaculture industry to keep pace with the demand for seafood, our challenge will be to ensure that fish farming is conducted in a way that sustains the health of our ocean and coastal ecosystems.

Today, nations in Asia and the Pacific Rim produce the vast majority of seafood from aquaculture. China alone produces 67 percent of the world total. Most fish grown there are omnivorous species like carp, tilapia, and catfish farmed in freshwater. Mariculture, or marine fish farming, is less common and in addition to shellfish such as oysters and abalone, it often involves carnivores of far higher value such as shrimp, tuna, and salmon. Farming such carnivores in the ocean and coastal zone tends to have greater impacts on the environment than freshwater aquaculture of omnivores and thus is more challenging to regulate.

Here in the United States we import more than 80 percent of our seafood from overseas, much of which is farmed. For many years, the United States has been a relatively minor player in aquaculture, except species like catfish in the southern states. Most U.S. aquaculture is either conducted inland (in freshwater) or in the coastal environment and is therefore regulated by the states. In California, for example, coastal shellfish farming alone—oysters, clams, and mussels—is worth more than $16 million each year (Kuiper 2009). Today, as our aquaculture industry considers expansion into offshore waters, we have a terrific opportunity to develop an effective regulatory regime from the outset. That is, our government in a good position to create a framework for the orderly and environmentally-responsible development of marine aquaculture in U.S. waters. We also have the opportunity to learn from our past and forego allowing aquaculture to follow the "boom and bust" history of our marine fisheries. Now is the time to establish a national offshore aquaculture policy and set of clear and concise national standards to support marine fish farming that is environmentally sustainable. Fortunately, we've learned some lessons in California and other states that may be useful as we develop a federal regulatory framework.

The First Step: Assessing Environmental Risks

The nation's oceans and coasts drive our economy and sustain our way of life. In 2007, coastal and Great Lakes states generated 83 percent of the nation's economic output. In California alone the ocean and coastal economy generates more than $46 billion annually. More than three-quarters of U.S. growth between 1997 and 2007 was in coastal states, whether measured by population, employment or Gross Domestic Product (Kildow et al, 2009). This means that the same ocean and coastal ecosystems that help generate our economic wealth are becoming increasingly vulnerable to a growing number of human activities. For this reason, the first and most important step in developing a management framework for offshore aquaculture is to fully address potential environmental risks.

The ecological risks associated with aquaculture vary according to the production system: Open-water cages or net pen farms rank as a 'high', or 'very high' risk for seven key ecological risks, including habitat alteration or destruction, pollution and eutrophication, contamination with pesticides and other drugs, genetic risks of escaped culture animals, introduction of exotic species, spread of disease to wild species, and use of wild fish for feed (Leung and Dudgeon, 2008).

Given these risks, the first step in developing an offshore aquaculture industry should be the preparation of a Programmatic Environmental Impact Statement, similar to the Programmatic Environmental Impact Review currently underway for marine aquaculture in California (see below). Fortunately, we know what to look for thanks to a large body of peer-reviewed scientific research on the risks involved in marine fish farming, the most notable of which include the following:

Escapes of farmed fish and harmful interactions with native ecosystems

Accidental or intentional introductions of non-native species have become an alarming

global environmental problem (Leung and Dudgeon, 2008). Aquaculture is considered one of the major pathways for introducing non-native aquatic species that may become harmful invasives (Weigle et al, 2005; Casal, 2006). The risk of accidental escape of farmed fish is especially high in open-water aquaculture systems and we can predict with absolute certainty that fish will escape from offshore facilities. In addition to the complex ecological interactions, the overall economic costs of harmful invasive species in the United States alone have been estimated at US$ 120 billion annually (Pimentel et al, 2000, 2005). Forty two percent of the species listed as threatened or endangered with extinction in the United States are at risk primarily because of exotic invasive species (Pimentel et al, 2005).

California prohibited the farming of non-native fish species in the state's ocean waters in 2003 in response to concerns about the potential impacts from escapes. Subsequently, California enacted several additional statutes to help protect the state from other ways in which non-native species can be introduced, including laws that prohibit ships from exchanging ballast water in ports; restrict the importation and transportation of a number of live animals and plants; restrict the placement of live aquatic animals or plants in state waters; and prohibit the cultivation, spawning, or incubation of any exotic species or any species of salmon.

Native farmed fish can also be genetically distinct from wild members of the same species due to domestication and selective breeding. The escape of native but genetically different farmed fish is associated with a variety of ecological impacts; for example, interbreeding with reproductively compatible populations in the wild can result in loss of adaptation in natural populations, introgression of new genetic material into species' gene pools and, in the extreme case, loss of locally adapted populations (Hallerman, 2008; McGinnity et al, 2003).

Pollution from excess nutrients, waste feed, and release of drugs and chemicals

Like terrestrial farm animals, aquatic animals—when raised in high numbers and dense concentrations—produce substantial quantities of waste (Islam, 2005). Due to economies of scale and the logistical challenges of operating some distance offshore, open-ocean fish farms are likely to be substantial in size. In California, for example, Hubbs-SeaWorld Research Institute in San Diego is proposing to produce 3,000 tons of farmed fish annually in offshore pens. A production biomass of 3,000 tons not only represents a substantial number of individual fish (about 2 million 1.5 kg fish), but also requires more than double this amount in feed.

The nitrogen and phosphorous-rich effluent resulting from the incomplete digestion of feed by farmed fish represents a substantial point source of pollution. Open net-pen production systems rely on the free ecosystem service provided by water currents and the surrounding environment to disperse, dilute, and break down farm wastes. The direct impacts of soluble and particulate wastes on offshore habitats are poorly understood. In addition, uneaten feeds usually attract other species outside the nets, causing unnatural aggregations of predators (e.g., sharks), and a subsequent need to control those predators (sometimes through lethal measures) for human safety. Therefore, effluent effects of open-ocean net pens should not be assumed to be negligible solely on the basis of dilution.

Another major area of concern for aquaculture is the environmental contamination and human health risks associated with veterinary drugs, particularly pesticides and antibiotics (Phillips and Subersinghe, 2008).

Introduction and spread of disease, pathogens, and parasites to the ocean environment

The importation of gametes, eggs, fry or breeding stocks for aquaculture have been responsible for the introduction of non-native pathogens and parasites (e.g. Briggs et al, 2005), and for the amplification and retransmission of native pathogens and parasites occurring naturally in the environment (Krkosek, 2007). Commercially devastating viral, bacterial and parasitic pathogens associated with a wide variety of aquaculture species have been introduced across the globe and have infected native wild populations (Kibenge et al, 2009).

In California, for example, the South African sabellid worm was introduced through the importation of abalone stock for aquaculture. The worm stunted the growth of cultured abalone and spread to the wild where it also impacted black turban snails. Researchers at the University of California, Santa Barbara had to remove more than a million infected snails in Southern California to eradicate the worm from the wild. This represents a rare example of the successful extermination of an invasive species; usually the ecological and socioeconomic impacts of invasive species introductions are unpredictable and irreversible.

In British Columbia, native sea lice have infected salmon farms and spread to wild fish in the same area. This caused high mortality rates in wild Pink and Chum salmon, threatening to eradicate some local stocks within generations if current levels of disease transmissions continue (Krkosek, 2007). The entire Chilean salmon farming industry, once the world's dominant salmon aquaculture producer and the leading exporter to the United States, has been crippled by the spread of a viral disease known as Infectious Salmon Anemia.

Heightened pressure on ocean ecosystems through wild capture of forage fish for feed

While many of the dominant aquaculture species produced globally can be cultured in freshwater ponds without the artificial feeding (e.g. carp, tilapia and catfish), offshore aquaculture in U.S. waters likely will be dominated by high-value species such as tuna and striped bass that are carnivorous (fish-eating) by nature. These species typically require a diet high in protein and often high in fat (Naylor et al, 2000). Fishmeal and fish oil are the two ingredients most commonly used to meet these nutritional requirements.

Scientists estimate that aquaculture annually consumes the equivalent of more than 16 million tons of wild fish; marine finfish require approximately twice as much wild-caught fish in the form of feed as they produce (Tacon and Metian, 2008). Some argue that even at this ratio, the conversion efficiency of wild forage fish to farmed fish is more efficient than the same farmed species of fish feeding and growing in the wild. But this argument ignores the other invaluable services provided by a functioning natural ecosystem in which these forage fish—such as sardines, herring, and anchovies—play a central role, namely the transfer of energy to recreational and commercial fish and wildlife and the stability of marine food webs to disturbances and climate change. If removed from their natural ecosystems to feed aquaculture

species, forage fish no longer play these functions and much of their nutritional content is wasted in the conversion to farmed species.

Risks associated with capture-based aquaculture

Capture-based aquaculture, also known as "ranching", relies on the collection of wild juvenile or adult fish for fattening in sea cages similar to offshore feedlots. For example, entire schools of bluefin tuna are captured by purse seines and transferred to net pens in Mexico and Australia where they are fed sardines and fattened for export. The capture of wild fish for ranching inevitably maintains or increases fishing pressure on wild fish stocks, both on the farmed species and the small fishes caught for feed. Today, ranching in coastal or offshore sea cages is only commercially viable for high-value species such as tuna, which are typically already heavily overfished (e.g., bluefin tuna). Because the wild-caught fish are not landed, their capture may not be recorded as catches or be taken into account in fishery statistics and management. Contrary to the notion that fish farming relieves pressure on wild stocks, capture-based aquaculture that catches juveniles before they are able to reproduce is one of the most effective paths to commercial fishery collapse.

Existing ranching operations rely almost exclusively on bait fish, such as sardines and anchovies, for feed. Indeed, virtually the entire Pacific sardine catch (California's largest volume fishery) goes to feed penned tunas in Mexico and Australia. But the conversion of sardines and other small pelagic fishes into ranched tuna and other species is typically very inefficient. It takes between 7 and 25 pounds of wild bait fish to grow one pound of ranched bluefin tuna, and ranching increases fishing pressure on these feed fisheries (Zertuche-González et al, 2008). Unlike the global trade in fishmeal and oil, fishing pressure to supply fresh wild fish for tuna ranching is typically concentrated locally in the region of the ranching operation. Overexploitation of the fisheries used to feed the pens can cause the collapse of the ranching operations themselves.

Developing a Comprehensive Framework to Manage Offshore Aquaculture

Currently, federal authority to manage aquaculture involves many different agencies under the authority of multiple laws. The absence of a coordinated and comprehensive governance system means regulatory uncertainty for fish farmers and a lack of unified criteria on which to base effective and environmentally-responsible management decisions. The following examples illustrate the need for clear federal guidance for offshore aquaculture development.

In southern California, numerous federal and state agencies currently are reviewing a proposal by Hubbs-SeaWorld Research Institute (HSWRI) to establish a commercial-scale offshore aquaculture project in federal waters. The goal of the project is to produce 3,000 metric tons a year of striped bass, white sea bass, yellowtail jack, and California halibut in surface cages located five miles off the coast of San Diego. Without a comprehensive federal framework to guide it, the regulatory process to approve the Hubbs-SeaWorld project has been ad hoc and piecemeal. It includes a patchwork of permits from the U.S. Army Corps of Engineers, Environmental Protection Agency, and other federal and state agencies, none of which was developed specifically for the purpose of siting an offshore aquaculture facility. No single

federal agency with marine management expertise is responsible for ensuring the integrity of the overall project, or for additional projects in the region that will likely be proposed in the near future.

A similar situation is occurring in the Gulf of Mexico, where the Gulf Regional Fishery Management Council has stepped in to fill a void caused by the lack of an overarching regulatory framework for offshore aquaculture. Last week, NOAA tacitly approved the Council's Open Ocean Aquaculture Fishery Management Plan but made it clear that final approval of offshore fish farming under the plan would await the development of a comprehensive national policy. Many fear that this will set a precedent for similar, fragmented approaches to aquaculture management in other U.S. offshore regions. It could also undercut the role of Congress in considering federal legislation to establish an appropriate, dedicated management framework that will set the course for sustainable offshore aquaculture development in all U.S. waters.

Offshore Aquaculture in California—the Sustainable Oceans Act

In recent years, California has taken significant steps towards achieving the goal of economically-productive and environmentally-responsible marine aquaculture development. In 2006, California enacted the Sustainable Oceans Act (SB 201) in anticipation of the impending growth of the marine finfish aquaculture industry in California. With SB 201, California became the first among state and federal governments to establish an overarching policy and set of standards for sustainable marine aquaculture in U.S. waters. Since 2006, the State has been engaged in a thoughtful and comprehensive effort to develop a regulatory program for offshore aquaculture. Currently State agencies are working to complete a Programmatic Environmental Impact Report (PEIR) on offshore aquaculture—mandated by SB 201—and are expected to complete it by December 2009.

The PEIR process is an essential step in the development of California's offshore program as it provides an opportunity to evaluate potential impacts of aquaculture operations on a large scale prior to ushering in new development. Significantly, it enables the state to address potential cumulative impacts on ecosystem health from multiple aquaculture operations in a given region, as well as the additive ecosystem effects of other human activities in the same area. If done properly, the PEIR process will also result in the creation of a streamlined permitting process, the development of a common set of best management practices, and the identification of the most appropriate locations to site aquaculture operations. To help ensure these outcomes, SB 201 requires the final PEIR to provide a management framework that, at a minimum, adequately considers all of the following:

- Appropriate areas for siting marine finfish aquaculture operations to avoid adverse impacts, and minimize any unavoidable impacts on user groups, public trust values, and the marine environment.
- The effects on sensitive ocean and coastal habitats.
- The effects on marine ecosystems, commercial and recreational fishing, and other important ocean uses.
- The effects on other plant and animal species, especially species protected or recovering under state and federal law.

- The effects of the use of chemical and biological products, pollutants, and nutrient wastes on human health and the marine environment.
- The effects of interactions with marine mammals and birds.
- The cumulative effects of a number of similar finfish aquaculture projects on the ability of the marine environment to support ecologically significant flora and fauna.
- The effects of feed, fish meal, and fish oil on marine ecosystems.
- The effects of escaped fish on wild fish stocks and the marine environment.
- The design of facilities and farming practices so as to avoid adverse environmental impacts, and to minimize any unavoidable impacts.

California, like other coastal states, has Public Trust responsibilities for the submerged lands, waters, and marine resources under its jurisdiction—typically up to three miles offshore. As such, California is obliged to manage activities that affect these areas and resources on behalf of all citizens, including future generations, which means recovering at least the cost of managing aquaculture operations for public benefit. The California Fish and Game Commission is in the process of modernizing the management of all aquaculture leases to better reflect these responsibilities, and require lessees to help cover management costs, including the costs of issuance, monitoring, and enforcement of leases. The state's management responsibilities are also reflected in the set of standards for leases in SB 201 that include:

- The lease site is considered appropriate for marine finish aquaculture in the programmatic environmental impact report.
- A lease shall not unreasonably interfere with fishing or other uses or public trust values, unreasonably disrupt wildlife and marine habitats, or unreasonably harm the ability of the marine environment to support ecologically significant flora and fauna. A lease shall not have significant adverse cumulative impacts.
- To reduce adverse effects on global ocean ecosystems, the use of fish meal and fish oil shall be minimized, and alternatives to these feed ingredients shall be utilized where feasible; and
- Lessees shall establish best management practices for each lease site that includes a regular monitoring, reporting, and site inspection program.
- The lessee shall provide baseline benthic habitat and community assessments of the proposed lease site.
- Finfish numbers and density shall be limited to what can be safely raised while protecting the marine environment.
- The use of all drugs, chemicals, and antibiotics shall be minimized.
- All farmed fish shall be marked, tagged, or otherwise identified as belonging to the lessee, unless deemed unnecessary.
- All facilities and operations shall be designed to prevent the escape of farmed fish into the marine environment.
- The lessee shall meet all applicable water quality requirements and shall prevent discharges to the maximum extent possible.

Essential Elements of a Management Framework

The development of a federal offshore aquaculture program can benefit tremendously from what we know about risks to ocean ecosystem health, and from California's leadership in advancing a sustainable management regime. The following essential components of a federal program are based on this understanding.

Mandate a precautionary approach

As noted above, the environmental risks associated with offshore aquaculture activities have the potential to dramatically alter ocean ecosystems on a large scale. These risks should be addressed both on an individual project basis and in the context of other human uses of ocean ecosystems. We still have a lot to learn about the cumulative impacts of multiple aquaculture operations on the marine environment, and about the additive effects of aquaculture and other human activities in ocean regions. For this reason, the United States should use a precautionary approach to guide the expansion of offshore aquaculture operations. The developers of potential offshore fish farms should be required to demonstrate that they will not harm associated marine ecosystems before permits are issued. Once permits are issued, robust research and monitoring programs must be mandated to continuously improve aquaculture management in U.S. waters. The goal of this program should be to increase our understanding of how to design and operate productive aquaculture facilities in ways that are compatible with healthy, functioning ocean ecosystems.

Articulate clear national standards

Throughout its history, Congress has understood the importance of providing national leadership with comprehensive policy and standards for the management of our natural resources. For example, the nation's principal law governing marine fisheries—the Magnuson-Stevens Fishery Conservation and Management Act—includes a set of ten National Standards that clearly articulate the nation's interest in achieving healthy, sustainable fisheries through effective management measures. Like the standards in California's Sustainable Ocean Act, the National Standards in the Magnuson-Stevens Act set goals for and provide direction to agencies regarding the management of marine resources. A similar set of strong and comprehensive standards must be included up-front in federal offshore aquaculture legislation.

Require ecosystem-based management and marine spatial planning

The ecosystem services provided by our oceans are dependent on biological, oceanographic, and geological processes that may be vulnerable to the impacts of offshore aquaculture. Examples of important ecological areas that are susceptible to aquaculture impacts include fish spawning areas, sensitive seafloor habitats (canyons, seamounts, corals, rocky reefs, etc), migratory corridors for highly mobile species (such as tunas, sharks, and whales), and foraging areas for seabirds, marine mammals, and commercial fish species. These areas should be identified in a comprehensive manner as a precursor to specifying appropriate areas to permit offshore aquaculture. Given the local and regional impacts that are inevitable with open ocean

aquaculture, it is critical that these operations are located extremely carefully, so as to minimize the spatial footprint of each operation and its effects on important ecosystem functions.

At the same time, the U.S. Exclusive Economic Zone is host to a growing number of ocean uses, including aquaculture, oil and gas development, renewable energy development, shipping, sand and gravel mining, tourism, scientific research, military operations, and many others. In recognition of our growing impact on the ocean environment, President Obama recently issued a memorandum calling for the development of a national ocean policy to guide the long-term conservation and use of ocean resources. The President also called on an Interagency Ocean Policy Task Force to recommend a framework for effective marine spatial planning that would establish an orderly and coordinated process for addressing emerging ocean uses such as offshore aquaculture and improving the management of existing activities. Accordingly, the management of offshore aquaculture activities should be guided by the national ocean policy, and integrated with the national marine spatial planning framework, once they are established.

Adequately address environmental risks

National standards for offshore aquaculture in federal waters should address the full suite of potential ecosystem impacts of these activities. The comprehensive standards and criteria included in California's Sustainable Oceans Act should be used to guide the development of the federal program; federal standards should be at least as protective as those codified in SB 201, and set the following goals:

- Prohibit the production of non-native species in offshore facilities.
- Prevent escapes of farmed species.
- Prevent the introduction, incubation, and spread of disease, pathogens, and parasites.
- Minimize the impact of nutrient discharges to the maximum extent practicable by mandating specific, measurable limits.
- Forestall negative impacts on native fish and wildlife, and their use of marine habitats.
- Avoid contributing to the overexploitation of forage fish or disruption of marine ecosystems.

These and other environmental standards should be incorporated into a programmatic review of the federal regulatory framework to evaluate the potential effects of this framework on a large and comprehensive scale. This review should include the same requirements prescribed in SB 201, and result in a greater understanding of the cumulative impacts of aquaculture operations, the development of a common set of best management practices, a streamlined permitting process, and the identification of the most appropriate places to locate aquaculture operations.

Preserve opportunities for coastal state review

Coastal states play an important role as stewards of ocean and coastal areas and resources. With the Coastal Zone Management Act (CZMA), Congress entrusted coastal states with the responsibility to manage coastal resources and review activities beyond the state's coastal zone that may affect it. CZMA authorizes states to reject offshore activities that are inconsistent with an approved coastal plan. As discussed earlier, there are a number of environmental risks

associated with the operation of offshore aquaculture facilities that have the potential to dramatically alter ocean ecosystems on a large scale. The potential for these impacts to affect state waters increases the closer these facilities are to the state's three-mile limit. This is the case with the Hubbs-SeaWorld project, which is to be located just five miles off the southern California coast. For these reasons, federal offshore aquaculture legislation should recognize and incorporate states' coastal management responsibilities into the federal regulatory program, and preserve the authority of coastal states under the CZMA.

Effectively address stakeholder interests

Input from stakeholders and other citizens in the program development and permitting process is critical for addressing the public's interest in the management of ocean resources, and for meeting the needs of user groups to the highest extent possible. In California, an Aquaculture Development Committee, first authorized in 1982, was recently reconvened to work with the Department of Fish & Game to provide advice on marine aquaculture under state jurisdiction. Members of the committee work with Department staff on various aspects of the state's program. Committee membership is comprised mostly of industry representatives, with NGO partners acting as observers. At the national level, a similar advisory body should be established to enable the entire range of interests—industry, academia, conservationists, fishermen, and others—to contribute to effective management of aquaculture in U.S. waters. In addition, federal offshore aquaculture legislation should include robust public participation and comment opportunities at key points in the regulatory process.

Conclusion

As aquaculture continues to grow across the globe, industry pressure for the development of offshore fish farming in U.S. waters likely will accelerate. Congress has the rare opportunity—and responsibility—to construct an entirely new regulatory framework to effectively manage a nascent industry in U.S. waters. Based on the potential significant risks to the ocean and coastal environment from aquaculture operations, this framework must place a high priority on the protection of wild fish and ecosystems. It must include clear and comprehensive standards to guide industry development, and adopt a precautionary and adaptive-management approach to scaling up aquaculture operations in U.S. waters. Following the example set by California, the federal program should support industry growth in a way that ensures the continued integrity of the overall ocean ecosystem and economy.

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