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and San Francisco Bay**

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Policy Analysis
of Invasive Species Regulations
in Sydney Harbour and San Francisco Bay



A Capstone Project

Presented to the Faculty of Science and Environmental Policy

in the

College of Science, Media Arts, and Technology

at

California State University, Monterey Bay

in Partial Fulfilment of the Requirements for the Degree of

Bachelor of Science

by

Alexis Radovich
Christina Schmunk
December 15, 2005

**Policy Analysis
of Invasive Species in Sydney Harbour, Australia
and San Francisco Bay, United States of America.**

By Alexis Radovich and Christina Schmunk

The demand for the mass transportation of goods throughout the world is threatening the biodiversity and native habitats of local scale aquatic assemblages. Efforts to preserve and protect marine communities are hampered by the danger of invasive species coming into native harbor community assemblages. In order to manage and conserve these ecosystems, it is necessary that we research and compiled the species in order to gain a better understanding of how legislation and regulations can be used in order to create systems that are sustainable for all species. The goal of this capstone is to examine current and past legislation and regulations as well as look at the species assemblages in San Francisco Bay and Sydney Harbour. We conducted an analysis and evaluation on the current policies of the harbors. To do this, previous data and research were examined; policies and laws were ascertained; and the ongoing impacts of invasive species were determined. Through a literature search we identified all the recorded known species present in each harbor and conducted biodiversity comparisons on the taxa. This paper analyzes and compares a range of factors that may influence policy implementation and legislation in the United States and Australia. Based on reviews of policy and literature, the cross country comparative analysis reveals the challenges and opportunities of the policies in each setting, and the relative strengths and weaknesses of the difference implementation approaches. The paper concludes with recommendations for the United States and Australia in terms of legislative approaches and a do nothing approach.

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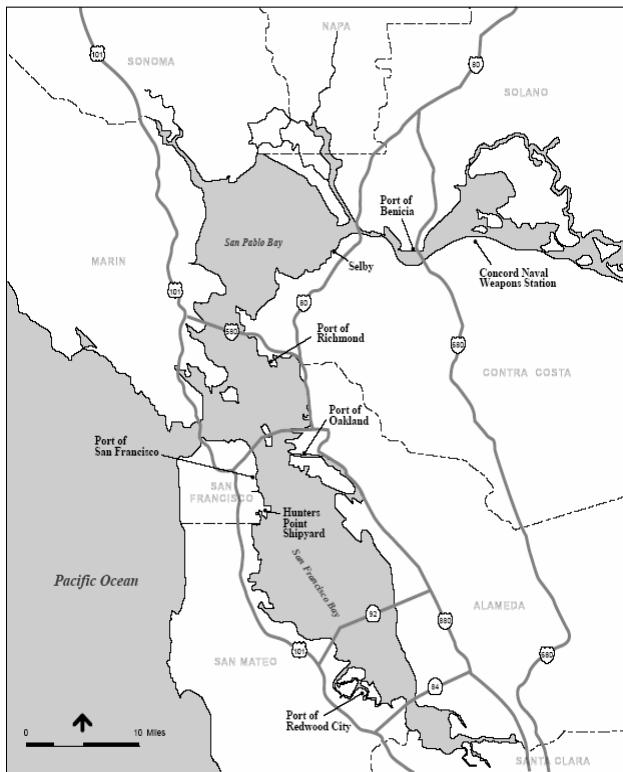


Figure 1. San Francisco Bay port locations (SPAC 2003).



Figure 2. Sydney Harbour's port locations (SPC 2003b).

Glossary and Acronyms

AB	Assembly Bill
Alien Species	see Non-indigenous
ANS	Aquatic Nuisance Species Task Force
Anti-Fouling Agent	Paint used to protect ships or aquaculture cages from attaching organisms.
APHIS	Animal & Plant Health Inspection Service
AQIS	Australian Quarantine and Inspection Service
Aquaculture	The cultivation of aquatic organisms, such as fish, shellfish, algae and other aquatic plants.
Assemblages	A portion of a community that is being examined (ie. the fish and aquatic plants of a specific water region, but not including all the other species and abiotic factors within that region).
Aust EPA	Australian Environment Protection Agency
Ballast	“Any solid or liquid weight placed in a ship to increase the draft, to change the trim, or to regulate the stability.” (NRC 1996) This includes sediment and water from the water column.
Biota	The living organisms of a region.
CCC	California Coastal Commission
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CMAR	CSIRO Marine and Atmospheric Research
CSLC	California State Lands Commission
Coastal Shipping	Commercial vessels undertaking voyages between two or more ports within one country’s waters.
CRIMP	CSIRO Centre for Research on Introduced Marine Pests
Cryptogenic	Organisms that are non-native species in many parts of the world, but their native range cannot be verifiably located.
CSIRO	Commonwealth Scientific Industrial Research Organisation
CSLC	California State Lands Commission
DAFF	Department of Agriculture, Fisheries and Forestry
Deballast	The release of ballast from a vessel.
DEH	Department of Environment and Heritage
Dispersal Vector	The transportation means of organisms from one region to another.
Disturbance	A direct or indirect irregularly occurring discrete events of destruction, whether natural or human-induced, that influences the future assemblages of an area (Thonicke, Venevsky, et al 2001).
DoC	United States Department of Commerce
DoD	United States Department of Defense
DoE	United States Department of Energy
DoI	United States Department of the Interior
DoT	United States Department of Transportation
DPI	New South Wales Department of Primary Industries
EEZ	Exclusive Economic Zone

EPBC	Environment Protection and Biodiversity Conservation
Estuary	A partially enclosed coastal bay where fresh water and sea water meet and mix.
Exotic	see Non-indigenous Species
Fouling	Marine organisms attached to vessels.
FWS	United States Fish and Wildlife Services
GPS	Global Positioning System
Hull	“The structural body of a ship, including shell plating, framing, decks, bulkheads, etc.” (NRC 1996)
IGA	Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions
IMO	International Maritime Organization
Introduced Species	see Non-indigenous
Invasive Species	Species that are non-native to a community and whose introduction causes or is likely to cause economic harm, environmental harm, or harm to human health
IPPC	International Plant Protection Convention
ITIS	North American Integrated Taxonomic Information System
Mariculture	A subset of aquaculture specific to marine aquaculture.
NANPCA	Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990
NDBC	National Data Buoy Center
NEPA	National Environmental Policy Act
NHT	Natural Heritage Trust
NIMPIS	National Introduced Marine Pest Information System
NISA	National Invasive Species Act of 1996
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NGO	Non-government Organization
nm	Nautical Mile
Non-indigenous	Any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organisms transferred from one country into another
NPDES	National Pollutant Discharge Elimination System
NPWS	New South Wales National Parks and Wildlife Services
NSW	New South Wales
Marine Pest	Species that are injurious, especially one harmful to humans.
OCS	Offshore Constitutional Settlement
OIE	World Organization for Animal Health
OSPR	Office of Spill Prevention and Response
RMP	Regional Management Plans
SPS Agreement	Agreement on the Application of Sanitary and Phytosanitary Measures
SWRCB	California State Water Resources Control Board
Taxon (pl. taxa)	A taxonomic category or group.
UC	University of California
UN	United Nations
UNCLOS	UN Convention on the Law of the Sea

Upwelling	Upwelling occurs where cooler thermocline waters are brought to the surface to replace the warmer surface waters. It is mainly observed in tropical regions of the ocean, where cooling of several degrees may occur. The upwelling is often caused by wind events along a coastal region, along the equator, or by a tropical cyclone. These upwelled waters are usually regions of high biological productivity.
USACE	United States Army Corp of Engineers
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USEPA	United States Environment Protection Agency
Vector	The physical means or agent by which a species is transported.
WTO	World Trade Organization

1. Introduction

Natural ecosystems are under attack by many harmful diseases species of plants and animals. Regardless of whether individual governments around the world recognize invasive species as a problem for their country, invasive species are becoming one of the biggest threats to the world's biodiversity. Non-indigenous aquatic species (also known as alien, aquatic nuisance species, exotic, introduced, or marine pests) are defined as "any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organisms transferred from one country into another" (Stemming the Tide 1996). Invasive species are species that are non-native to a community and whose introduction causes or is likely to cause economic harm, environmental harm, or harm to human health. While some species have invaded habitats on their own, human exploration and colonization have dramatically increased the diversity and scale of invasions by exotic species (Bax 2001). Introduced species often find no natural enemies in their new habitat and therefore spread easily and quickly (Parliament of Australia 2004). Invasive species are a problem on land and in the oceans, including deserts, islands, forests, rivers, lakes, farms, and almost everywhere.

Invasive species are quickly out competing native species in areas with high traffic. Estuaries that are home to large ports and harbors are becoming home to many of these world-wide travelers (Tamburri et al. 2002). The globalization of trade, travel, and transport is greatly increasing the number and diversity of invasive organisms being moved around the world and the rate at which they are moving (GISP 2003). At the same time, changes in land use and climate, facilitated by humans, are rendering some habitats more susceptible to invasions (Zalucki 2005). The problem is a growing one that will have to be monitored and possibly managed.

This case study investigates local-scale aquatic invasions across a range of taxa within San Francisco Bay, California and Sydney Harbour, New South Wales (NSW), two international shipping ports¹. In particular, through the use of case studies and an examination of the status of these harbors and legislative efforts to meet the challenge of invasive species on their environment, this paper seeks to:

1. understand the impact invasive species have on the two harbors: their ecosystems, humans, economy, and social behavior;
2. compare the biodiversity between the two sites;
3. examine how those impacts influenced the legislative and policy framework for the aforementioned harbors;
4. outline existing legislation and identify potential obstacles to addressing invasive species' manipulations of local systems;
5. perform an analysis and an evaluation of current policies for both harbors as they relate to invasive species;
6. recommend adjustments to future legislation and future studies.

1.1 Dispersal Vectors of Invasive Species

By examining routes of introduction of invaders, planned or unplanned, we find patterns that may help us predict the likelihood of particular impacts associated with different kinds of introductions. While impacts of invasive alien species are primarily local they also have national

¹ See Appendix 10.1 for a location diagram.

impact in that they can be spread from area to area. The root causes of their spread are regional and international; driven primarily by global trade, transport and tourism. In many cases, placing regulations on the vectors may prove easier than placing regulations on the organisms themselves. The introductions of these non-indigenous species into harbor and port assemblages are due to a wide variety of dispersal vectors, including ballast water, hull fouling, imported aquaculture equipment and species, imported aquarium species, and natural dispersal (Bax et al. 2001; Carlton 1999; Carlton and Geller 1993; Cohen et al 1995; Cohen and Carlton 1997; Ruiz et al 1997; A. Snell pers. comm.). These vectors continually move fish, plants, and other organisms across oceans and across country borders (Carlton 1985).

Despite the difficulty of proving that an invasive species has been introduced through a particular pathway, examination of ballast water has demonstrated the enormous potential importance of the pathway. Because ships have been around for centuries, organisms have been known to hitch rides on the hull of the ships. More recently however, this has become a problem of transporting organisms through the movement of ballast water. Invasive species have become more commonly transported internationally in the ballast water of ships (Foster 2000; Smith et al 1999; Tamburri 2002). Literally hundreds of species can be found alive in samples from a single ship. It has been estimated that at any given moment, 10,000 different species are being transported between biogeographic regions in ballast tanks (Parliament of Australia 2004). Ballast tanks are used to keep large cargo ships balanced and afloat and different vessels require different ballast systems (Boyer 2003; Stemming the Tide 1996). When ships take on ballast water to balance, they can also take on plants and animals from the same ecosystem as the water. However, even with ballast water dumping regulations, the problem remains that ships can't remove all foreign ballast water from their tanks (A. Snell pers. comm.). There is also the issue of the sediment that ballast tanks can accumulate. This accumulation provides just as many problems as ballast water can; however, the biota of this sediment is not well known (NRC 1996).

Another ship transportation problem has been hull fouling. Hull fouling organisms are marine creatures that attach to submerged objects, including vessels' hulls, and then they are able to hitch their rides around the world (A. Snell pers. comm.). Currently very little quantitative data exist to examine many aspects of the transfer of organisms via vessel hulls, but its importance is quickly being realized throughout the world. Historically, hull fouling was considered a primary vector for transporting species. Until recently the modern use of metal hulls and anti-fouling paints such as tri-butyl-tin (TBT) as well as decreasing time spent in ports and faster ship speeds contribute to a reduction in hull fouling. Due to the IMO's adoption of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, TBT has been banned as a legal anti-fouling agent since 2003 (Parliament of Australia 2004). While the US Navy is using cuprous oxide, there are many other forms of anti-fouling agents that are still being used. Although these advances help decrease the transfer of invasive species via hull fouling, an increase in shipping may counteract their benefits (National Surface Treatment Center n.d.).

Aquaculture activities have a history of introducing various negative effects on local communities (Cohen 2002). Aquaculture is the cultivation of aquatic organisms, such as fish, shellfish, algae and other aquatic plants. Mariculture is specifically marine aquaculture, and thus is a subset of aquaculture. Currently, the main types of marine organisms being produced through mariculture include seaweeds, mussels, oysters, shrimps, prawns, salmon and other species of fish (CBD n.d.). Aquaculture has been one of the fastest growing segments of global food production in recent decades, and has been hailed as an answer to declining wild fish stocks

caused largely by overfishing (FAO 1998). However, farmed species are not always native to the area in which they are farmed and when they escape they can compete with native assemblages and damage ecosystems just like other invasive species. Non-natives can also bring hidden bacteria and disease to aquaculture farms, which can weaken local indigenous species and impair their ability to compete with the farmed species that either escape or are seeded in the wild.

1.2 Impacts of Invasive Species on Ecosystems

It is important to understand the ecological, social, and economic impacts of invasive species in order to predict the vectors that could disseminate organisms, eliminate the threat posed to native assemblages, and defend ecosystems that have not been impacted from future potential invaders. Invasive species have had devastating effects on ecosystems, human health, agriculture, and industry (Figure 3). The United States, Australia and other countries are being impacted by non-native species dominating native environments.

There are two major impacts of invasive species: monetary and ecosystem. In the United States alone, scientists have identified 581 invasive species of marine plants, amphibians, fish, arthropods, and mollusks (USGS 2005) while Australia has at least 200 marine invaders (ISC 2004; CSIRO 2004). Pimentel (2000) states a conservative estimate of one billion dollars annually is spent on exotic fish species. Bjiergo et al (1995) stated a more specific amount for US cumulative losses from non-indigenous marine species; \$1.674 billion. He also states control costs for aquatic weeds were \$10 million dollars (Bjiergo et al 1995). Invasive species can also damage Australia's estimated \$52 billion marine industries value which includes tourism, oil and gas, shipping, fisheries and aquaculture, and ship and boat building (Wilcove et al 1998 as cited in Perrings et al 2000; CSIRO 2004; NAL 2004).

The overwhelming task of managing invasive species is increased by the fact that despite the harm they cause, many people accept some introduced species as normal parts of the environment. For example, Asian carp species have become introduced in many parts of the world and in the United States the fishing of the species has become a recreational sport. The acceptance of invasive species can also create a management challenge. Invasive species can become naturalized and sometimes native animals can learn to co-exist with them. For example, sometimes invasive pest animals can become integrated into the food chain (Parliament of Australia 2004). The arrival and establishment in 1989-90 of the Atlantic green crab, *Carcinus maenas*, in San Francisco Bay is an example of the effects on an ecosystem a species can have. This crab is capable of eating a wide variety of animals and plants and it can also inhabit a variety of communities. As a result this crab may change the food chain and may also change the inhabitants of the Bay (Cohen 1995). This change can impact the marine assemblages and the ecosystem when attempts are made to reduce their numbers.

Invasive species may also alter the stability of native ecosystems by affecting the way communities respond to disturbance (Mack and D'Atononio 1998). Community structure is regulated, in large part, by the disturbance regime. The Intermediate Disturbance Hypothesis states that very high or low levels of physical or biological disturbance are believed to lead to comparatively low diversity, while intermediate levels are associated with high diversity (Connell 1978). Invasive species use this to their advantage and weaken these responses by physically disturbing the environment themselves or biologically by altering the way species interact within the community (Ray 2005; Zalucki 2005).

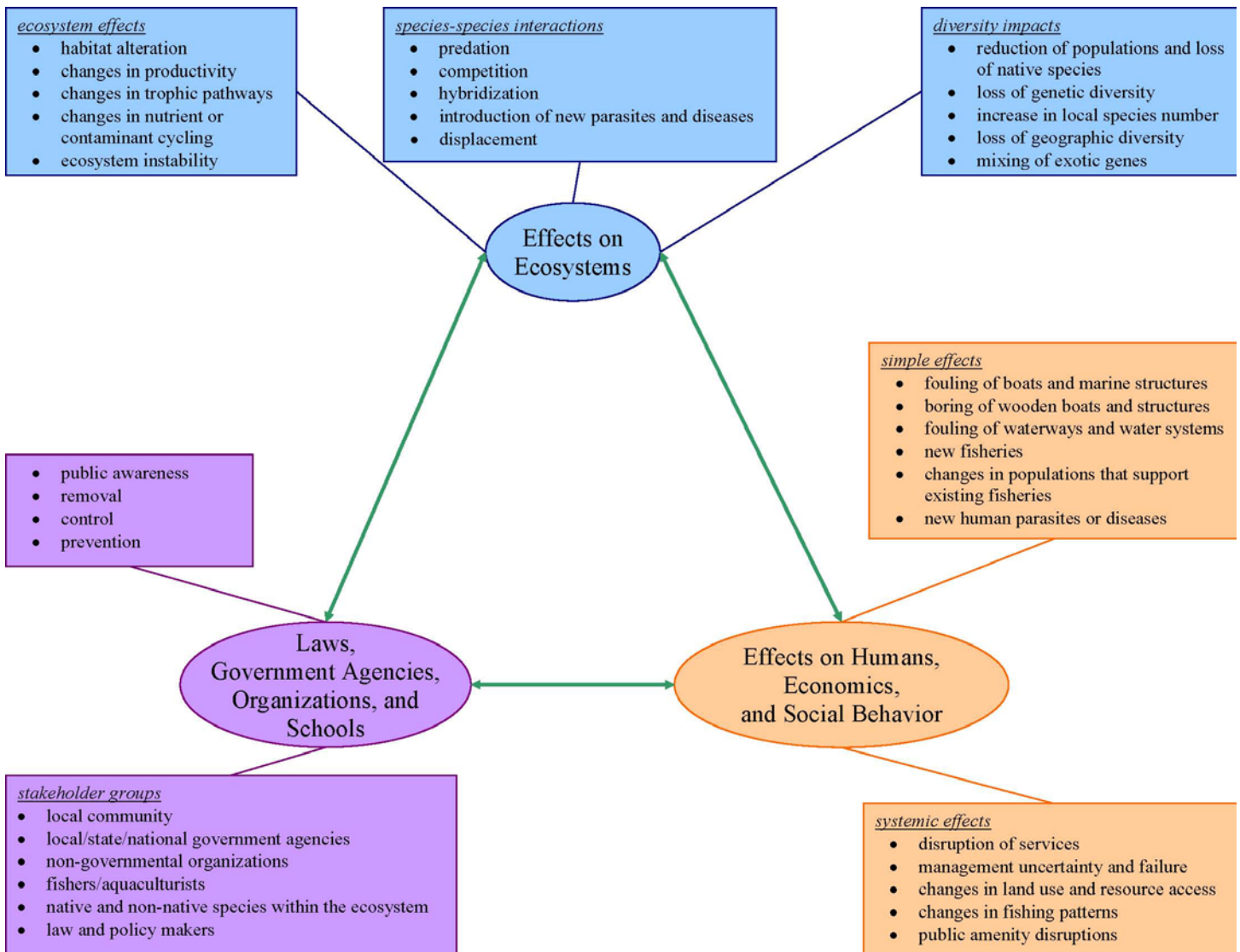


Figure 3. Type of effects diagram showing the environmental systems effects and the social, behavioral, and economic systems effects invasive species can cause, and the possibilities regulations, laws and organizations could take when considering the stakeholder groups (Parliament of Australia 2004; Cohen 1998a; A. Snell pers. comm.).

1.3 Stakeholders

With the question of whether species are injurious, not only to the ecosystem but also to humans, we need to examine how the species are affecting the stakeholders. The multiple stakeholders involved in this situation range from the citizens who use the water for recreational purposes to the scientists who are trying to prevent the invasive species from causing more harm to the native species².

In Australia, the local and state governments have set out in various forms to keep the Australian people aware of the impact invasive species can make on their country. The importance of community stakeholders in Australia can be demonstrated in the example of the Darwin Black Striped Mussel invasion of 1999. On a routine survey, divers found the pest in

² Many of the governmental stakeholders that are examined in this paper are addressed within Section 2.

three enclosed areas (DEH 2000). Because of the efficiency in the response to this outbreak, various stakeholder groups were able to coordinate efforts and eradicate the mussel from the areas. Through the use of media, the Northern Territory was able to have a direct link to stakeholders in the community, the government, and international sector (DEH 2000). This incident led to the Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions. In a terrestrial example of the public awareness, government advertising has also taken many forms since the invasion of the fire ant in Queensland in February 2001. Television commercials, brochures, backyard searches in high risk areas, and a nation wide education about the dangers of fire ants have been Australia's response to try and eradicate the species from its non-native land.

The governmental stakeholders in the United States such as the California Department of Fish and Game have initiated research studies focusing on major harbors and ports to evaluate the effect and number of invasive species. This group also participates with other stakeholders in the San Francisco Bay Joint Venture to protect both the Bay and the associated wetlands (DFG 2005; SBJV 2005). California also became the first state in the nation to require ballast water to be exchanged in the open ocean. Governmental agencies like Sea Grant, a US program under NOAA, have issued radio and television documentaries for teachers, students, and the shipping industry (Sea Grant 2002).

Fishers and aquaculturists are two stakeholder groups that stand to lose with this issue. Invasive species can bring substantial job and economic losses to commercial fishing industries. Invasive species can introduce pathogens which native or farmed stock cannot tolerate. They compete more successfully for the same prey. Fishers and aquaculturists are the ones who are trying to supply the nation with food, but without regulations that protect native fisheries, fishers could find themselves losing stock availability or reductions in diversity and aquaculturists could find themselves being hit with modifications to keep invasive species from infecting local stocks.

Another major stakeholder group involved with this issue is environmentalists. The consumer of seafood and the individuals who enjoy recreation at the sea shore are also stakeholders in this issue as there can be transportation of human pathogens in ballast water creating problems with recreation and the consumption of seafood (NBEP 2000).

Environmental groups advocate for or work toward protecting the natural environment from destruction or pollution. Most environmental organizations dealing with this issue are interested in protecting the native ecosystem from invaders. In this case, they are working toward the strict implementation of programs and legislation to block invasive species (Cangelosi 2002).

San Francisco Bay is considered the most invaded aquatic ecosystem in North America. In response to this, the scientific environmental stakeholders³ published an article in the National Geographic Magazine entitled "Attack of the Invasives" to increase public awareness of the issue (McGrath 2005). In addition, environmentalists have published a variety of books and articles over the last decade on alien species and the effect on the economy and the Bay (Cohen 2001; Cohen 2000; Grossinger et al 1998; Weinstein & Cohen 1998; Stevens 1996). A few of these organizations also have list servers dedicated to the problem of invasive species. Even governmental agencies like the Sea Grant have issued radio and television documentaries for teachers, students and the shipping industry (Sea Grant 2002).

³ Save the Bay, the Union of Concerned Scientists, Earth Justice, the National Resource Council, and the Sierra Club have held programs and posted notices on their web sites

The ultimate problem with the issue of invasive species as a global issue is that the various governments of the earth are unlikely to work together to formulate solutions that benefit all nations. All stakeholder groups have yet to be identified and in the end it is unlikely that one solution will satisfy all of the groups. This issue will require many hours and days, maybe up to years, of compromises. Fishers and aquaculturists can't live without income, but environmentalists do not want to allow ecosystems to become corrupt and die. Shippers do not want added increases in the costs of shipping products or restrictions on the ports they are able to visit. Port authorities who must enforce regulations such as ballast water management don't want ports that are not viable, nor do they want more regulations which are difficult to enforce. In the United States, there is likely to be community input no matter what legislation is proposed. In the end, many committees will need to examine different ways to protect the current ecosystems and their native species. While some of these laws may not be what any one stakeholder group wants, compromise may end up being the best solution to the problem.

1.4 Assumptions and the Future of this Case Study

It is important to address the assumptions, biases and values that we bring to this case study because there are aspects that can close your mind off to "thinking outside the box". The authors have continuously run into the problem of assuming the issue is solvable. While the individual governments will end up being the primary decision makers on the issues addressed in this case study, this paper is also written with researchers in mind. Especially considered were those that have been involved with the many aspects of this issue and even the researchers who have helped us put this report together. This issue is ultimately a world issue and in order for effective regulations to take place, stakeholders need to be summoned from world-wide organizations, countries, and eventually individuals from local communities. This will also mean that literature and resources should be gathered from across the world in order to assist in the determination of the best outcomes.

2. Background and History

2.1 History of Invasive Species in the United States

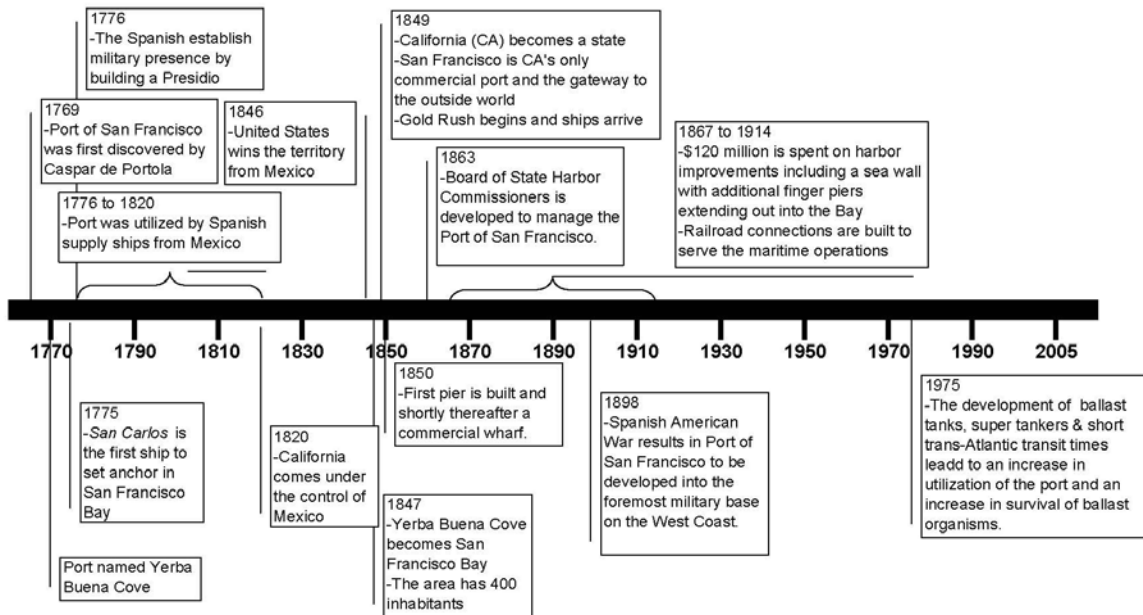
Throughout time trade has been utilized to develop alliances and to increase the power and wealth of various peoples of the world. Archeologists have found evidence of the movement of species by sea faring vessels between different continents from as early as 3000 B. C. (Erikson 2005). Erikson notes that Fofonoff, et al in 2003 found that while the rate of invasion of alien species was relatively flat from the 1800s until the 1900s it increased exponentially from 1900 until 2001 (Erikson 2005). Over the years, the United States has been subject to many species entering within the country's boundaries both intentionally and unintentionally. In the past 400 years, thousands of species of fresh water, brackish water, and salt water animals and plants have arrived at US ports (Cohen and Carlton 1995). The transport of goods and people has developed into a rapid, frequent business and international trade continues to increase with globalization and growth (Ericson 2005). One modern example of this is the Maersk Sealand Company which has over 300 shipping vessels and 950,000 containers traveling around the globe. The in comparison of the ships of the 1800s when one ship took months to years to reach its destination. Even these wooden ships transported species within them and on them however their numbers were small in comparison to today. Today with ships which hold thousands of gallons of sea

water and sediment the number of species which can be translocated is phenomenal (Ericson 2005; Carlton 1995).

In the United States the responsibility for the regulation of national resources falls under the Department of the Interior, however the states have primary responsibility for their lands and habitats. In California, the issue of invasive species fell to the state government departments, the Department of Fish and Game (DFG) and the State Water Resources Board (SWRB). It is this global scope of the non-native species, gaps in the regulations, and inability of local governments to act in the areas of international shipping, as well as legal action by some environmental groups, that has prompted national uniform regulations. Policies have been developed that now focus on all national ports and bodies of water. As a result the United States Department of the Interior, the Department of Transportation, the Department of Commerce, the Environmental Protection Agency, and the United States Congress have now become actively involved (GAO 2003; NISA 1996). The introduction of non-native species is second only to habitat destruction in threatening biodiversity and can cause the extinction of native species (Glowka et al., 1994; USGS 2003). Native species are important to the marine environment because they have adapted to the region they live in. They are able to keep up with and also sustain the chemical balance of the water system, such as through efficient recycling of nutrients. In some cases they are vitally important to different cultures that rely on fishing as a food source or as a trade product. The delicate balance of a marine ecosystem could also be altered forever by the unintentional introduction of non-native species. As an example, “ballast water has brought [the United States] mitten crabs-Asian crabs that burrow into riverbanks and damage levees” (NRDC 2001). Mitten crabs are more than just pests; they have affected commercial fishing operations. “Many are caught in trawl nets and must be removed, a time-consuming task” (DWR 1999). They can also damage fishing nets and kill shrimp that fishermen are trying to catch.

In San Francisco Bay, an average of one new species was introduced every 14 weeks between 1961 and 1995, and as of 1998, there were 164 introduced marine and estuarine species in the San Francisco Bay (Cohen and Carlton 1998). Since 1970 there has been, on average, a new species introduced every twenty-four weeks (SIMoN n.d.). Estimates indicate that up to 100% of the living matter in the areas of the bay are not native (Cohen and Carlton 1995). Ballast water is one major source of alien species due to the large amount of foreign ballast water the Bay receives (Cohen 1998). The United States Coast Guard has been charged with the monitoring of ballast water and ballast water exchange.

2.2 Timeline of San Francisco Bay Port Activity and History



2.3 Invasive Species Legislation in the United States

United States federal acts pertaining to invasive species have been implemented since before 1912 when the government recognized the need for a Plant Quarantine Act (NAL 2004). The Lacey Act of 1900 was the United States' first far-reaching federal wildlife protection law. "This act regulated the importation and interstate transfer of wildlife and allowed the Secretary of the Interior to designate injurious wildlife" (Claudi and Leach 1999). This enabled the government to begin identifying and regulating the possession and transportation of various animal and plant species which might be harmful to persons or the environment. In 1949 it was amended to prohibit the importation of animals listed in the Act to be injurious. Currently, there is a five step process to declare a species injurious and only 16 species, or groups of species, are listed as "injurious" under the provisions of the Lacey Act (USFWS n.d.). While there have been additional legislation enacted to address specific issues or concerns this Act is still enforced (CRS 1995).

"More recently, the harm caused by the introduction of the zebra mussels (*Dreissena polymorpha*) and the concern over a possible increase in the number of unintentional introductions of other invasive species resulted in the passage of a substantial piece of legislation, the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA)" which on October 3, 1996, became reauthorized as the National Invasive Species Act of 1996 (NISA) (Claudi and Leach 1999). NANPCA was the seminal legislation to prevent the introduction of non-indigenous species through ballast water in the United States. The 1990 Act established a program for preventing, researching, monitoring, and controlling infestations of non-indigenous aquatic species and required all vessels equipped with ballast water tanks entering the Great Lakes to undergo ballast water exchange. These regulations went into effect in 1993. The National Invasive Species Act of 1996 (NISA) expanded the United States' ballast management program to a national scope. NISA required the Coast Guard to issue voluntary guidelines to prevent the introduction and spread of non-indigenous species in all US waters by vessels

equipped with ballast water tanks that enter US waters from beyond the US Exclusive Economic Zone (200 miles), and to make those voluntary guidelines mandatory if the Coast Guard found lack of compliance or could not verify vessel compliance with the voluntary guidelines (Doelle 2003). In June 2002, with only 20 percent of vessels visiting US ports even bothering to report their ballast operations, “much less comply with the new management guidelines”, the US Coast Guard announced its intent to make the program mandatory because it could not verify compliance with the voluntary measures and began working on regulations to require mandatory ballast water management practices (Cangelosi 2002). The Coast Guard published its proposed rule on July 30, 2003 and the final rule became part of the Federal Register on July 28, 2004 (Volume 69, Number 144).

The Clean Water Act of 1972 (CWA) requires that all ballast discharges made within three miles of the coast must have a permit (EPA 2002). The exchange of coastal ballast water being exchanged for water from the open ocean thus diluting the contents was thought to protect ports from contamination. There have been few studies which evaluate the effectiveness of this method (Cawthorn Report 468 1998). Currently data is being compiled in the California Aquatic Non-native Organism Database to evaluate these questions in the long term (OSPR 2002). This legislation came as a result of “growing public awareness and concern for controlling water pollution” (EPA 2002). The goal was to make the nation’s waters safe for fishing and swimming, eliminate harmful discharges of pollution, and protect the nation’s wetlands.

The National Accounting Office found in 2002 that the federal government had made little progress in implementing the National Management Plan and recommended in conjunction with opinions from state legislators that integration of the legislative authority could result in increased cooperation. In 2001 several environmental groups sued the EPA for lax enforcement of clean water rules. The EPA denied a petition filed by several environmental groups that would require ships to obtain Clean Water Act permits for their ballast water discharges. The environmental organizations petitioned EPA in 1999 to repeal a regulation exempting ballast water discharges from National Pollutant Discharge Elimination System (NPDES) permits. The organizations stated ballast discharges should be regulated because they are a major pathway for the introduction of invasive species into U.S. harbors. The environmental groups sued in 2001 to force the agency to respond to the petition (Northwest Environmental Advocates v. EPA, N.D. Cal., No. 01-1297, 4/2/02; 67 DEN A-2, 4/6/01). In denying the petition, EPA said the federal government is engaged in numerous activities to control the introduction of species which are likely to be more effective and efficient than NPDES permits (EPA 2003). In 2005 a Federal judge ruled that the EPA can no longer exempt ballast water dumping from clean water legislation (Kay 2005).

On a state level, California has been busy in the last few years introducing new legislation regarding invasive species. In 2003 the California Marine Invasive Species Act (AB 433; MISA) was passed with the purpose of modifying and expanding the scope of the California State Lands Commission’s (CSLC) 1999 Ballast Water Management for Control of Non-Indigenous Species Act (AB 703) to be more efficient and eventually more proactive in addressing the invasive species threat. MISA monitors compliance with the management of ballast water from foreign countries and outlines five new California administration efforts regarding ballast water management, treatment, and hull fouling (MISA 2003). The San Francisco City Board of Supervisors also put forth regulations in 2003 regarding cruise ship wastewater management and ballast water management. These regulations prohibit cruise ships from discharging ballast, sewage and bilge water into state waters (SFGOV 2003). The State

Lands Commission has also initiated a ballast water performance standards advisory group which meets yearly. This group has only met once and consists of many stakeholders and of the advisory panel shall submit to the legislature and make available to the public, a report that recommends specific performance standards for the discharge of ballast water into the waters of the state, or into waters that may impact waters of the state. The performance standards shall be based on the best available technology economically achievable and shall be designed to protect the beneficial uses of affected, and potentially affected, waters. If the commission, based on the best available information, and in consultation with the board and in consideration of the advisory panel recommendations, determines that it is technologically and economically achievable to prohibit the discharge of non-indigenous species (Public Resources Code Section 71203 to 71210.5).

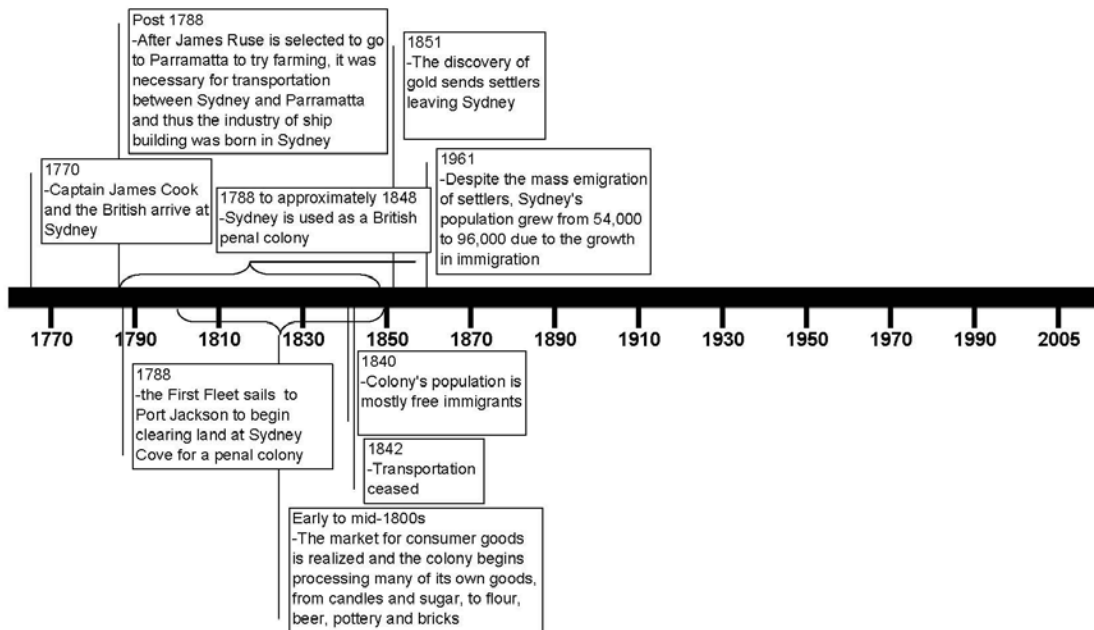
2.4 History of Invasive Species in Australia

European settlement over the past 200 years has led to drastic modifications of the natural environment (DPI 2005). Marine pests are introduced to Australian waters by a variety of vectors including ballast water discharge, aquaculture operations, aquarium imports, marine debris, and ocean currents to name a few (DEH 2004). Between 135 and 308 marine species have invaded Australia, and between 53 to 73 of those that have invaded are classified as having had economic and/or environmental consequences (Parliament of Australia 2004).

Threatened species can be particularly affected in the waters of this desert island, considering some species are only indigenous to this continent. For example in New South Wales one marine plant is presumed extinct and roughly 16 fish and aquatic invertebrates are considered threatened (DPI 2005). In New South Wales, the state in which Sydney Harbor is situated, there are two governmental organizations looking after the threatened aquatic species: NSW Fisheries which is under the New South Wales Department of Primary Industry (DPI) and NSW National Parks and Wildlife Service (NPWS) under the Department of Environment and Conservation. “NSW Fisheries looks after threatened freshwater and saltwater fish and invertebrates, and saltwater plants. Other types of animals, including whales, dolphins, seals and water birds, and plants, including freshwater plants, are the responsibility of NPWS” (DPI 2005). NSW DPI has specific responsibilities for controlling importation of non-native fish and participation in the National Introduced Marine Pests Coordinating Group, which seeks to prevent and manage the impacts of introduced marine pests.

The ocean and coast are an Australian icon, home and playground for most Australians, as more than 85% of Australians live within 50 kilometers of the coast (Australian Bureau of Statistics 2001), the coast is the most frequented place of recreation other than one's home and 90% of all domestic tourism is estimated to be coastal and marine (NOO 1997c). For many different types of marine recreation, water quality and ecological health are of major concern. As a result, many surfing and diving organizations have played an important role in opposing ocean sewage outfalls and cleaning up coastal and marine environments (NOO 1997c)

2.5 Timeline of Sydney Harbour Port Activity and History



2.6 Invasive Species Legislation in Australia

Under the Australian Constitution, specific and clear responsibility for the legislative and administrative framework within which natural resources are managed lies with the State and Territory governments. However Australia is quickly changing the role of the national government. The Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions (IGA) was signed in Darwin, Northern Territory on 15 April 2005. Although currently a voluntary program with the Australian Government, since the signing by all the state governments and the Northern Territory of this document, this new piece of legislation is expected to be mandatory in October 2006 (A. Snell pers. comm.; M. Holloway pers. comm). This agreement outlines the framework for a coordinated approach to and involvement by all key stakeholders – the Australian government, state and Northern Territory governments, marine industries, researchers and conservation organizations.

The Department of the Environment and Heritage (DEH) is one of the Commonwealth's two main departments that work cooperatively. It is responsible for environmental protection. DEH is responsible for the Environment Protection and Biodiversity Conservation (EPBC) Act of 1999. One of the objectives of the EPBC Act is to promote a co-operative approach to the protection and management of the environment that involves governments, the community, landholders and indigenous peoples (Parliament of Australia 2004). Implemented on 16 July 2000, it has also sought to clarify the Commonwealth's role in environmental jurisdiction. This legislation requires permits for the importation and exportation of wildlife.

The other Commonwealth department regulating this issue is the Department of Agriculture, Fisheries and Forestry (DAFF). DAFF and DEH work together as a de facto Memorandum of Understanding. DAFF's responsibility is to manage invasive species which pose a threat mainly to production values. This is primarily done through the Quarantine Act of 1908. The Quarantine Act recognizes the Commonwealth's responsibility in relation to pre-

border and border monitoring, detection and control arrangements in respect of humans, animals and plants (Parliament of Australia 2004).

NSW currently has no state regulations for dealing with ballast water (M. Holloway pers. comm.). Ballast water is managed by the Australian Quarantine and Inspection Service, a part of DAFF, under the Quarantine Act; however, AQIS only deals with international ships at their first port of call in Australia (M. Holloway pers. comm.). This means that any ships traveling internally, from other ports within Australia, are not bound by any legislation. On July 1 2001, Australia introduced mandatory ballast water management requirements (Australian Ballast Water Management Requirements), under AQIS, to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ship's ballast water (DAFF nd).

The main legislation regarding marine pests used in NSW is the NSW Fisheries Management Act 1994 and the related regulations, including the Fisheries Management Regulation of 2002 (M. Holloway pers. comm.). This legislation deals with the importation of live fish between states and includes a list of banned imports, release of fish (including invertebrates and mollusks) into the wild, listing of noxious species, listing of diseases, and emergency response powers (FMA 1994).

Although NSW, and therefore Sydney Harbour, is bound by the AQIS ballast water regulations and all other national legislation, it has no state-wide regulations for dealing with ballast water and hull fouling (M. Holloway pers. comm.). There is very little regulation in the aquarium trade, the main marine pest from this vector being *Caulerpa taxifolia*, an extremely invasive seaweed species (M. Holloway pers. comm.). While management of the main vectors for marine pests are ballast water, hull fouling, and the aquarium trade are currently limited, that will change with the new national system, IGA, once signed by the rest of the states (M. Holloway pers. comm.).

2.7 International Legislation

Management of marine resources has traditionally taken place through sectoral jurisdictions and responsibilities, where activities within the same ecosystem are managed separately, without coordination or adequate understanding of interactions or cumulative impacts (Juda 2003). By the 1960's it started becoming clear that a reactive, sectoral approach to use and management of natural resources is dysfunctional because of negative externalities, cumulative impacts and interactions between uses and ecosystem components (Reichelt & McEwan 1999; Juda 2003; Bateman 1999). This sectoral approach has been described as "a tyranny of small decisions and a jurisdictional nightmare, giving rise to multiple, overlaid, uncoordinated and collectively excessive use of resources" (NOO 1997a). In the 1960s and 1970s, the concept of integrated ocean policy began to emerge. Integrated ocean policy refers to a comprehensive and coordinated approach to decision-making to manage ocean ecosystems as a functional whole (FAO, IIRR & ICLARM 2000; Kenchington & Crawford 1993).

The United Nations (UN), in the mid 1960s, began the process of replacing the freedom-of-the-sea doctrine (free to all, belonging to none) with the UN Convention on the Law of the Sea (UNCLOS), which came into force in 1994. Through UNCLOS, coastal states are entitled to exclusive economic zones (EEZ) in which they have sovereign rights over ocean resources in the water column, on the ocean floor and in the subsoil extending 200 nautical miles (nm) out from the shoreline, thus substantially increasing the amount of ocean area subject to national jurisdiction and management (UN Division for Ocean Affairs and the Law of the Sea 1998).

Along with those rights comes the responsibility to ensure proper management and conservation of those resources.

UNCLOS acknowledges the need to manage the oceans as a complete system in an integrated way, rather than sector by sector. This is highlighted in the Convention's preamble which states that "the problems of ocean space are closely interrelated and need to be considered as a whole" (UN Division for Ocean Affairs and the Law of the Sea 1982). Australia ratified UNCLOS in 1994 and was among the first countries to define a coordinated national plan to manage the oceans that fulfills its responsibilities mandated under the convention (Reichelt & McEwan 1999). Currently, the United States of America has not signed UNCLOS; however they do recognize the 200 nm EEZ.

The United States and Australia are both signatories to several important pieces of international legislation⁴. On January 1, 1995, both countries began enforcement of the World Trade Organization's (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures, also known as the SPS Agreement. The aim of the SPS Agreement is to minimize the negative effects of health restrictions on international trade. To achieve this aim, the animal health measures established by countries to ensure the protection of human and animal life and health should be based on international standards, guidelines and recommendations developed by the Office International des Epizooties (OIE) and the International Plant Protection Convention (IPPC). These organizations create an international regime to prevent spread and introduction of plants and animals and their products through the use of sanitary and phytosanitary measures by participating countries. Parties establish national plant and animal protection organizations and agree to cooperate on information exchange and on the development of International Standards for Phytosanitary Measures.

For Sydney Harbour the World Trade Organization's 1995 Agreement on the Application of Sanitary and Phytosanitary Measures has the greatest international influence over Australia's ability to manage its borders to control entry of invasive species. As of recently, Australia has also signed on to the International Maritime Organization's International Convention for the Control and Management of Ships Ballast Water and Sediments. While only eight states⁵ have signed, "the Convention will be entered into force 12 months after ratification by 30 States, representing 35% of world merchant shipping tonnage (IMO 2005; M. Holloway pers. comm.). The Convention will require an exchange of ballast water according to prescribed standards along with the phasing in of on-board ballast water treatment systems over the next ten years (IMO 2005; M. Holloway pers. comm.).

The United States is currently reviewing two proposed pieces of international legislation prior to ratification. The International Maritime Organization's (IMO) International Convention for the Control and Management of Ships Ballast Water and Sediments⁶ is a set of non-mandatory guidelines which member states are urged to adopt voluntarily. If the convention is ratified by a sufficient number of nations and entered into force, it will be the first time international law has attempted to minimize the spread of non-indigenous, aquatic organisms by requiring ballast water management. This Convention also would establish the first performance standards applicable to ballast water treatment. Under the Convention, all new and existing

⁴ See Appendix 10.5 for a list of legislation.

⁵ Argentina, Australia, Brazil, Finland, Maldives, the Netherlands, Spain and Syrian Arab Republic equaling a total of 0.6% of world shipping (IMO 2005).

⁶ The US became a member of IMO in 1950 with Australia soon following in 1952. Both countries were members of the Convention's Drafting Committee.

vessels with ballast tanks will be required to implement ballast water management procedures and meet specific standards when on voyages entering a nation's waters from beyond its Exclusive Economic Zone (200 miles).

3. Methods

This report is divided into several sections. Section 3 goes on to describe the methods used for this policy analysis and biodiversity comparisons between the two harbors. It also explains information regarding the studies this paper used as sources for the species lists within each harbor. For this paper, we decided to use case studies with parallel categories to compare. We chose the Office of Spill Prevention and Response (2002) for San Francisco and the Australian Museum (commissioned by Sydney Ports Corporation) as the two studies to gather our species information because both were published around the same time (one year apart), both were assessments of the harbors. We also conducted a policy analysis and evaluation to determine the current policies and their effectiveness under the control variables discussed in Section 3.2. Section 4 details the results of this paper including: factors used for comparison, sea surface temperature data, species richness tables and percentages of invasion within each harbor, and legislation summaries. Section 5 begins the discussion. This section includes information on the database used to check the taxonomy of the species, cryptogenic species, domestic transportation of ships within a country, sea surface temperature results, and future research this paper could not conduct. Section 6 provides a conclusion section that contains a policy analysis with Section 7 containing the recommendations of this paper.

3.1 Study Areas

Our case study examined two similar harbors from two different countries: San Francisco Bay in the United States of America and Sydney Harbour in Australia⁷.

In addition to shipping, the Port of San Francisco has become home to many excursion boats, ferries, and cruise ships. San Francisco Bay is 1600 square miles (4143.98 square kilometers) in area. The entry to the port is through the Golden Gate, a strait between two peninsulas. The bay is as deep as 100 ft (30 m) in spots, with a channel 50 ft (15 m) deep maintained through the sandbar off the Golden Gate. San Francisco has approximately 24 vessels traveling to the 16 ferry docks in the bay⁸ (CEIC 2005).

Shipping is a vital part of the Australian economy and their dependence on coastal shipping is noticeably higher than that of the European Communities and the USA, compared to other modes of transport (BIE 1994). Today, Port Jackson or Sydney Harbour is an inlet of the Pacific Ocean, 21 square miles (54 square kilometers) forming Australia's finest harbor with the Parramatta River forming its western arm (Port Jackson 2005; AMBS 2002). Sydney on the south shore is connected with its northern suburbs by Sydney Harbour Bridge.

The importance of transportation on the water can be seen by just traveling to Sydney. Ferries have been around Sydney Harbour since around the time it was settled and although the ferries have changed over the years, they continue to carry people to various destinations throughout "the largest and busiest seaport in Australia" (Andrews 1975). Sydney Ferries Corporation has been transporting visitors and natives for over 135 years (Andrews 1975). Now

⁷ See Appendix 10.1 for a location diagram.

⁸ See Appendix 10.3.3 for a figure of San Francisco Bay's ferry routes.

they have 31 vessels traveling to the 37 wharves that are spread throughout the harbor⁹ (SFC n.d.).

3.2 Data Collection

A multi-step process of data collection was undertaken in order to pursue the issue of invasive species in San Francisco Bay and Sydney Harbour. An initial information gathering process was conducted to find similarities between the sites. A resulting spreadsheet described aspects of each site that were thought to be important for the comparison of the two sites. This spreadsheet includes the following categories (Table 1):

Size of harbor-It was determined that Sydney Harbour is 12 miles (19 km) long and 1.5 miles (2.4 km) wide at its mouth (Port Jackson 2005). San Francisco Bay is 50 miles (80 km) long and from 3 to 13 miles (4.8-21 km) wide (San Francisco 2005).

Depth of harbor-The range of depth of Sydney Harbour is 30 ft (9 m) to 155 ft (47.2 m) (Port Jackson 2005). San Francisco is as deep as 100 ft (30 m) in spots, with a channel at a maintained depth of 50 ft (15 m) deep (San Francisco 2005).

Amount of imports/exports per year-While no specific numbers could be found relating how much ballast has been released in Sydney Harbour, estimates are that 5.232 million tones of ballast are discharged from 327 vessels¹⁰. San Francisco has annually over 809 arrivals carrying over 10 million tones of ballast water (MARAD 2004). According to Cohen and Carlton (1995), bulkers and tankers discharge more than 68 million gallons of water from ballast tanks per year into San Francisco Bay.

Invasive species list-A total of 395 non-indigenous species were found in San Francisco Bay with 344 cryptogenic species. Sydney Harbour showed 121 non-indigenous species with 6 verified cryptogenic species.

Government departments involved in the protection of the harbors-A list of government departments that had some role in the protection of these harbors and assisted in the initial requests for information is displayed in Table 1.

Regulations/policies enacted on the harbor-A list of the regulations and policies enacted by any governing bodies pertaining to each of the harbors is provided in tables 7.9.1. and 7.9.2.

Estimated length of time invasive species have been entering-(see section 2.2 and 2.5) The start to invasions into these harbors could be since the start of shipping to the ports. For San Francisco this could be since 1769, while for Sydney Harbor this could be since the commencement of European settlement in 1788.

Sea Surface Temperature-(see Figures 4 and 5) Another comparison used between the sites was sea surface temperature. Even though both harbors are in the relatively same climate regime, California has upwelling currents off its coast from about March to September. These upwelling currents provide deep, cold water rich with dissolved nutrients from the decay of organic material that has sunk to the ocean floor that is responsible for high productivity and diverse assemblages.

⁹ See Appendix 10.4.3 for a figure of Sydney Harbour's ferry routes.

¹⁰ Information regarding the exact amount of ballast discharged in Sydney Harbour could not be found by the researchers. 1171 ships visited Sydney Harbour in 2000 (AMBS 2002). 327 of those vessels discharged ballast water in the port from a total of 627 tanks (AMBS 2002). Estimates are that 160 million tones of ballast are discharged at ports all across Australia from 10,000 ships (AMBS 2002). This number has been calculated according to a ratio comparison of the number of ships deballasting in Sydney Harbour and the amount of ballast/ number of ships deballasting in Australia, are discharged in Sydney Harbour in 2000.

The first phase consisted of identification of all known native and non-native species in the two environments. The second phase consisted of gathering all related international, Australian, New South Wales, Sydney Harbour, United States, California, and San Francisco Bay laws and policies that are related to invasive species and how they are implemented. The third phase examined how policy and laws are enforced. The final phase linked the enforcement and policies to the problem.

To keep track of the data needed for the first phase we designed a spreadsheet for each harbor (Table 1). Information was gathered regarding date of first invasion by non-native species to the harbors, native range, and known vector of dissemination. Research used included websites, scientific papers from journals, government reports, and current and past works done by scientists and organizations that have examined similar aspects. Personal contact was made with several individuals representing both Australian organizations and American organizations who have completed work in the same field. The categories for the spreadsheets included:

Taxonomy-Each species' taxonomy information was checked through the North American Integrated Taxonomic Information System (ITIS). This was done because some species were discovered to have a synonym name used. To ignore this situation and to leave the species name would have resulted in the examination of two different species on the list. A common database needed to be used. Any species not recognized by the ITIS database were researched via other means to determine taxonomy.

Status-The species' status was also determined. Three different categories were used to distinguish the species: native, non-native, and cryptogenic (or unknown). Cryptogenic was a term that we decided to use after the start of the study, based on information gathered from other resources. Further explanation of why this term was used can be found in the discussion of this paper.

Date of first record-Use of this category was restricted to non-native species located in the harbor. This was important to know in order to determine whether invasions are still occurring.

Native range or region of origin-This information provides some information as to how species arrived at the ports.

Known vector of dissemination-The research of this information was also restricted to non-indigenous species. The vectors were split into six categories based on the output of the Commonwealth Scientific Industrial Research Organisation's (CSIRO) National Introduced Marine Pest Information System (Hewitt et al 2002): agriculture, canals, fisheries, natural dispersal, ornamental, shipping, other/unknown. Because information is usually given by the species' history throughout the world, the cataloging vector may not be due to the introduction within the two study sites.

A similar method of tracking legislation and policy was implemented for the second phase¹¹:

- Law/policy name
- Year implemented
- Reason that triggered need
- Year amended
- Key purpose
- Government level
- Enforcement

¹¹ See Appendix 10.5 for non-indigenous species legislation for both harbors.

3.3 Source of San Francisco Bay Species List

In 1999, the Californian legislature passed the Ballast Water Management Act of 1999. One of the requirements under the Act was for the California Department of Fish and Game, as the primary agency responsible for the management of fish and wildlife and their habitats, to conduct a study to determine the location and geographic range of non-indigenous species populations along the California coast. The California Department of Fish and Game's (CDFG) Office of Spill Prevention and Response (OSPR) conducted an extensive survey of many locations along the California coast in 2000 and 2001, one being San Francisco Bay (CDFG 2002). They looked at a total of seven major ports where large vessels enter state waters. These seven were chosen as the most likely locations where ballast related introductions would have occurred (CDFG 2002). This information was used as a baseline to determine both the nature and extent of the problem in California, and to assess the effectiveness of future control measures on species introductions.

San Francisco Bay, which had already been extensively studied in recent years, (Cohen and Carlton, 1995), was not sampled (CDFG 2002). The information for San Francisco Bay was compiled from these previous studies with the assistance of the Smithsonian Environmental Research Center, which is a leading research center for environmental studies of the coastal zone, and the California Department of Fish and Game Bay/Delta Program (CDFG 2002).

A literature review was undertaken to compile information about introduced aquatic species in California (CDFG 2002). The review targeted information from peer reviewed scientific publications, web sites, agency literature, field surveys and personal communications (CDFG 2002). A small group of biologists has completed four, one-week "rapid assessments" of float-fouling communities around San Francisco Bay approximately annually between 1993 and 1997. Primary background for this project can be found in the PhD dissertations of James T. Carlton¹² and Andrew N. Cohen¹³. These two studies, 20 years apart, have provided a backbone for our understanding of bio-invasions in San Francisco Bay (San Francisco Bay Expeditions 1993-1997).

3.4 Source of Sydney Harbour Species List

In 2001, the Sydney Ports Corporation commissioned the Australian Museum to undertake a baseline survey of marine organisms from Sydney Harbour. There an extensive collecting by scuba divers from the harbor bottom and wharves from 30 March to 6 June 2001¹⁴, as well as grab samples, beam trawls, trapping and environmental data which were undertaken by Australian Museum staff in 57 different sites (AMBS 2002). The sites were selected from the following 11 berths (1-11) and two areas (12-13) outside the port facilities were nominated by the Sydney Ports Corporation for the Sydney Harbour survey:

1. White Bay berths 1-6
2. Glebe Island berths 1,2,7,8.
3. Darling Harbour berths 3-10
4. Sydney Cove Passenger Terminal
5. Gore Cove berths

¹² 1979. History, biogeography, and ecology of the introduced marine and estuarine invertebrates of the Pacific Coast of North America. University of California at Davis. p 904.

¹³ 1996. Biological invasions in the San Francisco Estuary: a comprehensive regional analysis. University of California at Berkeley. p 465.

¹⁴ See Appendix 10.4.1 for a figure of the harbor and locations of berths.

6. Berrys Bay berth
7. Balls Head Bay berth
8. Rozelle Bay berth
9. Blackwattle Bay berth
10. Garden Island berths
11. Chowder Bay berth
12. Clarke Island
13. Bottle and Glass Rocks

Visual surveys, epifaunal scrapings, fish poison stations and dinoflagellate sampling were performed for a total of 184 dives (AMBS 2002). GPS readings were also taken to record latitude and longitude, maximum depth was recorded and a photograph was taken from the boat at each site (AMBS 2002).

3.5 Data and Policy Analysis Methodology

Biodiversity comparisons were conducted because there was a large data set across the two harbors. Biodiversity indices provide researchers with simplified measures that can be used to examine the community structure (Molles 2002; Krebs 1994). The size and structure of the community are influenced by regional processes, including the geophysical properties and history of the region (e.g. age, geology, size and climate), and broad-scale ecological or evolutionary processes such as species migrations and invasions, speciation and regional extinction. These comparisons can provide a quantitative assessment of the community structure and be used to investigate the differences in communities. Total species richness¹⁵ was calculated for each site in the survey and for three categories: invertebrates, vertebrates, and plant species (C. Fellows pers. comm.). Ratios of invasive species to native species were then calculated for each site and within the three categories listed above (C. Fellows pers. comm.). Comparisons were then conducted between the two sites and the indicators of difference are explained later in this work by the accepted guidelines in ecology (C. Fellows pers. comm.).

When conducting a comparative policy analysis, the goal is to ascertain how (1) various policies will differentially impact individual human incentives and behavior and (2) how aggregate patterns of behavior arising from various policies impact the ecological and socioeconomic well being of the ecosystem. The research challenge in comparative policy analysis arises because there will be no simple answer for all situations. In some cases, the most efficient policy option will be education or other forms of community and/or institutional capacity building that enable invasive species to eventually be more effectively managed.

A policy review of public documents (legislation, policy documents, consultation records, annual reports and reviews), government websites and literature review of academic journals was conducted to uncover relevant information and develop understanding of the United States and Australia policy development and implementation processes.

For longer-term marine conservation and management initiatives, analysis at the constitutional choice level becomes important. At the constitutional level, choices are made about who is entitled to make lower level rules and how the rule-making process itself is governed (Ostrom 1990). Thus, the structure of governance – the private sector, public sector

¹⁵ The species richness approach to assessing biodiversity examines the distribution of all resident assemblages: invertebrates, vertebrates, plants, etc. Species diversity is the number of different species of assemblages living in an area.

and civil society organizations and institutions that help a society to steer itself (Hubbard 2000) – can be viewed as endogenous.

In pursuing some of the objectives for the case study, a qualitative focus was needed for the examination and comparison. The comparison looked at the following questions:

- How are invasive species included in the legislation to limit their entry into these harbors?
- How are the goals or objectives of the legislation being allocated amongst the local departments to assist with the desired outcome?
- How much collaboration was there among those departments?
- How do invasive species laws differ amongst the local, state, and national tiers of government between the two harbors?

3.6 Rationale for Cross Country Policy Analysis

Cross country comparative policy analysis between two similar port nations can offer more realistic insight and lessons about the consequences of policy decisions and implementation approaches (Rose 1973). While this does not mean each nation should adopt the same policy or respond in the same way, it provides an opportunity to learn from each other's relevant experiences and move forward in an educated and advantaged way (Rose 1988). A cross country comparative analysis can provide insight into the implementation of different policy approaches by identifying strengths and weaknesses of alternative approaches (Dogan & Pelassy 1990).

4. Results

4.1 Comparison of Harbors

Table 1. Comparison chart of major influences on Sydney Harbour and San Francisco Bay.

	Port Jackson aka Sydney Harbour	San Francisco Bay
Location of Harbor	New South Wales, Australia	California, United States
Size of Harbor	Sydney Harbour is 54 square kilometers (21 square miles) in area (City of Sydney Media Centre 2005). It is 12 miles (19 km) long and 1.5 miles (2.4 km) wide at its mouth (Port Jackson 2005).	San Francisco Bay is approximately 1600 square miles (4,143.98 square kilometers) in area (NOAA SFB, n.d.). It is 50 miles (80 km) long and from 3 to 13 miles (4.8-21 km) wide (San Francisco 2005).
Depth of Harbor	The range of depth of Sydney Harbour is 30 ft (9 m) to 155 ft (47.2 m) (Port Jackson 2005).	San Francisco is as deep as 100 ft (30 m) in spots, with a channel at a maintained depth of 50 ft (15 m) deep (San Francisco 2005).
Climate	Temperate	Temperate
Amount of Ballast Dumped/Ships Visited	In 2000, approximately 5.232 million tones of ballast were discharged from 327 vessels.	San Francisco (1998) has annually over 809 ¹⁶ arrivals carrying over 10 million tonnes of ballast water (MARAD 2004). According to Cohen and Carlton (1995), bulkers and tankers discharge more than 68 million gallons of water from ballast tanks per year.

¹⁶ The report uses literature including Carlton & Geller 1993; Cohen & Carlton 1998; Cohen & Carlton 1995

Invasive Species	In 2000: 121 non-indigenous ¹⁷	Compilation of studies (1998): 395 non-indigenous, 344 cryptogenic
Government Departments Involved	FEDERAL	
	Australian Environment Protection Agency - EPA	US Environmental Protection Agency - USEPA / National Estuary Program
	Department of Transport and Regional Services Australian Quarantine and Inspection Service - AQIS	Department of Transportation Department of Homeland Security / US Coast Guard
	Australia Department of Agriculture, Fisheries, and Forestry - DAFF	US Department of Agriculture / Animal and Plant Health Inspection Service US Department of the Interior US Fish and Wildlife Services - USFWS
	Australia Department of the Environment and Heritage - DEH	Department of Commerce / NOAA
	Australian Marine Safety Authority	American Association of Port Authorities
	Commonwelath Scientific and Industrial Research Organisation - CSIRO	--
	--	US Department of Defense / Army Corp of Engineers - USACE
	--	Interagency Committees Aquatic Nuisance Species Task Force - ANS
	STATE	
	New South Wales Department of Primary Industries Fisheries - DPI	California Department of Fish and Game - CDFG
	--	California State Lands Commission
	LOCAL	
	Sydney Port Authority	San Francisco Port Authority

¹⁷ The AMBS (2002) study on Sydney Harbour's invasive species did not include the number of cryptogenic species. At least 6 species from this study were found by the researchers of this paper to be cryptogenic from CSIRO's National Introduced Marine Pest Information System (NIMPIS). Tim Glasby (pers. comm.) from NSW DPI says "I don't know why AMBS would not have listed any species as cryptogenic." The problem becomes that the cryptogenic species is "not that well described compared to many northern hemisphere countries (e.g. I think most of our sponges would be classified as cryptogenic)".

Information on San Francisco Bay’s air and sea temperature was gathered from the United States National Oceanic and Atmospheric Administration’s (NOAA) National Data Buoy Center (NDBC). The buoy was located at approximately 37.75N 122.82W, 18NM west of San Francisco, and the data summary was calculated from information gathered from July 1982 to December 2001 (NDBC 2005; Figure 4). Sydney Harbour sea surface temperature information was gathered from CSIRO Marine and Atmospheric Research. The buoy was located at approximately 34.09S 151.2W, east of Sydney Harbour. The data was calculated from information gathered by CSIRO Marine and Atmospheric Research (CMAR; S. Edgar pers. comm.) from July 1982 to December 2001, although information was available from December 1942 to February 2005, so that a similar comparison between the two sites could be conducted (Figure 5). The indicators of difference for this comparison will be shown through the graphs that can be produced with this data and in combination with the biodiversity comparisons.

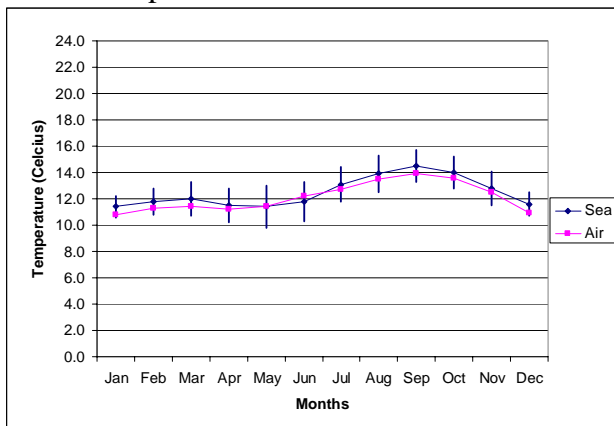


Figure 4. San Francisco Bay sea surface temperature data from January through December (winter through winter) compiled as a summary from 19 years of data by NDBC. Sea temperature one standard deviation is shown.

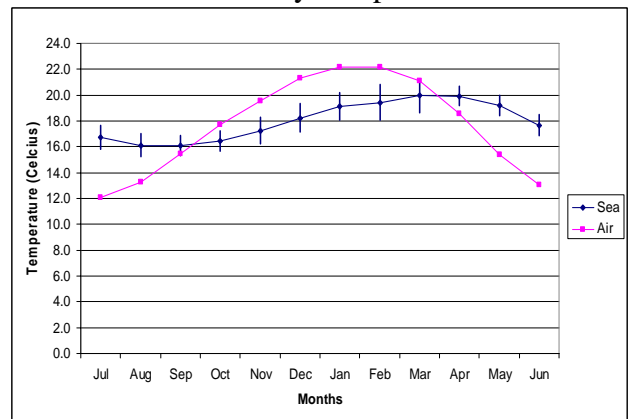


Figure 5. Sydney Harbour sea surface temperature data from July through June (winter through winter) compiled as a summary from 19 years of data by CMAR. Sea temperature one standard deviation is shown.

4.2 Species Richness

In the complete survey, 751 species were located in San Francisco Bay (Table 2) and 3752 species were encountered in Sydney Harbour (Table 3). In San Francisco Bay, 12 (1.6%) of the species were native to the local environment (Table 4) while Sydney Harbour had 3631 (96.8%) native species (Table 5).

Table 2. San Francisco Bay's species richness by phylum.

Phylum	No. of Species
<i>Invertebrates</i>	
Annelida	238
Arthropoda	167
Mollusca	66
Cnidaria	44
Ectoprocta	30
Porifera	14
Nemertea	7
Entoprocta	3
Platyhelminthes	2
Sipuncula	2
Acanthocephala	1
Echinodermata	1
Phoronida	1
Rotifera	1
Species Richness of Invertebrates	577
<i>Vertebrate</i>	
Chordata	85
Species Richness of Vertebrates	85
<i>Plants</i>	
Magnoliophyta	25
Bacillariophyta	14
Chlorophyta	12
Rhodophyta	9
Pyrrophytophyta	4
Phaeophyta	3
Cryptophycophyta	2
Species Richness of Plants	69
<i>Monerans</i>	
Cyanophycota	2
Species Richness of Monerans	2
<i>Protozoans</i>	
Ciliophora	16
Protozoa	2
Species Richness of Protozoans	18
<i>Total</i>	
Species Richness	751

Table 3. Sydney Harbour's species richness by phylum.

Phylum	No. of Species
<i>Invertebrates</i>	
Mollusca	1140
Arthropoda	588
Porifera	441
Ectoprocta	215
Annelida	205
Cnidaria	137
Echinodermata	123
Platyhelminthes	18
Nemata	7
Sipuncula	7
Ctenophora	3
Echiura	3
Phoronida	3
Entoprocta	2
Nemertea	2
Kinorhyncha	1
Species Richness of Invertebrates	2895
<i>Vertebrate</i>	
Chordata	785
Species Richness of Vertebrates	785
<i>Plants</i>	
Rhodophyta	40
Phaeophyta	14
Chlorophyta	13
Pyrrophytophyta	4
Phycophyta	1
Species Richness of Plants	72
<i>Total</i>	
Species Richness	3752

Table 4. San Francisco Bay's ratios of non-native species to native species.

	Number of Species
<i>Invertebrates</i>	
native	9
non-native	275
cryptogenic	293
ratio of non-native to native	30.5556
 <i>Vertebrate</i>	
native	0
non-native	79
cryptogenic	6
ratio of non-native to native	0.0000
 <i>Plants</i>	
native	3
non-native	33
cryptogenic	33
ratio of non-native to native	11.0000
 <i>Monerans</i>	
native	0
non-native	0
cryptogenic	2
ratio of non-native to native	0.0000
 <i>Protozoa</i>	
native	0
non-native	8
cryptogenic	10
ratio of non-native to native	0.0000
 <i>Total</i>	
native	12
non-native	395
cryptogenic	344
ratio of non-native to native	32.9167

Table 5. Sydney Harbour's ratios of non-native species to native species.

	Number of Species
<i>Invertebrates</i>	
native	2809
non-native	83
cryptogenic	3
ratio of non-native to native	0.0295
 <i>Vertebrate</i>	
native	768
non-native	17
cryptogenic	0
ratio of non-native to native	0.0221
 <i>Plants</i>	
native	54
non-native	16
cryptogenic	2
ratio of non-native to native	0.2963
 <i>Total</i>	
native	3631
non-native	121
cryptogenic	6
ratio of non-native to native	0.0333

4.3 Legislation

Between 1989 and 1993 Canada, Australia, New Zealand and the IMO adopted guidelines on ballast water management (Convention on Ballast Water Management) after scares about the potential spread of epidemic disease. Although these guidelines were primarily advisory and voluntary in nature, under their authority Australia prohibits the discharge of some ballast water into their coastal waters (AQIS).

In the US, awareness of the problems associated with non-indigenous species began in the 1980s, with the introduction of zebra mussels into the Great Lakes. Zebra mussels gained entry into US waters through the transport of ballast water that had been collected in European ports and subsequently released once vessels had reached their ports-of-call in the Great Lakes. Sufficient numbers of mussels or their larvae were introduced to establish a Great Lakes population and connected river systems, resulting in significant damage to city water supplies and electric utilities throughout the region. In November 1990 NANPCA was signed after concern over the zebra mussel invasion of the Great Lakes in 1986. NANPCA set up voluntary guidelines, which became mandatory requirements in 1993, for ballast water management by ships arriving from overseas ports and entering the Great Lakes. NISA became law in October 1996 and maintained the mandatory regulations for the Great Lakes and Hudson River. NISA also added similar voluntary guidelines for the rest of the country. However unlike NANPCA, in which the voluntary guidelines for the Great Lakes had automatically become mandatory within two years of enactment, under NISA the voluntary guidelines that apply to the rest of the country will remain voluntary unless the Secretary of Commerce determines that they are ineffective or not being complied with, following a mandated review process.

5. Discussion

5.1 ITIS Database

The Integrated Taxonomic Information System (ITIS) was the system chosen for this case study to check the taxonomic information for families (ITIS 2005). Because species lists were being formed from case studies regarding two sites in different countries, it was necessary to be able to check taxonomic information and make sure the previous research used a common taxonomic hierarchy. Otherwise, two species (one with the accepted scientific name and one with a synonym) could be examined and judged to be two different species. One reason for choosing this system was because its database can be cued from the organization's website.

ITIS was formed in 1996 as an interagency group within the US federal government, involving agencies from the Department of Commerce to the Smithsonian Institution (USDA 2005). It has now become an international body, with Canadian and Mexican government agencies participating, and collaborates with other international agencies (USDA 2005).

There are numerous lists of invasive species, although these are widely scattered and of variable taxonomic/nomenclatural reliability. ITIS aims to produce a complete and accessible database of taxonomic information for every recognized species and other taxa, including both its place in the hierarchical system of scientific classification and references to the authorities on which that placement rests (USDA 2005). However, biological taxonomy is not fixed, and opinions about the correct status of taxa at all levels, and their correct placement, are constantly revised as a result of new research, and many aspects of classification will always remain a matter of judgment. Inevitably, the information from ITIS cannot be final.

5.2 NIMPIS

Australia's dynamic database is called the National Introduced Marine Pest Information System (NIMPIS; NIMPIS 2002). This database is equivalent to the United States' ITIS database. In the course of our research many of the initial species on which we tried to find taxonomic information were not contained in the database. This database is the first of its kind in Australia and is still in the process of being developed. The project started in 2001 with \$338,000 in funding from the Commonwealth's Natural Heritage Trust (NHT) and support from the CSIRO and State/Territory agencies. It is currently supported by Environment Australia.

5.3 Cryptogenic Species

Although most of the species examined in this case study were classified under categories of introduced or invasive, some species have been classified by experts to be "cryptogenic" species, or as defined by Carlton (1996) as "a species that is not demonstrably native or introduced". We have become lax in our use of terminology in this field and normally classify species that are not shown to be introductions to a community assemblage as 'native'.

The reason so many marine species are cryptogenic is that many introductions happened before any surveys were done. Thus it is very difficult to tell whether a species is native or introduced.

5.4 Domestic Vessel Transportation

Both countries are mainly concerned with the transportation of invasive species through international waters (evident by the United States' NISA of 1996 and Australia's Quarantine Act of 1908). With all the focus on the invasive species problems that can stem from international shipping, little information is being processed regarding domestic shipping. Neither country has specific legislation dealing with this topic.

Transfers of ballast from invaded ports to uninvaded ports increases the risk of the spread of these invasions. The San Francisco Bay contains numerous non-indigenous aquatic species that do not occur elsewhere on the west coast, most of international origin (Cohen, 1998). The United States is home to many different ecosystems along the coasts of its states, and transfers of ballast water between these ecosystems are no different from a biological perspective than transfers of ballast between ecosystems in different countries. With Australia's allowing each state and territory to develop their own legislation on the matter, there is the possibility of some states being more invaded than others and some focusing their efforts on limiting the number of non-native species entering into their waters.

Coastal port-to-port exchange may also increase the potential for species establishment because of more similar environmental factors. The "greater the difference in the physical and chemical states of the donor (source) and receiver (target) regions, the lesser the probability of survival" (NRC 1996).

5.5 SST

Land and water have distinctive features that create differences in their ability to heat and cool. Land can heat and cool more rapidly than water since water heats by convection allowing temperature changes that can occur to depths of 20 feet or more below the surface. Land doesn't have this ability. The process of conduction slows the spread of heat through soil and rock. Because of this thin layer of heated land, during cold temperatures the land is able to cool faster than water. Another reason for the differences between land and water is specific heat, the

amount of heat needed to raise the temperature of 1 gram of a substance 1°C. Water's specific heat is more than three times greater than land's. Therefore, water requires more heat to raise its temperature the same amount as an equal quantity of land.

Surface ocean currents have an important effect on climate (D. Mautner pers. comm.). The "typical" California climate is similar to that of the Mediterranean—a near-desert in summer and a dripping landscape in winter. During the summer, the migrating Pacific high pressure cell (commonly referred to as the Pacific High) deflects storms northward to Oregon and Washington, nearly preventing any measurable precipitation (D. Mautner pers. comm.). In the winter, the strength of this high-pressure cell decreases and it shifts to the south, allowing moisture-laden storms to move in from the west (D. Mautner pers. comm.). Often, a series of low-pressure cells can deliver heavy rains and gale-force winds (Lutgens 2001).

Although dominated by the effects of high and low pressure cells, the climate of coastal California is moderated by the temperature of the northeastern Pacific Ocean. Ocean related regulation reduces the intensity of cold winter temperatures, provides the source of the enormous summer fog banks, and moderates the overall annual range in temperatures. The climate of the region surrounding the waters of San Francisco Bay lies somewhere between the extreme seasonal variations of the Central Valley and the more subdued climate of the coast because of the local topography and the constant interaction of continental and maritime air masses (Elford 1970).

Throughout the spring, the Pacific High increases in strength and moves closer to the coast. The combination of increased northwest wind stress and Coriolis force causes the southeastward-flowing California Current to turn to the right, away from shore (Thurman 1981; D. Mautner pers. comm.). The water that moves offshore is replaced by cold, nutrient-rich water that is upwelled near the coast from intermediate water depths. The upwelled water makes the surface water temperature colder in June and July than it is during the winter (D. Mautner pers. comm.).

This cold water is part of the "natural air conditioning" for which San Francisco is famous. As summer winds travel over the North Pacific, the air absorbs great quantities of moisture through evaporation. As it approaches the coast, the air is cooled by the sea, and condensation occurs. Whether the fog is thin and wispy or is so thick and heavy that anywhere else it would pass for rain depends on the temperature of the California Current and how much moisture is in the air (D. Mautner pers. comm.). As the strength of the California Current wanes in August, the fog disappears and "summer" comes to San Francisco from August to October, the three hottest months of the year (D. Mautner pers. comm.).

The relatively cooler water along the northern and central California coast is a key component of the summer climate. Technically known as "upwelling," it's the result of the interaction of atmospheric pressure, ocean currents and the geography of California.

Like other currents off the west coasts of South America and Africa, the California Current moves surface water offshore (D. Mautner pers. comm.). The displacement forces deeper water, rich in the nitrates and phosphates accumulated as marine organisms die and decay, up to the surface. In normal years the upwelling off the coast peaks in spring when northwest winds are strongest and slacks off in fall, allowing subtropical waters to move farther north.

Australia's climate variability is strongly influenced by the Pacific Ocean and sea surface temperature patterns in the Indian Ocean. The sea temperature is the effect of the East Australian Current and prevailing winds (D. Mautner pers. comm.). From August to December (autumn season in US), off the NSW coast, cooler sea water temperatures prevail, while the

warming effect of the sun is increasing to its maximum (in the summer). The sea breezes moderate temperatures in summer. Therefore, the contrast between land and sea surface temperatures becomes considerable during the mid-afternoon.

The East Australian Current runs southward down the eastern coast of Australia. This is a warm current that occasionally has upwelling of cold water onto the continental shelf; however, Australia does not have any significantly rich fishing grounds because the winds are generally not conducive to upwelling. The coastal ocean off Sydney, Australia, has the strongest upwelling influence in the outer zone from the East Australian Current. Water temperatures in the outer zone are low when the current passes close to the continental slope and high when it passes further out to sea (D. Mautner pers. comm.).

5.6 Recommendations for Future Research

- ***Domestic vessel and water transport vessel fouling (ie. water taxis and ferries)***

Ferries, water taxis, and water buses play an important role in both harbors. In Sydney Harbour, water transportation gets you to most of the local tourist destinations and even approximately 20 kilometers inland. Water transportation provides vectors for invasive species to increase their range. It is important to minimize the transportation of invasive species between ports and through local ecosystems. Information on this subject is needed when examining whether to include domestic vessel movements into the current ballast water management procedures to minimize the risk of introduced marine pests.

- ***Upwelling effect on invasive species in San Francisco Bay***

This paper briefly examined the sea surface temperature between the two harbors. California is well known for its nutrient rich upwelling which is not true for Sydney Harbour. The period from early spring to late summer is associated with cool surface waters. A future examination of whether upwelling has an effect on invasive species numbers would provide valuable information in the future management of upwelling ecosystems.

- ***The cost of controlling invasive species***

It is important that we track not only the dollars spent, but the effectiveness of the programs which are developed and utilized. The utilization of comparable programs and standardized protocols are important for the identification and detection of new species but also of established non-native species dispersion (NOAA Research 2005).

- ***Ongoing monitoring of San Francisco Bay and Sydney Harbour***

Research to evaluate changes in both native and non-native populations and their effect on the ecological balance within San Francisco Harbor would be of value so that changes in all aspects of the food chain and the competition which may occur for resources can be evaluated for their global effect on the health of the harbor. It would also be important to evaluate the effects of global climate change on the harbor and these populations and the significance of the changes on the ecosystem of the harbor.

- ***Cost formulations***

Another important aspect to consider in this topic is the costs of the current policies for each country in comparison to the respective state or national budgets. This would give a good comparison of the financial effort and emphasis each country places on the environment and invasive species monitoring, research, and the enforcement of legislation. We discovered that finding the budget information for each of the legislative pieces for this study was not possible. Another good comparison could be a cost benefit

analysis and/or a risk analysis for each national system with the examination of the effects of invasive species. This would be a difficult task because some aspects of the costs, and benefits, ratios are not currently quantifiable or measurable in any way. However there are examples and methods for dealing with cost benefit analyses on invasive species (ie. Anderson et al 2004).

6. Conclusion

From looking at our data and the legislation collected, the Port of San Francisco relies heavily on the federal laws and has few specific state laws, regulations, and enforced policies on the subject of invasive species. This differs greatly in Sydney Harbour where the states have all of the power and make decisions on laws and policies within each state. Some of the reasons for this are based in each country's individual legislation. In the US the federal government has reserved significant power regarding invasive species Whereas, the Australian arrangement leaves the states and territories with the ability of delegating specific legislation at the state level, or leaving legislation to localities.

For Australia, this separation between the state and local governments from the federal tier can become an obstacle in the future. Local government is the third tier of government; however, it is not recognized in the Australian Constitution. The local government's power derives from a State Local Government Act that grants local authorities certain powers. However, state legislation overrides local government laws and actions, and not all local governments have the same scope of power to deal with invasive species. Also, as with the national legislation, the state and territory legislation that relates to invasive species is often reactive and restricted in its capacity.

On December 23, 1998, the Commonwealth launched Australia's Oceans Policy. The purpose of an Oceans Policy is to provide a single and strategic framework for the planning, management and ecologically sustainable development of fisheries, shipping, petroleum, gas, and sea bed resources while ensuring the conservation of the marine environment. No Australian State, thus far, has signified its endorsement of the Oceans Policy (McPhail 2002). "Therefore, the Oceans Policy is not accepted as a national initiative, but is being perceived as an obstacle by the states" (McPhail 2002). As of January of 2000 the United States, following two years of intensive debate, has an Ocean Act. However, it essentially was confined to the establishment of the White House Ocean Council to write an ocean's policy.

In the United States, there is a lack of early intervention measures in invasive species legislation, and therefore their legislation tends to be more reactive. Australia has shown that they can deal with the emergence of invasive species when caught early enough. This however cannot be accounted for in San Francisco, because most of the bay is invasive. In San Francisco, where non-indigenous species have already been introduced and have taken hold, the focus needs to be on protecting the bay from further infestations.

While many different forms of on-shore and on-board ballast water treatment methods are being tested, ballast water exchange in the open ocean is one strategy that is considered to be the approved method of treatment (Ruiz et al 2005; Cohen 1998b; NRC 1996; Carlton et al 1995). The National Research Council (1996) stated ten years ago, this method to be the "favored technique". With this method, coastal organisms are exchanged for open ocean organisms between two ports, with a recommendation that this occur in waters at least 2,000 meters deep (Cohen 1998b). In this environment, coastal organisms are not expected to be able to survive or at the very least, thrive. Once arriving at the port, ships are then able to deballast, releasing

fewer oceanic organisms into an environment they are not expected to survive in. Not a lot of study has been conducted on this method of exchange, but Ruiz et al (2005) did show this method to decrease phytoplankton by 60% and zooplankton by 90%. However, even without the ballast exchange, both of the biota decreased during the duration of the voyage between ports. One notable conclusion that Cohen (1998b) emphasized was that “Although researchers have sampled and studied the organisms arriving in ballast water at many ports around the world, the ballast water arriving in the San Francisco Estuary has never been sampled.” This is important to understanding the influences and processes that vectors are having on the invaded bay. It is important to remember that invasive species do not acknowledge international borders; this means they do not acknowledge state borders either. Our study found an absence of measures to limit the interstate transport of invasive species. Invasions through local vectors including interstate transport and local transportation (water taxis and ferries) are also probable, although not documented.

6.1 Policy Analysis

The oceans are vast, dynamic, and still largely unexplored and incomprehensible. The ocean is the most highly connected environment on the planet, connected through global water circulation patterns, species migration, and chemical contaminants transport (Lien 2003). Despite this connectivity within the ocean environments, nation states have taken a highly fragmented approach to management (Berkes et al. 2001). As such, implementing integrated marine planning requires a fundamental paradigm shift from a sectoral to a holistic approach to management. A difficult and complex policy arena is created by: the high level of connectivity of the marine environment coupled with its fragmented management; our limited knowledge and understanding of the marine environment; and the global commons aspect of marine resources.

Australia has adopted a non-legislated, cooperative policy approach, where implementation is based on a bottom-up approach designed to build cooperation through a stakeholder-driven regional marine planning process and then to develop ways to implement this as the process progresses. Environmental decision-making in the United States has increasingly adopted a more precautionary approach.

Efforts to establish coherent and integrated invasive species policies are complicated in both countries by the fact that stakeholders in the coastal and marine environment are diverse (Juda 2003; NOO 1997b). The groups reveal a broad spectrum of interests, behaviors, ethics and ambitions. For example, a typical surfer might: be concerned about water quality, especially fecal coliform counts; want beach access maintained; impact the marine environment only minimally and locally (by trampling sensitive intertidal areas); and be dependant on the ocean for recreation, fitness and spiritual well-being. In contrast a typical bottom trawler might: be concerned about fish stocks and productivity; want access to the resource maintained; impact the marine environment significantly by removing large amounts of biomass from the ocean and damaging the diverse habitats of the seafloor; and be dependant on the ocean for their livelihood. The diversity of the target groups is particularly cumbersome when pursuing an inclusive, stakeholder-driven approach as adopted by the Regional Marine Plans in Australia. Representing all of the various interests at the same table can be very difficult and "finding ways to manage often competing and increasingly diverse resource interests has become, and continues to be a major challenge in oceans management" (DFO 2002a).

Jurisdiction in the marine environment, in both the United States and Australia, is highly sectoralized, and divided among the federal, state and territorial, and local governments, leading

to the fragmented management approach that can be seen in some division of responsibility. There are important differences that exist between the United States and Australia with respect to division of powers and responsibilities. There are two dimensions of division of power that need integration: integration between the federal and state/territory governments; and integration between agencies in the federal government with marine mandates. Effective integration is required to achieve the defragmentation of invasive species management that is written in both countries' policies.

In Australia, there is a rigid division of power between the Commonwealth Government and the states. The Offshore Constitutional Settlement (OCS) of 1983 established that the States would be responsible for the management of activities in the area from the low water mark to three nautical miles (nm) offshore, and the Commonwealth would have primary responsibility from three nm to the outer boundary of the EEZ and continental shelf (Rothwell & Kaye 2001; Haward 1989).

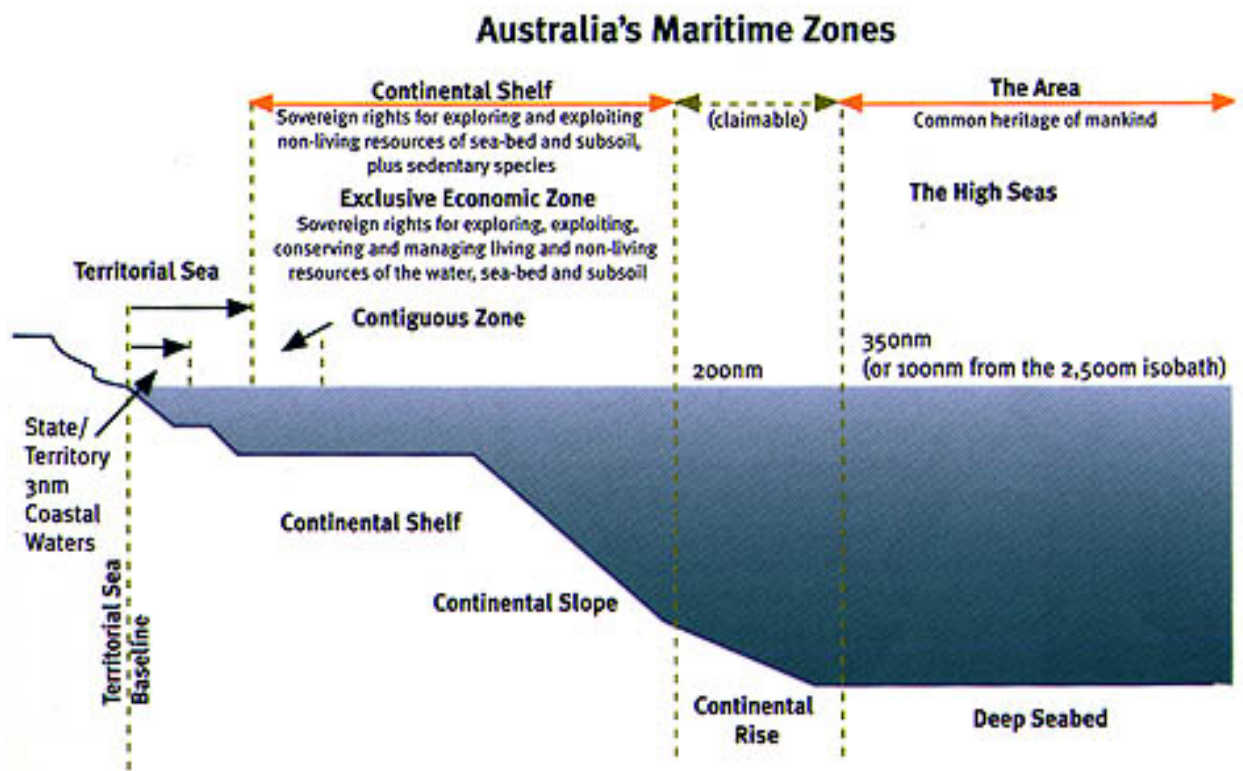


Figure 6. Visual description of the Australian maritime zones.

The OCS was hard-fought by the states and is therefore highly guarded (Herr & Haward 2001). This historical friction makes cooperation in the marine environment challenging (Foster & Haward 2003; Wescott 2000). When the Australia's Ocean Policy was launched in 1998, the government was not able to get full support of all of the states. In the interest of getting the policy out in the International Year of the Ocean (1998), they introduced the policy without formal state buy-in. So, while the RMPs are binding for all Commonwealth agencies, they are dependant on cooperation from the states in coastal waters (Juda 2003; Wescott 2000; Bateman 1999). Mechanisms are in place, however, to facilitate and encourage Commonwealth-State cooperation and coordination including the Natural Resource Management Ministerial Council (DEH 2004a). Despite these mechanisms for cooperation, cooperation of the states is a work in progress, something the Intergovernmental Agreement is trying to remedy.

A thorough analysis of media attention given to marine environmental issues in Australia would be necessary to fully assess how media affects policy implementation. This type of analysis is beyond the scope of this paper. Australia gives consistent and reasonable media attention to the issue of invasive species. The United States places less emphasis in this area. NGO's are a valuable asset in providing the public with information on environmental issues. NGOs are seen as having increasing importance in influencing governments to move away from sectoral views of oceans management (Wescott 2000; Knecht 1994).

Australia's cooperative approach may be too flexible to accomplish the significant change in oceans governance that is required. Many stakeholders appear to be content with current management arrangements and since it is a stakeholder-driven process, they have power in directing the outcomes. In addition, since state involvement is based on cooperation, participation is not ensured, which can undermine the ecosystem-based oceans management objectives of the policy. However, the cooperative, policy-based approach might more easily foster cooperation than legislation, since states and territories might be suspicious of oceans legislation as being a tactical way of taking power from them in the marine environment. So, while the lack of legislation reduces the policy's top-down implementation power, it may prevent conflict with the states and territories. The United States' top-down legislative approach depends on the responsible agency having high levels of leadership, commitment, funding, public trust and skills. Another problem arises when multiple organizations are in charge of implementation of legislation. Powers can then become unified and lines of who does what may not be as defined.

In a cooperative, policy-based approach, the lead agency must resolutely seek formal agreements and arrangements to achieve cooperation from those with which it shares power and to ensure compliance with policy outputs. In a legislative top-down approach, if the lead agency does not have high levels of leadership, commitment, funding, public trust and skills, its ability to successfully implement the policy may be impeded. When assigning a policy to an existing agency, it must be clear how the directives are to rank in the totality of an agency's responsibilities.

Education building within stakeholder groups is key to achieving effective and meaningful involvement. In addition, focus on economic diversification for coastal communities that are dependant on activities prohibited by policies can help to calm opposition by making the policy more economically viable. There should be inclusive, transparent, and meaningful participation and shared decision making power at multiple levels of the policy process. When members of the public, including stakeholder groups, are empowered with the opportunity to contribute to the decision-making process it may be easier to get them to cooperate and comply with the outcomes of decision making. This also allows the policy process to be informed by the wealth of knowledge within multiple stakeholder groups.

7. Recommendations

In a world with this many players trying to combat one problem, the solution will not come easily. Societies are laying solid foundations for the future in what they're trying to accomplish now. Anthony Snell (pers. comm.) said, "There are very few quick fixes in the world of shipping: if we came up with a perfect solution to ballast water and hull fouling concerns, and said that, from today all new ships must be built to match that solution, it would be at least thirty years before all the ships we see getting around would be in compliance." But even if there are no quick fixes, can we at least attempt to change what is happening now so that

we don't learn in 10 years time that our actions now aren't sustainable or might have been more effective?

National and international policy has begun to recognize that the resources of the oceans are finite, and that we will not always be able to have the benefits of ecosystems that currently exist. To be effective, policies should be based on an understanding of the biology and ecology of invading species and must place higher priorities on prevention of new introductions and stopping the further spread of invaders (Campbell, 1993). Policies should account for the causes of aquatic invasions and should take a hard look at limiting nonessential activities that contribute to invasions.

Better information on the organisms discharged with ballast water is needed to assess the necessity of implementing new ballast water management and in the case of San Francisco, needs to be done as a study for the bay. In particular, despite a growing number of well-documented invasions in marine systems (Carlton 1996, Cohen and Carlton 1998), comparatively little is known about the mechanisms underlying the success or failure of invasions and their consequences for native communities (Byers 2000). In order to learn more about these mechanisms we need additional knowledge in understanding invasive species life history traits. To aid invasive species policy decisions, accurate quantitative descriptions of the uncertainty in ecosystem outcomes under various possible policies are needed.

7.1 Recommendation for Australia

In Australia, a lack of nationally coordinated invasive species management legislation impacts the ability of states and territories to effectively manage introduced species. It can also lead to the dispersal of non-native species and the potential of those species to become invasive in other states.

In April 2005 the formation of an Intergovernmental Agreement began when the Australian Government, and the Tasmanian, Victorian and the Northern Territory Governments signed the National System for the Prevention and Management of Marine Pest incursions.

The agreement outlines the roles and responsibilities for implementing the three elements of the national system: prevention (introduction and translocation), emergency management and ongoing management/control. A framework for managing ballast water and biofouling was established to significantly reduce the risk of marine pests invading Australia's waters, helping to ensure Australia's emergency management and control measures are as effective as possible. Monitoring and research are also essential facets of this national approach. Through this Agreement the Australian government will attempt to ensure a coordinated approach to managing introduced pests that will involve all government levels along with industry, research and conservation stakeholders. Stakeholder groups have been consulted regarding this legislation and the Agreement has been developed around stakeholder concerns. The stakeholder group, National Introduced Marine Pests Coordination Group (NIMPCG), has representatives from federal and state governments, government agencies, industry personnel, including ports, shipping, fishing and aquaculture industries, CSIRO Marine Research, and conservation groups.

7.2 Recommendation for the United States

Once a species is introduced, it can be impossible to eradicate it. The US needs to find a way towards early detection, trying to identify the problem species as soon as they get here. Other efforts could be focused on preventing invasive species from even gaining access to an

ecosystem by trying to identify problem species that are not yet introduced, but which have caused problems in other places, in an effort to keep them from becoming established.

The tools currently available for the early detection of invasive species include general surveillance or collation of information, site-specific surveys, monitoring, diagnosis by taxonomic identification, and public-awareness campaigns. A significant developing tool is the use of information systems for regulatory purposes. There is a general consensus, by groups such as the Convention on Biological Diversity, on the need to enlarge databases on known and potential invasive species and to make this information accessible as part of global capacity-building on invasive species. Currently a major obstacle to the implementation of this tool is the coordinated effort needed to complete this task.

No multilateral environmental agreements require monitoring of introduced species for impacts on biodiversity. In some instances early detection depends on luck, and is reliant on workers in many different fields and members of the public. Public awareness schemes are widespread and, together with education and reporting mechanisms, can aid in the early detection of introduced species by the lay person. Within marine systems, there is currently no international system for the early detection of species introduced to new areas by ballast water. A few countries have instituted port biota surveys including Australia.

7.3 Recommendation To Do Nothing

So when getting rid of invasive species becomes unfeasible (economic, environmental), what is the solution? Sometimes the best response to something can be to do nothing. Legal and economic responses to biological invasions include the creation of laws that are difficult to enforce and the appropriation of large sums of money to attempt to control or eradicate the invader. Unfortunately, control and eradication of organisms that have already established large populations are often extremely difficult, if not impossible. Invasive alien species can take a heavy economic toll on governments, industries, and stakeholders (Pimentel 2002). Studies have also shown that it is preferable to act earlier rather than later (DEH 2004). The costs associated with invasive species, both in terms of the damage they do and the costs that will need to be incurred to deal with them, rise exponentially as the invasions proceed (CST 2002). The costs of trying to get rid of all of the invasive species would be more than trying to regulate future entrance of invasive species.

There should be a larger focus on finding out how the harbors are being affected and what we can do to prevent future damage. The policies being discussed at present should focus on federal regulations and the backing that they need to be enforced.

Some of the ethical ramifications of not establishing new policies and doing nothing about invasive species are that citizens have a right to know what is going on and participate in the issue, and harbor officials have a right to maintain a natural habitat, no matter what form that takes. The federal government is taking over the policies and enforcement, taking away from state rights. In the opinion of some this would give the federal government power that could result in the lack of funds going to this issue, if it were not deemed important on a national level.

The economic implications for any situation dealing with invasive species can be complex. The cost of implementing the hands off approach could be nothing. However, if the stakeholders chose to, they could set up a monitoring program with the intention of gathering information on whether the system changes to adapt to the modifications by invasive species. The costs of impacts could depend on: whether there was an aquaculture industry, along with its generated income; health impacts, whether for humans or the wellbeing of the system; and the

biological data on the potential for future introductions on the system and the spread of the current invasive species. Economic risks with invasive species include lost production, diminished quality, increased production costs, increased risks for human health, impacts on other species, and the willingness-to-pay of stakeholders to examine invaded ecosystems.

Through the work presented in this paper there is a bias that invasive species are a negative problem when that doesn't always seem to be the case. There are also assumptions made with little research being done specifically on marine invasive species and their impacts on natural habitats. There is also a bias that ignores the potential that the changes that are occurring are a natural evolution of the two harbors. It may be that invasive species are not the problem.

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10. Appendices

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10.1 Location of Harbors

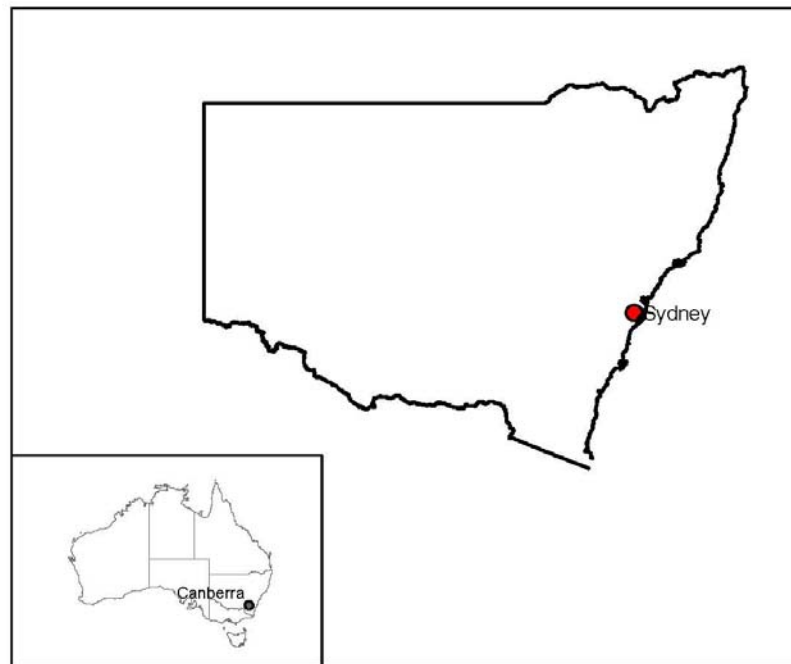
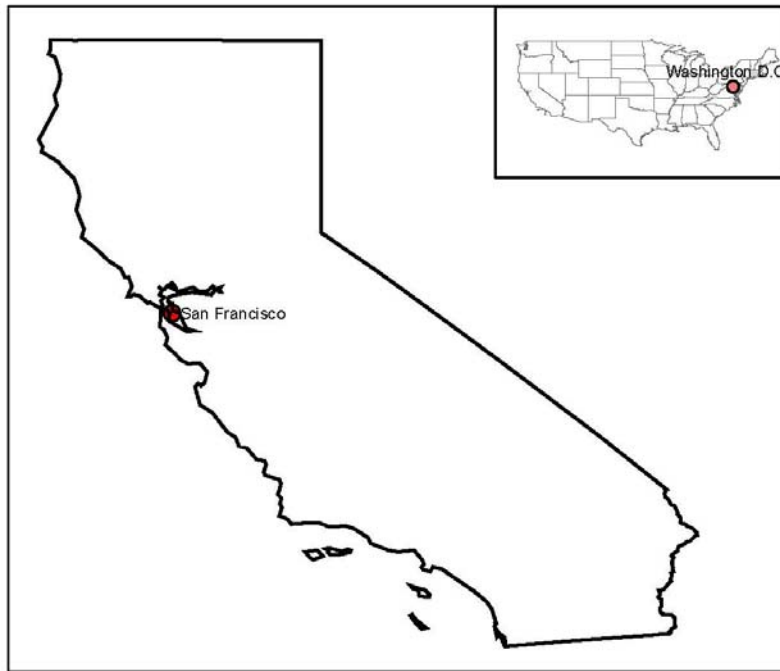
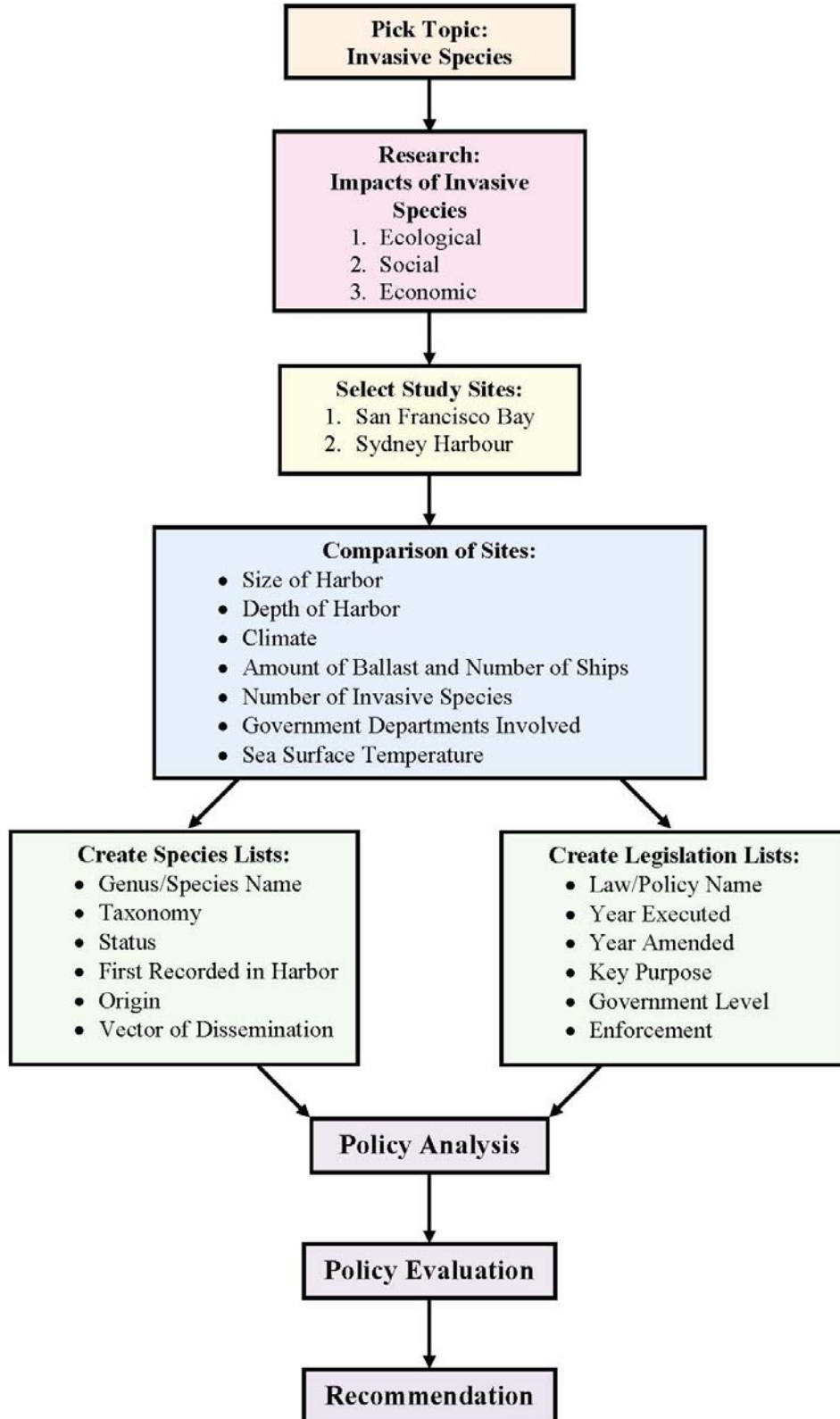


Figure 2. Harbor locator map of study locations. Smaller country maps are also shown to assist with the location of the state maps. Maps were drawn with ArcMap by Christina Schmunk.

10.2 Flow Chart of Methods



10.3 Figures of San Francisco Bay

10.3.1 Harbor

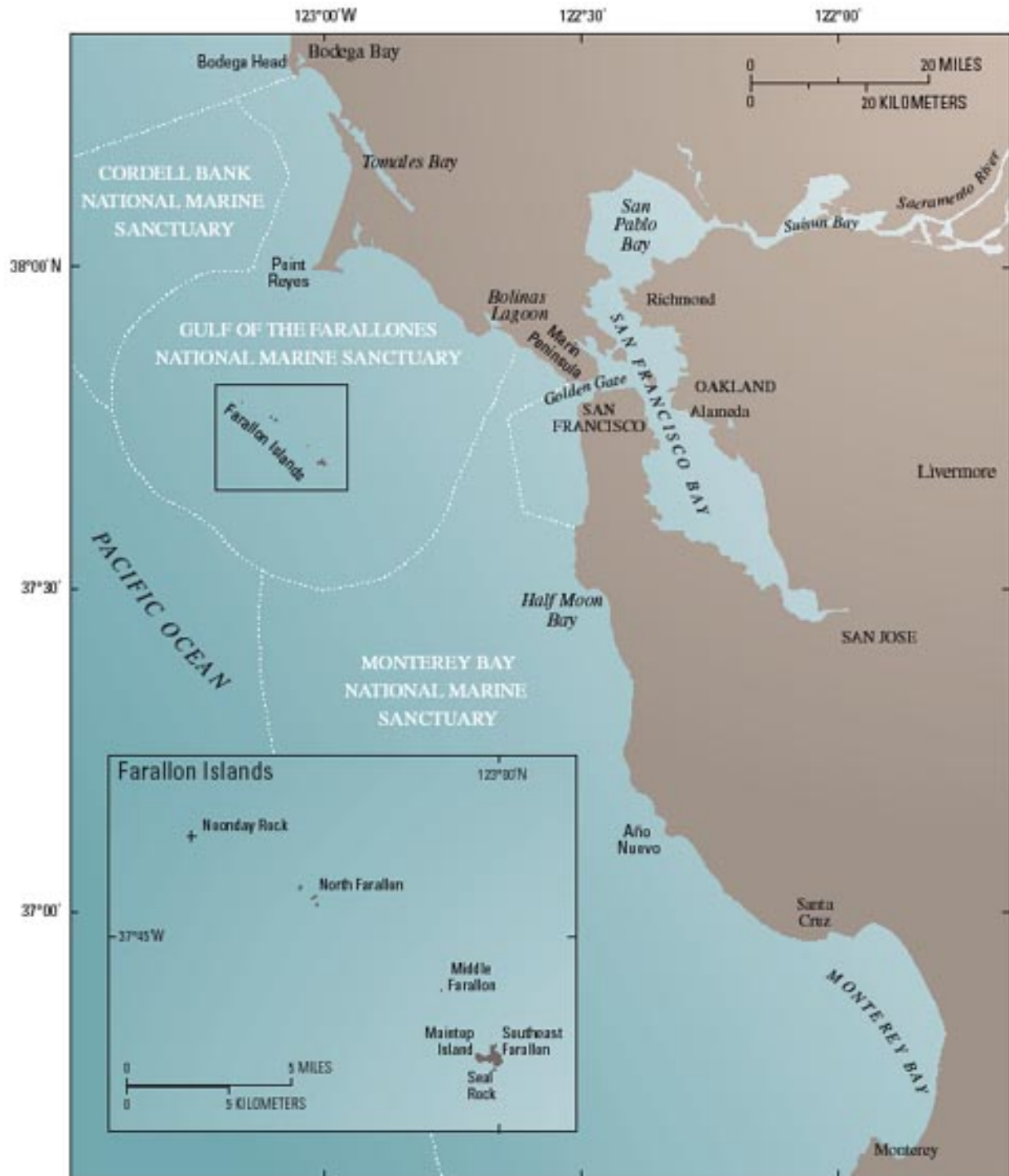


Figure 7. Map of San Francisco Bay (Karl 2002).

10.3.2 Port Facilities

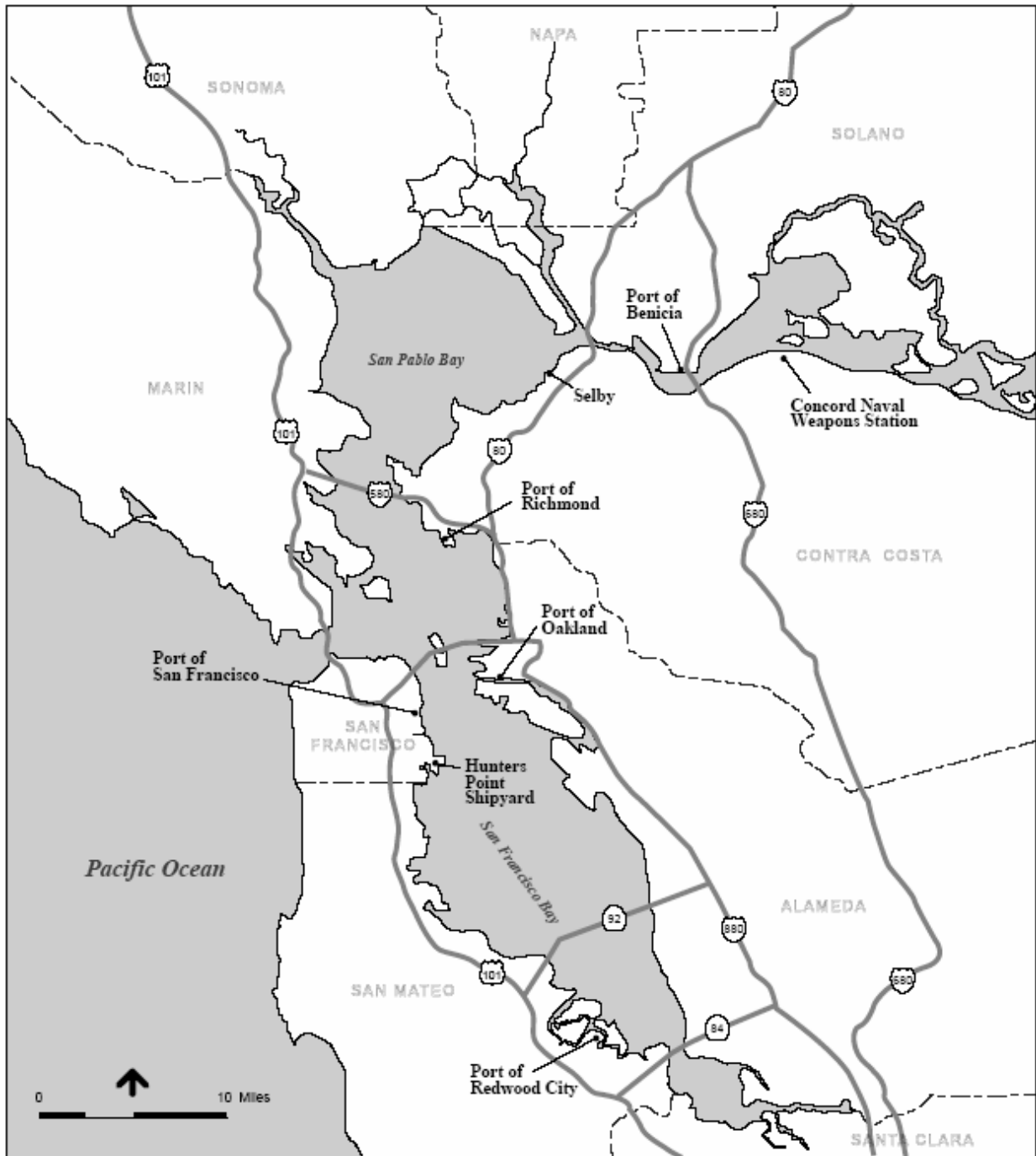


Figure 8. San Francisco Bay area port locations (SPAC 2003).

10.3.3 Ferry Routes

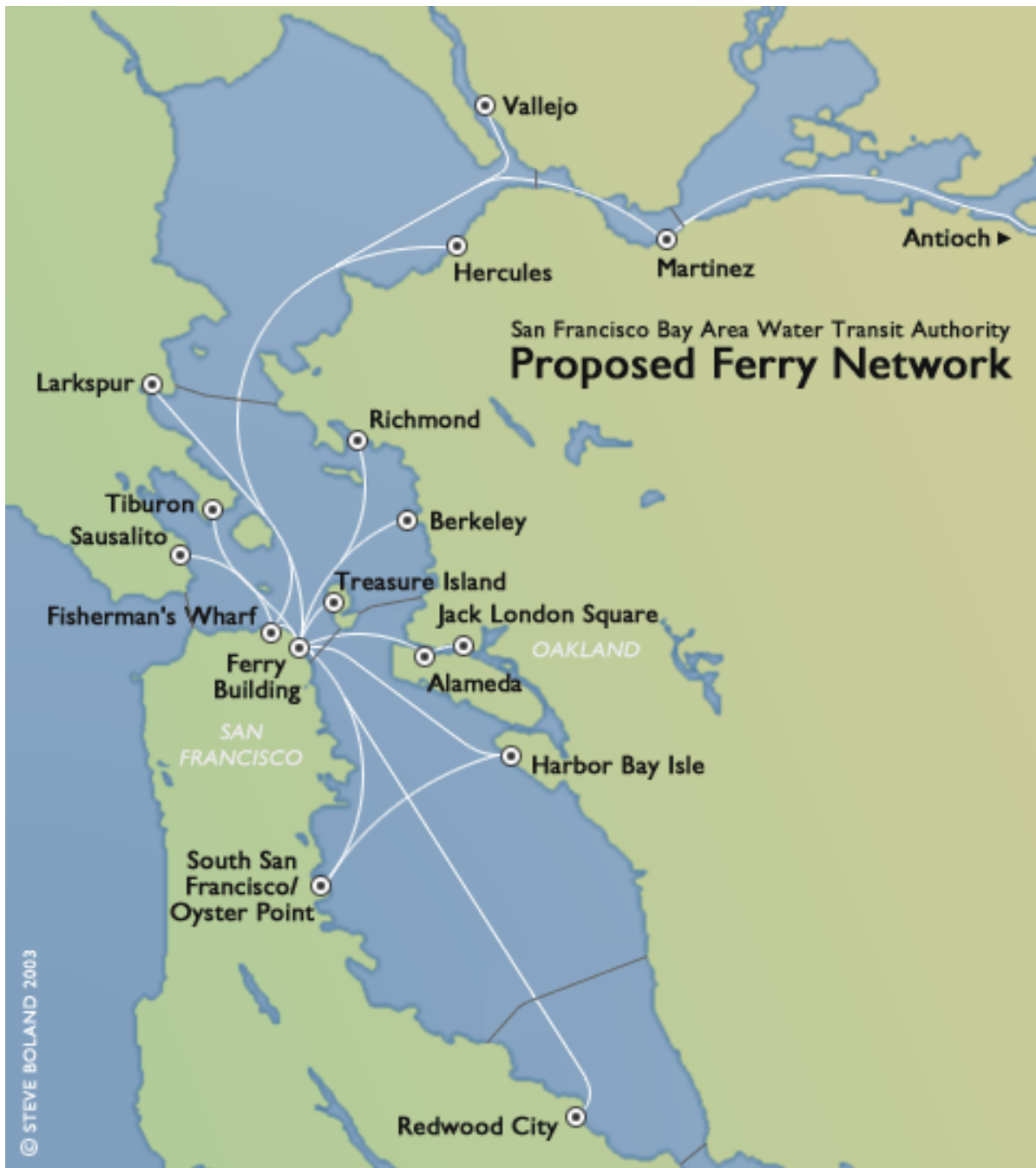


Figure 9. San Francisco Bay ferry routes, including the eight new routes that should be completed by 2015 (SF Cityscape 2005).

10.4 Figures of Sydney Harbour

10.4.1 Harbor

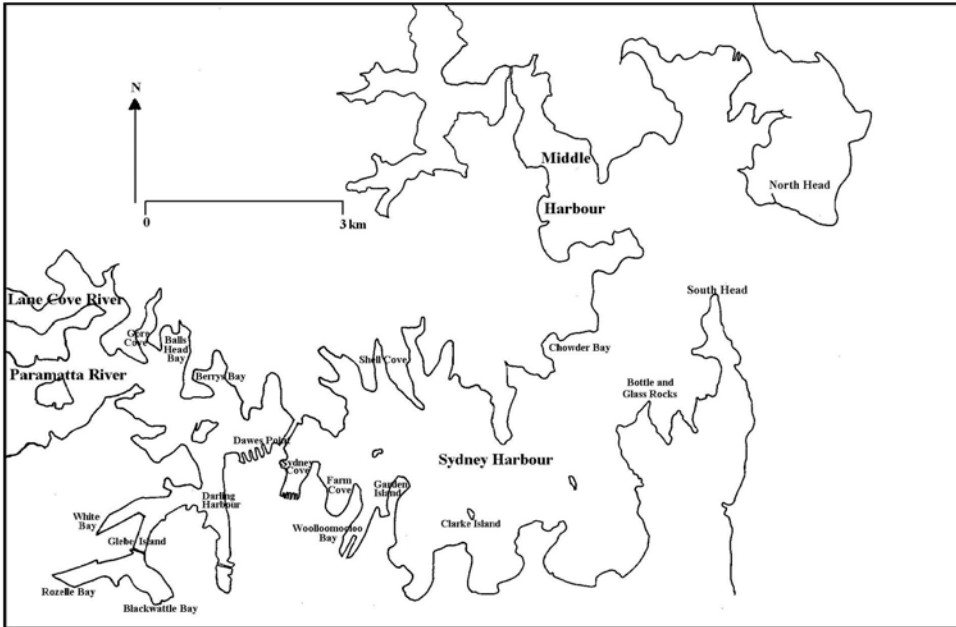
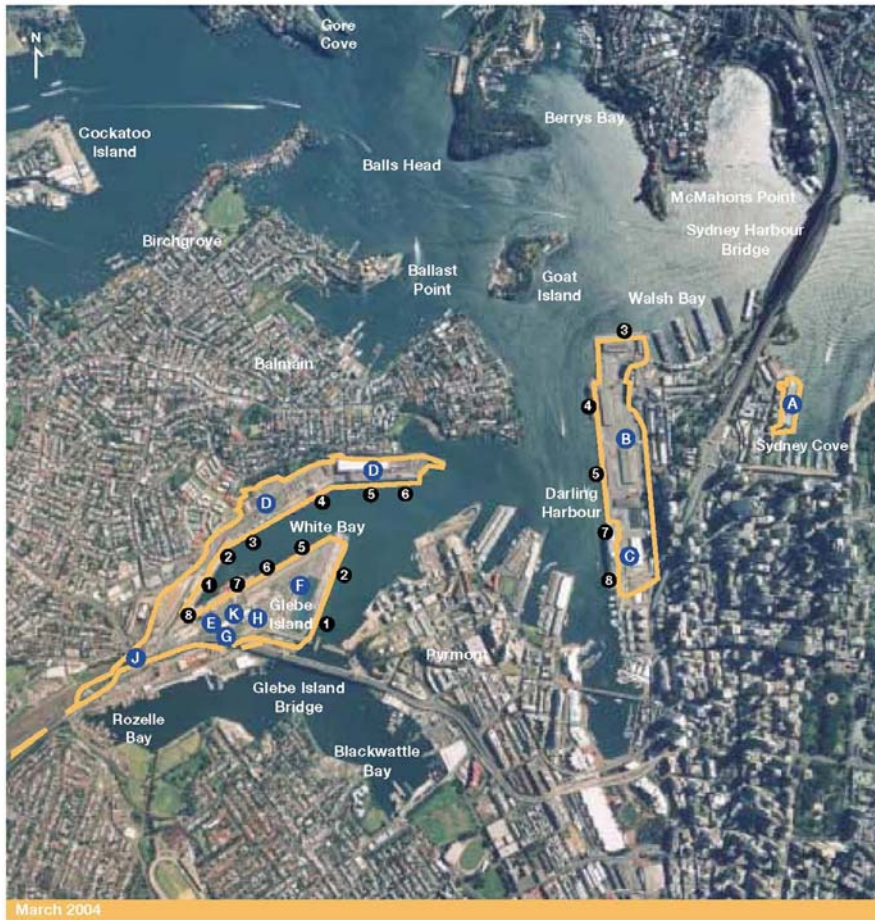


Figure 3. Locations in Sydney Harbour sampled in the Port Survey for Introduced Marine Species – Sydney Harbour (AMBS 2002).

10.4.2 Port Facilities



KEY

- | | |
|---|---|
| A Overseas Passenger Terminal | G Glebe Island – Cement Australia Ltd |
| B Darling Harbour – Patrick Corporation | H Glebe Island – Mackay Sugar Co-op |
| C Darling Harbour – Passenger Terminal | J Glebe Island – Sydney Ports Marine Operations |
| D White Bay | K Glebe Island – Gypsum Resources Australia |
| E Glebe Island – Penrice Soda Products | ● Berth Numbers |
| F Glebe Island – Australian Amalgamated Terminals Pty Ltd | ■ Sydney Ports' Property |

Figure 4. Locations of Sydney Harbour's port facilities with letter key written beneath (SPC 2003b).

10.4.3 Ferry Routes

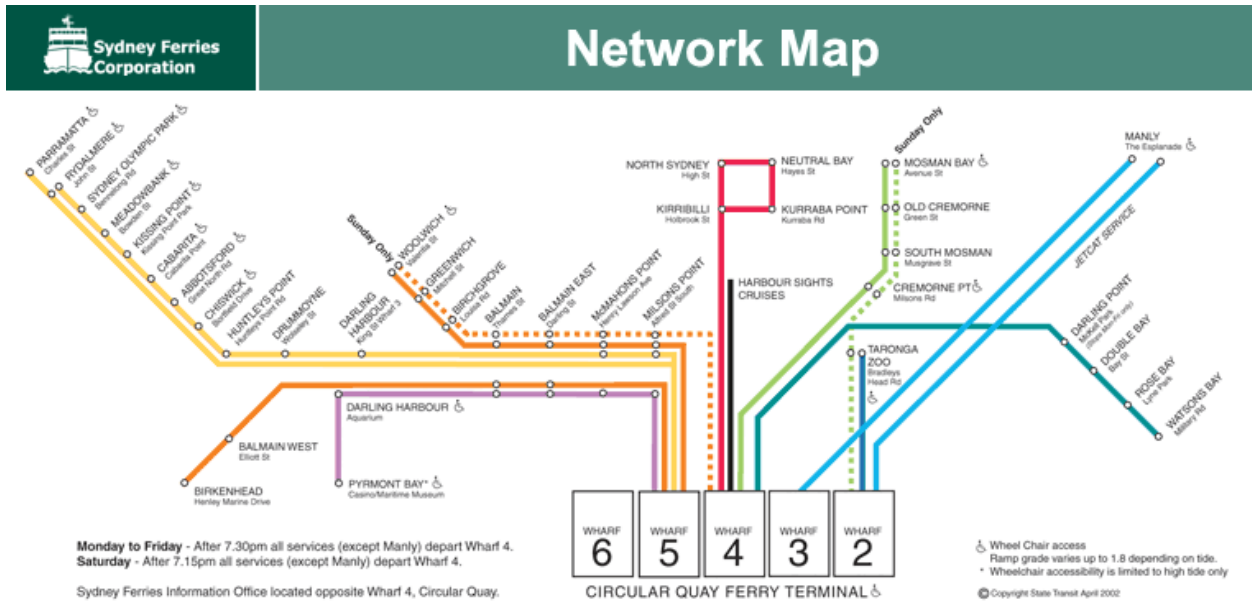


Figure 6. Sydney Harbour Ferries route map detailing stops from the central terminal at Circular Quay (SFC n.d.).

10.5 Non-indigenous Species Legislation

10.5.1 San Francisco Bay Legislation

Law/Policy Name	Year Enacted	Year Amended	Key Purpose	State Law	Fed Law	Int'l Law	Enforcement
Convention on Biological Diversity	29-Dec-93	4-Jun-96	Requires countries to develop and implement strategies for sustainable use and protection of biodiversity			xx	Not Ratified
International Maritime Organization International Convention for the Control and Management of Ships Ballast Water and Sediments	4-Jul-91	13-Feb-04	Standards and requirements in the regulations for the control and management of ships' ballast water and sediments.			xx	Not Ratified
United Nations Food and Agricultural Organization International Plant Protection Convention		18-Aug-72	To secure a common and effective action to prevent the spread and introduction of pests and plants and plant products, and to promote appropriate measures for their control.			xx	Department of Agriculture / APHIS
World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)			To set out the basic rules on food safety and animal and plant health standards.			xx	Department of Agriculture; DoI
Clean Water Act 33 U.S.C. §§ 1251-1387	1972	1977	Apply to the introduction of exotic organisms in ballast water as a discharge of biological pollutants.		xx		NMFS; EPA; USACE
Endangered Species Act 16 U.S.C. §§ 1531 et seq.	1973		Prohibiting the introduction of organisms if it can be determined that the introduction is likely to jeopardize a listed species.		xx		DoT; USFWS; NMFS; USACE
Executive Order 11987	24-May-77	see EO 13112	To restrict the introduction of exotic species into natural ecosystems, and restrict the export of native species for		xx		

			introduction into ecosystems where they do not naturally occur.			
Executive Order 13112	Feb-99		To prevent the introduction of invasive species and provide for their control, as well as to minimize the economic, ecological, and human health impacts that invasive species cause.	xx		DoI/FWS; DoT/USCG; USEPA; DoD/USACE; DoC/NOAA; APHIS; Department of State
Federal Ballast Water Regulations 33 CFR 151 Subpart D			Require mandatory ballast water reporting at least 24 hours prior to arriving in a U.S. port, with some exceptions if it is a short voyage.	xx		
Lacey Act 16 U.S.C. §§ 3371-3378	1900	1998	Prohibit the "importation, transportation or acquisition" of certain organisms listed as injurious, authorizing the Secretary of the Interior to add any fishes, mollusks or crustaceans, or their offspring or eggs, that are determined "to be injurious to human beings, to wildlife or the wildlife resources of the United States."	xx		DoT; NMFS
National Aquatic Invasive Species Act of 2003	2003	see NAISA 2005	Require vessels to have in place an Aquatic Species Management Plan.	xx		EPA; USCG
National Aquatic Invasive Species Act of 2005 (H.R. 1591)	2005		To amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 to reauthorize and improve that Act.	xx		EPA; USCG

National Environmental Policy Act 42 U.S.C. §§ 4321-4347			Determination of the likelihood of introducing or spreading invasive species and a description of the measures being taken to minimize their potential harm.				DoT; NMFS; EPA
National Invasive Species Act of 1996	1996		To address invasive species introductions in all U.S. waters.		xx		DoI/FWS; DoT/USCG; USEPA; DoD/USACE; DoC/NOAA; APHIS; Department of State
Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA)	Nov-90	see NISA 1996	To prevent unintentional introduction and spread of nonindigenous species into US waters via ballast water, as well as to coordinate research and prevention control, understand and minimize economic and ecological impacts of aquatic nuisance species		xx		DoI/FWS; DoT/USCG; USEPA; DoD/USACE; DoC/NOAA; APHIS; Department of State
Ballast Water (California Codes; Harbors and Navigation Code; Section 132)			Misdemeanor to throw ballast overboard.	xx			
Ballast Water (California Codes; Public Resources Code; Section 71200 - 71202)	1-Jan-04		Requires that the vessel master, owner, operator, agent, or person in charge of every vessel entering a California port or place regardless of origin, complete and submit a ballast water report form.	xx			CSLC; Board of Equalization; USCG
Ballast Water (California Codes; Public Resources Code; Section 71210 - 71213)	Jan-04		Establish and maintain an inventory of nonindigenous species populations in the coastal and estuarine waters.	xx			CDFG; USCG

Ballast Water Management for Control of Nonindigenous Species (1999-2000 Assembly Bill 703)	1-Jan-02		Compliance monitoring and research on ballast water treatment technology and the impacts of invasive species	xx			CSLC; CDFG; SWRCB; Board of Equalization
Ballast Water Management Practices (California Codes; Public Resources Code; Section 71202-71207)	Jan-04		Outlines ballast water management protocols for vessels entering into port.	xx			CDFG; USEPA; USCG
Ballast Water Management Program (California Codes; Fish & Game Code; Section 6430 - 6433)			Provisions for prevention of introduction of aquatic nuisance species from vessel ballast water.	xx			
Ballast Water Reporting Violations (California Codes; Public Resources Code; Section 71216)	Jan-04		Violations of ballast water reporting legislation.	xx			Attorney General
Ballast Water from Tankers (California Codes; Public Resources Code; Section 30260-30265.5)			Companies are required to have onshore deballasting facilities to receive fouled ballast water from tankers.	xx			CCC; CDFG; CSLC; DoI; DoE; USEPA; NOAA; USCG
Ballast Water from Tankers (California Codes; Public Resources Code; Section 30707)			New or expanded terminals need to have onshore deballasting facilities.	xx			
California Endangered Species Act (California Codes; Fish and Game Code; Section 2050 - 2085)			Prohibiting the introduction of organisms if it can be determined that the introduction is likely to jeopardize a listed species.	xx			CDFG
California Environmental Quality Act (California Codes; Public Resources Code; Section 21000 - 21177)	1970	1-Jan-05	Requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.	xx			Self-enforcing
Exotic Species Control Fund (California Codes; Public Resources Code; Section 71215)	Jan-04		Establishment of Marine Invasive Species Control Fund.	xx			State Board of Equalization

Exotic Species Introductions (California Codes; Food & Agricultural Code; Section 401 - 410)			Code requiring CDFA to prevent new introductions and the spread of current injurious species.	xx			CDFA
Illegal Transportation of Certain Species (California Codes; Fish & Game Code; Section 2116 - 2126)			List of species that are unlawful to import, transport, possess, or release alive.	xx			CDFG; CDFA; Attorney General
Infected, diseased or parasitized fish, amphibia or aquatic plants (California Codes; Fish & Game; Section 6300 - 6306)			Authorization to search for unlawful species.	xx			CDFG
Marine Aquaria Pet Trade (California Codes; Fish & Game Code; Section 8596 - 8598)			Illegal pet trade species.	xx			CDFG
Noxious Aquatic Weeds (California Codes; Food & Agricultural Code; Section 6048 - 6049)			Legislation on noxious aquatic weed <i>Hydrilla verticillata</i>	xx			CDFG; USDA; UC; other agencies

10.5.2 Sydney Harbour Legislation

Law/Policy Name	Year Executed	Year Amended	Key Purpose	State Law	Fed Law	Int'l Law	Enforcement
World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures	1995		To set out the basic rules on food safety and animal and plant health standards			xx	Biosecurity Australia independent agency in DAFF
United Nations Food and Agricultural Organization International Plant Protection Convention	03 Apr 1952	27 Aug 1952	To secure a common and effective action to prevent the spread and introduction of pests and plants and plant products, and to promote appropriate measures for their control			xx	AFFA
IMO International Convention for the Control and Management of Ships Ballast Water and Sediments	13 Feb 2004		Standards and requirements in the regulations for the control and management of ships' ballast water and sediments.			xx	Biosecurity Australia independent agency in DAFF
IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships	05 Oct 2001		Prohibit and/or restrict the use of harmful anti-fouling systems on ships.			xx	
Office International de Epizooties (World Organization for Animal Health)	1924	1927	The OIE has a mandate under the WTO SPS Agreement, to safeguard world trade by publishing health standards for international trade in animals and animal products.			xx	Biosecurity Australia independent agency in DAFF
Convention on Biological Diversity	05 Jun 1992	18 Jun 1993	Requires countries to develop and implement strategies for sustainable use and protection of biodiversity.			xx	
Australian Biological Control Act	1984		Control of non-indigenous species.		xx		
Australia Quarantine Act	1908		Control of import of non-indigenous species into Australia.		xx		AQIS under joint: DEH/DAFF

Australian Ballast Water Management Requirements (under Australia Quarantine Act 1908)	01 Jul 2001		Pre-border and border monitoring, detection and control arrangements in respect of humans, animals and plants.		xx		AQIS under DAFF
Australia's Oceans Policy	23 Dec 1998		To provide a single and strategic framework for the planning, management and ecologically sustainable development of Australia's ocean resources while ensuring the conservation of the marine environment.		xx		National Ocean's Office
Environmental Protection and Biodiversity Conservation Act 1999	16 Jul 2000		To clarify the matter of Commonwealth environmental jurisdiction		xx		Joint: DEH/DAFF
National System for the Prevention and Control of Marine Pest Incursions	15 Apr 2005		Sets out a framework for managing ballast water and biofouling to reduce the risk of marine pest invasions.		xx		
Seas and Submerged Lands Act	1973		Outlines maritime zones.		xx		
Voluntary Guidelines for Ballast Water and Sediment Discharge from Overseas Vessels Entering Australian Waters	01 Feb 1990				xx		
Offshore Constitutional Settlement	Feb 1983		To give the states a greater legal and administrative role in offshore areas.	xx	xx		
New South Wales Fisheries Management Act 1994	01 Sep 2002		Regulations dealing with importation of live fish, release of fish, listing of noxious species, and emergency response.	xx			NSW Fisheries
Threatened Species Conservation Act 1995	31 Dec 1995	Aug 2004	To conserve threatened species, populations and ecological communities of animals and plants	xx			