EXECUTIVE SUMMARY

This report was developed to meet the requirements of Chapter 46-17.3 of the Rhode Island General laws relating to ballast water management. It summarizes information from scientific and policy literature, using the most recent reports on the issue of ballast water and its relation to introduced non-native species. Information is presented on the ecological and economic impacts of introduced aquatic species, global and national management initiatives, and technologies under development to treat ballast water in order to reduce the risk of introduced species. The report also presents possible management responses that the State of Rhode Island could take to address management of ballast water releases and introduced species. Information for this report was drawn from university studies, government documents and websites (state, federal and private sector), master theses, and recent publications in the scientific literature.

Introduced Species and Ballast Water

Introduced species are a substantial and growing global threat due to the potential for significant economic and ecological harm as well as human health risk. Dr. James T. Carlton, of the Williams College Marine Program, a national expert on this issue, recently stated that "…every assessment indicates that the rate of marine introductions in the U.S. has increased exponentially over the past 200 years, and there are no signs that these introductions are leveling off. New introductions are occurring regularly on all coasts, producing immediate damaging impacts, and leading to millions of dollars (annually) in expenditures for research, control, and management efforts." (Carlton, 2001). The United States has already been seriously impacted by the introduction of species. From zebra mussels and Eurasian ruffes in the Great Lakes to the completely overturned ecosystem that exists in San Francisco Bay, it is a problem that has accelerated significantly over the last few decades.

Studies conducted in the United States and abroad have shown that the single largest transport vector of non-native introduced species for the marine environment is exchange or partial exchange of ballast water from transoceanic vessels as they pass through ports throughout the world (Carlton, 1996; Ruiz et al., 1997).

The scientific consensus is that current ballast water exchange protocols, while a helpful preventative measure, are not a completely effective method of reducing the risk of introduced species. Ship design generally does not allow for complete exchange of ballast; some water and sediments remain that still have the ability to harbor organisms and bacteria. In light of that, current management scenarios, while relying on ballast exchange as a beneficial immediate step, are increasingly concentrating on shipboard treatment of ballast water through a variety of combined technologies. New technologies to treat ballast water are being studied and tested by industry and university researchers (some with federal funding) that show promise for effective treatment to remove and destroy microorganisms and bacteria in ballast water.

Government officials and university researchers have not been the only perspectives evident in the ballast water management discussion. Industry and trade groups have been key players in the national dialogue on ballast water management. The American Association of Port Authorities (AAPA) recently called on the U.S. Congress to pass legislation requiring mandatory ballast water management. The AAPA position on ballast water is stated in the AAPA factsheet, “Prevent the Introduction of Aquatic Nuisance Species from Ballast Water; Replace State and Local Initiatives” (AAPA, 2001). The organization calls for (1) mandatory ballast water management; (2) ballast water management standards

to evaluate the effectiveness of ballast water technologies; (3) certification of ballast water technologies and practices; and (4) federal pre-emption of state regulations. The position paper notes that "mid-ocean exchange is widely recognized as only a stop-gap measure to minimize the introduction of nuisance species. There is a great need to develop more effective and efficient approaches to ballast management on ships."

Ballast Water and Species Transport

Ballast is drawn into a vessel by intake pumps located in the hull, below the waterline. It is taken on to provide stability and maneuverability in rough seas, and is used when the vessel is at less than maximum cargo load, either during a transit to pick up a product, or after dropping off a portion of the cargo before continuing on to the next port. Therefore, ballast waters can often be a mix of waters from many ports (Carlton, 2001. pers. comm., Armstrong, 2001; Tzankova, 2000). It is often discharged in order to raise the ship when entering shallower ship channel areas in port.

In order to decrease the risk of introducing foreign species, a small percentage of ships are now, when feasible and safe, voluntarily exchanging ballast at sea, taking in higher salinity ocean waters (more than 200 miles offshore) under the concept that inshore species won't survive the different offshore environment, and offshore species will be less likely to survive inshore. However, ballast exchange may lower but does not eliminate the risk of introduced species (Carlton, 2001). Not all ballast water can be pumped out of the tanks and sediments that settle to the bottom do not get removed. This allows microorganisms in cyst form, bacteria and some planktonic organisms to remain in the tanks and to be re-suspended and discharged when deballasting upon arrival at port.

Non-native species are introduced by transport vectors that allow them to move well beyond their natural range. As they evolve, organisms develop dispersal mechanisms in order to spread and expand their population. Entry of an aquatic species into a new environment is a normal evolutionary process when it takes place through a natural transport such as wind or ocean currents. However, it is becoming increasingly common, as a result of human activity, to have foreign species introduced far beyond their normal geographic ranges. Such introductions may set up circumstances that allow a species population to grow unchecked by their natural predators.

Problems Associated with Species Introduction via Ballast Water

The following table lists the range of impacts that are associated with aquatic nuisance species (adapted from National Aquatic Nuisance Species Taskforce Website, 2001):

Ecological Effects	*Economic Impacts*	*Public Health Concerns*
Predation	Industrial water users	Cholera risk
Parasitism	Municipal water systems	Paralytic shellfish poisoning
Competition	Nuclear power plants	Harmful algal blooms
Introduction of new pathogens	Other water sports	
Species shifts/loss of biodiversity	Damage to levees/dams	
Genetic changes	Commercial and recreational	
Habitat alterations	fishing	

Introduction of nonhuman pathogens has been shown to cause extensive ecological and economic damage to industries such as aquaculture and commercial fisheries (Daszak et al., 2000). In addition, the spread of human pathogens to new areas is associated with ballast discharge. Based on a National Sea Grant-funded study showing high concentrations of microbes in ballast water of ships entering

Chesapeake Bay from foreign ports, researchers at the Smithsonian Environmental Research Center (SERC) have reported that ballast discharges from transoceanic vessels "create a long-distance dispersal mechanism for human pathogens, and may be important in the worldwide distribution of microorganisms as well as the epidemiology of waterborne diseases affecting plants and animals" (Ruiz, et al., 2000)

Increasing Rate of Introductions

As stated above, introductions of species are not new, but what is new is the rate and scale at which it is now occurring. In this age of expanding global trade with international shipping being a primary mover of goods, there have been dramatic increases in the volume and frequency of ballast water discharges as well as an expanded list of donor sites. Currently, there are more than 45,000 commercial cargo-carrying vessels plying international seas (Carlton, J.T., 2001b). As an illustration of the rate of increase in shipping, arrivals of seaworthy freight containers at the Port of Los Angeles increased from 20 in 1958 to 3.2 million in 1998 (USDA/APHIS 2000). Modern transoceanic ships carry and discharge ballast water among hundreds of bays and estuaries worldwide.

Economic Impacts

In addition to ecological impacts, there are clear economic impacts from introduced species. A Congressional report (U.S. Congress, Office of Technology Assessment (OTA), 1993) found that, of 1,300 established nonindigenous species studied in the US, about fifteen percent have caused clear and severe harm to either the local ecosystem and /or the economy. That same Congressional report found that, between 1906 and 1991, 79 nonindigenous species caused documented losses of $97 billion. Another study of the economic impacts of invasive species (aquatic, terrestrial and plant), conducted by Cornell University researchers, updated parts of the OTA report and estimates that the cost of prevention and control of these species approaches $137 billion per year (Pimentel et al, 2000). Negative economic impacts from aquatic nuisance species include lost revenues from impacted fisheries (e.g., fishery value) due to predation, parasitism, and out-competition for resources; clearing/removal costs for clogged piping (cooling water intakes, etc.); costs for replacement and repair of docks and shoreline structures from introduced marine wood-borers; and damage from shore erosion due to burrowing behavior. A recent study estimated annual costs of $44 million per year to the New England shellfishery from impacts of the European green crab (Pimentel et al. 2000).

As Pimentel et al. (2000) notes, these up-front obvious damage and control costs are probably low compared with the actual unpredictable and extensive ecosystem damages already experienced globally from introduced species. An additional issue associated with ballast-introduced species with potential far-reaching human health and economic impacts is the risk of introduction of pathogenic bacteria and harmful algal blooms.

Rhode Island/New England Introductions

Rhode Island has seen a number of recent introductions. The intertidal Asian shore crab, *Hemigrapsus sanguineus*, migrated to the R.I. coast in the late 1990's from an original ballast source in New Jersey. It is now showing explosive growth in the midbay areas around Prudence Island. A large nuisance seaweed, *Grateloupia doryphora*, which seems to have come in from a source entering or passing the mouth of Narragansett Bay around 1996 (in the first East coast sighting of this Pacific species), is now found over wide regions of the Bay. The Narragansett Bay Rapid Assessment Survey, sponsored by R.I .CRMC, R.I. Sea Grant, the Narragansett Bay Estuarine Research Reserve and the Narragansett Bay Estuary Program, conducted in 2000, identified at least 24 newly recognized introduced species in Narragansett Bay, including the Asian shore crab (now found in significant numbers) and the striped Asian anemone.

Even with the introductions noted above, present risk to Narragansett Bay appears to be fairly low due to a low frequency of transoceanic vessel arrivals and the fact that the majority of shipping traffic involves non-ballasted towed barges and dry cargo and tank barges (Tables 3F-5F, Appendix F). The traffic either has no ballast at all or comes from geographically local areas and carries only local waters (Nield, 1999; Tzankova, 2000). While the risk of introductions may be currently assessed as fairly low, it is certainly above zero risk since Rhode Island has been identified as the first contact point for the large nuisance red macroalga, *Gratelupia doryphora* (Villalard-Bohnsack and Harlin, 1997). Based on review of introduced species literature, it is generally accepted as a qualitative statement in the scientific community that any significant increases in the number of ballast-carrying transoceanic vessels entering American estuaries using current ballast practices (i.e.., that do not exchange ballast in deep water and/or are not fitted with effective ballast water treatment technologies) represent an increase in the size and intensity of the ballast transfer vector, increasing the likelihood of new introductions, especially if they emanate from significant donor ports in Europe, Asia and Southeast Asia.

Most experts seem to agree that, at least for the aquatic environment, "predicting which species will arrive…whether they will survive, persist, spread, and proliferate, continue to challenge scientists who study invasion biology" (Carlton, 2001b). Therefore, there is little predictive capability, and it is extremely difficult to develop a "hit list" or "watch list" until the invasion has already begun nearby and one is merely watching the secondary spread of the original population invasion. At this time, quantitative assessments of risk for this ecologically complex problem are not feasible. The major problem with attempting to quantitatively predict risk levels is that the actual successful colonization of the new area is dependent on many factors, all influenced by timing: being in the right place at the opportune moment when the ecosystem receiving the foreign transplant(s) is vulnerable to that particular species (Carlton, 2001; Armstrong, 2001). The complexity of interactions between timing of potential introductions and the numerous environmental factors (e.g., water temperature, nutrient levels, and the extent and nature of pollution) make it extremely difficult to predict what the next invasive species will be or when and where the event will occur. Ruiz et. al (2000a) emphasized the need to establish standardized ecological surveys of non-indigenous species across coastal and estuarine areas. He also noted that, “at present, no program or framework exists to implement such quantitative measures of non-indigenous invasive species.”

Ballast Management Initiatives

Management initiatives at the international, national and state level regarding ballast water are in a state of flux, driven by a recognized need to effectively manage ballast water on a broad scale to prevent species introductions and by the development of new ballast treatment technologies. Several states that have experienced impacts from invasive species have, while supporting the passage of national legislation, passed their own ballast water management laws after determining that the existing system of voluntary ballast exchange was not effectively protecting their economic and ecological resources. Industry perspectives on regulatory schemes start with a call for national legislation and include recognition that ballast water treatment standards will be a necessary element of any management scenario.

Due to the fact that ballast water crosses international and national boundaries, the international community, the U.S. government and some state governments have taken some steps to address the introduction of species via ballast discharge.

At the international level, the UN-based International Maritime Organization (IMO) has developed guidelines for voluntary ballast exchange for ocean-going vessels. The track record of voluntary exchanges based on these guidelines has shown a pattern of considerable noncompliance. At this time, the IMO is considering adopting ballast water management protocols as part of amendments to

the International Convention on Marine Pollution (MARPOL). This act would require that all 130 members of IMO follow the ballast exchange guidelines.

In the U.S., the first significant response to ballast water issues was the Nonindigenous Aquatic Nuisance Prevention and Control (NANPCA) Act of 1990**,** which included a requirement that the U.S. Coast Guard develop guidelines that would eventually become regulations regarding mid-ocean ballast exchange and other control measures for international shipping. These exchange guidelines were made mandatory for vessels entering the Great Lakes and the Hudson River but not in any other U.S. waters. Currently, ocean-going vessels entering all U.S. waters are to follow the voluntary guidelines for ballast exchange and to submit ballast activity reports to the Coast Guard. However, a recent study found that there was only a 20.8 percent compliance rate – a low rate reflecting the lack of incentives (regulatory or otherwise) to comply with the guidelines.

Based on the lack of effective ballast management from the federal level, some states that have experienced invasive species impacts have passed state legislation requiring ballast exchange; some go further and anticipate the phase-in of required ballast treatment technologies. States with laws on the books are California, Washington, Oregon, Virginia and Maryland. Hawaii has a law on the books which could lead to ballast water regulations but implementation is not yet at that stage. Michigan lawmakers have been debating passage of a bill that requires that ballast on ships entering state waters be "sterilized" – a term that has raised the concerns of the shipping industry.

Industry has recognized that ballast water management practices need to be changed in order to prevent environmental and economic impacts. The American Association of Port Authorities (AAPA) recently called on the U.S. Congress to pass legislation requiring mandatory ballast water management. AAPA said that this legislation should include treatment standards using demonstrated, effective technologies. A federal law of this nature would pre-empt state laws and would, according to John Jamian of the Detroit/Wayne County Port Authority, help "avoid a crazy quilt work throughout the country" of varying state standards (Bureau of National Affairs, Environmental Reporter, 2001). In recognizing the need for ballast water treatment, Tom Chase, a spokesman for AAPA, stated that, " [AAPA] thinks the solution is……the technology for treating ballast in the vessels" (Detroit News website, Associated Press article, 2000).

Ballast Water Treatment Technologies

Most of the legislation and initiatives involving ballast water has had a strong focus on promoting research into solutions to species introduction through ballast water treatment, recognizing that ballast water exchange is not a complete solution. Recent research has targeted technologies that treat ballast water to remove or destroy the living organisms being carried. Going beyond ballast exchange, some examples of technologies that are been investigated for use are:

- Filtration/Physical Separation;
- Chemical Biocides;
- Ultraviolet Light;
- Heat Treatment;
- Ultrasound;
- Ozone; and
- Deoxygenation with nitrogen gas

Based on research to date, it appears that a single treatment method would not provide an effective solution; research results point to the use of combinations of technologies (Carlton et. al., 1995. in Tzankova, 2000). An interesting recent development in the ballast treatment field is a new technique

that removes oxygen from ballast water (deoxygenation). Researchers in California, with funding and support from government and industry, have tested a technology that not only reduces rust and corrosion caused by sea water in ballast tanks but kills a significant percentage of organisms being carried in that water (Tamburri, et. al., 2001). Nitrogen gas is bubbled into the ballast water, eliminating oxygen content. Without adequate oxygen, most organisms cannot survive for more than a few days. Tests conducted at the Monterey Aquarium Research Institute showed kill percentages of as much as 80 percent for organisms in the water. An added benefit: the process can save shipping companies as much as $100,000 a year in reduced maintenance costs. While not a perfect solution, this technology shows promise and provides a strong economic incentive for industry to comply.

Management Options

The State of Rhode Island should support the development of national ballast management program that includes mandatory, technology-based regulations on ballast water applicable to all U.S. waters and enforced by the federal government.

Due to the international and cross-jurisdictional nature of introduced species impacts, there is a general recognition among both the research and industry communities that a national (or international) system of ballast water control and treatment would be preferable to a system where many jurisdictions create their own control measures. A program of this sort would provide increased funding for enforcement, funding for research and technology, address the multiple vectors for introduction of aquatic species, provide for a rapid response program for eradication of invasive species, provide nationwide research efforts and databases, better asses ecological and economic impacts, and develop educational programs to raise public awareness.

In the absence of federal legislation that effectively protects U.S. waters from the introduction of non-native species and in the instance that, as other states have done, the State of Rhode Island determines that state legislation is needed in order to adequately protect the State's environment and economy:

The State of Rhode Island should develop legislation providing effective protection of State waters from ballast-borne introduced species from transoceanic vessels entering State waters.

Oregon's legislation recognizes that ballast water exchange is a partial solution and takes the approach that, as ballast treatment technologies become available, these would be phased into the law's requirements. This approach allows immediate ballast exchange controls to take effect while providing a mechanism to further effectively reduce the risk of species introduction as treatment technologies mature. Elements of such legislation would include a prohibition on discharges of untreated transoceanic ballast water; implementation of proven ballast treatment technologies; required ballast exchange outside of the 200-mile Economic Exclusion Zone; prohibition of discharge of ballast tank sediments; encouragement of "good housekeeping" practices by the shipping industry; mandatory ballast reporting form (already developed under federal law); investigation of incentives-based programs; and implementation of a vessel fee to cover costs of monitoring and enforcement. Some states have taken a more cautious approach and have passed legislation that mirrors the existing federal voluntary exchange legislation. Issues to consider in whether State legislation could be effective are capacity to implement, whether other states in the region are enacting controls, and whether there will be significant changes in shipping patterns and intensity, vessel type and trip origin.

The State of Rhode Island should appoint a state agency as lead agency on ballast water management.

Because management of ballast water is a complex issue that involves a variety of organizations and agencies, it would be useful to appoint one state agency as the lead contact on this issue. The lead

agency could possibly be responsible for developing and implementing State ballast water controls (if determined to be needed by the State), identifying and addressing research needs, informing key constituencies and the public of introduced species issues, providing technical and administrative support to the Rhode Island Invasive Species Council, participating in the development of an introduced species monitoring framework, and participating in national and regional efforts to control invasive species. While there might be one lead agency for coordination purposes, this should not necessarily prevent other agencies from taking on important roles in addressing this issue.

The State of Rhode Island should coordinate and cooperate with neighboring states on ballast water management.

Rhode Island shares Mt. Hope Bay with the Commonwealth of Massachusetts. At the head of Mt. Hope Bay is the city of Fall River and its regionally important port facility. In order to achieve consistent management of ballast water and to prevent gaps in ecosystem protection, Rhode Island should work with appropriate governmental and nongovernmental parties involved in port and shipping activities in the Massachusetts section of Narragansett Bay. Key areas for coordination are research and monitoring.

The State of Rhode Island should institute a State program to monitor status of introduced species and to identify new invasions, coordinated through the Coastal Institute at the University of Rhode Island.

The State's ability to assess risk from introduced species and to prepare eradication programs will depend on sufficient data on the status of existing introduced species and the identification of new introductions. Continuous monitoring data also will allow the State to evaluate existing and new management actions. This effort could build upon the baseline introduced species data from the 2000 Rapid Assessment Survey. Because the Coastal Institute is engaged in scientific research, ecological monitoring and development of ecological indicators, it is well suited to serve as a coordination center for introduced species monitoring and related research.

The Rhode Island Invasive Species Council should be expanded to include estuarine and marine interests to more effectively address plant, animal, and bacterial introductions into terrestrial and estuarine ecosystems.

The Rhode Island Invasive Species Council was created informally in early 2000 and has been primarily focused on terrestrial and freshwater introduced species. This Council intends to collect and publish a list of invasive plants in Rhode Island. While this is a proactive and needed effort, it should include the broad range of introduced species (plant, freshwater and estuarine/marine) and include representation of the various organizations that deal with this problem.

The State of Rhode Island should consider pursuing the development of options for ballast water controls as well as the larger issue of introduced and invasive species through the Coastal Institute at the University of Rhode Island.

The Rhode Island Invasive Species Council should also be affiliated with an entity that can help support its work. Because the nature of the introduced species problem crosses land, fresh and salt water environments in our coastal watersheds; and because it will require close coordination of management and research entities, the Coastal Institute at the University of Rhode Island could serve a key coordination and support role for efforts to prevent the introduction of non-native species to the State. The Coastal Institute has been proven to be an effective and neutral venue to bring scientists, resource managers and resource users together to help develop solutions for ecological problems.

The State of Rhode Island should ensure that the appropriate representatives from the Rhode Island Invasive Species Council be involved in the Northeast Regional Invasive Species Council and participate in the Panel working committees.

Under the provisions of the National Invasive Species Act (NISA) of 1996, the National Council is creating regional panels to ensure that invasive species activities are coordinated nationwide and that regional perspectives are accounted for. In the last year, a Northeast Panel has been convened and has met twice. The Panel deals with all aspects of invasive species (land, fresh and salt water) including research issues and education/outreach. The Panel has also convened several issue-specific working committees as part of the development of a coordinated action agenda. Rhode Island involvement in the Panel would ensure that state concerns are addressed in national initiatives and would be a conduit to bring policy and technical information to R.I. decision-makers.

The State of Rhode Island should provide or secure funding and resources to develop a State Aquatic Nuisance Species Management Plan.

Federal funds have been made available to the states through the National Invasive Species Council for the development of state aquatic nuisance species (ANS) management plans. Massachusetts (R.I.'s partner on the Narragansett Bay Rapid Assessment Survey for Introduced Species) has completed a draft ANS plan. These plans address all the transport vectors (from research activities, aquaria, plant nurseries, live and processes seafood, aquaculture, and intentional releases) for introduced species including ballast water introductions. The R.I. Invasive Species Council, with the support of the Coastal Institute, could coordinate securing funding and the development of the plan itself. By working through the Northeast Regional Invasive Species Panel, the plan would also be coordinated with plans from the other New England states.