Executive Summary

The Association to Preserve Cape Cod (APCC) submits this position statement regarding threats to Cape Cod's environment from the Pilgrim Nuclear Power Station (Pilgrim). APCC was founded in 1968 to promote policies and programs that protect Cape Cod's environment. APCC is the Cape's largest environmental organization and has 5,000 members from all 15 towns on Cape Cod. In our 46 years, we have successfully advocated for protection of the Cape's water resources, open space and natural resources, and adoption of regional growth management policies. As an environmental guardian for Cape Cod, our work is based on sound science and best environmental policies and practices (see www.apcc.org).

Cape Cod is one of the most ecologically valuable and sensitive areas in the Commonwealth of Massachusetts. Important natural resources include shellfish beds; commercially and recreationally important fisheries; habitat for fish, wildlife and rare species; numerous wetlands, ponds, lakes and streams; miles of coastal habitat and beaches; and a sole-source aquifer that supports most public water supplies. The Cape's economy relies upon healthy natural ecosystems; fishing, shellfishing, aquaculture and coastal tourism are a multimillion-dollar-industry that benefits the region and the Commonwealth. The Cape has a long history of environmental protection as evidenced by many protected areas, parks and open space.

Regarding Pilgrim, many organizations, agencies and officials have identified threats to human health and safety. Potential threats to the Cape's environment and resources have received less attention. Human health and environmental quality are linked. Our statement therefore focuses on the potential threats posed by Pilgrim to the Cape's environment as summarized below:

1) Safety issues at Pilgrim include power outages, a power-down in July 2013 due to seawater being too warm to cool the reactor, a fire that could have damaged the reactor, storage of spent nuclear fuel in overcrowded spent-fuel-pools, partial blockage of an emergency cooling system by mussels, and vulnerability to natural hazards and terrorism. In January 2014 the NRC downgraded Pilgrim's performance to "degraded"; only seven other nuclear power facilities in the nation are in this performance category. These issues point to aging infrastructure, outdated systems, failure to account for climate change, and inadequate maintenance, oversight and regulation. Safety issues increase the risk of a serious accident occurring that could damage the Cape's environment.

2) Pilgrim is causing environmental impacts nearby and in Cape Cod Bay, namely: release of radioactive materials, including releases of tritium into groundwater that exceed drinking water standards; impingement and entrainment of 90+ species of fish and shellfish which is affecting some species at the population level; discharge of heated seawater into Cape Cod Bay resulting in a thermal plume, erosion, barren and stunted areas, warm-water algal growth, and increased thermal burden on marine ecosystems that are already experiencing warming; potential impacts on rare species, fish and wildlife; and cumulative impacts of all of the above. Such impacts are unacceptable. Furthermore, regulatory agencies have allowed these impacts to continue, increasing the chances that a larger area such as Cape Cod will eventually be affected.

3) The Fukushima nuclear disaster provided important lessons: a) improbable accidents occur, and b) if an accident results in major radioactive contamination, there can be serious and widespread impacts on water resources, fish, wildlife, food webs, crops, the economy, human populations and society.

4) All of Cape Cod lies within a 50-mile radius from Pilgrim. If a nuclear accident were to occur at Pilgrim, impacts on Cape Cod would depend on many factors; but if a radioactive plume or radioactive fallout were to reach Cape Cod, the Cape's valuable resources could be severely affected.

Based on the importance of Cape Cod's natural resources and the impacts and threats posed by Pilgrim, APCC calls on public officials and regulatory agencies to revoke Pilgrim's permits and to require that Pilgrim be decommissioned in the shortest time and safest manner feasible. We also recommend additional measures to safeguard the Cape's environment and human population.

Abbreviations

Pilgrim	Pilgrim Nuclear Power Station
NRC	Nuclear Regulatory Commission
EPA	U.S. Environmental Protection Agency
NPDES	National Pollutant Discharge Elimination System permit for discharges
EIS	Environmental Impact Statement for relicensing Pilgrim

1. Introduction

Cape Cod is one of the most ecologically valuable and sensitive areas in the Commonwealth of Massachusetts. Important natural resources include shellfish beds; commercially and recreationally important fisheries; habitat for fish, wildlife and rare species; numerous wetlands, ponds, lakes and streams; miles of coastal habitat and beaches; and a sole-source aquifer that supports most public water supplies. These resources include:

- Water bodies and wetlands, including nearly 1,000 freshwater ponds and lakes totaling nearly 11,000 acres in area; 109 miles of streams and rivers; over 21,600 acres of freshwater wetlands; 6,800 acres of salt marsh; over 350 certified vernal pools; many potential vernal pools; a federally-designated sole-source aquifer that supports most of the Cape's water bodies and wetlands and supplies most of the Cape's drinking water [(1)].

- Coastal habitat, including 57 coastal embayments and watersheds; 430,000 acres of shellfish beds; over 390 public beaches; 41 diadromous fish runs; 5,400 acres of herring spawning habitat; and essential fish habitat for commercially and recreationally important finfish in the tidal waters around Cape Cod [(1)].

- High-quality habitat for fish, shellfish, wildlife and rare species, including over 135 rare species, five federally-listed whale species, four listed sea turtle species, rare shorebirds; and many other fish and wildlife species [(1, 2)].

- Numerous protected areas, including a national park, two wildlife refuges, two national estuary programs, an estuarine research reserve, federally-designated critical habitat for the endangered North Atlantic Right Whale, one nearby national marine sanctuary, five state parks, seven Areas of Critical Environmental Concern (ACECs) totaling 30,010 acres, twelve Districts of Critical Planning Concern, thousands of acres of preserved open space, federal No Discharge Area designation for all state coastal waters, and state ocean sanctuaries surrounding Cape Cod [(1)]. Many citizens, organizations (including APCC) and agencies have worked to designate these areas over the years, evidence of the Cape's strong support for environmental protection.

These natural resources support our economy and quality of life. Coastal tourism is a cornerstone of the Cape's economy and relies upon clean water and coastal access. Shellfishing, fishing and aquaculture are multimillion-dollar businesses that support hundreds of jobs. Estimates of annual average values include $6.3 million for commercial shellfishing, $646,000 for recreational

shellfishing, $4.5 million for shellfish aquaculture (2008 value), and $20 million for commercial fishing for two towns alone [1, 3]. A shellfish seed facility on Cape Cod Bay supplies much of the seed for aquaculture projects throughout the state and beyond. Most towns on Cape Cod have shellfish programs that require clean water. If these resources were damaged due to radioactive contamination, the resulting environmental, economic and social losses would be huge.

2. Safety issues at Pilgrim

Many organizations, agencies, elected officials and the media have expressed concerns about safety issues at Pilgrim. These include power outages that required plant shutdowns, a power-down in July 2013 due to Cape Cod Bay seawater being too warm to cool the reactor, a fire that could have caused damage to the reactor, storage of spent nuclear fuel in elevated spent-fuel-pools that are now overcrowded, partial blockage of an emergency cooling system due to mussel growth, vulnerability to natural hazards and terrorism, and other issues [4 through 8]. Between 2000 and 2012, there were 110 safety violations [8]. In November 2013, the Nuclear Regulatory Commission (NRC) downgraded Pilgrim's status to one of the 16 worst in the country due to safety issues, triggering more regulatory review and scrutiny [8]. In December 2013 the NRC cited Pilgrim for five security violations, some dating back to 2012 [8]. In January 2014, the NRC further downgraded Pilgrim's performance to "degraded", joining only seven other nuclear power facilities in this category [9].

Statement: Safety issues at Pilgrim point to aging infrastructure, outdated systems of cooling and operation, failure to take account of changes in ocean temperature affecting cooling, inadequate maintenance, oversight, and regulation. Safety issues are of great concern because they indicate below-par performance that raises the risk of harm to humans and the environment from ongoing operations or a nuclear accident. APCC believes that Pilgrim's inability to meet existing safety and performance requirements calls for termination of their permits.

3. Environmental impacts

Pilgrim is responsible for causing ongoing environmental impacts, listed below.

a) Release of radioactive materials: The NRC stated that nuclear power plants often discharge small amounts of radioactive gases and liquids into the environment [10]. At Pilgrim, radioactive releases consist of gases, particulates and liquids. As one example, in 2011 Pilgrim reported 29 discharges of radioactive liquids into the environment and/or Cape Cod Bay, plus releases of radioactive gases and particulates [11]. In another example, Pilgrim has been monitoring radioactivity in groundwater monitoring wells since 2007, and detected radioactive tritium from the plant at concentrations ranging from non-detect (< 295 picoCuries per liter, or pCi/L) up to 25,552 pCi/L). Pilgrim stated that the latter measurement exceeds EPA's drinking water standard of 20,000 pCi/L but that tritium was not affecting drinking water because the flow pathway was towards Cape Cod Bay where it would be diluted [11]. In late December 2013, levels of tritium measured in a groundwater monitoring well next to a catch basin that releases waste into Cape Cod Bay were the highest measured so far (69,000 pCi/L) [8]. This measurement again exceeded federal drinking water standards for tritium set by the EPA [12].

Release of radioactive substances into the environment is of great concern. First, it is important to realize that humans and other living organisms are exposed to background levels of radiation every day. Background radiation comes from natural sources (e.g., cosmic rays, naturally-occurring radioactive elements in rocks, soil, water and air) and manmade sources (e.g., radioactive fallout from nuclear weapons testing, nuclear accidents such as Fukushima and the 1986 Chernobyl disasters, and emissions from nuclear power plants). Humans may also be exposed to other manmade sources (e.g., medical and security X-rays, CT-scans, high-altitude plane flights, etc.). However, the effects of radiation on living organisms are cumulative; that is, the sum of all radiation that the organism is exposed to during its lifetime [13, 14].

Biological effects on living organisms and their cells depend on the radiation dosage, and can include: production of free radicals, breakage of chemical bonds, production of new chemical bonds, and damage to DNA, RNA, proteins and other molecules that regulate vital cell processes. At low doses, cells can repair such damage. At higher doses cell death results and at extremely high doses, cells cannot be replaced quickly enough and tissues fail to function [15]. Radiation can cause death, mutations, or pass up the food chain [16]. In humans, exposure to any ionizing radiation can increase the risk of cancer [13], but the risk increases in a direct manner above a dose of 100 millisieverts (mSv)[14]. For comparison, the average person receives 3 mSv per year from natural and manmade sources [13, 14]. In short, release of radioactive materials into the environment poses risks to the health of humans and other living organisms.

The effects of exposure to radioactivity also depend on the length of time of exposure. Radioactive nuclides released into the environment from nuclear weapons testing and nuclear accidents such as Fukushima and Chernobyl include nuclides with short half-lives (iodine-131 has a half-life of 8 days) as well as longer half-lives (i.e., cesium-137 has a half-life of 30 years and strontium-90 has a half-life of 29.1 years [14]. Radioactive nuclides with longer half-lives would be present in the environment for many years. Depending on the type, concentration and spread of radionuclides throughout the environment, humans and ecosystems could be exposed to radiation for a short time, several years or many years.

Statement: Radioactive discharges from Pilgrim pose a regional threat to environmental quality, human health and the health of Cape Cod Bay's ecosystems. Discharges of radioactive tritium into groundwater pose a threat to Plymouth's sole-source aquifer and to Cape Cod Bay's water quality and ecosystems. APCC believes that Pilgrim's discharge of radioactive materials should cease and that permits allowing for discharge should be terminated.

b) Seawater intake system impacts commercially and recreationally important fisheries in Cape Cod Bay: The once-through seawater intake system used to cool Pilgrim's nuclear reactor negatively impacts 91 species of marine and diadromous fish through entrainment and impingement. Each year millions to billions of fish eggs and larvae are entrained and thousands of fish are trapped (impinged) on the intake screens. Impacted species include commercially and recreationally important fish such as Atlantic silverside, winter flounder, alewife, blueback herring, rainbow smelt, hakes, windowpane flounder, tautog, Atlantic menhaden, tomcod, Atlantic herring, and others. NRC in its 2007 EIS for relicensing Pilgrim concluded that there were moderate impacts on winter flounder (up to 12.1% of the adult population of winter

flounder in western Cape Cod Bay are impacted) and Jones River rainbow smelt populations, and small to moderate impacts on other fish and shellfish [17].

Statement: Pilgrim's once-through seawater intake system adversely impacts commercially and recreationally important species of fish that are experiencing declines. Many local, state and federal agencies, organizations (including APCC) and citizens have expended time, effort and millions of dollars to protect and restore fisheries and their habitat. Allowing these impacts to continue counteracts protection and restoration efforts and represents a failure by regulators to protect fisheries. APCC believes that these impacts are unacceptable and should be ended.

c) Cumulative impacts of thermal plume and warming sea temperatures: Pilgrim's permit allows the seawater used for cooling the nuclear reactor to be heated up to 32°F above ambient water temperature. Pilgrim discharges seawater at temperatures of up to 27-30°F warmer than Cape Cod Bay water. The volume of seawater discharged is significant, an estimated 160+ billion gallons per year. The NRC states in its EIS that discharge of heated seawater into Cape Cod Bay creates a thermal plume covering an area of 14 to 216 acres which caused two fish kills in the 1970s and is causing scouring of the bottom, a denuded zone near the discharge covering up to 1,400 square meters ($m^{2)}$; a zone of stunted benthic growth located further from the discharge covering up to 2,900 m^2; and growth of warm-water algae (e.g., *Enteromorpha aragonensis*, *Bryopsis plumosa*, *Codium fragile*, *Gracilaria follifera*, and *Soliera tenera*) [17].

Ocean temperatures in the Northeast have been rising over time due to climate change. Potential impacts of rising temperature on marine ecosystems include shifts in species distributions, increased thermal stress, impacts on reproduction, growth and survival, changes in fisheries and the food web that supports them, and increased water column stratification [18, 19]. Pilgrim's permit requires that the temperature of seawater used for cooling the reactor be less than 75°F. In July 2013, the temperature of Cape Cod Bay water exceeded 75°F and Pilgrim had to power down operations because seawater was too warm to cool the reactor [20, 21]. Pilgrim is operating close to its permit limits for seawater temperature.

Statement: Pilgrim's discharge of heated seawater is environmentally detrimental and adds to the thermal burden on fish, wildlife and marine ecosystems that are already experiencing warming to climate change. These cumulative impacts could result in a tipping point for some marine species. Also, as ocean temperature continues to rise, it is uncertain whether Pilgrim can safely continue operations. APCC believes that discharge of heated seawater poses unacceptable risks for marine ecosystems and that Pilgrim's discharge permit should be terminated.

d) Changes in rare species, fish and wildlife populations were not considered. In its 2007 EIS for relicensing Pilgrim, the NRC found no impacts on marine mammals, sea turtles, or other rare species [17]. Regarding sea turtles, new information from the Wellfleet Audubon Sanctuary indicates that sea turtle strandings on the shores of Cape Cod Bay have increased in recent years from an average of 20 strandings per year in the 1980s to 250 strandings per year from 2009 - 2012. The increase in strandings may be due in part to climate change causing warmer seawater that attracts more turtles [22]. With regard to the endangered Northern Atlantic Right Whale, in 2013 a Right whale mother and calf were documented close to Pilgrim's discharge. Concerns were raised about potential impacts and the need to re-evaluate rare species impacts [23].

Statement: The environmental impact analyses for relicensing Pilgrim did not account for changes in the distribution of rare species, fish and wildlife populations that occurred after the permit was issued. This raises the risk that Pilgrim will cause impacts because permit conditions based on old information are not protective enough.

e) Cumulative impacts of fish impingement/entrainment, radioactive releases, thermal discharges and climate change were not adequately evaluated or regulated. Major permits for Pilgrim have not adequately accounted for cumulative impacts. These include the NRC's 2012 extension of Pilgrim's operating license for another 20 years, one year after the Fukushima disaster occurred, and EPA's NPDES permit which expired in 1996. The NPDES permit has been administratively extended since its expiration, and a new draft permit is overdue [24].

Statement: Cumulative impacts of fish impingement and entrainment, radioactive releases, thermal discharges and climate change were not adequately evaluated or regulated. Given Pilgrim's inability to avoid causing impacts, APCC believes that Pilgrim represents a serious threat to Cape Cod's resources and its permits should be revoked.

4. Lessons learned from Fukushima and other nuclear accidents

The Fukushima nuclear disaster in 2011 showed the world that improbable accidents can occur with devastating effects. Fukushima's impacts include radioactive contamination of several hundred square kilometers [25], deposition of 80% of the radioactivity on the Pacific Ocean (at Pilgrim 60% of the area within 50 miles is ocean), contamination of marine fisheries resulting in fisheries closures and a tightened safe-consumption limit, contamination of 40% of bottom-dwelling marine fish species [25, 26], contamination of freshwater fish and streams, rivers and lakes up to 400 kilometers away [27], and continuing releases of radioactive water into groundwater and the ocean even as the damaged reactors are being decommissioned [14, 28]. Radionuclides from Fukushima have entered the marine food web via plankton uptake and when invertebrates, fish and wildlife ingest contaminated food. Organisms also excrete radionuclides to water and sediments where benthic organisms feed. Rates of uptake, bioaccumulation and excretion of radionuclides vary greatly depending on species [26].

The effects of Fukushima on terrestrial plants, wildlife and ecosystems are slowly unfolding. An early survey of birds in the vicinity of the reactors in July 2011 showed 30% fewer birds than expected, suggesting significant mortality [29]. A native butterfly species suffered physiological and genetic damage from radiation that may impact the population [30]. Impacts of the 1986 Chernobyl nuclear accident on birds included reduced numbers and longevity of birds, diminished fertility in male birds, smaller brains, mutations, and local extinction of several species [29]. The scarcity of scientific studies of ecological impacts is a data gap that should be addressed in order to better understand how radioactivity affects terrestrial and aquatic food webs and living organisms.

Human health impacts resulting from Fukushima will take time to evaluate. So far, no one has died from the effects of Fukushima [31] but estimates of the cancer risk indicate that exposed infants and children have the greatest risk [13]. One study of human health risk related to

ingesting contaminated fish from the western and eastern Pacific concluded that the risk was less than risks due to exposure from background radiation; that is, below levels of concern [32]. The effects of low-level radiation on human health still remain uncertain [13, 14, 32] Other scientists and physicians have expressed strong concerns about the long-term human health effects of Fukushima radioactivity and ingesting contaminated fish, food and water [33]. A recent analysis of attitudes towards nuclear risks stated that "*Governments and the nuclear power industry have a strong interest in playing down the harmful effects of radiation from atomic weapons and nuclear power plants. Over the years, some scientists have supported the view that low levels of radiation are not harmful, while other scientists have held that all radiation is harmful."* Examination of radiation effects of nuclear bombs, nuclear weapons testing, nuclear accidents and power plant emissions shows that in each case there is "*a pattern of minimizing the damage to humans and attributing evidence of shortened life-spans mostly to stress and social dislocation rather than to radiation. While low-level radiation is now generally accepted as harmful, its effects are deemed to be so small that they cannot be distinguished from the much greater effects of stress and social dislocation. Thus some scientists declare that there is no point in even studying the populations exposed to the radioactive elements released into the atmosphere during the 2011 accident at Fukushima*" [34].

In summary, nuclear accidents can release radioactive materials into the environment that can enter the food web. The scale of impacts on humans and living organisms can range from individuals to populations and ecosystems. Most impact studies have focused on human health risks rather than effects of radiation on other living organisms or ecosystems. Despite the relative lack of studies on ecological effects, APCC believes that decision makers should proactively take steps to protect our resources from the effects of a nuclear accident.

Conclusions

All of Cape Cod lies within a 50-mile radius from the Pilgrim Nuclear Power Station [17]. If a nuclear accident were to occur at Pilgrim, impacts on Cape Cod would depend on many factors: the type and extent of the accident, amount and type of radiation released, human responses, prevailing weather and ocean currents, environmental conditions, and the types of resources impacted. However, if a radioactive plume or fallout were to reach Cape Cod, we are concerned that the following impacts could occur:

- Contamination of shellfish beds, aquaculture, and fishing areas;
- Contamination of water bodies (both freshwater and marine) affecting aquatic ecosystems and public uses;
- Contamination of drinking water supplies;
- Contamination of land, soil and sediments;
- Impacts on life, including plankton, invertebrates, fish, shellfish, wildlife, plants, their habitats, food webs, and ecosystem processes;
- Closure of swimming beaches;
- Impacts on local agriculture;
- Economic impacts resulting from the above; and last but not least,
- Impacts on Cape Cod's residents and communities due to health risks, dislocation, economic impacts and social disruption.

A nuclear accident at Pilgrim has the potential to significantly damage the Cape's environment, natural resources and economy. Given Pilgrim's safety record and history of causing impacts, we believe that it is unlikely that Pilgrim will be able to upgrade its facilities to ensure full safety and avoid impacts.

Therefore, APCC calls for Pilgrim's permits to be terminated and for the facility to be decommissioned. We also call on public officials and regulatory agencies to:

- Provide full regulatory oversight of the decommissioning process, including implementation of safeguards to protect public health and the environment before, during and after the decommissioning process, as outlined in NRC's process for decommissioning [(35)];
- Require storage of all spent fuel rods in dry cask storage, which represents the safest storage system in the absence of a national repository [(36)];
- Implement a radiation monitoring system on Cape Cod that includes monitoring of air, water, fish and shellfish, with reports to the public on a regular basis;
- Expand emergency planning throughout the 50-mile-radius zone to protect Cape Cod's residents and natural resources;
- Find safer and less polluting alternative energy sources for Pilgrim's customers. Replacing nuclear energy with greenhouse-gas-producing energy sources such as natural gas or other fossil fuels is not a satisfactory long-term solution, as climate change is also impacting the environment [(19)];
- Support scientific research on the effects of radiation on ecosystems; and
- Form an independent commission to oversee decommissioning of Pilgrim, to review progress and to identify problems to be addressed to help ensure safe and effective decommissioning.

Finally, APCC calls on public officials, agencies and organizations on Cape Cod to support these measures.

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