Seattle Journal of Environmental Law

Volume 1 | Issue 1 Article 5

5-31-2011

Our Blue Water Navy Goes Green

Tom Spahn

Our Blue Water Navy Goes Green

Tom Spahn[†]

The Navy has both a tradition and a future—and we look with pride and confidence in both directions.

–Admiral George Anderson, Chief of Naval Operations, August 1, 1961

I. INTRODUCTION

When one thinks of hybrid transportation, one commonly imagines small vehicles dedicated to ferrying people with few belongings through congested city streets. The Toyota Prius almost certainly comes to mind. Few could have foreseen integrating similar hybrid technology into the massive naval warships steaming the world's seven seas. Likewise, advanced fighter jets screaming off the decks of aircraft carriers seem unlikely tools of the green revolution. Yet new technologies on board these platforms represent a realization among military leaders that environmental stewardship and national security are not mutually exclusive goals.[1]

The U.S. Navy's new focus on the environment has taken many forms in the last few years.[2] Seeking to improve efficiency and sustainability, the Navy[3] has pursued new technologies for maritime propulsion.[4] Meanwhile, to safeguard ocean resources, the Navy has implemented

---

[†] Lieutenant, U.S. Navy Reserve; J.D. Candidate, Stanford Law School, 2011. Mr. Spahn served as a submarine officer in the U.S. Navy from 2001 to 2008. His service included a tour of duty on the nuclear fast attack submarine USS Chicago and a deployment to Afghanistan as an economic-development planner.

1. *See* Ray Mabus, U.S. Sec'y of the Navy, Remarks at the Navy League Sea-Air-Space Expo (May 5, 2010), *available at* http://www.navy.mil/navydata/people/secnav/Mabus/Speech/Sea-Air-Space%20Expo%205%20May10.pdf.

2. *See id.*

3. Unless indicated otherwise, all military branches referenced in this article are those belonging to the United States.

4. *See* RONALD O'ROURKE, CONG. RESEARCH SERV., RL33360, NAVY SHIP PROPULSION TECHNOLOGIES: OPTIONS FOR REDUCING OIL USE – BACKGROUND FOR CONGRESS 14-16 (2006), *available at* http://www.fas.org/sgp/crs/weapons/RL33360.pdf.

initiatives to protect fragile ecosystems and endangered marine species.[5] Other military branches have also realized the importance of environmental decisions and have embraced efforts to field renewable and alternative fuel technologies.[6]

The initiatives discussed herein show that the military is on the right track to fulfilling its promise of environmental stewardship while continuing to excel in its core mission of national defense.[7] Although a long journey remains to meet the goals of these programs, the plans in place show a promising future for implementing sustainable technologies and protecting the fragile ecosystems where the military operates.

II. THE HISTORY AND FUTURE OF NAVAL PROPULSION

The world's navies sprung into existence by harnessing environmentally friendly energy. From the tiny dinghies of the distant past to the monstrous ship of the line of the Napoleonic era, wind has long provided humans with seafaring locomotion.[8] In contrast, the use of fossil fuels for maritime propulsion is a relatively recent development. Although they offer a significant speed and flexibility advantage over sail power, petroleum- or coal-based fuels severely limits a ship's ability to stay at sea for prolonged periods of time. Many maritime foreign policy decisions of the mid-twentieth century centered on the limited distance that warships could travel without refueling.[9]

As globalization increased the flow of commerce around the world, the ability to project naval power over long distances became increasingly important.[10] Simultaneously, the worldwide increase in environmental consciousness intensified the awareness of the impact that our ocean travel has on the planet.[11] While recognizing the critical importance of a

---

5. The Navy highlights its various environmental protection initiatives in its magazine CURRENTS. *See, e.g.*, *NESDI Program Demos Technologies & Collects Data to Enhance Readiness: Recent Successes Include Better Water Quality Management Tools, Enhanced Anodizing Process*, CURRENTS, Summer 2010, at 40.

6. *See* Press Release, Alternative Fuel Tech., Inc., Alternative Fuel Technologies Inc. Announces Test Project with U.S. Army (June 15, 2009), http://www.marketwire.com/press-release/Alternative-Fuel-Technologies-Inc-Announces-Test-Project-With-US-Army-1004202.htm.

7. *See, e.g.*, Richard A. Matthew, The Environment as a National Security Issue, 12 J. POL'Y HIST. 101 (2000).

8. *See generally* ALFRED THAYER MAHAN, THE INFLUENCE OF SEA POWER UPON HISTORY: 1660-1783 (Boston, Little, Brown, & Co. 1890).

9. *See, e.g., Great White Fleet*, GLOBALSECURITY.ORG, http://www.globalsecurity.org/military/agency/navy/great-white-fleet.htm (last visited Aug. 3, 2010).

10. *See* COMMANDER PETER J. WINTER, U.S. ARMY WAR COLLEGE, THE ROLE OF THE U.S. NAVY IN SUPPORT OF THE NATIONAL STRATEGY OF MARITIME ACTIVITY, (Mar. 15 2006), *available at* www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA449645.

11. *Cf.* Stacy J. Silveira, *The American Environmental Movement: Surviving Through Diversity*, 28 B.C. ENVTL. AFF. L. REV. 497, 503-07 (2001).

highly capable navy, strategists have begun to recognize that embracing environmental stewardship can complement the military's quest for tactical advantages.[12]

As a leader in technological progress, the Navy is well situated and has the requisite research and development budget to take advantage of the numerous recent advances in propulsion technology. Investment in these environmentally friendly technologies can not only lead to tremendous monetary savings, but also can enhance the public opinion of the Navy as a leader in sustainability.

A. Extending the Fleet's Endurance: Nuclear, Hybrid, and Future Propulsion Solutions

The Navy has long been a leader in one particular alternative fuel source: nuclear energy.[13] Although the Navy developed nuclear submarines and aircraft carriers for their endurance potential, not necessarily to minimize environmental impacts, these vessels have patrolled the world's oceans, virtually emissions free, for decades.[14]

In the late 1940s and early 1950s, atomic power captured the hopes and imagination of groups ranging from industrialists to environmentalists; it offered a source of virtually unlimited and relatively cheap clean energy.[15] Led by the eccentric but brilliant Admiral Hyman G. Rickover, the Navy proved the viability of nuclear power for maritime propulsion shortly after the detonations of the first atomic weapons.[16] In 1955, the first nuclear powered submarine, USS Nautilus, sent its now legendary communication, "underway on nuclear power."[17] Several nuclear surface ships followed, including the first nuclear aircraft carrier, USS Enterprise.[18] Buoyed by the optimism of the early atomic age, naval architects

---

12. *FY10 Department of the Navy Posture: Hearing Before the Subcomm. on Def. of the S. Comm. on Appropriations*, 111th Cong. 1 (2009) (statement of Ray Maybus, U.S. Sec'y of the Navy).

13. Exec. Order No. 12,344, 47 Fed. Reg. 4,979 (Feb. 1, 1982). *See* John W. Crawford & Steven L Krahn, *The Naval Nuclear Propulsion Program: A Brief Case Study in Institutional Constancy*, 58 PUB. ADMIN. REV. 159, 159 (1998).

14. *See* Crawford, *supra* note 12.

15. *See, e.g.*, President Dwight D. Eisenhower, Remarks Before the 470th Plenary Meeting of the United Nations General Assembly (Dec. 8, 1953) (commonly referred to as the "Atoms for Peace" address).

16. *NASA's Organizational and Management Challenge: Hearing Before the H. Comm. on Sci.*, 108th Cong. 1 (2003) (statement of Admiral F.L. Bowman, Dir., Naval Nuclear Propulsion Program).

17. *Under Way on Nuclear Power: On a Trial Run the 'Nautilus' Proves Herself in Turbulent Seas*, LIFE, Jan. 31, 1955, at 24.

18. RONALD O'ROURKE, CONG. RESEARCH SERV., RL33946, NAVY NUCLEAR-POWERED SURFACE SHIPS: BACKGROUND, ISSUES, AND OPTIONS FOR CONGRESS 3 (2010).

dreamt of a global fleet of naval and merchant ships that could operate for twenty years without ever stopping for fuel.[19]

However, following the accidents at Three Mile Island and Chernobyl, enthusiasm for atomic power waned as hope for its potential as a clean energy source gave way to fear of the dangers of nuclear meltdowns or radiation leaks.[20] As costs mounted and public opinion turned against nuclear energy, the Navy scrapped its plans for an all-nuclear fleet.[21] Nevertheless, the nation's submarines and aircraft carriers continue to employ nuclear power plants for their energy needs.[22] The Navy currently operates eleven nuclear carriers and seventy-two nuclear submarines on station throughout the world.[23] Remarkably, the nuclear ships and submarines comprising the U.S. fleet have never suffered a nuclear accident in the combined 128 million miles that they have sailed since Nautilus's maiden voyage.[24] While nuclear vessels of the Cold War era required refueling approximately every twenty years, a costly and time-consuming operation, the current generation of ships will never need to refuel their reactor cores during their operating lifetimes of over thirty years.[25]

Coping with the radioactive waste byproduct of nuclear vessel operation remains a concern.[26] While the reactors with the newest designs produce substantially less waste than their predecessors, the radioactive components of all reactors must eventually find a safe and permanent home that is isolated from population centers.[27] Unfortunately, there are no clear solutions for this problem, especially with the political deadlock

---

19. *Nuclear-Powered Ships*, WORLD NUCLEAR ASSOC., http://www.world-nuclear.org/info/inf34.html (last updated Nov. 19, 2010). *See also* O'ROURKE, *supra* note 17, at 6.

20. Mark Stencel, *A Nuclear Nightmare in Pennsylvania*, WASH. POST, Mar. 27, 1999, *available at* http://www.washingtonpost.com/wp-srv/national/longterm/tmi/tmi.htm; Richard Stone, *The Long Shadow of Chernobyl*, NAT'L GEOGRAPHIC, Apr. 2006, at 4. These fears have likely been renewed with the recent events related to the tsunami in Japan. *See* David Sanger et. al, *U.S. Calls Radiation "Extremely High" and Urges Deeper Caution in Japan*, N. Y. TIMES, Mar. 16, 2011, *available at* http://www.nytimes.com/2011/03/17/world/asia/17nuclear.html?_r=1&hp.

21. Patrick Moore, *Going Nuclear*, WASH. POST. Apr. 16, 2006, a*vailable at* www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html; MARCO GIUGNI, SOCIAL PROTEST & POLICY CHANGE: ECOLOGY, ANTI-NUCLEAR, AND PEACE MOVEMENTS 44 (Rowan & Littlefield Publishers 2004).

22. GIUGNI, *supra* note 20.

23. *U.S. Navy Ships*, U.S. NAVY, *http://www.navy.mil/navydata/our_ships.asp* (last visited Feb. 5, 2011).

24. Bowman, *supra* note 15.

25. *Transformational Technology Core (TTC)*, GLOBALSECURITY.ORG, http://www.globalsecurity.org/military/systems/ship/systems/ttc.htm (last visited Aug. 3, 2010).

26. *See Radioactive Waste Disposal: an Environmental Perspective*, U.S. ENVTL. PROT. AGENCY www.epa.gov/rpdweb00/docs/radwaste (last visited Apr. 17, 2011).

27. Peter Fairley, *Cleaner Nuclear Power?*, MIT TECH. REV. (Nov. 27, 2007), http://www.technologyreview.com/energy/19758.

that has stalled the development of the national radioactive waste repository at Yucca Mountain, Nevada.[28]

When the Navy turned away from nuclear power for its smaller surface combatants,[29] it shifted to powerful, yet inefficient gas-turbine engines.[30] These propulsion plants currently provide the power for most surface warships, primarily the Navy's Arleigh Burke-class destroyers and Ticonderoga-class cruisers.[31] The gas-turbine engines used on these ships are essentially jet engines, similar to those found on the Vietnam-era F-4 Phantom, repurposed for surface platform propulsion and electrical power generation.[32] Although somewhat less efficient than many modern diesel engines, gas-turbine engines provide advantages over diesel counterparts, including increased power, greater maximum speed, simpler design and maintenance, and significantly smaller size and lower weight per unit of generated power.[33] However, future military planners may not have to choose between performance and efficiency. A new generation of ship designs, capable of meeting all of the Navy's performance requirements while satisfying all of the efforts to reduce fuel consumption, is likely to arrive in the near future.

In 2009, the Navy commissioned the USS Makin Island, its first hybrid electric warship.[34] The Makin Island's designers fitted the 844-foot vessel with auxiliary motors that allow the ship to cruise at low speeds using only electrical power.[35] For higher speeds, the ship retains gas-turbine engines.[36] Since many Navy ships spend the majority of time patrolling at low speeds, the ability to loiter on only electric motors results in enormous energy savings.[37] On its maiden voyage, the Makin Island used 900,000 gallons less fuel than comparable ships without the

---

28. Steve Tetreault, *DOE Asks to Halt Yucca Mountain*, LAS VEGAS REV. J. (Mar. 2, 2010), http://www.lvrj.com/news/nuclear-waste-blue-ribbon-panel-to-start-work-86253967.html.

29. The Navy produced a few non-aircraft carrier surface combatants in the 1960s and 1970s. All have since been decommissioned, leaving aircraft carriers as the only remaining US surface ship to employ nuclear propulsion. O'ROURKE, *supra* note 17, at 4.

30. Norman Friedman, *Going Electric*, YEAR IN DEFENSE NAVAL EDITION, Spring 2010, at 68, 71.

31. *DDG51 – Arleigh Burke Class Guided Missile Destroyer*, MILITARY.COM, http://tech.military.com/equipment/view/89176/ddg51—-arleigh-burke-class-guided-missile-destroyer.html (last visited Aug. 3, 2010).

32. Robert Sherman, *LM2500 Gas Turbine Engine*, FED'N OF AM. SCIENTISTS, http://www.fas.org/man/dod-101/sys/ship/eng/lm2500.htm (last updated Feb. 27, 1999).

33. P.P. WALSH & P. FLETCHER, GAS TURBINE PERFORMANCE 9–10 (2d ed. 2004).

34. Steve Liewer, *Navy Goes Green with New Hybrid Ship*, SAN DIEGO UNION-TRIB., Sep. 15, 2009, *available at* http://www.signonsandiego.com/news/2009/sep/15/navy-goes-green-new-hybrid-ship.

35. *Id.*

36. *Id.*

37. *Id.*

hybrid electric motors.[38] Over its life, analysts predict operational savings to reach $250 million.[39]

Although impressive, the Makin Island represents only the beginning of what could be possible for future Navy combatants. Currently, cruisers and destroyers employ four gas-turbine engines. If designers and strategists agreed to a small reduction in top speed, it may be possible to modify these propulsion plants by installing electric motors for use in low speed operations.[40] In 2009, the Navy demonstrated its commitment to expand hybrid naval propulsion beyond the Makin Island by investing $33 million in a proof-of-concept demonstration program for a hybrid electric propulsion system on Arleigh Burke-class destroyers.[41] Additionally, the newest and smallest U.S. naval surface combatant, the littoral combat ship, employs a similar combined power plant technology, along with efficient, steerable water-jet propulsion.[42] These advances allow the nimble, 374-foot vessel to enjoy a range of more than 3500 nautical miles while still maintaining a top speed greater than forty knots.[43]

These innovative uses of well-tested technologies demonstrate that the Navy is well-positioned to lead the way in sustainable energy technology. Using proven technologies saves long-term research costs and allows rapid fielding of vessels with improved efficiencies. Although more radical ideas are in development, even modest and relatively inexpensive efficiency improvements can amount to dramatic cost savings in the aggregate.

B. The Navy's Biofueled Fighter Jet: The "Green Hornet"

The Navy has not limited its pursuit of sustainable technologies to its surface vessels and submarines; some new technologies have literally taken off. The Navy has begun extensive testing of the "Green Hornet," a version of the mighty F/A 18 Super Hornet fighter jet, which is powered

38. *Navy Raises Fuel-efficiency with a Hybrid-Electric Ship*, WHARTON AEROSPACE & DEFENSE REPORT (Sep. 18, 2009), http://executiveeducation.wharton.upenn.edu/wharton-aerospace-defense-report/Navy-Raises-Fuel-efficiency-with-a-Hybrid-Electric-Ship-0909.cfm.

39. *Id.*

40. Philip Ewing, *New DDG-51s Could Get Tweaks, Upgrades*, NAVY TIMES (Aug. 1, 2008), http://www.navytimes.com/news/2008/08/navy_destroyer_upgrades_080108w/.

41. Michael Cooney, *Navy Spends $33 million for Hybrid of the High Seas*, NETWORK WORLD (Jul. 15, 2009), http://www.networkworld.com/community/node/43570.

42. *Nation's First Littoral Combat Ship Propulsion Plant Operational*, LOCKHEED MARTIN (July 10, 2008), http://www.lockheedmartin.com/news/press_releases/2008/071008_LCS1_Propulsion_Plant_Operational.html.

43. *Id.*

by an even blend of conventional fuel and camelina-based biofuel.[44] The Green Hornet recently became the first aviation platform to evaluate supersonic performance of a half-biofuel blend, proving the potential for sustainable fuel sources in combat operations.[45]

The ability to utilize fuel from the hardy, common, domestically grown camelina plant to power fighter jets gives the Navy significant flexibility and a step towards freedom from foreign fuels. Although the fleet's super-carriers only require refueling every twenty years thanks to their nuclear reactors, the jets that they carry are true gas guzzlers.[46] As part of the shift to biofuels, fleet leaders have partnered with Navy's fuel lab at Patuxent River, Maryland to develop certification standards to analyze and test a wide variety of renewable and alternative fuels for even greater source flexibility.[47]

In addition to shifting to sustainable biofuels, the Navy's investment in carrier-based autonomous aircraft may also help to reduce the environmental impact of the fleet's air wing. Since pilots can control unmanned aircraft remotely, they can rotate this duty to avoid fatigue. Drone aircraft can therefore remain in the air for extended periods of time, reducing the large fuel expenditures during launch and recovery.[48] Efficient autonomous aircraft, such as the RQ-4 Global Hawk, already rule the skies of Iraq and Afghanistan, providing commanders with unparalleled surveillance capability.[49] This drive for aviation innovation also extends to less conventional aircraft designs, such as modern blimp platforms. The Army recently recruited Northrop Grumman for a $500 million project to design and field three Long Endurance Multi-Intelligence Vehicles (LEMVs).[50] These modern dirigibles will remain aloft for three weeks at a time, replacing fuel guzzling surveillance plat-

---

44. Liz Wright, *Navy Tests Biofuel-Powered 'Green Hornet'*, NAVY.MIL, (Apr. 22, 2010) http://www.navy.mil/search/display.asp?story_id=52768.

45. *Id.*

46. A similar jet sold to the public consumes an incredible 80 gallons of fuel per hour. Steve Bloomfield, *A £1.6m Fighter Jet: The Ultimate Boy's Toy*, THE INDEPENDENT, Apr. 30, 2006, *available at* http://www.independent.co.uk/news/uk/this-britain/a-16316m-fighter-jet-the-ultimate-boys-toy-476217.html.

47. Wright, *supra* note 43.

48. Andrew Moseman , *The Navy's Fighter-Plane-Size UAV, the X-47B, Is Unveiled in California*, POPULAR MECHANICS, Oct. 1, 2009, *available at h*ttp://www.popularmechanics.com/technology/military/4296188.

49. Amy Butler, *Global Hawk UAV Supports Border Ops In Iraq*, AVIATION WEEK, Mar. 11, 2007, *available at* http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=awst&id=news/aw031207p1.xml.

50. *Northrop Grumman Awarded $517 Million Agreement for U.S. Army Airship With Unblinking Eye*, MARKETWATCH (June 14, 2010), http://www.marketwatch.com/...se-northrop-grumman-awarded-517-million-agreement-for-us-army-airship-with-unblinking-eye-2010-06-14?reflink=MW_news_stmp.

forms by simply floating at an altitude of around twenty thousand feet.[51] The LEMV could even be outfitted with solar panels that maximize its large surface area to further increase its endurance. Some analysts already predict that this return to blimp technology may stimulate similar civilian innovation, such as the use of airships as fuel-efficient cargo transports.[52]

Meanwhile, Boeing has developed a hydrogen-powered surveillance vehicle, the "Phantom Eye." The Phantom Eye is capable of loitering on station for up to ten days, which is ten times the duration of the Global Hawk.[53] In addition to having improved on-station endurance, engines use hydrogen fuel with triple the efficiency of standard aviation fuel.[54] To power the small engines mounted under each wing, Boeing worked with Ford Motor Company to adapt a standard four-cylinder car engine to high altitude applications.[55] This partnership provides yet another example how a basic product can be adapted in innovative ways to produce remarkable results.[56]

C. Other Applications of Sustainable Fleet Technologies

Complementing the environmental benefits, the Navy's use of alternative fuel sources and efficient engines can also bring significant flexibility to contingency or crisis operations. Newly developed energy technologies that can operate far from established supply lines reduce the need to maintain proximity to supply centers and enhance a commander's ability to respond to disasters. Nuclear carriers or submarines could possibly be used to provide electricity for large scale relief operations. Additionally, by adding ultra-efficient diesel engines or hybrid propulsion plants to cruisers or destroyers running disaster response missions,

51. *Id.* The SR-71, one of the Air Force's most successful surveillance platforms, required a tremendous amount of fuel to operate. RICHARD H. GRAHAM, SR-71 REVEALED 165 (1996).

52. *See* Erik Sofge, *4 New 'Blimp' Designs Bring Return of the Airship*, POPULAR MECHANICS, Dec. 18, 2009, *available at* http://www.popularmechanics.com/technology/aviation/airships/4242974.

53. Michael Hoffman, *UAV Could Spend Up to 10 Days Over Its Target*, MILITARY TIMES, Aug. 3, 2010, *available at* http://www.militarytimes.com/news/2010/08/airforce_phantom_eye_080110/.

54. *Id.*

55. Press Release, Randy Jackson and Chris Haddox, Phantom Eye Long Range High Endurance Aircraft Unveiled (Jun. 12, 2010), http://www.boeing.com/Features/2010/07/bds_feat_phantom_eye_07_12_10.html.

56. *Id.*

commanders could potentially use these ships as additional tools for rapid disaster relief.[57]

The potential for the use of developed energy technology was seen in the response to the earthquake in Haiti in January 2010. Within hours, the nuclear carrier USS Carl Vinson sailed from Virginia to support the international Haitian relief effort.[58] In addition to providing personnel and equipment, the commanding officer used the carrier's nuclear reactors to generate desperately needed clean, fresh water for the devastated country.[59]

D. The Promising Future for Sustainable Technologies at Sea

The Navy has a long and distinguished tradition of technological innovation.[60] Channeling this innovative spirit into future energy solutions fits seamlessly within national security strategy.[61] The current Navy leadership has made strong commitments to improve the fleet's overall efficiency and to increase its ability to take advantage of renewable fuel sources.[62]

The possibilities for propulsion technologies are limited only by human imagination. Soon, advances in nuclear technology may reopen the possibility of a nuclear, emission-free fleet.[63] The newest reactor design already fielded on the Virginia class submarines drastically improves upon the last generation by simplifying the design, reducing maintenance demands, limiting radioactivity, improving the nuclear fuel life cycle, and increasing safety and redundancy features. Although the technical specifications are classified, the newest civilian reactor designs, such as Westinghouse's AP1000, provide a sense of the magnitude of the improvements.[64]

Naval architects have considered even more radical innovations to harness renewable power. For example, engineers have affixed giant parachute-like sails, similar to those used by kite surfers, to ships in order to

---

57. *See* Admiral Gary Roughead, Chief of Naval Operations, Statement Before the House Subcommittee on Defense Committee on Appropriation on FY 2012 (2011), *available at* http://appropriations.house.gov/_files/030911HACD_Posture_CNO_final.pdf.

58. Nicholas Casey, *Aircraft Carrier Purifies Water; Challenge Is Delivery*, WALL ST. J. BLOGS (Jan. 16, 2010, 8:31 PM), http://blogs.wsj.com/dispatch/2010/01/16/aircraft-carrier-purifies-water-challenge-is-delivery/.

59. *Id.*

60. Roughead, *supra* note 56.

61. *Id*.

62. Mabus, *supra* note 1.

63. O'ROURKE, *supra* note 17, at 2.

64. *AP1000 at a Glance*, WESTINGHOUSE, http://www.ap1000.westinghousenuclear.com/ap1000_glance.html (last visited Aug. 5, 2010).

once again harness the power of the wind.[65] Additionally, some hypothesize that fuel cells, proven viable for the Navy through recent proof of concept testing, may satisfy future fleet power needs.[66]

Regardless of the ultimate path that the Navy chooses for its future propulsion needs, the benefits of improving efficiency and reducing environmental impact are promising. Technological advances leading to increases in engine efficiency will improve a ship's endurance with a relatively small sacrifice in top speed and can lead to significant fuel savings over the lifespan of the vessel.

III. WILDLIFE AND ECOSYSTEM PROTECTION

The Navy has long sought to establish the appropriate balance between maintaining combat readiness and safeguarding the ocean's bounty. The fleet often operates in environmentally sensitive areas, particularly close to shore. Also, most naval installations are located in or near sensitive coastal areas.[67] Often, many of the industrial operations vital to maintaining the military's equipment have unfortunately resulted in fouling fragile reef and harbor ecosystems.[68] For many years, the government ignored this damage and considered it a necessary evil in the struggle to maintain the fleet's combat readiness.[69]

The national culture of acceptance for wanton damage to the environment has changed in the last several decades. Instead, that complacent culture has been replaced with an understanding that environmental protection and national security are not mutually exclusive.[70] Often, a reasonable balance can be found for both the needs of the military and the concerns of environmentalists. Obtaining this balance requires the interested parties to compromise, cooperate, and communicate throughout the entire process.

The Navy has perceived this cultural shift, and has realized that its ability to continue operating in environmentally sensitive areas depends

---

65. Mark Rutherford, *Navy Charters Kite-Powered Cargo Ship to Deliver Equipment*, CNET NEWS (Oct. 11, 2008, 11:03 AM), http://news.cnet.com/8301-13639_3-10063876-42.html.

66. SECA Fuel Cell Proves Successful in Navy's Proof-of-Concept Testing Spinoff Applications Mark the Road to Widespread Commercialization, U.S. DEP'T OF ENERGY (Aug. 5, 2008), http://fossil.energy.gov/news/techlines/2008/08032-Fuel_Cells_Pass_Navy_Test.html.

67. For example, Naval Base San Diego, California, Puget Sound Naval Shipyard, Washington, Pearl Harbor, Hawaii, and many more.

68. *See* U.S. CORAL REEF TASK FORCE, THE NATIONAL ACTION PLAN TO CONSERVE CORAL REEFS 23 (Mar. 2, 2000), *available at* http://www.coralreef.gov/about/CRTFAxnPlan9.pdf.

69. CONG. BUDGET OFFICE, ENVIRONMENTAL CLEAN-UP ISSUES ASSOCIATED WITH CLOSING MILITARY BASES (Aug. 1992), *available at* http://www.cbo.gov/ftpdocs/102xx/doc10287/1992_08_environmentalcleanupissues.pdf (comparing the costs and benefits of environmental cleanup with the strain it will place on the military budget).

70. *Cf.* Silveira, *supra* note 10.

on civilian support.[71] Maintaining this civilian support requires that the Navy strike a balance between meeting military readiness requirements and causing the least environmental damage reasonably possible. There are certainly times when national security must take absolute priority. For example, when the United States was attacked at Pearl Harbor on December 7, 1941, it would not have been appropriate for the Navy to stop and consider the effect of defense on local marine life before responding. In contrast, for peacetime operations environmental stewardship can complement, rather than detract from, the Navy's role as guardian of the seas.

A. Protecting Whales While Safeguarding our National Interests

Since submarine technology's infancy, engineers have struggled to find effective ways to hunt down stealthy adversaries. The most effective solution to date involves sonar; that is, either passively listening for the sound emitted from a target submarine or actively creating noise which bounces off the target.[72] Environmentalists and military leaders have long battled over the priorities of national defense and environmental protection. This struggle has most clearly manifested itself in recent years in the battle over sonar use off the Southern California Coast. [73]

Although the technologies are more advanced, the basic principle of active acoustic submarine prosecution remains essentially the same. In its simplest form, ships or submarines can emit large blasts of sound underwater and interpret the echoes that bounce off the target submarine to determine its location.[74] The searching ship can determine range based on the delay from emission to detection, and can triangulate position by measuring a series of returns over time.[75] Typically, the louder the sound emitted, the better the return signal and the more precise targeting information generated.[76] This loud sound blast creates problems for wildlife.

Many creatures dwelling in the darkness of the ocean depths rely on their own sonar systems to navigate, hunt, and communicate.[77] Their sensory organs have developed into incredibly sensitive tools, capable of

---

71. Roughead, *supra* note 56.

72. Winter v. Nat. Res. Defense Council, Inc., 129 S. Ct. 365, 370 (2008).

73. *See id.*

74. Chief of Naval Operations Submarine Warfare Division, *Submarine Frequently Asked Questions*, NAVY.MIL, http://www.navy.mil, *available at* http://www.navy.mil/navydata/cno/n87/faq.html (last visited Feb. 10, 2011).

75. *Id*.

76. *Id*.

77. *See e.g. Communication of Whales*, WHALES.ORG, http://www.whales.org.za/facts_communication.aspx (last visited Feb. 10, 2011).

detecting even minor acoustic disturbances.[78] Marine biologists have speculated that the sound emitted by active sonar systems could harm marine species.[79] Some experts even suggest that naval sonar may be to blame for the incidents of mass whale beachings that have occurred in recent years.[80] In the past, the Navy long denied the connection between sonar use and harm to marine species, citing inadequate data and no actual proof linking sonar and whale injury.[81] Moreover, military leaders often cited national security concerns as overriding potential threats to marine species.[82]

In 2007, this argument came to a head when the Natural Resources Defense Council (NRDC) sued the Navy to stop sonar use in specific "sensitive" areas including some of the military exercise areas off the Southern California Coast.[83] This controversy eventually came before the U.S. Supreme Court in 2008.[84] The case centered on the fact that the Navy had not complied with the Marine Mammal Protection Act of 1972 (MMPA) or the National Environmental Policy Act of 1969 (NEPA).[85]

In 2007, the Defense Department granted the Navy a two year exemption from the MMPA, provided that the Navy adopt several mitigation procedures, including (1) training lookouts to spot and identify marine mammals close to their ships, (2) stationing additional marine mammal watches on each ship, (3) requiring any operator that spotted a marine mammal to report the sighting, (4) reducing sonar levels when a marine mammal approaches one thousand yards of the ship and securing sonar at two hundred yards, (5) operating sonar at the "lowest practicable level" at all times, and (6) adopting procedures to coordinate these actions throughout the fleet.[86] That same year, the Navy completed an envi-

78. *Id*.

79. *Beaked Whales Perform Extreme Dives to Hunt Deepwater Prey*, WOODS HOLE OCEANOGRAPHIC INST., (Oct. 19, 2006), http://www.whoi.edu/page.do?pid=39139&tid=282&cid=16726&ct=162.

80. Bill Mears, *Are Sonar Tests Harming Whales? The Supreme Court Weighs In*, CNN.COM, (Oct. 8, 2008), http://www.cnn.com/2008/TECH/science/10/08/sonar.whales/index.html; Marc Kaufman, *Whale Stranding in N.C. Followed Navy Sonar Use*, WASH. POST, Jan. 8, 2005, at A03, *available at* http://www.washingtonpost.com/wp-dyn/articles/A42788-2005Jan27.html.

81. *Id*.

82. *Id*.

83. *Winter*, 129 S. Ct. at 374. For a detailed analysis of the court battle, see Lisa Lightbody, *Winter v. Natural Resources Defense Council, Inc.*, 33 HARV. ENVTL. L. REV. 593 (2009).

84. *Winter*, 129 S. Ct. at 374.

85. *Id.*; 16 U.S.C. §§ 1362(13), 1372(a) (2006) (prohibiting any individual from harassing, hunting, capturing, or killing a marine mammal); 42 U.S.C. § 4332(2)(C) (2006) (requiring a federal agency to prepare a detailed environmental impact statement when it proposes to take a major federal action significantly affecting the quality of the human environment).

86. *Winter*, 129 S. Ct. at 365.

ronmental assessment (EA) which concluded that its sonar use does not have a significant impact on the environment.[87]

Weighing the public interests, the Supreme Court found that "the overall public interest in this case tip[s] strongly in favor of the Navy," noting that "the President—the Commander in Chief—has determined that training with active sonar is essential to national security."[88] However, the Court reversed only the part of the district court's injunction and favored the Navy's proposed mammal mitigation measures.[89] The Navy, therefore, remains appropriately bound to its voluntary marine mammal mitigation measures.

However, the Navy has since adopted a more progressive approach to environmental stewardship. After many years of essentially ignoring the laws limiting potentially damaging sonar activities, commanders have acknowledged that they can strike a better balance between training for combat readiness and safeguarding the environment.[90] Many environmental advocates still argue that the Navy has not implemented sufficient restrictions despite the recent marine mammal mitigation policy changes,[91] or that the Navy merely altered its policies after being forced by time-consuming and costly litigation. Regardless, recent measures taken to protect marine life without coercion by civilian action show a new attitude on the Navy's part.

In 2009, the Navy announced that it would voluntarily limit sonar emissions in Puget Sound to minimize impacts to marine mammals.[92] Lingering concerns of sonar use in the area date back to 2003 when the destroyer USS Shoup startled several killer whales during an exercise in the Puget Sound.[93] In late 2010, the Navy agreed to discontinue use within the Strait of Juan de Fuca. However, naval exercises further off the coast remain controversial.[94] Thus far, the Navy and environmental groups have not reached a compromise regarding these exercises, and may delve into a litigation battle similar to the fight over the Southern California operating areas.[95]

---

87. *Id. See also* 40 C.F.R. §§ 1508.9(a), 1508.13 (2007) (discussing environmental assessment requirements).

88. *Winter*, 129 S. Ct. at 378.

89. *Id.* at 379.

90. Roughead, *supra* note 56.

91. *See Lethal Sounds*, NAT'L RES. DEFENSE COUNCIL (Oct. 6, 2008), http://www.nrdc.org/wildlife/marine/sonar.asp.

92. *Id*.

93. *Id.*

94. Jennifer Olney, *Environmentalist Outraged at Increased Navy Training*, ABC LOCAL KGO-TV (Dec. 14, 2010), http://abclocal.go.com/kgo/story?section=news/assignment_7&id=7838655.

95. *Id.*

The need for balance and compromise cuts in both directions. The Navy's previous passive approach to environmental concerns was likely short-sighted, but the pendulum should not be allowed to swing too far the other direction. The fear of any environmental impact, even small and well mitigated, should not deter the Navy leaders from taking steps to hone critical anti-submarine warfare skills.[96]

The Navy's need to hone its anti-submarine skills has become imperative due to the proliferation of diesel-electric submarines.[97] It may come as a surprise, but the threat that submarines pose to world stability has only increased since the end of the Cold War.[98] The most dangerous submarines today are not the monstrous Soviet Typhoon missile boats that fueled the cat-and-mouse games of *The Hunt for Red October* fame.[99] The most dangerous submarines are small, inexpensive, and easily operated by diesel-electric engines.[100] Without the pumps required to cool a nuclear reactor, diesel-electric submarines are extremely quiet and hard to track using passive sonar.[101] Although the diesel-electric power plant provides limited endurance relative to a nuclear reactor, diesel-electric submarines can prove very effective when operating close to shore or in strategic straits and shipping lanes.[102]

The danger posed by these inexpensive weapons became clear when the South Korean vessel, Cheonan, exploded in the Yellow Sea in March 2010.[103] Although North Korea continues to deny involvement, the evidence clearly points to a diesel submarine attack.[104] Iran operates similar submarine platforms, small, silent Kilo-class submarines purchased from Russia.[105] Iranian Kilos could wreak havoc on the congested

---

96. *Winter*, 129 S. Ct. at 365.

97. *Id*. at 370

98. *See Key Points: Blair Trident Statement*, BBC NEWS (Dec. 4, 2006, 16:43 GMT), http://news.bbc.co.uk/2/hi/uk_news/politics/6207148.stm; Associated Press; *Officials Say U.S. Ship Harassed by China was Hunting Submarine Threats*, FOX NEWS (Mar. 11, 2009), http://www.foxnews.com/story/0,2933,508805,00.html; *Terrorism Threat to Trident Submarine*, THE SEATTLE TIMES, Aug. 2, 2001, *available at* www.komonews.com/news/archive/4015996.html.

99. *See* TOM CLANCY, THE HUNT FOR RED OCTOBER (United States Naval Institute Press 1984).

100. *Winter*, 129 S. Ct. at 370 n.4.

101. Tara Murphy, *Security Challenges in the 21st Century Global Commons*, 5 YALE J. INT'L AFFAIRS 28, 34 (Jul. 2010).

102. Frank Bantell, et al., *Detecting Conventionally Powered Submarines: Team SPAWAR Contributions to the DESI and Maritime Strategy*, CHIPS, Jul. 2009, at 30.

103. Evan Ramstad, *Downed South Korea Ship Spurs Rescue, Questions*, WALL ST. J., Mar. 27, 2010, *available at* http://online.wsj.com/article/NA_WSJ_PUB:SB10001424052748704100604575145683306658178.html.

104. David E. Sanger, *U.S. Implicates North Korean Leader in Attack*, N.Y. TIMES, Mar. 22, 2010, *available at* http://www.nytimes.com/2010/05/23/world/asia/23korea.html.

105. *Submarine Proliferation: Iran Current Capabilities*, NUCLEAR THREAT INITIATIVE (Jan. 2010), http://www.nti.org/db/submarines/iran/index.html.

shipping lanes in the Middle East. China also operates Kilos and similar domestically built Song-class submarines, one of which embarrassed the United States by evading detection and surfacing unexpectedly next to the aircraft carrier USS Kitty Hawk in 2007.[106]

Hopefully hostilities that require defense against submarines will never again occur. Nevertheless, in light of potential future adversaries, the Navy must practice its anti-submarine warfare skills. Although commanders should consider environmental impacts in their operations, the key to satisfying both national security demands and ecosystem protection responsibilities lies in achieving the appropriate balance to mitigate potential impact. It is important that both military leaders and environmentalists are increasingly willing to communicate and discuss potential compromises.

B. Other Navy Environmental Protection Initiatives

Although less publicized than the high-profile whale protection initiatives, the Navy has implemented many other beneficial environmental programs. The Navy operates a monthly magazine, *Currents*, that highlights initiatives, successes, and challenges in environmental protection.[107] Detailed programs include installing technology to reduce maritime disposal of plastics from ships underway, spending $20 million annually to research ways to better protect marine mammals, and developing coastal protection programs.[108] Simultaneously, many naval shore installations have embraced renewable energy technologies, including solar arrays and wind turbine generators.[109] For example, at the Naval Station Guantanamo Bay in Cuba, efficiency initiatives save 650,000 gallons of fuel every year, reducing airborne pollutants by thirteen million pounds.[110] Because these shore-based environmental projects are highly visible and often directly impact nearby communities, they are

106. Matthew Hickley, *The Uninvited Guest: Chinese Sub Pops Up in Middle of U.S. Navy Exercise, Leaving Military Chiefs Red-Faced*, MAIL ONLINE (Nov. 10, 2007, 00:13 AM), http://www.dailymail.co.uk/news /article-492804/The-uninvited-guest-Chinese-sub-pops-middle-U-S-Navy-exercise-leaving-military-chiefs-red-faced.html.

107. *See, e.g.*, Jim Brantley & Kenneth Hess, *Sonar Allows for Real-Time Training Scenarios & Minimizes Impacts on Marine Mammals*, CURRENTS, Spring 2008, *available at* http://www.enviro-navair.navy.mil/currents/spring2008/Spr08_Active_Sonar_Marine_Life.pdf.

108. U.S. Navy, *Land-Based Efforts,* ENERGY, ENVIRONMENT & CLIMATE CHANGE, http://greenfleet.dodlive.mil/environment/land-based-efforts/ (last visited Jan. 6, 2011).

109. *See, e.g.*, Blair Heusdens, *On GITMO Small Gestures, Big Projects Save Energy*, ARMY NEWS SERV. (Apr. 16, 2009), http://www.army.mil/-news/2009/04/16/19746-on-gitmo-small-gestures-big-projects-save-energy/.

110. *Id.*

particularly important as a vehicle to enhance the public's perception of the Navy's commitment to environmental stewardship.

As evidenced by the lawsuits challenging operations in sensitive areas, the Navy must earn the public's trust in its ability to operate in environmentally sensitive places without causing excessive damage. Losing public support could mean the Navy will no longer enjoy the public acceptance desired to effectively operate and train in areas near the coast.

C. The Future of Ecosystem Protection

The Navy is well suited to take the lead in ecosystem protection in the maritime and coastal environments. Many Navy leaders now understand that defense of the world's oceans involves more than merely facilitating safe passage.[111] By minimizing the impact on the environment and by effectively managing resources, the Navy fulfills its ultimate duty to protect the oceans both from potential enemy combatants and from our own environmental damage.

While many initiatives address the current state of ecosystem protection, early preventative action can ultimately save a tremendous amount of time and money. By implementing programs to ensure the Navy's industrial activities do not foul fragile areas, commanders are essentially investing in the future. As the civilian and military sectors have learned after spending billions of dollars to decontaminate several of the nation's superfund sites, the old maxim, "an ounce of prevention is worth a pound of cure," rings true.[112] Similarly, investing in sustainable technologies to power the Navy's shore-based infrastructure can eventually result in dramatic cost savings over time.

Ultimately, the Navy's ability to train and operate effectively depends on public support. This public trust does not develop automatically, rather it must be earned. Taking care to make reasonable concessions to protect marine mammals and their habitat, when possible, represents the first crucial step in earning public trust.

IV. WAR, THE MILITARY, AND FOREIGN OIL

The Navy does not stand alone in its commitment to environmental stewardship. The mounting financial burden associated with prolonged warfare has prompted all military branches to find alternatives to reduce

111. *See, e.g.,* Mabus, *supra* note 1.

112. CONG. BUDGET OFFICE, ENVIRONMENTAL CLEAN-UP ISSUES ASSOCIATED WITH CLOSING MILITARY BASES (Aug. 1992), *available at* http://www.cbo.gov/ftpdocs/102xx/doc10287/1992_08_environmentalcleanupissues.pdf.

fuel expenditures.[113] These technologies not only provide environmental benefits, but also dampen the financial impact of the country's overseas military operations and its reliance on foreign sources for oil.

A. Sustainable Humvees: An Oxymoron?

"High Mobility Multipurpose Wheeled Vehicles" (HMMWV), better known as "Humvees" or "Hummers," have long been symbolically antithetical to environmental sustainability. Designed to replace the ubiquitous Army Jeep, the Humvee rumbles through harsh terrain all over the world while drinking heavily from the fuel spigot. With an average fuel efficiency of about six miles per gallon, fuel efficiency is not a label synonymous with the Humvee.[114] Appeal for this vehicle waned in Iraq and Afghanistan combat operations primarily because it lacks a V-shaped hull necessary to deflect blasts from beneath. Nevertheless, the Humvee will remain the primary vehicle used throughout the military until a better vehicle, such as the XM1124, replaces it.[115]

As war continues in the Middle East and Central Asia, massive expenditures on foreign oil become increasingly difficult to justify. Much of it is purchased from nations with which America has delicate relations.[116] Excessive oil expenditures become even less logical considering the abundance of alternative fuels already used in many vehicles throughout the United States. Recognizing these concerns, the Army developed a hybrid version of the Humvee, the XM1124.[117] In addition to doubling the fuel economy and reducing emissions by seventy-five percent, the XM1124 has a higher top speed and a faster acceleration compared to the original Humvee.[118] Moreover, hybrid technology in the Humvee also has less obvious benefits: a lower thermal signature, the ability to move silently utilizing only the electric motor, and the capacity to serve as a portable generator for remote outposts.[119] In addition to the obvious environmental benefits, this new hybrid vehicle technology will

---

113. AMY BELASCO, CONG. RESEARCH SERV., RL 33110, THE COST OF IRAQ, AFGHANISTAN, AND OTHER GLOBAL WAR ON TERROR OPERATIONS SINCE 9/11 (Sept. 2, 2010).

114. John Donnelly, *Military Wants a More Fuel-efficient Humvee: Pentagon Makes an Energy Push*, BOSTON GLOBE, Oct. 2, 2006.

115. *Hybrid Humvee Will Get a Battery from EnerDel, Says U.S. Army,* DAILYTECH (Nov. 9, 2009), http://www.digitaltrends.com/international/cool-tech/hybrid-humvee-will-get-a-battery-from-enerdel-say-u-s-army/; *XM1124 Hybrid Electric HMMWV*, GLOBALSECURITY.ORG, http://www.globalsecurity.org/military/systems/ground/hmmwv-he.htm (last visited Aug. 2, 2010).

116. *U.S. Imports by Country of Origin*, U.S. ENERGY INFO. ADMIN (Dec. 12, 2010), http://www.eia.doe.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbl_m.htm.

117. *Id.*

118. *Id.*

119. *Id.*

increase commanders' options and flexibility, while minimizing dependence on foreign oil.

B. A Sustainable Footprint from "Boots on the Ground"

A protected and reliable fuel supply is one of the most critical lifelines for combat troops operating in the field, and energy efficient operations in theatre can reduce the dependency on this logistical challenge. Since armies began using mechanized vehicles, providing a steady fuel supply to an ever-thirsty fleet has been essential to sustaining a military operation.[120] On today's battlefield, leveraging modern electronic tools has allowed armies to accomplish more with fewer troops.[121] However, as electronic technology becomes increasingly pervasive, the Army's need for energy will correspondingly increase. From remote outposts in the Afghan mountains to the massive Green Zone in the city center of Baghdad, Iraq, military operations depend on a nearly constant supply of energy.[122]

Because the survival of any military base is dependent upon maintaining its fuel supply, dependence presents a significant vulnerability to military operations.[123] Taliban attacks on fuel shipments arriving through the Khyber Pass in Afghanistan highlight the vulnerability of the supply line and the risks that military personnel take on even in modern warfare.[124] A recent Army study showed that fuel accounted for fifty percent of all convoy loads moving through Afghanistan and Iraq.[125] If the military reduced its fuel demand it would also reduce its vulnerability to a fuel shortage. In fact, the Army report concludes that "a ten percent fuel reduction over five years could lead to a reduction of thirty-five casualties over the same period."[126]

Currently, inefficient and expensive diesel generators supply the majority of combat outposts' electrical needs.[127] Because these outposts are generally only temporary, building larger, more permanent, cleaner

---

120. Sandra I. Erwin, *Tough to Free Troops from Oppressive Tyranny of Fuel*, NAT'L DEFENSE MAG., Feb. 2010, *available at* http://www.nationaldefensemagazine.org/archive/2010/February/Pages/ToughtoFreeTroopsFromOppressiveTyrannyofFuel.aspx.

121. *Id.*

122. *Id.*

123. *Id.*

124. Gregg Carlstrom, *Nato's Dangerous Supply Lines*, AL JAZEERA (June 10, 2010, 3:53 AM GMT) http://english.aljazeera.net/news/asia/2010/06/20106917552890245.html.

125. *Casualty Costs of Fuel and Water Resupply Convoys in Afghanistan and Iraq*, ARMY-TECH.COM (Feb. 26, 2010), http://www.army-technology.com/features/feature77200/.

126. *Id.*

127. *Frontline Commanders Requesting Renewable Power Options*, DEF. INDUSTRY DAILY (Sept. 2006), http://www.defenseindustrydaily.com/commanders-in-iraq-urgently-request-renewable-power-options-02548/.

electric generating facilities is generally not an option to improve overall efficiency.[128] Similarly, most wind and solar power stations, while successfully providing energy to many domestic bases, either require permanent installation or are not adequately structurally sound to provide a viable option for installation in combat zones.[129] While shifting some generators to bio-fuels may improve overall sustainability, bio-fuel will not alleviate the fuel supply challenges.

The Marine Corps has emerged as an unexpected champion for improvements in renewable energy to overcome these survivability issues.[130] In an effort to demonstrate the viability of solar energy to power small, remote bases, the Marines established a fully operational forward operating base (FOB) during Operation African Lion, an exercise in Morocco.[131] The Marines had installed solar arrays on nearly every available surface, including tents and vehicles, within three hours. Early in the operation, the FOB successfully generated more power than the inhabitants needed.[132] Additionally, the base purified water using an advanced reverse osmosis system and gained a tactical advantage by operating without noisy generators and frequent resupply.[133]

Despite progress using renewable energy to provide power to small combat outposts, the need for large, temporary power sources with minimal need for fuel resupply suggests a more advanced and controversial possibility: small, portable nuclear reactors. The Army toyed with the idea of using submarine style reactors throughout the 1950s, 1960s, and

---

128. The debate over establishing new permanent U.S. military bases in foreign countries can be fiery. For example, Republican Senator Lindsey Graham of South Carolina proposed to establish permanent U.S. bases in Afghanistan, giving the Taliban fresh rhetorical ammunition against the United States. *See Remarks of Lindsey Graham About Permanent Bases in Afghanistan Lifts the Curtain from the Colonialist Motives of America: Taliban*, THE NATION, Jan. 5, 2011, *available at* http://www.nation.com.pk/pakistan-news-newspaper-daily-english-online/International/05-Jan-2011/Remarks-of-Lindsey-Graham-about-permanent-bases-in-Afghanistan-lifts-the-curtain-from-the-colonialist-motives-of-America-Taliban/1.

129. On the other hand, smaller mobile units may soon enjoy the benefits of portable renewable power options. *See, e.g.*, CONG. BUDGET OFFICE, *supra* note 111. *Frontline Commanders Requesting Renewable Power Options*, DEF. INDUSTRY DAILY (May 26, 2010), http://www.defenseindustrydaily.com/commanders-in-iraq-urgently-request-renewable-power-options-02548.

130. Press Release, Paul Greenberg, U.S. Africa Command, Marines Test Alternative Energy System in African Lion (May 25, 2010), *available at* http://www.africom.mil/getArticle.asp?art=4470.

131. *Id.*

132. *Id.*

133. *Id.* A recent symposium hosted by the Marine Corps demonstrates its commitment to continuing to pursue progress in this area. *See* Symposium Brochure, Event #0820, USMC Expeditionary Power & Energy Symposium (Jan. 26, 2010), *available at* http://www.dtic.mil/ndia/2010MCexpeditionary/Agenda.pdf.

1970s.[134] Submarine reactors are quite small, making them easy to transport, but the reactors rely on ocean water for cooling, making their use on land impractical. For the Army to take advantage of portable nuclear technology, it would need a completely new reactor design.

Although such innovation may take decades, the Army can glean technological advances from current civilian reactor technology.[135] Notably, Microsoft founder Bill Gates recently funded a start-up company, TerraPower, to develop small, self-contained, maintenance-free reactors designed to power small communities.[136] Without the need for any human intervention, maintenance, or oversight, these reactors could transition well into a military role, especially if combined with future plug-in hybrid or electric vehicles. Even a reactor small enough to fit on a mobile trailer could satisfy all of the electricity needs of a medium-sized military installation, eliminating the risk associated with fuel supply lines.[137] This technological advance could revolutionize warfare, while simultaneously reducing emissions and advancing sustainable base-load technology. Nevertheless, significant threat issues, such as enemy attacks and acquisition, remain obstacles that strategists will need to overcome before these portable reactors could be used in combat operations.

C. Environmental Initiatives: Creating a Tactical Advantage

Fifty years ago, environmental concerns presented obstacles to combat readiness rather than opportunities. Today, however, a new generation of leaders seems to have embraced the concept that renewable, alternative, and efficient technologies can provide a significant tactical edge.[138] With improved resource management and technological innovation comes what a modern military cherishes: flexibility and mobility.

The Army of the future may no longer require traditional supply lines. A single nuclear reactor, safely sealed and requiring no maintenance, could power a relatively large base, including all of its vehicles, equipment, and, possibly, aircraft. This power generation technology, if further developed, could have wide-ranging civilian applications, par-

---

134. Robert A. Pfeffer & William A. Macon, Jr., *Nuclear Power: An Option for the Army's Future*, 33 ARMY LOGISTICIAN 4, 6 (2001), *available at* http://www.almc.army.mil/alog/issues/SepOct01/MS684.htm.

135. *Id.* at 7-8.

136. Robert A. Guth & Daisuke Wakabayashi, *Bill Gates Start-Up in Talks on Small Nuclear Reactor*, WALL ST. J., Mar. 22, 2010, *available at* http://online.wsj.com/article/NA_WSJ_PUB:SB10001424052748704841304575138530498037398.html.

137. Gabriele Rennie, Lawrence Livermore Nat'l Laboratory, *Nuclear Energy to Go: A Self-Contained, Portable Reactor*, SCIENCE AND TECH. REV. 20 (Jul.–Aug. 2004), *available at* https://www.llnl.gov/str/JulAug04/Smith.html.

138. Roughead, *supra* note 56.

ticularly in developing countries where expanding infrastructure or large-scale power projects prove extremely difficult.

V. CONCLUSION

Since the days of the sail, navies have served their countries at sea while forming a special bond with the waters that carry them. In an increasingly environmentally-conscious era, those who have carried out their trade on the world's oceans have naturally become champions of sustainability for their nation's defense and for nature's protection.

As a new dawn of sustainability, efficiency, and ecosystem protection arrives, new military technologies represent the first products of sustainable innovation. The U.S. military is poised to take advantage of the momentum already fueling this revolution. Just as the race to the moon inspired the last generation of dreamers to solve some of the most difficult challenges in space exploration, the effort to improve energy efficiency and sustainability will inspire this generation's technological innovators.

For those of us who serve our country on the high seas, we have long counted on the oceans to bring us safely home. It is our duty to return the favor as environmental stewards of the twenty-first century.