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OVERSIGHT HEARING ON
ENDOCRINE DISRUPTION IN FISH AND WILDLIFE

BEFORE THE
COMMITTEE ON NATURAL RESOURCES
SUBCOMMITTEE ON INSULAR AFFAIRS, OCEANS AND WILDLIFE
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Introduction

Good morning, Madam Chairwoman, and members of the Subcommittee. My name is Tracy Collier, I am the Director of the Environmental Conservation Division, in the Northwest Fisheries Science Center of the National Marine Fisheries Service (NMFS), within the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Research conducted within my Division focuses on the effects of human activities on marine and freshwater ecosystems and resources under the stewardship of NOAA. Thank you very much for the opportunity to come before you today to discuss the issue of endocrine disruption in fish and wildlife. This issue is increasingly recognized as another way human activities are affecting the resilience of our aquatic ecosystems. I am encouraged that the Subcommittee is interested in learning more about this complex issue.

In the invitation letter for this testimony you requested our views on three aspects of endocrine disrupting chemicals (EDCs), namely: (1) the widespread nature of EDCs; (2) their impacts on fish and wildlife; and (3) possible solutions for removing them from the environment. These aspects are addressed in order in the following written testimony. We also provide a brief perspective on the need to better monitor our marine and estuarine ecosystems for the presence and impacts of these compounds. As an appendix to this written testimony we have also provided you with a list of scientific articles that support the statements made herein.

The widespread nature of EDCs

Endocrine systems, or hormone systems, serve the very important function in all mammals, birds, and fish of regulating the biological processes of the body. They are made of a complex system of glands, hormones and receptors that send messages

dictating the development and growth of our nervous and reproductive systems. Endocrine disrupting chemicals are substances that, when introduced into the body, will block or mimic the naturally occurring hormones, and disrupt body functions. Some of these chemicals are particularly problematic because they often tend to be persistent in the environment, meaning they are resistant to environmental degradation, and they bioaccumulate in animals higher in the food chain.

A wide range of chemicals can cause endocrine disruption in fish and wildlife. These include contaminants that have been known to be reproductive and endocrine toxicants for many years, including polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethanes (DDTs) and other organochlorine pesticides, dioxins, polycyclic aromatic hydrocarbons (PAHs), organotins, and other metals. These chemicals are transported to fish habitats primarily via surface runoff. The use and production of many EDCs, such as PCBs, DDTs, and other organochlorine pesticides, has been discontinued in the United States, and their levels have declined over the past twenty years in marine and estuarine environments (http://ccma.nos.noaa.gov/about/coast/nsandt/). Accordingly, these compounds are often referred to as 'legacy' pollutants, yet they are still found worldwide, even in remote areas such as alpine regions and the Arctic. Similarly, levels of PAHs, derived from petroleum and the burning of fossil fuels, have declined in some areas because of reductions in burning of coal and improved emission controls. However, they are still a concern because of their presence as non-point source pollutants in road runoff.

Many EDCs are chemicals of emerging concern, such as synthetic hormones, pharmaceuticals and personal care products, excreted natural steroids, plant phytoestrogens, and man-made industrial/commercial chemicals including flame retardants (e.g., polybrominated diphenyl ethers (PBDEs)), plasticizers, and surfactants. Some fungicides and herbicides (e.g., vinclozin and atrazine) also have endocrine-disrupting activity. As analytical techniques have improved, scientific documentation of the presence of pharmaceuticals is accumulating. A U.S. Geological Survey (USGS) study conducted during 1999-2000 measured trace levels of 33 of 46 different pharmaceuticals in a survey of 139 streams across the United States. Pharmaceuticals and related EDCs have been found in wastewaters from municipal wastewater treatment plants, in biosolids, in wastewaters from on-site waste disposal facilities, in landfill leachate and seepage, in wastewater effluent from hospitals, in wastewaters from livestock production facilities and fish farms, and in soils and ground water after irrigation with treated wastewater.

PBDEs have been identified in the environment and in tissues of many aquatic animals, especially organisms collected in urban areas and near wastewater treatment plants. PBDEs are known to be thyroid-disrupting pollutants that are also turning out to be environmentally persistent and bioaccumulative. NOAA study, released in March of this year, showed that PBDEs are ubiquitous in the U.S. coastal zone, including the Great Lakes. Highest concentrations were detected in the Southern California Bight, Puget Sound, and Hudson-Raritan Estuary, including the waters around Los Angeles, Seattle, and New York City. Overall, the highest concentrations were found near industrial and

urban locations, and both sediment and shellfish concentrations directly correlated with local human population density. A retrospective analysis revealed that PBDE concentrations have been on the rise over the past decade (http://ccma.nos.noaa.gov/about/coast/nsandt/PBDEreport.html).

Pulp and paper mills are also important modern-day sources of endocrine-disrupting chemicals in aquatic habitats. They produce a complex cocktail of chemicals that are found in the waste products associated with the processing of wood for commercial products, including dioxins (a byproduct of the bleaching process) as well as sterols, lignins, resin acids, and naturally occurring hydrocarbons (e.g., retene).

In general, surveys by USGS, NOAA, and other agencies indicate that EDCs are most prevalent in industrialized, agricultural, and/or urbanized areas, with particularly high concentrations of these compounds near sewage treatment plants, or other sources of wastewater, feedlots, pulp and paper mills, and in urban and industrial areas with high levels of organic chemical contamination. Populations of fish and other aquatic organisms residing in these areas are at greatest risk for endocrine disruption.

The impacts of EDCs on aquatic organisms

Fish. The endocrine-disrupting properties legacy contaminants like PCB and DDT, have been recognized for many years. The concentrations of these chemicals in fish tissues have gradually declined since their uses were banned in the 1970s. Although these pollutants are no longer being actively introduced into the environment they are often still present at levels that can impair fish growth, reproduction, and immune function. In recent years, NMFS and others have examined sentinel marine fish species for indications of endocrine disruption, particularly in urban embayments. Fish collected from embayments contaminated with PCBs show various forms of reproductive dysfunction, including depressed levels of reproductive steroids, reduced gonadal growth, and reduced egg and larval viability. These effects have been documented in fish from Puget Sound, San Francisco Bay, Los Angeles, Hudson Bay, Chesapeake Bay, and other coastal habitats. Exposure to legacy industrial and agricultural contaminants has also been linked to reduced reproductive success in freshwater fish from many U.S. river systems.

Legacy contaminants have also been found to have negative impacts on fish growth. Numerous laboratory and field studies have shown that PCBs, DDTs, and other legacy contaminants (e.g., other banned organochlorine pesticides) interfere with metabolic function in a variety of ways that ultimately reduce larval and juvenile growth. This effect has been observed in salmon from Puget Sound, white sturgeon from the Columbia River, striped bass from San Francisco Bay, and Sacramento splittail from the Sacramento-San Joaquin river delta in California's Central Valley. Because the survival of many fish species depends to a large extent on juvenile growth, this interference with individual fish growth may have detrimental effects on wild fish populations as a whole. PAHs, though not bioaccumulative contaminants in fish, also have endocrine disrupting effects on fish species. Like PCBs, PAHs are associated with reproductive and

developmental problems in wild fish, and can also interfere with growth, energy metabolism, and immune function. PAHs are a continuing concern because they are common as non-point source pollutants.

Considerable research has also focused on the effects of legacy contaminants can have on the fish immune system. This work has revealed that contaminant-exposed fish are more susceptible to infection by pathogens, resulting in disease and increased mortality. Thus, while endocrine-disrupting chemicals may not be causing overt fish kills in coastal ecosystems, they can interact with other threats in ways that can ultimately lead to the death of the exposed animals. Numerous studies, for example, have linked PCB exposures to reduced disease resistance in fish from estuaries on the west coast (e.g., salmon from Puget Sound) as well as the east coast (e.g., striped bass from the Chesapeake Bay).

In addition to the well documented impacts of legacy contaminants, recent studies also have revealed the toxic effects of some currently-used pesticides on fish reproduction, growth, and immune function. Widely used agricultural herbicides, for example, have been shown in laboratory studies to disrupt the metabolism, growth, and osmoregulation (the maintenance of the osmotic pressure of an organism's fluids) of estuarine fish such as red drum and mummichog. Common insecticides can interfere with the spawning physiology and immune function of migratory salmon during freshwater life stages.

Chemicals of emerging concern, including naturally occurring and synthetic hormones, pharmaceuticals, and personal care products, are also known to have endocrine disrupting effects on fish. Many of these substances mimic the actions of estrogen, a reproductive hormone in both fish and humans. Evidence of environmental exposure to estrogen-like substances has been widely demonstrated in wild fish populations throughout the United States. This has been accomplished in part by monitoring the abnormal production of the yolk protein vitellogenin. Whereas vitellogenin is normally found only in female fish, this protein is commonly detected in male fish that have been collected (or placed in cages) near sewage treatment plants or other sources of wastewater. This feminization of male fish was first reported in the United Kingdom, and subsequent studies have documented the phenomenon in urban embayments across the United States, including Puget Sound, the Southern California Bight, Chesapeake Bay, and the New York and New Jersey Harbors. Male feminization has also been observed in freshwater fish species from lakes and rivers throughout the nation. Estrogenic chemicals have been linked to a variety of other physiological and developmental abnormalities in fish, including reduced male fertility, reduced embryo viability, impaired seawater tolerance (migratory salmon), altered social behaviors, and disrupted courtship behavior. The connection between these initial laboratory studies and the health of fish under real-world exposure conditions is an ongoing and active area of scientific investigation.

Specific cause-and-effect relationships between endocrine-disrupting chemicals and wild fish populations have been investigated using both epidemiological methods and conventional toxicity identification procedures. For example, a recent study conducted in the Experimental Lakes Area of western Ontario showed a diversity of endocrine effects

in resident fathead minnows. Whole-lake treatment with an environmentally representative concentration of the pharmaceutical called ethinylestradiol over the course of seven years caused drove the minnow population in this otherwise pristine lake to near extinction. The minnow decline was then followed by a collapse in the population of predatory lake trout. This study demonstrated how endocrine disruptors and other toxic chemicals can have indirect, bottom-up effects on aquatic food webs.

Similar studies are obviously not practicable in rivers, estuaries, or the ocean. It therefore remains a challenge to assess the cumulative impacts of endocrine disruptors on marine fish stocks. Moreover, from a research standpoint, many important information gaps remain. While estrogenic compounds have been studied in considerable detail, there are many chemicals that interfere with other components of the fish endocrine system. For example, striped bass show important behavioral changes when exposed to an antidepressant (a serotonin-specific reuptake inhibitor). At present, there is much that we do not know concerning the risks that pharmaceuticals and personal care products pose for freshwater and marine ecosystems.

In recent years, NOAA and its partners have monitored sentinel marine fish species for indications of endocrine disruption, particularly in urban embayments. Agency research has also addressed potential threats to especially vulnerable trust resources, including threatened and endangered populations of Pacific salmon in California and the Pacific Northwest. Endocrine disruptors may be contributing to the decline of several imperiled salmon stocks in Puget Sound and the Columbia River Basin. For example, the measured levels of PCBs and DDTs in these fish are high enough to impair both growth and immune function, thereby limiting juvenile survival. Salmon are also showing signs of exposure to estrogenic compounds (abnormal vitellogenin induction) as they migrate through urbanized habitats. The consequences of these exposures for longer term effects on salmon health and species recovery are not yet fully understood.

Overall, fish species in nearshore habitats where chemical discharges are more concentrated are likely to be at a greater risk than fish living offshore, although it should be noted that some persistent organic pollutants (e.g., PCBs) now permeate entire ocean ecosystems. Future research will continue to combine laboratory studies, field investigations, mathematical modeling, and other strategies to improve our understanding of these contaminants as a threat to our nation’s living marine resources.

Aquatic invertebrates. Endocrine disrupting compounds can also have important negative impacts on populations of marine and freshwater invertebrates. One of the most extensively documented examples of this is the phenomenon of imposex in gastropod molluscs (e.g., snails and whelks) exposed to organotin compounds leaching from antifoulant paints on vessels. Imposex is a condition in which female animals develop male sexual characteristics, resulting in sterility. The sterilization of females in turn has led to the decline of gastropod populations around the world in areas with elevated ship traffic. Tributyltin (TBT), for example, is one example of an organotin compound contained in antifouling paint, and is known to be one of the most toxic compounds ever released into the marine environment. The U.S. partially banned the use of TBT in 1988

for use on boats less than 25m in length, drastically limiting its use on many recreational vessels. NOAA’s long-term national contaminant monitoring record suggests the presence of TBT in coastal, marine, and Great Lakes ecosystems has exhibited marked declines in response to the ban.

Research on organotin-induced imposex notwithstanding, little is known about endocrine disruption in invertebrates. NOAA research on grass shrimp has shown that the pesticide endosulfan slows reproductive development, reduces the number of gravid (egg bearing) females and increases the hatching time in exposed animals. Many current insecticides are designed to target the insect endocrine system, and thus are likely endocrine disruptors for insects and crustaceans (e.g., crabs and shrimp) in freshwater and estuarine habitats. Since these species are important components of aquatic food webs, pesticides may have adverse indirect impacts on fish and other species at higher levels in the food chain. Lastly, petroleum hydrocarbons from oil spills or urban stormwater runoff can be toxic to mussels, clams, and other shellfish species. Overall, however, the effects of endocrine disruptors on invertebrates are only beginning to be investigated.

Marine mammals. Many species of marine mammals are long-lived, top-level predators in marine food webs. As a consequence, they can accumulate relatively high levels of legacy contaminants (e.g., PCBs, DDTs, and PBDEs) in their tissues. Since the 1960s, many studies have monitored the levels of these endocrine-disrupting chemicals in the tissues of marine mammals from highly populated coastal regions, as well as those from more remote areas of the world. These studies have shown that age, sex, birth order, nutritional status, and other life history characteristics can influence an animal’s lifetime accumulation of legacy contaminants. One important finding for eastern North Pacific killer whales is that adult mothers transfer PCBs to their calves during gestation and lactation. Because of this, adult females have lower contaminant levels than adult males, and first-born calves have higher levels of toxics in their tissues than do their siblings. Among the endangered Southern resident killer whale population from Puget Sound and the Straits of Georgia, juvenile animals have the highest tissue levels of persistent PBDEs. This shows how exposures to endocrine-disrupting chemicals can vary by individual animal within a marine mammal population.

The effects of legacy contaminants on marine mammal growth, reproduction, and immune system function are not well understood. Studies of marine mammals are costly and difficult to conduct, particularly for populations from remote regions of the world. Nevertheless, a few studies (primarily in Europe) have assessed the health effects of PCBs and DDTs. For example, concern over a population decline driven by a large decrease in pup production among harbor seals from the western portion of the Wadden Sea provided the impetus for a semi-controlled study to determine the effects of PCB exposure on seal reproductive success. Female harbor seals fed PCB-contaminated fish collected from the western region of the Wadden Sea had decreased reproductive success relative to females fed fish collected from a less contaminated region of the Wadden Sea. In the United States, female California sea lions that produce stillborn pups and aborted fetuses have significantly higher levels of PCBs and DDTs in their blubber relative to females that produce normal pups. Similar to fish, legacy contaminant exposure is associated with immune suppression in marine mammals.

Beyond the legacy contaminants, there is virtually no direct exposure information for other known (or suspected) endocrine disruptors in marine mammals. Although there have been studies on PBDEs in polar bears and grey seal pups that have provided initial evidence for disruption of the thyroid-associated endocrine system, the logistics for these kinds of studies are very complicated. Most of the analytical methods currently used to measure these compounds are specific to certain kinds of environmental samples such as water, sediments, or sewage sludge. Almost no analytical methods have been developed for marine mammal tissues. Moreover, to conduct studies on the effects of these contaminants on marine mammals would require the collection of blood, bile, and other types of biological samples that are practically impossible to collect from some of the free-ranging marine mammals such as the large cetaceans. Endocrine-disrupting chemicals have the potential to impact marine mammals indirectly via food webs, but these ecological connections remain largely unexplored.

Possible solutions for removing EDCs from the environment

As described earlier, reports show that legislation banning a subset of EDCs has had a measurable effect in reducing levels of these contaminants. However, the persistence of some of these chemicals in the food chain and their introduction into pristine environments due to long-range transport suggests it may be impossible to completely eliminate them from our ecosystems. This highlights the need for prompt attention to address EDCs of emerging concern.

It is generally the responsibility of the Environmental Protection Agency (EPA) and state/local environmental agencies to consider actions to remove EDCs from our manufacturing processes, or to oversee the treatment of effluents (e.g. from publicly owned treatment works and stormwater) in order to remove them before discharge into surface waters. Various practices currently are being developed and tested for reducing concentrations of these substances in wastewater. In addition, EPA is implementing a four-pronged strategy for addressing pharmaceuticals and personal care products that includes strengthening the science; improving public understanding; promoting partnerships and stewardship; and taking regulatory action where appropriate. Because NOAA has authority under the *Endangered Species Act* and under the Essential Fish Habitat provisions of the *Magnuson-Steven Fisheries Management and Conservation Act* to consult with other federal agencies on the effects of their actions, we can make recommendations on how to reduce or minimize the effects of EDCs on our trust resources. As more scientific understanding is obtained, these findings can be used to support such consultations and recommendations.

As we work to minimize concentrations of EDCs, we should be cognizant that the EDCs described in this testimony are not necessarily always responsible for the endocrine disruption we are seeing in biota in the field. Much remains to be done to link biological responses in the environment back to specific exposures. Scientists are increasingly realizing that other factors, such as low levels of dissolved oxygen, can cause endocrine disruption. Temperature can also have profound effects on endocrine function and the regulation of development, growth, and reproduction in many fish and wildlife species.

These confounding factors should be kept in mind when evaluating evidence of endocrine disruption in wild populations.

Because we often do not understand the specific causal linkages between the presence of EDCs in our surface waters and the occurrences of endocrine disruption observed in biota, we should not rely only on reductions in EDCs in effluents in order to protect our living resources. Rather, we need to continue to investigate the linkages between exposure to EDCs and biological impacts, and to monitor and assess these linkages in the real world, not just in laboratory settings. This "effectiveness monitoring" of biota will be very useful in guiding management actions aimed at protecting marine and freshwater ecosystems from deleterious effects of EDCs. NOAA's National Status and Trends Program (NSTP) provides a good framework from which to build a biologically-based effectiveness monitoring effort that will address this need. One component of NSTP is Mussel Watch, which began in 1986 and is the longest running, continuous annual monitoring program that is national in scope (Figure 1). A complementary component was the National Benthic Surveillance Project, which ran from 1984 through 1994, which examined the biological effects of chemical contaminants on the health and fitness of coastal fish populations. These coastal assessment efforts and strategies could be readily adapted to help better understand and mitigate the potential threats posed by EDCs to our nation's living marine resources.

Conclusion

In closing, I would like to reaffirm my gratitude, Chairwoman Bordallo and members of the Subcommittee, for this opportunity to discuss the issue of endocrine disrupting chemicals and their impacts on fish and wildlife. I will be happy to answer any questions that you may have.

Figure 1. *Distribution of NOAA's Mussel Watch monitoring sites throughout the U.S., including Alaska, Hawai'i, and Puerto Rico.*