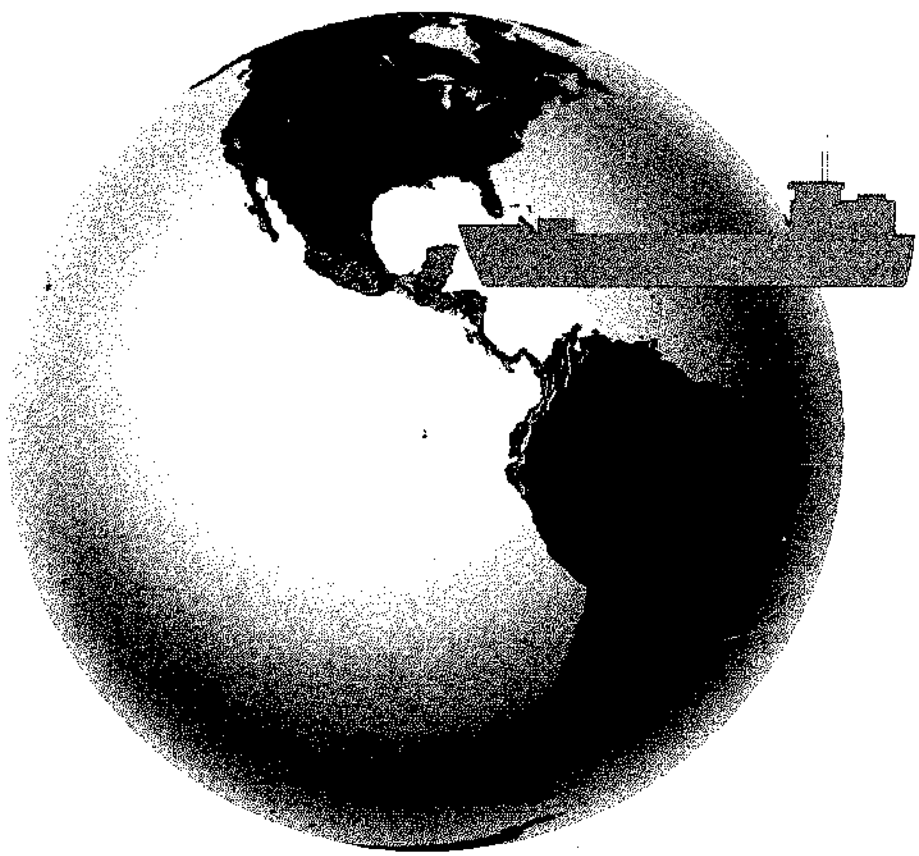
Assessing the Potential for Introduction of Nonindigenous Species Through U.S. Gulf of Mexico Ports

This white paper was prepared for the transoceanic ports in the Gulf of Mexico region as part of a regional outreach project to control the dispersal of nonindigenous species. The project was funded by the National Sea Grant College Program. Prior to publication, the points made herein were presented on October 7, 1998 at the annual meeting of the American Association of Port Authorities in Houston, Texas.



Assessing the Potential for Introduction of Nonindigenous Species Through U.S. Gulf of Mexico Ports

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INTRODUCTION

Although nonindigenous (non-native) nuisance species have probably been entering the U.S. through all ports and shorelines for over 200 years, few people considered this factor important until recently. National and state government officials around the world became concerned when some of these species actually changed the natural balance of animals and plants in a lake or river and others disrupted major industrial operations. Many of these species may never become nuisances or foulants, but bad experiences in the past suggest that some will be nuisances in the future. In response to government concerns and directives, both the International Maritime Organization (IMO) and the U.S. Coast Guard have recommended actions by shippers and ports as a significant method of preventing or reducing the possibility of future invasions. This paper was written to help ports in the Gulf of Mexico region understand and address this issue.

Why are ballast exchange and nonindigenous nuisance species port issues?

The potential for the introduction of nonindigenous nuisance species through U.S. Gulf of Mexico ports is not easy to determine, but must be addressed. The IMO and Coast Guard recommendations are based on recent research. In it, ballast has been identified nationally and internationally as a major conduit for the unintentional transfer of aquatic nonindigenous organisms because ballast water carrying animals and plants is often jettisoned or taken aboard near shore or in port. It has been established that the largest volume of ballast is discharged by bulk carriers (bulkers), and several U.S. Gulf of Mexico ports rank among the top 10 in the nation for bulker trade.

The probability that a specific port or region will be invaded by any or many nonindigenous species depends upon several related factors. This paper describes these factors. When examined relatively, these can result in a broad qualitative invasion risk assessment that will help port officials identify points of vulnerability to nonindigenous species. Ports may use the resulting information to introduce policy or procedures to reduce risk. To clarify the vulnerability of ports in the Gulf of Mexico region, there is a definite need for a better scientific understanding of each port's risk of serving as a conduit for future invasions from nonindigenous species. Although several ports may eventually develop similar risk-reducing policies or procedures, each port should be encouraged to analyze and identify port-specific points of vulnerability.

THE GENERAL SITUATION

Over the years, nonindigenous species have been entering U.S. waters and recently, the ballast in transoceanic shipping has been identified as a major conduit. Some of these non-native species have become nuisances or foulants in their new environments. Because most of these known nuisances or fouling nonindigenous species are freshwater dwellers, exchanging freshwater ballast with saltwater from the open ocean has been identified as a deterrent. It establishes a negative environment — a place where nonindigenous freshwater species cannot live — reducing the possibility that vessels might unintentionally disperse these pest species in U.S. waters.

Is ballast water a significant source of these pests?

A recent government-funded shipping study estimates that transoceanic cargo vessels release over two million gallons of ballast water containing alien plants and animals into U.S. waters every hour [Carlton, Reid, and Leeuwen, Shipping Study I, 1995]. Related studies confirm that plants, animals, and pathogens can live and grow over a long period in ballast tanks and cargo holds [Smith, Wonham, McCann, Reid, Carlton, Shipping Study II, 1996].

The consequences of such successful nuisance species inoculations in the Great Lakes have been documented in the media and in professional publications. In reaction to the primarily economic impact from recent zebra mussel and ruffe invasions, the Great Lakes have become the focus of extensive nonindigenous species research, which has, in turn, focused federal attention on the role played by ballast discharges. Research also has been done on the possibilities for unintentional nuisance species inoculations through ports along the Atlantic and Pacific coasts, particularly in the Chesapeake and San Francisco Bay areas, although these areas have not recently experienced the serious disruptions to business noted in the Great Lakes region [Chesapeake Bay Commission 1995; Smith, Wonham, McCann, Reid, Carlton, Ruiz, Shipping Study II, 1996; Cohen and Carlton, Biological study: Nonindigenous Aquatic Species in San Francisco Bay, 1995]. However, little research has been done on these topics for the coastline or ports of the country's southern marine boundary, the Gulf of Mexico. The exception is a still-unpublished study of Florida by the US Geological Survey [McCann, Arkin, Williams, Nonindigenous Aquatic and Selected Terrestrial Species of Florida, 1996].

In terms of this issue, what do ports in the Gulf of Mexico region have in common with each other and with ports in other regions of the U.S.?

The World Ocean

Ships cross the World Ocean to enter ports located either directly on or adjacent to it. The term "World Ocean" is used because the world's oceans are not separate. Together they form an interconnected body of saltwater occupying the depressions in the earth's surface. This body of saltwater does not directly contact all of the world's nations or ecosystems, but waters from all nations flow into it. The waters in the comparatively small basin of the World Ocean known as the Gulf of Mexico wash several sovereign nations such as Cuba, the United States, and Mexico. Within these nations' port waters are only a few animals and plants that are common to the entire region and some that also live in other parts of the World Ocean. In addition, the one ocean makes possible natural movement of animals and plants. For example, some pelagic deep water species living in the Atlantic use Gulf of Mexico coastal waters as nurseries and others use more than one depression in the World Ocean to feed. Even so, most species of aquatic animals and plants are indigenous to a specific area of the World Ocean or land adjacent to it. Many of the species in Gulf waters are specific to the region or even a specific part of the Gulf region. [Courtenay, Hensley, Taylor, McCann, 1986; Robinson, 1994].

Similarly, ships move freely through this continuous waterbody. Figure A shows the relative size and location of the Gulf of Mexico with other US coastal waterbodies

Figure A

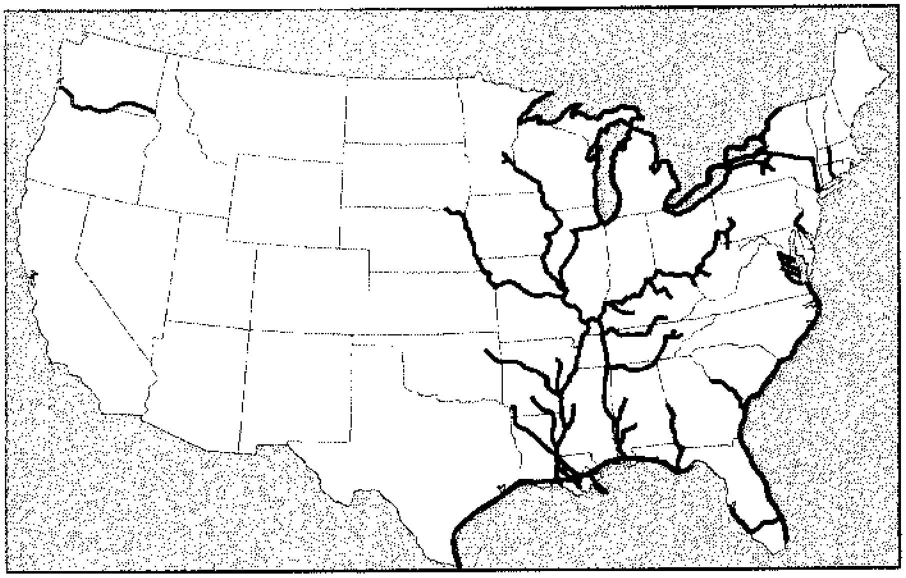


Figure B. Inland navigable waterways of the U.S.

and the aquatic links with the Atlantic Ocean via the Florida Straits and with the Caribbean Sea through the Yucatan Channel. That channel is a trade-intensive link between the Gulf of Mexico ports and those on the Caribbean Sea. Less visible than these natural links is the man-made link with the Pacific Ocean via the Panama Canal.

How are Gulf of Mexico region ports different from those in other U.S. regions?

Since the gulfs and bays in the Atlantic and Pacific regions function similarly, one might conclude that controls for dispersal of or invasion by nonindigenous species could be generally developed for all U.S. ports. This conclusion has some value only once each port has determined its vulnerabilities to nonindigenous species, because every port and port region is unique.

The Gulf of Mexico region has both coastal ports like Miami, Tampa, or Galveston and riverine ports like Mobile, Houston and those ports on the Mississippi in south Louisiana (includes New Orleans). In addition, over half of the country's freshwaters flow into the Gulf of Mexico along two of the nation's largest inland waterway systems, the Mississippi River System and the Tennessee-Tombigbee Waterway, and through a couple of the ports. Most of the coastal and riverine ports are linked by the Gulf Intracoastal Waterway. (See Figure B, inland waterways and the Gulf of Mexico).

In addition, the ports in the Gulf of Mexico region have in common a volume of international trade among the countries bordering the Gulf of Mexico and the Caribbean Sea that is not common to other U.S. regions. This trade must be considered when assessing possible vulnerabilities to invasion by or dispersal of nonindigenous species.

Ports Link One Ocean with Many Environments

Similar to foreign and domestic trade in all ports on the World Ocean, trade in Gulf of Mexico ports involves cargo transfer, which, in turn, sometimes involves a change in ballast. In the Gulf Region, this exchange of water and sediment can have far reaching effects.

Why were ports identified as significant to species transported on world oceans?

This can be understood by looking at a worst case scenario using a nonindigenous species already known to be a problem in the U.S. An unloaded dry bulk or chemical carrier enters a Gulf of Mexico port to take on a full load of cargo for transshipment to another country. This vessel discharges ballast while in transit to the docks or at the dock during loading. That ballast contains several nonindigenous species that, unnoticed, take up residence in port waters. One of these is the zebra mussel. Eventually, some of this new zebra mussel population is taken in by another bulker during ballasting and carried to another Gulf of Mexico port and the mussels settle therein. Over a period of months or years, these species multiply. The young zebra mussels, seeking their own space to live and reproduce, settle in the raw water intake of a municipal water plant on the river flowing from the port. Eventually that new colony become large enough to occlude the intake pipe and reduce intake pressure to the detriment of the power plant and its customers. (A similar event actually occurred with zebra mussels in the Great Lakes.) In addition, other young zebra mussels might enter the sea chests and/or attach to the external recesses of keel coolers on towboats carrying cargo between this port and other destinations in as much as half of the nation's interior. Zebra mussels can detach at any time or they can live in the towboat, reproduce, form a colony and eventually be cleaned out of the towboat during routine maintenance. If not killed, they will take up residence wherever they are dumped and the possibility of entry into other raw water intakes continues. A different species might have a different effect — it could compete with animals living in the area for food, thus reducing or even eliminating a population that is commercially harvested or popular in sport fishing. Thus, Gulf of Mexico ports can be hubs for the import and export of nonindigenous species while they are serving as hubs for foreign and domestic goods.

- **Because** *U.S. and IMO guidelines and regulations identify ports as one of the possible points for controlling invasion and dispersal of nonindigenous species because some ballasting and deballasting occurs in ports.*

Because they are the primary common denominator in transoceanic trade, ships, shippers, and ports have been assigned a large responsibility for controlling this invasion. The U.S. Coast Guard and the IMO have concluded that one effective method of reducing accidental invasions is to reduce the potential for live plants and animals to be introduced in port through release of ballast water. They are requesting that shippers exchange ballast water in open ocean to kill freshwater species that may be living in ballast holds and tanks and to record this action in order to evaluate the solution. But both acknowledge that open ocean ballast exchange may jeopardize safety under certain sea conditions so it will not be done 100% of the time. Specifically, the U.S. Coast Guard's proposed mandatory and voluntary ballast water regulations and the IMO's ballast exchange guidelines both ask vessel masters to take certain steps and complete certain documents before entering a nation's waters in order to trade in port. These requests are based upon the conclusion that ballast exchange, generally exercised to maintain stability when cargo is offloaded or onloaded, causes dispersal or inoculation with nonindigenous species.

By directive from Congress in the 1990 Nonindigenous Aquatic Nuisance Prevention and Control Act (Public Law 101-646) and the 1996 National Invasive Species Act (Public Law 104-332), the Coast Guard is in the process of developing final regulations for open ocean ballast exchange for ships entering US ports. In an original draft, these guidelines were mandatory for transoceanic ships entering Great Lakes ports and voluntary for those entering all other US ports [Federal Register, 63FR17782,April 10, 1998]. Public response to the original draft, especially from shippers, emphasized the issue of safety during open ocean ballast exchange and the need for some uniformity in regulations when entering all US ports. The portion of the original draft that required masters of all vessels destined for a U.S. port to voluntarily report their ballast exchanges to the Coast Guard was not the subject of most responses, possibly because the Coast Guard stated that lack of voluntary reports could lead to mandatory reporting [IMO Marine Environmental Protection Committee, 42nd Session, Aug.7, 1998.] Many of the responses to the original draft are available online at the Coast Guard world wide web site [http://www. uscg.mil/hq/g-m/regs/reghome.html]

The purpose of the Coast Guard regulations and guidelines is to reduce the introduction of freshwater aquatic or bottom dwelling species from foreign into U.S. freshwater bodies or water bottoms. Report data will be reviewed by the Smithsonian Institution to develop information on level of compliance, type of compliance, and locations of compliance. It will be coordinated with information on last port of call, next port of call, etc., and may be used in the future to help ports and other areas continue to assess risk [Miller, 1999]. These plans are described at the website http://www.serc.si.edu/invasions/ballast.htm under the subheading National Ballast Water Information Clearinghouse.

The IMO has come to a similar conclusion about the role played by ballast water in the introduction of nonindigenous species throughout the world. This international body recommends open ocean ballast exchange when possible, but it also is seeking ways that ports might provide ships' masters with information about locations in port where ballast exchange can be safely conducted so that the vessel can avoid taking on ballast water contaminated with pathogens, known nuisance species, foulants, etc. It also recommends that the ports establish receptacles or other mechanisms to safely accept ballast water and sludge from ballast holds in order to prevent contaminating port waters [Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens, Resolution A.868(20), 1998].

- **Because** *Coast Guard and IMO guidelines and regulations link ports with ships as if they are integrated businesses rather than separate entities.*

Note that these "rules and guidelines" from both the Coast Guard and the IMO are based upon a common view that ballast exchange has been scientifically identified as a vector for introducing foreign plants, animals, or pathogens into a new environment. Both guidelines identify ships as dispersal vectors, carriers of nonindigenous species. In addition, both link ships and ports although these are separate businesses. Because of this oversimplified description of the shipping trade process, the Coast Guard's rules and guidelines reflect the view of ports as gateways to the U.S. while the IMO's guidelines reflect a view of ports as "hubs" — receivers and contributors of nonindigenous species. These views increase the need for ports to scientifically identify their more specific potential vulnerabilities for invasion or unintentional dispersal separate from ship operations.

FACTORS GULF OF MEXICO PORTS SHOULD CONSIDER

Potential for introduction of nonindigenous species is considerable since the Gulf of Mexico is home to eight of the ten largest ports (ranked by tonnage) in the country according to the U.S. Army Corps of Engineers Water Resources Support Center. Research in the ballast tanks and ballasting procedures suggests that bulk carriers exchange a large volume of ballast and thus, may be more likely to introduce nonindigenous species. In addition, the studies show that the number of bulkers alone would not be as significant as the number of bulkers arriving without cargo to take on shipments if these vessels have to jettison ballast in port during the cargo loading process. Furthermore, container vessels are more likely to support life of a transported species because they make faster, more direct voyages, providing opportunities for plants and animals to live in cargo holds or survive a short period in a saltwater environment [NaBISS, Shipping Study II, ADA 321543, 1996].

Studies also indicate that port location and vessel type, traffic or operations are not the only variables that might affect the likelihood of the introduction of a new species. The survival of specific species also depends upon variations such as the location of ballast exchange in the port relative to chemical or sewage outfalls, water quality of port water in contrast to water quality characteristics of the ballast water, the season relative to species' life cycles as well as the length of time the species lived in the ballast [Great Lakes Shipping Study I-A, ADA 325351, 1997, and NaBISS, Shipping Study II, ADA 321543, 1996].

All of these factors suggest that the Gulf of Mexico ports should have experienced invasion by many nonindigenous species, yet the reported number of invasions by nonindigenous species in the Gulf of Mexico region is low in comparison to other U.S. regions and waterways [Shipping Study I, 1995]. Carlton suggests that this may be due to any or all of the basal variations or to the practices of researchers to assume a new species is native and as yet undiscovered rather than alien, especially when it has no negative effect on human life [NaBISS, Shipping Study II, 1996]. To clarify the vulnerability of ports in the region, there is an urgent need for a better scientific understanding of each port's risk of serving as a conduit for future invasions from nonindigenous species.

ASSESSING RISK, IDENTIFYING VULNERABILITY IN PORT

What factors should the Gulf of Mexico region ports use to assess risk?

Each port should consider the following factors in relation to one another and to ballasting:

- total tonnage and total export tonnage
- types and proportions of transport vessels and cargoes
- trade partners
- origin of ballast
- natural environment and port water quality compared to water quality of trade partners
- location of known pests and foulants in port

Total Tonnage and Total Export Tonnage

- **Factor 1:** *Total tonnage qualified by type of vessel, type of cargo and total export tonnage.*

On the basis of the tonnage handled in the Gulf of Mexico ports and the conclusions of the shipping studies described above, it can be concluded that a large proportion of the cargo loading and unloading and potentially associated ballast exchange within U.S. ports, occurs in the U.S. Gulf of Mexico region. Table 1 shows that two Gulf of Mexico ports and one East Coast port handle the most tonnage in the U.S., and that the three ports handling the highest amount of export tonnage in the country are all located along the Gulf of Mexico — the Port of South Louisiana, the Port of Houston, and the Port of New Orleans.

The ranks change little from year to year. For example, trade rank by tonnage in 1995 varied only slightly from 1996. South Louisiana, Houston, and New York-New Jersey were also the top three ports on the 1995 list, and the balance of the ports, except for one (Tampa), were the same although their descending order differed: Baton Rouge, Valdez, New Orleans, Plaquemines, Corpus Christi, Long Beach, and Tampa, Florida [US Army Corps of Engineers Water Resources Support Center. Similar information is online at www.seaportsinfo.com/usgulf/html].

Table 1. Top Ten US Ports by Tonnage (1996)

Source: US Army Corps of Engineers Water Resources Support Center, Navigation Data Center, Alexandria, VA.

Rank	Port Name	Total Tons	Domestic	Foreign	Imports	Exports
1	Port of South Louisiana	189,814,564	106,045,081	83,769,483	25,172,134	58,597,349
2	Houston, TX	148,182,876	61,124,588	87,058,288	58,041,465	29,016,823
3	NY,NY & NJ	131,601,244	75,115,630	56,485,614	48,472,360	8,013,254
4	New Orleans, LA	83,726,470	36,813,969	46,912,501	20,840,444	26,072,057
5	Baton Rouge, LA	81,009,253	45,222,690	35,786,563	24,803,274	10,983,289
6	Corpus Christi, TX	80,460,088	23,841,943	56,618,145	49,158,007	7,460,138
7	Valdez, AK	77,116,459	74,962,144	2,154,315	28,006	2,126,309
8	Plaquemines, LA	66,910,237	46,221,107	20,689,130	6,394,967	14,294,163
9	Long Beach, CA	58,395,243	22,367,442	36,027,801	17,586,084	18,441,717
10	Texas City, TX	56,393,758	21,062,739	35,331,019	32,895,245	2,435,774

Table 2. Cargo in Gulf of Mexico Ports Listed in the Top 10 for Tonnage

Sources: Gulf of Mexico Program, AAPA Seaports, Plaquemines Parish Master Plan

Port	Primary Inbound/Import Products	Primary Outbound/Export Products
South Louisiana	crude oil, aluminum ores, petroleum products	corn, animal feeds, oil seeds, wheat
Houston	petroleum products, steel, organic chemicals	petroleum products, organic chemicals, grain
New Orleans	steel, crude and refined petroleum products, rubber, plywood, coffee, cotton, machinery, and foodstuff	forest products, steel, foodstuffs, chemicals, cotton, rubber
Baton Rouge	petroleum, molasses, rail, steel coils, chemicals	grain, forest products, chemicals, coke/coal, petroleum products, pipe, and sugar
Corpus Christi	petroleum & petroleum products	petroleum & petroleum products
Plaquemines	petroleum & petroleum products	grain, grain products, petroleum & petroleum products
Texas City	petroleum & petroleum products	petroleum & petroleum products
Tampa	petroleum, phosphate, other dry bulk products	phosphate and related products

Types and Proportions of Transport Vessels and Cargo

Reviewing the proportion of the tonnage by types of cargo and transport vessels will provide added information for assessing the risk. Handling a high proportion of tonnage does not represent the same risk to all Gulf of Mexico ports. For example, Table 2 shows that primary import and export cargoes in these ports for both 1995 and 1996 include bulk products like petroleum and petroleum products, aluminum ores, corn, animal feeds, oil seeds, grain, and organic chemicals as well as other cargo like machinery, foodstuffs, forest products, pipe, and steel coils.

It is important to determine the proportion of types of vessels carrying these cargoes because ballast exchange procedures differ according to the vessel type. Some bulk cargo is transported in tankers, others in bulkers. Remember, as noted previously, dry bulkers entering port empty have been identified as the type of transoceanic vessel exchanging the largest volume of ballast. In addition, containerized and general containerized-cargo carriers move from port to port more quickly and directly than bulkers or tankers. As a result, researchers suggest that nonindigenous species living in the cargo holds or ballast tanks of these vessels are more likely to survive transit or even open-ocean ballast exchange [NaBISS Shipping Study II, 321543. 1996].

- **Factor 2:** *Volume and proportion of dry bulk and containerized export.*

Looking only at types of cargo in those U.S. Gulf of Mexico ports listed in Table 2, the Ports of South Louisiana, Houston, Corpus Christi, Texas City, and Tampa handle more types of cargo transported in bulk than New Orleans, Baton Rouge, Plaquemines and Texas City. On the basis of tonnage and bulk cargo characteristics, this would suggest that the first four ports might have greater risk than the latter four. However, the ports of New Orleans and Baton Rouge have much trade on carriers that might release living organisms to settle in their waters.

Analysis should not be confined to those Gulf of Mexico ports ranked in the top 10 U.S. ports for tonnage (Table 1). For example, Table 3 shows Mobile, ranking 11th, has primary inbound/imports of petroleum, coal, and iron ore and primary outbound/exports of forest products, coal, petroleum. Many of these are transported in bulk. Galveston ranking 49th in tonnage, handles bulk sugar and grain as well as several containerized cargoes. The cargo handled in Gulfport, ranking 115, is transported primarily by specialized carriers (bananas, mahogany, and pineapples, containerized cargo and frozen poultry). The approximate quantities or proportions of total trade volume of these cargoes imported and exported in bulkers or containerized carriers will help to evaluate risk.

Table 3. Cargo in Other Gulf of Mexico Ports

Sources: Gulf of Mexico Program and AAPA personal communication

Port	Primary Inbound/Import Products	Primary Outbound/Export Products
Mobile	petroleum, coal, iron ore	forest products, coal, petroleum
Gulfport	bananas, ilmenite ore ($FeTiO_3$), mahogany, pineapples	containerized cargo and frozen poultry
Galveston	bulk sugar, bananas/fruit, agricultural/heavy machinery	bulk grain, machinery, sacked goods, cotton

Batelle used such quantities in a formula to approximate the amount of ballast water being released in the ports of Houston, the Lower Mississippi River, Gulfport, Mobile and Tampa. Continuing the same example: with this formula, Batelle calculated that bulkers carrying export cargo from the Port of Mobile in 1996 accounted for 24 percent of annual cargo which converts to approximately 1.1 million metric tons of released ballast water [Batelle, 1998, pp.1-4]. This mathematical formula is based upon known ballast capacities and an estimate of the portion of ballast water that never leaves the tank made by direct examination and measurement in a few vessels [NaBISS, Shipping Study II, ADA 321543, 1996]. This highly statistical approximation may be unnecessary for ports to calculate. However, it is important for ports to recognize, as shown in this example, that many metric tons of ballast may be jettisoned in port even when the amount of export trade carried by bulkers is a comparatively small portion of its total trade, and to also recognize that a certain amount of ballast water remains in every vessel, providing an existing ecosystem for all kinds of species that may reproduce and, at some point, be released.

- **Factor 3:** *Tonnage and cargo in port-specific facilities.*

Details about an individual port are equally important. For example, Mobile has the largest bulk coal facility in the Gulf Coast and the second largest in the U.S. The bulk cargo area of that port is therefore a significant consideration when evaluating the potential of nonindigenous species transfer although the port is not ranked in the top 10 U.S. ports for tonnage. Thus, the quantity of tonnage and type of transport must be qualified by quantity of export tonnage, type of cargo, and special details about the port.

Trade partners

Identifying the location of a port's trade partners is useful for assessing the risk. Although the World Ocean is one unit and all trade partners are located somewhere on or adjacent to it, all saltwater species do not live in all areas of it. In addition, most freshwater species that might be carried in ballast water are concentrated in specific areas of the world. Logically, trade between neighboring ports would be expected to be less likely to result in the introduction of new or nonindigenous species than trade between ports on opposite sides of the globe since neighboring areas may share environments and species. However, this assumption is not entirely valid because sometimes species are very different in neighboring countries. A good example of this is the Gulf region of the U.S. and its Mexican neighbor. In addition, neighboring ports with the same or similar climates, water quality characteristics, or other environmental factors may be the source of invasion or dispersal when a bulker jettisons some ballast in each of the successive ports of call or when an inland carrier calls between coastal ports.

- **Factor 4:** *Trade partners qualified according to proximity and environment.*

Identifying trade partners' locations as foreign or domestic is also useful. It can be assumed that, generally, foreign trade has a greater potential for carrying in or taking away nonindigenous species because foreign usually implies far away or in a different environment. For example, in all the major Gulf of Mexico ports (Table 4), note that New Orleans has almost an equal amount of foreign and domestic trade, while Corpus Christi's foreign trade is twice its domestic trade. In this comparison, Corpus Christi should make more effort than New Orleans to identify trade partners since much of its trade could be in places with aquatic species that are not native to Texas waters. However, Corpus Christi officials can better qualify the need to identify trade partner locations by looking at the types of vessels and types of cargo. If Corpus Christi's foreign trade is primarily in petroleum (tankers) in which ballast may be moved from one ballast hold to another rather than jettisoned, identifying the trade partners may be less significant than if that is bulker trade. The almost equal balance of foreign and domestic trade in the Port of

- **Factor 5:** *Trade partners qualified as domestic or foreign.*

Table 4: Tonnage in Top Ten US Ports + larger Gulf of Mexico Ports (1996)

Source: US Army Corps of Engineers Water Resources Support Center, Navigation Data Center, Alexandria, VA.

Rank	Port Name	Total Tons	Domestic	Foreign	Imports	Exports
1	Port of South Louisiana	189,814,564	106,045,081	83,769,483	25,172,134	58,597,349
2	Houston, TX	148,182,876	61,124,588	87,058,288	58,041,465	29,016,823
3	NY,NY & NJ	131,601,244	75,115,630	56,485,614	48,472,360	8,013,254
4	New Orleans, LA	83,726,470	36,813,969	46,912,501	20,840,444	26,072,057
5	Baton Rouge, LA	81,009,253	45,222,690	35,786,563	24,803,274	10,983,289
6	Corpus Christi, TX	80,460,088	23,841,943	56,618,145	49,158,007	7,460,138
7	Valdez, AK	77,116,459	74,962,144	2,154,315	28,006	2,126,309
8	Plaquemines, LA	66,910,237	46,221,107	20,689,130	6,394,967	14,294,163
9	Long Beach, CA	58,395,243	22,367,442	36,027,801	17,586,084	18,441,717
10	Texas City, TX	56,393,758	21,062,739	35,331,019	32,895,245	2,435,774
11	Mobile, AL	50,863,944	25,368,474	25,495,470	13,133,946	12,361,524
13	Tampa, FL	49,292,651	32,455,085	16,837,566	6,503,848	10,333,718
49	Galveston	11,640,754	3,980,977	7,659,777	2,726,346	4,933,431

- **Factor 6:** *Trade partners' environments and climates relative to vessel and cargo types.*

New Orleans makes identification of trade partner locations quite important. This research will be easier by identifying vessel and cargo types. Attention should be directed first to the foreign bulker trade with neighboring countries along the Gulf of Mexico and Caribbean with similar environments and significantly different species. Trade with areas of the world like northern Russia or the Scandinavian countries should receive less research attention because the climate is so different that species arriving from those waters are more likely to die than settle and reproduce.

Domestic trade should not be ignored however. For example, the Port of Valdez in Alaska has a much larger volume of domestic than foreign trade (Table 4), primarily petroleum and petroleum products destined for west coast states. While the concept of domestic trade gives the impression that this port has comparatively few visits from foreign ports, Alaska does trade with ports on the Pacific Coast in the lower 48 having similar environments but species that are not found in Alaska so domestic trade does present some risk. In the Gulf of Mexico region, inland trade along the GIWW as well as coastwise trade between neighboring U.S. ports should be examined because there are nuisance species that are not common to all ports. Florida, for example, has many nuisance species not found in other Gulf states. [Courtenay, Hensley, Taylor, McCann, 1986]

Origin of Ballast

What indicators show the origin of ballast water ?

Early on, some concluded the last port of call (LPOC) might be a better way to evaluate risk from trade partners since vessels often call at several ports on a voyage, and only a portion of the ballast may be exchanged during offloading and onloading. Research has proved this assumption to be incorrect, and the need for considering multiple factors when evaluating a port's risk is clarified by it. (See Appendices A and B for more on this topic.)

- **Indicator 1:** *Last Port of Call.*

In the National Biological Invasions Shipping Study [NaBISS, Shipping Study II, 1996], researchers identified the number of vessels in ballast from foreign ports using information published by the Bureau of Census in its Monthly Vessel Entrances (TM-385) and Clearances (TM-785). In ballast means that the vessel is traveling with no cargo and therefore (more or less) fully ballasted. The data include all of the major types of ships in ballast. Even so, only 77% of these ships could be classified as bulk carrier, tanker, general cargo, or passenger vessels. But, among these data from this mixed group of vessels, the LPOC listed by country was a poor indicator of the actual source of ballast water found on board. In the NaBISS sample set, there was no ballast on board from the actual LPOC for over half (53%) of all vessels and 63% of those specifically classified as container ships. LPOC data accurately identified the origin of ballast water in ships with very direct voyages such as woodchip bulkers destined for Japan, but it was a poor general indicator of the ballast water's origin.

- **Indicator 2:** *The FAO region.*

However, when the LPOC data were expanded to FAO regions (standardized ocean regions used by the United Nations Food and Agriculture Organization), a more accurate indicator resulted. In the NaBISS sample set, 66% of all vessels arriving in ballast had at least some or all of their ballast water from the FAO region corresponding with their last port of call. Note that the indicators were not equally accurate for all vessel types. The ballast in 84% of the container ships came from the FAO region of their LPOCs while only 33% of tankers had any ballast from the FAO region of the LPOC [Shipping Study II, 1996].

In Figure C, LPOC data on four Gulf of Mexico ports have been applied to FAO regions. Two of the ports (New Orleans and Houston) rank in the top 10 U.S. ports for tonnage and two are major ports although not ranked in the top 10 (Galveston and Tampa). [NaBISS data adjusted for geographical inconsistencies and oversights. See Appendix A for explanation and complete data.] Note that the largest percentage of trade entering these four ports come from LPOCs in FAO region G, the Western Central Atlantic — ports in the Caribbean islands, northern coast of South America, Mexico, as

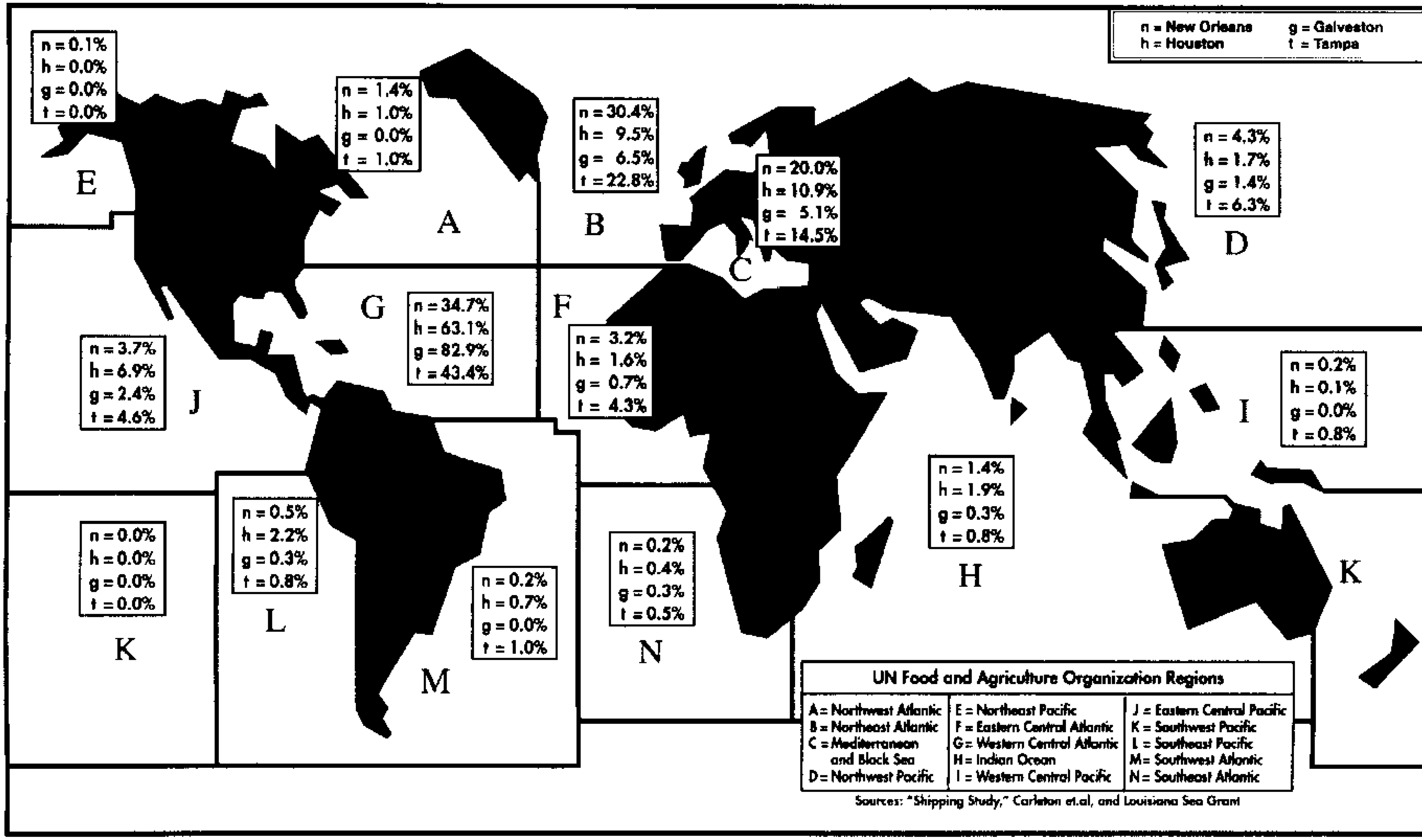


Figure C. Last Foreign Port of Call for Ships in Ballast Selected Gulf Ports, 1991 (FAO Region).

- **Indicator 3:** *Climate and ecosystems in the FAO region, even when it includes Gulf waters.*

well as the coastal U.S. Some of these are foreign but neighboring ports, located comparatively close by on the World Ocean, some with similar climates, environments, or water quality characteristics. Because the plants and animals living in these areas are not all identical, some risk of introduction, even from nearby trade partners must be considered. When these data are considered along with information on the type of cargo and type of transoceanic vessels coming from the LPOCs, some tentative conclusions can be made. Since coastwise trade is also prevalent in the Gulf of Mexico region, it is also important that a port identify regular vessel origins from which nonindigenous species might be accidentally introduced. If transoceanic vessels call at more than one Gulf of Mexico region port before leaving U.S. waters, it is also important that each port consider the possibility that they might receive and support life for a non-native nuisance species and then unintentionally serve as a conduit via transoceanic ships in U.S. waters for the spread of nonindigenous nuisance species among neighboring Gulf of Mexico ports. (See Appendix C for more information on ballast.)

Natural Environment and Port Water Quality

Why are a port's water quality characteristics important?

The nature of environmental risk can be further refined by looking at the water quality characteristics and the native species in the port. Water quality information is available in databases at many of the state universities along the Gulf Coast and from NOAA. The national estuary organizations in the Gulf Region also maintain such databases. Some ports, like Corpus Christi, maintain some of their own data. Recently, a database of native and nonindigenous Gulf Region plants and animals was established by the Gulf of Mexico Program at the Gulf Coast Research Laboratory in Biloxi, MS. It is available online at http://www.ims.usm.edu/~musweb/invaders.html.

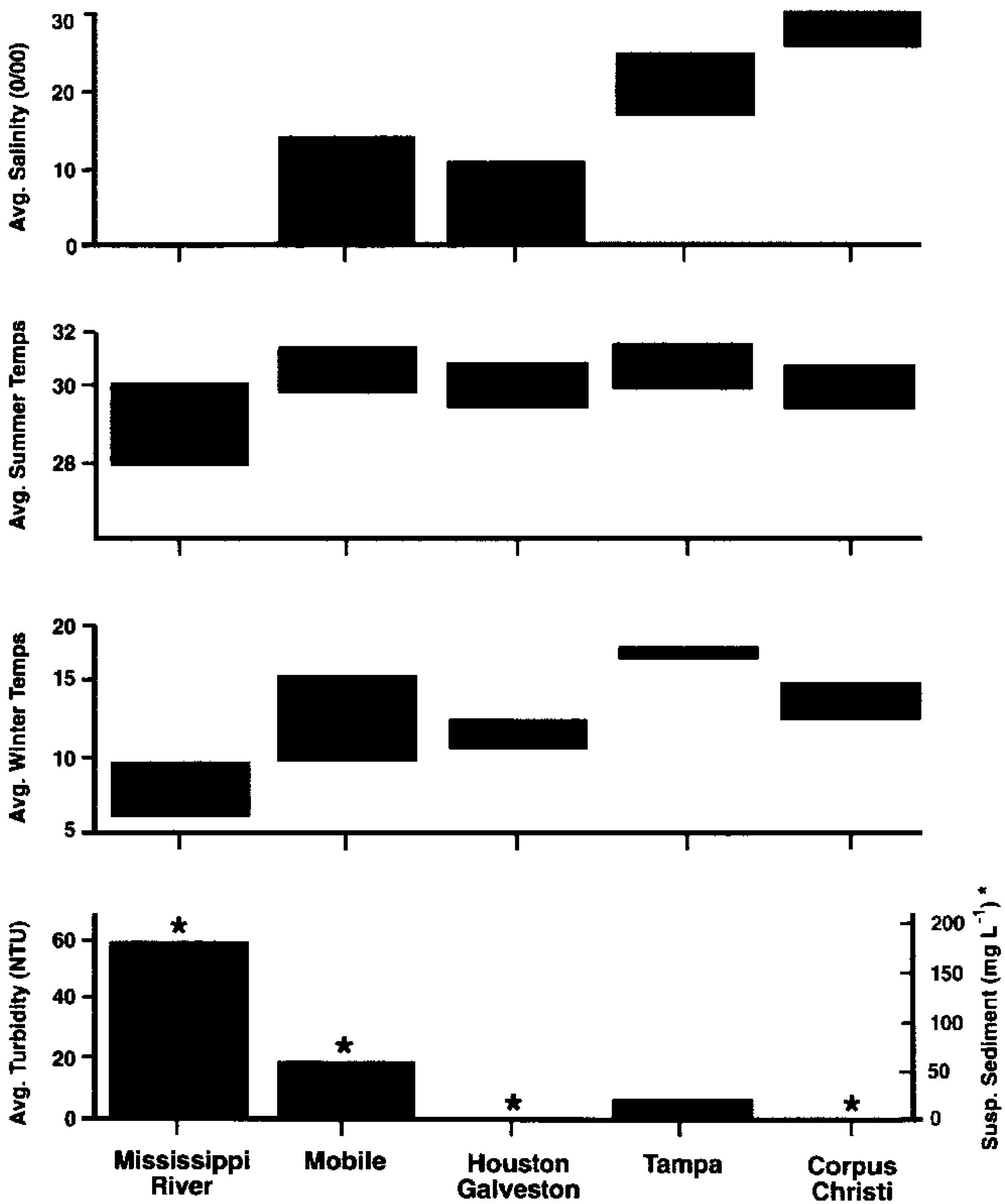
Although neighboring ports share climate and sometimes geological characteristics, they do not always share water quality characteristics. Each port needs a profile of water quality characteristics to evaluate risk. A comparison of a port's water quality profile with the same characteristics for its major trade partner-ports and neighboring Gulf of Mexico ports will quickly reveal those trade partners that are extremely different and those that are extremely similar. Species thriving in ports with extremely different water quality and climate characteristics are less likely to survive if transferred, and thus vessels carrying ballast from regions with different water quality characteristics present less risk. The opposite is true for vessels in ballast coming from ports that have extremely similar water quality and climate characteristics. This process will help Gulf of Mexico ports evaluate the level of risk for invasion as well as for serving as a conduit for nuisance species to neighboring ports.

- **Reason 1:** *Each species survives under certain water quality conditions.*

- **Reason 2:** *Vessels calling on more than one Gulf of Mexico port could disperse nonindigenous species in several places with similar water quality characteristics, increasing the possibility of settlement and survival.*

Table 5 is an example of a comparison of five neighboring Gulf of Mexico ports using data from several existing sources. (The port marked Mississippi River actually includes the five deepwater ports on both sides of the river in south Louisiana from Baton Rouge to Plaquemines.) Note that the waters in the ports of Mobile and Houston are similar in terms of temperature and salinity. Thus, those species that thrive in one would have a better chance of thriving in the other if these water quality factors were identical and the only factors affecting survival. Note in this table that range of summer water temperatures in the port of Corpus Christi is almost identically to the port of Houston's and thus, this Texas port might support the life of species that are also supported in Houston's and Mobile's waters. However, the port of Corpus Christi's winter temperature range is quite different from Houston's and similar only to a portion of the winter water temperature range in the port of Mobile. This demonstrates that one water quality characteristic is not enough to evaluate risk. Other water quality factors such as turbidity, quantity of suspended solids, and salinity must all be considered. For example, the port of Corpus Christi's salinity is much higher than the salinity in the other Gulf region ports, reducing the potential for freshwater species to survive if they were accidentally dispersed by jettisoned ballast.

Table 5. Water Quality Chracteristics of Selected Gulf of Mexico Ports.



The other factors discussed in this paper (tonnage, vessel and cargo type, trade partners and origin of ballast) should be considered relative to water quality. In this same example, cargo enters and departs from the port of Corpus Christi primarily on tanker vessels which do not jettison ballast in port. Thus, the water quality data would be useful in conjunction with other factors to evaluate risk from the comparatively small volume of bulker or carrier traffic. None of the three ports should ignore this water quality data, however, because a port's water quality conditions are useful to identify possibility of invasion by a known nonindigenous nuisance species. In the Gulf of Mexico region, all ports have some coastwise traffic involving both ocean-going and inland commercial transport that can carry live species in ballast, in the sea chest, or on the surface from one port to the other. [See Appendix D for data on most ports in this table.]

In Table 5, the five deepwater ports labeled the Mississippi River stand alone in terms of temperature, salinity, and high turbidity. In addition, it is known that they are freshwater riverine ports with high flow rates, high turbidity, and they are part of the inland waterway system. One could assume that vessels from Mobile, Tampa, Corpus Christi and Houston, or vessels that had come from ports with a saline aquatic environment in other parts of the world would present a low risk of dispersing nonindigenous species that would live in these Mississippi River ports. It would be more accurate for port officials to conclude that bulkers or carriers coming into these ports from FAO regions with riverine ports could have a large quantity of freshwater ballast or be supporting live freshwater species, and those coming from foreign riverine ports in similar climates could present a greater risk of bringing animals, plants, or pathogens that might thrive. In addition, animals and plants living in this fresh water environment, transported in ballast water taken aboard in the Mississippi could be identified as nonindigenous in other parts of the world, and could become nuisances.

The ports of Tampa and Corpus Christi differ from the other ports in Table 5. Compared to other Gulf of Mexico ports, Tampa has higher average winter temperatures and lower turbidity and it's water is influenced by the tide. Tampa's high winter temperature can also support species that cannot live in the lower winter water temperatures of the other Gulf ports or ports in most of the U.S. This port's waters could support saltwater rather than freshwater nonindigenous species from warm climates. Like Tampa, the port of Corpus Christi is in a highly estuarine area with a higher range of salinity than Tampa. Thus, it also might support some saltwater nonindigenous species. Port officials will have to examine water quality information with data about export tonnage, types of vessels and cargoes, trade partners, and FAO regions in order to identify the points of vulnerability.

- **Reason 3:** *Some locations in port may present risk to vessels exchanging ballast while onloading or offloading because they have nuisance species or pathogens living there.*

Location in Port of Known Foulants or Pests

After all of these factors have been weighed and the areas of vulnerability have been identified, it is important to remember that additional natural variables can affect the likelihood of the introduction of a new species. These include the location of a vessel when exchanging ballast relative to chemical or sewage outfalls in a port and/or the season relative to invading species' life cycles as well as the length of time the species lived in the ballast water [Great Lakes Shipping Study I-A, ADA 325351, 1997 and NaBISS, ADA 321543, 1996]. Port officials should identify these locations.

HOW CAN GULF OF MEXICO PORTS PREVENT THE SPREAD OF NONINDIGENOUS INVASIVE SPECIES?

In conclusion, it is suggested that each Gulf of Mexico port do the following:

- Conduct a risk evaluation as outlined in this paper. If a specific and realistic risk is identified, a port may further choose to identify a location in the harbor where ballast exchange is least likely to result in the survival of introduced nonindigenous species.

- If risk is identified, adjust port procedures or policies to reduce the possibility of nonindigenous species surviving in port waters and, possibly, being further dispersed by ocean going carriers or commercial inland towboats and passenger vessels.

- Work with shipping interests to notify ocean carriers of the IMO voluntary guidelines for open ocean ballast exchange [IMO Resolution A.868 (20].

- Support educational and outreach programs about proactive ballast water control measures directed toward vessel operators and ocean carriers. These include using open ocean ballast exchange and other practices to reduce uptake and survival of nonindigenous nuisance species and avoiding identified "hot spots" where nuisance species or pathogens may be living.

- Work closely with the U.S. Coast Guard to support timely finalization of USCG guidelines.

- Support full voluntary compliance with IMO and USCG regulations and guidelines as long as these can be conducted safely.

- Work closely with the research community, federal and state water quality agencies to conduct studies that address the feasibility of other ballast water treatment measures such as those using chemical, heat, or other measures to remove nonindigenous species from ballast water.

What should ports do?

- *Conduct port-specific risk evaluation*
- *Adjust port procedures and policies to reduce risk*
- *Work with shipping interests to implement IMO guidelines*
- *Support education and outreach on proactive ballast water control measures for vessels*
- *Work with Coast Guard to support timely finalization of regulations and guidelines*
- *Support voluntary compliance with IMO and Coast Guard guidelines and regulations*
- *Work with researchers and government agencies to study feasibility of alternative measures to reduce dispersal from ballast water*

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APPENDICES

What do these tables represent?

These tables offer a more precise listing of the last port of call data from the FAO Region map. Here again, all of the incoming vessels in this data set arrive in ballast, directly from foreign ports of call. The countries/coasts are grouped by FAO Region in descending order of traffic volume. Countries with one uninterrupted coastline on a single body of water are listed simply by country (e.g. Italy or Jamaica). Countries with multiple coastlines are listed by country and coastline (e.g. Panama, Caribbean or USSR, Black Sea).

The "Rank" column indicates the coastline's relative significance in terms of traffic volume (the United Kingdom is the 11th largest source of in-ballast ships coming directly from foreign ports of call). The "Total vessels entering Gulf" column is the horizontal sum of the totals of the four selected ports for each coastline. The "% of total # of entering vessels" is determined by dividing number in the "Total vessels" column by 2643, the total number of in-ballast vessels entering the Gulf from foreign ports of call.

Referring to the first table, the Northeast Atlantic is the second largest FAO Region for the four selected Gulf ports in terms of ship traffic. The Netherlands is the largest source of ships for this FAO Region, but the 3rd largest source overall. The total number of in-ballast ships entering these four ports from the Netherlands was 163, or 6.17% of the total number of vessels entering in 1991.

How were these data obtained?

Information for these tables came from the 1995 National Biological Invasions Shipping Study (NABISS). The researchers identified the number of vessels in ballast from foreign ports through information published by the Bureau of Census in its Monthly Vessels Entrances (TM-385) and Clearances (TM-785). This particular data set came from the 1991 TM-385 forms for the above mentioned Gulf ports.

This data set included all types of ships in ballast. Seventy-seven percent of the ships fall under the classification of Bulk Carrier, Tanker, General Cargo, or Passenger. Twenty-one different ship types make up the remaining 23% of the traffic.

What do these data tell us about the origin of the ballast water discharged in Gulf ports?

The NABISS research showed that *last port of call* (LPOC), listed by country, was a poor indicator of the actual source of ballast water on board. In the NABISS sample set, there was no ballast on board from the LPOC country for 53% of all vessels. For the specific category of container ships, this number reached 63%. While LPOC data was accurate for ships with very regular direct voyages, it was generally a poor indicator of the ballast water's origin.

When the LPOC data was expanded to FAO Regions, the relationship improved. In the NABISS sample set, 66% of all vessels arriving in ballast had at least some or all of their ballast from the FAO Region of their LPOC. Here again, there was significant variance among the vessel groupings. Container ships had the highest percentage, with 84% of the ships having some or all of their ballast come from the FAO Region of their LPOC. Tankers had the lowest percentage with only 33% of the vessels having any water from the FAO Region of their LPOC.

Notable changes to the NABISS data

Due to some inconsistencies and apparent oversights found in the NABISS FAO groupings, the map (Figure C, page 11) reflects three minor differences in the regional distributions.

1. For ships en route to New Orleans and Tampa, the NABISS study grouped ships with Brazilian last ports of call in Group L (Southeast Pacific). The map groups all Brazilian ships in Group M (Southwest Atlantic).

2. For ships en route to Houston, the NABISS grouped ships with last ports of call from Gibraltar in Group F (Eastern Central Atlantic). The map groups all ships from Gibraltar in Group C (Mediterranean and Black Sea).

3. The NABISS formed two regions in addition to the fourteen FAO Regions. For the purpose of the study, Carlton et. al created separate regions for Australia and the Great Lakes. Due to the minimal amount of in ballast traffic from these regions to the Gulf, and for the purpose of simplicity, these additional regions were not used in this map. Ships from the Great Lakes were included in Group A (Northwest Atlantic) and ships from Australia were included in Group H (Indian Ocean).

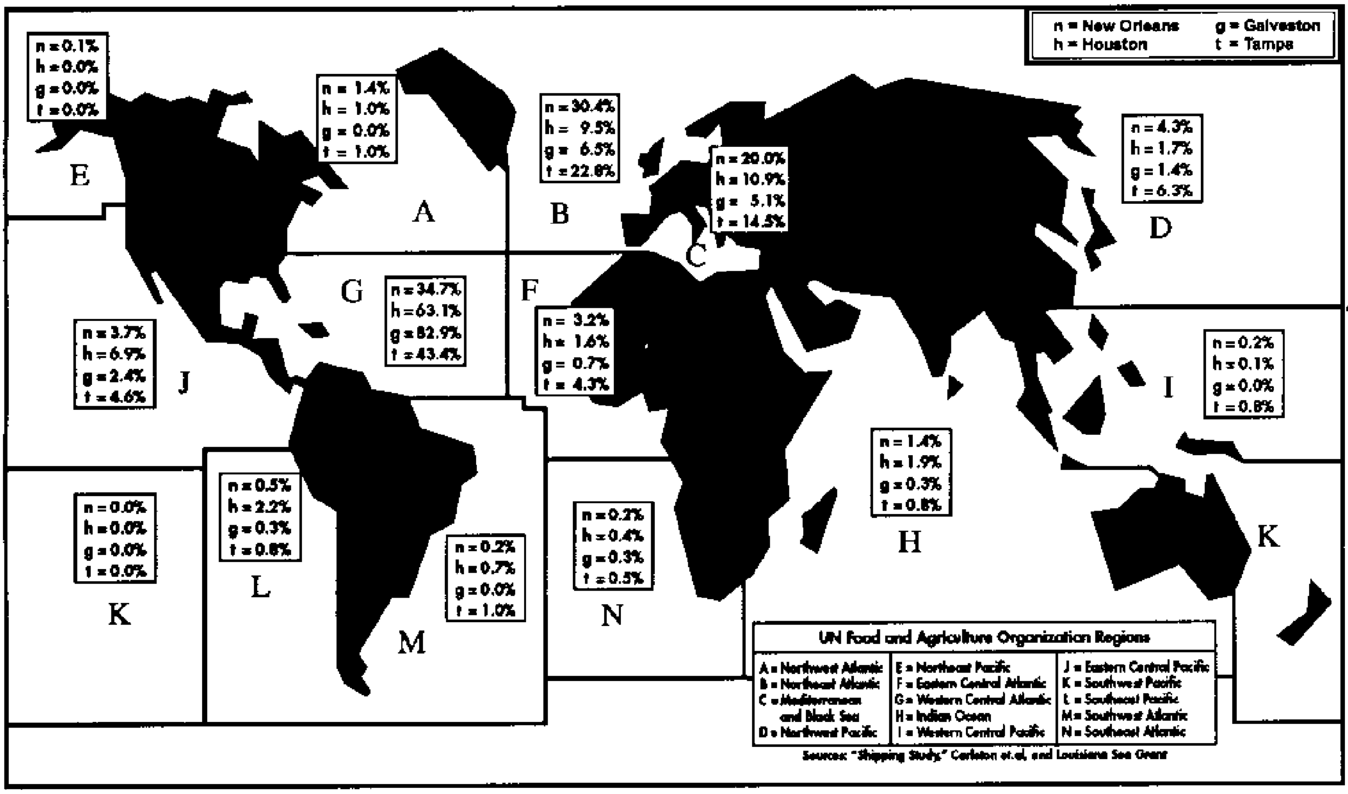

Figure C. Last Foreign Port of Call for Ships in Ballast Selected Gulf Ports, 1991 (FAO Region).

Last Port of Call by Individual Country/Regions for Foreign Ships "in Ballast" to Selected Gulf Ports. Source: "Shipping Study," Carlton et al.

Rank	Coast line	# of vessels Tampa	# of vessels New Orleans	# of vessels Houston	# of vessels Galveston	*Total vessels entering Gulf*	*% of total # of entering vessels*
	Western Central Atlantic					1290	48.81%
1	Mexico, Gulf	31	152	163	34	380	14.38%
2	High Seas	6	10	1	164	181	6.85%
4	Jamaica	11	61	25	8	105	3.97%
5	Venezuela	8	47	43	4	102	3.86%
6	Colombia, Caribbean	16	19	43		78	2.95%
7	Dominican Republic	14	39	18	3	74	2.80%
10	Cuba	12	20	23	5	60	2.27%
15	Haiti	17	8	20		45	1.70%
18	Guatemala, Caribbean	2	12	24	2	40	1.51%
21	Honduras, Caribbean	12	17	7	1	37	1.40%
24	Gulf of Mexico	2	5	5	18	30	1.14%
28	Panama, Caribbean	3	3	22		28	1.06%
33	Caymans	20	1	1		22	0.83%
37	Aruba & Antilles	2	7	8	1	18	0.68%
38	Costa Rica, Caribbean	1	5	11	1	18	0.68%
41	Bahamas	1	4	10	1	16	0.61%
48	Trinidad & Tobago	4	6	4		14	0.53%
55	Belize	3	2	5		10	0.38%
57	Guyana	2	7	1		10	0.38%
68	Barbados		3	1	1	5	0.19%
69	Leeward & Windward Islands	2	2	1		5	0.19%
74	French W. Indies	1	3			4	0.15%
76	Turks & Caicos Islands	1	3			4	0.15%
83	French Guiana			2		2	0.08%
91	Bermuda			1		1	0.04%
109	Suriname		1			1	0.04%
	Northeast Atlantic					558	21.11%
3	Netherlands	27	114	17	5	163	6.17%
9	Belgium & Luxembourg	11	49	12		72	2.72%
11	United Kingdom	15	39	5	1	60	2.27%
12	France, Atlantic	7	41	7	3	58	2.19%
13	Germany, Atlantic	14	32	5	3	54	2.04%
22	Spain, Atlantic- N of Portugal	2	23	6	2	33	1.25%
25	USSR, Baltic	1	20	7	2	30	1.14%
29	Spain, Atlantic- S of Portugal	2	22	3	1	28	1.06%
43	Poland	4	10	2		16	0.61%
46	Denmark		11	1	2	14	0.53%
51	Ireland	4	8			12	0.45%
61	Sweden	1	7			8	0.30%
65	Norway	1	4	1		6	0.23%
82	Finland		2			2	0.08%
84	Germany, Baltic	1	1			2	0.08%
	Mediterranean & Black Sea					400	15.13%
8	Italy	8	48	13	5	74	2.80%
14	Algeria	10	22	14	1	47	1.78%
16	USSR, Black Sea	3	39	2	1	45	1.70%
17	Spain, Mediter.	4	32	5	1	42	1.59%
20	Greece	8	23	4	3	38	1.44%
26	Gibraltar	7	12	8	1	28	1.06%
32	Turkey	3	18	2		23	0.87%
35	Egypt, Mediterr.	4	14	3		21	0.79%
36	France, Mediterr	1	12	7		20	0.76%
44	Romania	4	9	2	1	16	0.61%
53	Israel, Mediterr		6	5		11	0.42%
59	Tunisia	1	6	2		9	0.34%
64	Malta & Gozo	1	2	2	1	6	0.23%
66	Yugoslavia		6			6	0.23%
70	Morocco, Mediterr	1		4		5	0.19%
73	Bulgaria	1	2	1		4	0.15%
78	Cyprus	1		2		3	0.11%
110	Syria		1			1	0.04%
100	Libya				1	1	0.04%

Rank	Coast line	# of vessels Tampa	# of vessels New Orleans	# of vessels Houston	# of vessels Galveston	*Total vessels entering Gulf*	*% of total # of entering vessels*
	Eastern Central Pacific					*119*	*4.50%*
23	Panama, West Coast	8	11	12		*31*	1.17%
31	Mexico, West Coast	5	8	8	2	*23*	0.87%
34	Ecuador	2	5	11	4	*22*	0.83%
47	El Salvador	2	5	7		*14*	0.53%
56	Colombia, West Coast		5	4	1	*10*	0.38%
58	Costa Rica, W Coast	1	5	3		*9*	0.34%
62	Guatemala, West Coast		5	2		*7*	0.26%
80	Nicaragua, West Coast		2	1		*3*	0.11%
	Northwest Pacific					*95*	*3.59%*
19	Japan	11	26	1	2	*40*	1.51%
42	China, North Coast	4	9	2	1	*16*	0.61%
45	S. Korea	4	7	4	1	*16*	0.61%
54	Taiwan	2	5	4		*11*	0.42%
72	USSR, Arctic	2	2	1		*5*	0.19%
77	USSR, Eastern Region		4			*4*	0.15%
86	Hong Kong	1	1			*2*	0.08%
101	N Korea	1				*1*	0.04%
	Eastern Central Atlantic					*70*	*2.65%*
27	Madeira Islands	4	20	2	2	*28*	1.06%
49	Morocco, Atlantic	5	8			*13*	0.49%
52	Canary Islands	4	6	1		*11*	0.42%
67	Azores	1		4		*5*	0.19%
79	Ivory Coast	2		1		*3*	0.11%
81	Senegal		1	2		*3*	0.11%
85	Ghana		2			*2*	0.08%
92	Cameroon	1				*1*	0.04%
95	Gabon		1			*1*	0.04%
99	Liberia		1			*1*	0.04%
102	Nigeria		1			*1*	0.04%
106	Sierra Leone			1		*1*	0.04%
	Indian Ocean					*33*	*1.25%*
39	Egypt, Red Sea	2	10	4	1	*17*	0.64%
71	Saudi Arabia	1	1	3		*5*	0.19%
89	Australia			1		*1*	0.04%
90	Bangladesh		1			*1*	0.04%
94	Ethiopia		1			*1*	0.04%
96	Iran			1		*1*	0.04%
97	Jordan			1		*1*	0.04%
98	Kenya			1		*1*	0.04%
103	Oman		1			*1*	0.04%
104	Pakistan		1			*1*	0.04%
107	Sri Lanka		1			*1*	0.04%
108	Sudan			1		*1*	0.04%
111	Yemen			1		*1*	0.04%
	Northwest Atlantic					*29*	*1.10%*
30	Canada, Atlantic	4	15	6		*25*	0.95%
75	Montreal, Canada		3	1		*4*	0.15%
	Southeast Pacific					*25*	*0.95%*
40	Peru	3	6	8		*17*	0.64%
60	Chile			7	1	*8*	0.30%
	Southwest Atlantic					*12*	*0.45%*
50	Brazil	4	3	5		*12*	0.45%
	Southeast Atlantic					*8*	*0.30%*
63	South Africa	2	2	3		*7*	0.26%
88	Angola				1	*1*	0.04%

Rank	Coast line	# of vessels Tampa	# of vessels New Orleans	# of vessels Houston	# of vessels Galveston	*Total vessels entering Gulf*	*% of total # of entering vessels*
	Western Central Pacific					*3*	*0.11%*
87	Singapore		2			*2*	0.08%
105	Philippines			1		*1*	0.04%
	Northeast Pacific					*1*	*0.04%*
93	Canada, Pacific		1			*1*	0.04%
	Totals	*394*	*1260*	*696*	*293*	*2643*	100.00%

Last Port of Call by Individual Country/Regions for Foreign Ships "in Ballast" to the Port of Galveston.

Rank	Coast line	# of vessels Galveston	% of total # of entering vessels
	Western Central Atlantic	***243***	***82.94%***
1	High Seas	164	55.97%
2	Mexico, Gulf	34	11.60%
3	Gulf of Mexico	18	6.14%
4	Jamaica	8	2.73%
7	Cuba	5	1.71%
8	Venezuela	4	1.37%
10	Dominican Republic	3	1.02%
14	Guatemala, Caribbean	2	0.68%
25	Honduras, Caribbean	1	0.34%
28	Aruba & Antilles	1	0.34%
29	Costa Rica, Caribbean	1	0.34%
31	Bahamas	1	0.34%
38	Barbados	1	0.34%
	Northeast Atlantic	***19***	***6.48%***
5	Netherlands	5	1.71%
11	France, Atlantic	3	1.02%
12	Germany, Atlantic	3	1.02%
16	Spain, Atlantic- N of Portugal	2	0.68%
17	USSR, Baltic	2	0.68%
20	Denmark	2	0.68%
21	United Kingdom	1	0.34%
27	Spain, Atlantic- S of Portugal	1	0.34%
	Mediterranean & Black Sea	***15***	***5.12%***
6	Italy	5	1.71%
13	Greece	3	1.02%
22	Algeria	1	0.34%
23	USSR, Black Sea	1	0.34%
24	Spain, Mediter.	1	0.34%
26	Gibraltar	1	0.34%
33	Romania	1	0.34%
37	Malta & Gozo	1	0.34%
40	Libya	1	0.34%
	Eastern Central Pacific	***7***	***2.39%***
9	Ecuador	4	1.37%
19	Mexico, West Coast	2	0.68%
35	Colombia, West Coast	1	0.34%
	Northwest Pacific	***4***	***1.37%***
15	Japan	2	0.68%
32	China, North Coast	1	0.34%
34	S. Korea	1	0.34%

Rank	Coast line	# of vessels Galveston	*% of total # of entering vessels*
	Eastern Central Atlantic	***2***	***0.68%***
18	Madeira Islands	2	0.68%
	Southeast Atlantic	***1***	***0.34%***
39	Angola	1	0.34%
	Southeast Pacific	***1***	***0.34%***
36	Chile	1	0.34%
	Indian Ocean	***1***	***0.34%***
30	Egypt, Red Sea	1	0.34%
	Totals	***293***	100.00%

Source: "Shipping Study," Carlton et al.

Last Port of Call by Individual Country/Regions for Foreign Ships "in Ballast" to the Port of Houston.

Rank	Coast line	# of vessels Houston	*% of total # of entering vessels*
	Western Central Atlantic	***439***	***63.07%***
1	Mexico, Gulf	163	23.42%
2	Venezuela	43	6.18%
3	Colombia, Caribbean	43	6.18%
4	Jamaica	25	3.59%
5	Guatemala, Caribbean	24	3.45%
6	Cuba	23	3.30%
7	Panama, Caribbean	22	3.16%
8	Haiti	20	2.87%
9	Dominican Republic	18	2.59%
16	Costa Rica, Caribbean	11	1.58%
17	Bahamas	10	1.44%
20	Aruba & Antilles	8	1.15%
33	Gulf of Mexico	5	0.72%
36	Belize	5	0.72%
40	Trinidad & Tobago	4	0.57%
23	Honduras, Caribbean	7	1.01%
61	French Guinana	2	0.29%
62	High Seas	1	0.14%
64	Caymans	1	0.14%
67	Guyana	1	0.14%
69	Barbados	1	0.14%
70	Leeward & Windward Islands	1	0.14%
77	Bermuda	1	0.14%
	Mediterranean & Black Sea	***76***	***10.92%***
11	Algeria	14	2.01%
12	Italy	13	1.87%
18	Gibraltar	8	1.15%
25	France, Mediterr	7	1.01%
32	Spain, Mediter.	5	0.72%
35	Israel, Mediterr	5	0.72%
37	Greece	4	0.57%
44	Morocco, Mediterr	4	0.57%
46	Egypt, Mediterr.	3	0.43%
50	USSR, Black Sea	2	0.29%
52	Turkey	2	0.29%
55	Romania	2	0.29%
56	Tunisia	2	0.29%
58	Malta & Gozo	2	0.29%
59	Cyprus	2	0.29%
72	Bulgaria	1	0.14%
	Northeast Atlantic	***66***	***9.48%***
10	Netherlands	17	2.44%
13	Belgium & Luxembourg	12	1.72%
22	France, Atlantic	7	1.01%

Rank	Coast line	# of vessels Houston	% of total # of entering vessels
24	USSR, Baltic	7	1.01%
28	Spain, Atlantic- N of Portugal	6	0.86%
30	United Kingdom	5	0.72%
31	Germany, Atlantic	5	0.72%
45	Spain, Atlantic- S of Portugal	3	0.43%
54	Poland	2	0.29%
65	Denmark	1	0.14%
68	Norway	1	0.14%
	Eastern Central Pacific	***48***	***6.90%***
14	Panama, West Coast	12	1.72%
15	Ecuador	11	1.58%
19	Mexico, West Coast	8	1.15%
26	El Salvador	7	1.01%
42	Colombia, West Coast	4	0.57%
47	Costa Rica, W Coast	3	0.43%
57	Guatemala, West Coast	2	0.29%
75	Nicaragua, West Coast	1	0.14%
	Southeast Pacific	***15***	***2.16%***
21	Peru	8	1.15%
27	Chile	7	1.01%
	Indian Ocean	***13***	***1.87%***
38	Egypt, Red Sea	4	0.57%
49	Saudi Arabia	3	0.43%
76	Australia	1	0.14%
78	Iran	1	0.14%
79	Jordan	1	0.14%
80	Kenya	1	0.14%
83	Sudan	1	0.14%
84	Yemen	1	0.14%
	Northwest Pacific	***12***	***1.72%***
39	S. Korea	4	0.57%
53	China, North Coast	2	0.29%
41	Taiwan	4	0.57%
63	Japan	1	0.14%
71	USSR, Arctic	1	0.14%
	Eastern Central Atlantic	***11***	***1.58%***
43	Azores	4	0.57%
51	Madeira Islands	2	0.29%
60	Senegal	2	0.29%
66	Canary Islands	1	0.14%
74	Ivory Coast	1	0.14%
82	Sierra Leone	1	0.14%
	Northwest Atlantic	***7***	***1.01%***
29	Canada, Atlantic	6	0.86%
73	Montreal, Canada	1	0.14%
	Southwest Atlantic	***5***	***0.72%***
34	Brazil	5	0.72%

Rank	Coast line	# of vessels Houston	% of total # of entering vessels
	Southeast Atlantic	***3***	***0.43%***
48	South Africa	3	0.43%
	Western Central Pacific	***1***	***0.14%***
81	Philippines	1	0.14%
	Totals	***696***	100.00%

Source: "Shipping Study," Carlton et al.

Last Port of Call by Individual Country/Regions for Foreign Ships "in Ballast" to the Port of New Orleans.

Rank	Coast line	# of vessels New Orleans	% of total # of entering vessels
	Western Central Atlantic	***437***	***34.68%***
1	Mexico, Gulf	152	12.06%
3	Jamaica	61	4.84%
6	Venezuela	47	3.73%
8	Dominican Republic	39	3.10%
18	Cuba	20	1.59%
21	Colombia, Caribbean	19	1.51%
23	Honduras, Caribbean	17	1.35%
26	Guatemala, Caribbean	12	0.95%
31	High Seas	10	0.79%
36	Haiti	8	0.63%
40	Aruba & Antilles	7	0.56%
42	Guyana	7	0.56%
45	Trinidad & Tobago	6	0.48%
50	Gulf of Mexico	5	0.40%
52	Costa Rica, Caribbean	5	0.40%
58	Bahamas	4	0.32%
61	Panama, Caribbean	3	0.24%
63	Barbados	3	0.24%
64	French W. Indies	3	0.24%
66	Turks & Caicos Islands	3	0.24%
67	Belize	2	0.16%
70	Leeward & Windward Islands	2	0.16%
77	Caymans	1	0.08%
91	Suriname	1	0.08%
	Northeast Atlantic	***383***	***30.40%***
2	Netherlands	114	9.05%
4	Belgium & Luxembourg	49	3.89%
7	France, Atlantic	41	3.25%
9	United Kingdom	39	3.10%
11	Germany, Atlantic	32	2.54%
15	Spain, Atlantic- N of Portugal	23	1.83%
17	Spain, Atlantic- S of Portugal	22	1.75%
19	USSR, Baltic	20	1.59%
30	Denmark	11	0.87%
33	Poland	10	0.79%
39	Ireland	8	0.63%
43	Sweden	7	0.56%
59	Norway	4	0.32%
74	Finland	2	0.16%
80	Germany, Baltic	1	0.08%
	Mediterranean & Black Sea	***252***	***20.00%***
5	Italy	48	3.81%
10	USSR, Black Sea	39	3.10%
12	Spain, Mediter.	32	2.54%
14	Greece	23	1.83%
16	Algeria	22	1.75%
22	Turkey	18	1.43%
25	Egypt, Mediterr.	14	1.11%

Rank	Coast line	# of vessels New Orleans	% of total # of entering vessels
27	Gibraltar	12	0.95%
28	France, Mediterr	12	0.95%
35	Romania	9	0.71%
47	Israel, Mediterr	6	0.48%
48	Tunisia	6	0.48%
49	Yugoslavia	6	0.48%
69	Malta & Gozo	2	0.16%
72	Bulgaria	2	0.16%
92	Syria	1	0.08%
	Northwest Pacific	***54***	***4.29%***
13	Japan	26	2.06%
34	China, North Coast	9	0.71%
41	S. Korea	7	0.56%
54	Taiwan	5	0.40%
60	USSR, Eastern Region	4	0.32%
71	USSR, Arctic	2	0.16%
81	Hong Kong	1	0.08%
	Eastern Central Pacific	***46***	***3.65%***
29	Panama, West Coast	11	0.87%
37	Mexico, West Coast	8	0.63%
51	Ecuador	5	0.40%
53	El Salvador	5	0.40%
55	Colombia, West Coast	5	0.40%
56	Costa Rica, W Coast	5	0.40%
57	Guatemala, West Coast	5	0.40%
73	Nicaragua, West Coast	2	0.16%
	Eastern Central Atlantic	***40***	***3.17%***
20	Madeira Islands	20	1.59%
38	Morocco, Atlantic	8	0.63%
46	Canary Islands	6	0.48%
75	Ghana	2	0.16%
79	Senegal	1	0.08%
85	Gabon	1	0.08%
86	Liberia	1	0.08%
87	Nigeria	1	0.08%
	Indian Ocean	***16***	***1.27%***
32	Egypt, Red Sea	10	0.79%
78	Saudi Arabia	1	0.08%
82	Bangladesh	1	0.08%
84	Ethiopia	1	0.08%
88	Oman	1	0.08%
89	Pakistan	1	0.08%
90	Sri Lanka	1	0.08%
	Northwest Atlantic	***18***	***1.43%***
24	Canada, Atlantic	15	1.19%
65	Montreal, Canada	3	0.24%
	Southeast Pacific	***6***	***0.48%***
44	Peru	6	0.48%

Rank	Coast line	# of vessels New Orleans	% of total # of entering vessels
	Southwest Atlantic	***3***	***0.24%***
62	Brazil	3	0.24%
	Southeast Atlantic	***2***	***0.16%***
68	South Africa	2	0.16%
	Western Central Pacific	***2***	***0.16%***
76	Singapore	2	0.16%
	Northeast Pacific	***1***	***0.08%***
83	Canada, Pacific	1	0.08%
	Totals	***1260***	***100.00%***

Source: "Shipping Study," Carlton et al.

Last Port of Call by Individual Country/Regions for Foreign Ships "in Ballast" to the Port of Tampa.

Rank	Coast line	# of vessels Tampa	*% of total # of entering vessels*
	Western Central Atlantic	***171***	***43.40%***
1	Mexico, Gulf	31	7.87%
3	Caymans	20	5.08%
4	Haiti	17	4.31%
5	Colombia, Caribbean	16	4.06%
7	Dominican Republic	14	3.55%
9	Cuba	12	3.05%
10	Honduras, Caribbean	12	3.05%
11	Jamaica	11	2.79%
15	Venezuela	8	2.03%
21	High Seas	6	1.52%
32	Trinidad & Tobago	4	1.02%
37	Panama, Caribbean	3	0.76%
40	Belize	3	0.76%
41	Guatemala, Caribbean	2	0.51%
43	Gulf of Mexico	2	0.51%
46	Aruba & Antilles	2	0.51%
52	Leeward & Windward Islands	2	0.51%
50	Guyana	2	0.51%
57	Costa Rica, Caribbean	1	0.25%
58	Bahamas	1	0.25%
68	French W. Indies	1	0.25%
69	Turks & Caicos Islands	1	0.25%
	Northeast Atlantic	***90***	***22.84%***
2	Netherlands	27	6.85%
6	United Kingdom	15	3.81%
8	Germany, Atlantic	14	3.55%
12	Belgium & Luxembourg	11	2.79%
19	France, Atlantic	7	1.78%
29	Poland	4	1.02%
34	Ireland	4	1.02%
42	Spain, Atlantic- N of Portugal	2	0.51%
44	Spain, Atlantic- S of Portugal	2	0.51%
55	USSR, Baltic	1	0.25%
61	Sweden	1	0.25%
63	Norway	1	0.25%
71	Germany, Baltic	1	0.25%
	Mediterranean & Black Sea	***57***	***14.47%***
14	Algeria	10	2.54%
16	Italy	8	2.03%
17	Greece	8	2.03%
20	Gibraltar	7	1.78%
24	Spain, Mediter.	4	1.02%
27	Egypt, Mediterr.	4	1.02%
30	Romania	4	1.02%
36	USSR, Black Sea	3	0.76%
38	Turkey	3	0.76%

Rank	Coast line	# of vessels Tampa	*% of total # of entering vessels*
56	France, Mediterr	1	0.25%
60	Tunisia	1	0.25%
62	Malta & Gozo	1	0.25%
65	Morocco, Mediterr	1	0.25%
67	Bulgaria	1	0.25%
70	Cyprus	1	0.25%
	Northwest Pacific	***25***	***6.35%***
13	Japan	11	2.79%
28	China, North Coast	4	1.02%
31	S. Korea	4	1.02%
49	Taiwan	2	0.51%
53	USSR, Arctic	2	0.51%
72	Hong Kong	1	0.25%
74	N Korea	1	0.25%
	Eastern Central Pacific	***18***	***4.57%***
18	Panama, West Coast	8	2.03%
22	Mexico, West Coast	5	1.27%
45	Ecuador	2	0.51%
48	El Salvador	2	0.51%
59	Costa Rica, W Coast	1	0.25%
	Eastern Central Atlantic	***17***	***4.31%***
23	Morocco, Atlantic	5	1.27%
25	Madeira Islands	4	1.02%
35	Canary Islands	4	1.02%
54	Ivory Coast	2	0.51%
73	Cameroon	1	0.25%
64	Azores	1	0.25%
	Southwest Atlantic	***4***	***1.02%***
33	Brazil	4	1.02%
	Northwest Atlantic	***4***	***1.02%***
26	Canada, Atlantic	4	1.02%
	Southeast Pacific	***3***	***0.76%***
39	Peru	3	0.76%
	Indian Ocean	***3***	***0.76%***
47	Egypt, Red Sea	2	0.51%
66	Saudi Arabia	1	0.25%
	Southeast Atlantic	***2***	***0.51%***
51	South Africa	2	0.51%
	Totals	***394***	***100.00%***

Source: "Shipping Study," Carlton et al.

APPENDIX A.2 - DISCUSSION OF FAO REGIONS PIE CHARTS

What do these charts represent?

These charts show the percentage of vessels arriving *in ballast*[1] at four (4) selected Gulf ports from each of the 14 *FAO Regions*[2] of the world. All of the incoming vessels in this data set come directly from *foreign ports of call*[3]. The last ports of call for the incoming ships are grouped by their respective FAO Regions to provide a better representation of the actual origins of the ballast water on board the incoming vessels. The four selected Gulf ports are Galveston, Houston, New Orleans, and Tampa.

These charts represent the same data set as the FAO Regions Map. The pie chart groupings help illustrate the relative dominance of three FAO Regions in the Gulf trade network. Vessels from the Western Central Atlantic, the Northeast Atlantic, and the Mediterranean and Black Sea account for 80-95% of the foreign in ballast traffic to each of the four selected ports.

How were these data obtained?

Information for these charts came from the 1995 National Biological Invasions Shipping Study (NABISS). The researchers identified the number of vessels in ballast from foreign ports through information published by the Bureau of Census in its Monthly Vessel Entrances (TM-385) and Clearances (TM-785). This particular data set came from the 1991 TM-385 forms for the above mentioned Gulf ports.

This data set included all types of ships in ballast. Seventy-seven percent of the ships fall under the classification of Bulk Carrier, Tanker, General Cargo, or Passenger. Twenty-one different ship types make up the remaining 23% of the traffic. The raw data follows the individual charts.

Notable Changes to the NABISS data

Due to some inconsistencies and apparent oversights found in the NABISS FAO groupings, these charts reflect three minor differences in the regional distributions.

1. For ships en route to New Orleans and Tampa, the NABISS study grouped ships with Brazilian last ports of call in Group L (Southeast Pacific). The charts group all Brazilian ships in Group M (Southwest Atlantic).
2. For ships en route to Houston, the NABISS grouped ships with last ports of call from Gibraltar in Group F (Eastern Central Atlantic). The charts group all ships from Gibraltar in Group C (Mediterranean and Black Sea).

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[1]*In Ballast*—used here to describe vessels that are traveling with no cargo and therefore (more or less) are fully ballasted.

[2]*FAO Region*—standardized ocean regions of the world as used by the United Nationsf Food and Agriculture Organization.

[3]*Foreign Ports of Call*—any port outside of the United States (including Hawaii and Alaska). For instance, the map shows that 0.1% of all foreign ships in ballast to New Orleans came from FAO Region E (the Northeast Pacific). These vessels were exclusively from Canadian Pacific ports. No vessels from Alaskan ports are included in this figure, as they would not qualify as foreign ports of call.

3. The NABISS formed two regions in addition to the fourteen FAO Regions. For the purpose of the study, Carlton et. al created separate regions for Australia and the Great Lakes. Due to the minimal amount of in ballast traffic from these regions to the Gulf, and for simplicity, these additional regions were not used in these charts. Ships from the Great Lakes were included in Group A (Northwest Atlantic) and ships from Australia were included in Group H (Indian Ocean).

Monthly Arrivals of Foreign Ships In Ballast (199
(from Census TM385/Vessel Entrances)

Month	Tampa		New Orleans		Houston		Galveston	
	Arrival	In Ballast	Arrival	In Ballast	Arrival	In Ballast	Arrival	In Ballast
Jan	156	41	337	100	343	55	42	12
Feb	123	40	342	116	356	72	57	9
Mar	138	35	352	140	351	62	48	17
Apr	118	34	288	85	360	50	101	49
May	136	35	314	89	374	53	83	32
Jun	110	30	288	81	366	56	49	31
Jul	110	29	355	137	361	54	43	12
Aug	106	25	333	112	354	58	71	44
Sep	112	28	277	73	342	58	74	42
Oct	113	29	333	107	349	59	73	32
Nov	128	37	314	90	321	51	40	5
Dec	126	33	366	132	349	68	53	8
Total	1476	396	3899	1262	4226	696	734	293

Source: "Shipping Study," Carlton et al.

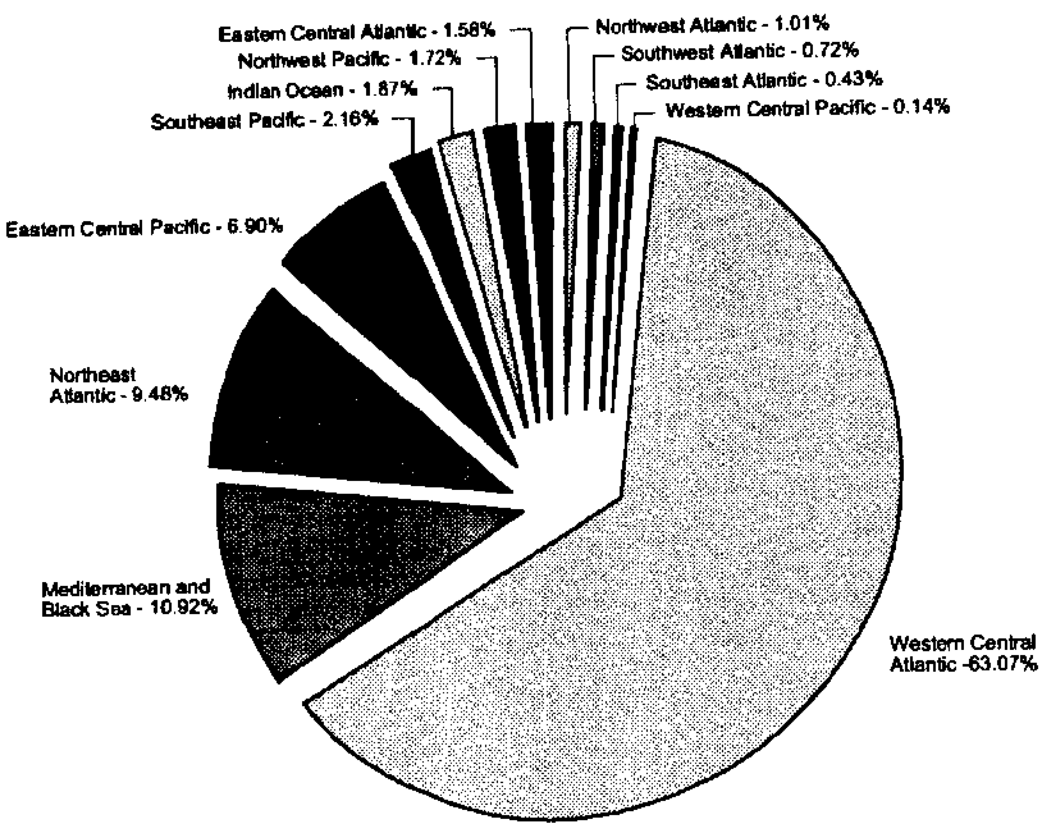
LPOC by FAO Region for Ships in Ballast from Foreign Ports, 1991
(from Census TM385/Vessel Entrances)

Port of Houston

FAO region	FREQ	% of total foreign ships in ballast
Western Central Atlantic	439	63.07%
Mediterranean and Black Sea	76	10.92%
Northeast Atlantic	66	9.48%
Eastern Central Pacific	48	6.90%
Southeast Pacific	15	2.16%
Indian Ocean	13	1.87%
Northwest Pacific	12	1.72%
Eastern Central Atlantic	11	1.58%
Northwest Atlantic	7	1.01%
Southwest Atlantic	5	0.72%
Southeast Atlantic	3	0.43%
Western Central Pacific	1	0.14%
Total	696	100.00%

Source: "Shipping Study," Carlton et al.

LPOC by FAO Region for Ships from Foreign Ports - Houston



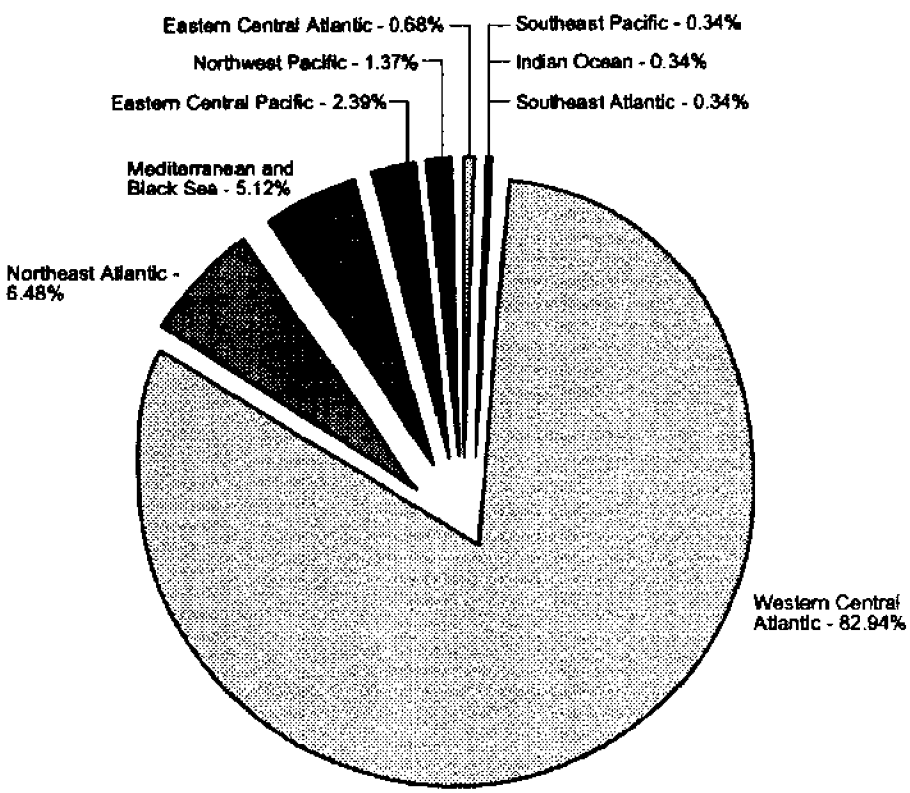
LPOC by FAO Region for Ships in Ballast from Foreign Ports, 1991
(from Census TM385/Vessel Entrances)

Port of Galveston

FAO region	FREQ	foreign ships in ballast
Western Central Atlantic	243	82.94%
Northeast Atlantic	19	6.48%
Mediterranean and Black Sea	15	5.12%
Eastern Central Pacific	7	2.39%
Northwest Pacific	4	1.37%
Eastern Central Atlantic	2	0.68%
Southeast Pacific	1	0.34%
Indian Ocean	1	0.34%
Southeast Atlantic	1	0.34%
Total	293	100.00%

Source: "Shipping Study," Carlton et al.

LPOC by FAO Region for Ships from Foreign Ports - Galveston



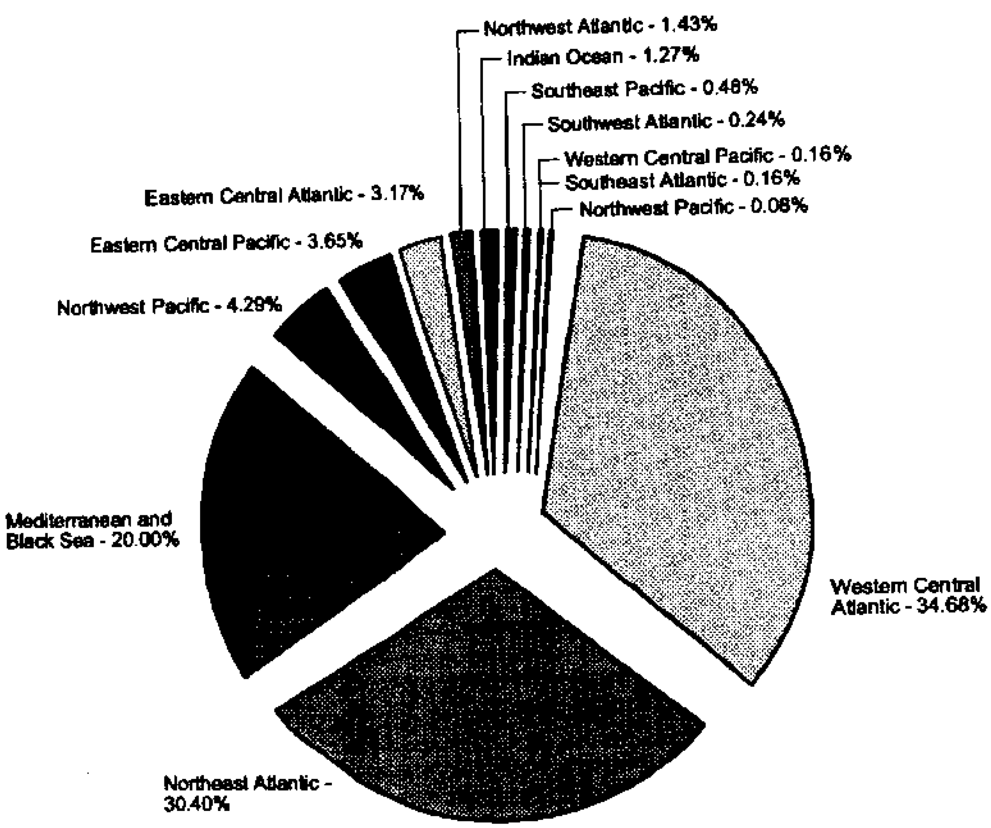
LPOC by FAO Region for Ships in Ballast from Foreign Ports, 1991
(from Census TM385/Vessel Entrances)

Port of New Orleans

FAO region	FREQ	foreign ships in ballast
Western Central Atlantic	437	34.68%
Northeast Atlantic	383	30.40%
Mediterranean and Black Sea	252	20.00%
Northwest Pacific	54	4.29%
Eastern Central Pacific	46	3.65%
Eastern Central Atlantic	40	3.17%
Northwest Atlantic	18	1.43%
Indian Ocean	16	1.27%
Southeast Pacific	6	0.48%
Southwest Atlantic	3	0.24%
Western Central Pacific	2	0.16%
Southeast Atlantic	2	0.16%
Northeast Pacific	1	0.08%
Total	1260	100.00%

Source: "Shipping Study," Carlton et al.

LPOC by FAO Region for Ships from Foreign Ports - New Orleans



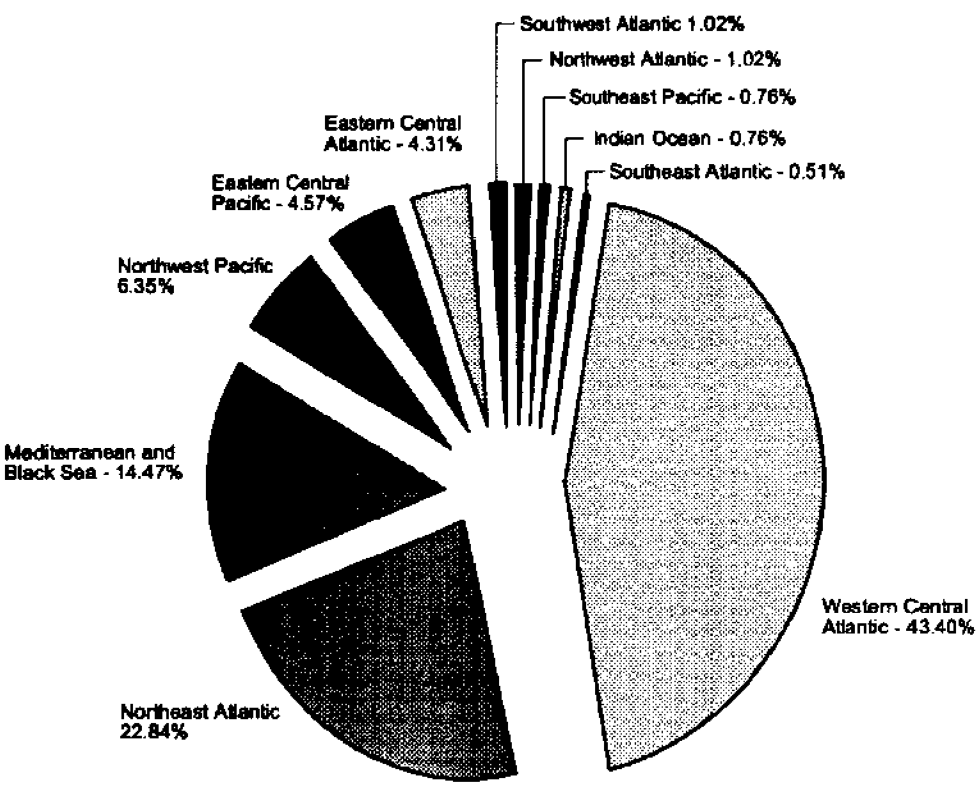
LPOC by FAO Region for Ships In Ballast from Foreign Ports, 1991
(from Census TM385/Vessel Entrances)

Port of Tampa

FAO region	FREQ	foreign ships in ballast
Western Central Atlantic	171	43.40%
Northeast Atlantic	90	22.84%
Mediterranean and Black Sea	57	14.47%
Northwest Pacific	25	6.35%
Eastern Central Pacific	18	4.57%
Eastern Central Atlantic	17	4.31%
Southwest Atlantic	4	1.02%
Northwest Atlantic	4	1.02%
Southeast Pacific	3	0.76%
Indian Ocean	3	0.76%
Southeast Atlantic	2	0.51%
Total	394	100.00%

Source: "Shipping Study," Carlton et al.

LPOC by FAO Region for Ships from Foreign Ports - Tampa



APPENDIX B - DISCUSSION OF FAO REGION MAP

What does this map represent?

This map shows the percentage of vessels arriving *in ballast*[1] to four (4) selected Gulf ports from each of the 14 *FAO Regions*[2] of the world. All of the incoming vessels in this data set come directly from *foreign ports of call*[3]. The last ports of call for the incoming ships are grouped by their respective FAO Regions to provide a better representation of the actual origins of the ballast water on board the incoming vessels. The four selected Gulf of Mexico ports are Galveston, Houston, New Orleans, and Tampa.

For example, the map shows that in FAO Region B (the Northeast Atlantic), Tampa (t)= 22.8%. This figure states that in 1991, 22.8% of all ships traveling in ballast to the Port of Tampa from a foreign last port of call came from the Northeast Atlantic.

How were these data obtained?

Information for this map came from the 1995 National Biological Invasions Shipping Study (NABISS). The researchers identified the number of vessels in ballast from foreign ports through information published by the Bureau of Census in its Monthly Vessels Entrances (TM-385) and Clearances (TM-785). This particular data set came from the 1991 TM-385 forms for the above mentioned Gulf ports.

This data set included all types of ships in ballast. Seventy-seven percent of the ships fall under the classification of Bulk Carrier, Tanker, General Cargo, or Passenger. Twenty-one different ship types make up the remaining 23% of the traffic.

What do these data tell us about the origin of the ballast water discharged in Gulf ports?

The NABISS research showed that last port of call (LPOC), listed by country, was a poor indicator of the actual source of ballast water on board. In the NABISS sample set, there was no ballast on board from the LPOC country for 53% of all vessels. For the specific category of container ships, this number reached 63%. While LPOC data was accurate for ships with very regular direct voyages (for example woodchip bulkers from Japan), it was generally a poor indicator of the ballast water's origin.

When the LPOC data was expanded to FAO Regions, the relationship improved. In the NABISS sample set, 66% of all vessels arriving in ballast had at least some or all of their ballast from the FAO Region of their LPOC. Here again, there was significant variance among the vessel groupings. Container ships had the highest percentage, with 84% of the ships having some or all of their ballast come from the FAO Region of their LPOC. Tankers had the lowest percentage with only 33% of the vessels having any water from the FAO Region of their LPOC.

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[1]*In Ballast*—used here to describe vessels that are traveling with no cargo and therefore (more or less) are fully ballasted.

[2]*FAO Region*—standardized ocean regions of the world as used by the United Nations' Food and Agriculture Organization.

[3]*Foreign Ports of Call*—any port outside of the United States (including Hawaii and Alaska). For instance, the map shows that 0.1% of all foreign ships in ballast to New Orleans came from FAO Region E (the Northeast Pacific). These vessels were exclusively from Canadian Pacific ports and Alaskan ports.

Notable Changes to the NABISS data

Due to some inconsistencies and apparent oversights found in the NABISS FAO groupings, this map reflects three minor differences in the regional distributions.

1. For ships en route to New Orleans and Tampa, the NABISS study grouped ships with Brazilian last ports of call in Group L (Southeast Pacific). This map groups all Brazilian ships in Group M (Southwest Atlantic).
2. For ships en route to Houston, the NABISS grouped ships with last ports of call from Gibraltar in Group F (Eastern Central Atlantic). The map groups all ships from Gibraltar in Group C (Mediterranean and Black Sea).
3. The NABISS formed two regions in addition to the fourteen FAO Regions. For the purpose of the study, Carlton et. al created separate regions for Australia and the Great Lakes. Due to the minimal amount of in ballast traffic from these regions to the Gulf, and for the purpose of simplicity, these additional regions were not included in this map. Ships from the Great Lakes were included in Group A (Northwest Atlantic) and ships from Australia were included in Group H (Indian Ocean).

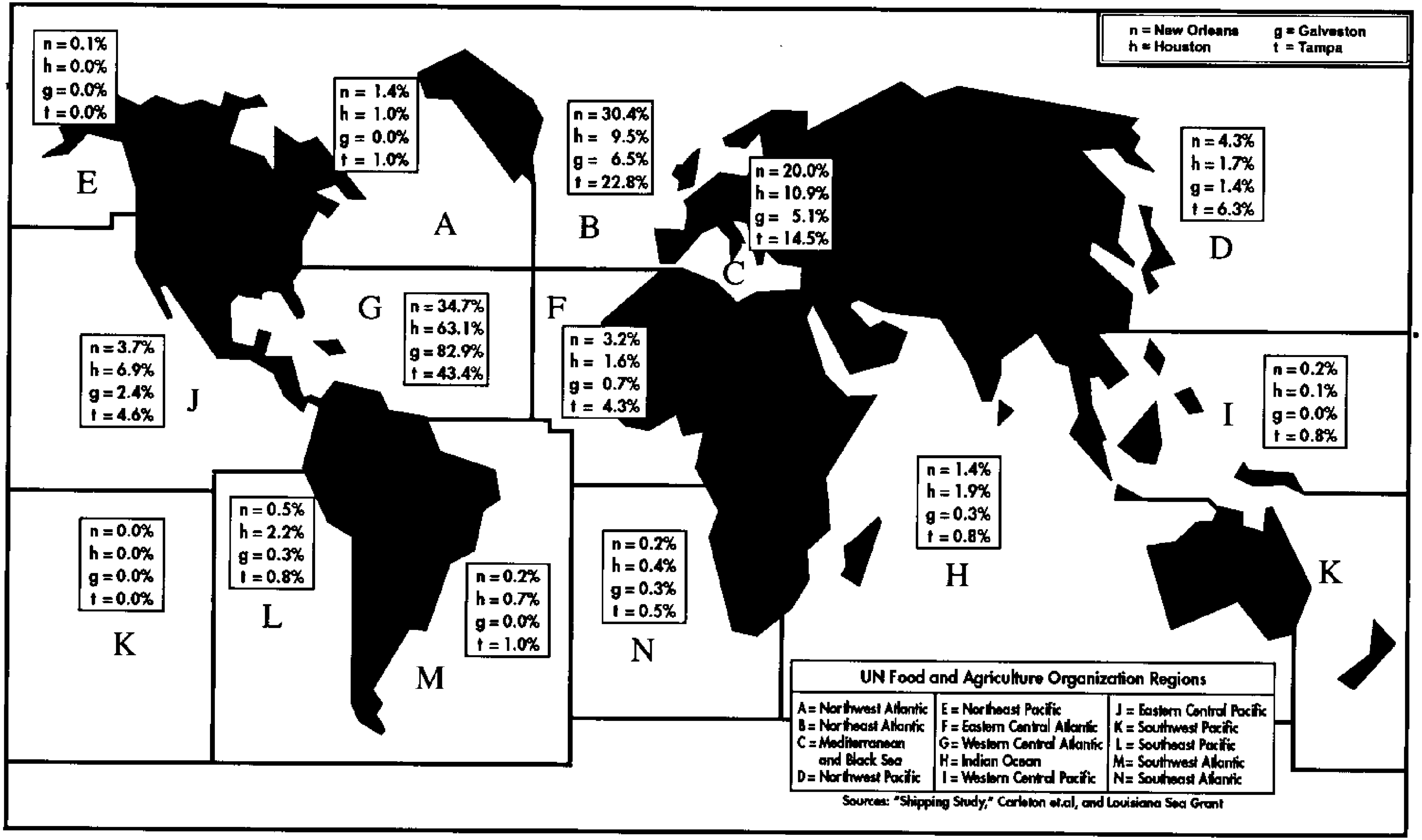


Figure C. Last Foreign Port of Call for Ships in Ballast Selected Gulf Ports, 1991 (FAO Region).

APPENDIX C.1 - DISCUSSION OF UNACKNOWLEDGED BALLAST GRAPHS

What do these graphs represent?

These graphs show the estimated tonnage of unacknowledged ballast water arriving at five selected ports from in ballast vessels. This data set includes both in ballast and in cargo traffic. The graphs are grouped by ship type. For the port of New Orleans, two relevant comparisons between acknowledged and unacknowledged ballast are made. The five selected ports are New Orleans, Tampa, Galveston, and Houston.

This information is useful because it illustrates that a great deal of life-transporting ballast remains on board vessels even when they are in cargo. The sediment and unpumpable ballast that remains on board is a virtual "biological island," transporting a wide array of nonindigenous species around the globe.

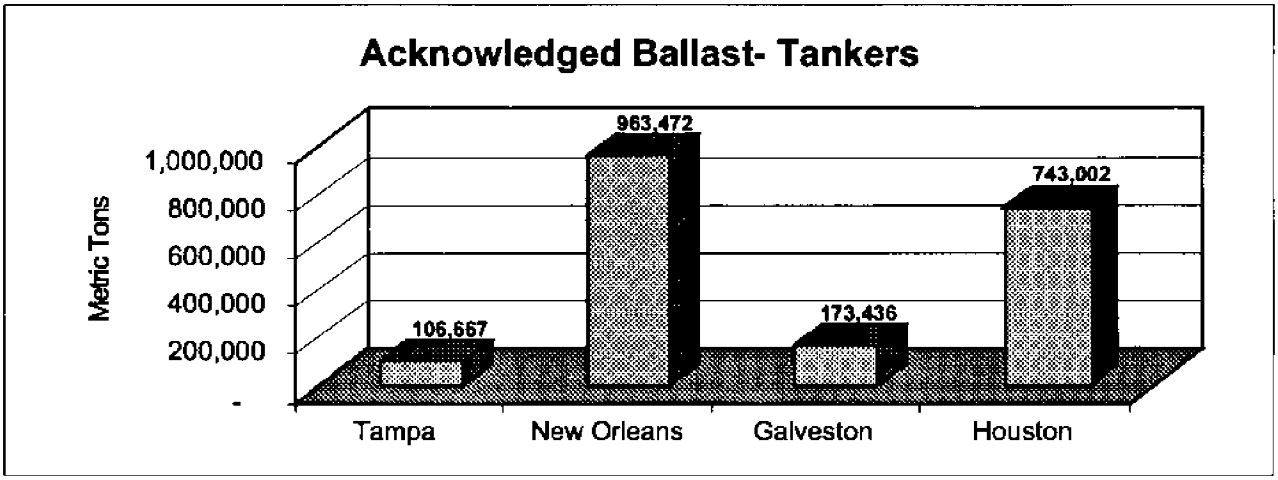
How were these data obtained?

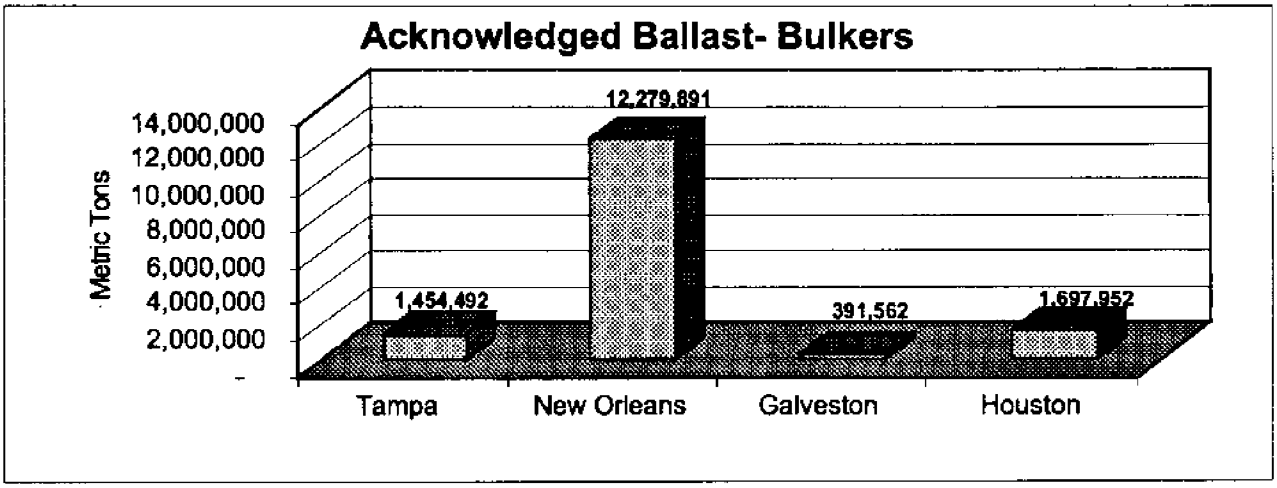
Information for these graphs came from the 1995 National Biological Invasions Shipping Study (NABISS). The researchers identified the number of vessels in ballast from foreign ports through information published by the Bureau of Census in its Monthly Vessel Entrances (TM-385) and Clearances (TM-785). This particular data set came from the 1991 TM-385 forms for the above mentioned Gulf ports.

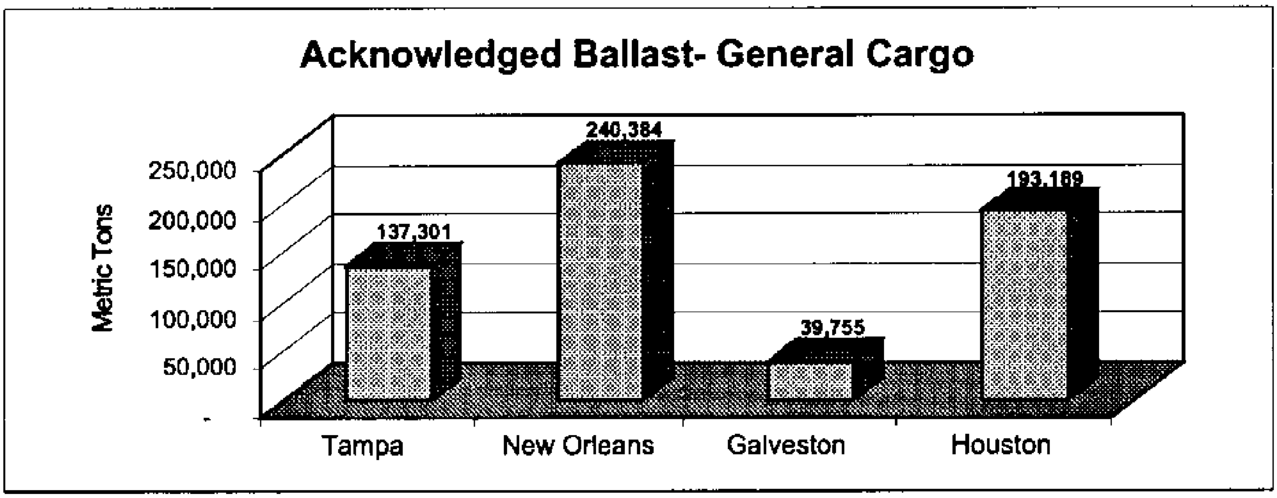
A sub-sample of the first 48 ships from every other month (beginning with January) was taken for each of these ports (n=288 for each port) from Vessel Entrances TM385 Census data (1991), and included vessel name, flag, net registered tonnage (NRT), last port of call and ballast/cargo condition. Vessel name, flag and NRT information was used to identify ship type in Lloyd's Register. Ballast/Cargo condition information indicated if the ship arrival was foreign or domestic and in ballast or in cargo.

For each of the ships in each of the ports, the proportion of ships that were from foreign ports and in cargo was determined. This percentage was then multiplied by the total number of vessels arriving from foreign ports in cargo. This was then multiplied by the average percentage that BWARR (Ballast water carried on arrival) represented of BWCAP (Ballast water capacity) when in cargo in order to estimate the average unacknowledged ballast entering a port. The average ballast tonnages used in theses calculations were derived from NABISS boarding data.

This data set **does not** include all types of ships in ballast. The data set considers only the three largest ship the classifications: Bulk Carrier, Tanker, and Container ships. These three ships were chosen since they represented a majority of the vessel traffic. The raw data for these graphs precedes the graphs.


Acknowledged Ballast- Tankers
Metric Tons
1,000,000
800,000
600,000
400,000
200,000
-
106,667
963,472
173,436
743,002
Tampa
New Orleans
Galveston
Houston


Acknowledged Ballast- Bulkers
Metric Tons
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
1,454,492
12,279,891
391,562
1,697,952
Tampa
New Orleans
Galveston
Houston


Acknowledged Ballast- General Cargo
Metric Tons
250,000
200,000
150,000
100,000
50,000
-
137,301
240,384
39,755
193,189
Tampa
New Orleans
Galveston
Houston

Acknowledged Ballast- Tankers
(from TM385 Census Data)

Port	Vessels In Ballast	Mean Ballast Capacity	Total Ballast Capacity	Estimated Ballast Arrival
Tampa	33	4,217	139,161	106,667
New Orleans	63	19,952	1,256,976	963,472
Galveston	34	6,655	226,270	173,436
Houston	128	7,573	969,344	743,002
TOTAL	258		2,591,751	1,986,577

Acknowledged Ballast- Bulkers
(from TM385 Census Data)

Port	Vessels In Ballast	Mean Ballast Capacity	Total Ballast Capacity	Estimated Ballast Arrival
Tampa	184	11,099	2,041,106	1,454,492
New Orleans	882	19,538	17,232,516	12,279,891
Galveston	49	11,253	549,484	391,562
Houston	160	13,694	2,382,756	1,697,952
TOTAL	1275		22,205,862	15,823,897

Acknowledged Ballast- General Cargo
(from TM385 Census Data)

Port	Vessels In Ballast	Mean Ballast Capacity	Total Ballast Capacity	Estimated Ballast Arrival
Tampa	99	1,955	193,545	137,301
New Orleans	168	2,017	338,856	240,384
Galveston	20	2,802	56,040	39,755
Houston	209	1,303	272,327	193,189
TOTAL	496		860,768	610,629

APPENDIX C.2 - DISCUSSION OF UNACKNOWLEDGED BALLAST GRAPHS

What do these graphs represent?

These graphs show the estimated tonnage of unacknowledged ballast water arriving at five selected ports from in ballast vessels. This data set includes both in ballast and in cargo traffic. The graphs are grouped by ship type. For the port of New Orleans, two relevant comparisons between acknowledged and unacknowledged ballast are made. The five selected ports are New Orleans, Tampa, Galveston, and Houston.

This information is useful because it illustrates that a great deal of life-transporting ballast remains on board vessels even when they are in cargo. The sediment and unpumpable ballast that remains on board is a virtual "biological island," transporting a wide array of nonindigenous species around the globe.

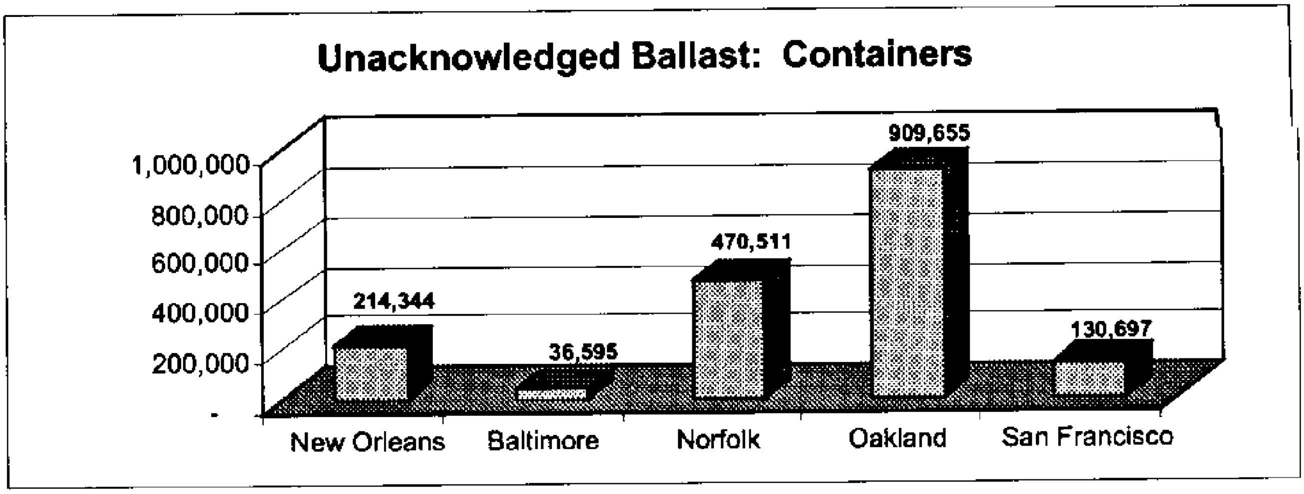
How were these data obtained?

Information for these graphs came from the 1995 National Biological Invasions Shipping Study (NABISS). The researchers identified the number of vessels in ballast from foreign ports through information published by the Bureau of Census in its Monthly Vessel Entrances (TM-385) and Clearances (TM-785). This particular data set came from the 1991 TM-385 forms for the above mentioned Gulf ports.

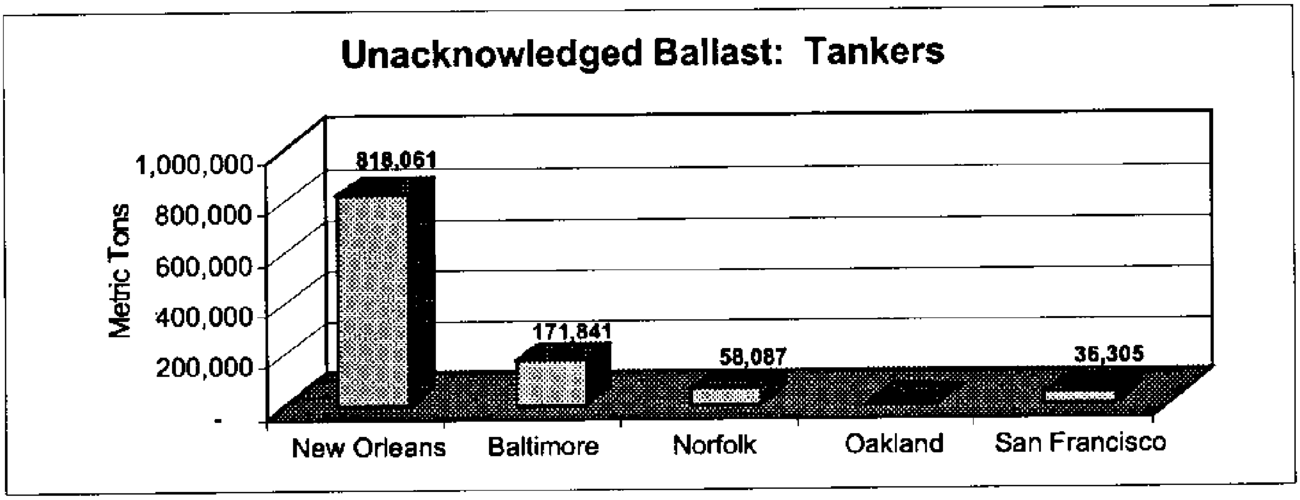
A sub-sample of the first 48 ships from every other month (beginning with January) was taken for each of these ports (n=288 for each port) from Vessel Entrances TM385 Census data (1991), and included vessel name, flag, net registered tonnage (NRT), last port of call and ballast/cargo condition. Vessel name, flag and NRT information was used to identify ship type in Lloyd's Register. Ballast/Cargo condition information indicated if the ship arrival was foreign or domestic and in ballast or in cargo.

For each of the ships in each of the ports, the proportion of ships that were from foreign ports and in cargo was determined. This percentage was then multiplied by the total number of vessels arriving from foreign ports in cargo. This was then multiplied by the average percentage that BWARR (Ballast water carried on arrival) represented of BWCAP (Ballast water capacity) when in cargo in order to estimate the average unacknowledged ballast entering a port. The average ballast tonnages used in theses calculations were derived from NABISS boarding data.

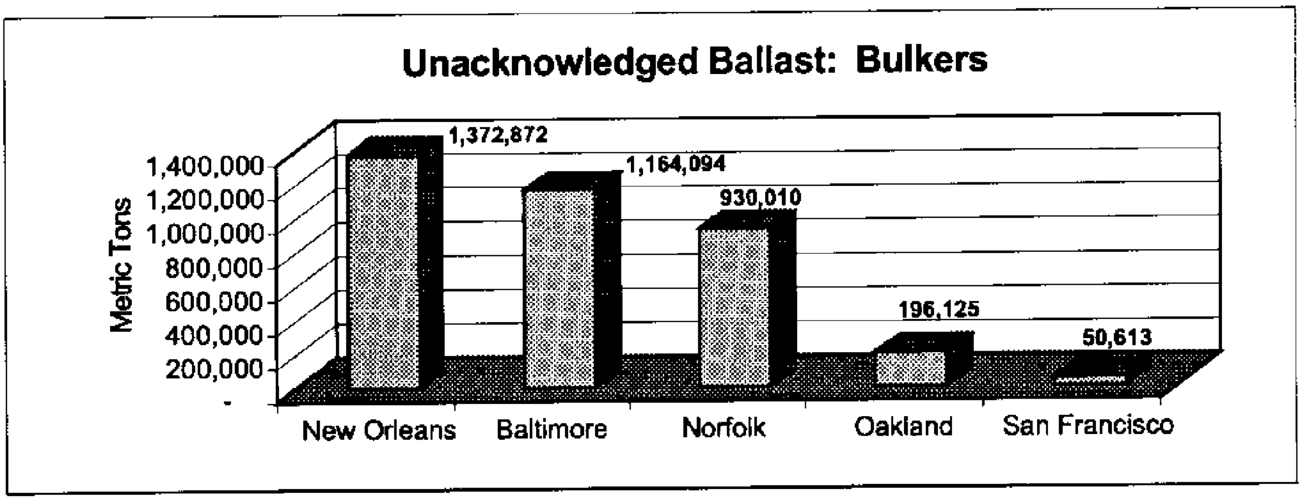
This data set does not include all types of ships in ballast. The data set considers only the three largest ship the classifications: Bulk Carrier, Tanker, and Container ships. These three ships were chosen since they represented a majority of the vessel traffic. The raw data for these graphs precedes the graphs.



Unacknowledged Ballast: Containers
1,000,000
800,000
600,000
400,000
200,000
-
214,344
36,595
470,511
909,655
130,697
New Orleans
Baltimore
Norfolk
Oakland
San Francisco

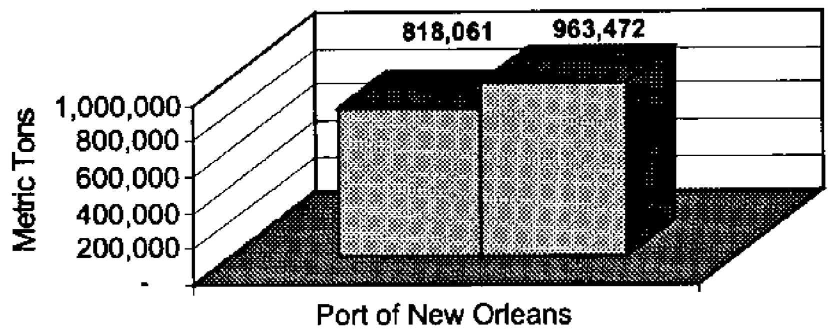


Unacknowledged Ballast: Tankers
Metric Tons
1,000,000
800,000
600,000
400,000
200,000
-
818,061
171,841
58,087
36,305
New Orleans
Baltimore
Norfolk
Oakland
San Francisco

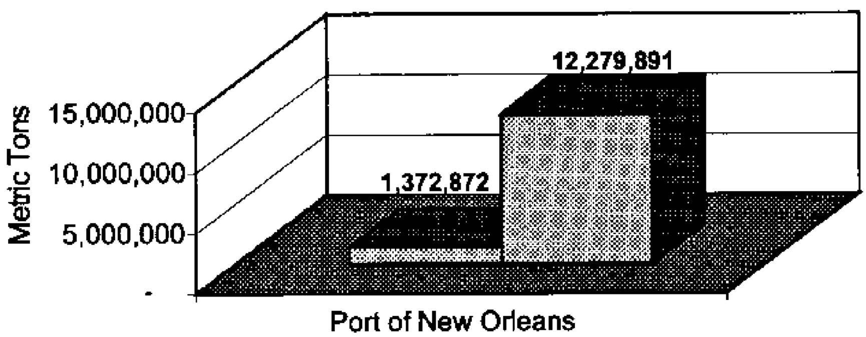


Unacknowledged Ballast: Bulkers
Metric Tons
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
1,372,872
1,164,094
930,010
196,125
50,613
New Orleans
Baltimore
Norfolk
Oakland
San Francisco

Unacknowledged vs. Acknowledged Ballast: Tankers



Unacknowledged vs. Acknowledged Ballast: Bulkers



Port of New Orleans

Source	% Foreign In Cargo	Estimated Arrival	Average Ballast	Average Unaknowledged Ballast
Bulkers	5.56	217	6,326.6	1,372,872
Containers	1.04	41	5,227.9	214,344
Tankers	8.68	338	2,420.3	818,061
	Total	596	Total	2,405,277

Port of Baltimore

Source	% Foreign In Cargo	Estimated Arrival	Average Ballast	Average Unaknowledged Ballast
Bulkers	9.03	184	6,326.6	1,164,094
Containers	0.35	7	5,227.9	36,595
Tankers	3.47	71	2,420.3	171,841
	Total	262	Total	1,372,530

Port of Norfolk

Source	% Foreign In Cargo	Estimated Arrival	Average Ballast	Average Unaknowledged Ballast
Bulkers	6.25	147	6,326.6	930,010
Containers	3.82	90	5,227.9	470,511
Tankers	1.04	24	2,420.3	58,087
	Total	261	Total	1,458,608

Port of Oakland

Source	% Foreign In Cargo	Estimated Arrival	Average Ballast	Average Unaknowledged Ballast
Bulkers	2.43	31	6,326.6	196,125
Containers	13.54	174	5,227.9	909,655
Tankers	0	0	2,420.3	-
	Total	205	Total	1,105,780

Port of San Francisco

Source	% Foreign In Cargo	Estimated Arrival	Average Ballast	Average Unaknowledged Ballast
Bulkers	1.04	8	6,326.6	50,613
Containers	3.47	25	5,227.9	130,697
Tankers	2.08	15	2,420.3	36,305
	Total	48	Total	217,615

APPENDIX D - WATER QUALITY DATA

These water quality data were provided by the individual ports. They are the basis for Table 5, page 13.

Water Quality Parameters for the Port of Galveston

Site #	Date yymmdd	Depth m	pH su	DO mg/L	WaterTemp. cent	Salinity ppth	Turbidity SECCHI meters
13372	940823	0.3	7.9	5.9	28.4	25.1	1.24
13372	940823	3.1	7.9	5.1	28.9	28.6	
13372	940920	0.6				20.5	
13372	940128	0.6				11.1	
13372	941101	0.6				6.4	
13372	941206	0.3	7.9	9.8	18.2	18.6	0.9
13372	941206	3.1	7.8	9.6	17.9	21.7	
13372	950105	0.6				23.1	
13372	950222	0.3	8.1	9.4	15.3	21.9	0.64
13372	950222	3.1	8.0	8.5	14.5	25.5	
13372	950317	0.6				11.6	
13372	950406	0.6				7.3	
13372	950504	0.6				24.3	
13372	950601	0.6				10.9	
13372	950710	0.6				21.0	
13372	950803	0.6				22.4	
13372	950915	0.6				21.0	
13372	951129	0.3	8.0	8.0	17.0	24.8	1.03
13372	951129	3.1	8.0	8.0	17.0	25.5	
13372	950523	0.3	8.0	6.2	27.8	24.9	0.88
13372	960523	3.1	8.0	6.1	27.8	24.9	
13372	960820	0.3	8.0	5.6	30.4	31.3	1.28
13372	950820	3.1	8.0	5.6	30.3	31.7	

Source: Texas Natural Resource Conservation Commission, Water Quality Division.

Water Quality Parameters for the Port of New Orleans

Site #	Date yymmdd	pH	Water Temp.	DO	Salinity	Turbidity ?	Turbidity SECCHI
306	970107	7.59	14.08	9.26	8.7	7.0	31
306	970218	7.63	11.90	10.16	5.5	2.5	56
306	970311	7.89	18.59	9.27	4.9	4.0	39
306	970415	8.09	15.82	9.09	0.2	51.0	9
306	970513	8.84	22.83	9.16	2.7	8.6	26
306	970610	7.72	26.90	5.61	4.8	8.8	33
306	970775	7.47	29.93	3.58	12.2	5.1	47
306	970812	7.33	30.01	2.93	10.8	4.0	47
306	970909	8.30	28.22	7.94	-	8.2	30
306	971014	7.70	24.29	7.28	4.4	18.0	23
306	971118	7.79	13.70	9.56	7.5	3.9	54
306	971209	7.65	13.68	12.02	3.4	6.9	39
320	970106	7.67	8.70	9.97	1.0	70.0	8
320	970217	7.65	6.02	10.91	1.0	82.5	7
320	970310	7.74	11.17	8.67	1.0	105.0	5
320	970414	7.89	15.43	7.95	1.0	35.0	10
320	970512	7.46	18.07	7.43	1.0	68.0	6
320	970609	7.99	22.83	6.73	1.0	56.0	7
320	970714	7.72	29.15	5.37	1.0	36.0	15
320	970811	8.20	30.67	6.41	1.0	9.5	33
320	970908	8.17	28.99	7.30	1.0	12.0	30
320	971014	8.02	24.63	7.48	1.0	12.0	20
320	971117	8.14	13.70	9.64	1.0	15.0	20
320	971208	8.22	11.11	10.53	1.0	15.0	30

Source: Louisiana Department of Environmental Quality.

Water Quality Parameters for the Port of Mobile

Date yymmdd	pH su	Water Temp C	DO mg/L	Salinity ppt	Turbidity NTU
970127	7.2	9.0	11.3	0.3	33.0
970205	7.1	11.0	8.8	0.4	68.0
970310	7.4	18.0	7.1	0.1	59.0
970402	7.3	20.0	7.7	2.4	13.5
970529	6.9	25.0	6.4	0.8	39.0
970626	6.8	26.0	5.4	0.2	38.0
970805	6.9	29.0	5.5	2.9	18.0
970930	7.4	29.0	4.4	6.1	13.4
971120	7.9	16.0	8.3	4.1	11.1
971209	6.6	14.0	8.7	0.8	17.0
980128	7.1	9.5	8.8	0.1	49.0

Source: Alabama Department of Environmental Management.

Site #	DATE yymmdd	DEPTH ft	TURB NTU	PH middle units	TEMP.WAT middle °C	DO middle mg/l	SAL middle ppt	P.TOTAL mg/l	N.TOTAL mg/l
2	970114	3.5	2	7.7	19.2	5.8	27.6	0.11	0.71
2	970211	3.5	2	7.9	19.5	5.8	27.1	0.09	0.55
2	970311	4.0	3	7.6	23.9	6.1	26.8	0.23	0.95
2	970408	4.5	7	7.8	23.9	6.0	28.3	0.22	0.62
2	970513	4.8	3	7.8	26.1	5.7	27.0	0.27	0.75
2	970610	4.3	3	7.6	27.8	3.9	27.8	0.18	0.80
2	970715	6.0	4	7.8	31.3	3.5	26.9	0.28	0.71
2	970812	4.8	5	7.6	31.0	1.3	24.3	0.31	0.74
2	970909	5.8	3	7.8	29.9	3.8	26.5	0.26	0.78
2	971007	6.0	2	7.3	29.1	1.1	22.6	0.30	1.08
2	971112	4.5	5	7.7	22.2	4.5	20.3	0.27	0.77
2	971203	3.0	1	7.3	20.0	5.6	12.6	0.29	1.15
8	970114	3.0	3	8.0	17.7	7.3	28.6	0.26	0.62
8	970211	1.5	5	8.3	18.6	8.6	28.6	0.16	0.51
8	970311	2.3	5	8.0	26.2	7.7	26.9	0.37	0.63
8	970408	2.0	7	7.9	24.3	6.7	27.6	0.43	0.70
8	970513	2.3	4	7.9	26.4	7.0	26.6	0.35	0.76
8	970610	2.0	8	7.8	27.3	5.3	28.4	0.30	0.65
8	970715	2.5	4	8.1	30.1	4.3	26.8	0.39	0.74
8	970812	1.8	5	7.7	30.4	3.0	16.0	1.01	1.22
8	970909	2.0	5	8.3	29.1	8.6	24.3	0.38	0.85
8	971007	1.3	4	7.8	27.1	4.7	16.0	0.68	1.35
8	971112	3.0	5	8.1	21.8	7.6	20.5	0.36	0.81
8	971203	1.5	3	7.8	20.4	6.5	21.7	0.37	0.81
23	970128	14.5	1	8.0	17.0	7.6	32.4	0.05	
23	970225	14.5	1	8.0	20.4	7.0	33.2	0.01	
23	970325	15.0	3	8.1	23.4	6.9	33.4	0.14	
23	970422	15.0	1	8.0	21.9	6.8	33.8	0.12	
23	970527	15.0	1	8.0	28.4	6.2	32.3	0.02	
23	970624	15.5	1	8.0	29.9	6.0	33.9	0.11	
23	970729	14.5	1	8.1	30.7	5.2	32.3	0.16	
23	970826	14.0	1	8.1	30.4	5.3	31.6	0.15	
23	970923	14.0	3	8.0	29.2	5.4	30.8	0.18	
23	971021	14.0	1	8.0	23.9	6.3	26.9	0.25	
23	971124	13.5	1	8.0	20.1	7.3	26.5	0.21	
23	971216	13.8	3	7.9	16.8	7.8	22.9	0.37	
36	970107	8.0	2	8.0	20.7	7.0	28.7	0.07	
36	970204	8.0	5	8.1	18.8	7.3	29.2	0.10	
36	970304	8.0	2	8.0	24.6	6.2	28.9	0.18	
36	970401	10.0	3	8.1	23.3	7.4	29.1	0.22	
36	970506	8.5	4	8.0	24.7	6.7	28.8	0.17	
36	970603	10.0	2	7.9	27.4	5.8	28.9	0.17	
36	970708	11.5	3	8.2	30.7	7.7	29.0	0.17	
36	970805	8.5	3	8.1	29.5	5.9	27.6	0.19	
36	970902	12.0	3	8.1	29.6	5.7	27.0	0.28	
36	971001	8.5	8	8.1	28.5	6.3	23.8	0.26	
36	971104	6.3	3	8.0	22.7	8.4	22.5	0.29	
36	971202	8.0	4	7.9	19.7	7.7	22.6	0.21	

Site #	DATE yymmdd	DEPTH ft	TURB NTU	PH middle units	TEMP.WAT middle °C	DO middle mg/l	SAL middle ppt	P.TOTAL mg/l	N.TOTAL mg/l
51	970107	5.8	1	8.0	20.8	6.9	27.5	0.03	
51	970204	8.0	4	8.1	18.2	7.1	28.3	0.15	
51	970304	8.0	2	8.0	24.3	6.2	28.6	0.16	
51	970401	7.5	4	7.9	23.2	6.3	29.0	0.21	
51	970506	8.5	4	7.9	24.8	5.8	27.4	0.18	
51	970603	9.0	2	7.9	27.3	5.9	28.4	0.15	
51	970708	10.6	2	8.1	30.0	6.1	28.4	0.16	
51	970805	8.5	4	8.1	29.3	5.5	27.1	0.19	
51	970902	7.5	2	8.0	29.2	4.8	26.6	0.26	
51	971001	9.3	3	8.0	28.0	6.5	22.4	0.23	
51	971104	8.5	5	7.8	22.3	6.6	22.7	0.27	
51	971202	6.0	3	7.8	18.9	6.7	22.0	0.20	
52	970114	6.5	2	8.0	18.1	7.6	28.5	0.14	0.46
52	970211	8.0	4	8.2	20.6	7.3	28.6	0.18	0.52
52	970311	7.3	5	8.1	25.5	7.8	28.3	0.24	0.75
52	970408	6.5	6	8.1	24.2	8.6	28.7	0.24	0.59
52	970513	7.3	4	7.9	26.6	5.9	27.5	0.26	0.70
52	970610	13.0	8	7.8	27.3	5.5	28.5	0.24	0.61
52	970715	7.0	2	8.1	31.2	4.9	27.5	0.29	0.67
52	970812	6.8	4	7.9	32.3	4.3	25.8	0.31	0.76
52	970909	7.0	4	8.0	29.1	4.7	27.1	0.30	0.74
52	971007	6.5	2	8.1	28.1	6.6	22.6	0.36	1.10
52	971112	8.0	5	8.1	22.2	7.6	21.1	0.39	0.73
52	971203	7.0	3	7.8	20.3	7.0	23.1	0.29	0.72
55	970114	7.5	3	8.0	17.2	7.6	28.1	0.12	
55	970211	8.0	5	8.2	19.2	7.2	28.4	0.22	
55	970311	8.8	8	8.0	23.9	6.4	28.4	0.32	
55	970408	8.0	9	8.0	23.8	7.5	29.1	0.25	
55	970513	8.8	4	7.9	25.8	6.4	27.3	0.25	
55	970610	8.5	8	7.8	27.1	5.6	28.3	0.32	
55	970715	8.8	2	8.2	29.5	7.1	26.9	0.32	
55	970812	8.0	3	8.0	30.5	3.6	25.9	0.34	
55	970909	8.5	7	8.0	28.0	4.9	26.4	0.36	
55	971007	7.8	2	7.9	27.2	5.6	21.5	0.38	
55	971112	9.0	4	8.1	21.2	7.0	21.1	0.30	
55	971203	7.5	4	7.7	19.6	6.4	22.8	0.31	
68	970107	8.3	2	8.0	20.6	6.7	28.6	0.07	
68	970204	8.5	3	8.1	18.7	7.5	29.2	0.17	
68	970304	9.0	2	8.0	24.6	6.6	29.0	0.14	
68	970401	6.5	3	8.0	23.4	6.8	29.3	0.20	
68	970506	10.0	5	8.0	25.0	6.5	28.9	0.19	
68	970603	8.5	3	7.9	27.6	5.9	29.0	0.20	
68	970708	6.8	4	8.2	30.6	7.1	28.5	0.23	
68	970805	10.0	4	8.1	29.6	5.8	27.6	0.23	
68	970902	6.0	3	8.1	29.7	5.7	26.9	0.29	
68	971001	9.8	11	8.0	28.7	6.5	24.5	0.30	
68	971104	10.0	4	8.0	22.1	7.3	21.6	0.24	
68	971202	6.0	5	7.9	19.1	7.1	21.7	0.20	

Site #	DATE yymmdd	DEPTH ft	TURB NTU	PH middle units	TEMP.WAT middle °C	DO middle mg/l	SAL middle ppt	P.TOTAL mg/l	N.TOTAL mg/l
80	970114	3.8	4	8.0	17.6	7.7	28.7	0.13	
80	970211	3.8	4	8.2	19.5	7.4	28.8	0.23	
80	970311	4.8	7	8.0	24.0	6.5	29.1	0.28	
80	970408	4.5	7	8.1	23.4	7.2	29.6	0.27	
80	970513	5.0	3	7.9	25.8	6.5	28.0	0.20	
80	970610	5.5	5	7.9	27.5	6.1	29.3	0.24	
80	970715	4.5	4	8.1	30.4	5.8	28.5	0.31	
80	970812	4.0	2	8.2	31.4	6.7	25.1	0.35	
80	970909	4.5	3	8.1	28.1	7.0	27.1	0.32	
80	971007	4.5	2	8.0	27.0	5.7	22.5	0.36	
80	971112	5.5	3	8.0	21.6	6.9	22.6	0.38	
80	971203	5.5	2	7.8	19.6	6.8	23.5	0.28	
82	970128	6.0	2	8.0	17.7	7.6	29.8	0.21	
82	970225	6.0	3	8.0	21.1	7.2	29.9	0.09	
82	970325	6.5	10	8.1	23.9	7.2	30.2	0.22	
82	970422	6.5	1	8.1	22.7	7.3	32.2	0.11	
82	970527	6.3	1	8.0	28.5	6.5	29.4	0.02	
82	970624	6.5	2	8.0	30.4	6.7	31.1	0.16	
82	970729	6.0	2	8.1	30.5	6.3	28.7	0.23	
82	970826	5.5	3	8.2	30.4	6.3	27.3	0.22	
82	970923	6.0	5	8.0	29.9	6.0	28.1	0.22	
82	971021	5.5	2	8.0	24.6	6.7	24.4	0.26	
82	971124	5.5	2	8.0	19.6	7.6	23.0	0.25	
82	971216	5.5	3	7.8	17.0	7.8	22.0	0.40	

Source: Environmental Protection Commission of HillsboroughCounty, Water Management Division.