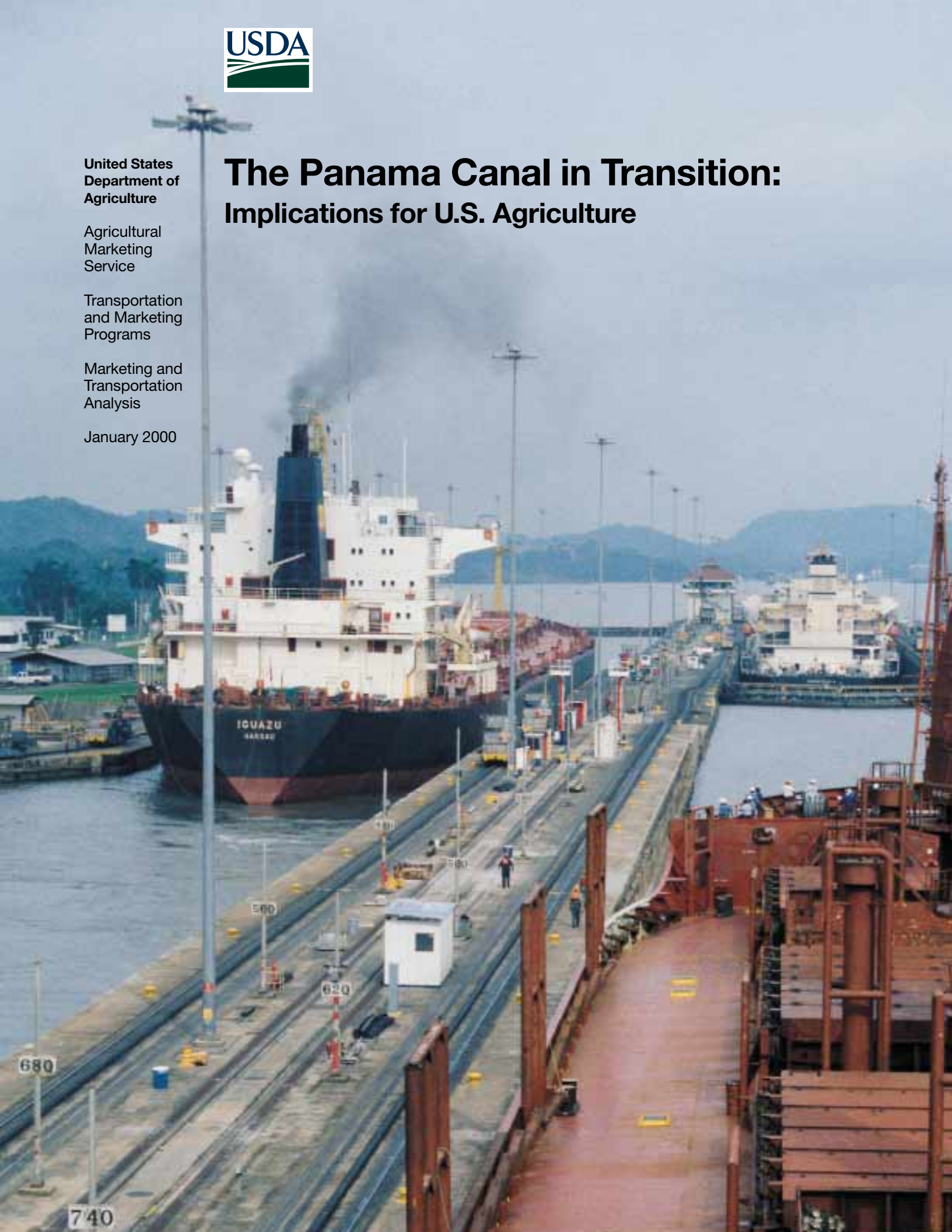

The Panama Canal in Transition:
Implications for U.S. Agriculture

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The Panama Canal in Transition:
Implications for U.S. Agriculture

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Abstract

As part of the Panama Canal Treaties of 1977, the United States turned over to the Government of the Republic of Panama on Dec. 31, 1999, its control of the Panama Canal, which it financed, built, and maintained. U.S. agricultural shipments are cargoes important to the canal. In 1998, they made up more than one-fifth of the canal cargo volume, more than two-thirds of all agricultural shipments, and more than half of the U.S. cargo volume transported through the canal. The canal is also important to U.S. producers of corn and soybeans in that it gives them an efficient and effective transport route to foreign markets. Without the canal, it is estimated that U.S. exports of corn and soybeans could be 2 percent lower, which would lower producer revenues by $303.6 million. This report addresses how the Panama Canal transition to Panamanian control will affect U.S. agriculture.

Key words: Grain transportation and Panama Canal

Acknowledgments

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Summary

Analysis of the shipment of U.S. agricultural commodities and products through the Panama Canal provides vital information on how the canal affects U.S. agriculture. It also provides a framework to assess potential policy changes resulting from the Panama Canal Treaties of 1977, which transferred control of the Panama Canal from the United States to the Republic of Panama on Dec. 31, 1999. This analysis covers the years 1989-98, provides information on the canal's history and future from discussions with its users and operators, and includes a discussion on recent research that quantifies the value of the canal for U.S. agriculture.

A new canal organization superseded the Panama Canal Commission (PCC), the U.S. agency that operated the canal when the treaties were enacted in 1979, 2 years after the treaties were signed. As a U.S. government agency, the PCC operated the canal on a nonprofit, break-even basis. Revenues were generated by ship transits, and the PCC used them to operate, maintain, and invest in the canal. The new organization, the Panama Canal Authority (PCA), will be an autonomous agency of the Government of the Republic of Panama and will operate as a for-profit organization and institute its own management structure.

Ships transit the canal to move between the Atlantic and Pacific Oceans. The volume of ship traffic at the Panama Canal is determined largely by world economic conditions and global trade routes between countries and trading regions. Traffic on the global trade routes during the mid-1990's, for instance, expanded considerably, causing oceangoing transits through the canal also to increase. Between 1989 and 1998, oceangoing ship transits increased 8 percent to 12,924 transits. The volume of cargo transported through the canal by those ships increased 27 percent during the same time period to 195.2 million metric tons (mmt). The average volume of cargo carried by a ship increased about 2,200 metric tons (mt) to 14,863 mt. Revenues generated by those ship transits increased 65 percent from $327.9 million in 1989 to more than $543.0 million in 1998. Both the number of ship transits and cargo carried through the canal are expected to increase with expansion in world trade through the first decade of the new millennium (2001-2010).

U.S. agricultural shipments are important cargoes transported through the canal. In 1998, they made up 21 percent of the canal cargo volume, 69 percent of all agricultural shipments, and 52 percent of the total U.S. waterborne export volume transported through the canal. Shipments of U.S. grains make up most of the U.S. agricultural volume going through the canal. In 1998, grain shipments totaled 34.6 mmt. By 2008, exports of corn, soybeans, and wheat transported through the canal could total 40 mmt—a 16-percent increase from 1998. These shipments are important revenue-generating cargoes for the canal. One metric ton of corn or soybeans transported through the canal generates $1.50 in revenue for the canal, while the same metric ton of grain generates less than $1 per mt in revenue for U.S. producers of corn and soybeans. If changes in canal management result in increased tolls or closure of the canal, U.S. grain exports would decrease no more than 2 percent while canal revenues most likely would decrease more significantly. If vessels bypass the Panama Canal and sail around the Cape of Good Hope, vessel operators lose 5 percent on the vessels' average daily revenue. To compensate for the lost daily

revenue, the ocean freight rate to transport grain would likely increase.

The shipping community will need to watch closely how the new organization, the PCA, manages and operates the canal. Many in the industry have indicated that the most important issues in canal management and operation are safety, maintenance, tolls, canal services, and capacity. Highly trained and highly skilled Panamanians operate the canal. The shipping industry, though, has raised concerns that the PCA might cut critical services and training after 2 or 3 years of operating the canal in an effort to be profitable. Many in the industry suggest that for now they will monitor the canal operations and evaluate how the new organization affects its business.

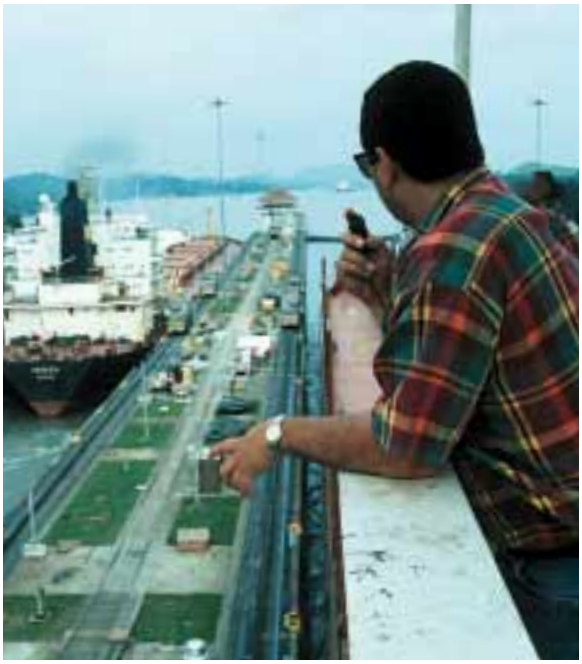
Since opening in 1914, the canal has provided the world trade and the maritime industry with 800,000 vessel transits. The efficiency of the canal relies on oceangoing ships carrying the world's cargo through the canal. The canal's most important cargo, though, is U.S. grain. Changes in canal policy affect U.S. grain shipments through the canal and, as a result, affect the canal's revenues and profitability. Any changes or adjustments in canal policy will have to be evaluated for their effects on U.S. agricultural shipments, which make up the largest traffic volume and toll revenues transiting the canal.

Introduction

The Panama Canal Treaties of 1977, signed by the governments of the Republic of Panama and the United States, were fulfilled at noon on Dec. 31, 1999.[1] At that time, the United States turned over to Panama the control of the canal that it financed, built, and maintained as well as its military assets—installations, facilities, and land. (See the sidebar on the U.S. military pullout from Panama.) In return, the Republic of Panama took the helm of a highly efficient and very lucrative transportation arterial. The 21st century begins a new era for Panama. The world will be watching, especially how Panama manages and operates the canal.

A new canal organization supersedes the Panama Canal Commission (PCC), the U.S. agency operating the canal since the treaties were enacted in 1979. As a U.S. Government agency, the PCC operated the canal on a nonprofit, break-even basis. The PCC used revenues it generated to operate, maintain, and invest in the canal. The new organization, the Panama Canal Authority (PCA), is an autonomous agency of the Government of the Republic of Panama. It will operate as a for-profit organization and will institute its own management structure, without influence from the Panamanian Government. The President of Panama will appoint 10 members to the board of directors, with the Panamanian National Assembly approving nine of those members and appointing the tenth member. Terms of each member will be staggered to ensure political independence.

[1] The Panama Canal Treaty and the Treaty of the Permanent Neutrality and Operation of the Panama Canal.



Pilot overseeing M.V. Aspilos transit through Panama Canal locks

The canal, approximately 80.5 kilometers long (equivalent to approximately 50 miles), shortens the transit time for vessels carrying cargo and military armaments between the Atlantic and Pacific Oceans. Since it opened in 1914, close to 800,000 vessels carrying 6.4 billion metric tons (mt) of the world's waterborne commerce have transited the Isthmus of Panama, traveling between the Atlantic and Pacific Oceans (figure 1). Ships transiting the canal are lifted 26 meters from sea level through three lock chambers to Gatun Lake and then lowered back to sea level through three more lock chambers (appendix). In 1998, cargo transported through the canal totaled 195.2 million metric tons (mmt), an increase of 27 percent from 154.1 mmt in 1989 (table 1).

Figure 1–North and South America and trade routes through Panama

The volume of traffic at the Panama Canal is a function of economic conditions around the world and traffic on the global trade routes between countries and trading regions. Traffic on the global trade routes during the mid-1990's, for instance, expanded considerably, causing ocean-going transits through the canal to increase. As an example, by comparing 1989-91 and 1995-97, ship transits increased 10 percent, averaging 1,200 more transits by 1995-97 than during 1989-91. In 1997 and 1998, an economic recession affected Asian countries and other major users of the canal, causing ship transits to drop 4 percent from a peak of 13,539 in 1996 to fewer than 13,000 in 1998 (table 1).

Ships using the Panama Canal have increased in size. The PCC measured each ship to assess a toll for the ship's canal transit. The measurement, the Panama Canal Universal Measurement System (PC/UMS), is a volumetric measure of a ship's cargo-carrying capacity. The larger the ship, the larger the PC/UMS, and conversely, the smaller the ship, the smaller the PC/UMS. The average PC/UMS per transit in 1989 was 15,495, which increased 11 percent to 17,149 in 1998 (table 1). Ships also are transporting more cargo through the canal. The average oceangoing ship carried 12,648 mt through the canal in 1989. In 1998, the average volume transported on ships transiting through the canal was 14,863 mt, up 18 percent from 1989 (table 1).

U.S. agricultural shipments are cargoes important to the canal. In 1998, they made up 21 percent of the canal cargo volume, 69 percent of all agricultural shipments through the canal, and 52 percent of the total U.S. export volume transported through the canal (figure 2). Shipments of U.S. grains make up most of the U.S. agricultural volume going through the canal. Between 1995 and 1998, U.S. grain exports transported through the canal averaged 33.4 mmt per year. In 1998, three grains accounted for more than 95 percent of the U.S. grain transported through the canal, corn (two-thirds), soybeans (one-quarter) and wheat (8 percent).

The canal has served global shipping well for the past 85 years. Its effectiveness as an efficient shortcut between the Atlantic and Pacific Oceans, for instance, has given U.S. grain exports

Table 1–Panama Canal traffic, transits, tolls, cargo, and Panama Canal Universal Measurement System (PC/UMS) tonnage, fiscal years 1989-98

Year	Transits	Tolls ($1,000)	Cargo (million metric tons)	PC/UMS[1] net tonnage (million)	Average toll ($)	Average cargo	Average PC/UMS	Transits per day
1989[2]	11,989	327,851	154.1	185.8	27,346	12,648	15,495	33
1990	11,941	353,726	159.6	181.6	29,623	13,154	15,208	33
1991	12,572	372,280	165.3	191.8	29,612	12,941	15,255	34
1992[3]	12,454	365,716	161.8	188.5	29,365	12,789	15,137	34
1993	12,086	398,232	160.2	186.4	32,950	13,048	15,423	33
1994	12,337	416,803	173.3	194.3	33,785	13,823	15,749	34
1995	13,459	460,045	193.4	215.4	34,181	14,139	16,001	37
1996	13,539	483,115	201.2	226.9	35,683	14,629	16,758	37
1997[4]	13,043	491,635	192.8	216.9	37,693	14,550	16,628	36
1998[5]	12,924	543,036	195.2	221.6	42,018	14,863	17,149	35

[1] Panama Canal Universal Measurement System — a volumetric measure of a vessel's cargo-carrying capacity used for assessing each vessel transit toll

[2] Toll per PC/UMS: Laden = $2.01; Ballast = $1.60; and Displacement = $1.12

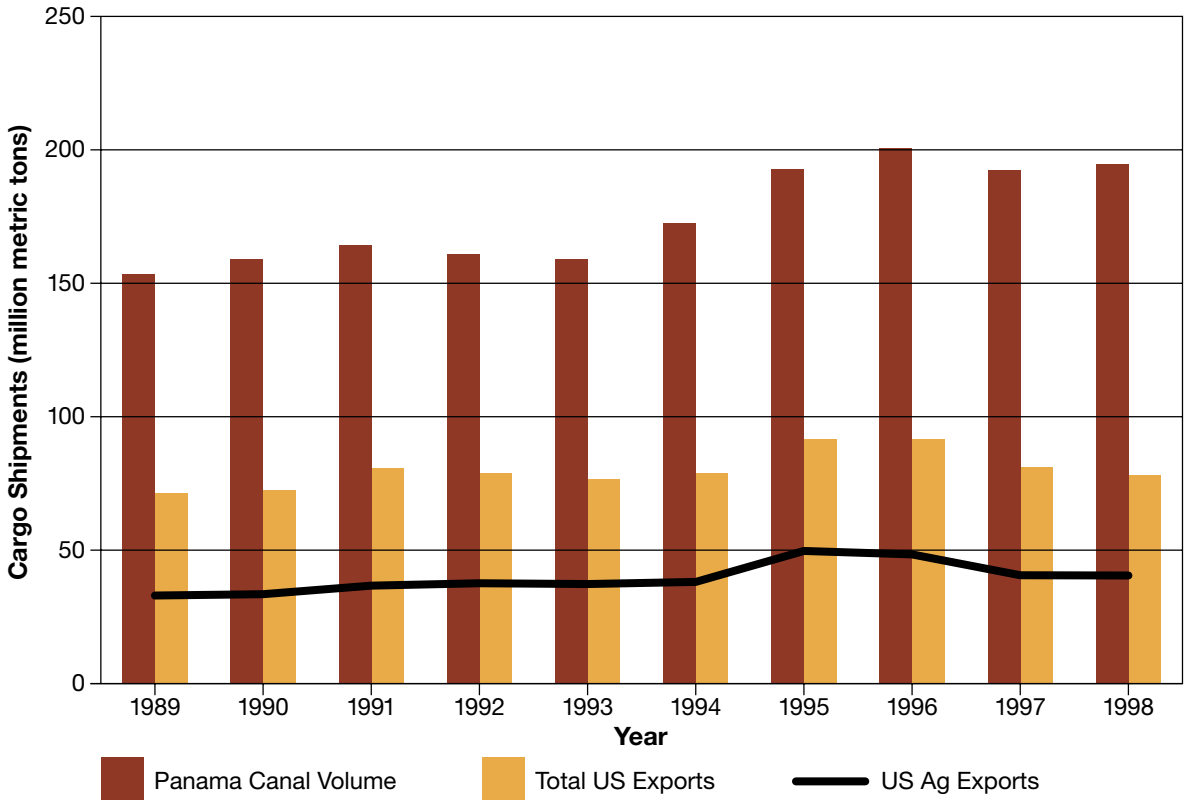
[3] New toll per PC/UMS: Laden = $2.21; Ballast = $1.76; and Displacement = $1.23

[4] New toll per PC/UMS: Laden = $2.39; Ballast = $1.90; and Displacement = $1.33

[5] New toll per PC/UMS: Laden = $2.57; Ballast = $2.04; and Displacement = $1.43

SOURCE: Panama Canal Commission, Annual Reports

Figure 2–Total U.S. exports, U.S. agricultural exports, and cargo volume transiting the Panama Canal, 1989-98 (million metric tons)



SOURCE: Panama Canal Commission

U.S. Military Pullout from Panama

As part of the canal treaties, the U.S. military no longer will maintain installations or a troop force in Panama after Dec. 31, 1999. The military's presence in the Panama area dates back to before the United States constructed the canal, when it protected U.S. merchant trade lanes. Even during construction, the military supplied engineers, labor, and security (McCullough). The U.S. military's Southern Command, headquartered in Panama, oversaw components of the Air Force, Army, Marine Corps, and Navy stationed there. Its mission was to assist Panama in defending the canal, command U.S. joint operations, promote democracy and cooperation throughout the Western Hemisphere, and support the U.S. drug control strategy. The Air Force, Army, Marine Corps, and Navy components occupied 5,420 buildings in an area of 36,000 hectares with functional utilities and infrastructure (roads, airstrips, and port areas). The permanently assigned military strength of the Southern Command in Panama numbered 8,500. In October 1997, the Southern Command headquarters relocated to Miami, FL, as part of the military pullout from Panama (U.S. Department of Defense). By the end of 1999, all remaining military installations, facilities, and land reverted to the Republic of Panama.

from the U.S. Gulf a competitive advantage in Asia. But that competitive advantage could be affected if that shortcut becomes more costly.

This report describes the canal's development, importance, and transition issues of the Panama Canal to Panamanian control that are most likely to affect U.S. agriculture. The first issue is management of the canal in the 21st century. Canal management includes setting and collecting transit tolls and related fees, and the day-to-day operations and maintenance of the canal. A second issue is the capability of the canal to handle increased traffic from the expansion of world trade.

The first two sections of this report discuss Panama's politics and economy and the canal's development, importance, and post-treaty transition. The next section evaluates the importance of the canal for U.S. agriculture. The last section, the conclusion, includes a discussion of how the turnover of the Panama Canal is most likely to affect U.S. agriculture in the 21st century.

Information and data used in this report came from several sources and personal interviews.

Panama's Politics and Economy

The treaties of 1977 and changes in Panama's political landscape will usher in a new era for the Panama Canal. Panamanians elected their first female president, Mireya Moscoso, widow of former President Arnulfo Arias. She defeated President Martin Torrijos in 1999. President Torrijos' father deposed Moscoso's husband in his last year as president and signed the 1977 canal treaties with U.S. President Jimmy Carter. Moscoso was elected as leader of the Arnulfista party to continue to promote her late husband's populist and nationalist ideas. As president, she receives the Panama Canal as an autonomous organization, which the Government of Panama is not to influence. As a candidate and as president-elect, she has stated publicly that her administration would not politicize the Panama Canal Authority (PCA—the new canal organization superseding the Panama Canal Commission) but would encourage an efficient changeover by introducing national anticorruption and anticronyism measures (*Journal of Commerce*, May 1999).

With a population of 2.8 million people, Panama has a service-oriented economy. In 1997, Panama's gross domestic product (1982 prices) totaled $6.5 billion, with annual government revenues and expenditures of $2.4 billion and a national debt of $7.26 billion. The Panama Canal generated more than a half-billion dollars in revenue in 1998, equivalent to one-quarter of total revenues of the Government of Panama (U.S. Department of State, *CIA Fact Book*, and Panama Canal Commission).

In 1994, Panama began to liberalize its trade policy and privatize state-owned enterprises in order to attract foreign investment. The largest ports were privatized in 1997, the Panama Canal

Two-way traffic at Gaillard Cut

railroad was sold in 1998, and the electrical company is currently being privatized. Despite the reform and privatizing efforts by the Government of Panama, unemployment is at 13.1 percent, and more than one in three persons lives below the poverty line. Its labor force totals a little more than 1 million workers. One-third work in the government sector, and 27 percent work in the agriculture, hunting, and fishing sector. The Panama Canal employs 9,000 people (98 percent of the canal work force is Panamanian). Panama is a nation largely dependent on imports. For every dollar's worth of goods Panama exported in 1997, it imported 5 dollars in goods (U.S. Department of State, *CIA Fact Book*, and Panama Canal Commission).

The turnover of the Panama Canal is not the only challenge for the Republic of Panama. Attracting business and industry is necessary to improve employment and opportunities, raise personal income, and stabilize the national debt. Compounding high unemployment and low personal income is the pullout of the U.S. military (See the sidebar on the U.S. military pullout from Panama.), which employed Panamanians on its installations and contributed to the local economy.

The new canal organization will operate in a for-profit manner. It may reduce wages and lay off employees in an effort to reduce costs. Panama's economy might endure localized hardships as a result of the U.S. military pullout and any changes in the canal operations. In the long term, the country will most likely depend upon the canal as an effective attraction for business and industrial expansion.

Panama Canal: Development, Importance, and Post-Treaty Transition

Development of the Panama Canal

In 1903, the United States entered into the Hay-Bunau-Varilla Treaty with Panama for the perpetual use, occupation, and control of a 10-mile-wide piece of land across Panama from the Atlantic to the Pacific Oceans to construct and defend a canal. The United States purchased the rights to construct a canal through Panama for $40 million from the French Canal Company (FCC), which had attempted to construct and finance a sea-level canal, only to fail two decades after starting construction in 1880. The United States paid the Republic of Panama $10 million and an annual annuity of $250,000 to build and use the land on which the canal was constructed (McCullough). The annuity gave the United States the rights to operate the canal in perpetuity. The U.S. government needed 10 years and $387 million to design and construct the canal, which opened in 1914. Since 1903, the United States has invested $3 billion to modernize and update the canal, but has recovered more than two-thirds of that investment (Panama Canal Commission).

To construct the canal, the United States had to overcome engineering, sanitation, and organizational challenges. Engineering the canal required extensive digging through the Continental Divide, building the largest dam at the time, installing enormous canal locks and gates, and obtaining adequate water storage for the system to function. Disease had been a major problem for the FCC during its construction attempt. The United States implemented sanitation and insect-control programs around the Canal Zone to reduce deaths related to disease. An estimated

Widening the Gaillard Cut

Ship bow in Panama Canal's Gatun Lock

25,000 people died of disease and accidents during the entire construction period (McCullough). An extensive organization was also required to design the canal, allocate funds for construction, coordinate labor, and attend to visitors (Panama Canal Commission).

The Panama Canal opened to oceangoing vessels on Aug. 15, 1914. Its benefit to world trade was as a shortcut between the Atlantic and Pacific Oceans. For the United States, the canal meant a quicker trip by water between New York and San Francisco. Before the canal, there were only three feasible routes: sailing around Cape Horn, a 67-day, 12,000-mile journey; sailing to Panama's narrowest point between the Atlantic and Pacific Oceans (the present location of the canal), where passengers and cargo were unloaded and transported over the isthmus and the Continental Divide to the other ocean, then reloaded on another ship to complete the journey; or a transcontinental journey across North America.

Since 1914, the United States has operated the canal, managed the land extending 5 miles on either side of it (the Canal Zone), and set tolls for transiting vessels through the Panama Canal Company—the U.S. organization that operated the canal at that time. During the early years, the Panamanians complained they did not receive a fair share of revenues generated by the canal, and they resented the United States' operation of the canal. In 1936, the two nations amended their 1903 treaty to increase the annual annuity paid to Panama to $430,000, and the United States gave up its right to intervene in Panama and maintain public order. In 1955, another amendment increased the annual annuity to $1.93 million, limited the U.S. involvement in Panama's internal affairs, established a single pay scale for Americans and Panamanians employed by the Panama Canal Company, and made Spanish an official language along with English within the Canal Zone. In 1955, the Panama Canal Company turned over to the Republic of Panama the Panama City railroad yards and other properties, valued at $22 million. Seventeen years later, in 1972, the annuity was adjusted again to $2.1 million, and then again in 1973 to $2.33 million (Panama Canal Commission).

Panama had long resented the U.S. control of the Canal Zone and by 1974, the two countries agreed to negotiate the eventual turnover of the canal to Panama. Three years later, the U.S. Government and the Republic of Panama signed two treaties to jointly operate, manage, and defend the canal over a 20-year period and guarantee the neutrality of the canal after the turnover.

The treaties were enacted on Oct. 1, 1979. At that time, the Panama Canal Commission (PCC), a U.S. Government agency, was formed to replace the Panama Canal Company, to operate and manage canal activities. Revenues that were generated by tolls and transit services supported the operation, labor and maintenance expenses, and capital investment programs. The revenue also provided Panama a $10 million fixed, annual payment, a $10 million inflation-adjusted payment for public services that Panama provided, an annual percentage of toll revenues, and a payment of up to $10 million if revenues exceeded PCC expenditures in a given year (U.S. Department of State). During the transition period, the PCC replaced American staff, ship pilots, and members of the board of directors with Panamanians trained to operate and manage the canal after the turnover.

M.V. Aspilos in the Gaillard Cut

The canal organization that succeeded the PCC on Dec. 31, 1999, the Panama Canal Authority (PCA), operates autonomously as a for-profit business. As such, the PCA will be able to streamline, restructure, or expand certain aspects of canal tolls, operations, and services. Many critics have expressed concern that as a for-profit venture, the PCA could raise revenues too high through increased tolls, eliminate certain important services, lay off employees, and lower wages, while allowing Panamanian politics to influence contract and labor negotiations.

Importance of the Panama Canal

The canal's purpose is to allow vessels of various types and sizes to move between the Atlantic and Pacific Oceans. Bulk ships carry homogeneous commodities, containerships transport unitized containers loaded with numerous commodities and products, and tankers carry bulk liquid products. Military vessels, such as battleships and submarines, use the canal during deployment. Passenger ships carry vacationing tourists, and mariners take their yachts, sailboats, and other personal water craft through the canal.

By allowing vessels to transit between the Atlantic and Pacific Oceans, the Panama Canal saves time and money for the transport of waterborne goods. For cargo shipped from the U.S. Atlantic or Gulf Coast (U.S. East Coast) to destinations in Asia, for instance, the canal saves about 10 days' sailing time, savings which are integral to route selection by shipowners and operators. The canal is a preferred alternative for shipowners if the average daily revenue of a vessel's transit through the canal is more than an extra 10-day routing. For example, assume that a 65,000 deadweight tonne (dwt) dry bulk vessel transports 52,000 mt of grain from the Gulf of Mexico to Japan via the Panama Canal at a freight rate of $18.75 per mt. Clarkson Research Studies of London, England, estimates the vessel's average daily revenue to be $7,336.[2] An extra 10-day sailing reduces the average daily revenue of the vessel by 5 percent to $6,975 per day. A Panama Canal transit generates $361.50

[2] Clarkson Research Studies estimates average daily revenue by subtracting shipping costs (port costs, bunkers, and canal charges) from total revenue (the freight rate, dollars per metric ton times cargo tons) then dividing the difference by voyage days:

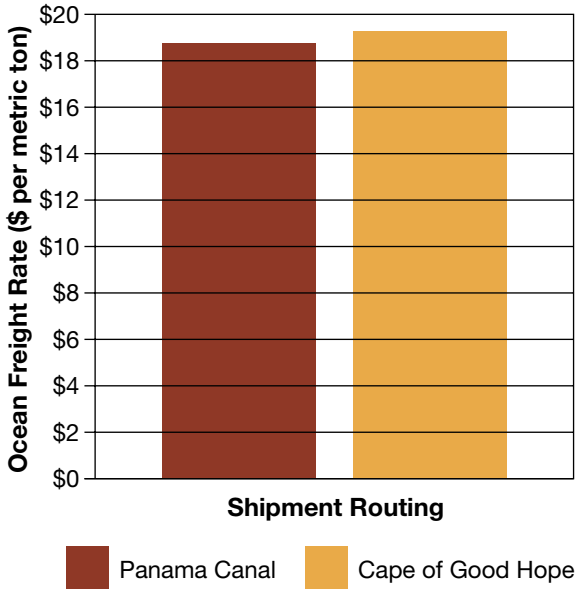
{[($18.75 × 52,000) – ($181,530.50 + $242,633.50 + $85,000)] ÷ 63.5} = $7,336.00

Data were obtained from Clarkson Research Studies and the Clarkson Research Studies "Shipping Intelligence Weekly," Issue No. 381, Aug. 13, 1999, to estimate average daily revenue.

more revenue per day for a vessel than the extra 10-day sailing schedule. Although the vessel avoids paying the canal toll by sailing around the Cape of Good Hope, it requires 15 percent more bunkers and revenue distributed over an additional 10 days. Clarkson Research Studies estimate the canal charge to be $85,000. If the goal of the vessel operator were to generate $7,336 in daily revenue by sailing around the Cape of Good Hope, the required shipping rate would have to increase about 3 percent to $19.26 per mt from $18.75 per mt (figure 3). The shipping rate is the shipper's cost to have the grain transported to Japan.

Over the past decade, more than 138,000 ships have transited the canal. In 1998, ship transits were up 8 percent from 1989 while cargo volume was up 27 percent. The average ship carried 19 percent more cargo in 1998 than in 1989. Vessel transits were most frequent in 1995 and 1996, at nearly 13,500 each year (table 1).

Figure 3–Ocean rate comparison from U.S. Gulf to Japan, via Panama Canal versus around the Cape of Good Hope ($ per metric ton, based on a grain shipment of 52,000 metric tons)



SOURCE: Rates estimated using data obtained from Clarkson Research Studies, "Shipping Intelligence Weekly," Aug. 13, 1999

Ships transit the canal en route to the Pacific Ocean from the Atlantic or to the Atlantic from the Pacific. Since 1989, ships going to the Pacific Ocean from the Atlantic averaged 52 percent of all oceangoing transits. In 1998, Pacific-bound transits totaled 6,511—also more than half of all transits in that year alone (table 2). The higher number of Pacific-bound transits reflects the importance of the canal for particular world trade routes. The principal trade routes using the canal, with percentages of total average transits, are U.S. East Coast (includes U.S. Atlantic Coast, Great Lakes, and Gulf Coast) to the Far East (44 percent); Europe to the West Coasts of the U.S. and Canada (9 percent); and U.S. East Coast to West Coast South America (9 percent). The volume of Pacific-bound cargo also is more than the Atlantic-bound cargo. In 1998, more than 112 mmt of cargo moved through the canal to the Pacific Ocean, 57 percent of all cargo taken through the canal (table 2).

The principal commodities transported through the canal, as a percentage of total average cargo volume, include grains (23 percent); petroleum and products (14 percent); and containerized cargo (13 percent) (Panama Canal Commission). Shipments of agricultural commodities and products accounted for 30 percent (58.8 mmt) of total cargo volume transiting the canal in 1998, with grain and oilseed shipments totaling 36.1 mmt or 61 percent of all agricultural shipments. Grain shipments through the canal peaked at 44.2 mmt in 1995 and have averaged 35.3 mmt over the 10-year period between 1989 and 1998. Corn, soybeans, and sorghum have accounted for nearly 90 percent of all grain shipments through the canal. During 1989-98, corn shipments made up 30 percent of all agricultural shipments. Before 1995, grain shipments averaged 32.4 mmt and, since 1995, have averaged 39.6 mmt—a 22-percent increase in size. Though shipments declined in 1997 with the recession of the Asian economies, shipments in 1997 and 1998 were still higher annually than any year from 1989 through 1994 (table 3).

Table 2–Panama Canal oceangoing transits and cargo (million metric tons) by direction, fiscal years 1989-98

	Atlantic to Pacific		Pacific to Atlantic		Total	
Year	Transits	Cargo	Transits	Cargo	Transits	Cargo
1989	6,311	89.7	5,678	64.4	11,989	154.1
1990	6,274	92.4	5,667	67.2	11,941	159.6
1991	6,557	101.1	6,015	64.3	12,572	165.4
1992	6,374	98.4	6,080	63.4	12,454	161.8
1993	6,212	98.8	5,874	61.5	12,086	160.3
1994	6,352	104.2	5,985	69.0	12,337	173.2
1995	6,933	122.8	6,526	70.6	13,459	193.4
1996	6,902	126.2	6,634	75.0	13,536	201.2
1997	6,692	117.4	6,351	75.4	13,043	192.8
1998	6,511	112.0	6,413	83.2	12,924	195.2
Average	6,512	106.3	6,122	69.4	12,634	175.7

SOURCE: Panama Canal Commission, Annual Reports

Most agricultural shipments move through the canal from the Atlantic Ocean to the Pacific Ocean. Between 1989 and 1998, 70 percent of the agricultural shipments through the canal moved from the Atlantic to the Pacific Ocean (table 3). In 1998, shipments of corn and soybeans made up 67 percent of total agricultural shipments destined for the Pacific (table 3).

U.S. agricultural commodities and products shipped through the canal between 1989 and 1998 accounted for 68 percent of all agricultural shipments and 21 percent of all canal cargo volumes. In 1998, U.S. agricultural shipments totaled 40.5 mmt, a 23-percent increase from 1989. Agricultural cargo originating from the U.S. East Coast (U.S. Atlantic Coast, Great Lakes, and Gulf Coast) and transiting the canal to the Pacific constitutes 95 percent of all U.S. agricultural shipments, which have increased steadily since 1989 and peaked in 1995 and 1996 (table 4).

The size of a ship transiting the canal is limited by the size of each lock chamber. Vessels must measure less than 32.3 meters (m) at the beam (width), 294.1 m in length for containerships and 289.6 m in length for other commercial vessels, and 12 m in draft.[3] The largest ship capable of transiting the canal is called a "Panamax."[4] Ships too large to transit the canal are called "post-Panamax." Transits of Panamax vessels are increasing, representing one-fifth of all transits in 1983 and one-quarter of all transits in 1988 (Bastian). By the mid-1990s, one out of every three ships was a Panamax transit (Panama Canal Commission). The average size of a ship in the world oceangoing fleet is increasing and more ships are being built as post-Panamax vessels. During the 1980's, about 92 percent of the world cargo fleet could use the Panama Canal, but by 2000, it was expected that only 82 percent would be able to use it (Panama Canal Commission staff).

Panamax-size ships make a more effective transit through the canal by carrying more cargo, but they diminish the efficiency of the canal because they are limited, by canal policy, to daylight transits, require extra pilots and line handlers, take longer to traverse a set of locks, and are restricted to single passage through the narrowest portions of the canal in the Gaillard Cut. In fact, the lockage of a laden Panamax vessel requires 40 percent more time than a vessel with a beam under 30 m because the narrowest passageways through the Gaillard Cut prevent the largest vessels from safely passing one another (Bastian).

[3] Vessel draft is the portion of the vessel submerged below the water line.

[4] PCC classifies ships with beams of more than 30.5 meters as Panamax.

Table 3–Principal agricultural shipments (million metric tons) via the Panama Canal, fiscal years 1989-98

Commodities	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total Shipments										
Barley	0.2	0.3	0.7	0.2	0.6	0.3	0.6	0.6	0.5	0.3
Corn	10.7	14.2	15.3	14.6	16.3	16.2	24.3	24.7	18.4	18.6
Oats	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Rice	0.5	0.7	0.6	0.7	0.7	0.6	0.7	0.8	0.8	1.1
Sorghum	2.0	2.1	1.8	2.0	2.1	1.6	1.9	1.5	1.6	1.9
Soybeans	5.3	6.3	6.4	7.3	8.0	7.3	8.6	8.8	10.5	10.2
Wheat	11.2	6.9	8.1	7.7	5.9	7.8	7.7	6.0	3.3	3.6
Oilseeds	0.2	0.2	0.1	0.3	0.3	0.3	0.5	0.4	0.4	0.3
Other	0.0	21.0	22.0	22.1	20.8	22.1	25.0	24.9	25.1	22.7
Total	30.1	51.7	55.0	55.0	54.7	56.1	69.2	67.7	60.5	58.8
Atlantic to Pacific										
Barley	0.0	0.0	0.1	0.1	.070	0.0	0.3	0.2	0.3	0.2
Corn	10.6	14.2	15.2	14.6	16.3	16.2	24.2	24.5	17.8	18.2
Oats	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Rice	0.2	0.2	0.2	0.1	0.1	0.2	0.3	0.3	0.2	0.7
Sorghum	2.0	2.1	1.8	2.0	2.0	1.6	1.9	1.5	1.6	1.9
Soybeans	5.3	6.2	6.4	7.3	8.0	7.2	8.6	8.7	10.5	10.2
Wheat	10.1	5.5	5.9	5.5	3.8	4.4	5.8	4.3	1.8	1.8
Oilseeds	0.0	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.3	0.2
Other	6.0	5.8	7.4	8.3	7.3	8.5	10.3	10.4	10.5	9.0
Total	34.1	34.1	37.1	38.2	37.7	38.2	51.7	50.1	43.0	42.2
Pacific to Atlantic										
Barley	0.2	0.3	0.6	0.1	0.6	0.2	0.2	0.3	0.2	0.2
Corn	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.6	0.4
Oats	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rice	0.4	0.4	0.4	0.6	0.6	0.4	0.4	0.5	0.5	0.3
Sorghum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soybeans	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Wheat	1.2	1.4	2.2	2.2	2.1	3.4	1.9	1.7	1.5	1.8
Oilseeds	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.0
Other	14.5	15.3	14.6	13.8	13.5	13.6	14.7	14.5	14.6	13.7
Total	16.4	17.6	17.9	16.8	16.9	17.9	17.6	17.5	17.5	16.6

SOURCE: Panama Canal Commission

Table 4–Panama Canal cargo volumes (million metric tons) by U.S. origin coast, total, and agricultural cargoes, fiscal years 1989-98

Origin	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total ECUS[1]	64.0	64.5	72.0	69.5	69.5	70.2	84.8	84.5	74.8	70.9
Ag ECUS	31.2	31.3	33.9	35.0	35.6	35.3	48.5	47.3	39.8	39.6
Total WCUS	7.2	8.0	8.9	9.6	7.3	8.6	6.9	7.2	6.5	7.2
Ag WCUS	1.8	2.2	2.8	2.6	1.8	2.8	1.2	1.2	0.8	0.9
Total US	71.2	72.5	80.9	79.1	76.8	78.8	91.7	91.7	81.3	78.1
Ag US	33.0	33.5	36.7	37.6	37.4	38.1	49.7	48.4	40.6	40.5

Note: ECUS is East Coast U.S. and includes U.S. Gulf and Atlantic Coasts, Ag ECUS is agricultural shipments from the ECUS, WCUS is West Coast U.S., and Ag WCUS is agricultural shipments from the WCUS.

SOURCE: Panama Canal Commission

Post-Treaty Transition of the Panama Canal

The canal is an important transportation artery for oceangoing vessels and world trade, and the ability of the PCA to meet the demand for canal services will influence trade patterns and growth. This section looks at the PCA, its capacity expansion efforts, its environmental resources, port and railroad privatization, and world trade and ocean fleet projections.

Panama Canal Authority

The Panama Legislative Assembly established the Panama Canal Authority to manage, maintain, use, and conserve water resources of the canal watershed, and to modernize the canal as a safe and profitable enterprise to serve the Republic of Panama for the economic development of the country. The objective of the PCA "is that the canal always remain open to the peaceful and uninterrupted transit of vessels from all nations of the world, without discrimination…" (Panama Legislative Assembly Law No. 19, June 11, 1997). A board of 10 directors will manage the PCA. The President of Panama appoints one as the chair of the board of directors with the rank of Minister of State for Canal Affairs, but the Legislative Assembly freely appoints or removes a director. The president appoints the remaining nine directors, with consent of the Cabinet Council and ratification by an absolute majority of the Legislative Assembly. Each director serves a 9-year term—three are appointed every 3 years (Panama Legislative Assembly Law No. 19, June 11, 1997).

The PCA board of directors appoints, removes, and establishes the salary and benefits of the administrator, deputy administrator, and the inspector general. The board also determines the vessel admeasurement system and sets tolls, rates, and fees for use of the canal, subject to final approval of the Cabinet Council. The directors prepare and approve an annual budget for consideration by the Cabinet Council and the Legislative Assembly. They also establish canal labor relations and procedures for selection and promotion, as well as wage scale and benefits, and they determine applicable contracting, supply acquisition, and rendering of appropriate services. The PCA may expand its operations by engaging in any commercial or industrial activities or services complementing the profitability of the canal (Panama Legislative Assembly Law No. 19, June 11, 1997).

Transiting into the 21st Century

Actively planning for its management and operation of the canal after Dec. 31, 1999, the PCA announced in March 1999 that toll rates would not change during the first year of its operation of the canal. The PCA surmised that the PCC had increased tolls sufficiently in previous years to generate adequate revenue for canal operations. Since the canal opened in 1914, the tolls have been increased eight times, from 90 cents per PC/UMS to $2.57 per PC/UMS, a 186-percent increase (table 5). They have increased five times since 1989, from $2.01 per PC/UMS to $2.57 per PC/UMS in 1998, a 28-percent increase. Revenues in 1989 totaled about $328 million from 11,989 transits. A decade later, revenues increased 66 percent to $543 million, with 12,924 oceangoing transits (table 1).

Labor and staffing of the canal will be different under the PCA. PCC employees had expressed concern that the PCA might cut wages and positions to reduce costs and improve the profitability of the canal. In January 1999, the PCA announced plans to lay off ship pilots and reduce from two pilots to one the number required to assist a wide-beam vessel transit. The pilots' organization appealed to the PCA and to the international maritime community, claiming that such a reduction would compromise safety. Two ship captains confirmed the pilots' position by saying that without enough pilots on a ship, the vessel, its crew, cargo, and other vessels are in more danger (personal contact with ship captains). Laying off experienced pilots also could reduce the quality of the canal training program if new pilots cannot obtain adequate training with the experienced pilots. Extra pilots on the largest vessels increase safety and minimize incidents (wrecks and collisions with other vessels or canal structures) for vessels moving through the canal.

The PCA, in many ways, has proven itself capable of managing the canal even before it took over the management of the canal. More than 98 percent of the employees, including the administrator, are Panamanian. These individuals most likely will continue to work the canal. Consequently, the turnover of the canal should be uneventful, with ships transiting in 2000 as ships did in 1999. Although several individuals in the maritime community, ship captains, PCC staff and pilots, ship agents, and others, have expressed concern that Panamanian politics might affect canal management and operations, these individuals believe that 2-3 years beyond the turnover might reveal how well the PCA will operate the canal over time.

World Trade and the Ocean Fleet Projections

World trade volume through 2002 is expected to increase 3-4 percent annually, while the world fleet of oceangoing vessels is forecast to increase 1-2 percent annually (USDOT- MARAD/ USCG). Trade carried by bulk ships is expected to increase 3-4 percent, while the dry bulk fleet is expected to expand by 1-2 percent (USDOT-

Table 5–Historical toll rates (in U.S. dollars) per Panama Canal Universal Measurement System net ton (PC/UMS), 1914-present

Date	Laden	Ballast	Displacement	Average Percentage Increase
Before July 8, 1974	0.90	0.72	0.50	--
July 8, 1974	1.08	0.86	0.60	19.7
November 18, 1976	1.29	1.03	0.72	19.5
October 1, 1979	1.67	1.33	0.93	29.3
March 12, 1983	1.83	1.46	1.02	9.8
October 1, 1989	2.01	1.60	1.12	9.8
October 1, 1992	2.21	1.76	1.23	9.9
January 1, 1997	2.39	1.90	1.33	8.2
January 1, 1998	2.57	2.04	1.43	7.5

SOURCE: Panama Canal Commission

MARAD/USCG). Both the containership fleet and containerized cargo will likely increase 8-10 percent annually to 2002, as shown in table 6 (USDOT-MARAD/USCG). The PCC expects its traffic to grow at the same rate as the growth in world trade by each vessel type (discussion with Panama Canal staff).

Most vessels now built for the world's container fleet are too large for the canal. These larger vessels are built to carry more containers and make fewer port calls. In practical terms, larger ships mean the operating costs of a vessel can be distributed across more containers. These larger ships, however, require ports with deeper drafts and more shoreside services, and are in port longer to unload and load-back containers. As such, these ships are scheduled to call on fewer ports and use alternative inland modes to transport containers to final position, rather than transit through the Panama Canal (see the sidebar on U.S. alternatives to the Panama Canal).

Expanding the Canal

To keep up with the growth in the world seaborne trade and the larger ships being built, the PCC has embarked upon a capital investment program to expand capacity for expected increases in vessel traffic. The efficiency of canal operation is measured two ways: ship transits per day and the average canal water time[5] (CWT) of a vessel. The maximum allowable capacity of the canal is 37 to 42 ship transits per day (Panama Canal Commission). Daily ship transits indicate the effectiveness of ship lockage and vessel speed through the canal waters. The benchmark is a 24-hour CWT (Panama Canal Commission). A lower CWT gains efficiency, while an increase is a loss in efficiency.

[5] Canal water time (CWT) is a time measurement of a vessel from the moment it is ready to transit the canal until it exits canal waters. The canal waters include those areas beyond the canal locks on the Atlantic and Pacific Oceans and include the breakwater or anchorage areas. Once a vessel enters the first set of locks on either side of the canal, the transit time averages 9 hours. The time waiting to enter the first set of locks increases the CWT.

Table 6–World trade growth compared to fleet growth, 1998-2002

Vessel/Trade	Trade Growth (percent)	Fleet Growth (percent)
Dry Bulk	3-4	1-2
Tanker	2-3	1-2
Product	4-5	3-4
Crude	1-2	0-1
General Cargo	6-7	2-3
Container	8-10	8-10
Average	3-4	1-2

SOURCE: USDOT-MARAD/USCG

The CWT can fluctuate with increased traffic volumes, larger ships transiting the canal, and mechanical delays operating the locks. But as transit traffic increases, the CWT will most likely continue to increase—pressuring the PCA to expand the canal while maintaining its present system. In order to finance future canal expansion, the PCA may increase tolls or obtain financing through capital loans. In the past, the PCC financed capital improvement projects through toll-generated revenues.

The transit capacity of the canal, under normal operating conditions, is a function of vessel sizes, lock outages, and direction of transits. Panamax vessels increase CWT because they are limited to daylight transits and one-way passage through the Gaillard Cut and take longer to traverse a set of locks. During daylight hours, the number of ship transits ranges from 10 to 15 per day, depending upon ship sizes. Daylight transits make up less than half of the canal's maximum daily capacity. Lock outages and interruptions in the canal also increase CWT (Panama Canal Commission staff).

The average size of a vessel in the world fleet and those transiting the canal has increased—with wider beams (the vessel's width), longer lengths, and deeper drafts. For example, 25 percent of the world fleet is currently Panamax in size, while by 2010, more than one-third of the vessels are expected to be Panamax (Panama Canal Commission staff).

U.S. Alternatives to the Panama Canal

Waterborne cargo exported from or imported to the United States does not require an all-water route to reach a final market position. The United States has an intermodal system that expands the routing selection for cargo shipped. For instance, larger ships that transport containers to the United States call on two or three ports for unloading and loading containers. The larger ships carrying containers from an Asian country to the U.S. East Coast would be too large for the Panama Canal. The ships would call on a U.S. West Coast port, where the containers are unloaded and then transferred onto rail cars for an intermodal delivery across the United States to final markets. This service, called the "land-bridge," eliminates an all-water delivery of a container and avoids use of the Panama Canal. Containers land-bridged across the United States from the U.S. West Coast to New York, for instance, save about 7 days and $600 to $2,600, depending on the cargo mix, instead of using the Panama Canal ("Lloyd's Shipping Economist," September 1998).

The land-bridge method has served U.S. trade efficiently, but its effectiveness as an alternative to the canal is constrained by increased demand for domestic inland transportation and limited rail capacity. Demands for rail service fluctuate with the economy of the United States and the world. The ability of railroads to offer a beneficial service requires nearly flawless performance from moving trains. In late 1997, for instance, the Union Pacific Railroad experienced significant rail service problems merging with the Southern Pacific, while making the two systems compatible. The incompatibilities of the two railroads nearly closed the western rail network. As a result, grain trains and intermodal rail service moved slowly, severely hampering rail service (Norton and Brennan). That incident, coupled with a large volume of containerized imports at the time, slowed down West Coast port operations. In response, containership companies that had moved cargo from west to east across the United States used smaller vessels and used the canal as a workable alternative to move cargo.

U.S. grain exporters also have several transportation options. Most grain produced in the United States and destined for export moves by barge to elevators in the U.S. Gulf (Eriksen, Norton, and Bertels, March 1999). Elevators in the Pacific Northwest (PNW) on the Columbia River and on Puget Sound, on the St. Lawrence Seaway, or the Atlantic Coast also have grain exporting facilities. Exports of corn through the PNW, for example, first move by rail to PNW elevators before being loaded onto a bulk vessel. The vessel then transports that grain to its ultimate market destination, mostly Far Eastern markets, and avoids the Panama Canal. Grain grown in the Western Corn Belt and then exported most commonly is shipped through PNW elevators, while grain produced in the Midwest, within economical trucking distances of navigational waterways, moves by barge to Gulf elevators. Any problems on the U.S. inland river system will cause domestic shipments of grain exports to shift to the PNW or, conversely, with problems with rail service for grain shipments to the PNW, that grain will move toward the river for delivery, to provide an efficient alternative to other competitive routes.

By 2005, a major capital improvement program to increase capacity, costing nearly $1 billion, should be completed, and the sustainable operating capacity will increase 20 percent. The program includes widening the Gaillard Cut, augmenting the tugboat fleet, adding locomotives, modernizing the vessel traffic management system, converting the miter gates and rising stem valves to hydraulics, and automating the machinery controls. Each of these improvements is described in the Panama Canal capital improvement program sidebar.

Environmental Resources

As traffic at the canal reaches capacity and transit time increases, ship operators and owners will consider alternate maritime routes. To keep the canal competitive with other routes, the PCC has conducted several studies to expand the canal's capacity beyond just widening the Gaillard Cut. Once the widening is complete, Panamax vessels will be able to pass each other throughout the canal waters, although ships of any size and type still will have to wait through the longer lockage times of Panamax vessels. The PCC will have to consider lock expansion or the construction of new locks in the future.

The challenge of increasing lock sizes or constructing another set of locks is having an adequate water supply to assist ships through the canal. Each ship transit uses 53 million gallons of fresh water from the canal watershed; i.e., Gatun Lake. Rain water keeps the watershed full. However, in 1998, El Nino brought a drought to Panama, lowering Gatun Lake's water levels. As a result, the PCC restricted the draft of vessels transiting the canal to 11 m. The restriction limited the amount of cargo loaded on Panamax ships and cut the daily revenues of those ships. Consequently, heavily laden vessels bypassed the canal and steamed around the Cape of Good Hope.[6] Sailing around the Cape of Good Hope added 10 days and extra bunkers to complete the trip, but the vessels transported full shipments of cargo (Eriksen, May 1999).

The PCC eased the draft restrictions as much as possible by implementing water-saving techniques. The canal has an adequate water supply in its watershed to service current traffic levels. Adding locks or expanding current locks, however, will require additional water sources to maintain safe water levels throughout the canal.

Three plans have been proposed to expand the canal's capacity to accommodate vessels up to 150,000 dwt, and each plan requires significant water volumes. One project would add a third set of locks at each lock site. Another project proposes making a sea-level canal through Panama, and the third project would involve constructing high-rise locks for the larger vessels (personal communication with PCC staff).

To expand canal capacity could take up to two decades and several billion dollars. The PCC continues to study world trade patterns and trends to determine the likely growth patterns and best expansion plan for the canal (personal communication with PCC staff).

[6] The Cape of Good Hope is the southern tip of Africa, where the Atlantic and Indian oceans meet.

Panama Canal Capital Improvement Program

Gaillard Cut. It took more than 20 years to dig, blast, and remove a mountain of rock and soil to make a "ditch" across the Continental Divide, known as the Gaillard Cut, the narrowest passage in the Canal Zone. The original width of the cut was 91 m and later was increased to 152 m. The planned program increases the width to 192 m in the straight sections and to 223 m at the curves. This project, estimated to cost $218.7 million, will be completed by 2002.

Widening the Gaillard Cut, which is nearly 12.6 kilometers (km) long, will permit the safe two-way passage of wide-beam vessels. In May 1999, the PCC began testing two-way passage of wide-beam ships and, in June 1999, double-passage began through the cut. The dry excavation of the cut (above water) is 90 percent complete, while the below-water rock blasting is 85 percent complete and the dredging (below water) is 53 percent complete.

Locks Machinery Conversion and Controls System. The mechanical systems at each set of the locks date from 1914, and these aging components require significant maintenance. The PCC began modernizing them by converting the systems to hydraulics and programmable controllers in 1998. The total cost of the improvements, expected to be completed by 2003, will exceed $22 million.

Panama Canal Locomotives. Integral to moving ships through each set of locks are the canal locomotives, which are located on both sides of a lock lane and run on tracks. They assist by towing, braking, and keeping the vessels secure while in the lock structures. Cables from each locomotive attach to a vessel to tow it. Up to eight locomotives might be used to tow a vessel, four on each side.

The current canal locomotive fleet totals 82 units, and many of them were built before 1965. By 2002, the PCC plans to increase its locomotive fleet to 108 units, at a cost of $93.7 million. The new, faster units will have larger traction motors.

Communication, Traffic, and Navigation System. The PCC is implementing an advanced traffic control system to manage vessel traffic through the canal. This system will allow canal operators to see ships as they move by using a satellite global positioning system (GPS). The system, which costs more than $22 million, was put into use in July 1999. Another newly implemented computer system will have real-time, up-to-date information, also using GPS for canal operations and for pilots aboard vessels, using one central computer. It will track vessel location and speed, available for display to allow operators to make more informed decisions. For example, the vessel display will allow ship pilots to see the location of other vessels in the canal waters and allow them to coordinate safer and more efficient vessel transits.

Panama Canal Tugboat Improvement Project. Tugboats assist vessels through the canal and are available for emergency response. The current fleet supports the present level of daily canal traffic, but increases in vessel traffic will require additional tugs. The PCC is updating its fleet of 20 tugboats to handle the increases in vessel traffic. By 2002, the fleet will increase by four new tugboats at a cost of $33.3 million.

Port and Rail Privatization

Panama's plan to modernize and increase capacity is not limited to the canal. It also is expanding and modernizing its ports and railroad system (see the Panama ports and rail sidebar). Projects at Panama's ports allow the largest containerships to use Panama as a vital transshipment point for the world container trades. The ports are located near the entrances of the Panama Canal, at Balboa on the Pacific and at Colon on the Atlantic. A rail line runs nearly parallel to the canal between the ports and is scheduled for reconstruction as a trans-isthmian double-stack container service. This rail service could minimize the need for vessels to transit the canal and, in effect, increase canal capacity for other ship transits.

A transshipment service would allow container lines that transit the Panama Canal to offer flexible worldwide shipping alternatives. For instance, vessels using the canal often wait several hours in canal waters before their transit. Ship companies are using the ports located near the canal entrances to discharge containers, which are transshipped onto other vessels for other foreign destinations. This service permits a vessel to efficiently use its time waiting for a transit and allows the shipping line to expand its service options for its customers. Most vessels that currently transship containers in Panama also transit the canal. Containerships built today are too large to transit the Panama Canal and generally use round-the-world services to avoid Panama altogether or use Panama for transshipment services. Once the rail line is in service, the largest containerships could call on Panama for transshipping containers across the isthmus, using the double-stack rail service as an alternative to the canal and the U.S. land-bridge system. Panama's ports and rail will provide a trans-isthmian service, giving Panama an advantage in the container trade business while enhancing the canal's capacity.

Panama Ports and Rail

Ports. The Panama Ports Company (PPC) purchased operating concessions for the ports of Balboa and Cristobal, while the Manzanillo International Terminal, Panama S.A. (MIT), and the Colon Container Terminal, S.A. (CCT) purchased concessions at the port of Colon. Each concession is a joint venture between a Panamanian business and a foreign affiliate. The PPC is a subsidiary of China's Hutchison Port Holding, and MIT is operated by Stevedoring Services of America (SSA) Panama, Inc., affiliated with the Seattle-based SSA and the Motta and Heilbron families of Panama. The CCT is affiliated with Evergreen International S.A., Panama, and Taiwan's Evergreen Group. Each concession allows the respective port operator to invest in terminal rehabilitation and expansion.

The terminal construction and modernization program at PPC's Balboa facility includes 12 "super post- Panamax" quay cranes, capable of servicing the largest containerships being built, 1,500 m of deep-water quay, 50 hectares of container storage, and 28 rubber-tired gantry cranes. This program will allow the PPC to handle more than 1.5 million 20-foot-equivalent containers (TEU's) annually. The modernization program also includes facilities for break- bulk cargo. The PPC's Cristobal terminal's updating will include two Panamax quay cranes (capable of servicing Panamax vessels), new rubber-tired gantry cranes, and a new harbor crane. Annual container capacity at PPC's Cristobal terminal might exceed 300,000 TEU's (Troetsch).

The initial modernization and construction phases at port facilities operated by MIT and CCT at Colon were completed in 1998, but after 2000, both terminal operators will expand their terminals again (Urriola Tam, McGivern, and Romero). MIT provides terminal services to 19 shipping lines and handles more than 1 million TEU's.

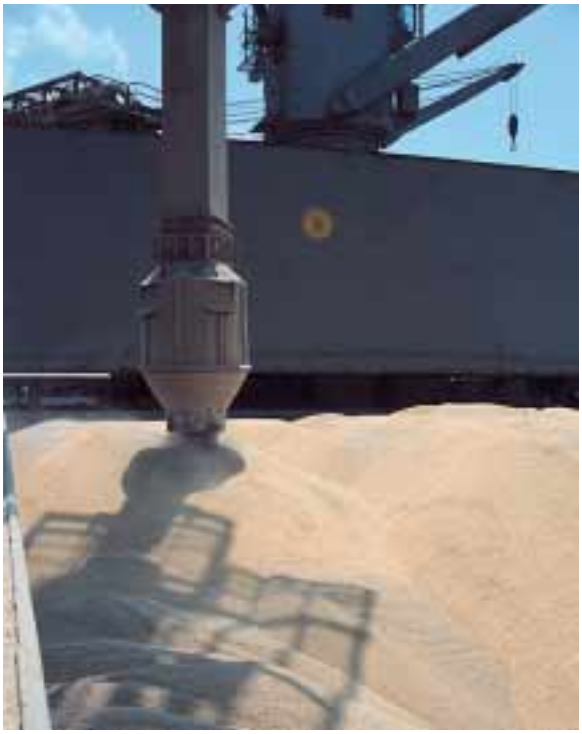
Panama Canal Railway Company (PCRC). A 76.6 km railroad crosses the Panamanian isthmus, connecting the Atlantic and Pacific Oceans. The PCRC will begin rehabilitation and reconstruction of the 143-year-old rail line during 2000. It will complement the canal and provide an efficient container transshipment service between the oceans. The PCRC anticipates moving 75,000 containers in its first full year of service and expanding to 400,000 containers per year with 20 trains daily.

The PCRC formed in 1998 as a joint venture between the Kansas City Southern Railway of Kansas City, MO, and Mi-Jack Products, Inc. of Hazelcrest, IL. The Government of Panama awarded the joint venture an exclusive 25-year concession to operate the railway. The PCRC will invest about $80 million to rehabilitate the railway, construct terminals, and purchase terminal equipment (http://www.kcsi.com/pcrc.html, Panama Canal Commission, and personal communication with PCC staff).

U.S. Agriculture and the Panama Canal

U.S. agricultural products are traded competitively throughout the world. Most U.S. agricultural exports have consisted of grain and oilseeds, exported from several U.S. port regions, including the U.S. Gulf (Gulf), the Pacific Northwest (PNW), Atlantic Coast, or the St. Lawrence Seaway. Grain exported from those locations can move there by barge, rail, or truck from inland grain production areas. U.S. grain and oilseed production totaled 401 mmt in 1997-98, with 24 percent (97 mmt) of it exported (USDA-NASS). Most of those exports were shipped from elevators in the Gulf (65 percent) or in the PNW (23 percent) (USDA-FGIS/GIPSA). Corn, soybeans, and wheat make up most grain exports. Corn and soybeans are exported predominantly from the Gulf, while wheat is exported mainly from the Gulf and PNW. Once at the elevators, the grain is loaded onto bulk oceangoing vessels for transport worldwide. The predominant markets for U.S. grain are countries throughout Asia, with Japan receiving one-fifth of all U.S. grain exports.

The Panama Canal allows U.S. agricultural commodities to be traded competitively throughout the world. It offers significant advantages for U.S. corn and soybean exporters, especially in delivering grain and oilseeds to Asia. For example, in 1998, 51 percent of all grain inspected for export from the Gulf went through the Panama Canal, more than 33 mmt (table 7) (USDA-FGIS/GIPSA). Corn and soybeans from the United States make up more than four-fifths of the world's grain shipped through the Panama Canal. In 1998, about 66 percent of the corn inspected for export from the Gulf went through the canal, and of those shipments, 50 percent went to Japan. Two-thirds of Japan's U.S. corn imports move through the Panama Canal.



Grain loading in ship hold

Agricultural exports through 2008 are forecast to increase by 39 percent to 138 mmt from 99 mmt in 1998 (USDA-WAOB). If that forecast holds, and assuming grain exports through the canal from the Gulf remain constant, grain transported through the Panama Canal will total approximately 40 mmt, a 16-percent increase from 1998 (table 8).

Future expansion in U.S. grain exports from the Gulf with delivery through the Panama Canal will also depend on the management and operation decisions of the PCA, which has a mandate to operate the canal as a profitable venture. If the PCA raises more revenue through increased tolls, U.S. agricultural shipments will be most affected (personal communication with PCC

Table 7–Estimated U.S. grain inspections (million metric tons) for export transiting the Panama Canal, 1989-98

Grain	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Corn	10.8	13.6	13.3	15.3	15.5	17.4	26.0	23.2	16.7	21.8
Soybeans	5.1	5.2	6.2	6.8	7.4	6.0	7.6	9.8	9.5	8.9
Wheat	9.8	5.3	6.7	4.9	4.8	3.2	5.7	3.7	1.7	2.7
Other	2.0	2.1	1.4	1.4	1.6	1.7	1.9	1.7	1.9	1.2
Total	27.7	26.2	27.6	28.4	29.3	28.4	41.2	38.4	29.8	34.6

SOURCE: USDA-FGIS/GIPSA

Table 8–Projected U.S. Gulf grain exports (million metric tons) using the Panama Canal to 2008

Year	Corn	Soybeans	Wheat	Total
1997	16.7	7.3	1.7	25.7
1998	23.4	7.7	2.8	33.9
1999	17.5	7.5	4.7	29.7
2000	19.0	7.7	5.0	31.7
2001	19.7	7.9	5.0	32.6
2002	20.2	7.7	5.2	33.1
2003	21.3	7.7	5.3	34.3
2004	21.9	7.9	5.4	35.2
2005	22.7	7.9	5.5	36.1
2006	23.4	8.2	5.6	37.2
2007	23.9	8.4	5.8	38.1
2008	24.6	8.7	6.0	39.3

Note: Projections were determined by applying the average volume of grain inspections for export from the Gulf (1989-98) and average volume of inspections estimated to transit the Panama Canal to the World Agricultural Outlook Board baseline projections, 1997 to 2008.

staff). USDA's Agricultural Marketing Service conducted a study with Texas A&M University's Department of Agricultural Economics to evaluate the effect of increased Panama Canal tolls on U.S. grain exports. The report concludes that increased tolls would reduce grain exports via the Gulf, increase exports via PNW ports, reduce quantities transiting the canal, and increase shipments around the Cape of Good Hope to East Asia. Total U.S. corn and soybean exports, though, would decline no less than 2 percent if the canal were closed.

The study, "The Panama Canal and Its Effect on the Competitiveness of the United States in International Grain/Oilseed Markets," estimated how canal management and canal performance affect corn and soybean exports. It developed two scenarios to quantify the effects. The first scenario evaluated incremental increases in the toll rate, and the second scenario evaluated the effects of closing the canal. The results were obtained using a spatial equilibrium model.

Under the first scenario, toll rates were raised incrementally from a base $1.50 per mt up to $5.50 per mt. In the base model, total U.S. corn and soybean exports were estimated at 68.8 mmt with about 72 percent of the volume routed through Gulf elevators, 16 percent through PNW elevators, and the remaining 12 percent through other port ranges. Fifty-four percent of the corn and soybean exports routed through the Gulf went through the Panama Canal, as shown in table 9 and figure 4.

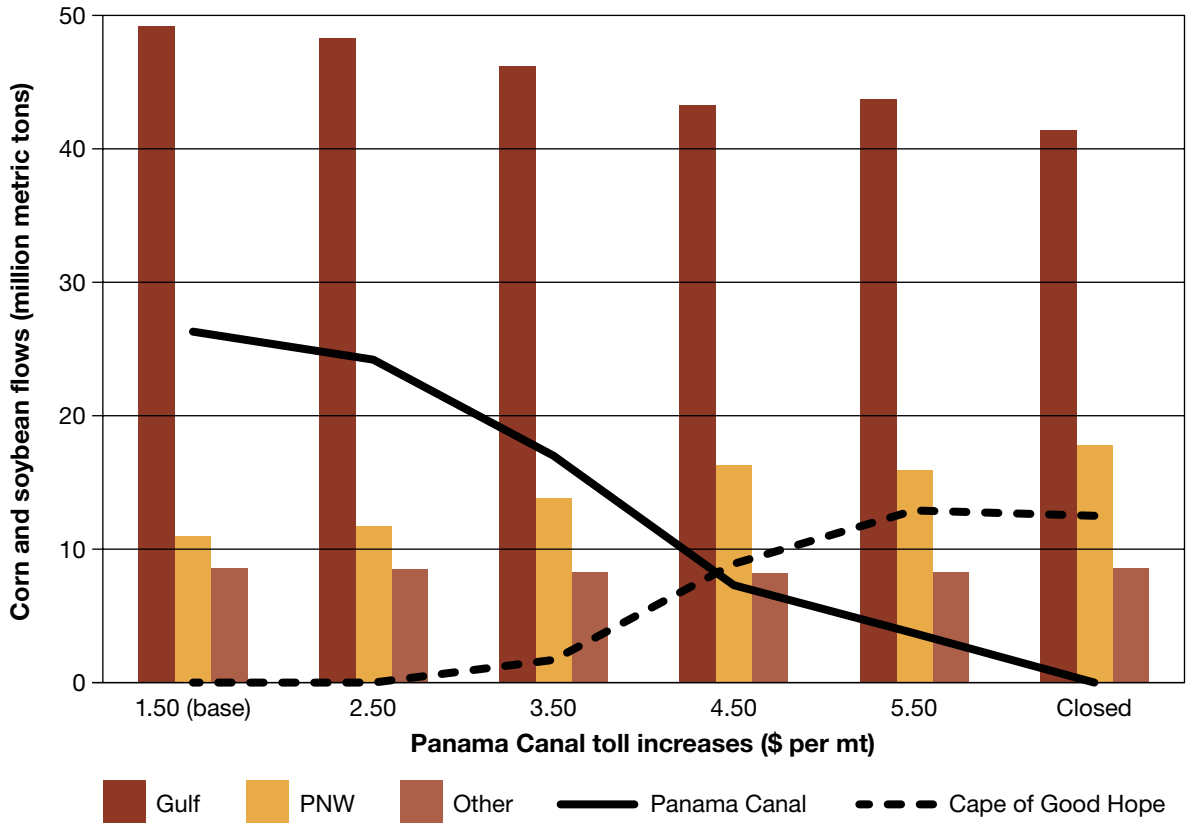
If toll rates were increased by $1 to $2.50 per mt under this scenario, total U.S. corn and soybean exports would be decreased 0.6 percent to 68.4 mmt. Exports through the Gulf decreased 2 percent to 48.3 mmt, while shipments through the PNW increased 6 percent to 11.7 mmt. Shipments through the Panama Canal decreased 8 percent to 24.2 mmt. If tolls were increased $4 to $5.50 per mt, total U.S. corn and soybean exports would decrease 1 percent to 68.0 mmt. Gulf shipments decreased 11 percent to 43.7 mmt, and shipments through the canal decreased 86 percent to 3.7 mmt. Eighty-nine percent of the Gulf's (4.9 mmt) lost volume moved through PNW elevators, which increased volume at PNW elevators 44 percent to 15.9 mmt. Fifty-seven percent of the lost canal volume (22.6 mmt) then moved around the Cape of Good Hope (table 9 and figure 4).

Table 9–Estimated U.S. corn and soybean flows (million metric tons) resulting from increasing Panama Canal tolls and closing the canal

Routing of U.S. Exports	Base Quantities	$2.50/ton toll ($1 increase)	% change	$3.50/ton toll ($2 increase)	% change	$4.50/ton toll ($3 increase)	% change	$5.50/ton toll ($4 increase)	% change	Canal close	% change
Gulf	49.2	48.3	(1.8)	46.2	(6.1)	43.3	(12.0)	43.7	(11.2)	41.4	(15.9)
PNW	11.0	11.7	6.4	13.8	25.5	16.3	48.2	15.9	44.5	17.8	61.8
Other	8.6	8.5	(1.2)	8.3	(3.5)	8.2	(4.7)	8.3	(3.5)	8.6	0.0
Total	68.8	68.4	(0.6)	68.3	(0.7)	67.9	(1.3)	68.0	(1.2)	67.7	(1.6)
Panama Canal	26.3	24.2	(8.0)	17.0	(35.4)	7.3	(72.2)	3.7	(85.9)	0.0	(100.0)
Cape of Good Hope	0.0	0.0		1.7	∞	8.9	∞	12.9	∞	12.5	∞

SOURCE: Fuller, Stephen W., Luis Fellin, and Ken Eriksen. "The Panama Canal and Its Effect on the Competitiveness of the United States in International Grain/Oilseed Markets." College Station, TX: Texas Agricultural Market Research Center Report, Department of Agricultural Economics, Texas A&M University. TAMRC International Market Report No. IM 1-99, June 1999

Figure 4–Estimated U.S. corn and soybean flows (million metric tons) resulting from increasing Panama Canal tolls and closing the canal



SOURCE: Fuller, Stephen W., Luis Fellin, and Ken Eriksen. "The Panama Canal and Its Effect on the Competitiveness of the United States in International Grain/Oilseed Markets." College Station, TX: Texas Agricultural Market Research Center Report, Department of Agricultural Economics, Texas A&M University. TAMRC International Market Report No. IM 1-99, June 1999

If the canal were closed, total U.S. corn and soybean exports would be decreased less than 2 percent, but the distribution of the shipments was altered significantly. Shipments via the Gulf decreased 16 percent while shipments via the PNW increased 62 percent. Thirty percent of the exports via the Gulf were shipped around the Cape of Good Hope (table 9 and figure 4).

Changes in tolls or canal operations affect not only shipments, but also producer revenues. Increasing the toll $1 per mt to $2.50 per mt decreased corn and soybean producer revenues $95.6 million per year while increasing the toll $4 per mt to $5.50 per mt decreased revenues by $247.6 million. Under a canal-closed scenario, producer revenues decreased $303.6 million per year (table 10). The decrease in revenue from closing the canal represents 99 cents per mt, or 3 cents per bushel of the corn and soybeans produced in the United States in 1997-98 (USDA-NASS). Changes in the toll or shutting down the canal most affected corn and soybean producer revenues in Illinois. A $1 toll increase decreased Illinois producer revenues $23.1 million per year, while a $4 increase reduced revenues $63.8 million, and closing the canal reduced revenues $76.0 million (table 10).

U.S. grain and oilseed shipments are important revenue-generating cargoes transported through the Panama Canal. Increases in tolls or closing of the canal would affect U.S. grain exports by no more than 2 percent while canal revenues would decrease significantly. The distribution of U.S. grain and oilseed exports shifted toward Europe and Africa from the Gulf, with shipments to Asia transported from the PNW and around the Cape of Good Hope. Total producer revenues from corn and soybeans decreased less than $1 per mt, or less than 3 cents a bushel produced.

Table 10–Estimated annual reduction in U.S. corn and soybean producer revenues resulting from increased tolls ($ per metric ton) or closing the Panama Canal, by State

State	($1 increase) $2.50/ton toll	($2 increase) $3.50/ton toll	($3 increase) $4.50/ton toll	($4 increase) $5.50/ton toll	Canal close
	Decrease in producer revenues ($ millions)				
Arkansas	2.7	3.9	4.3	4.8	8.3
Iowa	14.5	19.8	26.1	26.6	33.5
Illinois	23.1	45.3	63.6	63.8	76.0
Indiana	12.2	25.3	35.5	35.6	42.3
Michigan	2.1	5.2	7.7	7.9	8.4
Minnesota	9.9	20.3	27.6	28.2	31.9
Ohio	6.3	14.9	20.9	21.9	26.7
Other States	24.8	41.2	56.2	58.8	76.5
Total	95.6	175.9	241.9	247.6	303.6

SOURCE: Fuller, Stephen W., Luis Fellin, and Ken Eriksen. "The Panama Canal and Its Effect on the Competitiveness of the United States in International Grain/Oilseed Markets." College Station, TX: Texas Agricultural Market Research Center Report, Department of Agricultural Economics, Texas A&M University. TAMRC International Market Report No. IM 1-99, June 1999

Conclusion

Many vessel owners, operators, shippers, and users of the Panama Canal have indicated that the transfer of the canal to Panamanian control could lead to a reduction in service and safety and higher tolls, although most anticipate that the PCA's first 2-3 years should be smooth.

The PCA inherits an integrated staff of Panamanians and Americans that is well-trained and that has managed and operated the canal efficiently and effectively for several years. The canal itself has served world trade adequately for 85 years with 800,000 vessel transits. Yet, the shipping community has many questions about the long-run credibility of the PCA, which affects their shipping operations. For instance, questions the maritime community asks include: Will the PCA maximize revenues and profits through toll increases? Will the PCA discontinue or cut important canal services? How will the PCA finance future capital investment programs to expand the capacity of the canal and increase its operations for larger vessels? With no U.S. military presence in Panama, who will protect the canal and ensure the Canal Zone remains neutral? How will Panamanian politics influence canal operations? The shipping community also wonders whether bureaucracy will impede vessel transits and canal safety, maintenance, and investment. Most of these questions, though, do not have immediate answers. The PCA has answered at least one of them by indicating that tolls will not be raised in its first year of operating and controlling the canal. For the moment, the shipping community has adopted a wait-and-see approach. The PCA may take 5-10 years to identify and incorporate an operating philosophy to make the canal profitable.

Shipments of U.S. grain and oilseed exports move through the canal to destinations throughout the world. The canal relies on those shipments for about 21 percent of its cargo volume. If the canal were to become inoperable or toll rates were increased substantially, U.S. agricultural exports would not have to use the canal to get to international markets. Alternative markets would open up for those shipments; otherwise, grain and oilseeds would be exported from other U.S. export positions or around the Cape of Good Hope. Transporting grain around the Cape of Good Hope increases the transport cost to shippers 3 percent. The value of the canal to U.S. corn and soybean producers is less than $1 per mt, less than 3 cents a bushel. Yet, a metric ton of grain transiting the canal generates $1.50 for the canal.

The canal relies on oceangoing traffic transits carrying the world's cargo. Its most important cargo, though, is U.S. grain. Policies affecting U.S. grain shipments via the canal affect its revenues and profitability.

Appendix
Shipping a U.S. Grain Cargo Through the Panama Canal

Information on how grain and oilseeds are transported into the world market through the Panama Canal is discussed in this appendix. The discussion is specific to grain shipments originating from the U.S. Gulf to Japan, the largest importer of U.S. grain.

The world trade in grain and oilseed commodities is highly competitive and relies on an effective and efficient transport system to move those commodities to a final market position. Factors that influence the export of grain and oilseeds include commodity price, quality and availability, and transport costs. Exporters in the United States offer sufficient quantities of high-quality grain at a competitive world price. The U.S. transport system allows grain; e.g. corn, to be sold from two predominant export positions: export elevators located in the U.S. Gulf and the Pacific Northwest (PNW). Nearly two-thirds of all export grain is shipped from the Gulf and another one-fifth from the PNW.

Corn production is concentrated in 10 Midwestern States (Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin). Except for Nebraska, Kansas, and South Dakota, each State borders the navigable Illinois, Mississippi, and Ohio Rivers. Corn sold to the export market from these States moves predominantly to the rivers and is loaded onto barges. The grain then moves down the rivers to the lower portion of the Mississippi River to export elevators in the New Orleans area. The corn is unloaded and stored until it is loaded onto an oceangoing vessel, which transports the grain to its final destination.

U.S. grain exports to Asian markets move predominantly through Gulf ports. In 1998, 65 percent of the grain destined for Asian markets moved through the Gulf. For example, Japan imported 38 percent of U.S. corn exports in 1998, and 76 percent of that corn was shipped from the Gulf. Grain shipped to Japan (or any Asian market) from the Gulf is shipped through the Panama Canal. Forty-three percent of all grain exported from the Gulf ships through the Panama Canal to Asia, Mexico, and South American countries.

A shipment of grain from New Orleans to Japan moves on vessels capable of transiting the Panama Canal. The vessel has to fit through each of the six lock chambers of the canal, which limits vessels to 32 m at the beam (width) and 290 m in length. The maximum draft of 12 m through the Panama Canal also restricts the volume of grain that can be loaded onto a vessel to less than 60,000 mt because 2,000 mt of grain equals one-third of a meter in draft. For a 60,000-mt shipment, the grain adds 9 meters to the ship's draft. The remaining 3 meters of draft allow for the ballast of the vessel, its ship stores, and bunkers.

Once the vessel is loaded in New Orleans, a ship agent coordinates the tug assist, pilot, linesman, final sale transactions, and cargo paperwork before the ship moves down the Mississippi River toward the Gulf of Mexico (Ricard). At that time, the captain of the vessel will contact the Panama Canal Commission (PCC) Vessel Traffic Control Center (TCC) and a Panama ship agent with an estimated time of arrival. Once a ship is under full steam, about 13 knots in the Gulf of Mexico, it needs about 4 days to travel the 2,324 km distance to Panama Canal

waters. The captain will maintain daily contact with a ship agent in Panama. The ship agent in Panama represents and attends to the financial aspects of the vessel transiting the canal, coordinates required logistics, and resolves any problems the vessel may encounter throughout the transit. The ship agent also keeps the TCC apprised of the vessel's arrival at Panama Canal waters (Wilson and Sorenson).

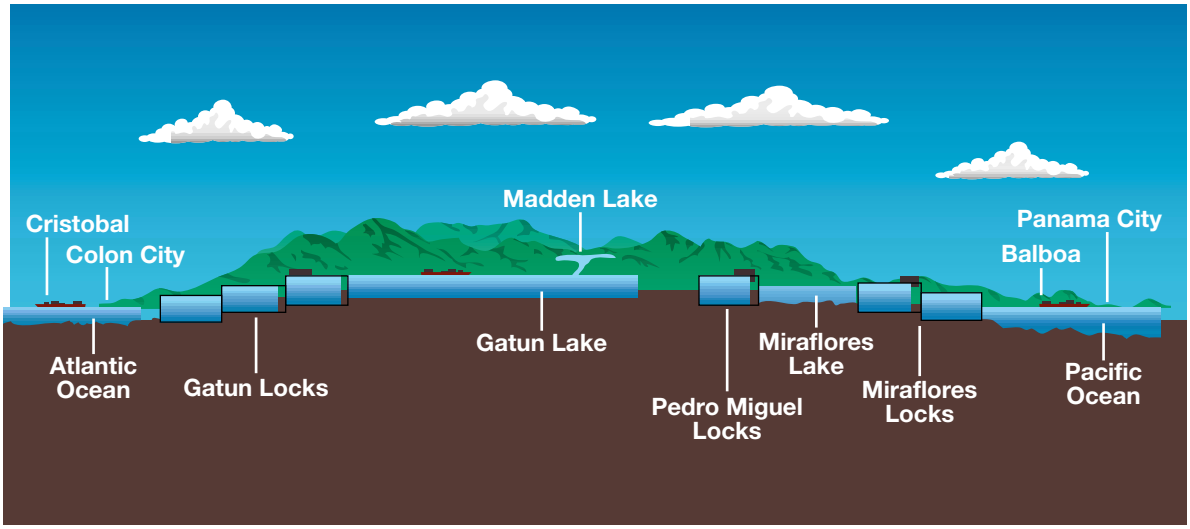
The Panama Canal, 80.5 km long and connecting the Atlantic and Pacific Oceans, extends northwest to southeast. Three sets of locks raise and lower vessels 26 m above sea level over the Continental Divide. The Atlantic entrance is 53.9 km north and 43.5 km west of the Pacific entrance (appendix figure A).

A ship carrying grain from the U.S. Gulf enters the Panama Canal waters of Limon Bay from the breakwater at Cristobal. From there, the vessel steams 10.4 km under tug assist to the Gatun Locks, the first set of locks. Three "steps" at Gatun Locks, individual chambers into which ships are maneuvered, raise the vessel 26 m to Gatun Lake. Each chamber is 34 m wide and 305 m long. This first set of locks is about 2 km long.

Vessels are scheduled to transit the canal in one of two manners: first-come, first-to-transit or through a transit reservation system. Panamax vessels, the largest vessels capable of transiting the canal, were restricted until recently to daylight transits. They may enter the first lock at about 6 a.m. to begin the 9- to 12-hour transit. Once in Panama Canal waters, the vessel will await a transit time assigned by the transit scheduler at the TCC or if the ship has a reservation, the captain will wait until the reservation time can be honored (Panama Canal Commission staff). Reservations can be made in advance for 26 cents per Panama Canal Universal Measurement System,[1] which is in addition to the $2.57 PC/UMS assessed for a loaded vessel transiting the canal. If a vessel fails to meet its reserved time, it loses the paid fee and transits the canal in a first-come, first-to-transit schedule. Upon arrival in Panama Canal waters, if a vessel is not scheduled to transit that day, it will drop anchor and wait for its scheduled transit time. Otherwise, the vessel will sail toward the first lock.

[1] Panama Canal Universal Measurement System—a volumetric measure of a vessel's cargo—carrying capacity used for assessing each vessel's transit toll.

Appendix Figure A–Profile of the Panama Canal System



SOURCE: Panama Canal Commission

The vessel can begin its transit only after the bank receives payment for transit. Before the transit, a launch boat will deliver Panamanian inspectors, Panama Canal ship pilots, and other service providers to the ship. The Panamanian inspectors check the vessel manifest and its cargo, and they conduct admeasurements to assess the PC/UMS (if it is the vessel's first Panama Canal transit). The Panama pilots take control of the vessel during its transit through Panama Canal waters. The chief pilot will instruct the ship's captain as to the speed and direction of the vessel. The chief pilot also will tell the tug operators, line-handlers, and locomotive engineers what assistance they need to provide, while the pilot remains in contact with the Panama Canal TCC and each lock tower.

The captain then relays the pilot's instructions to his crew members, who perform the proper maneuver. As the vessel approaches the first set of locks, another launch boat delivers line-handlers to the ship. The line-handlers board the vessel and prepare to receive the cables, attached to each locomotive, that pull the vessel through each lock chamber. A Panamax vessel requires 20 line-handlers, 12 locomotives (six at the bow and six at the stern, three to port and three to starboard), and one tug pushing from the stern to assist the vessel through each lock. One pilot will remain on the bridge at all times, moving between the wheel room and to either wing bridge to call out instructions, "full ahead," "rudder 10 degrees," "ahead one-third," "midships," etc. The other pilot will move about the vessel from bow to stern, port to starboard, keeping watch on the ship's progress throughout the canal transit.

At the first lock, Gatun Lock, the chief pilot will have the captain's crew maneuver the vessel to the approach wall, where the line-handlers attach the cables of the locomotives to the vessel. The pilot continues calling out maneuvers to the captain, and the vessel continues forward with assistance from the tug at the stern. When the vessel reaches the first chamber of the lock, line-handlers will attach the cables of the remaining locomotives to the vessel and draw them tight to stabilize the vessel for entry into the chamber.

Together with the locomotives and tugs and under its own power, the vessel moves into the first chamber, where miter gates close behind the vessel's stern to lock it into the chamber. Water from the second chamber flows into the first chamber and lifts the vessel to the water level of the second chamber. Once the vessel has stopped rising, the miter gates at the vessel's bow open, and the vessel moves forward into the second chamber with assistance from the locomotives and under its own power. The process repeats for the second chamber. In the last chamber, the vessel is lifted to the level of Gatun Lake. In each chamber lockage, raising a vessel requires about 15 minutes, and each lock transit will last from 45 minutes to more than an hour. Transit time, however, will vary with daily vessel traffic. Once the miter gates of the last chamber open and the vessel has cleared the gates, the cables from each locomotive are released, and the vessel steams through the tropical waters of Gatun Lake under its own power 37.8 km from the Gatun locks to the Gaillard Cut. The water in Gatun Lake pushes ships through the lock chambers, using 201 million liters of water for each ship transit.

The Gaillard Cut traverses 12.6 km through the Continental Divide of Panama at the highest point of the isthmus. Before construction of the canal, the cut was more than 123 m above sea level and 91 m wide. One portion was widened to 152 m during the 1930's and 1940's, and the remaining portions were completed by 1971. Currently, the cut is being widened to 192 m in the straight sections and 223 m at the curves to allow double passage of Panamax vessels. Panamax ships are limited to single passage through the canal until the widening project is complete. The PCC conducted tests in May 1999 to determine the safety of a double passage of Panamax vessels and measure vessel performance. In June 1999, double passage of Panamax vessels began. The widening of the cut will be finished by 2002 and will increase transit capacity by about 20 percent.

Once past the Gaillard Cut, the vessels encounter the first of two locks that will lower the vessel to the level of the Pacific Ocean. The first lock, Pedro Miguel, has one chamber, 1⅓ km long, which will lower the vessel 9 m. From Pedro Miguel, the vessel sails into Lake Miraflores and proceeds about 2 km to the Miraflores Locks, whose two chambers lower the vessel to sea level. From the Miraflores Locks, the vessel moves toward the Pacific Ocean under the Bridge of the Americas, where the pilot returns the vessel to the captain and boards the launch boat.

A complete transit takes 9-12 hours after entering the first set of locks, although a vessel may anchor in the canal waters, waiting to transit the canal, from a few hours to a few days. The author details a timeline of a partial transit in appendix table A.

Appendix Table A–Timeline of a partial Panama Canal transit of the M/V Aspilos[1]

Canal Location	Time
Balboa	1435
Enter Gaillard Cut (speed: 9-11 mph)	1445
Exit Gaillard Cut	1545
Line-handlers embark vessel	1550
Approach wall of Pedro Miguel	1620
In Pedro Miguel's chamber and miter gates closed	1640
Miter gates open	1655
Final locomotive disengaged	1715
Approach wall of the Miraflores	1750
In Miralflores first chamber and miter gates closed	1800
Miter gates open to Miraflores second chamber	1815
In Miraflores second chamber and miter gates closed	1825
Miter gates open and M/V Aspilos leaves second chamber	1840
Final locomotive disengaged	1845
Line-handlers disembark	1850
Pass under Bridge of the Americas	1900
Pilot disembarks, vessel steams into Pacific Ocean to Guyamas, Mexico	1910
Partial transit time for M/V Aspilos, from Gaillard Cut to disembarkation	5 hours 45 minutes

[1] The M/V Aspilos, built in 1982, is a dry bulk vessel (It transports grain, ore, and logs.), operated by Greek owners and officers with a Philippine crew under the Panamanian flag. The M/V Aspilos has five holds and five cranes and hauled 37,000 mt of white corn from New Orleans, LA (Continental Grain elevator), to Guyamas, Mexico. The weather was overcast, with high clouds, a slight breeze, the temperature in the high 90's, and high humidity.

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