No. 07-219

IN THE
Supreme Court of the United States

EXXON SHIPPING CO. AND EXXON MOBIL CORP.,
Petitioners,

v.

GRANT BAKER, ET AL.,
Respondents.

On Writ of Certiorari to the
United States Court of Appeals for the Ninth Circuit

BRIEF OF JEAN-MICHEL COUSTEAU AND OTHER NATURAL AND SOCIAL SCIENTISTS AS AMICI CURIAE IN SUPPORT OF RESPONDENTS

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INTEREST OF AMICI CURIAE

Amici are a combination of natural and social scientists who have studied and devoted much of our professional careers to the understanding of how oceanic ecosystems function and the necessity for their preservation[1]: **Jean-Michel Cousteau** is president of the Ocean Futures Society; **Peter Auster**, Ph.D., holds the position of Science Director for the National Undersea Research Center; **John Avise**, Ph.D., is Distinguished Professor of Ecology and Evolutionary Biology at the School of Biological Sciences, University of California at Davis; **Donald F. Boesch**, Ph.D., is President of the University of Maryland Center for Environmental Science; **Benjamin Cuker**, Ph.D., is Professor of Marine and Environmental Studies at Hampton University; **Dan Esler**, Ph.D., is a Research Scientist at the Centre for Wildlife Ecology at Simon Fraser University, in British Columbia.; **Michael Fry**, Ph.D., is the Director of Conservation Advocacy; **Gregory Golet,** Ph.D., is a senior ecologist for the Nature Conservancy; **Roger Green**, Ph.D., is Professor Emeritus at the University of Western Ontario; **Burr Heneman** is a co-founder and the current

[1] Letters of consent to the filing of this brief from all parties have been filed with the Clerk. Pursuant to Rule 37.6, *amici* state that no counsel for a party authored any part of this brief, nor did any person or entity other than *amici* or its counsel make a monetary contribution to its preparation or submission. The views of any signer to this brief do not necessarily reflect the views of that signer's organization unless specifically stated.

Ocean Policy Director of Commonweal; **Richard Kocan**, Ph.D., is Professor Emeritus at the School of Aquatic and Fishery Sciences at the University of Washington; **Jane Lubchenco**, Ph.D., is the Wayne and Gladys Valley Professor of Marine Biology & Distinguished Professor of Zoology at Oregon State University; **Craig Matkin**, M.S., is a founding member and director of the North Gulf Oceanic Society; **John Ogden**, Ph.D., is the Director of the Florida Institute of Oceanography; **Thomas Okey**, Ph.D., is the founder and current science director for the Conservation Science Institute; **Daniel Pauly**, Ph.D., is the Director of the Fisheries Centre of the University of British Columbia, Vancouver; **Charles "Pete" Peterson**, Ph.D., is Alumni Distinguished Professor in the Department of Marine Sciences at University of North Carolina - Chapel Hill; and **John Teal,** Ph.D., is currently Scientist Emeritus for the Woods Hole Oceanographic Institution.[2]

As professionals who have devoted our careers to understanding the interdependent nature of

[2] See Appendix "A" for biographical summaries of each *amicus curiae*. *Amici Curiae* Charles "Pete" Peterson, Ph.D., and Richard Kocan, Ph.D., served as expert witnesses on behalf of the Plaintiffs at the time of trial after having prepared expert reports which summarized their research prepared for the joint state-federal Exxon Valdez Oil Spill Council. Roger Green, Ph.D., and Michael Fry, Ph.D., prepared similar expert reports but did not testify at the trial. In the thirteen years since that trial, none of these four *amici* has received any compensation from Plaintiffs or Plaintiffs' counsel. Nor are any of these four *amici* being compensated in any way for their appearance or participation in this brief.

oceanic ecosystems, as well as man's participation in those ecosystems, we believe that we are in a unique position to evaluate and describe the effects that the Exxon Valdez Oil Spill ("EVOS") has had on the North Alaskan ecosystem surrounding Prince William Sound. Indeed, *Amici* are convinced that it is only with the benefit of the scientific information currently available that courts and other policy makers may understand the real costs of massive oil and toxic chemical spills, and most particularly the devastating effects caused by the Exxon Valdez Oil Spill. It is as a result of our understanding of these very real costs that we feel compelled to submit this brief urging this Court to affirm the verdict below.

SUMMARY OF ARGUMENT

There is no question that the spillage by the Exxon Valdez of 43 million liters (11 million gallons) of Alaska North Slope crude oil into Prince William Sound was a catastrophic event. It had an immediate impact not only directly and adversely on the salmon and herring on which commercial fishers in the region rely and the much larger group of animals on which Native Alaskans subsist, but also on the entire interdependent ecosystem. Furthermore, government studies over the past two decades belie comments Exxon has made in its briefing to this Court about the total long-term impact of this tragedy or Exxon's efforts to restore Prince William Sound to its native condition. These studies have consistently demonstrated the breadth of the incredible immediate devastation caused by the spill. They further show that the injury to the entire ecosystem and to the humans whose lives and livelihood have depended upon that ecosystem has been far greater than it was possible to discern at either the time of the spill or even at the time of trial in 1994.

To this day, residual oil remains a destructive force to the entire ecosystem. Diverse interdependent animal populations – clams, mussels, fishes, birds, sea otters, and killer whales – have continued to suffer in ways which were not appreciated at the time of the spill or its immediate aftermath. Moreover, after causing the spill, Exxon substantially compounded the harm by the massive pressure washing of beaches, a process which disrupted the naturally protective physical structure of those beaches and by itself resulted in the destruction of intertidal habitats for decades to come.

Exxon claims that it has already paid dearly for what is widely considered the number one spill worldwide in terms of damage to the environment and the communities that depended on it. But Exxon certainly has not paid for the full impact of the destruction it has caused in the oil spill region of Prince William Sound and beyond. Science shows us almost twenty years later that complete recovery is at minimum decades away, if ever. This scientific research demonstrates that the need for deterrence is even greater now than initially would have been thought. To the extent that punitive damage awards are meant to provide deterrence or compensation where "the injury is hard to detect or the monetary value of non-economic harm might have been difficult to determine," *BMW of North America, Inc.* v. *Gore,* 517 U. S. 559, 582 (1996), this is undoubtedly one such example.

INTRODUCTION

The coastal or nearshore ecosystem of the Pacific Northwest is one of the most biologically productive on the planet, comparable to tropical rainforests and the most highly managed and fertilized terrestrial agricultural systems. This high production has for millennia reached upwards through the food web to support diverse and abundant populations of fishes, seabirds, and marine mammals. Quite simply, the coastal region of the northern Gulf of Alaska has been a spectacular treasure trove of the bounty of the sea, recognized worldwide in its wealth of economically and culturally important fish and shellfish and its simultaneous showcase of spectacular wildlife.

As part of this system, before the 1989 spill, Prince William Sound was a pristine environment with abundant and diverse fish and wildlife. The abundance of fish and wildlife inhabiting the region and concentrating in the coastal habitats for reproduction and intense feeding just at the late spring-to-summer period (at the very time of the spill) was a testament to the natural productivity and integrity of the ecosystem and the near universal absence of toxic contaminants in the supportive environment. In fact, that environment was able to support an economy nearly wholly dependent upon the natural resources it provided. Although small in population, Cordova was one of the top 10 U.S. ports when ranked by value of its commercial fishery landings. Subsistence harvest was a dominant way of life and a cultural heritage for Native Alaskans in Prince William Sound and in neighboring areas of Kodiak Island and both the Kenai and Alaskan Peninsulas.

The spillage by the Exxon Valdez of 43 million liters of Alaska North Slope crude oil into this pristine environment has proven to be a devastating, massive experiment in ecotoxicology. Due to its magnitude, the spill has become the most studied environmental disaster in history. Unfortunately for the environment, these studies, ongoing to this day, have consistently demonstrated the magnitude, broad scope, and long temporal duration of the disaster.[3] Far from causing only acute injury to the ecosystem, considerable evidence demonstrates that EVOS has caused long-term, chronic, direct, indirect and delayed effects that even now will likely take

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[3] In very large part the scientific research upon which this brief is based was prepared for the EVOS Trustee Council in cooperation with federal and state government scientists as part of one of more of the following projects: 00090, 00454, 00459, 00476, 030012, 030423, 030585, 040159, 040574, 040708, 050751, 94166, 95074, 98012, 98191, 99025, 99328, 99379. Reports for those projects are publicly available through the Council and on the Council's website at http://www.evostc.state.ak.us/ or separately at the Alaska Resources Library and Information Service http://www.arlis.org. The Trustee Council was formed shortly after the spill and is composed of representatives of the United States Department of the Interior, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration, as well as the Alaska Departments of Fish and Game, Environmental Conservation, and the Department of Law. The Trustee Council requested and oversaw most of the science discussed in this brief.

decades to recover from. Below we discuss a number of these effects.

ARGUMENT

I. The Continuing Devastation Makes it Clear That Exxon Has Not Yet Fully Paid for the Harm Which it Caused

"The spill was immediately known. There was no possibility of hiding it, even for a few minutes. Exxon made no profit, and had no prospect of profit, from any of the activities that plaintiffs point to as wrongful. If Exxon made mistakes, it has paid dearly for them. But that does not change the grounding into a situation economically appropriate for punitive damages. The rules of maritime law, designed to protect maritime commerce, ought to be shaped by this Court to fit economic reality."

Petitioners' Brief at 54-55

This statement, made by Exxon itself, raises the question of precisely what Exxon "paid for." Exxon certainly did not pay to return this pristine environment to anything approaching what these areas were like before the spill. While it is true that shoreline clean-up assessment teams initially estimated that by 1993 the extent of oiled shoreline had decreased from 783 km to 10 km and that most of the oil remained on the surface in the upper intertidal zones, Exxon incorrectly took the position that the remaining oil spilled on the relatively high-energy beaches of Prince William Sound would soon diminish to negligible amounts and have no residual effect on the plants, wildlife or other natural resources of the Sound. Exxon's assessment is, and was, incorrect. Both the oil from Exxon's spill and adverse affects caused by that spill to the ecosystem of Prince William Sound and the neighboring areas of Kodiak Island and both the Kenai and Alaskan Peninsulas have continued to this very day.

We in the scientific community understood even in 1994 that the assumption which was the basis for Exxon's cleanup effort was not valid. At the trial, Plaintiffs' expert James Bush correctly demonstrated that there was likely substantial, mostly subsurface, oil still remaining (*Trial Trans*. 4376-4385). Moreover, the jury members, as a result of an Exxon motion for a "jury view," had the opportunity to observe for themselves that even in assertedly pristine beaches, a little digging showed substantial residual oil. (*Clerk's Docket* 5743).

What was not understood was that to this day reservoirs of oil would still persist buried at shallow depths in the intertidal shores of many coastlines. This oil has not been degraded because it is protected from light, physical disturbance, oxygen, and microbes that would otherwise promote degradation of hydrocarbons. As a result, we now understand that its toxicity will likely persist for decades, causing a cascade of effects: (i) chronic persistence of oil in shallow sedimentary reservoirs, leading to biological exposures, then sub-lethal and lethal impacts to vertebrates using these intertidal sediments for reproduction and foraging; (ii) delayed population impacts of exposure as a consequence of impaired survival or reproduction of individuals with compromised health or suppressed growth; (iii) indirect effects of trophic and other interaction cascades, such as through losses of keystone species and individuals important to critical social organization functions; and (iv) delayed impacts, including habitat degradation, prey declines, trophic cascades, and other indirect effects of ecosystem perturbation from the spilled oil and the clean-up interventions.

Since the oil spill, substantial research has revealed the persistence of ecologically significant amounts of still toxic Exxon Valdez oil in shallow subsurface reservoirs throughout the intertidal zone of many oiled beaches. In 1997, eight years after the spill, researchers encountered significant residual oil. The largest quantities with the least weathering occurred at depths of 25-50+ cm under the protective cover of a well-sorted cobble/boulder armor on intermittently exposed, coarse-grained gravel beaches within Prince William Sound. Researchers found that a stable armor had developed over the upper and lower platforms of these more exposed, coarser-grained gravel beaches. Once such armoring is achieved, only extreme erosional events will mobilize the coarse armor. In the absence of such events, little to no change in degree of weathering of the oil had occurred at these sites since earlier measurements made in 1994.

In 2001, 12 years after the spill, researchers from the National Oceanic and Atmospheric Administration ("NOAA") conducted extensive surveys in Prince William Sound to assess both the volume of oil remaining in and on the beaches and the area of beach still contaminated by the spill to determine whether the spilled oil still was a long-term reservoir of toxic hydrocarbons. Surface and subsurface oil was measured in nearly 6000 pits, which were randomly located along shorelines previously identified as heavily oiled. The study found Exxon Valdez oil on 58 of 91 beaches randomly selected according to their oiling history, suggesting that the area of oiled beach had probably changed very little since 1992. Although the researchers concluded that their study likely underestimated (by 30%) the volume of oil remaining, the conservative estimate totaled nearly 60,000 kilograms of Exxon Valdez oil still remaining, or more than twice what had been estimated back in 1993.

Prior to this 2001 survey, the hypothesis presented by Exxon – that oil persisted only in the upper intertidal zone – was based on the conjecture that oil would adhere better to rock surfaces in the drier upper intertidal areas, where it would form biologically inert asphalts. The most disturbing revelation from NOAA's study in 2001 was that most of the subsurface oil was located much lower in the intertidal zone than expected and that it persisted in liquid state with minimal weathering, typical of what would occur in only a week or two of exposure. Furthermore, its presence only about 10 cm below the sediment surface in the mid and lower intertidal zone, where key invertebrate prey like clams and mussels are abundant, poses a much greater risk to the food chain and especially vertebrate consumers that forage by excavating intertidal invertebrates. Analysis of the oil by chemical fingerprinting indicated that over 90% of the surface oil and all of the subsurface oil was from the Exxon Valdez.

This research provided evidence that EVOS oil was having a material impact on many nearshore and intertidal dependent wildlife, and was contributing to their documented slow recovery in some parts of Prince William Sound. Because the remaining oil is buried and not exposed to elements like light, oxygen, physical disturbance, and oil-degrading microbes that could degrade it, this persistent oil could remain hazardous to wildlife for decades to come.

To assess the extent of that ongoing risk to the ecosystem, a similarly composed team of NOAA researchers examined 32 shorelines selected at random in 2003 from oiled shores in Herring Bay, Lower Pass, and Bay of Isles in Prince William Sound. They evaluated the vertical distribution of oil remaining from the 1989 Exxon Valdez oil spill and then estimated the probability that key wildlife such as sea otters and sea ducks, which depend on foraging in the intertidal zone, would encounter oil while foraging. The study involved 662 randomly dug, shallow pits along 32 stretches of shoreline. The researchers encountered Exxon Valdez-fingerprinted oil at 14 of 32 sites, more than half of which were in the biologically rich, lower intertidal zone, where predators may encounter it while disturbing sediments in search of prey. Calculating the probability that foraging wildlife would encounter subsurface oil based on the amount of oil remaining led the researchers to conclude that sea otters and diving ducks that routinely excavate sediments while foraging within the intertidal zone would likely encounter subsurface Exxon Valdez oil repeatedly during the course of a year. The researchers estimated that a sea otter might dig 1000 pits per year while foraging, sufficient to cause a high likelihood of intermittent encounter and exposure to oil. The substantial probability of encountering oil in the lower intertidal is particularly relevant biologically because the availability of molluscan prey of sea otters, diving ducks, and shorebirds increases in the intertidal zone as tidal elevation falls.

In 2005 members of the same NOAA team returned again to Prince William Sound and the Gulf of Alaska shorelines to focus on the rate of removal and the processes which were contributing to the persistence of relatively unweathered oil from the spill. They found that oil stranded by the 1989 Exxon Valdez spill had persisted in subsurface sediments of exposed shores now for 16 years. They calculated that annual loss rates had slowed down from about 68% in the first years down to less than 3-4% after 2001. The conclusion was that the persistence of the most toxic polycyclic aromatic hydrocarbons (PAHs)[4] is prolonged by burial for decades with little change. The trends that they had documented since 2001 indicate that there will be ever slower loss rates for the subsurface oil which has remained. Such persistence of only partially weathered oil: i) creates a persistent source of chronic low-level contamination to intertidal and nearshore dependent species; ii) poses a contact hazard to intertidally foraging sea otters, sea ducks, and shorebirds; iii) discourages subsistence in a region where traditional subsistence harvest along rocky shores has been intense and important; and iv) degrades the wilderness character of protected lands.

These NOAA studies of the long-term persistence of oil in intertidal sediments have been

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[4] The multi-ringed, higher molecular weight polycyclic aromatic hydrocarbons or "PAHs" are among the most toxic family of compounds found in petroleum products. These can become air or waterborne and be ingested by living creatures.

complemented and validated by other studies of oil persistence and its causes. A 2006 study showed that Exxon Valdez oil persisted for a decade as subsurface mousse along the high-energy coast of the Alaska Peninsula under conditions where boulder armoring protected the underlying sediments from physical disturbance. This oil was also maintained for 10 years in a largely unweathered condition, compositionally similar to 11-day old oil.

Exxon Valdez oil has also been shown to persist for long periods of time in another intertidal environment likewise physically protected from disturbance and weathering. Intertidal mussels often form extensive beds, which blanket the underlying sediments. Oil has seeped deeply into and under these beds on heavily oiled shores of Prince William Sound. Because mussels represent such important prey organisms for shorebirds, diving ducks, sea otters and many invertebrates and are valued as subsistence, oil mussel beds were left undisturbed during clean-up operations during the summers of 1989-1991 in the hope that natural processes would cleanse them. Later studies have shown, however, that these beds have become a source of chronic contamination and exposure to oyster-catchers and likely other vertebrates. Repeated sampling of many of these oiled mussel beds has provided evidence that the oil will persist for 30 years or more. Consequently, the very locus of dense and preferred prey for many predatory vertebrates is also a hotspot of prolonged contamination – an unfortunate conjunction likely dooming these shoreline predators to long-term contamination and subsequent harm.

The studies of Prince William Sound complement research from petroleum spill sites on the East Coast performed by researchers at Woods Hole Oceanographic Institute which shows persistent toxicologically active hydrocarbons 30 and 40 years after a spill into the protected environment of coastal salt marshes. The explanation for why oil has persisted for so long in salt marsh sediments is consistent with what researchers have concluded from studying EVOS oil in intertidal sediments: wherever oil can become buried in physically protected environments, degradation can become inhibited and persistence occur.

This continued persistence of subsurface Exxon Valdez oil, often only minimally or moderately weathered, means that to this day a reservoir of biologically available polycyclic aromatic hydrocarbons (PAHs) remains on beaches impacted by the spill. Furthermore, its extension into the more biologically productive middle and lower intertidal zones has created the potential for long-term biological effects on beaches most heavily impacted by the spill as well as to those plants, fish, and wildlife that use these beaches for foraging and reproduction.

II. EVOS Has Had a Devastating Long-term Effect Not Only on Critical Fish Populations but Throughout the Entire Food Chain

"The spill did not cause a fish kill …."

Petitioners' Brief at 6

With these few words, Exxon cavalierly and inaccurately dismisses the devastating impact that

EVOS has had on fish in the marine environment and, as a result, on the commercial fishers and subsistence users who rely on its resources. Truncated descriptions of short-term acute mortality ignore the very real short-term and long-term consequences of exposure of marine ecosystems to Exxon's petroleum hydrocarbons. In fact, population impacts from chronic exposures have occurred at extraordinarily low pollutant concentrations. (*See* National Research Council, OIL IN THE SEA III: INPUTS, FATES, AND EFFECTS (2003) at 123 *et seq*.)

At trial, the jury heard testimony about the injuries to commercial fisheries and awarded several hundred million dollars in damages to fishermen for the fish killed and not caught. However, the extent of the harm has proven to be immeasurably greater than was believed at that time. Important commercial fish have continued to suffer because for crucial early life stages of keystone fish species in this ecosystem, the multi-ringed, polycyclic aromatic hydrocarbons (PAHs) in Exxon's crude oil has proven to be not only the most toxic component, but also the most persistent. This is particularly problematic for fish like salmon, sand lance, and capelin that deposit eggs to incubate in sediments, but also impacted herring. The resulting chronic exposure to Exxon's oil even at very low concentrations (a few parts per billion), has resulted in substantial fish population losses through lowered survival and reproductive success.

The losses in susceptible fish have cascaded through the ecosystem to cause long-lasting declines in predatory vertebrates dependent upon them. Moreover, because oil has often persisted in intertidal sediments for many years without degrading, foraging seaducks and sea otters have themselves continued to be exposed to contamination that has enhanced mortality and prevents population recovery. Smooth-skinned marine mammals like killer whales have experienced mortality and, even more significantly, losses to their populations grew more serious over time as their social structures degraded. In sum, the EVOS has had a significant effect on populations of commercial pink salmon and herring, as well as sea otters, harlequin ducks, Barrow's goldeneyes, pigeon guillemots, killer whales, harbor seals and many other interdependent species.

A. Short and Long-term Consequences for Pink Salmon

Wild pink salmon are a major component of the Prince William Sound ecosystem and, along with hatchery-raised pink salmon, are the dominant contributor to the region's commercial fisheries. Juvenile salmon are also a source of prey for certain nearshore predators and once adults have returned to spawn, their carcasses serve to enrich the spawning areas along streams where they die.

At the time of the spill, at trial, and in its briefing here, Exxon's claims that fish would not be killed by spilled oil have been based largely on testing acute toxicity in short-term laboratory exposures. After the Exxon Valdez oil spill, however, research on the toxicology of weathered crude oil on fish embryos and larvae has clearly shown that chronic exposures cause substantial mortality of exposed eggs and larvae and resulting population losses.

In fact, the life cycle of pink salmon has made them especially at risk. Nearly all pink salmon of Prince William Sound are intertidal spawners, spawning in freshwater reaches of streams at low tide. Spawning occurs from mid-July through September, not long after the spilled oil was heavily deposited there, forming what has been described as the "oil bathtub ring" located at the tide line. Eggs deposited into the intertidal gravels hatch between late October and December, and alevins continue to incubate in gravel until about April, giving them 8-9 months of total potential exposure to the sediments and any sediment contaminants. Following emergence from the gravel, pink salmon juveniles migrate immediately to potentially oiled estuaries for an additional 3 to 4 months of initial feeding and growth in nearshore waters before they migrate to open ocean.

By the time of trial of this matter, scientists knew that through 1993 salmon eggs in oiled streams exhibited higher mortality rates than those deposited in unoiled streams. Because these results were disputed by Exxon-funded investigators, a government team from NOAA's National Marine Fisheries Service conducted laboratory studies to test the impact to salmon embryos exposed to very low concentrations of weathered oil under controlled conditions similar to field exposures. The results showed unequivocally the damage to eggs and larvae of pink salmon as a consequence of chronic exposure to low concentrations of weathered crude oil. PAH concentrations as low at 1 ppb of weathered Exxon Valdez crude oil killed directly, and indirectly through reduction in fitness, a large fraction of pink salmon embryos exposed to the same type of persistent stranded oil located alongside salmon streams.

Pink salmon, exposed as embryos to low concentrations of spilled oil PAHs in water percolated through the spawning gravel, have been shown to have suffered a significant decrease in marine survival when compared to unexposed salmon. This has been attributed to delayed growth in those juveniles that survived the embryonic exposures and lower fitness of the smaller salmon in the marine phase of their life. These long-term adverse effects of exposure to weathered oil during the development of pink salmon suggest that recovery of salmon breeding habitats may be even slower than ever assumed. The effects of even low concentrations of weathered PAHs on incubating salmon include not only egg mortality and sublethal effects of slower growth of survivors, but also reduced survival during the marine phase as a combined consequence of predation, disease, and perhaps food competition. In other words, smaller size at the time of departure from the natal stream implies lower fitness such that sublethal effects on growth transform into population effects later in the life history of pink salmon, before they can return to spawn.

Synthesizing all these consequences of exposure to persistent oil, it has been estimated that the survival reduction across all life stages of the pink salmon caused by chronic oil exposure reduces the numbers of mature adults returning to spawn by half. These definitive experiments conform with a growing scientific understanding of how exposure to toxins at sensitive early stages in vertebrate development can lead to enhanced mortality and reproductive impairment later in life through endocrine disruption and developmental abnormalities.

Historical pink salmon data were analyzed and population modeling was conducted for the purpose of addressing how observed decreases in survival caused by chronic contamination could influence equilibrium population size. This analysis concluded that the equilibrium size of a simulated pink salmon population diminished with increasing contamination of their spawning and rearing habitat, even leading to increased risk of local extinction from the anadromous stream. Exposed populations can recover if the contamination is removed, but if the equilibrium population falls far enough because of chronic contamination over many generations, that population faces an appreciable risk of extinction from naturally fluctuating environmental factors.

Consideration of the studies showing long-term persistence of significant reservoirs of Exxon Valdez oil in intertidal sediments and those showing persistence of exposure in spawning habitat leads to the conclusion that the toxicity of oil spilled into this coastal environment may have adverse effects on pink salmon for many more years than previously assumed. The pockets of persistent oil serve as toxic PAH reservoirs that sit waiting for environmental perturbations, such as storms, to release the oil into the nearshore ecosystem where it again will induce long-term, delayed effects on eggs and larvae of pink salmon that may, in turn, produce population declines over generations.

B. Long-term Consequences for Herring

Herring also play crucial roles in the ecosystem by sustaining both a commercial fishery and by serving as a universal prey species for a large number of predators in the coastal zones – marine mammals, seabirds, and other larger fishes. Thus, spill-related impacts to the herring population have had significant repercussions economically, culturally, and ecologically.

The timing of the Exxon Valdez oil spill matched the spring season of adult return, spawning, larval and post-larval development of Pacific herring. Studies have shown that newly hatched larvae exposed to oil had many structural and genetic abnormalities, which challenge their ultimate survival. Lower viability of larvae exposed to oil was confirmed by other studies demonstrating much higher rates of larval mortality in oiled areas as well as lower growth rates when compared to larvae from unoiled areas. The results of field studies have been verified by laboratory experiments in which exposure to an Exxon Valdez type of crude oil causes genetic damage, physical deformities, lower hatch weights, and premature hatching.

Later laboratory studies have shown that these lethal and sublethal abnormalities occur at extremely low exposures. A study of herring eggs exposed to oil of similar composition and at similar concentrations to those prevailing at the time of the spill has found significant dose-related sub-lethal effects, including malformations, reduced swimming ability, and genetic damage, which all led to consequent higher mortality to herring embryos after exposure to PAHs at a few parts per billion. Again, these sublethal effects matched those documented in the field after the spill in 1989.

By analyzing herring egg deposition counts on oiled and unoiled shores and applying the observed differential in larval mortality rates, it has been estimated that 40-50% of the eggs deposited in 1989 were exposed to oil and 99% of expected herring survivors were killed on the oiled shores. As calculated, this loss would lead to reduction of over 40% in the expected total production of the 1989 year class of herring from Prince William Sound. In fact, when adults derived from this 1989 year class returned to spawn in 1993, the 1989 year class was one of the smallest on record despite the high spawn deposition reported by the annual survey carried out by Alaska Fish and Game. When researchers reviewed several independent lines of evidence (historic patterns of herring spawn, anomalies in the historic fisheries model predictions, as well as a database of acoustic measurements of herring biomass), the analysis showed that the beginning of the herring decline was coincident with the oil spill, and that the decline took place over a five-year period.

This research also showed how the herring collapse appears to be linked to several negative indirect and long-term impacts on many of the fish-eating marine wildlife species in Prince William Sound whose winter food source has traditionally been herring. Many species of seabirds with depressed populations, like pigeon guillemots and marbled murrelets, and marine mammals like harbor seals, are still falling short of recovery in part because they once fed heavily on herring. The rare

Kittlitz's murrelet similarly suffered acute mortality from contact with surface oil during the spill. That along with depressed herring populations may be enough to drive this already declining population to extinction.

Indeed, although herring populations up to 1989 had been at record highs, and have remained high in other areas of the North Pacific and Gulf of Alaska like unoiled Sitka Sound, herring populations in the oiled areas have remained extremely low ever since 1993. Even now, herring adult numbers in Prince William Sound remain insufficient to permit a return of full-scale commercial fishing. The spill thus appears to have induced a persistent reduction in reproductive success of this intertidal and shallow subtidal spawner, with potentially long-term consequences at a population level.

C. Long-term Consequences for Sea Otters

Sea otters did not avoid the floating oil. Despite their swimming ability and intelligence, they experienced initially high acute mortality through contamination of pelage, dysfunction of insulation, ingestion of oil, and inhalation. More than a decade of study of sea otter population dynamics after EVOS has revealed important delayed impacts which have slowed their recovery, presumably caused by the loss of animals with compromised health, chronic exposures by ingestion of contaminated prey, or direct contact while excavating oiled sediments during feeding.

After 1989, the rate of sea otter recovery at about 4% per annum (averaged throughout western

Prince William Sound) has fallen far short of the 10% expected from earlier population recoveries observed after termination of trade in sea otter pelts. At heavily oiled northern Knight Island, sea otters have remained at half the estimated pre-spill numbers with no recovery initiated by 2000, whereas the unoiled Montague Island population doubled just in the period from 1995 to 1998. Modeling of population dynamics based on historic carcass survey data indicates that sea otter survival in oiled areas of Prince William Sound was generally lower in the years after the spill and that survival declined rather than increased in years immediately following the oil spill.

It is clear that sea otters have been consistently exposed to PAH contamination as a result of the spill. First, persistent exposure of otter populations to oil in 1996-98 is confirmed by higher levels of the detoxification enzyme CYP1A in individuals from northern Knight Island than in those from Montague Island. One likely reason is that suspension-feeding clams and mussels, the otter's main food source, concentrate and only slowly metabolize hydrocarbons, which leads to chronically elevated PAH contamination in their tissues when persistently exposed. Additionally, sediments in protected areas, including oiled mussel beds and shallow eelgrass habitats, also retained contamination, with recovery to background in oiled mussel beds estimated from repeated sampling to require up to 30 years. As recent research on the persistence of subsurface oil in the mid and lower intertidal zones demonstrates, it is likely that otters and other intertidal foragers encounter oil repeatedly as part of their normal foraging in oil-contaminated areas. As a result, foraging sea otters suffer chronic exposure to residual petroleum hydrocarbons from both sediment contact and ingestion of bivalve prey with exterior shell and tissue contamination.

It has also been concluded that progress toward recovery of sea otters in Prince William Sound where initial oil effects were greatest is suppressed and may be constrained by residual spill effects, which include elevated mortality and induced emigration. The result has been a protracted recovery period, prolonged by long-term spill effects on survival and emigration and intrinsic limits to population growth.

D. Long-term Consequences for Harlequin Ducks

Because harlequin ducks reside for much of the year in nearshore marine environments while feeding on benthic invertebrates in the intertidal zone, they are particularly susceptible to any impacts to that environment. Individual ducks remain faithful to their particular wintering sites. Like other sea ducks, they have relatively low annual productivity but long life spans to make up for it. Also, because of their small body size, they are limited in the amount of energy reserves they can carry, leaving them dependent on reliable and safe food sources to survive the winter.

In contrast to Exxon's position that oil spill effects on bird populations would be relatively short in duration, restricted to the period of direct contact between floating or grounded oil and bird feathers, research conducted between 1995 and 1998 determined that adverse impacts on harlequin duck populations were still exhibited at least 9 years after the spill. Because harlequins were in many of the areas where oil persisted in the benthic environment, individual ducks in oiled areas continued to have significant exposure to oil, as evidenced by elevated cytochrome P4501A (CYP1A) induction in 1998. This ongoing exposure of harlequin ducks to oil for years after the Exxon Valdez oil spill is further corroborated by studies of other nearshore vertebrate predators of benthic invertebrates during 1995-1999. More recent data from March 2005 demonstrate that harlequin ducks continued to have elevated CYP1A in oiled areas.

By attaching radio transmitters to harlequin ducks, an EVOS Trustee Council research group found that adult females survived less well in oiled than in unoiled areas during the study period from 1995 through 1998, the same period during which continued exposure to residual oil was documented by the CYP1A evidence. Other government researchers doing population surveys found that fall counts of harlequin ducks declined significantly on oiled areas from 1995 through 1997, which contrasted to stable population counts in unoiled areas. Furthermore, population surveys over the 16 years after the spill have indicated that wintering numbers have not increased in oiled areas, indicating suppressed recovery.

As a result, harlequin recovery has been constrained by exposure to and ingestion of residual oil through at least 1998, which led to decreased adult female survival during periods of winter stress. The studies on this population indicate that exposure to oil and delays in population recovery have occurred over a much longer time period for harlequin ducks than urged by Exxon at the time of the spill.

E. Long-term Consequences for Other Intertidal Predators

Analogous tissue sampling of Barrow's goldeneye, adult pigeon guillemots, and various fishes indicate that several nearshore vertebrate predators in oiled areas of western Prince William Sound were exposed years after the spill to lingering Exxon Valdez oil, based on elevated levels of the biomarker CYP1A.

Barrow's goldeneye is another diving duck that occupies nearshore waters, foraging for mussels and other invertebrates, making them susceptible to long-term contamination from persisting reservoirs of subsurface oil in the intertidal zone, especially in oiled mussel beds. Organ tissue evidence of long-term exposure to oil by Barrow's goldeneye in oiled areas of Prince William Sound after EVOS serves to explain why Barrow's goldeneye populations in the oiled areas of western Prince William Sound have continued to fall.

Pigeon guillemots were relatively abundant in Prince William Sound before EVOS. This seabird species feeds close to shore during chick rearing, typically within 0.5 km of the nest. Chicks are fed almost exclusively fish and historically their prey of choice were schooling fishes like sand lance and herring, while adults would augment their diet with nearshore benthic invertebrates. USFWS shoreline boat survey data have demonstrated significant declines in pigeon guillemots in oiled areas of western Prince William Sound as compared to unoiled shoreline segments, documenting not only that the population declined after the spill but that recovery has subsequently been suppressed. The finding of elevated CYP1A enzyme concentrations in oiled areas 10 years after the spill indicate that recovery from losses suffered during the oil spill may be suppressed by chronic exposure of adults to residual oil during foraging for benthic prey. An additional factor limiting recovery has been the post-spill shortage of high-quality forage fish such as herring, sand lance and capelin. Thus, chronic challenges to recovery of this seabird are likely to be the result of contributions from multiple sources, directly or indirectly caused by EVOS.

F. Long-term Consequences for Killer Whales

Killer whales are apex predators at the top of the marine food web. These whales are long-lived and aggregate in matrilineal groupings and travel in pods of closely related whales. They mate with other whales exclusively outside the pod during multi-pod aggregations. Individual whales never leave their pod and their life span is, on average, 30-60 years. Because of their group stability and individually distinctive markings, there is a very well documented history of each individual killer whale in the groups that regularly use Prince William Sound.

There are two ecologically distinct types of killer whales, the fish eating "resident" whales and mammal eating "transient" whales. Killer whales from one resident pod and a unique transient population whose range centers in Prince William Sound were photographed swimming through the oil following EVOS. Using photo identification methods to monitor these two killer whale populations from five years before to 16 years after the spill has revealed that one resident pod, AB pod, and the small AT1 transient population, suffered losses of 33% and 41% respectively during the year of the spill and the following year. The synchronous losses of unprecedented numbers of killer whales from two ecologically and genetically separate groups and the absence of other obvious perturbations strengthens the link between the high killer whale mortalities and the oil spill as well as their lack of recovery after EVOS.

Population growth (at an annual rate of 3.2%) of all resident pods other than AB pod over the 23-year study suggests that conditions in the northern Gulf of Alaska as a whole (including southeastern Alaska) have been near optimal for resident killer whales. However, despite such ideal conditions, recruitment in AB pod in 16 years since the spill was considerably less than expected as a consequence of the disproportionate loss of reproductive and juvenile females at the time of the spill and the resulting loss in long-term reproductive potential. The AT1 transient population, which lost nine members following the spill, has had no recruitment since, and has continued to decline toward extinction.

Three key aspects of killer whale behavior and ecology leave them highly vulnerable to oil spills. First, free-ranging killer whales do not or cannot detect or avoid crude oil sheens at the water's surface and are thus susceptible to inhalation of vapors and to oil-lung contact, and, especially in the case of mammal-eating transients, to ingestion of oil. Second, resident killer whale pods, even under optimal conditions, may take decades to recover from the impacts of an oil spill if reproductive and nurturing functions of females are lost. Third, in a small, isolated and threatened population like the AT1, a major environmental perturbation can greatly increase the probability of extinction through stochastic effects (accidents matter more to lineages of small families).

Although it appears that the AB resident fish-eating pod will eventually recover if other atypical and unforeseen mortalities do not occur, recovery may take decades because of the demographic consequences of the removal of breeding females. The outlook for the AT1 mammal-eating population is bleak and the group will likely go extinct within the next several decades. Although the future fate of these two injured populations of killer whales differs, each has exhibited suppressed recovery and thus persistent impacts of the spill expressed through altered social demographics that reduce breeding.

Given the small numbers of individuals in these apex predator populations, their potential role in structuring ecological communities, and their cultural value to coastal residents, indigenous populations, and visitors from around the world, the deaths in AB pod and the impending extinction of the AT1 transients represent losses of and damage to resources of international ecological and cultural significance.

G. Long-term Consequences for Harbor Seals

Harbor seals suffered acute mortality (302 individuals) during EVOS from exposure to oil and concentrated fumes. Seals became lethargic and disoriented and many died showing evidence of brain lesions during autopsy. Using counts during moulting, it has been shown that the decline that occurred in 1989 after the oil spill was far greater in oiled than in unoiled areas of Prince William Sound. Subsequent to the oil spill, continued censuses during moulting failed to detect any trend toward recovery in the oiled portions of the Sound. The delayed recovery of harbor seals in the oiled portions of Prince William Sound may be a response to low availability of forage fishes, including herring that were significantly depressed by the spill, crashed thereafter, and have not yet begun to recover.

III. Contrary to Exxon's Representations Regarding its Clean-up Efforts, Those Efforts Were Not Only Often Ineffectual but at Times Harmful

"Exxon acknowledged responsibility for the spill and initiated a massive cleanup, ultimately spending $2.1 billion on that effort"

Petitioners' Brief at 16-17.

In undertaking the clean-up after the grounding of oil along hundreds of miles of initially pristine beaches, Exxon's preferred method was to use high-pressure water washing during the summers of 1989, 1990, and 1991 in an effort to disperse the spilled oil and displace it from the beaches. This high-pressure washing by itself caused significant additional injury to plants and animals of both rocky and mixed-soft intertidal beaches by thermal shock and physical disturbance.

Moreover, recovery of the washed ecosystems has in many cases been delayed more so than on beaches that were not cleaned at all. Recovery of rocky intertidal communities on oiled but uncleaned beaches appeared to have recovered to the status of unoiled beaches within 5 years. By contrast, a considerable proportion of mixed-soft beaches in the treated areas of the Sound remained extremely disturbed and functionally impaired in their ability to support important foraging of clams by humans and nearshore vertebrate predators such as sea otters when studied 13 years after the spill.

For example, large, long-lived hard-shell clams remained in 2002 66% less abundant at washed sites than at unoiled reference sites. Based on several lines of evidence, it has been concluded that the delay in clam recovery has been attributable in large part to the beach washing; namely, the disruption of the physical structure and surface armoring of mixed soft beaches whereby coarser materials accumulate on the surface. When these sedimentary structures become organized by armoring, this structural layer provides newly settled clams with more effective protection from physical hydrodynamic disturbances and predators than sediments lacking organization by armor. In the absence of this natural armoring, clam recovery has been widely suppressed. Consequently, recovery of clams has been suppressed by recruitment failures on beaches where armoring has been disrupted. The destruction of these armored beaches, which were quite common in Prince William Sound, has proven especially significant to predatory invertebrates, shorebirds, diving ducks, sea otters, and subsistence users of shellfish. Yet, based on the recovery trajectory to date, it has been predicted that recovery to pre-spill status will still take several more decades for those beaches that were pressure washed resulting in the destruction of their armoring.

Similarly, intertidal communities have at times suffered more from the clean-up intervention than from the oil. Short-term measurements of losses of plants and invertebrates on intertidal rocks have demonstrated greater acute injury to intertidal algae and invertebrates from the high-pressure washing than from the oil itself. Furthermore, the joint impacts of oiling and clean-up modified communities of plants and invertebrates in ways that led to subsequent indirect effect cascades, so the injuries ramified and extended over longer time frames. The loss of the structural habitat-providing rockweed and its gradual recovery over several years suppressed abundances of many invertebrates like small snails and crustaceans that are dependent on the rockweed for protection against physical environmental extremes like desiccation during sunny low tides, for substratum on which to live, and as food for grazing herbivores. Many other similar interactions among species induced indirect impacts of the oil spill and its clean-up on multiple rocky shore populations, extending the duration of injury for years beyond the period of acute mortality and delaying recovery.

IV. The Public Purpose of Punitive Damages Is Demonstrated by Exxon's Failure to this Day to Acknowledge Both the Near- and Long-Term Effects Caused by its Oil Spill

"It is unclear what public purpose could support allowing an Alaska jury to transfer to Alaska plaintiffs a windfall of $2.5 billion, on top of the full compensation they already received for their (purely economic) losses."

Petitioners' Brief at 49

Oceans cover 70% of our planet and encompass 99% of the inhabitable three-dimensional space for life on Earth. As Professor Jane Lubchenco has pointed out: "Oceans provide a wealth of benefits in the form of food, fiber, medicines, pharmaceuticals, blueprints for new materials, a storehouse of knowledge, the recycling of nutrients, detoxification of pollutants, partial regulation of the water cycle, partial climate regulation, regulation of gases in the atmosphere and the provision of spectacular places for recreation, tourism, inspiration and enjoyment – essentials we call ecosystem goods and services." Lubchenco, "Lessons from the Land for Protection in the Sea: The Need for a New Ocean Ethic," in OPEN SPACES (2007).

The types of goods and services collectively provided by the diversity of ocean ecosystems are rarely represented more fully than in Prince William Sound: kelp forests, salt marshes, mud flats, estuaries, rocky shores, sandy beaches, continental shelves, and open oceans. Optimally, each ecosystem harbors a complex assemblage of species that interact with each other and their specific physical and chemical environment to produce the services that are the byproducts of the proper functioning of an intact ecosystem. The economic value of Nature's services is often taken for granted but is clearly enormous,[5] dwarfing the production of most human enterprises.[6]

Preserving intact ocean ecosystems so that this natural capital can continue to provide its free production of goods and services is in the hands of managers and the abuse of the natural production engine as occurred via EVOS externalizes extensive service losses to diverse human enterprises.

The implications of the many long-term studies of the effects of EVOS are now quite sobering. In many areas to this day oil is retained that might last for decades. Persistence of minimally weathered still toxic oil in shallow subsurface reservoirs in the intertidal zone of the spill area has caused long-term population impacts on important vertebrate predators tied closely to the nearshore and intertidal zone for feeding or reproduction. Consumers like sea otters and diving ducks can themselves ingest residual oil passed upwards from eating contaminated clams and from contact during excavation of prey with residual reservoirs of oil. Meanwhile, beaches that Exxon aggressively cleaned with pressurized water have been seriously impacted

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[5] Daily, G., NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS, Island Press, Washington, DC (1997).

[6] Costanza R., et al. *The value of the world's ecosystem services and natural capital*, NATURE 387(15): 253-260 (1997).

by the modifying of the physical structuring of the sediments so as to render those beaches largely uninhabitable for these clams for several decades after the washing.

The full extent of an oil spill or any other major perturbation to a natural ecosystem can only be assessed by including a basic appreciation of the interconnectivity among multiple species and their environment. This perspective, generally ignored by Exxon, has revealed the long-term, chronic, and indirect effects of the spill on the marine environment and on the natural resources that environment sustains, as well as on the humans who have depended on those systems for their lives and livelihood.

For example, pink salmon populations have suffered for many years from enhanced egg mortality in gravels contaminated by residual oil and the larvae and juveniles that did survive grew less and suffered higher mortality at sea from size-dependent mortality processes. This has prevented many from returning to spawn, thereby reducing the total population dramatically. The sub-lethal effect on growth rate in an early life stage has been transformed into a population reduction by the size-dependency of the interactions between salmon at sea and marine predators, competitors, and other challenges.

When the herring population crashed after the oil spill, a cascade of indirect effects influenced both the many human and non-human vertebrate consumers of herring. Among the many vertebrate consumers of herring that continue to suffer delays in recovery as an indirect result of the oil spill are marbled murrelets and Kitlitz's murrelet, the latter of which seems headed for extinction.

In fact, as of November 2006, in its most recent "Update on Recovery of Injured Resources and Services,"[7] the Trustee Council concluded that 17 years after the spill only 9 out of 22 studied indicator species could be classified as fully recovered. For instance, sea otter recovery even today is incomplete on northern Knight Island and not even initiated in Herring Bay. Harlequin ducks suffered added mortality of over-wintering adults over a decade after the spill and their population recovery is as yet incomplete.

Clearly, the Exxon Valdez oil spill has had a significant long-term impact on the coastal marine ecosystem and the economy which long depended upon that ecosystem, none of which Exxon acknowledges when it represents to this Court that full compensation has been paid. The efforts of those studying the spill and its impacts over long time frames now approaching two decades have resulted in the discovery of immeasurably greater long-term impacts than were understood at the time of the punitive damages award in this case. Indeed, it is clear that recovery of Prince William Sound is far from complete even today – almost twenty years later. It is on this basis that we conclude that to the extent punitive damage awards are meant to provide deterrence or compensation where "the injury is hard to detect or the monetary value of non-economic harm might have been difficult to determine," *BMW*

[7] www.evostc.state.ak.us/Publications/injuredresources.cfm

of North America, Inc. v. *Gore,* 517 U. S. 559, 582 (1996), this is undoubtedly one such example.

CONCLUSION

For the reasons stated herein, the Ninth Circuit's decision should be affirmed.

Respectfully submitted,

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Appendix A

Amicus **Jean-Michel Cousteau** is the son of ocean explorer Jacques Cousteau. As such, he spent much of his life with his family exploring the world's oceans aboard Calypso and Alcyone. Honoring his heritage, Jean-Michel founded the Ocean Futures Society in 1999 to carry on this pioneering work. As Executive Vice President of The Cousteau Society for nearly 20 years, and now as Founder and President of Ocean Futures Society, Jean-Michel travels the globe, meeting with leaders and policymakers at the grassroots level and at the highest echelons of government and business. He served as a spokesman on water issues at the United Nations World Summit on Sustainable Development in Johannesburg, at the Third World Water Forum in Kyoto, and at the Dialogues on Water for Life and Security in Barcelona.

His diplomatic achievements as a voice for the ocean were recognized in 2000 when he was the first person to represent the Environment in the Opening Ceremonies of the 2000 Olympic Games, and in December 2003 when he was the first person to receive the Ocean Hero Award from Oceana, recognizing his commitment to communicate the value of the oceans and the threats they face to people of all nations and generations.

Jean-Michel has been Executive Producer of over 75 films and is currently the Executive Producer of "Jean-Michel Cousteau's Ocean Adventures," a twelve-part series in partnership with KQED, a PBS-affiliate, which first aired in 2006. He has been awarded the Emmy, the Peabody Award, the 7 d'Or, and the Cable Ace Award, among other film tributes.

He is dedicated to educating young people, documenting stories of change and hope, and lending his reputation and support to energize alliances for positive change. In recognition of his many and diverse contributions to learning, Pepperdine University awarded Jean-Michel an Honorary Doctor's Degree in Humane Letters in 1976. He has received DEMA's 1994 Reaching Out Award and the 1995 NOGI Award from the Academy of Underwater Arts and Sciences. In 1996, Jean-Michel was awarded the SeaKeepers Award from Showboats International, and the John M. Olguin Marine Environment Award from the Cabrillo Marine Aquarium.

Ocean Futures Society, a non-profit marine conservation and education organization, serves as a voice for the ocean by communicating in all media the critical bond between people and the sea and the importance of wise environmental policy.

Amicus **Peter Auster, Ph.D.**, is the Science Director for the National Undersea Research Center and an Associate Research Professor of Marine Sciences at the University of Connecticut. His research focuses on the ecology and conservation of fishes. Dr. Auster has a Bachelors degree in ecology, a Masters in biological oceanography and a Ph.D. in zoology. For the past 15 years, Dr. Auster has conducted studies to define how variation in underwater landscapes mediate the distribution and abundance of fishes, understand the linkages between habitat level processes and population-community dynamics, and develop methods for monitoring the dynamics of habitat attributes and habitat use. He serves on a number of panels and committees that are focused on marine resource management and conservation and he is involved in several outreach initiatives that are targeted at informing the public about marine conservation issues. He is a recipient of the Pew Marine Conservation Fellowship in 1999, a NOAA Environmental Hero Award in 2000 and was a Distinguished Conservation Scholar at Duke University Nicholas School of the Environment in 2001. In 2005, he was elected a fellow at the American Institute of Fishery Research Biologists.

Amicus **John Avise,** Ph.D., is Distinguished Professor of Ecology and Evolutionary Biology at the School of Biological Sciences, University of California at Davis. He has a Ph.D. in Genetics from UC Davis, 1975. Dr. Avise is a current and past member of the editorial boards for 15 scientific journals and he is a fellow of several honorific academies (including the National Academy of Sciences and the American Academy of Arts and Sciences). He is also the recipient of numerous distinguishing academic awards. Dr. Avise is an expert at ecological and evolutionary genetics, natural history and conservation biology. His research involves use of genetic markers (e.g. from allozymes, microsatellites, and mitochondrial DNA) to analyze the natural histories and evolution of wild animals. Topics range from micro- to macro-evolutionary: genetic parentage, mating patterns, geographic population structure, gene flow, hybridization, introgression, phylogeography, speciation, systematics, and phylogenetics. Research has been conducted on all major groups of vertebrates plus some invertebrates, and has involved taxa from marine, freshwater, and terrestrial environments. The primary goal typically is to unveil ecological, behavioral, or evolutionary features of the organisms themselves; an important secondary concern is to elucidate molecular and evolutionary properties of protein and DNA molecules.

Amicus **Donald F. Boesch, Ph.D.**, is a Professor of Marine Science and President of the University of Maryland Center for Environmental Science (UMCES). Dr. Boesch is a biological oceanographer who has conducted research in coastal and continental shelf environments along the Atlantic Coast and in the Gulf of Mexico, eastern Australia and the East China Sea. He has published two books and more than 85 papers on marine benthos, estuaries, wetlands, continental shelves, oil pollution, nutrient over-enrichment, environmental assessment and monitoring and science policy. Presently his research focuses on the use of science in ecosystem management. UMCES conducts comprehensive research, trains graduate students, contributes to public education, and advises public agencies and others on environmental and natural resource management from its three laboratories distributed across the state. A native of New Orleans, Don Boesch received his B.S. from Tulane University and Ph.D. from the College of William & Mary. He was a Fulbright Postdoctoral Fellow at the University of Queensland. He assumed his present position in Maryland in 1990.

Amicus **Benjamin E. Cuker, Ph.D.**, is Professor of Marine and Environmental Studies at Hampton University. He is noted for creation of student-based programs to promote diversity in the aquatic sciences. These include the American Society of Limnology and Oceanography Minorities Program (ASLOMP), Multicultural students At Sea Together (MAST), and the Hall-Bonner program for minority doctoral scholars in the ocean sciences. These programs are supported by external grants and have impacted hundreds of minority students from across the nation. Dr. Cuker was named a Pew Fellow in Marine Conservation and given the ASLO Distinguished Service Award for these efforts. He has 16 peer-reviewed publications.

Amicus **Daniel Esler, Ph. D.**, is a research scientist at the Centre for Wildlife Ecology at Simon Fraser University, in British Columbia. He received his doctorate in wildlife science from Oregon State University, in 2000. His research interests are in nearshore marine systems, avian ecology and conservation, sea duck biology, nutritional and physiological ecology, population biology and demography, population structure and genetics, wildlife habitat associations, and oil spill impacts and recovery.

Amicus **Michael Fry, Ph.D.**, is the Director for the Conservation Advocacy at American Bird Conservancy. Dr. Fry is an avian toxicologist with research interests in the effects of pollutants and pesticides on ecosystems, with a focus on wild birds. He received his doctorate at the University of California-Davis, where he then went on to be a research physiologist in the Department of Avian/Animal Sciences for 23 years, and joined American Bird Conservancy in 2005. Dr. Fry has been a panel member for the National Academy of Sciences on hormone active chemicals in the environment and has participated in toxicology reviews and international symposia for the Organization for Economic Cooperation and Development (OECD) and for the United Nations University in Japan. He is a current member of the Scientific Committee of the Dept. of Interior, Minerals Management Service Advisory Board, and an advisory committee member for EPA. He served on a National Academy of Science panel on hormone active agents in the environment, was a committee member for OECD in revising avian toxicity test methods and was a member of the EPA Ecological Committee for Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Risk Assessment Methods (ECOFRAM).

Amicus **Gregory H. Golet, Ph. D**., is a senior ecologist for the Nature Conservancy. The Nature Conservancy is the leading conservation organization working around the world to protect ecologically important lands and waters for nature and people. Dr. Golet is a senior advisor for the restoration of the Sacramento River project. Dr. Golet also served with the U.S. Fish and Wildlife agency, and has been a project scientist for the Exxon Valdez Trustee Council. He received his Ph.D. from the University of California, Santa Cruz.

Amicus **Roger Green, Ph.D.**, is Professor Emeritus at the University of Western Ontario in Zoology. His Ph.D. was done at Cornell in ecology with minors in genetics and biogeochemistry. After working in Australia on a Fulbright postdoctoral fellowship at the University of Queensland he returned to serve as Resident Ecologist at the Woods Hole Oceanographic Institute. From there he joined the faculty at the University of Manitoba. During this time he began consulting for private and governmental entities on study design and statistical analysis of data. In 1976-77 supported by a National Research Council contract he wrote one of the leading textbooks on sampling design and biostatistics, Sampling Design and Statistical

Methods for Environmental Biologists (Wiley, 1979). Dr. Green is widely published in the field of study design and statistics, having authored more than 80 articles for peer reviewed journals or presentations and numerous contributions to books or other documents. He has given workshops and presentations in this field around the world. He has consulted for both private industry and government, including most particularly as member of the Scientific Advisory Committee of the Prince William Sound Regional Citizens Advisory Council and for the Exxon Valdez Oil Spill Trustee Council.

Amicus **Burr Heneman** is a co-founder and the current Ocean Policy Director of Commonweal, Burr has been involved in marine policy and science at the state, national, and international levels since the 1970s. He formerly was director of the (now) Ocean Conservancy's Pacific region (1991-1994); consultant to BirdLife International and the Saudi Arabian wildlife agency on the Gulf War oil spill and fires (1991); consultant to the U.S. Marine Mammal Commission on marine debris and conflicts between marine mammals and fisheries (1985-1988); and executive director of PRBO Conservation Science (1980-1984). Mr. Burr received a Bachelor of Arts degree from Yale University. His marine conservation activities now concentrate on the intersection of policy, management and science. At different times his focus has been policy development, legislation, policy implementation, dispute resolution and initiation of marine monitoring programs. Investigation of various marine issues has taken Mr. Burr to the Farallon Islands (seabird and great white shark research and conservation); the Pribilof Islands (seabirds and marine debris); the Lesser Antilles, Baja California, and the Yucatan (marine debris); Prince William Sound (the Exxon Valdez oil spill); the Galapagos Islands (seabirds and fisheries); the Persian Gulf (the Gulf War oil spills and fires); Shetland (oil spill prevention and seabird/fisheries conflicts); the Gulf of Maine (seabird research and restoration); Belize (shark research); and Fiji (seabird conservation). Mr. Heneman serves on the Stakeholder Council of the Marine Stewardship Council. He was awarded a Pew Fellowship in Marine Conservation in 1999.

Amicus **Richard Kocan** is Professor Emeritus at the School of Aquatic and Fishery Sciences at the University of Washington. Dr. Kocan has a Bachelor's degree from Hiram College, a Masters in Microbiology and Public Health, University of Michigan and a Ph. D. in Microbiology and Public Health, University of Michigan. Dr. Kocan specializes in aquatic toxicology, environmental pathology and aquatic animal diseases. He has been a consultant to a number of state and federal agencies, corporations and Indian Tribes, including the State of Washington, Department of Fish and Game, Exxon Valdez Trustee Council reviewing fish studies in Prince William Sound, the State of Alaska Department of Fish and Game. Some current projects include: An investigation into herring diseases in Prince William Sound Alaska following the Exxon Valdez oil spill, diseases in Yukon River salmon, toxic effects of agricultural pesticides and PCB effects upon trout.

Amicus **Jane Lubchenco, Ph.D**., is Wayne and Gladys Valley Professor of Marine Biology & Distinguished Professor of Zoology at Oregon State University. She graduated from Colorado College, received her Ph.D. from Harvard University in marine ecology, taught at Harvard for two years, and has been on the faculty at Oregon State University since 1978. Dr. Lubchenco leads an interdisciplinary team of scientists who study the marine ecosystem off the west coast of the U.S. which is learning how the ecosystem works, how it is changing and how humans can modify their actions to ensure continued benefit from ocean ecosystems. She is a former President of the International Council for Science, the American Association for the Advancement of Science (AAAS) and the Ecological Society of America. She was a Presidential appointee to two terms on the National Science Board which advises the President and Congress and oversees the National Science Foundation. She is a member of the National Academy of Sciences, the American Philosophical Society and the American Academy of Arts and Sciences.

Amicus **Craig Matkin, M.S.**, is a founding member and director of the North Gulf Oceanic Society (NGOS). NGOS is a federally recognized non-profit research and education organization that specializes in long-term marine mammal research. Mr. Matkin completed his M.S. in Zoology in 1980 at the University of Alaska, Fairbanks, and has worked with marine mammals for 25 years. He has authored more than 50 scientific reports and articles on marine mammals. His work has included identification, detailed life histories, geneology, acoustic vocalization and language patterns, and movement of individual whales and whale aggregations, as well as DNA and contaminant analyses. Because NGOS has been monitoring individual killer whales and their clan groups since well before the EVOS, they have detailed data on the status of these populations before and after the spill.

Amicus **John Ogden** is the Director of the Florida Institute of Oceanography (FIO) and Professor of Biology at the University of South Florida since 1988. He received his undergraduate degree from Princeton University and his Ph.D. in Biological Sciences from Stanford University in 1968. After two years at the Smithsonian Tropical Research Institute in Panama he joined Fairleigh Dickinson University, built the West Indies Laboratory (WIL) in St. Croix in the Virgin Islands, and began his continuing fieldwork on global coral reefs and associated ecosystems. Dr. Ogden was Director of WIL from 1981-1988, operated the saturation diving facility Hydrolab for NOAA during this period, and directed the construction and initial operations of Aquarius, the only currently operational facility. Dr. Ogden has published over 100 scientific papers, has contributed to several books, and has produced several television films on tropical ecosystems. He has served on federal and state commissions dealing with coastal ecosystem management and was a member of the founding Advisory Council of the Florida Keys National Marine Sanctuary. He presently serves on the Technical Advisory Committee of the Sustainable Seas Expedition, the Board of the World Wildlife Fund, and is a Fellow of the American Association for the Advancement of Science.

Amicus **Thomas Okey, Ph.D.**, is a marine ecologist and conservation biologist who studies the scientific, management and policy issues related to the effects of climate change on marine ecosystems and on distinguishing these impacts from those caused by fisheries mismanagement and pollution. His research has ranged from subtidal experimental studies of the effects of natural disturbances and production subsidies on marine soft sediment communities to broad syntheses of ecosystem knowledge and fisheries impacts using and refining food web trophodynamic modeling techniques. Dr. Okey received his doctorate from the University of British Columbia in the area of zoology, which compliments his Bachelors and Master degrees in Marine and Coastal Biology. Dr. Okey is the founder and current science director for the Conservation Science Institute, an organization that provides science support and education for conservation goals. He is also a Pew Fellow in Marine Conservation, a Scientist-in-Residence at the Bamfield Marine Sciences Centre, and an Adjunct Professor at the University of Victoria School of Environmental Studies. During the late 1990s, he was the director of the Center for Marine Conservation's Pacific Fisheries Program. He expanded that program from areas adjacent to California, Oregon, and Washington to those adjacent to Alaska and Hawaii. During this time, Dr. Okey also chaired a national working group on Essential Fish Habitat, sat on Marine Mammal Take Teams, and developed marine protected area strategies and teams.

Amicus **Daniel Pauly, Ph.D.**, is the Director of the Fisheries Centre of the University of British Columbia, Vancouver, Canada. Educated in Germany, he has spent most of his working life inventing new approaches for fisheries research and management in data-sparse settings and teaching on these issues in four languages in Europe, Africa, Asia, Oceania and Latin America. Besides numerous and well-cited journal articles, books and other publications, his work led to the creation of software (ELEFAN, Ecopath) and scientific databases (FishBase) now used throughout the world. His work links to concepts now structuring a wide span of research in marine biology, notably on “fishing down marine food webs,” which impacts all the world's aquatic systems, but which many do not notice because of the “shifting baseline syndrome of fisheries.” Dr. Pauly is Principal Investigator of the Sea Around Us Project, funded by the Pew Charitable Trusts, Philadelphia and is devoted to investigating the global impact of fisheries on marine ecosystems. He has received numerous scientific awards, including UBC's Distinguished University Scholars and elected a Fellow of the Royal Society of Canada (Academy of Science). In 2004, he received the Roger Revelle Medal from IOC/UNESCO, and the Award of Excellence of the American Fisheries Society.

Amicus **Charles “Pete” Peterson, Ph.D.**, is Alumni Distinguished Professor in the Department of Marine Sciences at The University of North Carolina at Chapel Hill. He was trained at Princeton University and the University of California at Santa Barbara. Dr. Peterson has spent his working career of some 40 years in academia conducting research in marine fisheries and conservation ecology. He serves presently as editor of two international scientific journals, has published over 160 peer-reviewed papers, and regularly reviews papers for over 50 scientific journals and for the basic science foundations of several countries. Dr. Peterson has served on 5 panels of the U.S. National Academy of Sciences. His awards include National Science Foundation, Woodrow Wilson Foundation, Ford Foundation, and Japan Society for Promotion of Science fellowships. In 1994, he was named a Pew Charitable Trust Scholar in Conservation and the Environment. He served the U.S. Department of

State for several years as a national representative to the ICES (International Council for Exploration of the Sea) Shellfish and Mariculture Committees. Dr. Peterson may be the most highly cited of all scholars with a primary research focus on marine communities, habitats, and ecosystems based on sedimentary bottoms. Presently, his research focus is on developing ecosystem-based management for marine resources.

Amicus **John Teal, Ph.D.**, is currently Scientist Emeritus for the Woods Hole Oceanographic Institution. Dr. Teal's professional career began in the early 1950's with his Ph.D. thesis on the trophic relationships in a tiny cold spring in Massachusetts. After getting his degree, he joined the University of Georgia Marine Institute at Sapelo Island where he studied salt marshes. After four years, he went to the new oceanography center at Dalhousie University in Halifax, NS. He joined Woods Hole Oceanographic Institution in 1961 and has been Scientist Emeritus there since 1995. In addition to research on coastal wetlands, he has worked on effects of hydrostatic pressure on deep sea animals, physiology of large, warm blooded fishes, bird migration over the oceans, oil pollution, wastewater treatment, and restoration ecology. He is currently involved with constructed wetlands for wastewater treatment and with marsh restoration in fresh, brackish and salt wetlands. For the last six years, he has worked on a salt marsh restoration project in Delaware Bay that encompasses 32 square miles. He has served on National Academy of Science committees, editorial boards of scientific journals, published in the scientific literature, written popular articles and books, and served on local committees. He has also served on the board of the Conservation

Law Foundation of New England since 1978 and been vice chair since 1980 and serves as an advisor to local land trusts.