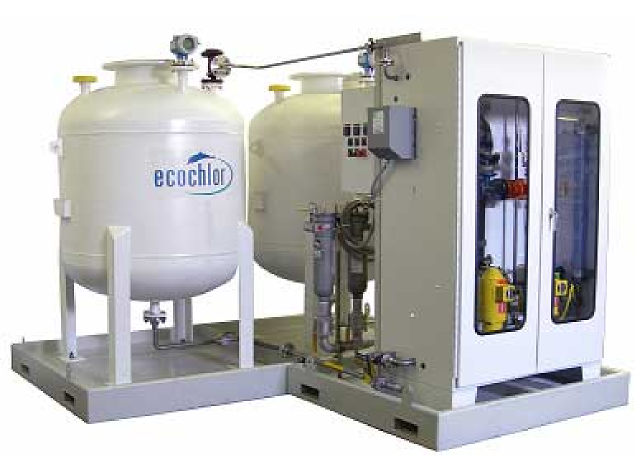
Draft Environmental Assessment
Review of the Application by Atlantic Container Lines for Acceptance of the Vessel M/V *Atlantic Compass* and the Ecochlor Inc. Technology into the USCG Shipboard Technology Evaluation (STEP) Program



October 2007

Prepared by
US Coast Guard

Table of Contents

1.0 PURPOSE AND NEED FOR ACTION

1.1 Introduction

The USCG established the Shipboard Technology Evaluation Program (STEP) in 2004 (USCG 2004). STEP was established to facilitate the testing of prototype ballast water treatment systems under operational conditions on board vessels. Under STEP, treatment system developers acquire increased access to ships for purposes of testing prototype treatment systems; vessel owners get assurances that prototype systems installed on their vessels will be deemed acceptable by the Coast Guard; and the Coast Guard and the public acquire rigorous and credible data on the actual performance of the prototype systems. While in STEP, owners are required to use the prototype treatment system as the primary method of Ballast Water Management (BWM) during the five year evaluation period. The applicants must monitor the engineering performance of the system, and in all years, submit detailed reports to the Coast Guard on the system performance and results of efficacy tests per the vessel's study plan. (USCG 2004).

The USCG previously prepared a Programmatic Environmental Assessment (PEA) for the implementation of the USCG's Shipboard Technology Evaluation Program (STEP). The STEP PEA, along with the Finding of No Significant Impact, was published in the Federal Register on December 8, 2004. This Environmental Assessment (EA), is specific to the review of the Atlantic Container Line Inc. (ACL) application into STEP of their vessel the combination Roll-on Roll-off (RO/RO) and containership *Atlantic Compass* with the Ecochlor ballast water treatment (BWT) system and tiers from the PEA. The PEA should be consulted for much greater background information, legislative history and detail on the STEP goals and requirements as well as additional discussion of environmental and social impacts related to the Program as a whole.

This EA was prepared in accordance with the Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) implementing regulations, the Department of Homeland Security Management Directive 5100.1 and the United States Coast Guard Commandant Instruction 16475.1D (COMDTINST 16475.1D). Specifically, the EA examines the probable impacts of accepting the ACL *Atlantic Compass* with the Ecochlor BWT system into STEP, including the experimental test and evaluation of the routine operation of the chlorine dioxide treatment system described in the application.

1.2 Background

The *Atlantic Compass* is a 292m combination RO/RO containership of 57,225 gross tons and carries a crew of 15. The *Atlantic Compass* runs an established route between Europe and the US ports of Newark, NJ; Baltimore, MD; and Portsmouth, VA (ACL 2006). The M/V *Atlantic Compass* has an established history of discharging approximately 4,500 metric tons of ballast water per port on this itinerary (ACL2006).

The Ecochlor ballast water treatment system uses a dilute solution of chlorine dioxide (ClO_2), generated on board as needed, and administered in a single stage dosing as ballast water is taken on board. The ClO_2 solution strength is determined by operational parameters (flow rate, target dosage) and adjusted automatically during the ballasting operation to establish the target concentration of 5ppm (Ecochlor 2006). The vessel has two voyage modes, cross-ocean (approximately 7 days) and coastwise (1-3 days). Treated water remains in the ballast water tanks for the duration of the voyage where the ClO_2 continues to degrade. For the ocean transits Ecochlor has presented data showing ClO_2 levels of 0 ppm in the discharged treated water, and very low levels of other chlorine species. For the shorter coastwise trips, there are residual ClO_2 levels of 1-3 ppm at the time of discharge. Other chlorine residuals include chlorate and chlorite which also act as biocides as they interact with organic matter in the ballast water. Further study on the fate of these treatment residuals is part of the testing program. The testing program is fully described in the PEA, but briefly consists of 3 challenge experiments in the first and fifth years of operation, which will analyze ballast water before and after treatment and versus control water taken up at the same time, location and pumping method, to determine treatment system efficacy. Levels of treatment residuals in discharged treated water will be tested on a regular basis as part of both the experimental evaluations and the longer-term monitoring. Finally if the vessel is accepted into STEP the treatment system will be used for all ballast water management.

1.3 Purpose and Need

The proposed action is to accept the *Atlantic Compass* with the Ecochlor BWT system into the STEP to gain valuable scientific information on the system's efficacy.

The purpose of this acceptance is to further the USCG efforts to prevent the introduction and spread of Non-Indigenous Species (NIS) from ballast water discharges as directed by the National Invasive Species Act of 1996 (NISA). The USCG has recognized that alternatives to the existing approved procedures of: 1) ballast water exchange (BWE) and 2) retention of ballast water, could be useful to prevent the introduction and spread of NIS.

Participants in STEP, such as the *Atlantic Compass* with the Ecochlor BWTS, will aid in fulfilling the need of the Coast Guard to develop and implement a BWM Program as directed by the NISA. The development of effective ballast water treatment (BWT) technologies will create more options for vessel owners seeking to comply with NISA but having concerns with BWE. The USCG believes that information gained through STEP will provide scientific validation for new systems and aid in the deployment of effective and practicable BWT technologies which will result in reducing or eliminating ballast water as a source of further NIS invasions.

If the *Atlantic Compass* is denied entrance into STEP, the USCG would miss the opportunity to acquire novel scientific data on the performance of the prototype treatment system and on the practicability of on-board test methods, under operational circumstances. This ground truth data, in advance of establishing and implementing a general program for BWT systems would be of considerable benefit to the environmental protection goal of the NIS prevention laws, treaties and policies. With a denial of the application, the USCG would lose this opportunity to gain information that would be critically important for establishing and procedures for BWT system testing and approval.

1.4 PEA for STEP

The PEA examined the reasonably foreseeable consequences that could result from the implementation of the program as a whole. It considered the potential environmental impacts for the vessels wishing to use unique experimental technologies to control ballast water mediated invasive species introductions.

The main conclusions of that analysis were STEP participation would not represent significant environmental impacts because:

- a very small number of ships relative to the total number calling on the US would be involved in STEP, so any possible impacts would be very small;

- a treatment system passing the STEP acceptance criteria would almost certainly provide greater protection of US waters from NIS than the current requirements for BWE which allows for discharge of ballast water with no treatment at all under frequent circumstances; and
- there is a positive benefit of having considerable data to validate and verify BWT system efficacy and impacts.

The PEA also found that any impacts abroad would also be less than significant, because the Coast Guard's primary interest with STEP is vessels that discharge ballast water in U.S. ports rather than foreign ports. When operating outside of the STEP application specified route, the experimental treatment system may be used only if the operator does so in full compliance with US, foreign and international BW management rules as applicable.

1.5 Scope

The STEP PEA established the need for site-specific analyses for each of the applicants to the program to verify no significant localized impacts.

This analysis tiers off the STEP PEA, considering the resource issues pertinent to the technology and trade route being proposed. Water quality and biological resources (including NIS) are the main issues concerning this proposed action.

There were also several resources that were initially considered but dismissed from further analysis. After initial analysis it was determined that the following resources would not be impacted in a significant manner and will not be considered further in this EA:

transportation,
infrastructure,
coastal barrier systems,
topography and floodplains,
geology and soil,
cultural and historic resources,
socioeconomic resources
air pollution.

The *Atlantic Compass* is not expected to operate more frequently with the BWT system installed. Thus, the proposed action should not have any measurable effects on routes or frequency of transportation, or any relevant infrastructure. We expect the impact on coastal barriers to be minimal because the action does not involve increased vessel activity, and the treatment system is expected to have no impact on water quality, biological resources, currents, sediment transport, or other mechanisms that might affect such systems. As the Proposed Action deals solely with a vessel, no measurable effects on land resources, including floodplains or soils, are expected. There are no vulnerable historic properties (e.g., shipwrecks) located in the potentially affected port areas. The technology examined involves one ship making occasional port arrivals, therefore there is very minimal economic impact. The BWT system is not expected to have a measurable effect on the vessel's electrical service capacity and therefore will not engender any additional vessel emissions. Additionally, there should be no emissions from the BWT systems itself, with the exception of the off-gassing of chlorine dioxide. Because of the small amounts and sporadic use of the chemical, any off-gassing is not expected to result in significant adverse impacts to air quality at the locations where the system is used (see Appendix C for support of this conclusion). The public health and safety aspect of chlorine dioxide off-gassing is addressed in Section 4.3 of this EA.

This EA is vessel, treatment technology and route specific. Therefore any significant changes to operations (e.g., schedule changes involving new U. S. ports where treated ballast water would be discharged, or changes in the engineering and operation of the BWT system) would require revisions to the application, and a new review and approval decision by the USCG.

2.0 ALTERNATIVES

The USCG has received an application to STEP from ACL, and therefore must make a decision about whether to accept the vessel into STEP. For this decision, the USCG has two options to consider: grant or deny the *Atlantic Compass* with the Ecochlor system acceptance to the program. This EA will examine these two alternatives and their associated potential impacts. In the PEA for STEP, the USCG assessed three options: no action, STEP as currently structured, and testing BWTS on federal vessels. Only the second option, STEP, was deemed appropriate for accomplishing the needed facilitation of technology development. At the current stage, the decision before the USCG is whether to accept a specific combination of vessel, route, BWTS, and test plan into STEP. At this stage, the only options are to accept or deny the application. If the test program proposed by the applicant were found to be unacceptable, the USCG would deny the application and inform the applicant of the reasons. The applicant would then have the option of revising the application to address the concerns or deficiencies, and/or submitting a new application with a different treatment option.

2.1 <u>Alternative 1</u>: No Action Alternative- Deny Application

Under the no action alternative, the *Atlantic Compass* with the Ecochlor BWTS would continue to manage ballast water under the provisions of the current regulations. Since the *Atlantic Compass* currently has a safety waiver from conducting BWE, the vessel is allowed to discharge sufficient un-exchanged ballast water in a US port in order to conduct cargo operations. Ro/Ro container ships use ballasting (taking on as well as discharging) extensively as they offload their cargo. Finally when moving from one US port to another, current USCG regulation provides that vessels are not required to conduct BWE.

2.2 <u>Alternative 2</u>: Proposed Action Alternative- Accept Application

Under the proposed Action Alternative, the Coast Guard would accept the vessel into STEP. While participating in STEP, in addition to making the ship and BWT system available for initial and periodic physical inspections by USCG personnel, ACL would submit to the USCG detailed annual reports on the performance of the treatment system, including the results and interpretations of rigorous tests of system performance in reducing the concentration of living organisms in discharged ballast water. The USCG would take this information into consideration during the development or refinement of regulations, policies, and procedures related to BWM strategies, requirements, and the regulatory program procedures for treatment system approval and compliance testing.

Acceptance to STEP would grant the applicant equivalency to current (at the time of acceptance) and future BWM regulations regarding transportation of invasive species in ballast water. The period of equivalency for the *Atlantic Compass* with the Ecochlor BWTS would be the life of the vessel or of the treatment system, whichever is shorter. Under this alternative, the vessel would be free to discharge ballast water treated by the experimental treatment system into U.S. waters as their operations dictated. The actual amounts of ballast water taken on, treated and available for discharge at any given port varies; averaging around 4,000 metric tons and depends upon voyage-specific cargo loading and unloading.

2.2.1 Vessel Activities

The *Atlantic Compass* is in liner service that calls on several international and domestic ports. On a typical journey, the vessel departs from Gothenburg, Sweden and visits other European ports such as Antwerp, Belgium and Liverpool, England. The first North American port visited is usually Halifax, Nova Scotia, followed by United States ports, in the following sequence: Newark, New Jersey; Baltimore, Maryland; and Portsmouth, Virginia. A typical return journey would entail the following sequence of port visits: Newark, Halifax, Liverpool, Antwerp, Bremerhaven (Germany) and finally Gothenburg. The round trip voyages typically last about 35 days and are executed year round (ACL 2006).

According to the *Atlantic Compass's* ballast water reporting forms, the vessel invokes the safety exemption provided by Coast Guard regulations and does not perform BWE because the hull could incur unacceptably high stresses. The vessel only ballasts in port based on cargo loading and draft requirements.

Ballast water volumes vary greatly depending on the cargo mix from port to port. As cargo is offloaded or taken on at Newark, Baltimore, and Portsmouth, the vessel will subsequently ballast or deballast un-exchanged ballast water as needed for stability and draft requirements. The ballast system on the *Atlantic Compass* consists of 33 separate tanks, most of which occur in symmetric pairs, port and starboard. Double bottom tanks are loaded with ballast by gravitation and then topped off and emptied by ballast water pump. The remaining tanks must be filled by pump but can be discharged by gravity feed. All ballast tanks are dedicated for ballast; therefore, pipe flushing is not a part of the standard procedures.

The vessel typically de-ballasts between two and seven tanks in each U.S. port. Discharged ballast water can be from a variety of ports and with holding times from one day to a few months, depending upon which tanks are emptied. Additionally, since not all of the tanks are emptied at once, ballast water taken from any port on the route may be discharged at any other port along the route. The vessel total ballast water capacity is 24,000 metric tons. On average, the vessel discharges approximately 10,000 metric tons of ballast in a 35-day cycle (ACL 2006) between all ports visited. From ACL's ballast water discharge forms, they reported a range of no discharge at all to up to 5,000 metric tons discharged in a particular port.

2.2.2 Description of Technology

The Ecochlor™ system consists of a generation module, a programmable logic controller (PLC), a booster pump (to ensure sufficient motive water pressure to drive the chlorine dioxide solution mixture mechanism) and two self-contained chemical storage modules. The system onboard the *Atlantic Compass* is housed in a 20-ft shipping container located on an intermediate vehicle deck (ACL 2006).

A licensed Engineering Officer is responsible for ballasting operations. The Ecochlor™ BWT System itself is fully automated and is interlocked into the ballast water system. Ballast tank monitoring is conducted by sounding, with the operation station of the system at the engine control room. Valves and pumps that are manually controlled segregate the ballast system (ACL2006).

The Ecochlor™ BWT System monitors a variety of key parameters, including but not limited to; key ballast water valve positions, ballast water flow direction, ballast water flow rate and ballast tank levels. This information is processed by the PLC and used by the PLC to automatically adjust chlorine dioxide solution feed rates. The system identifies when ballasting operations are terminated or interrupted and halts the dosing accordingly. There is system feedback available to the crew during ballasting operations, as well as enable/disable and emergency shut down capabilities at the control location (ACL2006).

Conditioning of Treated Water Prior to Discharge, and Assessment of Discharge

The *Atlantic Compass'* treatment system subjects ballast water to chlorine dioxide at 5.0 ppm level. The treated water then remains stored in dedicated ballast tanks for the duration of the voyage. Based on laboratory tests, residual chemical levels are thought to be below applicable EPA and state discharge standards (see discussion in Section 4.1.2, and appendices E and F). As part of STEP the ballast water will be regularly monitored to determine actual residual levels.

Management of treatment waste streams

Other than residuals discussed above, this treatment system generates no separate waste streams. The source chemicals used to generate the ClO_2 are: sulfuric acid (H_2SO_4) and Purate (a proprietary mixture of sodium hypochlorite ($NaClO_3$) and hydrogen peroxide (H_2O_2)). The chemical reaction yields ClO_2, oxygen, water and sodium sulfate (Na_2SO_4). All reaction products and uncombined reactants are injected and mixed into the ballast water and subsequently discharged to the sea when the ship deballasts.

3.0 AFFECTED ENVIRONMENT

To assist the USCG in understanding the potential environmental impacts of these alternatives, this chapter describes the potentially affected environmental resources in their current condition. Based on this description of affected aquatic ecosystems, the impacts of the alternatives will be presented and compared in Chapter 4. Further detail on the broader programmatic scale is in the STEP PEA. The affected environment for this project is based on the *Atlantic Compass'* typical voyage itineraries, as described in Section 2-2-1, and thus focuses on the U.S. ports of Newark, NJ, Baltimore, MD, and Portsmouth, VA.

3.1 Biological Resources

This section presents information on the specific characteristics of the affected aquatic ecosystems, biological organisms, threatened and endangered species, and essential fish habitat. For information on the general characteristics and biological organisms of U.S. aquatic ecosystems, general NIS impacts, and relevant regulatory background, refer to the STEP PEA.

3.1.1 Newark Bay

Newark Bay is a tidal back bay of New York Harbor formed at the confluence of the Passaic and Hackensack Rivers. On its south end, it is connected to Upper New York Bay by the Kill Van Kull, as well as to Raritan Bay by the Arthur Kill. Although the Bay is a shallow tidal estuary, navigational channels are periodically dredged to accommodate deep draft ships. Newark Bay is currently designated as an USEPA CERCLA study area.

The Hackensack River and its tributaries have been altered at different times to meet specific needs. The lower section in proximity to the Harbor has historically been dredged to handle barge traffic, and the USACE currently maintains a shipping channel at an average depth of twelve feet. Additionally, ditches and canals have been dug to control mosquitoes and the flow of water into surrounding tidal marshes. In the Meadowlands, major inputs of freshwater to the Hackensack River are from industrial and municipal discharges, stormwater runoff, and water spilling over the Oradell Dam. The Hackensack River has a disturbed flow regime, and essentially acts as a trough in which the tidal waters echo upstream and downstream, only gradually getting flushed to the sea. The Passaic River has a long history of industrialization, which has resulted in degraded water quality, sediment contamination, loss of wetlands, and abandoned or underutilized properties along the shore. The USACE has identified the Lower Passaic River as one of the priority restoration areas within the Hudson-Raritan Estuary on the basis of water resources and sediment quality related problems and needs.

Port Newark-Elizabeth Marine Terminal is the port facility in Newark Bay that serves as the principal container ship facility for goods entering and leaving New York City and the northeastern quadrant of North America. The Port is the fifteenth busiest in the world. Planned and built during the 1950s by the Port Authority, it is the largest container port in the eastern United States and the third largest in the country. Container ships typically arrive through the Narrows and the Kill Van Kull before entering Newark Bay, although some ships enter Newark Bay via the Arthur Kill.

The existing land use surrounding the Port supports the industrial, transportation and waterborne commercial nature of the area. Land use adjacent to the Harbor ranges from tidal wetlands to heavy urban development. Inland, the land uses are devoted more to residential, commercial and industrial purposes. The Harbor is in the northeast's north-south transportation corridor and the immediate area is crisscrossed by major interstate highways. The estuary is considered degraded and the National Estuary Program Coastal Condition report score is poor, but water quality measures and estuary health have improved dramatically in the last 30 years (USEPA 2007).

Waves in the Harbor are limited due to the protection afforded by the adjacent land masses. Currents generally range from 0.6 to 2 feet per second (fps) throughout the Harbor. Tides throughout the Harbor are semi-diurnal, with a mean tide range of approximately 5.0 feet. As a result of the hydraulic condition, sedimentation rates in the region vary widely depending on location: around the Elizabeth peninsula it ranges from 1.5 inches per year (in/yr) to 5 in/yr around the Newark peninsula, from 5 in/yr at the inshore end of Newark Channel to 18.8 in/yr at the Pier head Channel. In the vicinity of Shooters Island it is approximately 11.7 in/yr and in the vicinity of Port Jersey it is approximately 2.7 in/yr.

Benthos

In general, the benthic habitats within the Newark Harbor area are predominantly unconsolidated sediments comprised of silt and sand. Benthic sampling of Newark Bay has been conducted in association with USACE harbor projects in 1976, 1985, 1993, and 1995-96 (USACE 1997).. Although there has been some variability in the dominant species described in studies conducted in Newark Bay due to differences in sampling methods and seasons when samples were collected, the studies consistently documented the Newark Bay benthic communities are dominated by polychaetes and bivalves of which many of the species are characteristic of polluted or organically enriched environments. The Newark Bay benthic community exhibits relatively low species diversity, moderate to low abundance levels, and dominance by polychaete worms which have life history characteristics, such as high reproduction and turnover rates and high dispersal ability that allow them to be resilient to changing environmental conditions. In this respect, the benthic community of Newark Bay is similar to the soft sediment benthic community found throughout the NewYork/New Jersey Harbor complex.

Six polychaetes were among the ten most abundant species identified in Newark Bay sediment samples. Dominant species were the spionids *Scoloplos* sp. , *Streblospio benedicti, Scolecolepides viridis* and *Polydora ligni; the* cirratulid polychaete *Tharyx* sp., the orbinid *Leitoscoloplos robustus*, the capitellid, *Mediomastus ambiseta*, and the nereid *Nereis succinea*. Bivalves commonly found include *Mulinia lateralis*, *Mya arenaria*; *and Tellina agilis*. Crustacea include the cumaceans *Leucon americanus and Oxyurostylis smithii*., and the isopod *Cyathura polita*. Common epibenthic crustaceans in subtidal and tidal areas include blue crab (*Callinectes sapidus*), mud fiddler crab (*Uca pugnax*), white-fingered mud crab (*Rhithropanoepus harrisii*), mysid shrimp (*Neomysis americana*), sand shrimp (*Crangon septemspinosa*), grass shrimp (*Palaemonetes pugio*), and several species of amphipods. Common mollusks occurring in mudflats and marshes include the mud snail (*Nassarius obsoleta*) and the ribbed mussel (*Geukensia demissa*).

Plants and Wetlands

Common reed (*Phragmites australis)* is a predominant species within the palustrine emergent wetlands and the tidal open water areas of the Harbor and its surrounding lowlands. Other species characteristic of the palustrine wetlands of the area are goldenrod species including rough-leaved goldenrod (*Solidago patula*) and rough-stemmed goldenrod (*S. rugosa*), umbrella sedge (*Cyperus strigosus*), and lady's thumb (*Polygonum persicaria*). Although not very common within the project area, estuarine emergent wetlands provide valuable functions, including dissipating tidal erosive forces, binding and stabilizing sediments, and trapping and retaining suspended sediments and chemical toxins. Wetland fringe areas are located at Shooters Island and along an area of shallow mudflats that exists in the southwest corner of Newark Bay, bordering the Arthur Kill along the U.S. Dike. In southwestern Newark Bay lies a rectangular shaped area generally known as the "mudflats." In addition, the Jersey Flats are located off the Military Ocean Terminal- Bayonne (MOTBY) and Port Jersey Peninsulas, and the Bay Ridge Flats are bordered by the Bay Ridge and Red Hook channels. These shallow areas are utilized by a number of fish and wildlife species. Greater benthic activity and higher dissolved oxygen levels provide important habitat for fish species, as well as feeding and resting areas for waterfowl and shorebirds.

Waterfowl and Birds

The greater New York Harbor area of which Newark Harbor is a part lies within the coastal migratory corridors and the north-south oriented migratory corridors of the Hudson Highlands region. Thus, coastal as well as overland migrating species are channeled through the region. The various habitats in the area provide food and rest for these migratory birds. The New York Harbor Estuary also supports large and flourishing populations of year-round resident aquatic birds. (HEP 1996).

Extensive and long-standing urbanization has resulted in significantly reduced bird populations compared to that which would occur otherwise. Nevertheless, many common species associated with estuaries are present within and near Newark Harbor. Shooters Island, located in the southern end of Newark harbor is noted for its importance for breeding populations of wading birds, seabirds and waterfowl. Shooters Island is located in an important habitat area known as the Harbor Herons Complex that extends from Shooters Island southward along the Arthur Kill to just south of the Isle of Meadows, and eastward onto Staten Island to the edge of existing development east of the West Shore Highway. Shooters Island was identified as an important mixed heronry in the mid-1970's, and species diversity and abundance are reported to have greatly increased since then (USACE 1996). Shooters Island and other areas around Newark harbor are part of the Harbor Herons Complex. First documented in the industrial Arthur Kill waterway in the 1970s, the complex has become a regionally significant heron and egret nesting rookery. Species of nesting birds observed in the complex include great egret (*Casmerodius albus*); snowy egret (*Egretta thula*); the tricolored heron (*E. tricolor*); the cattle egret (*Bubulcus ibis*); the black-crowned night heron (*Nycticorax nycticorax*); the yellow crowned night heron (*Nyctanassa violacea*), the green heron (*Butorides striatus*); the glossy ibis (*Plegadis falcinellus*); the double crested cormorant (*Phalacrocorax auritus*); herring gull (*Larus argentatus*); the great black backed gull (*L. marinus*); Canada goose (*Branta canadensis*); and the mallard (*Anas platyrhynchos*).

Midwinter waterfowl surveys have documented that Newark Bay is used by the greater scaup (*Aythya marila*); lesser scaup (*A. affinis*); the canvasback; the mallard; the black duck; the gadwall (*A. strepera*), bufflehead; the hooded merganser (*Lophodytes cucullatus*). Large overwintering rafts of diving ducks forage and rest within the NY/NJ estuary. About 15 species of diving ducks can be expected to pass through and use portions of the greater NY/NJ estuary for migration stopovers and for overwintering. Concentrations are comprised primarily of canvasbacks (*Aythya valisineria*), greater scaup, and buffleheads (*Bucephala albeola*), with lesser number of common merganser (*Mergus merganser*); and the red breasted merganser (*M. serrator*). In addition, mallards (*Anas platyrhynchos*) and black ducks (*A. rubripes*) are common nesters in the area, with occasional nesting by gadwall (*A. strepera*), green-winged teal (*A. carolinensis)*, and bluewinged teal *(A. discors)*. Overwintering species include gadwalls, black ducks, pintails *(A. acuta*), and Canada goose (*Branta canadensis*) and mallards. A variety of shore birds including plovers, woodcock, snipe, turnstones, sandpipers, yellowlegs, dunlin, and sanderling migrate through the area.

Fish

The greater New York Harbor area has over 100 species of fish. The system supports viable recreational and commercial fish populations and provides a major resource for sports fishing. There is a very large and active recreational fishery in Raritan Bay, Jamaica Bay, Sandy Hook Bay, the Navesink River, and Shrewsbury River for such species as striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), fluke (*Paralichthys dentatus*), and winter flounder (*Pleuronectes americanus*). In the Lower Bay area, commercial fisheries exist for species such as blue crab (*Callinectes sapidus*), winter flounder, menhaden (*Brevoortia tyrannus*), bluefish, weakfish (*Cynoscion regalis*), and crayfish (*Orconectes virilis*) (HEP 1996).

Several studies associated with USACE projects in Newark Harbor, conducted throughout the 1980s and '90s document that Newark Bay and Kill Van Kull contain a diverse fish community dominated by the abundance of a relatively small number of species (USACE 1997). The findings in the various studies were quite consistent, even though sampling equipment, methods, and sample designs varied among the studies. The dominant species - striped bass, winter flounder, bay anchovy, and Atlantic tomcod - were abundant or common in each study. The presence of large numbers of the smaller individuals of the dominant species shows that Newark Bay is an important nursery area for some species. A number of species occur commonly, but on an annual basis are generally present in smaller numbers or were present only for short periods of time.

The most likely resident species were winter flounder and tomcod. Numerically important migrant species included bluefish (*Pomatomus saltatrix*) and a suite of species belonging to the herring group (e.g., shad (*Dorosoma cepedianum)*; alewife (*Alosa pseudoharengus)*; menhaden (*Brevoortia tyrannus)*; Atlantic herring (*Clupea harengus)*; and blueback herring (*Alosa aestivalis*)). Other common species include striped anchovy (*Anchoa hepsutus*), blueblack herring (*Alosa aestivalis*), mummichog (*Fundulus heteroclitus*), Atlantic silverside (*Menidia menidia*), inland silverside (*Menidia beryllina*), white perch (*Morone americana*), brown bullhead (*Ameriurus nebulosus*), striped killifish (*Fundulus majalis*), striped bass (*Morone saxatilis*), pumpkinseed sunfish (*Lepomis gibbosus*), and American eel (*Anguilla rostrata*). Anadromous fish using the upper harbor and marshes in the spring include alewife, blueback herring, American shad, Atlantic tomcod, and striped bass, and marine fish, such as Atlantic menhaden and bluefish.

Threatened and Endangered Species

Threatened and endangered species in the greater New York Harbor area, including coastal waters adjacent to the Harbor entrance, freshwater sections of tributary rivers, and uplands include: (1) mammals: blue whale (*Balaenoptera musculus*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaengliae*), northern right whale (*Eubalaena glacialis*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), Indiana bat (*Myotis sodalist*); (2) birds: peregrine falcon (*Falco peregrinus*), piping plover (*Chardadrius melodus*), roseate tern (*Sterna dougallii*); (3) reptiles: green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricate*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*); (4) fish: shortnose sturgeon (*Acipenser brevirostrum*); insects: Karner blue butterfly (*Lycaeides melissa samuelis*), northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*); (5) mollusks: dwarf wedge mussel (*Alasmidonta heterodon*); and (6) plants: American chaffseed (*Schwalbea americana*), Knieskern's beaked rush (*Rhynchospora knieskernii*), northern wild monkshood (*Aconitum noveboracense*), sandplain gerardia (*Agalinis acuta*), sensitive joint vetch (*Aeschynomene virginica*), sea-beach amaranth (*Amaranthus pumilus*), small whorled pogonia (*Isotria medeoloides*), swamp pink (*Helonias bullata*) (USFWS 2006a). Additionally, the northeastern beach tiger beetle is a federally listed insect species that was historically found along New Jersey's undeveloped coastal beaches.

Ten percent of the nesting population of the federally listed endangered peregrine falcon, on the East Coast, is located in the area.

In response to a letter of inquiry in accordance with Section 7c(1) of the ESA, the Migratory Bird Treaty Act, and other pertinent legislation, regulations, or treaties regarding the protection of endangered species, the USFWS indicated (appendix E) that Newark Harbor lies within the distribution ranges for piping plover (*Charadrius melodus*), roseate terns (*Sterna dougalli dougalli*), seabeach amaranth (*Amaranthus pumilus*), and eastern tiger beetles (*Cicindela dorsalis dorsalis*). However, the proposed activities of the *Atlantic Compass* in the Newark Harbor if accepted into STEP is not expected to result in any impacts to these species known to occur in the Harbor area. The yellow crowned night heron occur within the project area and is listed as threatened by the state of New Jersey.

Non-indigenous Species

Two of the main examples of aquatic NIS in the New York Harbor area are the shipworm (*Teredo bartschi*) and a small isopod crustacean known as the gribble (*Limnoria tripunctata*), which have invaded marine waters in New York and other northeast states. These two species have caused extensive structural damage in New York Harbor, by boring into wooden structures such as piers, bulkheads and boat hulls (NYS 2005). Another species that has caused significant damage to the New York Harbor Area is the Common Reed (*Phragmites sp.*). Its introduction into the New York Harbor Estuary and tidal marshes has resulted in significant impacts to native populations by crowding out native species of wetland plants. While over 200 non-indigenous aquatic species have been reported for other urban estuaries with significant commercial shipping traffic (Ruiz et al., 2000), little is known about the extent of biological invasions in Newark Harbor. As one of the busiest container ports on the eastern seaboard, there is little reason to doubt that a significant number of estuarine species have been introduced and become successfully established.

3.1.2 Chesapeake Bay

The other two U.S. ports visited by the *Atlantic Compass*, Baltimore, Maryland and Portsmouth, Virginia, are located in the Chesapeake Bay. The Chesapeake Bay is the largest estuary in the United States. It lies off the Atlantic Ocean, surrounded by Virginia and Maryland. More than 150 rivers and streams drain into the Bay. The main stem of the Bay itself is 189 miles (304 km) long, from the Susquehanna River in the north to the Atlantic Ocean in the south. At its narrowest point near Annapolis, Maryland, the Bay is four miles (6.4 km) wide; at its widest point, near the mouth of the Potomac River, it is 30 miles (50 km) wide. The lands surrounding the Bay are highly urbanized. The estuary is considered degraded and the National Estuary Program Coastal Condition Report overall score is fair, while water quality is scored as poor (USEPA 2007).

Baltimore is in the north central part of the state of Maryland, on the Patapsco River, a tributary to the Chesapeake Bay. The Port of Baltimore is one of two eastern U.S. ports having a 50-foot deep main shipping channel (Maryland State Archives 2007). The general geologic setting of the Baltimore Harbor is comprised of a series of wedge-shaped sediment layers dipping and thickening bayward. The older and generally harder Cretaceous sediments are encountered farthest to the north and west within Baltimore Harbor, while younger and less compact Tertiary and Quaternary sediments are typically encountered eastward. The harbor floor is covered with a layer of mud.

Benthos

Baltimore Harbor

Currently, the benthic macroinvertebrate community in Baltimore Harbor is substantially poorer in biomass and species diversity compared to historical conditions and to other areas in the Chesapeake Bay. Although benthic communities are degraded, they are improving due to recent environmental laws and regulations. Few mollusks and crustaceans can be found in the area, and no oyster bars are known to exist in the Harbor today. The layer of fluid mud that exists in most of the project area constitutes a poor substrate for many benthic species. The benthic communities that survive in the project area are not well developed and are comprised of mainly pollution-tolerant species. A 1975 study found that the tubifex worm, a species tolerant of pollution, was fairly common in the Harbor, but that crustaceans and mollusks (species relatively intolerant to pollution) were scarce. The low biomass and diversity of benthic organisms indicate that conditions in the area can be characterized as semi-polluted to polluted. A 1983 study of the benthic community found that diversity declined from the mouth of the Harbor to its head. The benthos consisted mainly of ephemeral, surface-dwelling opportunistic species in the region of the anchorages, while longer-lived, deep-dwelling species were absent. Annelids, marine worms that live in sediments closest to the surface, comprised over 90 percent of the benthic community. The study found that larvae of the common Baltic clam *(Macoma balthi*a) settled in the project area in large numbers; however, they did not survive to achieve significant growth.

Portsmouth Harbor
Probability-based sampling allows an annual characterization of the overall condition of the benthic communities of the Elizabeth River watershed. In 1999 the condition of the macrobenthic communities of the Elizabeth River watershed was characterized for five subareas consisting of the Mainstem of the River, the Lafayette River, the Southern Branch, Western Branch and Eastern Branch (Dauer 2000). The 1999 intensive sampling serves as a benchmark for all future analyses. The subareas were characterized in terms of benthic community condition into three categories: (1) the best condition in the Mainstem of the river, (2) the worst condition in the Southern Branch, and (3) intermediate condition in the Eastern Branch, Western Branch and Lafayette River. The Mainstem of the river had the highest average benthic index of biological integrity (B-IBI) value of 2.9, the Southern Branch the lowest value of 2.0 and the other branches had values between 2.5 and 2.7 with an overall average of 2.5.

In 2004 and 2005 the average watershed-level value for the B-IBI was the lowest recorded since 1999 and the area of benthic habitat not meeting the Chesapeake Bay Benthic Restoration Goals was the highest recorded since 1999. Compared to the Chesapeake Bay Benthic Restoration Goals the macrobenthic communities of the Elizabeth River can be characterized as (1) having lower than expected species diversity and biomass, (2) abundance levels generally higher than reference conditions and (3) species composition with levels of pollution indicative species higher than reference conditions and levels of pollution sensitive species lower than reference conditions.

Plants and Wetlands

Overall, approximately 1.5 million acres of wetlands remain in the Chesapeake Bay watershed, less than half of the wetlands that were present during colonial times. Of the remaining wetlands, 13% are tidal and 87% are non-tidal (CBP 2006). There are 14 common species of submerged aquatic grasses commonly found in the Chesapeake Bay or nearby rivers.

Baltimore Harbor
Surveys performed by the EPA have indicated that there is no submerged aquatic vegetation (SAV) in Baltimore Harbor. In addition, the depths of much of the harbor area, which ranges from 23 to 35 feet, are not conducive to the establishment of SAV. The tidal wetlands that once occupied 3 square miles of the Harbor area have been virtually eliminated over time by industrial and commercial development, reducing the quality of environmental resources in the area. The remaining wetlands in Baltimore Harbor consist primarily of patches of common reed *(Phragmites communis*), which are considered to be less valuable to fish and wildlife than historic undisturbed marshes.

Portsmouth Harbor
Wetlands in Portsmouth harbor are typical for the Chesapeake as described already. Portsmouth Harbor is an urban, highly developed region of Virginia with land uses dominated by high density residential districts, commercial and industrial development, and military reservations. The waterways are an integral part of life in the city, and uses on the landscape have evolved around these systems. Heavy industrial, military, commercial, and residential waterfront development prevails. In many areas, undisturbed shoreline miles are almost nonexistent. Development continues to encroach on remaining pristine reaches and threatens the natural ecosystems which remain. Additionally waterfront property values have been rapidly increasing driving shoreline development pressure higher. Tidal shoreline protection at federal, state, and local levels are the only constraints to development activities at the shore.

Fisheries

Chesapeake Bay freshwater tributaries provide spawning and nursery sites for several commercially important species of fish, such as white and yellow perch, striped bass, herring, and shad. During the warmer months, numerous marine species including bluefish, weakfish, Atlantic croaker, menhaden, and summer flounder enter the Bay to feed.

Historically the Chesapeake has been the largest producer of blue crabs in the country, contributing more than a third of the nation's catch. In 2002, however, the Bay's blue crab harvest was only 50 million pounds, well below the long-term average of 73 million pounds (CBP 2006).

Striped bass (probably the most closely monitored fish in the Bay) populations have increased about 25% a year since 1984, after falling to low levels in the early 1980's (USGS 2006a). Increases are at least partially attributed to a moratorium on harvest to allow improvement of the age and sex structure of the spawning stock and extensive hatchery efforts. American shad have declined in Chesapeake Bay in recent decades; unlike the stripers, this species has not shown a strongly positive population response despite moratoria on fishing in Maryland and Virginia (USGS 2006a).

A number of resident and migratory fishes inhabit Baltimore Harbor, although the abundance of species in Baltimore Harbor is dramatically reduced. There are very few bottom-dwelling species present, and there is a high occurrence of diseased fish. It is expected that the low numbers and the loss of diversity of fish in the project area is partly a result of the water quality problems and degraded benthic habitat. Anadromous species, particularly alewife *(Alosa pseudoharengu*s), blueback herring *(A. aestivali*s), and American eel *(Anguilla rostrat*a) migrate through the Patapsco estuary en route to and from spawning areas in the upper non-tidal section of the river. Other migratory and resident fishes found in Baltimore Harbor include white perch *(Morone american*a), anchovy *(Anchoa mitchill*i), hogchoker *(trinectes maculatu*s), silversides *(Menidia menidi*a), bluefish *(Pomatomus saltatri*x), channel catfish *(Ictalurus punctatu*s), and striped bass *(M. saxitili*s); the blue crab *(Callinectes sapidu*s) is a common shellfish in the harbor. White perch is the most abundant migratory species, with large numbers of both adults and juveniles present.

Portsmouth Harbor
Striped bass (*Morone saxatilis)*, catfish (order *Siluriformes*), Atlantic croaker (*Micropogonias undulates)* and flounder (*Paralichthys* sp*.)* are commercial important finfish, with Blue Crab (*Callinectes sapidus)*, sea scallops (fam. *Pectinidae*), ocean quahog *(Arctica islandica)*, horseshoe crab *(Limulus polyphemus)* and channel whelk (*Busycotypus canaliculatus)* catches are the commercially significant invertebrates.

Waterfowl
Chesapeake Bay is the winter home for tundra swans (*Cygnus columbianus columbianus*), Canada geese (*Branta canadensis)* and a variety of ducks, including canvasbacks (*Aythya valisineria)*, pintails (*Anas acuta)*, scoters (*Melanitta sp.)*, eiders (*Somateria* sp.) and ruddy ducks (*Oxyura jamaicensis)*. On average, nearly one million waterfowl winter each year on Chesapeake Bay (CBP 2006). It is also a major nesting area for the bald eagle. The Bay region also is home to the world's largest population of osprey (*Pandion haliaetus*), with more than 2,000 nesting pairs (USGS 2006a).

Baltimore Harbor
Two waterbird nesting colonies exist near the Harbor. An established colony of black-crowned night herons, consisting of approximately 350 breeding pairs, nest at Sollers Point near the northern end of the Francis Scott Key Bridge. Approximately 500 pairs of herring gulls nest at a site on Sparrows Point. Many resident species such as great blue herons, cormorants, and osprey also occur in the Harbor area. Additionally, a variety of waterfowl species winter in the Harbor area. These include mallards, scaup, bufflehead, goldeneye, ruddy duck, canvasbacks, canada geese, and black duck.

Portsmouth Harbor
Birds in the harbor are typical for those of the larger Chesapeake Bay.

Threatened and Endangered Species

Endangered species in the affected environment of the Chesapeake Bay area include several oceanic species, such as the shortnose sturgeon (*Acipenser brevirostrum)*, green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricate*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), and dwarf wedge mussel (*Alamidonta heterodon).* Threatened, or endangered birds include the peregrine falcon. (USFWS 2006b).

Baltimore Harbor
The USFWS, in its Section 7 coordination letter, identified American bald eagles and peregrine falcons as listed endangered species in the Baltimore Harbor area. Peregrines have consistently been observed nesting in downtown Baltimore at the Inner Harbor. Another pair of falcons nests less successfully on the Key Bridge. Their diet generally consists of pigeons, but they occasionally will prey on various waterbirds. Since the date of that letter the USFWS has delisted the American Bald Eagle.

Portsmouth Harbor
There is no designated critical habitat in the Portsmouth area. Endangered species that transit the area include Chesapeake Bay turtle species, and the peregrine falcon.

Non-Indigenous Species in Chesapeake Bay

The invasive plants and animals known in and around the Chesapeake Bay include mammals, such as nutria (*Myocastor coypus*); plants, such as *Phragmites* ; and hydrilla (*Hydrilla verticillata*) in the tidal freshwater portions of the Potomac River (USGS 2006a); birds, such as mute swans (*Cygnus olor)*; and other species, including the Asiatic clam (*Corbicula fluminea*), the rapa whelk (*Rapana venosa*), and the tiger mosquito (*Aedes albopictus*). Some species, such as the Asiatic clam, are thought to have entered the Bay in ballast water, but most were brought here intentionally.

Baltimore Harbor
Recently, Chinese mitten crabs, *Eriocheir sinensis*, have been found in the vicinity of the entrance to Baltimore Harbor , as well as lower down in the Chesapeake bay, and in neighboring Delaware Bay (Smithsonian Environmental Research Center 2007). Native to East Asia, the crab is significant as a potentially harmful invasive species that has caused economic damage in Europe and on the West Coast of the U.S. Chinese mitten crabs may have been introduced to the area via ships' ballast water, or by illegal releases of live crabs by person's hoping to establish a population of the species, which is the focus of a significant commercial fishery in Asia. The crabs may also have been introduced to the Bay unintentionally in association with the illegal importation of crabs as seafood sold in ethnic markets.

Portsmouth Harbor
The Rapa whelk, *Rapana venosa*, was discovered to have invaded the Chesapeake Bay in 1998, and has become increasingly abundant in the lower Chesapeake Bay and in the James River-Hampton Roads area in particular, which is the same location as Portsmouth Harbor (Virginia Institute of Marine Science, 2005). The Rapa whelk is a predator that is considered to be a particular threat to the ecologically and economically important native oyster, *Crassostrea virginica*. Originating from the Sea of Japan, the Rapa whelk may have been introduced to the Chesapeake Bay in ballast water discharged into the Hampton Roads area.

3.2 Water Quality

This section describes water quality in the Newark and Chesapeake Bay areas, in terms of physical and chemical properties. Since Newark Bay is part of the Inner Harbor area of New York Harbor, description of New York Harbor area resources will be used as generally applicable for Newark Bay. Since Baltimore, MD and Portsmouth, VA are both in the same general geographic and hydrographic area, the description of Chesapeake Bay area resources will be applicable to both locations.

3.2.1 Newark Bay

Newark Bay is a well-mixed estuary, receiving freshwater from two polluted, and at times nearly anaerobic, rivers in heavily industrialized surroundings. The bay meets the mouth of the Hudson River and Raritan Bay on the Atlantic side. Throughout a typical year, the bay waters experience temperatures between 4 and 25 °C, dissolved oxygen concentrations between less than 2 and 11 mg/l, and chlorophyll-a concentrations between 3 (winter) and over 80 µg/l (spring and summer). The large point sources of industrial runoff and sanitary pollutants combined with large non-point source inputs, especially from the Passaic River during periods of high precipitation, contribute to the degradation of water quality in Newark Bay. The high pollutant loadings lead to increases in turbidity, bacteria populations, organic matter, phosphorus levels, and biological oxygen demand.

Water quality standards, which identify indicator levels that are harmful to aquatic life or human health, have been established for four major thresholds of environmental change in the New York Harbor Estuary: fecal coliform (FC) bacteria, chlorophyll a, dissolved oxygen (DO), and Secchi transparency (DEP 2004). Most of the Inner Harbor area, excluding the Kill van Kull and Arthur Kill, is classified by New York State for uses such as fishing or boating. The Kills are classified for fish survival only, with the exception of the far southern reach of Arthur Kill.

Newark Harbor and the lower reaches of the two tributaries (Hackensack and Passaic Rivers, and the passageway from the Bay to the larger New York Harbor (Kill van Kull) have been listed in the state's 305(d) report of impaired waters (NJDEP 2006). Causes for the impairment are largely due to contamination by industrial activities, which have left a legacy of dioxin, PCBs, PAHs, pesticides, chlordane, and metals, including mercury, zinc, copper, lead, cadmium, and thallium. The Department of Environmental Protection has issued a fish consumption advisory of "do not catch/do not eat" for blue crabs for Newark Bay, due to elevated concentrations of dioxin,

3.2.2 Chesapeake Bay Area

The Chesapeake Bay has been listed as an "impaired water body" under the Clean Water Act due to low DO levels that were responsible for killing fish and other organisms, as well as producing its poor water clarity. The variability of stream flow due to seasonal and yearly changes in rainfall and ground water affects salinity, DO, and water clarity in Chesapeake Bay (USGS 2006b).

Large quantities of toxic pollutants threaten the living resources of Chesapeake Bay and the watershed, as well as public health (USGS 2006b).

Data from 2003 to 2005 indicate "that conditions in 48 percent of Chesapeake Bay's waters met acceptable levels of algal abundance as measured by chlorophyll a." Scientists attribute the poor conditions in the rest of the Bay to the pulse of nutrients washed into Chesapeake Bay during spring rains (CBP 2006). Based on bay grass acreage data from 2003 to 2005, 20 percent of Chesapeake Bay's segments met water clarity standards (CBP 2006). Most of Chesapeake Bay's living resources are adapted to these large swings in salinity, but extreme floods or droughts can lead to stressful conditions (CBP 2006).

Baltimore Harbor

The water quality in the Harbor is impacted by the heavy volume of urban runoff in combination with industrial and commercial discharges. Polluted discharge and runoff from land activities have degraded the overall water quality as well as the bottom habitat. Nutrient levels are relatively high and algae blooms are frequent. During summer months, waters separate into lower salinity, warm surface waters and higher salinity, cool deeper waters. Saline waters at greater depths frequently become hypoxic (dissolved oxygen less than 2 mg/l) during the summer months. Natural factors also influence water quality. The project area lies just to the south of the turbidity maximum of the Upper Bay, and suspended sediment levels may reach 150 mg/liter.

Baltimore Harbor was identified on the State of Maryland's 1996 303(d) list of water quality limited segments submitted to the U.S. Environmental Protection Agency (EPA) as impaired by nutrients, bacteria (fecal coliform), toxics (PCBs), metals (chromium, zinc and lead), suspended sediments, and by impacts to biological communities. Water quality analyses conducted by the State indicate that the dissolved oxygen criteria for the deep channel areas of the Harbor cannot be met, due to nutrient inputs from tributaries and the Chesapeake Bay mainstem, even after projected nutrient reductions from point sources and the application of Tributary Strategy reductions for nonpoint sources.

Portsmouth Harbor
The water quality of the Elizabeth River can be generally characterized as nutrient enriched with both nitrogen and phosphorus, although long-term trends show improvement (Dauer et al. 2003a,b; 2005). In 1993, the Chesapeake Bay Program identified the Elizabeth River system as a Region of Concern as it is one of the most highly polluted bodies of water in the entire Bay watershed. Much of the Elizabeth River, upon which Norfolk Harbor is located, has been listed as impaired in the Virginia 303(d) report (VADEQ 2006). Significant causes of impairment include highly polluted conditions due to TBT, PCBs, and PAHs. Three sites on the Elizabeth River have been placed on the National Priorities List ("Superfund" sites) by EPA that include Atlantic Wood Industries, Norfolk Naval shipyard, and the U.S. Navy St. Juliens Creek Annex (ERP, 2003)

3.3 Public Health and Safety

The relevant geographic scope of the Proposed Action, with regard to public health and safety is onboard the ship and within the port facilities themselves and their immediate environs. It does not include surrounding public spaces and buildings, residential areas, or businesses. The ports themselves are industrialized areas, and only appropriately authorized and trained personnel have general access. The BW treatment system is constructed in accordance with applicable codes for shipboard machinery, electrical installation and chemical storage. It has been assessed by an independent classification society for conformance to these codes. Finally it is located in a normally unoccupied vessel space and operates autonomously. Therefore little crew contact with the equipment is likely and when such proximity is required, the crew have the same level of safety protection as with all other ships machinery installations.

3.4 Environmental Justice

Consideration of environmental justice falls under the authority of Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations", and Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments". Low-income and minority populations may be present within the cities adjacent to these ports. However, given the proposed action, any potential impacts would be focused on the marine environment. Hence, the only impact of concern may be subsistence fishing.

There are no known treaties governing Native American fishing rights in the ports reviewed.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Biological Resources

4.1.1 No Action Alternative

Under the No Action Alternative, the *Atlantic Compass* with the Ecochlor BWT system would not be accepted to the program.

The vessel could continue to test or operate the experimental technology as a private action. However, the *Atlantic Compass* would not be granted equivalency to current and future BWM regulations, and therefore would be required to comply with current BW management requirements, and any applicable future Coast Guard regulations. Since the *Atlantic Compass* currently does not conduct BWE for ships safety reasons, it does routinely discharge untreated ballast water into US ports. Therefore, under the current regulations, the possibility for future introductions of invasive species from this ship remains. However, it would be difficult to link these impacts to any one ship; therefore, no significant impact to biological resources can definitively be attributed to non acceptance of the *Atlantic Compass* as a result of the No Action.

4.1.2 Proposed Action Alternative

Under the Proposed Action, the *Atlantic Compass* with the Ecochlor BWT system would be accepted to STEP. The BWT system would process all ballast water taken on and discharged by the ship. All discharged water would be treated rather than exchanged or untreated.

This alternative is expected to slightly reduce the chance of a release of non-indigenous organisms in ballast water discharge from the *Atlantic Compass* since the existing rules allow for the release of untreated unexchanged ballast water in port areas under certain circumstances. It is therefore believed that use of the system will be as, or more effective in reducing the delivery of healthy non-indigenous species than the vessels current practice of discharging untreated, unexchanged BW , and thus also likely to reduce the probabilities of invasion.

Further the greatest impact of acceptance of the *Atlantic Compass* into STEP is that the USCG will gain significant empirical and practical data from the operational use of BWT technology which is critical to the development, refinement and enforcement of a robust national BW discharge treatment standard.

In accordance with ESA, the USCG has initiated informal consultation with the USFWS and the NMFS to determine if any threatened and endangered species in the affected environment could be affected by implementing the subject BWTS. Initial responses received from the consulted agencies have been considered in this analysis and are included in Appendix D.

The USFWS believes that the proposed discharge of treated ballast water would not likely affect ESA listed species in Appendix D.

A possible impact to biological resources could occur from the residuals of chlorite, chlorate and chlorine dioxide remaining in the discharged water. As further discussed below, given the highly reactive nature of chlorine dioxide and chlorite with organic matter, especially in the presence of light, and the relatively small volumes of discharged ballast water involved (compared to the waters of the estuaries and ports visited) it is unlikely that the discharges treated with the Ecochlor BWTS as used by the *Atlantic Compass* will have any discernable effect on the highly organic environments of the already heavily impacted industrial wetlands in the East Coast port sites. The primary receptor of potential impacts from this action will be the planktonic community and possibly fish. Birds would only be affected indirectly through any change (decline) in their food supply (plankton dependent fish). EPA-compiled toxicity data for all three chemical species (Appendix F) suggest strongly that the expected concentrations on discharge of ClO_2 (30 ug/l), chlorite (2,000 ug/l), and chlorate (500 ug/l) are likely below the levels associated with significant toxicity to aquatic organisms. The compiled toxic levels (LC50) are mostly greater than 1000 ug/l for ClO_2; greater than 75,000 ug/l for chlorite (although two aquatic zooplankter, *Daphnia* and *Americamysis* had LC50 concentrations under 500 ug/l); and greater than 1,000,000 ug/l for chlorate.

The system establishes an initial concentration of 5.0 ppm of chlorine dioxide (ClO_2) to the incoming ballast water in the main ballast line. Within approximately 30 minutes, the ClO_2 concentration is typically reduced down to between 1.0 ppm and 3.0 ppm by a rapid reaction with organic matter (Ecochlor 2006). This initial consumption is defined as the “ClO_2 demand” of the treated ballast water. Residual ClO_2 then exponentially decays at a substantially lower rate until it is totally consumed.

The half-life of ClO_2 in the treated ballast water depends greatly on the organic matter content of the water into which it is introduced (i.e., source where ballast water is taken into the ship) and temperature. Analysis of treatment tests conducted by Ecochlor have shown that levels of ClO_2 in Newark harbor water drops from the 5 ppm level initially to between 0.1 and non detectable within 24 hours at 10°C. Half-lives of ClO_2 in other source waters differed but not significantly. Chlorine dioxide injected into ballast tanks is typically 99% consumed in 1.5 - 3 days at these temperatures regardless of source water tested (Ecochlor 2006b).

ClO_2 use will form some chlorite as an intermediate. Ecochlor’s testing has found in the laboratory, and through shipboard testing, that chlorite appears in ballast water at levels between 25% and 60% of the initial ClO_2 dosage (ACL2006). This chlorite level will also decay over time as it reacts with various substances (organics, metals) in the water. Laboratory studies have revealed that chlorite has a half-life of up to 30.3 days at 20°C in Newark and 10.5 days at 20°C in Baltimore waters. By these numbers, it would take approximately 200 days in Newark waters to achieve 99% decomposition of chlorite. Similarly, it could take up to 70 days in Baltimore waters for chlorite to decompose by 99%.

Previously, it was assumed that the organic matter contained in the receiving waters would provide sufficient “chlorite demand” (i.e., an initial rapid consumption of chlorite in 15-30 min by reaction with organic matter contained in the receiving water) to rapidly consume any chlorite discharged. However, availability of reactive organic matter does not seem to be the sole determining factor in the reaction with chlorite. Environmental chlorite demand consumes a relatively constant fraction of chlorite, irrespective of the degree to which it is diluted in the environment. Also, it appears that different receiving waters possess differing chlorite demand. For example, Newark water demand consumes half to two-thirds of the available chlorite, whereas Baltimore water consumes only about one-fourth of available chlorite. Therefore, until further site specific data are collected, dilution of chlorite in the receiving waters will be the primary determinant considered in reducing its concentration.

The reaction of chlorite (and ClO_2) appears to accelerate in sunlight. While studies have shown that ClO_2 is very rapidly consumed in sunlight, only qualitative evidence suggests this for chlorite. The chlorine dioxide decomposition by-product chlorate, is a relatively minor end product of the ultimate fate of ClO_2 with chlorate levels at approximately 10% of the ClO_2 dose, or about 0.5 ppm or less appearing as chlorate (Ecochlor 2006b).

Because the US voyages of the *Atlantic Compass* are less than five days, residual ClO_2 in recently used ballast tanks may not have decayed to undetectable levels by the time the ship arrives in the Chesapeake Bay from Newark for further cargo operations and ballasting. However any remaining ClO_2 discharged in US waters is reported by the applicant to be at levels low enough to be below EPA discharge standards for chlorite, chlorate and chlorine dioxide residuals. (Ecochlor 2006b)

Chlorine dioxide, sodium chlorate and sodium chlorite are EPA Registered chemicals for use as biocides in water.

4.2 Water Quality

4.2.1 No Action Alternative

Under the No Action Alternative the *Atlantic Compass* with the Ecochlor BWT system would not be accepted into STEP and would continue to be required to comply with current and future Coast Guard ballast water management regulations. Therefore, under the No Action Alternative, the practices of the *Atlantic Compass* would be expected to remain unchanged. Under the existing regulations, the *Atlantic Compass* regularly exercises a safety waiver from conducting BWE. Therefore it routinely discharges ballast water into US ports potentially taken from any of its route ports of call in Western Europe and North America. Therefore the risk of a NIS introduction from the *Atlantic Compass*, as with any vessel discharging unexchanged or untreated ballast water remains.

4.2.2 Proposed Action Alternative

Under the proposed action, the *Atlantic Compass* would be accepted in to STEP, and the vessel would use the Ecochlor BWTS to reduce the abundance of organisms in discharged ballast water. The killing of various species, and their degradation and settling in the ballast tanks during transit, may result in a lower organic matter load at discharge. The possible residuals of chlorite, chlorate and chlorine dioxide remaining in the discharged water was described and discussed above.

The BWTS will also sometimes discharge treated ballast water that is of a lower pH (<0.6 units lower) than harbor receiving waters. However, as pH typically varies more than 0.2 units in many estuarine waters and since the discharge pH will still generally be near neutrality, the slightly acidic discharged water would not pose a significant negative impact. In addition, as waters being discharged can come from a variety of ballasting locations, even without the BWTS it is likely that the characteristics of the discharge waters will differ from the waters receiving the discharge (e.g Newark versus Baltimore or Portsmouth).

Overall, it is expected that the potential water quality impacts associated with the *Atlantic Compass* discharging treated ballast water would be negligible. As part of the evaluation of the performance of the Ecochlor BWTS on the *Atlantic Compass,* the treated ballast water discharged from the vessel will be monitored regularly to assess the degree to which concentrations of residuals conform to the predicted levels. Any discharges exceeding the design levels will be noted and reported in the regular submitted reports. All discharges must comply with applicable federal and state requirements.

4.3 Public Health and Safety

Since the system has already been installed, either alternative has the same risk to public health and safety arising from the chlorine dioxide gas used for the treatment.

Chlorine dioxide is a reactive substance. It is poisonous to humans; it is also a skin, eye, and respiratory irritant. Additionally, it can enhance the combustion potential of other substances. (OSHA, 2007). However, even though chlorine dioxide is a poisonous gas, there are no applicable emissions standards regulating emissions of chlorine dioxide. This is because chlorine dioxide quickly breaks down in air; and, it is unlikely for the average person to be able to breathe air containing dangerous levels of chlorine dioxide. There could be adverse consequences to public health and safety from this action if the chlorine dioxide is not handled appropriately. However, the

Ecochlor system does not store any ClO_2, rather it generates it as needed as a 0.25% solution, which is then diluted down to a concentration of 5 ppm in the ballast water tanks (Ecochlor 2006). Finally, chlorine dioxide has been used in municipal and industrial water disinfection for over 50 years, and safe handling procedures are well developed and have been incorporated into the standard operation and maintenance procedures for the Ecochlor system, which comply with OSHA handling standards. Therefore, although adverse consequences are possible with the use of chlorine dioxide, the risk would be low and therefore impacts to public health and safety are reasonably concluded to be well mitigated and not significant.

5.0 CUMULATIVE IMPACTS

The Council on Environmental Quality defines cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 CFR 1508.7).

5.1 Cumulative Impacts Associated with the Alternatives

- No Action Impacts: In current practice the *Atlantic Compass* discharges into US waters unexchanged Ballast Water (BW) from various ports of Europe and North America. This discharge, represents a small but real risk of additional NIS introductions into US waters. In the context of the cumulative effects of coastal and estuarine development and commercial and recreational boating activities which have very significant impacts to marine habitats, resource sustainability and ecosystem resilience, any single ship could serve as the vector for an NIS that tips the ecological balance in a given US water body. Because the *Atlantic Compass* routinely exercises an exemption so that it does not conduct BW management, the threat of NIS introductions from its current operations under no action would remain real.

- Proposed Action Impacts:

  The STEP PEA discusses the scope of shipboard experiments sought by the USCG for informing the development, implementation and enforcement of a National BW management program that is protective of US waters from NIS introductions. Since only a small number of ships are intended to operate experimental treatment technologies, no significant cumulative impact from the proposed action is expected. Further, all ballast water discharged from the *Atlantic Compass* will have been treated by the chemical dosing system, with resultant NIS concentrations intended to meet or exceed the STEP's treatment performance requirements. Directly this leads to a much lower probability of this ship facilitating viable NIS entering US waters via ballast water. However, given the low frequency and volumes of discharges in the ports receiving discharged ballast water, the primary impact of the proposed action will be the gathering of data for development and refinement of a ballast water discharge standard and BWT testing procedures. Indirectly, this will lead to a net cumulative environmental benefit as a more robust and effective ballast water management regulatory regime can be promulgated.

6.0 COMPARISON OF THE ALTERNATIVES AND CONCLUSION

Table 6-1 compares the potential consequences of the Proposed Action Alternative and the No Action Alternative.

Table 6-1: Comparison of the Environmental Impacts Associated with the NEPA Alternatives

Category	No Action Alternative	Proposed Action Alternative
Biological Resources	No adverse impacts	Negligible adverse impacts; potential beneficial impacts
Water Quality	No adverse impacts	Negligible adverse impacts; potential beneficial impacts
Air Quality	No adverse impacts	Negligible adverse impacts
Public Health and Safety	No adverse impacts	No adverse impacts
Socioeconomics and Environmental Justice	Negligible adverse impacts.	No adverse impacts, potential beneficial impacts

Conclusion

There is a long term, programmatic benefit of the Proposed Action alternative. By accepting the *Atlantic Compass* and the Ecochlor BWT system into STEP, the USCG would acquire valuable information on the shipboard performance and treatment effectiveness of the Chlorine Dioxide dosing BWT system. This information will be critical in the further development of effective ballast water treatment technologies and in the development of feasible and sound ballast water management policy and regulations as mandated by Congress. Such benefits would have wide geographic scope as prototype treatment technologies move to larger scale production and installation on larger numbers of ships.

The conclusion of the environmental consequences analysis is that negligible adverse impacts would result from the implementation of the Proposed Action. Additionally, based on the logic presented in Sections 4 and 5, the Proposed Action may potentially result in minor beneficial impacts through the reduction of risk of the introduction of NIS from the *Atlantic Compass*.

7.0 LIST OF PREPARERS

United States Coast Guard

Richard Everett
Environmental Protection Specialist
B.A., Biology, University of California, Santa Cruz
Ph. D., Zoology and Integrative Biology, University of California, Berkeley

Ronald P. Jackson
Environmental Protection Specialist
B.A. Chemistry, LaSalle University
J.D. University of Baltimore School of Law

LCDR Brian Moore
Staff Officer
B.S. Secondary Education, Earth Sciences, University of Texas, Austin
M.S. Environmental Earth Science and Policy, Johns Hopkins University
M.S. Quality Systems Management, National Graduate School, Falmouth MA

Volpe National Transportation Systems Center

Nicole R. Grewell
Environmental Protection Specialist
B.S. Biology, Messiah College
M.S. Environmental Engineering and Urban and Environmental Policy, Tufts University

Amishi Joshi
Environmental Scientist
B.A. Geology, Pomona College
Ph.D. Earth and Environmental Science, University of Pennsylvania

Adam F. Klauber, Leadership in Energy and Environmental Design AP
Environmental Protection Specialist
B.A. Political Science, Hobart and William Smith Colleges
M.P.A. Environmental Science and Policy, Columbia University

José G. Mantilla
Environmental Engineer
B.S. Industrial Engineering and Operations Research, Universidad Javeriana
M.S. Environmental Engineering, Massachusetts Institute of Technology

Paul Valihura
Environmental Scientist
B.S. Industrial Management, Lowell Technological Institute
M.S. Environmental Studies, University of Lowell
Ph.D. Urban and Environmental Studies, Rensselaer Polytechnic Institute

Coastal Environmental Associates

Brian L. Howes
Professor, University of Massachusetts Dartmouth
B.A. Biology, Rutgers College
M.A. Biology, Boston University Marine Program
Ph.D. Biology, Boston University Marine Program

Craig D. Taylor
Associate Scientist, Woods Hole Oceanographic Institution
B.S. Biology, Portland State University
M.S. Biology, Portland State University
M.S. Microbiology, University of Illinois, Urbana
Ph.D. Microbiology, University of Illinois, Urbana

8.0 LIST OF AGENCIES AND PERSONS CONSULTED

Deb Carter
Division of Endangered Species
U.S. Fish and Wildlife Service

Pat Carter
Division of Endangered Species
U.S. Fish and Wildlife Service

Jayson Cahn
Office of Protected Resources
U.S. National Marine Fisheries Service

John Lishman
Headquarters Office
U.S. Environmental Protection Agency

Gary Stern
Office of Protected Resources (California)
National Marine Fisheries Service

Arlene Pangelinan
Office of Protected Resources (Hawaii)
National Marine Fisheries Service

9.0 REFERENCES

Atlantic Container Line (ACL) 2006. Shipboard Technology Evaluation Program (STEP) Application for the *Atlantic Compass* using the Ecochlor Ballast Water Treatment System. Washington, D.C.: US Coast Guard.

Chesapeake Bay Program (CBP) 2006. Chesapeake Bay Program. http://www.chesapeakebay.net/. (accessed October 9, 2006).

Ecochlor 2006. Ecochlor Ballast Water Treatment System. http://www.ecochlor.com/ecochlor_system.htm (accessed September 18, 2007).

Ecochlor 2006b. Chlorine Dioxide Fate Study. Unpublished white paper. Ecochlor.

Harbor Estuary Program (HEP) 1996. Final Comprehensive Conservation and Management Plan. New York-New Jersey Harbor Estuary Program. http://www.seagrant.sunysb.edu/hep/mgmt.htm (accessed December 20, 2006)

Harbor Estuary Program (HEP) 2006. New York-New Jersey Harbor Estuary Program. Available online: http://www.seagrant.sunysb.edu/hep/index.htm (accessed December 20, 2006).

Maryland State Archives 2007. Maryland at a Glance. www.msa.md.gov/msa/mdmanual/01glance/html/port.html (accessed May 4, 2007).

Noel 2006. Personal Communication from George Noel of the Volpe Center Air Quality Facility (Cambridge, Massachusetts) to Amishi Joshi of the Volpe National Transportation Systems Center on September 19, 2006.

New York Department of Environmental Protection (DEP) 2004. New York Harbor Water Quality – Regional Summary. New York City Department of Environmental Protection. http://www.ci.nyc.ny.us/html/dep/html/news/hwqs.html (accessed October 20, 2006).

New York State (NYS) 2005. Final Report of the New York State Invasive Species Task Force. New York State Department of Environmental Protection. http://www.dec.state.ny.us/website/dfwmr/habitat/istf/istfreport1105.pdf (accessed December 15, 2006).

Ruiz, G. M.(2000), P. W. Fofonoff, J. T. Carlton, M. J. Wonham, and A. H. Hines. Invasion of coastal marine communities in North America: Apparent patterns, processes, and biases. Annual Review of Ecology and Systematics 31: 481-531

United States Environmental Protection Agency (EPA) 1995. Environmental Protection Agency. *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources.* AP 42, Fifth Edition. Washington, D.C.: Environmental Protection Agency.

United States Environmental Protection Agency (EPA) 1997. Environmental Protection Agency. "Fact Sheet: National Emission Standards to Control Hazardous Air Pollutants Emitted From Pulp and Paper Mills." Washington, D.C.: Environmental Protection Agency.

United States Environmental Protection Agency. National Estuary Program Coastal Condition Report - NEP CCR (2007) http://www.epa.gov/owow/oceans/nepccr/index.html

United States Coast Guard (USCG) 2000. National Environmental Policy Act: Implementing Regulations and Policy for Considering Environmental Impacts. COMDTINST M16475.1D. Washington D.C.:

United States Coast Guard (USCG) 2004a. United States Coast Guard's Shipboard Technology Evaluation Program. http://www.uscg.mil/hq/g-m/mso/step.htm. (accessed December 2, 2006).

United States Coast Guard (USCG) 2004b. Final Programmatic Environmental Assessment for Shipboard Technology Evaluation Program (STEP) for U.S. Waters. Washington, D.C.: United States Coast Guard. http://dmses.dot.gov/docimages/pdf90/307046_web.pdf (accessed November 12, 2006).

United States Fish and Wildlife Service (USFWS) 2006a. The Endangered Species Program. http://www.fws.gov/Endangered/ (accessed December 20, 2006).

United States Fish and Wildlife Service (USFWS) 2006b. Threatened and Endangered Species. Chesapeake Bay Field Office. http://www.fws.gov/chesapeakebay/EndSppWeb/index.htm (accessed December 19, 2006).

United States Geological Service (USGS) 2006a. Natural Resources in the Chesapeake Bay Watershed. http://biology.usgs.gov/s+t/noframe/m4148.htm (accessed December 14, 2006).

United States Geological Service (USGS) 2006b. Chesapeake Bay Activities – Water Quality and Quantity. http://chesapeake.usgs.gov/water.html (accessed December 14, 2006).

United States Occupational Safety and Health Administration (OSHA) 2007. Chemical safety data sheet for Chlorine Dioxide, accessed 17 Oct 2007. http://www.osha.gov/SLTC/healthguidelines/chlorinedioxide/index.html

10.0 APPENDICES

Appendix A. Acronyms and Abbreviations

ANS	Aquatic Nuisance Species
B-IBI	Benthic- Biological Index
BW	Ballast Water
BWD	Ballast Water Discharge
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWTS	Ballast Water Treatment System
CAA	Clean Air Act of 1990
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
ClO_2	Chlorine Dioxide
EA	Environmental Assessment
E.O.	Executive Order
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act of 1973
FONSI	Finding of No Significant Impact
NAAQS	National Ambient Air Quality Standards
NANPCA	Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990
NEPA	National Environmental Policy Act of 1969
NIS	Non-indigenous Species
NISA	National Invasive Species Act of 1996
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NVIC	Navigation and Vessel Inspection Circular
PAH	Poly Aromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PEA	Programmatic Environmental Assessment
PLC	Programmable Logic Controller
ppb	Parts Per Billion
ppm	Parts Per Million
psu	Practical Salinity Units
SAV	Submerged Aquatic Vegetation
SSDG	Ship Service Diesel Generator
STEP	Shipboard Technology Evaluation Program
TBT	TributylTin
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOCs	Volatile Organic Compounds

Appendix B. Example of Section 7 letter sent to resource agencies.

September 15, 2006

Contact Name, Title
Address

Dear [Title],

I am writing you on behalf of the United States Coast Guard (USCG), who is currently using the NEPA process to evaluate the impacts of a proposed project under the USCG's Shipboard Technology Evaluation Program (STEP). STEP is a voluntary program through which vessel owners can apply for acceptance of experimental ballast water treatment (BWT) systems installed and tested on board their operating vessels. STEP is available to all vessels subject to the USCG Ballast Water Management (BWM) regulations (33 CFR § 151 Subparts C and D). The USCG prepared a Draft Programmatic Environmental Assessment (PEA) for the implementation of the Shipboard Technology Evaluation Program (STEP) in April 2004.

The program is designed to provide incentive to ship owners and operators to install experimental treatment systems with demonstrated potential for effective removal or destruction of non-indigenous species (NIS) in ballast water. The USCG and the applicant enter into an agreement where the applicant's vessel is accepted into the STEP for a specific period of time, whereby valuable experimental data accrues to the Federal government and, during which operation of the experimental system is considered equivalent to meeting applicable regulatory requirements for ballast water management.

In order to be accepted into the STEP, each application must undergo an associated environmental review. The Atlantic Container Line (ACL) has applied to the STEP for its vessel, the *Atlantic Compass*, thereby initiating a review for acceptance to the program. ACL plans to utilize the Ecochlor treatment system, which uses chlorine dioxide as the key treatment element, on the vessel to remove the NIS from the ballast water taken from and dispelled to these locations. According to their application, ACL operates a regular route with stops in Newark, NJ; Baltimore, MD; and Portsmouth, VA.

The USCG is proposing to grant ACL acceptance to the program, and will be evaluating the impacts of the proposed action in an Environmental Assessment. A concerning issue to be examined in the EA is the residuals discharged from the system and any potential impacts associated with those discharges. According to their application, the Ecochlor treatment system uses a chlorine dioxide dosage level of 5 ppm, residuals of which quickly decay. Chlorine dioxide may also form chlorite and chlorate as a by-product. According to testing completed by ACL and Ecochlor, the levels of chlorite ions in the ballast water discharge may range from 2.09-2.48 mg/L. The testing regarding levels of by-products are currently being reviewed, and further tests will ensue toward this end.

The purpose of this letter is to notify you that concurrent with the NEPA process, the USCG intends to meet its obligations under the Endangered Species Act (ESA) of 1973. In accordance with Section 7c(1) of the ESA, the Migratory Bird Treaty Act, and any other pertinent legislation, regulations, or treaties regarding the protection of endangered species, I am writing to officially request information on whether any species, or their critical habitats, which are listed, proposed to be listed, candidates to be listed, or otherwise protection may be present within the potential study areas. The USCG will use this information to determine potential effects of the proposed action on those identified species and habitats.

We will be sending you a copy of the Draft EA shortly. Please advise us of any environmental concerns that you feel should be addressed. Should you have any questions, please feel free to contact me.

Sincerely,

Nicole R. Grewell
Environmental Protection Specialist
USDOT Volpe Center
55 Broadway
Cambridge, MA 02142
617-494-2494
617-494-2789 (f)

Appendix C. Air Quality Analysis

Air Quality Standards

The Federal Clean Air Act of 1990 (CAA) protects and enhances the quality of the Nation's air resources, promoting public health and welfare and the productive capacity of its population. The CAA regulates air pollutant emissions via the establishment of National Ambient Air Quality Standards (NAAQS). Since the system under consideration is already installed onboard the ship, the two alternatives considered in this EA use the same amount of ships service electricity to operate and the amount of energy required to operate the system is negligible relative to the overall ship generation needs.

Air Quality in the Affected Environment

New Jersey, Maryland and Virginia monitor air quality to assess compliance with NAAQS. If levels of an air pollutant violate the NAAQS, the EPA designates the area as a 'nonattainment area' and measures must be taken to improve air quality for that pollutant including forbidding all activities which contribute additional pollutants. An area can also be designated as a 'maintenance area', which means that it recently exceeded the ambient standards, but it is now in attainment. Of the U.S. ports listed in the planning area, all were found to be in a nonattainment or maintenance area for at least one pollutant.

Environmental Consequences

Under the Proposed Action Alternative, air quality impacts associated with the BWT technology being evaluated in this EA may arise from one source: the emissions from the SSDG that powers the Ecochlor treatment system. This is a particular concern at all the US ports as they are located in a nonattainment or maintenance area for at least one pollutant.

As mentioned, the *Atlantic Compass* uses the SSDG to generate shipboard electrical power, and this electricity powers the Ecochlor system. In general, vessels such as the *Atlantic Compass* have 2-3 SSDGs sized between 2000 and 5000 kW on board. Thus, during ballasting operations (when the Ecochlor system is in use), there would be some incremental added loading of the SSDG – the Ecochlor system uses a maximum of 4.74 kilowatts (kW) of the ship's electrical power. The Ecochlor technology would likely be activated for less than a total of 200 hours annually.

A preliminary emissions inventory, using emissions factors (for stationary internal combustion sources) found in AP 42 (EPA 1995), indicated that 5 kW of energy supplied by a large stationary diesel-fuel engine for 200 hours annually would result in annual emissions of each pollutant of far less than one ton. If an emissions amount of one ton were put into a screening model (e.g. SCREEN3 (EPA's air pollution screening model)), using conservative inputs for characteristics from a vessel such as the *Atlantic Compass*, then the ground level concentrations of that pollutant would be negligible to immeasurable (Noel 2006).

Furthermore, it is unlikely that an SSDG would be activated solely for the purposes of operating the BWT system; in other words, the BWT system would simply draw more current from an SSDG that is running regardless. Finally, no additional sources of electrical power would be installed onboard to accommodate the BWT system. Therefore, using the Ecochlor system would not result in any new emissions, as it is possible that no additional electrical power sources are being operated or installed.

As emissions from the operation of the Ecochlor system are negligible, local or regional levels of pollutants will not be affected, including levels in the aforementioned area of concern in New Jersey, Maryland and Virginia.

Emissions of chlorine dioxide gas are of concern when evaluating air quality impacts of the Ecochlor system. However, because chlorine dioxide gas is so unstable, it would exist only in the immediate vicinity of the point of release, and disintegrate quickly to chlorine gas and oxygen (EPA 1997). Regarding air quality in the workplace environment, the concentration of chlorine dioxide in the workplace air of industries that use chlorine dioxide has been measured at anywhere from <1 to 300 parts per billion (ppb) (EPA 1997). OSHA sets the occupational exposure limit for an 8-hour workday, 40-hour workweek at 0.1 ppm. The high end of the range of measured levels of chlorine dioxide in workplace air has the potential to exceed the OSHA regulation. However, that higher concentration of chlorine dioxide (300 ppb) was measured in the bleach/chemical preparation area of a pulp mill. It is unlikely that such ambient concentrations of chlorine dioxide would be produced as a result of the sporadic use of the Ecochlor system for BWT. Nevertheless, all applicable and prudent workplace safety regulations and precautions should be taken during the operation of the Ecochlor system. It can be concluded that the Proposed Action Alternative will have negligible impacts on air quality.

Appendix D. Correspondence received via agency consultation.

Appendix E. Ecochlor chemistry

Chlorine dioxide is generated in a turnkey system in which a commercially available feedstock, Purate (a mixture of sodium chlorate [$NaClO_3$] and hydrogen peroxide [H_2O_2]), is mixed with commercial sulfuric acid. The resulting ClO_2 containing solution is metered into the flowing ballast water (upon uplift via a manifold that is downstream of the ballast pump) to achieve a target dosage of 5.0 parts per million (ppm) ClO_2. Chorine dioxide is a strong oxidant and readily reacts with organic matter including organisms contained in the ballast water. The typical transformation of ClO_2 in its interaction with organic matter follows the general sequence of reactions in Equation 1:

$$ClO_2 \rightleftharpoons ClO_2^{1-} \rightarrow ClO_3^{1-} + Cl^{1-} \qquad \text{Equation 1}$$

Equation 1 shows the transformation of ClO_2 first into the intermediate chlorite (ClO_2^{1-}) and ultimately into the terminal products chlorate (ClO_3^{1-}) and chloride (Cl^{1-}). A fraction of the ClO_2^{1-} formed can be disproportionated back into ClO_2. The relative rates of these reactions are very much influenced by temperature, pH, organic matter content of the water, and the presence or absence of light (for more details, see Appendix B). Within approximately 30 minutes, the ClO_2 concentration is typically reduced to a residual concentration between 1.0 ppm and 3.0 ppm by a rapid reaction with organic matter within the ballast water (ACL 2006). The initial rapid consumption is defined as the “ClO_2 demand” of the treated ballast water. This residual then decays at a substantially lower rate until it is totally consumed.

According to Ecochlor, there should be no ClO_2 residual in the ballast water at the time of discharge (ACL 2006). It was suggested that the holding times for treated ballast water on the ACL would typically be approximately five days, consistent with the BWTS effectiveness testing using a 5 day end-point. However, ballast reporting forms provided by ACL indicate that very short ballast water holding times of one or two days are typical (Newark to Baltimore, one day; Halifax or Portsmouth to Newark, two days; and likely Baltimore to Portsmouth one day). Therefore, in order to assess the level of ClO_2 and chlorite/chlorate residuals discharged in treated ballast water from the ACL BWT system in U.S. ports, it was necessary to determine the likely holding times and ballast discharge volumes as holding time is a key component of degradation. Since holding times and volumes vary with the specific logistics of each voyage, the assessment focused on conservative numbers based upon data provided by ACL. Minimum holding times and maximum volumes were determined, as these define the likely upper limits of the concentration of residuals in discharge. Maximum discharge volumes were based upon the assumption that all of the water discharged at a port was taken on board at the previous port where ballasting occurred. Ballast water minimum holding times, based upon records October 17 - November 27, 2006, ranged as follows:

- Newark, NJ Ballast - Baltimore, MD Deballast
    - 10/18/06, 1 day holding time
    - 11/24/06, 2 day holding time.
- Newark, NJ Ballast - Portsmouth, VA Deballast
    - 11/25/06, 3 day holding time.
- Portsmouth, VA Ballast - Newark, NJ Deballast
    - 11/27/06, 2 day holding time
- Halifax, NB Ballast - Newark Deballast
    - 11/22/06, 2 day holding time

The maximum ballast water discharge in any port was 4,847 metric tons (sourced from several ports). However, 1,533 metric tons was ballasted in a single port (Newark).

Analysis of residuals examined both short (one to two days), intermediate (three to five days) and long duration (30 days) voyages (see Ecochlor 2006b). The half-life of ClO_2 in seawater depends greatly on the organic matter content of the water into which it is introduced and temperature. Organic content of water can vary greatly among locations, depending on numerous circumstances, and this will affect the amount of residual remaining in the ballast water. For example, laboratory studies conducted by Ecochlor

(2006b) have shown that the half life of ClO_2 in Newark harbor water is quite short, ranging between 0.43 hours and 2.7 hours at 24°C and 4°C, respectively (the typical seasonal temperatures the *Atlantic Compass* would experience). Over this temperature range, ClO_2 is 99 percent consumed in around 3 to 18 hours, respectively.

Chlorine dioxide decay studies completed in Baltimore waters show a substantially slower decomposition rate. The half-life of ClO_2 collected from Baltimore Harbor was found to be 9.1 hours at 20°C, with 99 percent decomposition achieved around 61 hours (or 2.5 days). This is longer than most of the ballast holding times reported by ACL for transits between regularly visited U.S. ports. If temperature effects[1] are similar to that of Newark harbor, the half-life of ClO_2 decomposition at 4°C in Baltimore waters could be as high as 45 hr (1.9 days), therefore requiring almost 13 days to achieve 99 percent decomposition (ACL 2006). When the initial ClO_2 demand in Baltimore waters (as measured by the Ecochlor studies) is taken into consideration[2] a 5 ppm dose of ClO_2 is decomposed to about 0.5 ppm in five days, 1 ppm in three days, 1.45 ppm in two days and 2.08 ppm in one day at 4°C. Therefore, under most circumstances at moderate temperatures (e.g., 5 - 20° C), there would likely be ClO_2 residual in the ballast water at the time of discharge, after short (1-2 day) and moderate (3-5 days) length voyages, but not after longer (10-30 days) voyages However, at low winter temperatures, Baltimore ballast water at discharge may contain significant residual ClO_2 of 1.45-2.08 ppm after short voyages (1-2 days) and 1-0.5 ppm after moderate (3-5 days) duration voyages. Even during warmer months, treated Baltimore ballast water would contain approximately 0.5 ppm after 1 day.

Study of Baltimore water was conducted only at 20°C.

[2] Initial rapid decomposition (ClO_2 demand) reduces the dose of ClO_2 from 5ppm to as high as 3 ppm, which in turn is decomposed with a half-life of approximately 1.9 days. This results in ballast water ClO_2 residuals of about 0.5 ppm after residing in the ballast tank for 5 days; but only approximately 2 ppm after 1 day at 4°C.

Appendix F Toxicity of Applicable Chlorine species

Table F-1. Toxicity of chlorine dioxide on all organisms.

Toxicology studies from the primary scientific literature on aquatic organisms

Use(s): Microbiocide, Water Treatment Chem Class: Inorganic U.S. EPA PC Code: 020503 CAS Number: 10049-04-4

Sorted by Organism Group, Effect, Measurement, Endpoint and LatinName.

Note: Only partial study information is reported on these pages. Full study information can be found at the U.S. EPA AQUIRE web site.

Records 1 to 37 of 37

First Previous Next Last

Common Name Scientific Name	Effect	Measurement	Life Stage	Study Time	Toxicity Endpoint	Toxic Dose			Conc Units	Conc Type	Chem Desc	Exper. Type	Acute Tox Rating	Outlier	Year
						Mean	Min	Max							
Green or Europeon shore crab Carcinus maenas	Mortality	Mortality	ADULT	48 h	LC50	500,000	-	-	ug/L	T	DOXCIDE	Renewal	Not Acutely Toxic		1971
Common shrimp, sand shrimp Crangon crangon	Mortality	Mortality	ADULT	48 h	LC50	500,000	-	-	ug/L	T	DOXCIDE	Renewal	Not Acutely Toxic		1971
Aesop shrimp Pandalus montagui	Mortality	Mortality	ADULT	48 h	LC50	500,000	-	-	ug/L	T	DOXCIDE	Renewal	Not Acutely Toxic		1971
Red swamp crayfish Procambarus clarkii	Mortality	Mortality	adult	48 h	LC50	610,000	503,000	774,000	ug/L	F	NR	Static	Not Acutely Toxic		2000
Purple sea urchin Strongylocentrotus purpuratus	Growth	Abnormal	EMBRYO	48 h	NR	25,000	-	-	ug/L	T	AQ, 25 %	Static			1989
Purple sea urchin Strongylocentrotus purpuratus	Growth	Abnormal	EMBRYO	48 h	NR	2,500	-	-	ug/L	T	AQ, 25 %	Static			1989
Harlequinfish, red rasbora Rasbora heteromorpha	Mortality	Mortality	1-3 CM	24 h	LC50	9,600,000	-	-	ug/L	F	2% CHLORINE DIOXIDE, DOXCIDE 50	Flow through	Not Acutely Toxic	Outlier	1975
Harlequinfish, red rasbora Rasbora heteromorpha	Mortality	Mortality	1-3 CM	96 h	LC50	6,500,000	-	-	ug/L	F	2% CHLORINE DIOXIDE, DOXCIDE 50	Flow through	Not Acutely Toxic		1975
Brown trout Salmo trutta	Mortality	Mortality	YEARLING, FINGERLING	48 h	LC50	10,000,000	-	-	ug/L	F	DOXIDE 50	Not reported	Not Acutely Toxic		1974
Atlantic salmon Salmo salar	Mortality	Mortality	199.5 DEGREED, POST STRIPPING EGGS	24 h	LD50	1,807,500	-	-	ug/L	T	NR	Not reported			1993
Kelp bass Paralabrax clathratus	Mortality	Mortality	EGGS, 24 H	48 h	NR	2,500	-	-	ug/L	T	AQ, 25 %	Static			1989
Atlantic salmon Salmo salar	Mortality	Mortality	EGGS, 233.2-334 DEGREE	21 d	NR	-	6,250	25,000	ug/L	T	NR	Pulse			1993

			DAYS POST/												
Fungi Saprolegnia parasitica	Population	Abundance	NR	1 h	NR	-	12,500	25,000	ug/L	T	NR	Pulse			1993
Zebra mussel Dreissena polymorpha	Behavior	Ability to detach from substrate	NR	NR d	NR	-	125.0	500.0	ug/L	T	NR	Flow through			1993
Cockle Cerastoderma edule	Mortality	Mortality	ADULT	48 h	LC50	500,000	-	-	ug/L	T	DOXCIDE	Renewal	Not Acutely Toxic		1971
Zebra mussel Dreissena polymorpha	Mortality	Mortality	NR	24 h	LC50	400.0	-	-	ug/L	T	NR	Flow through	Highly Toxic		1992
Zebra mussel Dreissena polymorpha	Mortality	Mortality	ADULT, >=10 MM	NR d	LC50	13,000	-	-	ug/L	F	NR	Pulse	Slightly Toxic		1996
Zebra mussel Dreissena polymorpha	Mortality	Mortality	ADULT, >=10 MM	72 h	LC50	490.0	-	-	ug/L	F	NR	Flow through	Highly Toxic		1996
Zebra mussel Dreissena polymorpha	Mortality	Mortality	ADULT, >=10 MM	96 h	LC50	350.0	-	-	ug/L	F	NR	Flow through	Highly Toxic		1996
Asiatic clam Corbicula manilensis	Mortality	Mortality	<1.0 MM, JUVENILE	~ 0.7 d	LT50	1,210	-	-	ug/L	T	NR	Flow through			1989
Asiatic clam Corbicula manilensis	Mortality	Mortality	<1.0 MM, JUVENILE	~ 0.6 d	LT50	4,740	-	-	ug/L	T	NR	Flow through			1989
Green algae Cladophora sp.	Biochemistry	Chlorophyll	THREE 3 CM FILAMENTS, 300 CELLS	24 h	NR	2,600	-	-	ug/L	T	NR	Static			1969
Green algae Cladophora sp.	Cell(s)	Cell changes	THREE 3 CM FILAMENTS, 300 CELLS	24 h	NR	52,000	-	-	ug/L	T	NR	Static			1969
Giant kelp Macrocystis pyrifera	Reproduction	Reproduction, general	MEIOSPORES	48 h	NR	25,000	-	-	ug/L	T	AQ, 25 %	Static			1989
Giant kelp Macrocystis pyrifera	Reproduction	Reproduction, general	MEIOSPORES	48 h	NR	2,500	-	-	ug/L	T	AQ, 25 %	Static			1989
Water flea Daphnia pulex	Intoxication	Immobile	adult	48 h	EC50	1,800	900.0	2,700	ug/L	F	NR	Static			2000

Table F-2. Toxicity of Sodium Chlorite on all Organisms

Toxicology studies from the primary scientific literature on aquatic organisms

Use(s): Microbiocide, Water Treatment Chem Class: Inorganic U.S. EPA PC Code: 020502 CAS Number: 7758-19-2

Sorted by Organism Group, Effect, Measurement, Endpoint and LatinName.

Note: Only partial study information is reported on these pages. Full study information can be found at the U.S. EPA AQUIRE web site.

Common Name Scientific Name	Effect	Study Time	Toxicity Endpoint	Toxic Dose	Conc Units	Exper Type	Acute Tox Rating	Year
Sheepshead minnow Cyprinodon variegatus	Mortality	96 h	LC50	75,000	ug/L	Flow through	Slightly Toxic	2000
Bluegill Lepomis macrochirus	Mortality	96 h	LC50	196,000	ug/L	Static	Not Acutely Toxic	2000
Bluegill Lepomis macrochirus	Mortality	96 h	LC50	231,000	ug/L	Static	Not Acutely Toxic	2000
Bluegill Lepomis macrochirus	Mortality	240 h	LC50	165,000	ug/L	Flow through	Not Acutely Toxic	2000
Bluegill Lepomis macrochirus	Mortality	96 h	LC50	-	ug/L	Static	Not Acutely Toxic	2000
Bluegill Lepomis macrochirus	Mortality	72 h	LC50	207,000	ug/L	Static	Not Acutely Toxic	2000
Bluegill Lepomis macrochirus	Mortality	96 h	LC50	270,000	ug/L	Static	Not Acutely Toxic	2000
Rainbow trout,donaldson trout Oncorhynchus mykiss	Mortality	96 h	LC50	216,000	ug/L	Static	Not Acutely Toxic	2000
Rainbow trout,donaldson trout Oncorhynchus mykiss	Mortality	312 h	LC50	38,000	ug/L	Flow through	Slightly Toxic	2000
Fungi Trichoderma hamatum	Population	48 h	LOEC	-	ug/L	Not reported		1998
Marine sponge Microciona prolifera	Cell(s)	10 mi	NR	-	ug/L	Static		1997
American or virginia oyster	Intoxication	96 h	EC50	14,300	ug/L	Flow through		2000

Crassostrea virginica								
Zebra mussel Dreissena polymorpha	Mortality	30 mi	NR	-	ug/L	Flow through		1996
Green algae Selenastrum capricornutum	Populati on	4 d	EC50	1,180	ug/L	Static		2000
Blue-green algae Nostoc calcicola	Populati on	14 d	EC50	-	ug/L	Not reported		1998
Green algae Selenastrum capricornutum	Populati on	96 h	EC50	-	ug/L	Not reported		1998
Brown algae Ectocarpus variabilis	Populati on	14 d	LOEC	-	ug/L	Not reported		1998
Blue-green algae Nostoc calcicola	Populati on	14 d	LOEC	-	ug/L	Not reported		1998
Green algae Selenastrum capricornutum	Populati on	96 h	LOEC	-	ug/L	Not reported		1998
Green algae Selenastrum capricornutum	Populati on	96 h	LOEC	-	ug/L	Not reported		1998
Brown algae Ectocarpus variabilis	Populati on	14 d	NOEC	-	ug/L	Not reported		1998
Blue-green algae Nostoc calcicola	Populati on	14 d	NOEC	-	ug/L	Not reported		1998
Green algae Selenastrum capricornutum	Populati on	96 h	NOEC	-	ug/L	Not reported		1998
Water flea Daphnia magna	Intoxicati on	48 h	EC50	21.0	ug/L	Static		2000
Water flea Daphnia magna	Intoxicati on	48 h	EC50	250.0	ug/L	Flow through		2000
Opossum shrimp Americamysis bahia	Mortality	96 h	LC50	440.0	ug/L	Flow through	Highly Toxic	2000

Table F-3. Toxicity of Sodium Chlorate on all Organisms

Toxicology studies from the primary scientific literature on aquatic organisms

Use(s): Defoliant, Herbicide, Microbiocide Chem Class: Inorganic U.S. EPA PC Code: 073301 CAS Number: 7775-09-9

Sorted by Organism Group, Effect, Measurement, Endpoint and LatinName.

Note: Only partial study information is reported on these pages. Full study information can be found at the U.S. EPA AQUIRE web site.

Common Name Scientific Name	Effect	Measurement	Life Stage	Study Time	Toxicity Endpoint	Conc Units Mean	Conc Type	Exper. Type	Acute Tox Rating	Year
Duckweed Lemna perpusilla	Mortality	Mortality	NR	7 d	NR	1,000,000	ug/L	Not reported		1974
Aquatic sowbug Asellus hilgendorfi	Mortality	Mortality	1-5 MG	24 h	LC50	4,100,000	ug/L	Static	Not Acutely Toxic	1976
Aquatic sowbug Asellus hilgendorfi	Mortality	Mortality	1-5 MG	48 h	LC50	3,400,000	ug/L	Static	Not Acutely Toxic	1976
Aquatic sowbug Asellus hilgendorfi	Mortality	Mortality	1-5 MG	96 h	LC50	2,800,000	ug/L	Static	Not Acutely Toxic	1976
Cherry salmon, yamame trout Oncorhynchus masou	Avoidance	Chemical avoidance	PARR, 4 G	2 d	NR	-	ug/L	Lotic		1975
Sea lamprey Petromyzon marinus	Behavior	Observed stress	LARVAE, 8-13 CM	24 h	NR	5,000	ug/L	Static		1957
Rainbow trout,donaldson trout Oncorhynchus mykiss	Growth	Growth, general	8.6-8.8 G	NR wk	NR	60,000	ug/L	Lotic		1975

Cyprinus carpio	Mortality	Mortality	NR	96 h	LC50	2,340,000	ug/L	Static	Not Acutely Toxic	1986
Cherry salmon, yamame trout Oncorhynchus masou	Mortality	Mortality	3.0 G, 6.9 CM, FINGERLING	24 h	LC50	4,000,000	ug/L	Renewal	Not Acutely Toxic	1976
Cherry salmon, yamame trout Oncorhynchus masou	Mortality	Mortality	3.0 G, 6.9 CM, FINGERLING	48 h	LC50	3,300,000	ug/L	Renewal	Not Acutely Toxic	1976
Cherry salmon, yamame trout Oncorhynchus masou	Mortality	Mortality	3.0 G, 6.9 CM, FINGERLING	96 h	LC50	1,100,000	ug/L	Renewal	Not Acutely Toxic	1976
Rainbow trout,donaldson trout Oncorhynchus mykiss	Mortality	Mortality	NR	48 h	LC50	1,100,000	ug/L	Static	Not Acutely Toxic	2000
Hasu fish Opsariichthys uncirostris	Mortality	Mortality	NR	96 h	LC50	2,340,000	ug/L	Static	Not Acutely Toxic	1986
Minnow Phoxinus phoxinus	Mortality	Mortality	NR	96 h	LC50	2,340,000	ug/L	Static	Not Acutely Toxic	1986
Fathead minnow Pimephales promelas	Mortality	Mortality	0.91-2.56 G, 3.7-5.4 CM	96 h	LC50	13,800,000	ug/L	Static	Not Acutely Toxic	1974
Fathead minnow Pimephales	Mortality	Mortality	0.56-2.88 G, 3.8-5.5	96 h	LC50	13,600,000	ug/L	Static	Not Acutely Toxic	1974

promelas			CM							
Fathead minnow Pimephales promelas	Mortality	Mortality	0.65-1.78 G, 3.6-5.0 CM	96 h	LC50	13,500,000	ug/L	Static	Not Acutely Toxic	1974
Harlequinfish, red rasbora Rasbora heteromorpha	Mortality	Mortality	1.3-3 CM	24 h	LC50	8,600,000	ug/L	Renewal	Not Acutely Toxic	1969
Roach Rutilus rutilus	Mortality	Mortality	NR	96 h	LC50	2,340,000	ug/L	Static	Not Acutely Toxic	1986
Brown trout Salmo trutta	Mortality	Mortality	YEARLING, FINGERLING	48 h	LC50	7,300	ug/L	Not reported	Moderately Toxic	1974
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.5 G, 4.0 CM	6 h	LC50	4,900,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.5 G, 4.0 CM	12 h	LC50	4,700,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.5 G, 4.0 CM	24 h	LC50	4,200,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.5 G, 4.0 CM	48 h	LC50	3,800,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon	Mortality	Mortality	0.5 G, 4.0 CM	96 h	LC50	3,800,000	ug/L	Static	Not Acutely Toxic	1976

hakonensis										
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.25 G, 3.2 CM	24 h	LC50	4,000,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.25 G, 3.2 CM	48 h	LC50	3,800,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.25 G, 3.2 CM	96 h	LC50	3,300,000	ug/L	Static	Not Acutely Toxic	1976
Japanese barbel Tribolodon hakonensis	Mortality	Mortality	0.25 G, 3.2 CM	10 d	LC50	2,000,000	ug/L	Static	Not Acutely Toxic	1976
Goldfish Carassius auratus	Mortality	Mortality	60-90 MM, 3-5 G	> 4 d	NR	1,000,000	ug/L	Static		1937
Cherry salmon, yamame trout Oncorhynchus masou	Mortality	Mortality	PARR, 8 G	1 d	NR	-	ug/L	Lotic		1975
Cherry salmon, yamame trout Oncorhynchus masou	Mortality	Mortality	PARR, 4 G	4 d	NR-ZERO	-	ug/L	Lotic		1975
Fungi Penicillium verrucosum	Population	Population growth rate	DSM 1250 STRAIN	48 h	NOEC	796,171	ug/L	Not reported		1998
Fungi Trichoderma hamatum	Population	Population growth	DSM 63055 STRAI	48 h	NOEC	796,171	ug/L	Not reported		1998

		rate	N							
Caddisfly Stenopsyche griseipennis	Mortality	Mortality	0.35 G	24 h	LC50	3,100,000	ug/L	Static	Not Acutely Toxic	1976
Caddisfly Stenopsyche griseipennis	Mortality	Mortality	0.35 G	48 h	LC50	3,100,000	ug/L	Static	Not Acutely Toxic	1976
Caddisfly Stenopsyche griseipennis	Mortality	Mortality	0.35 G	96 h	LC50	2,700,000	ug/L	Static	Not Acutely Toxic	1976
Mayfly Ephemera japonica	Mortality	Mortality	NYMPH	4 d	NR	-	ug/L	Lotic		1975
Mayfly Baetis tricaudatus	Mortality	Survival	FINAL INSTAR NYMPH	10 d	NR	-	ug/L	Static		1997
Dasycorixa hybrida	Mortality	Survival	ADULTS	10 d	NR	-	ug/L	Static		1997
Beetle Haliplus sp.	Mortality	Survival	ADULTS	10 d	NR	-	ug/L	Static		1997
Stonefly Isoperla longiseta	Mortality	Survival	FINAL INSTAR NYMPH	10 d	NR	-	ug/L	Static		1997
Stonefly Isoperla transmarina	Mortality	Survival	FINAL INSTAR NYMPH	10 d	NR	-	ug/L	Static		1997
Mayfly Tricorythodes minutus	Mortality	Survival	FINAL INSTAR NYMPH	10 d	NR	-	ug/L	Static		1997

Planarian Polycelis nigra	Mortality	Mortality	NR	48 h	LT50	15,966,000	ug/L	Static		1941
Green algae Scenedesmus subspicatus	Development	Color	CCAP 276/20 STRAIN, EXPO GRO PHASE	NR h	LOEC	3,137,000	ug/L	Static		1995
Green algae Scenedesmus subspicatus	Development	Color	CCAP 276/20 STRAIN, EXPO GRO PHASE	NR h	NOEC	1,569,000	ug/L	Static		1995