Reconnaissance of Vessel Navigation Requirements Updated Report

Agreement 36893013
DOT&PF Project 67698
Federal Project ACHP-0922(5)

Prepared for
STATE OF ALASKA
Department of Transportation and Public Facilities
6860 Glacier Highway
Juneau, Alaska 99801

Prepared by
THE GLOSTEN ASSOCIATES, INC.
600 Mutual Life Building
605 First Avenue
Seattle, WA 98104-2224

Under contract to
HDR ALASKA, INC.
712 West 12th Street
Juneau, AK 99801

Original Report
October 1999

MAY 2003

Contents

List of Figures

List of Tables

1—Introduction

In support of the Gravina Access Project and together with a similar effort to identify aviation requirements, this updated reconnaissance of vessel navigation requirements supports the process of identifying practical alternatives for improving access between the City of Ketchikan and Gravina Island in southeast Alaska.

This report identifies the number and characteristics of vessels using Tongass Narrows and assesses effects of the proposed project alternatives on marine navigation. Included are projections of future cruise ship traffic in Tongass Narrows and an analysis of the navigation impacts of the proposed bridge alternatives—Alternatives C3(a), C4, C3(b), D1, F1, and F3—especially impacts on cruise ship schedules and costs.

1.1 Brief Description of Tongass Narrows

Tongass Narrows (see Figure 1) is a continuation of Revillagigedo Channel that extends northwest to the Guard Islands in Clarence Strait. Tongass Narrows is divided at its lower end by Pennock Island. The channel northeast of the island is called East Channel, and the channel southwest of the island West Channel. According to the *United States Coast Pilot*, both channels accommodate vessels of any draft.

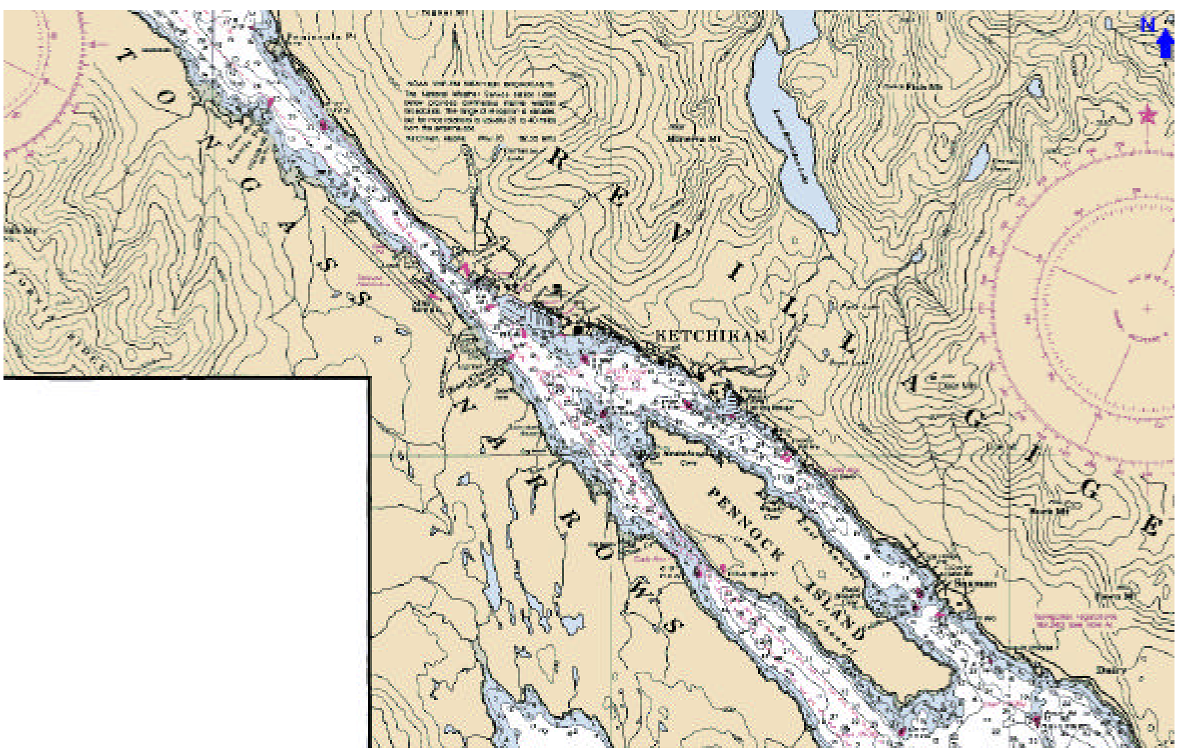


FIGURE 1
TONGASS NARROWS FROM SAXMAN TO PENINSULA POINT

Cruise ships bound for Ketchikan generally use East Channel, because it aligns better with the cruise ship docks. Barges and vessels of the Alaska Marine Highway System tend to use West Channel to avoid cruise ship traffic and because there is less shoreline development along West Channel to be affected by wake.

The Code of Federal Regulations (33 CFR §162.240) prescribes the following speed restriction for marine navigation in Tongass Narrows:

> *No vessel, except for public law enforcement and emergency response vessels, floatplanes during landings and take-offs, and vessels of 23 feet registered length or less, shall exceed a speed of 7 knots in the region of Tongass Narrows bounded to the north by Tongass Narrows Buoy 9 and to the south by Tongass Narrows East Channel Regulatory marker at position 55 deg. 19' 22.0" N, 131 deg. 36' 40.5" W and Tongass Narrows West Channel Regulatory marker at position 55 deg. 19' 28.5" N, 131 deg. 39' 09.7" W, respectively.*

Because of the heavy and diverse character of marine traffic in Tongass Narrows, vessel operations there are also currently subject to the voluntary guidelines of the "Tongass Narrows Voluntary Waterway User Guide," published March 18, 1999.

1.2 Brief Description of Project

The Gravina Access Project's mission is to identify practical alternatives for improving access between Ketchikan and Gravina Island. Alternatives that were considered in earlier phases of the project include no change, bridges, submerged tubes, tunnels, and improved ferry service. The alternatives retained for further evaluation under the current phase are: various locations and alignments of bridges, improved ferry service, and no change. As the project progresses, a preferred alternative will be identified and outlined in the environmental impact statement (EIS). A final design will follow approval of the EIS.

2—Marine Traffic Volumes

This section presents summarized data characterizing the traffic volume and salient dimensions of the principal classes of vessels using Tongass Narrows. Data are derived from diverse sources and are, in general, complementary. Projections of future cruise ship traffic calling at Ketchikan are presented and discussed in Section 4.

2.1 Waterborne Commerce Traffic Volumes and Trends

The U.S. Army Corps of Engineers (COE), Waterborne Commerce Statistics Center (WCSC), collects and compiles data regarding vessel movements on navigable waters of the United States. Statistical summaries of these data are published annually under the title *Waterborne Commerce of the United States* (e.g., Reference [1]), and additional data and statistics may be obtained by contacting WCSC directly.

The legal authority for the collection, compilation, and publication of waterborne commerce statistics by the COE is Section 11 of the Rivers and Harbors Appropriation Act of 1922 (42 Stat. 1043), as amended, and codified in 33 U.S. Code (U.S.C.). 555, which provides the following:

> *"Owners, agents, masters, and clerks of vessels and other craft plying upon the navigable waters of the United States, and all individuals and corporations engaged in transporting their goods upon the navigable waters of the United States, shall furnish such statements relative to vessels, passengers, freight and tonnage as may be required by the Secretary of the Army: Provided. That this provision shall not apply to those rafting logs, except upon a direct request upon the owner to furnish specific information.*
>
> *Every person or persons offending against the provisions of this section shall, for each and every offense, be liable to a fine of not more than $5,000 or imprisonment not exceeding two months, to be enforced in any district court of the United States within whose territorial jurisdiction such offense may have been committed. In addition, the Secretary may assess a civil penalty of up to $2,500 per violation against any person or entity, that fails to provide timely, accurate statements required to be submitted pursuant to this section by the Secretary."*

The waterborne commerce traffic movements are reported to the COE by all vessel operators of record on ENG Forms 3925 and 3925b (or equivalent). The reports are generally submitted on the basis of individual vessel movements completed. Cargo moved for the military agencies in commercial vessels is reported as ordinary commercial cargo; military cargo movements in Department of Defense vessels are not collected. All vessels in commercial operation (i.e., carrying either cargo or passengers for hire) and traveling more than three miles are required to report their movements.

In summarizing the domestic commerce, certain movements are excluded: cargo carried on general ferries, coal and petroleum products loaded from shore facilities directly into ship's bunkers as vessel fuel, and insignificant amounts of government materials (less than 100 tons) moved on government-owned equipment in support of Army Corps of Engineers projects.

The National Marine Fisheries Service (NMFS) furnished the fish landing data. No domestic fishing vessel trips are included in the data of the Trips and Drafts Section of Reference [1], but Alaska ferry movements are included.

Figure 2 shows the total reported tonnage of waterborne cargo handled through Tongass Narrows (inclusive of Ketchikan harbor). The cargo tonnage shown in Figure 2 includes all cargo (i.e., shipped, received and "through" cargo). The past ten years of data indicate a downward trend of tonnage handled through Tongass Narrows, most likely reflecting the closure of the Ketchikan pulp mill and general regional declines in forest and fishing commerce.

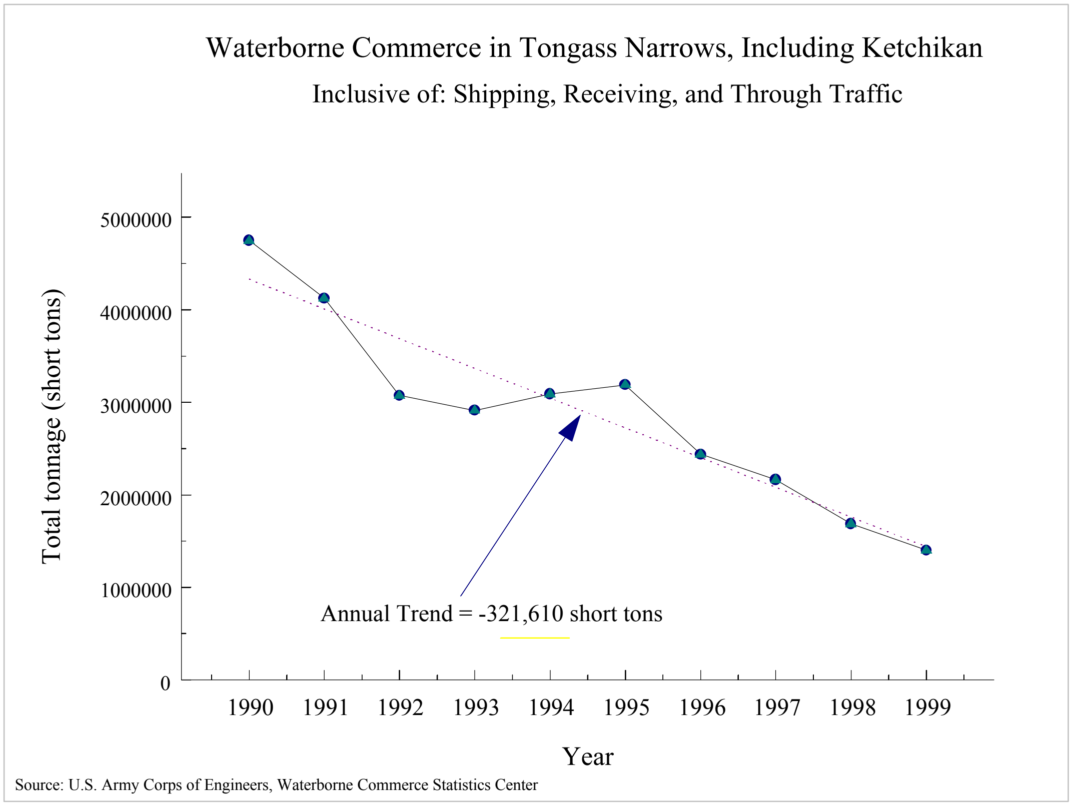


FIGURE 2
WATERBORNE COMMERCE IN TONGASS NARROWS

Table 1 gives the total reported trips, by year, in Tongass Narrows (including Ketchikan) – with statistics describing the distribution of vessel drafts. The "Maximum" column contains the greatest draft for which any trips were reported. The percentile columns indicate the draft below which the specified percent of all trips fall. For example, in the year 1990, 98% of all vessel trips reported had a draft equal to or less than 17.36 feet.

TABLE 1
TONGASS NARROWS (INCLUDING KETCHIKAN): TOTAL TRIPS AND DRAFTS BY YEAR

Year	*Total Trips*	*Draft (feet)*				
		Maximum	*98th Percentile*	*95th Percentile*	*90th Percentile*	*75th Percentile*
1990	9,687	28	17.36	16.77	16.32	15.07
1991	6,552	34	20.07	17.72	16.77	15.79
1992	6,885	35	20.13	18.35	17.43	15.92
1993	7,624	28	19.58	18.69	17.71	15.56
1994	10,339	36	27.37	24.24	16.47	14.17
1995	10,400	35	27.19	24.24	16.30	13.81
1996	10,094	37	26.47	23.86	16.37	14.24
1997	9,983	36	26.54	23.62	16.34	14.51
1998	9,228	Data not available#				
1999	13,989	Data not available#				
Average	9,478	33.62	23.09	20.94	16.71	14.88

Source: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center

\# *Unlike in previous years, the percentile distribution of trips and drafts was not available*

The average number of yearly trips given in the final row of Table 1 is the average of the data for 1990–1999. The draft averages are based on the data for 1990–1997.

Table 2 provides (for each year and for each of five vessel categories) the total number of reported trips in Tongass Narrows (including Ketchikan), and the maximum reported draft. The data include trips and drafts corresponding to both domestic and foreign vessels. Note that, while the total reported tonnage of waterborne cargo handled through Tongass Narrows has shown a declining trend over the past decade (Figure 2), there has not been a decline in the number of trips. Figure 3 shows the total number of recorded trips per year, from 1991 through 2000, for the different vessel types.

TABLE 2
TONGASS NARROWS (INCLUDING KETCHIKAN):
TOTAL TRIPS AND MAXIMUM DRAFTS, BY VESSEL TYPE AND YEAR

Year	*Self-Propelled Passenger & Dry Cargo*		*Self-Propelled Tanker*		*Self-Propelled Tow or Tug*		*Non-Self-Propelled Dry Cargo*		*Non-Self-Propelled Tanker*		*Total*	
	Trips	*Max. Draft*	*Trips*	*Max. Draft*	*Trips*	*Max. Draft*	*Trips*	*Max. Draft*	*Trips*	*Max. Draft*	*Trips*	*Max. Draft*
1990	Data are not readily available.											
1991	2,511	20	18	34	2,480	17	1,372	15	172	14	6,553	34
1992	2,755	20	18	35	2,129	18	1,842	13	143	13	6,887	35
1993	2,818	20	16	28	2,506	20	2,243	16	43	13	7,626	28
1994	4,495	15	27	34	2,831	18	2,743	15	245	16	10,341	34
1995	4,288	32	24	35	3,102	22	2,692	25	295	17	10,401	35
1996	4,369	37	24	28	2,903	16	2,369	18	431	20	10,096	37
1997	4,591	36	5	22	2,845	20	2,074	25	471	16	9,986	36
1998	4,811	29	0	—	2,066	18	2,012	29	339	16	9,228	29
1999	7,940	29	0	—	2,855	22	2,660	29	534	15	13,989	29
2000	6,796	31	0	—	3,267	21	2,759	23	336	18	13,158	31
Maximum	7,940	37	27	35	3,267	22	2,759	29	534	20	13,989	37
Average	4,537	26.9	13.2	21.6	2,698	19.2	2,276	20.8	300	15.8	9,826	32.8

Source: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center

The maximum in the next-to-last row is the greatest value occurring in each particular column, and the average appearing in the final row is the average of the nine years of data for each particular column. The maximum and average drafts, however, are for the years 1991–1997.

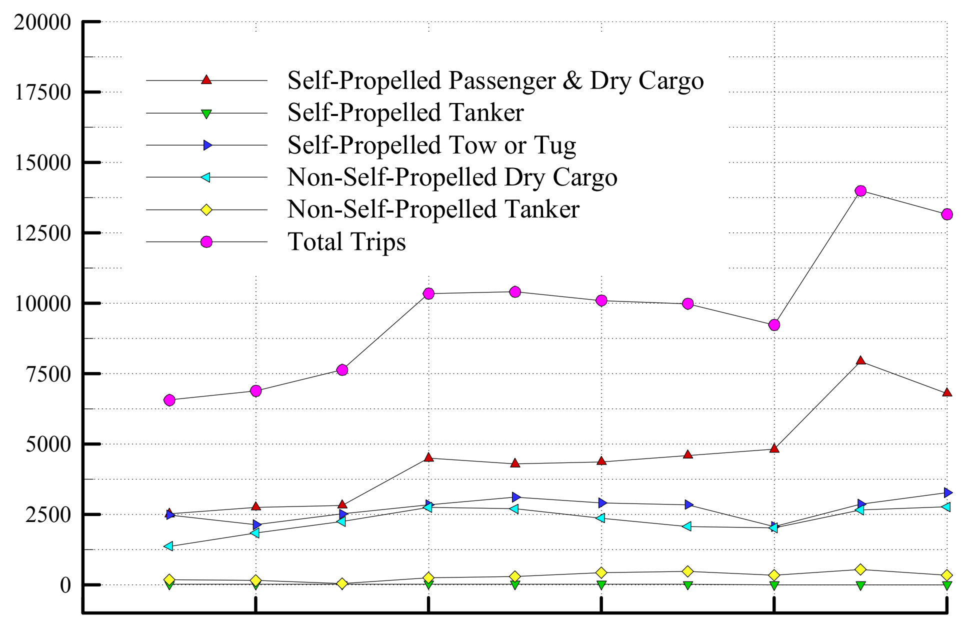


FIGURE 3
TOTAL TRIPS PER YEAR IN TONGASS NARROWS (INCLUDING KETCHIKAN)

2.2 Cruise Ship Traffic

The largest vessels routinely using Tongass Narrows are cruise ships that call seasonally at Ketchikan, primarily from May through September. As a consequence of the Passenger Services Act,[1] most of the large cruise ships operating in Alaska operate from Vancouver, British Columbia. Therefore, nearly all of the large cruise ships calling at Ketchikan pass under the Lions Gate Bridge located at the First Narrows, at Vancouver, BC Vessels taking the inside passage of Vancouver Island must also pass under the Seymour Narrows power cable crossing, located north of Campbell River. As described in Section 3 of this report, the vertical clearance of the Lions Gate Bridge is 200 feet and the vertical clearance of the Seymour Narrows power cable is currently 180 feet. However, the available clearance under overhead cables may be less—by about 16 feet, unless otherwise prescribed—given regulations to avoid a dangerous electrical discharge between the cable and a vessel passing under it. This is discussed further in Section 3.

Table 3 provides principal dimensions and other data regarding the large cruise ships that operated in southeast Alaska during the 2001 summer cruise season.

Table 4 provides principal dimensions and data for large cruise ships currently on order by cruise lines that have historically operated in southeast Alaska. These cruise lines have significant operations in other parts of the world; therefore, some of the new vessels were not destined for southeast Alaska operations. In particular, the largest of the new cruise ships are generally regarded as more suitable for other markets, such as the Mediterranean, which are currently experiencing rapid growth and are not inhibited by the restricted waterways characteristic of southeast Alaska cruising.

The largest modern cruise ships are designed as destinations in their own right, making the actual ports of call somewhat less important. The architectural focus of these ships is inward, whereas the essence of southeast Alaska cruising is the spectacular scenery external to the vessel and the ports of call. Thus, the very large new cruise ships are best suited to "cruises to nowhere" or to less-scenic ports of call—the antithesis of Alaska cruising. For these reasons, it is not anticipated that the largest of the new cruise ships will be frequently seen in southeast Alaska in the foreseeable future.

P&O Princess Cruises took delivery of the *Grand Princess* (178-foot air draft) in 1998 and Royal Caribbean took delivery of the *Voyager of the Seas* (208-foot air draft) in October 1999. The *Voyager of the Seas* is currently the world's largest active cruise ship, a title previously (if briefly) held by the *Grand Princess*. Table 4 includes the pertinent data for these two vessels. Additional vessels of these two classes are on order and under construction.

Table 5 lists cruise ships worldwide that are 83,000 gross tons or larger. Included in Table 5 are active vessels, vessels currently under construction, and vessels for which firm orders have been placed. The data in Tables 3, 4 and 5 were collected from a variety of sources. These include pilot cards and wheelhouse posters of several vessels, the official Websites of the respective cruise lines and shipyards, and a variety of cruise ship industry resources in print (Reference [2]) and on the Internet (e.g., CruiseNewsDaily.com).

The ships that called at Ketchikan in the years 1990–1999 are highlighted (in bold) in Table 5, to provide a better perspective of southeast Alaska cruise ship operations. Interestingly, the three ships in Table 5 that have called at Ketchikan first did so in the 2001 season. This is in tune with trends in cruise ship traffic in the area, which are discussed below in light of additional data.

[1] The Passenger Services Act imposes restrictions on the operations of foreign-built passenger vessels. The Jones Act places similar restrictions on foreign-built freight vessels. These are both basic cabotage acts that limit the carriage of passengers and freight between domestic ports to vessels constructed in the United States. To circumvent the Passenger Services Act, foreign-built cruise ships operate from the foreign port of Vancouver, BC

Data for cruise ship traffic at Ketchikan over the years 1991 through 2001 are tabulated in Table 6. The trends in cruise ship traffic and passenger volumes to Ketchikan are also plotted in Figures 4 through 6. The data were obtained from References [3] and [4].

Figure 4 shows the number of cruise ship passengers calling at Ketchikan and indicates that the mean linear trend over the past decade is an annual increase of 37,722 passengers per year. Figure 5 shows the number of cruise ships in the Ketchikan trade, with the mean linear trend over the past decade being an annual increase of 1.52 ships per year. Figure 6 shows the number of cruise ship stops in Ketchikan, and indicates the mean linear trend over the past decade to be an annual increase of 16.84 stops per year. Note that Figures 4, 5 and 6 include data for large and small cruise ships. Small cruise ship operators in southeast Alaska are discussed further in Section 2.3.

The capacity ratios shown in Table 7 are based on the reanalysis of the Ketchikan Visitors Bureau cruise ship calendars shown in Table 6 ,and cruise ship passenger actual totals for the years 1991 through 2000 (also provided by the Ketchikan Visitors Bureau). The lowest capacity ratios (on the order of 93%) occurred in the years 1991 and 1995. In five of the ten years, the capacity ratios equaled or exceeded 100%. Capacity ratios exceeding 100% are possible because cruise ship capacity is rated on the basis of lower berths; i.e., upper berths represent additional (unrated) capacity). Of significance, the most recent three years all have capacity ratios exceeding 100%, indicating that all cruise ships are running essentially sold-out and full.

Figures 7 through 11 indicate trends in large cruise ship principal dimensions and gross register tonnage. Trends are indicated for the world fleet and also for the subset of cruise ships operating in southeast Alaska. Figure 7 indicates the trend in maximum navigation draft; Figure 8, the trend in maximum beam; and Figure 9, the trend in overall length. Figure 10 shows the trend in gross register tonnage, a measure of the total enclosed volume of the ship; and Figure 11, the trend in air draft, including future points representing new vessels under construction by cruise lines that have historically operated in southeast Alaska.

TABLE 3
LARGE CRUISE SHIPS OPERATING IN SOUTHEAST ALASKA DURING 2001 CRUISE SEASON

Operator	*Ship*	*Passenger capacity in lower berth (Max.)*	*Gross Tonnage*	*Displacement (metric tons)*	*Length Overall (feet)*	*Register Length (feet)*	*Beam Maximum (feet)*	*Beam Register (feet)*	*Maximum Draft (feet)*	*Air Draft (feet)*
Carnival	*Carnival Spirit*	2,114 (2,680)	85,920	44,920	960		128.4	105.6	26.2	172.2
Celebrity	*Infinity*	1,950	91,000		965			105.0	26.3	
	Mercury	1,870 (2,681)	77,713		866			105.6	25.5	
Crystal Cruises	*Crystal Harmony*	960	49,400	28,180	790	676	105.0	97.1	24.6	143.0^
Holland America	*Ryndam*	1,629	55,451	31,338	720	607	111.6	101.1	24.6	173.0
	Statendam	1,629	55,451	31,338	720	607	111.6	101.1	24.6	173.0
	Veendam	1,629	55,451	31,338	720	607	111.6	101.1	24.6	173.0
	Volendam	1,440 (1,824)	61,000	33,870	780	663	113.0	105.8	26.6	157.4^
	Westerdam	1,494	53,900	33,083	800	723	106.0	95.1	23.6	155.2^
	Zaandam	1,440 (1,824)	61,000	33,870	780	663	113.0	105.8	26.6	157.4^
Norwegian Cruise Line	*Norwegian Sky*	2,002 (2,400)	77,104	39,000	848		118.1	105.8	26.2	168.0
	Norwegian Wind	1,748	50,760		754	624	105.3	93.5	22.0	

^ This is the stated height to the top of the stacks. The maximum air draft (to the top of the radio antennae) may be as much as 10 to 18 feet more, based on the known difference between the two air drafts for some large cruise ships.

TABLE 3, CONTINUED
LARGE CRUISE SHIPS OPERATING IN SOUTHEAST ALASKA DURING 2001 CRUISE SEASON

Operator	*Ship*	*Passenger capacity in lower berth (Max.)*	*Gross Tonnage*	*Displacement (metric tons)*	*Length Overall (feet)*	*Register Length (feet)*	*Beam Max (feet)*	*Beam Register (feet)*	*Maximum Draft (feet)*	*Air Draft (feet)*
NYK Cruises	*Asuka*	600	28,856		632					
Princess Cruises	*Dawn Princess*	1,950 (2,342)	77,441	39,997	857	762	132.2	105.8	26.6	159.1[&]
	Ocean Princess	1,950 (2,342)	77,441		857	762	132.2	105.8	26.6	159.1[&]
	Regal Princess	1,590	70,000		811			115.0		
	Sea Princess	1,950 (2,342)	77,441		857	762	132.2	105.8	26.6	159.1[&]
	Sun Princess	1,950 (2,342)	77,441		857	762	132.2	105.8	26.6	159.1[&]
Radisson Seven Seas Cruises	*Seven Seas Mariner*	700			709					
Royal Caribbean Inc.	*Rhapsody of the Seas*	2,000 (2,416)	78,491	38,917	915		116.3	105.6	25.4	170.5^
	Radiance of the Seas	2,100 (2,501)	90,090	46,500	962		131.2	105.6	27.9	173.2^
	Vision of the Seas	2,000 (2,416)	78,491	38,917	915		116.3	105.6	25.4	170.5^
World Explorer Cruises	*Universe Explorer*	737	23,500	22,886	617	570	88.0	84.0	27.3	130.0

[&] *This corresponds to the maximum air draft with the mast lowered.*

^ *This is the stated height to the top of the stacks. The maximum air draft (to the top of the radio antennae) may be as much as 10 to 18 feet more, based on the known difference between the two air drafts for some large cruise ships.*

TABLE 4
RECENT DELIVERIES AND NEW LARGE CRUISE SHIPS ON ORDER (AMONG ALASKA OPERATORS)

Operator	*Ship*	*Passenger capacity in lower berth (Max.)*	*Gross Tonnage*	*Displacement (metric tons)*	*Length Overall (feet)*	*Register Length*	*Beam Max @ Bridge (feet)*	*Beam Register (feet)*	*Maximum Draft (feet)*	*Air Draft (feet)*	*Year Finished*
Carnival	*Carnival Victory**	2,758 (3,400)	101,509	50,800	894		141.7	116.5	27.2	208.0	2000
	Carnival Pride	2,114 (2,680)	85,920	44,920	960		128.4	105.6	26.2	172.2	2002
	Carnival Legend	2,114 (2,680)	85,920	44,920	960		128.4	105.6	26.2	172.2	2002
	*Carnival Conquest**	2,976	110,000		~954		~141.7	~116.5	~27.2	~208.0	2002
	Carnival Miracle	2,114 (2,680)	85,920	44,920	960		128.4	105.6	26.2	172.2	2003
	*Carnival Glory**	2,976	110,000		~954		~141.7	~116.5	~27.2	~208.0	2003
	*Carnival Valor**	2,976	110,000		~954		~141.7	~116.5	~27.2	~208.0	2004
Celebrity	*Summit*	1,950	91,000		965			105.0	26.3		2001
	Constellation	1,950	91,000		965			105.0	26.3		2002
Holland America	*Amsterdam*	1,380 (1,738)	61,000	32,500	781	663	111.6	105.8	26.6	152.5^	2000
	Zuiderdam	1,848	84,000		951						2002
	Oosterdam	1,848	84,000		951						2003
Holland America	Vista Class 3	1,848	84,000		951						2004
	Vista Class 4	1,848	84,000		951						2004
	Vista Class 5	1,848	84,000		951						2005

* *Post-Panamax vessels*

^ *This is the stated height to the top of the stacks. The maximum air draft (to the top of the radio antennae) may be as much as 10 to 18 feet more, based on the known difference between the two air drafts for some large cruise ships.*

TABLE 4, CONTINUED
RECENT DELIVERIES AND NEW LARGE CRUISE SHIPS ON ORDER (AMONG ALASKA OPERATORS)

Operator	*Ship*	*Passenger capacity in lower berth (Max.)*	*Gross Tonnage*	*Displacement*	*Length Overall (feet)*	*Register Length (feet)*	*Beam Max (feet)*	*Beam Register (feet)*	*Maximum Draft*	*Air Draft*	*Year Finished*
Norwegian Cruise Line	Norwegian Sun	2,002 (2,400)	77,104	39,000	848		118.1	105.8	26.2	168.0	2001
	Norwegian Star	2,244 (4,080)	91,000		965			105.6	26.2		2001
	Norwegian Dawn	2,300	91,000								2002
Princess	Grand Princess	2,600 (3,100)	109,000		951	792	158.1	118.1	26.2	177.2	1998
	Ocean Princess	1,950 (2,342)	77,441		857	762	132.2	105.8	26.6	159.1&	2000
	Golden Princess	2,600 (3,100)	109,000		951	792	158.1	118.1	26.2	177.2	2001
	Star Princess	2,600 (3,100)	109,000		951	792	158.1	118.1	26.2	177.2	2002
	Coral Princess	1,950	88,000		886						2002
	Island Princess	1,950	88,000		886						2003
	Diamond Princess	2,600	113,000								2003
	Sapphire Princess	2,600	113,000								2004

& This corresponds to the maximum air draft with the mast lowered.

TABLE 4, CONTINUED
RECENT DELIVERIES AND NEW LARGE CRUISE SHIPS ON ORDER (AMONG ALASKA OPERATORS)

Operator	*Ship*	*Passenger capacity in lower berth (Max.)*	*Gross Tonnage*	*Displacement (metric tons)*	*Length Overall (feet)*	*Register Length*	*Beam Max @ Bridge (feet)*	*Beam Register (feet)*	*Maximum Draft (feet)*	*Air Draft (feet)*	*Year Finished*
Royal Caribbean	Explorer of the Seas	3,138 (3,840)	142,000	64,474	1,020		157.4	126.6	28.2	207.0^	2000
	Adventure of the Seas	3,138 (3,840)	142,000	64,474	1,020		157.4	126.6	28.2	207.0^	2001
	Brilliance of the Seas	2,100 (2,501)	90,090	46,500	962		131.2	105.6	27.9	173.2^	2002
	Navigator of the Seas	3,138 (3,840)	142,000	64,474	1,020		157.4	126.6	28.2	207.0^	2002
	Serenade of the Seas	2,100 (2,501)	90,090	46,500	962		131.2	105.6	27.9	173.2^	2003
	Voyager Class 5	3,138 (3,840)	142,000	64,474	1,020		157.4	126.6	28.2	207.0^	2003
	Jewel of the Seas	2,100 (2,501)	90,090	46,500	962		131.2	105.6	27.9	173.2^	2004
American Hawaiian Cruises	Queen of the Americas	1,900	72,000		840			105.7	26.3	<180 ft	2003
	Hawaii 2	1,900	72,000		840			105.7	26.3		

^ This is the stated height to the top of the stacks. The maximum air draft (to the top of the radio antennae) may be as much as 10 to 18 feet more, based on the known difference between the two air drafts for some large cruise ships.

Comment: The American Hawaiian vessels under construction at Ingalls Shipyard in Pascagoula, Mississippi, are the first large cruise ships built in the United States in more than 40 years. While designed for Hawaiian service, these vessels are U.S.-built and U.S.-flagged, and thus may embark/disembark passengers on voyages between any U.S. ports.

TABLE 5
LARGE CRUISE SHIPS WORLDWIDE

Ship	*Passenger capacity in lower berth*	*Gross Tonnage*	*Length Overall (feet)*	*Beam Max @ Bridge (feet)*	*Maximum Draft (feet)*	*Air Draft (feet)*	*Status/ Estimated Inaugural*
Queen Mary 2	2,620	150,000	1,131	147.5	32.8	236^	Late 2003
Voyager of the Seas	3,138	142,000	1,020	157.4	28.2	207^	Active
Explorer of the Seas	3,138	142,000	1,020	157.4	28.2	207^	Active
Adventure of the Seas	3,138	142,000	1,020	157.4	28.2	207^	Nov. 2001
Navigator of the Seas	3,138	142,000	1,020	157.4	28.2	207^	Oct. 2002
Voyager Class 5	3,138	142,000	1,020	157.4	28.2	207^	Fall 2003
Diamond Princess	2,600	113,000					Jul. 2003
Sapphire Princess	2,600	113,000					May 2004
SuperStar Sagittarius II	3,000	112,000	1,037				Oct. 2003
SuperStar Capricorn II	3,000	112,000	1,037				Oct. 2004
Carnival Conquest	2,976	110,000	~954	~141.7	~27.2	~208	Nov. 2002
Carnival Glory	2,976	110,000	~954	~141.7	~27.2	~208	Mid-2003
Carnival Valor	2,976	110,000	~954	~141.7	~27.2	~208	Fall 2004
Grand Princess	2,600	109,000	951	158.1	26.2	177	Active
Golden Princess	2,600	109,000	951	158.1	26.2	177	Active
Star Princess	2,600	109,000	951	158.1	26.2	177	Mar. 2002
Costa Fortuna	2,720	105,000	894	141.7	27.2	208	Late 2003
Costa Magica	2,720	105,000	894	141.7	27.2	208	Late 2004
Carnival Triumph	2,766	102,353	894	141.7	27.2	208	Active
Carnival Victory	2,758	101,509	894	141.7	27.2	208	Active
Carnival Destiny	2,642	101,353	894	141.7	27.2	208	Active
P&O (unnamed)	2,600	101,000					Spr. 2004
Norwegian Star	2,244	91,000	965		26.2		Nov. 2001
Norwegian Dawn	2,300	91,000					Oct. 2002
Celebrity Millennium	1,950	91,000	965		26.3		Active
Celebrity Infinity	1,950	91,000	965		26.3		Active
Celebrity Summit	1,950	91,000	965		26.3		Oct. 2001
Celebrity Constellation	1,950	91,000	965		26.3		Jun. 2002
Radiance of the Seas	2,100	90,090	962	131.2	27.9	173^	Active
Brilliance of the Seas	2,100	90,090	962	131.2	27.9	173^	Apr. 2002
Serenade of the Seas	2,100	90,090	962	131.2	27.9	173^	Jun. 2003
Jewel of the Seas	2,100	90,090	962	131.2	27.9	173^	Jun. 2004
Coral Princess	1,950	88,000	886				Oct. 2002
Island Princess	1,950	88,000	886				Jun. 2003

^ This is the stated height to the top of the stacks. The maximum air draft (to the top of the radio antennae) may be as much as 10 to 18 feet more, based on the known difference between the two air drafts for some large cruise ships.

TABLE 5, CONTINUED
LARGE CRUISE SHIPS WORLDWIDE

Ship	*Passenger capacity in lower berth*	*Gross Tonnage*	*Length Overall (feet)*	*Beam Max @ Bridge (feet)*	*Maximum Draft (feet)*	*Air Draft (feet)*	*Status/ Estimated Inaugural*
Carnival Spirit	2,114	85,920	960	128.4	26.2	172	Active
Carnival Pride	2,114	85,920	960	128.4	26.2	172	Jan. 2002
Carnival Legend	2,114	85,920	960	128.4	26.2	172	Mid-2002
Carnival Miracle	2,114	85,920	960	128.4	26.2	172	Spr. 2004
Zuiderdam	1,848	84,000	951				Sep. 2002
Oosterdam	1,848	84,000	951				Jul. 2003
Vista Class 3	1,848	84,000	951				Jan. 2004
Vista Class 4	1,848	84,000	951				Sep. 2004
Vista Class 5	1,848	84,000	951				May 2005
Disney Magic	1,760	83,000	964				Active
Disney Wonder	1,760	83,000	964				Active

Comment: The ships that have called at Ketchikan (during 1991–2001) are indicated in bold. All three of them first called at Ketchikan in the 2001 season.

TABLE 6
HISTORICAL CRUISE SHIP TRAFFIC AT KETCHIKAN, ALASKA

	Total			*Small Cruise Ships*			*Large Cruise Ships*			
Year	*Pass.*	*Ships*	*Stops*	*Pass.*	*Ships*	*Stops*	*Pass.*	*Ships*	*Stops*	*Avg Capacity*
1991	261,459	27	393	5,983	5	71	255,476	22	322	793
1992	263,046	23	364	8,190	6	94	254,856	17	270	944
1993	321,780	28	421	11,619	10	138	310,161	18	283	1096
1994	380,522	31	453	9,211	10	115	371,311	21	338	1099
1995	381,805	33	445	9,927	10	110	371,878	23	335	1110
1996	437,491	35	494	11,090	11	129	426,401	24	365	1168
1997	496,981	35	472	10,351	13	121	486,630	22	351	1386
1998	520,151	35	489	13,179	14	145	506,972	21	344	1474
1999	541,381	32	452	9,261	11	104	532,120	21	348	1529
2000	549,114	38	461	9,994	15	113	539,120	23	348	1549
2001	652,486	39	519	11,962	15	134	640,524	24	385	1664

Based on independent reanalysis of Ketchikan Cruise Ship Calendars prepared by the Ketchikan Visitors Bureau (KVB) for years 1991 through 2001. In a few instances, this table presents passenger totals with minor differences when compared to totals previously published by KVB (e.g., 1995). These minor differences are attributed to identifiable arithmetic errors.

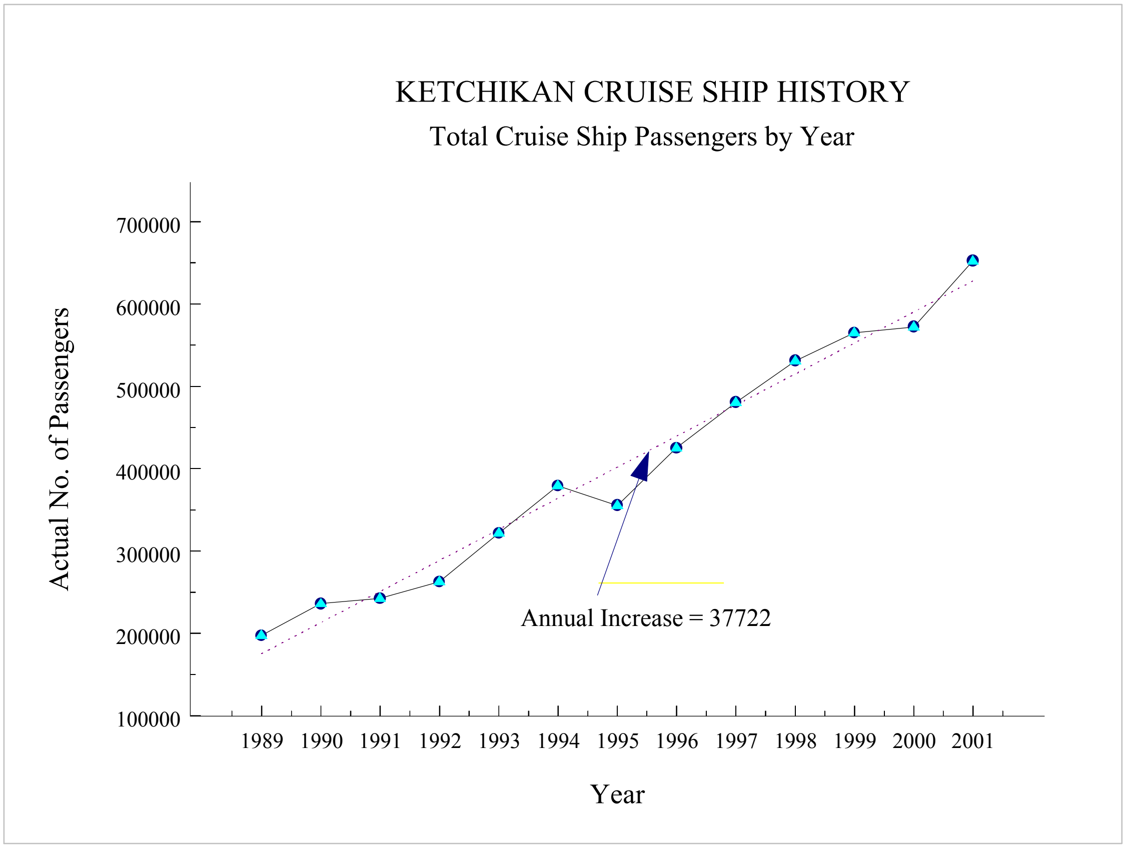


FIGURE 4
TOTAL CRUISE SHIP PASSENGERS CALLING AT KETCHIKAN BY YEAR

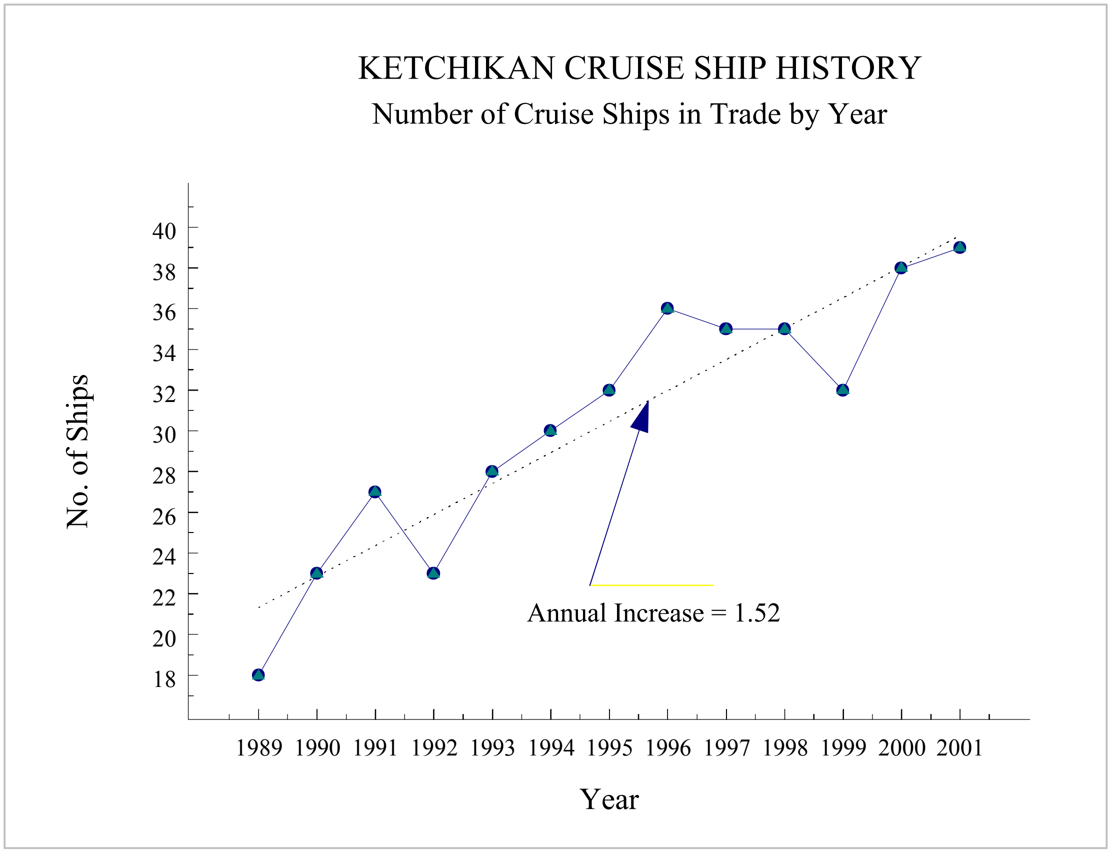


FIGURE 5
NUMBER OF CRUISE SHIPS IN TRADE BY YEAR

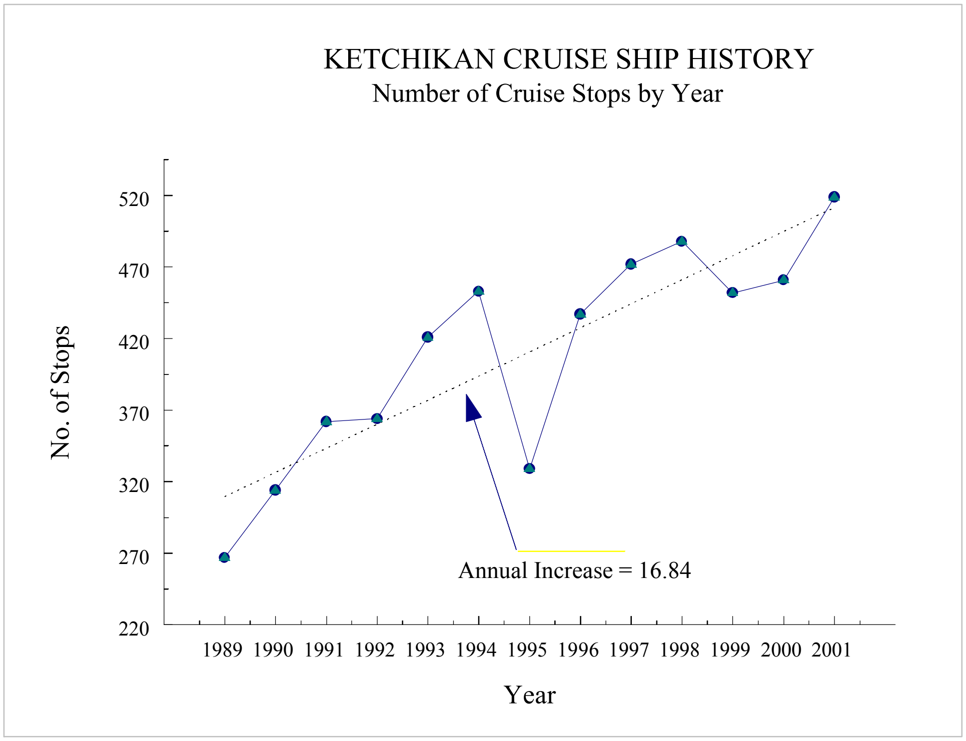


FIGURE 6
NUMBER OF CRUISE SHIP STOPS AT KETCHIKAN BY YEAR

TABLE 7
CAPACITY RATIO FOR CRUISE SHIPS CALLING AT KETCHIKAN IN THE YEARS 1991 THROUGH 2000

Year	*Aggregate Capacity (Lower Berth)*	*Cruise Passengers (Actual)*	*Capacity Ratio*
1991	261,459	242,755	92.85%
1992	263,046	263,046	100.00%
1993	321,780	321,780	100.00%
1994	380,522	379,645	99.77%
1995	381,805	355,784	93.18%
1996	437,491	426,232	97.43%
1997	496,981	480,688	96.72%
1998	520,151	531,108	102.11%
1999	541,381	565,005	104.36%
2000	549,114	572,464	104.25%

Capacity ratios exceeding 100% are possible because cruise ship capacities are rated based on lower-berth capacity.

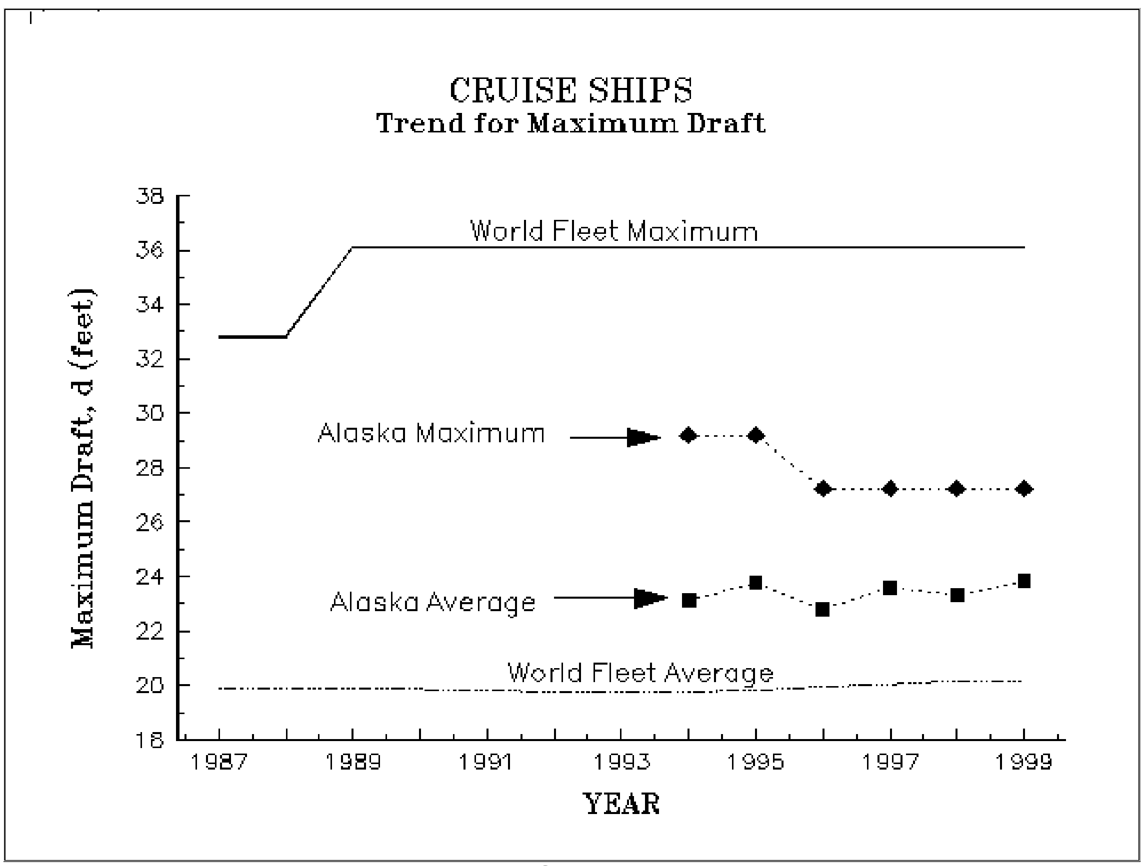


FIGURE 7
LARGE CRUISE SHIP NAVIGATION DRAFT TRENDS

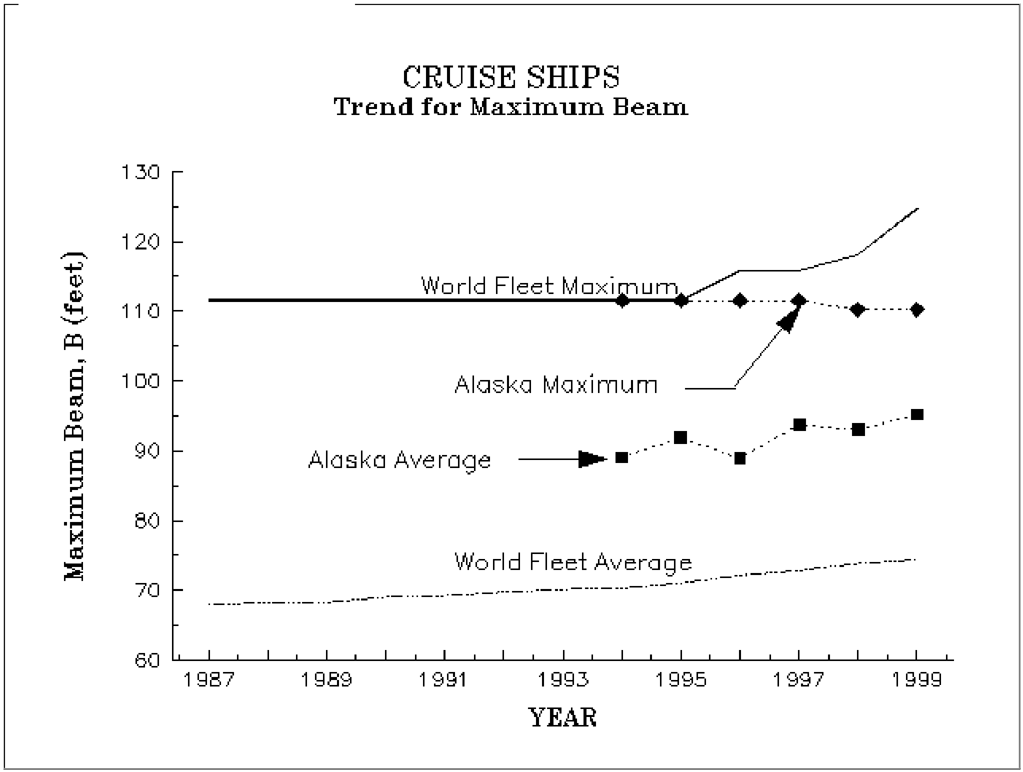


FIGURE 8
LARGE CRUISE SHIP MAXIMUM BEAM TRENDS

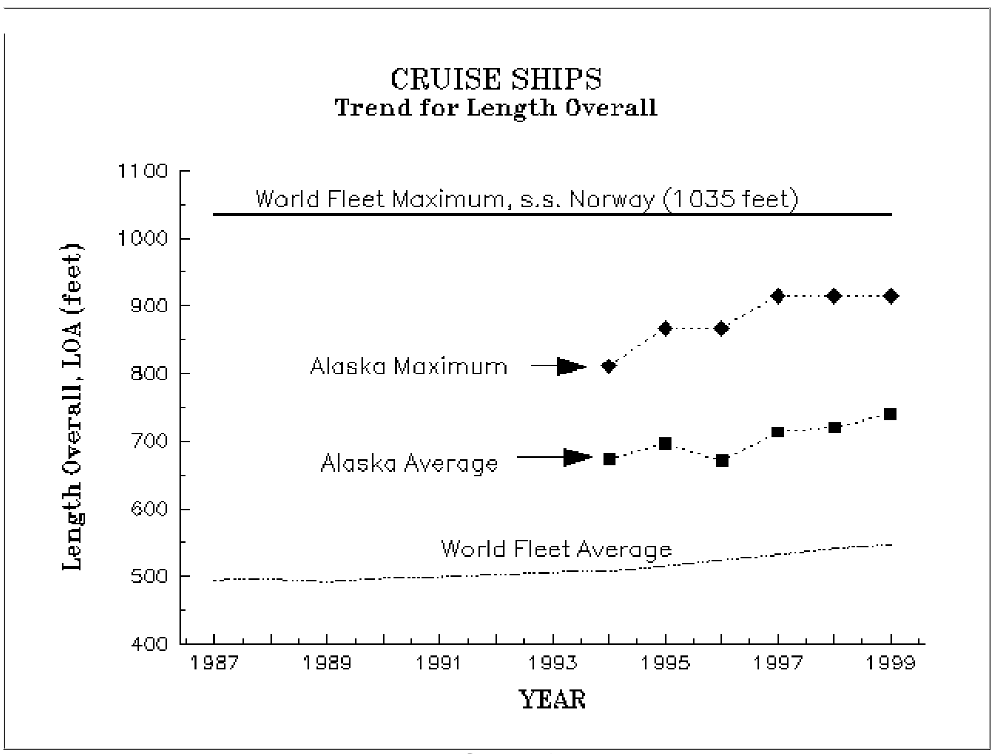


FIGURE 9
LARGE CRUISE SHIP LENGTH OVERALL TRENDS

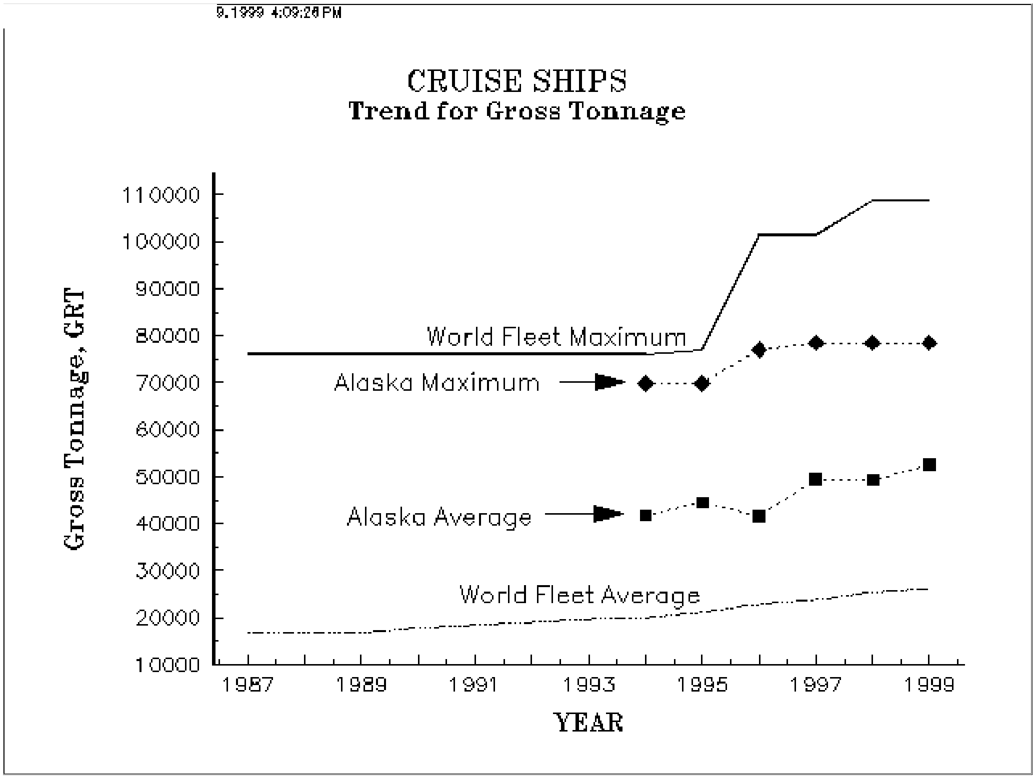


FIGURE 10
LARGE CRUISE SHIP GROSS REGISTER TONNAGE TRENDS

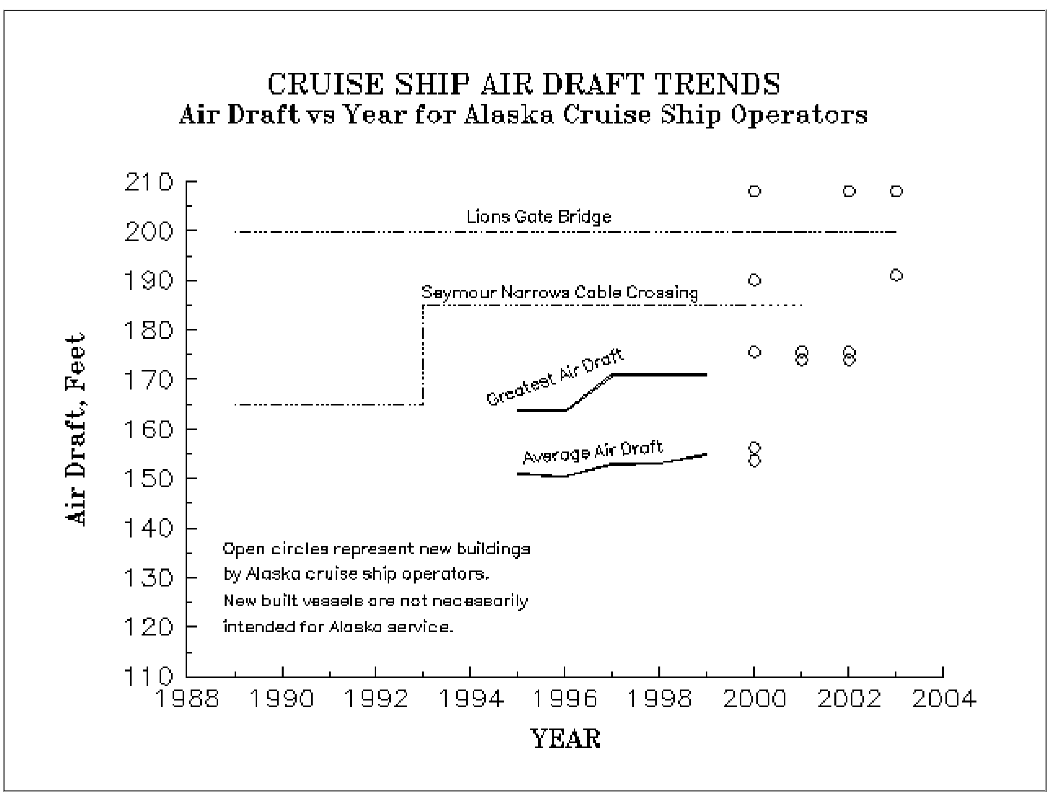


FIGURE 11
LARGE CRUISE SHIP AIR DRAFT TRENDS

2.3 Small Cruise Operators

In addition to the large cruise ships operating in southeast Alaska and calling at Ketchikan, a growing number of small cruise ships offer adventure and/or nature-oriented cruising opportunities. Table 7 (taken from the Ketchikan Visitors Bureau's cruise ship calendar for 2001) provides a representative sample of these vessels.

To put the small-cruise operations into perspective: of the 39 cruise ships scheduled to call at Ketchikan in the 2001 season, 24 were large cruise ships and 15 were small cruise ships. In terms of the potential number of passengers arriving on these ships: the potential total for 2001, including large and small cruise ships, was estimated at 652,486; of these, the potential total for the 15 small cruise ships was 11,962—about 1.8% of the total number of potential passengers for 2001.

Because of their dimensions and maneuverability, small cruise ships are not expected to impose constraints on any of the proposed Gravina Access Project bridge alternatives.

TABLE 8
SMALL CRUISE VESSELS OPERATING IN SOUTHEAST ALASKA

Operator	*Vessel*	*Number of Passengers*	*Length Overall (feet)*	*Beam (feet)*	*Draft (feet)*	*Tonnage*
Alaska's Glacier Bay Tours and Cruises	*Executive Explorer*	49	98.5	36.75		
	Wilderness Adventurer	74	156			
	Wilderness Discoverer	88	169	38		95
	Wilderness Explorer	36	104			
Clipper Cruise Lines	*Clipper Odyssey*	114	338			
	Yorktown Clipper	138	257	43	8	99.5
Special Expeditions	*Sea Bird*	70	152	31	8	99.7
	Sea Lion	70	152	31	8	99.7
Alaska Sightseeing/ Cruise West	*Spirit of Discovery*	84	166			94
	Sheltered Seas	90	90			95
	Spirit of Glacier Bay	58	125			97
	Spirit of Alaska	82	143			97
	Spirit of Columbia	78	143			98
	Spirit of '98	101	192			96
	Spirit of Endeavor	102	219			99

2.4 Alaska Marine Highway System

The Alaska Marine Highway System (AMHS) serves twenty-one southeast Alaska communities, while also connecting with Prince Rupert, British Columbia, and Bellingham, Washington. To do so, it operates five mainline and two feeder vehicle and passenger ferries in southeast Alaska. The mainline vessels are the *Columbia, Kennecott, Malaspina, Matanuska,* and *Taku*. Currently the *Columbia, Kennicott, Matanuska* and

Taku routinely call at Ketchikan. The feeder vessels are *Aurora* and *Le Conte*. Under current schedules, the *Aurora* routinely calls at Ketchikan.

2.4.1 Current Operations

Table 9 indicates the principal dimensions of the AMHS vessels that currently have routine operations in southeast Alaska. Note that the AMHS fleet also includes the *Bartlett* (193' long; 190 passengers, 29 vehicles), which operates in Prince William Sound, and the *Tustumena* (296' long; 210 passengers, 36 vehicles), which operates in Prince William Sound and southwest Alaska (out to Unalaska).

Figure 12 indicates that AMHS port calls at Ketchikan have been remarkably steady over the past decade. Table 10 shows annual port calls, by vessel, at Ketchikan during 1997 and 1998. Table 11 shows Ketchikan port calls during the peak-traffic month in the 2001 annual cycle (August). The data in Figure 12 and Table 10 were obtained from References [5] and [6], while the data in Table 11 were obtained from the AMHS Website (Reference [7]).

The 116 AMHS port calls at Ketchikan in August 2001 represent an average of 3.74 port calls per day. According to the 2001 schedule, the peak number of AMHS vessel calls is 6 per day.

TABLE 9
DIMENSIONS OF ALASKA MARINE HIGHWAYS VESSELS OPERATING IN SOUTHEAST ALASKA

Vessel	*Capacity (Passengers/ Vehicles)*	*Length Overall (feet)*	*Beam (feet)*	*Draft (feet)*	*Air Draft (feet)*
Columbia	625 / 134[A]	418	85	17.5	106+
Malaspina	500 / 88[A]	408	74	16.67	106+
Matanuska	500 / 88[A]	408	74	16.67	106+
Taku	450 / 69[A]	352	74	16.67	90+
Kennicott	748 / 120[B]	382	85	17.5	95
Aurora	250 / 34[A]	235.75	57.33	14	65.33
Le Conte	250 / 34[A]	235.75	57.33	14	65.33

A 20-ft lengths

B Alaska standard vehicles

Notes: 1) Drafts are maximum navigation drafts, corresponding variously with the loadline and/or the draft used in American Bureau of Shipping scantling determinations.

2) Air drafts followed by a plus sign '+' are measured from the design waterline. The maximum air draft could be greater under some light loading conditions. In general, the increase in air draft should be no more than 3 feet.

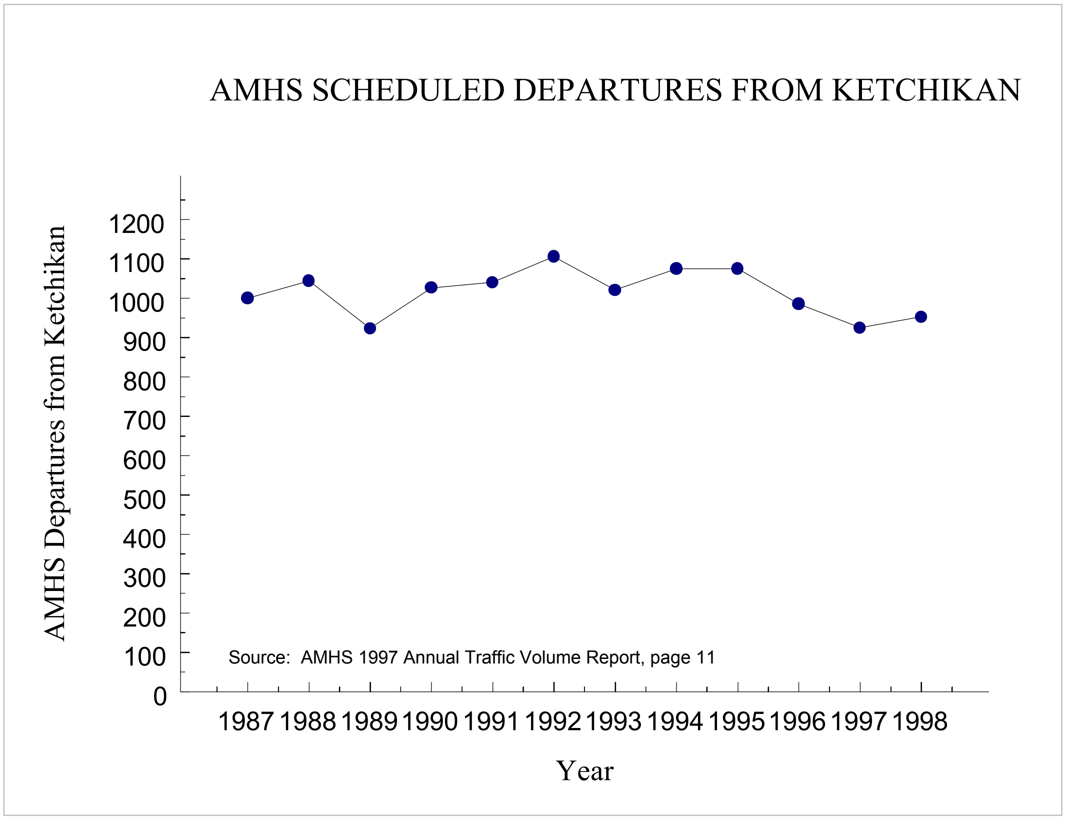


FIGURE 12
AMHS PORT CALLS AT KETCHIKAN

TABLE 10
ALASKA MARINE HIGHWAYS VESSEL CALLS AT KETCHIKAN

Vessel	*1997*	*1998*
Columbia	62	49
Malaspina	124	11
Matanuska	82	88
Taku	159	114
Aurora	566	576
Le Conte	50	37
Kennicott	—	34
	1043	**909**

Source: Based on data in the "AMHS Annual Traffic Volume Report," 1997 (p. 26) and 1998 (p. 27)

TABLE 11
ALASKA MARINE HIGHWAYS VESSEL CALLS AT KETCHIKAN, AUGUST 2001

	August 2001
Columbia	9
Malaspina	0
Matanuska	9
Taku	18
Aurora	64
Le Conte	0
Kennicott	16
	116

Source: AMHS Official Summer 2001 Schedule

2.4.2 Effect of Southeast Alaska Transportation Plan

In March 1999, the Alaska Department of Transportation & Public Facilities (DOT&PF) approved a new regional-transportation master plan for southeast Alaska (Reference [8]). Known as the "Southeast Alaska Transportation Plan" (SATP), the plan proposed significant changes in the way in which ferry service is delivered in the southeast Alaska region. Consequently, it will alter the future character of the AMHS vessels calling at Ketchikan.

Earlier this year, in February 2001, the Southeast Region of the DOT&PF, which was tasked with implementing the SATP, issued an Addendum One to the SATP (Reference [9]). The addendum further refines the plan, and summarizes the results of the studies commissioned in accordance with the SATP and the transportation initiatives taken in response to the results of those studies and public input.

The SATP planning horizon is the period between 2000 and 2020. When implemented, the SATP will result in continued service throughout southeast Alaska by the existing mainline vessels (*Columbia, Kennicott, Matanuska, Malaspina* and *Taku*), as well as daily service from new smaller vessels providing regional, community, or shuttle services as defined in the SATP. These smaller vessels may be either conventional or high-speed vessels, depending on route.

It may be of interest to note the planned construction of the Sitka Shuttle Ferry (also known as the Fast Vehicle Ferry), which will operate between Juneau and Sitka when it goes into service in 2004. The ferry will have an aluminum catamaran hull and a service speed of 32 knots. It has the approximate principal dimensions listed below and a capacity of 250 passengers and 35 standard automobiles (or 30 standard automobiles with an additional 90,000 pounds of capacity for commercial vans, trailers, and/or large recreational vehicles).

Length:	≈	243 feet
Beam:	≈	65 feet
Draft:	≈	12 feet
Air Draft:	≈	99 feet

The specific proposals pertaining to Ketchikan that were outlined in Reference [9] include the following; their updated status was obtained through References [10] and [11].

- The construction of terminal improvements at Ketchikan, which should be completed before the end of 2001.
- The selection of an open-deck, heavy-weather vessel type for the Ketchikan–Metlakatla run ("Metlakatla Ferry") to implement service prior to the completion of a road and new terminal on Annette Island. This shuttle ferry service, which will permit direct service between the Ketchikan-Saxman area and Metlakatla, has been accelerated to May 2003.
- A sister ship ("Ketchikan Shuttle") to the Sitka Shuttle ferry for service between Ketchikan and South Mitkof. Currently, it is expected to go into service in mid-2005. (Two other sister shuttles—the "Cordova Shuttle," slated for service in early 2005, and the "Juneau Shuttle," are expected to be in service in 2006.)
- A shuttle ferry ("Southern Gateway Shuttle") between Ketchikan and Prince Rupert. The timeline for this service remains to be determined.
- The construction of two local services (one between Ketchikan and Hollis, and the proposed second for service between Coffman Cove, Mitkof Island, and Wrangell) to be owned and operated by the Inter-Island Ferry Authority, as discussed in more depth in Section 2.4.3.

Notwithstanding these planned improvements, because of the smaller size and maneuverability of the new vessels, they are unlikely to impose governing constraints on any of the proposed Gravina Access Project bridge alternatives.

2.4.3 Inter-Island Ferry Authority (IFA)

The Inter-Island Ferry Authority (IFA), an Alaska port authority established in 1997 under the Municipal Port Authority Act, has initiated plans for the construction of two new passenger and vehicle ferries to meet the growing demand for ferry transportation between Prince of Wales Island communities and Ketchikan, Wrangell, and Petersburg.

The first ferry is a conventional displacement monohull similar to (although somewhat smaller than) the existing AMHS vessels *Aurora* and *Le Conte*. It was designed by Elliott Bay Design Group, Ltd., Seattle. Construction of the ferry was begun by Dakota Creek Industries in Anacortes, Washington, in December 2000, and the shipyard is expected to deliver the vessel in late 2001.

The dimensions of this ferry—to be named *Prince of Wales*—are:

Length:	=	197.5 feet
Beam:	=	53.0 feet
Draft:	=	11.0 feet
Depth:	=	17.8 feet
Air Draft:	=	66.0 feet

The ferry will provide service on a route between Clark Bay (Hollis) on Prince of Wales Island and Ketchikan, a route currently served by *Aurora*. The IFA plans to provide year-round, twice-daily summer service (May through September) and once-daily winter service on this route, while anticipating the use of a sixteen-hour-long, two-shift operating day to provide this level of service. This would work out to approximately 515 calls at Ketchikan annually. In comparison, in 1998 the number of sailings between Ketchikan and Hollis by *Aurora* and *Le Conte* were, respectively, 547 and 24, for a total of 571. Therefore, when the *Prince of Wales* commences service and displaces the *Aurora* and *Le Conte* on this route, a small reduction in the number of port calls at Ketchikan may result.

A third berth at the Ketchikan terminal is being constructed by South Coast, Inc, and the work is expected to be completed in October. When completed, this new, custom-designed facility will serve the *Prince of Wales*, the Ketchikan Shuttle, and also (until the Saxman Terminal is completed) the Metlakatla Ferry.

The proposed second new ferry will initiate a new service linking Coffman Cove on Prince of Wales Island, South Mitkof, and Wrangell. The IFA initially plans to offer seasonal (May through September) service on this route and anticipates initiating this service with a one-shift operating day. It also anticipates that this route could experience significant growth of traffic and service over time. However, because the ferry will not routinely operate into Ketchikan, no impact on the Gravina Access Project bridge alternatives is expected.

2.5 Barges

Tug and barge transportation is the principal mode of delivery for both dry and liquid cargoes throughout southeast Alaska.

The waterborne commerce statistics indicate an average of 2,223 trips per year by dry cargo barges in Tongass Narrows (including Ketchikan) for the years 1990 through 1999, as shown in Table 2. Three major common carriers that provide containerized barge service make a total of four scheduled calls per week to Ketchikan year-round, for a potential total of about 624 calls (3 carriers times 4 calls/week times 52 weeks), corresponding to 1,248 transits, or about 15% of the average total reported transits.

Petroleum products are also delivered almost exclusively by barge, there being an average of 297 petroleum barge trips in Tongass Narrows (including Ketchikan) for the reported years, as shown in Table 2. It is interesting to note that the number of tanker transits has dropped to zero (with a steep drop since 1996), while there has been an increase in petroleum barge transits. Diminishing tanker traffic is believed to be due to the retirement of old tankers from the trade, so the 1999 figures (534 petroleum barge trips, which is also the maximum in the last decade) should better reflect future traffic patterns.

Through-traffic by barges is a significant contributor to total annual volume, though not necessarily an issue in peak congested-traffic periods. Some barge operators have expressed a preference for transiting Tongass Narrows in the stormy winter months, as this route minimizes the exposure time crossing Dixon Entrance. In the summer months, the same operators would more likely head westward across the Gulf at Dixon Entrance, or use the alternative route through Clarence Strait to avoid the congestion in Tongass Narrows.

2.6 Tankers

As described in the previous subsection, the number of tanker transits in Tongass Narrows has dropped to zero, accompanied by a rise in petroleum barge transits. While it is not expected that this trend may reverse, it is worthwhile to point out the salient characteristics of tankers that have transited Tongass Narrows in years past.

Coast Range and *Blue Ridge*, sister tanker ships owned and operated by Crowley Petroleum Transport, Inc., have called at Ketchikan. (They were formerly operated by Unocal–Standard Oil of California–but are now operated by Crowley.) According to Crowley Petroleum, these are about as large a tanker as one would ever consider sending to Ketchikan.

All three vessels were built at NASSCO in San Diego. *Coast Range* was built in 1981; its register dimensions are 635.5-foot length, 100.1-foot beam, and 42.9-foot hull depth. (Note that the overall length may be about 685 feet.) They are propelled by steam turbines and have a nominal deadweight capacity of 40,631 long tons. The distance from keel to the top of the radar mast is 150 feet, the maximum navigation draft is about 36 feet, and the ballast condition navigation draft is 23 feet aft. This suggests the following two conditions:

- Full load (inbound, loaded): Navigation draft of 36 feet and air draft of 114 feet
- Ballast condition (presumptive departure condition): Navigation draft of 23 feet (aft) and air draft of 127 feet

Crowley has confirmed (Reference [12]) that neither *Coast Range* nor *Blue Ridge* has sailed to Ketchikan in the last four years; nor are there plans to send them to Ketchikan in the future. To the extent that Crowley participates in fuel deliveries to Ketchikan, Crowley has stated that it would use smaller tankers or, alternatively, tank barges.

2.7 U.S. Coast Guard

The U.S. Coast Guard operates from a base located between Ketchikan and Saxman on Revillagigedo Island. Two cutters and one buoy tender (BT) operate from this base, with salient characteristics as shown in Table 12.

TABLE 12
DIMENSIONS OF U.S. COAST GUARD CUTTERS STATIONED AT KETCHIKAN

Vessel	*Length Overall (feet)*	*Beam (feet)*	*Draft (feet)*	*Air Draft (feet)*
Achusnet (Cutter)	213	40.67	13.92	100
Anthony Petit (BT)	175	36	7.9	Undetermined
Naushon (Cutter)	110	21.92	7.33	60

Sources: Internet (http://www.uscg.mil/datasheet/dataindx.htm) and phone conversation with Lt. Cdr. Corporon, USCG, Ketchikan, 17 September 2001

Other, larger U.S. Coast Guard buoy tenders will occasionally call at Ketchikan. These buoy tenders have a length of 225 feet, a beam of 42.67 feet, a draft of 13.5 feet, and an air draft of 90 feet.

The largest vessels operated by the U.S. Coast Guard are its 378-foot Hamilton class cutters and its ice breakers *Polar Sea*, *Polar Star,* and *Healy*. However, these Coast Guard vessels rarely, if ever, call at Ketchikan. Table 13 provides additional characteristics of these large cutters.

TABLE 13
DIMENSIONS OF LARGE U.S. COAST GUARD CUTTERS STATIONED ELSEWHERE

Vessel Class	*Length Overall (feet)*	*Beam (feet)*	*Draft (feet)*	*Air Draft (feet)*	*Stationed At*	*Primary Operating Areas*
Polar Class	399	83.5	28	138	Seattle (2 vessels)	Arctic and Antarctic
Healy	420	82	29.25		Seattle	Arctic and Antarctic
Hamilton	378	43			See Note 1	Throughout the world's oceans

Source: Internet (http://www.uscg.mil/datasheet/dataindx.htm)

Note 1. Twelve ships in class with home ports of Alameda, California (4); San Diego, California (2); Charleston, South Carolina (2); Seattle, Washington (2); and Honolulu, Hawaii (2)

2.8 U.S. Navy

There are no known significant U.S. Navy operations in Tongass Narrows. However, the U.S. Coast Guard base is designated as an emergency port facility for submarines making use of the Back Island acoustic range on Behm Canal.

While U.S. Navy vessels do not routinely operate in Tongass Narrows, it is instructive to consider the principal dimensions of major classes of naval vessels as given in Table 14. (The data were obtained from Reference [13].)

TABLE 14
CHARACTERISTIC DIMENSIONS OF LARGE U.S. NAVY VESSEL CLASSES

Class Designation	Vessel Type	Displacement (feet)	Condition	Length (feet)	Beam (feet)	Draft (feet)	Air Draft (feet)
CVN	*Aircraft Carrier*	*81,600*	*Standard*	*1092*	*134*	*37*	*207*
CG	*Cruiser*	*9,100*	*Loaded*	*563*	*55*	*31*	*201*
CGN	*Cruiser*	*11,000*	*Loaded*	*585*	*63*	*30*	*190*
AOE	*Fast Combat Support*	*53,600*	*Loaded*	*793*	*107*	*40*	*---*
LHD	*Amphibious Assault*	*40,500*	*Loaded*	*844*	*106*	*27*	*---*
SSBN	*Ballistic Missile Submarine*	*18,700*	*Submerg ed*	*560*	*42*	*36.5*	*91*

Source: Internet and Norman Polmer, The Ships and Aircraft of US Fleet, *12th edition, Naval Institute Press, Annapolis, Maryland, 1983.*

Note: SSBN 732, USS Alaska *has made a courtesy port call at Ketchikan in the recent past.*

2.9 Commercial Fishing Boats, Charter Vessels, and Small Craft

The Ketchikan area has seven small-boat harbors. Their capacities are shown in Table 15, and the distribution of boat types is shown in Table 16, as obtained from Reference [14].

TABLE 15
KETCHIKAN HARBOR CAPACITIES

	<21'	21'-30'	31'-40'	41'-50'	51'-70'	71'-100'	>100'	Total
Bar Harbor North	*53*	*109*	*61*	*34*	*7*	*2*	*0*	*266*
Bar Harbor South	*110*	*165*	*92*	*30*	*31*	*3*	*0*	*431*
City Float	*14*	*0*	*0*	*0*	*0*	*0*	*0*	*14*
Thomas Basin	*50*	*30*	*55*	*27*	*20*	*0*	*0*	*182*
Ryus Dock		*Transient and Lighterage Moorage Only*						
Hole-in-the-Wall	*17*	*9*	*2*	*0*	*0*	*0*	*0*	*28*
Knudsen Cove	*29*	*20*	*0*	*0*	*0*	*0*	*0*	*49*
TOTAL	*273*	*333*	*210*	*91*	*58*	*5*	*0*	*970*

Source: Alaska DOT&PF, Ports & Harbors, Alaska Harbor Management System, Operations Management Report, 1994

TABLE 16
1994 KETCHIKAN HARBOR CENSUS

	Recreational	Fishing Charter	Commercial Fishing	Other	Total
Bar Harbor North	174	24	47	19	264
Bar Harbor South	288	21	97	13	419
City Float		Transient Only			
Thomas Basin	90	12	73	2	177
Ryus Dock		Transient and Lighterage Moorage Only			
Hole-in-the-Wall	25	0	3	0	28
Knudsen Cove	42	1	4	0	47
TOTAL	619	58	224	34	935

Source: Alaska DOT&PF, Ports & Harbors, Alaska Harbor Management System, Operations Management Report, 1994

In 1998, the City of Ketchikan Port & Harbors Department recorded the following:

Transient boats:	3,000 to 4,000
Boat-days of transient moorage:	6,050
One-month transient moorage permits:	158
Three-month transient moorage permits:	528
Charter boats in harbors:	62
Commercial fishing boats in harbors:	800
Reserved stalls billed out in July 1998:	844
Port calls by 335 ships:	1,045

In addition to the recreational small craft, fishing charter boats, and commercial fishing boats in harbors, there are three very active boat launching ramps in the Ketchikan area: Bar Harbor, Mountain Point, and Knudsen Cove. Launching permits issued by the City of Ketchikan Port & Harbors Department in 1998 are given in Table 17.

TABLE 17
1998 KETCHIKAN BOAT LAUNCH PERMITS

Day Permits	
Bar Harbor	354
Mountain Point	537
Knudsen Cove	672
Total Day Permits	1,563

Annual and Semiannual Permits	
Commercial Permit	2
Annual Permits	436
Semiannual Permits	74
Free Annual Permits To Reserve Moorage Clients (Estimate)	~ 400
Total Annual and Semiannual Permits	912

On summer weekends, the boat launches are in continuous use for at least 12 hours per day. Estimating that an average launch or retrieval takes approximately 5 minutes, the total number of launches and retrievals on a summer weekend must be on the order of 3 times [12*60/5], which is 432 for the three launch ramps.

2.9.1 Kayaks

A large number of kayaks operate on the waters of Tongass Narrows. During the summer tourist season several outfitter and guide operations offer kayak excursions originating in Ketchikan. In addition, local residents also kayak on Tongass Narrows. Kayaks are not easily observed by sight or on radar, and hence are at risk from other vessels. The *Tongass Narrows Voluntary Waterway User Guide* of March 18, 1999 (Reference [15]) identifies two kayak operating zones, one (north kayak zone) extending from Hansen Float to the northern end of Pennock Island and the second (south kayak zone) extending from Thomas Basin to Pennock Island immediately north of Radenbough Cove.

Appendix One of Reference [15] is the *1998 Power Vessel Operator and Kayaker Suggested Guidelines for Safe Operations in Alaska*, which addresses specific operating practices intended to enhance the safety of kayak operations.

2.9.2 Personal Watercraft

Personal watercraft include vessels such as jet skis. Many personal watercraft are small and able to achieve high speeds (on the order of 50 knots). Reference [15] states:

> *Although these craft are not restricted in Tongass Narrows, due to the high volume and variety of traffic in Tongass Narrows, mariners wishing to operate personal watercraft should not operate them in Tongass Narrows.*

The Ketchikan harbormaster has indicated that few personal watercraft operate there (i.e., “less than ten”), but some personal watercraft operate from Knudsen Cove and south of town.

2.10 Gravina Island Ferry

The Gravina Island Ferry currently adds to the traffic congestion in Tongass Narrows. Furthermore, it represents crossing traffic. If a bridge is constructed, the ferry operation might be stopped, and would therefore no longer be a traffic congestion factor. If the expanded-ferry-service alternative is selected, then there would be a nominal increase in cross-channel traffic. However, long-channel traffic enjoys right-of-way privilege and the cross-channel ferries maneuver so as to avoid impeding such traffic.

2.11 Floatplanes

Floatplanes landing and taking off from Tongass Narrows are currently subject to the operational guidelines in Reference [15]. That guide identifies two narrow floatplane operating zones, one in front of the Ketchikan waterfront, and one hugging the Gravina Island shore and extending northwest from the Ketchikan Airport terminal. A third floatplane operating area is located in the vicinity of Ward Cove. As described in the *Tongass Narrows Voluntary Waterway User Guide*, floatplane traffic on Tongass Narrows is seasonally quite heavy, comprising in excess of 500 takeoffs and landings on an average summer day. Aviation is the topic of a separate reconnaissance report that complements this report, and which should be consulted for a more thorough examination of aviation issues.

3—West Coast Bridges and Aerial Cable Crossings

Existing West Coast bridges and aerial cable crossings present significant constraints on the ultimate size and operations of large shipping. The Lions Gate Bridge (located at the First Narrows in Vancouver, BC) and the Seymour Narrows power cable crossing (located north of Campbell River) have recently been acknowledged as design constraints for the new U.S.-built cruise ships to be constructed at Ingalls Shipyard in Mississippi for American Classic Voyages (AMCV).

At 180 feet vertical clearance, the Seymour Narrows power cable crossing is the current controlling constraint for cruise ship traffic. Before 1995, the vertical clearance was 165 feet. The cable crossing was raised in 1995 at a cost on the order of $300,000 (U.S.). Officials at BC Hydro have indicated that the cable could be raised another 3.0 meters (9.8 feet) at a cost probably not exceeding $100,000 (U.S.). This additional three meters of clearance could be achieved by increasing the tension in the cable and reducing the catenary sag. However, this procedure would have the adverse consequence of increasing the fatigue of the power conductor and would thereby increase the risk of interruptions to the electrical power service.

Officials at BC Hydro have also speculated that, for a cost in excess of $1,000,000 (U.S.), the cable could be raised further, to 200 feet, thus achieving a clearance equal to that of the Lions Gate Bridge. Raising the clearance to that extent would entail building new towers and guy arrangements, which accounts for the substantial cost.

It is important to note that the allowable vertical clearance at the Seymour Narrows cable crossing is likely less than the clearances discussed in the previous two paragraphs. This is due to the following pertinent caution from paragraph 126, page 12, of *Sailing Direction –British Columbia Coast (South Portion)*, issued by the Department of Fisheries and Oceans, Ottawa, Canada (Reference [16]):

> *An overhead cable may conduct high voltages and contact, or even close proximity to one, poses extreme danger. If the clearance to avoid a dangerous electrical discharge between a cable and a vessel passing under it is not obtainable from local authorities, then 5 m (16 ft.) less than the vertical clearance should be allowed. Sufficient clearance must also be allowed under an overhead cable bearing in mind that the actual clearance will differ from the charted clearance due to changes in atmospheric and water level conditions.*

Therefore, the useable vertical clearance at the Seymour Narrows cable crossing is closer to 164 feet at present, rather than 180 feet. It is possible that timing a ship's passage for near low tide might add about ten feet to the effective clearance. However, this is not always practical and is not without risk.

Table 18 presents the vertical clearances (uncorrected by the restriction in Reference [16]) for significant bridges and cable crossings on the west coast of the United States and Canada.

TABLE 18
EXISTING WEST COAST BRIDGES AND CABLE CROSSINGS

Bridge or Cable Crossing	*Location*	*Maximum Vertical Clearance*	*Reference for Vertical Clearance**	*Comments*
Near Island Bridge	Kodiak, AK	101 feet	MHHW	200 feet horizontal clearance
Seymour Narrows Cable Crossing	Campbell River, BC	55 m (180 feet)	MHHW	Most Alaska-bound cruise traffic transits Seymour Narrows
Lions Gate Bridge	Vancouver, BC	61 m (200 feet)	MHHW	Most Alaska-bound cruise traffic passes under Lions Gate Bridge
Tacoma Narrows Bridge	Tacoma, WA	180 feet	MHHW	
Astoria highway bridge	Astoria, OR	205 feet	MLLW	Access to Swan Island shipyards
Longview highway bridge	Longview, WA	185 feet[#]	Columbia River Datum	Access to Swan Island shipyards
Saint Johns highway bridge	Portland, OR	205 feet	Columbia River Datum	Access to Swan Island shipyards
BN RR Lift Bridge	Portland, OR	200 feet	Columbia River Datum	499 feet of horizontal clearance; access to Swan Island shipyards
Columbia River Cable Crossings	Various	216 feet	MLLW	Access to Swan Island shipyards
Golden Gate Bridge	San Francisco, CA	225 feet	MHHW	
San Francisco – Oakland Bay Bridge	San Francisco, CA	204 feet in recommended channel	MHHW	220 feet in some spans with cautions regarding span sag due to traffic live load & temperature
Vincent Thomas Bridge	Los Angeles, CA	185 feet	MHHW	Old cruise ship terminal is upstream of bridge, but new terminal is down-stream of bridge.
Coronado Bridge	San Diego, CA	195 feet	MHHW	Access to NASSCO shipyard

** MLLW = mean lower low water; MHHW = mean higher high water.*

[#] According to NOAA Chart 18524. The U.S. Coast Pilot states: "The Lewis and Clark Bridge, at Mile 57.3 (66.0) between Longview and Rainier, has a fixed span with a clearance of 187 feet."

To provide a sense of the horizontal navigation clearances with which marine pilots must contend, Table 19 lists the horizontal clearances at a number of bridge crossings and channels worldwide.

TABLE 19
AVAILABLE HORIZONTAL CLEARANCES
AT SOME BRIDGE CROSSINGS AND CHANNELS WORLDWIDE

Bridge	*Bridge Type*	*Horizontal Clearance*	*Vertical Clearance*	*Volume of Large Ship Traffic*	*Large Ship Types*
Coos Bay, OR	Railroad bridge Highway	197 feet	Unlimited (swing bridge) 149 feet	198 ships in 1999 with drafts exceeding 20 feet	100% dry cargo (but historical traffic included tankers)
Corpus Christi, TX	Harbor bridge	300 feet	138 feet	2,836 ships in 1999 with drafts exceeding 20 feet	71% tankers and 29% passenger & dry cargo
Burlington Northern R.R. Bridge, Portland, OR	Lift bridge	499 feet	200 feet (Up)	Approximately 845 ships in 1999 with drafts exceeding 20 feet	100% dry cargo
Houston Ship Channel, TX		500 feet #	175 feet #	10,016 ships in 1999 with drafts exceeding 20 feet	50.5% tankers and 49.5% passenger & dry cargo
Coronado Bridge, San Diego, CA		600 feet	195 feet	Two 600-ft. spans available supporting two-way traffic	Includes large commercial vessels and large naval vessels
Mississippi River, New Orleans, LA		750 feet #	133 feet #	Two-way traffic	
Lions Gate Bridge, Vancouver, BC		≈ 1270 feet	200 feet	Approximately 6,098 transits by large ships in 2000	1,053,989 cruise passengers in 2000 and 76 million metric tons of cargo
Ketchikan, AK				781 ships in 1999 with draft exceeding 20 feet	100% passenger & dry cargo (dominated by passenger, but historical traffic includes some tankers & dry cargo)

 # U.S. Coast Guard bridge guide clearance for specified navigable water

Table 19 suggests that ships are able to navigate safely under a variety of conditions through bridge crossings and channels that offer horizontal clearances significantly less than those recommended by the Permanent International Association of Navigation Congresses.

3.1 Horizontal Navigation Clearances at Coos Bay, OR

Coos Bay, OR, was selected as an example of one of the channels offering low horizontal clearance (based on the ratio of horizontal clearance to ship beam). Following are the salient characteristics of the channel.

Depth. Channel depth is 47 feet/14.33 meters MLLW at entrance range; channel depth is maintained at 37 feet/11.28 meters MLLW for the length of the 15.2-mile/ 24.5-kilometer channel.

Width. The deep-draft navigation channel is wide enough to allow safe transit of vessels entering the bay. The channel width is approximately 1,150 feet/ 350.7 meters at the entrance mark, and is reduced to approximately 700 feet/213.5 meters at Channel Mile 0, then reduced through the entrance jetties to Channel Mile 1.0. From that point to the railroad bridge (see clearances below) at Channel Mile 9.2, the authorized width is 300 feet/91.5 meters; the authorized width from Channel Mile 9.2 through Channel Mile 15.0 is 400 feet/122.0 meters.

Clearances. Horizontal clearance is 197 feet/60.08 meters at the railroad bridge, Channel Mile 9.2; 149 feet/45.45 meters vertical restriction (0 tide) at McCullough Highway Bridge (U.S. 101), Channel Mile 9.5.

Tidal Ranges and Current.. Mean is 5.6 feet/1.7 meters; diurnal is 7.3 feet/2.2 meters; maximum is 12 feet/3.7 meters; tidal ebb is to 3 knots.

Winds and Weather. Prevailing winds are from the northwest. Storm events may produce winds from the southwest and southeast..

The railroad swing bridge at Coos Bay, OR, is instructive regarding the horizontal clearances and the objective navigation challenges with which expert marine pilots may contend. Figure 13 shows the general setting of the bridges at Coos Bay.

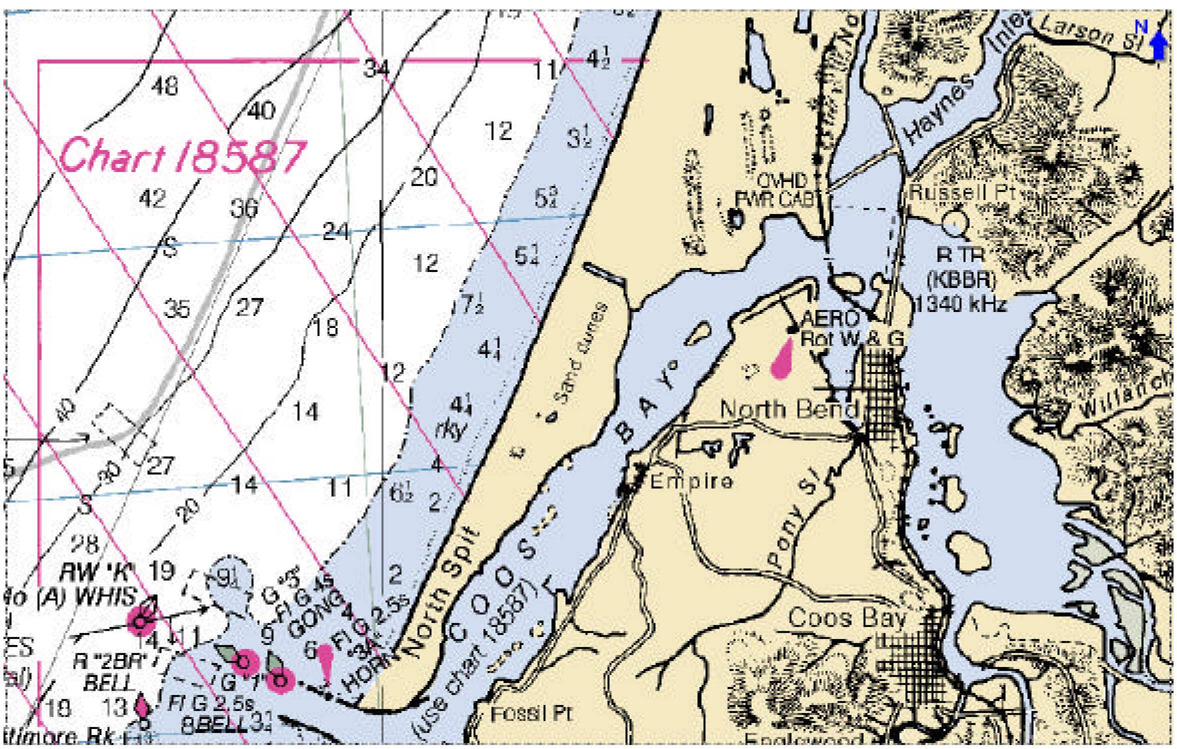


FIGURE 13
GENERAL SETTING AT COOS BAY, OREGON

The highway bridge, with vertical clearance of 149 feet, runs from North Bend north towards Russell Point. The railroad swing bridge is located a short distance to the west. Coos Bay is subject to current from the Coos River, which empties into Coos Bay, and the vessel track between the highway and railroad bridges is subject to sheering tidal currents from Haynes Inlet to the north.

Figures 14 and 15 show additional views and details of the deep-draft ship channel passing under the highway bridge and through the railroad swing bridge.

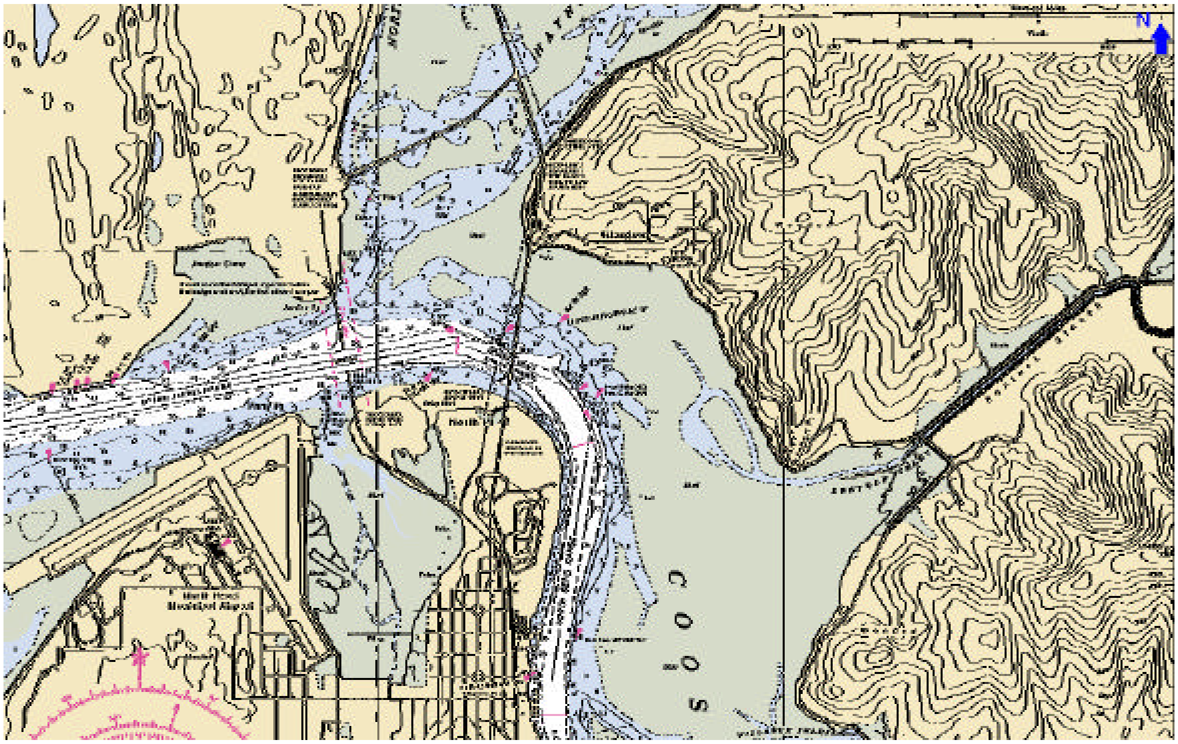


FIGURE 14
SHIP CHANNELS AT COOS BAY, OREGON

Figure 14 clearly shows that outbound ships must negotiate the Coos Bay highway bridge while negotiating a significant bend (North Bend) in the channel. Once clear of the highway bridge, outbound ships are exposed to the combined effects of the sheering currents from Haynes Inlet and the wind. Ships typically line up to transit the north opening of the railroad swing bridge (see detail in Figure 15).

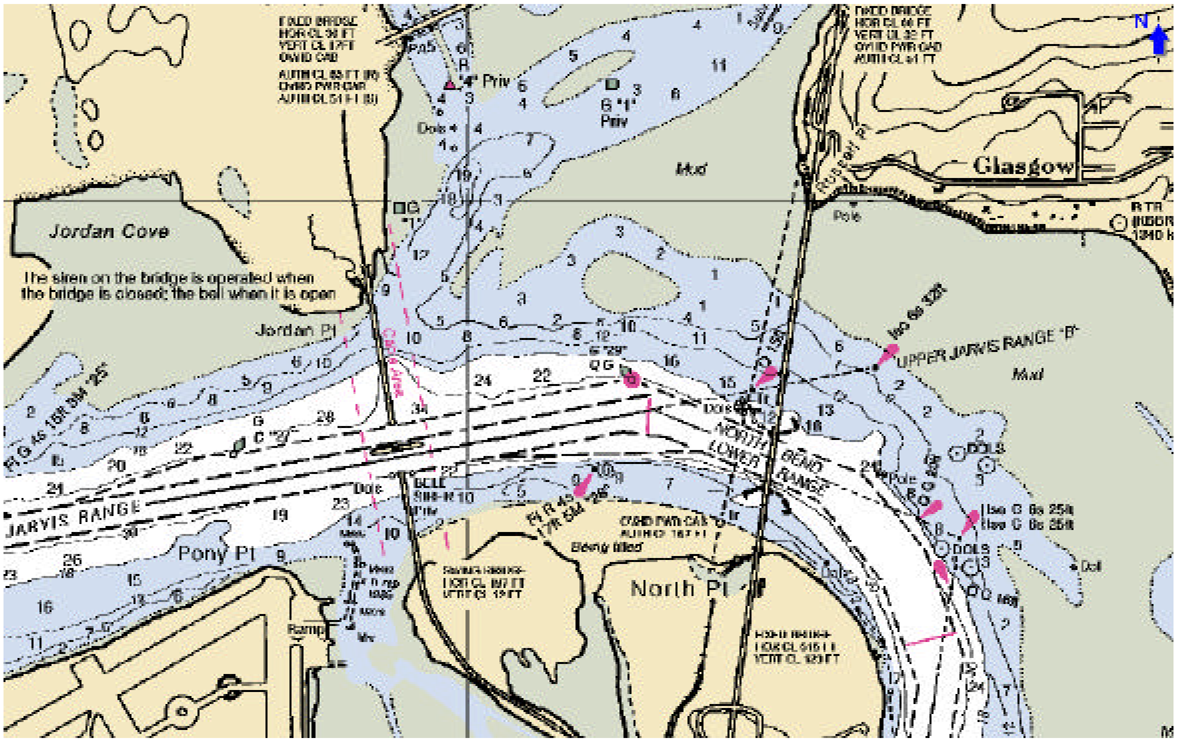


FIGURE 15
DEEP DRAFT SHIP CHANNEL AT COOS BAY BRIDGES

The horizontal clearance at the swing bridge is 197 feet. Furthermore, because the bridge is a swing bridge, the ship must stay carefully aligned with the channel for a distance of about 400 feet while passing through the bridge.

Typical ships calling at Coos Bay are Panamax log carriers and bulk commodity carriers with lengths on the order of 800 feet and beams up to 108 feet, leaving a nominal 44 feet on each side of the ship when it is passing through the swing bridge. The typical ship calling at Coos Bay is a low-powered, single-screw vessel with a conventional rudder. Some ships may not even have bow thrusters. Ships are typically operating free (without tug assistance or tethered tug escort) when transiting the Coos Bay railroad swing bridge.

4—Cruise Ship Traffic Projections

In investigating ways to improve access between Ketchikan on Revillagigedo Island and Gravina Island, it is important to take into account the prospect of future large-ship traffic congestion in Tongass Narrows. It is also possible that such congestion may be exacerbated by bridges with low vertical clearance. Both of these issues have been addressed in a separate report, "Cruise Ship Traffic Projections – Technical Memorandum" (Reference [17]). The relevant findings from that report are presented in this section.

This projection of future cruise ship traffic calling at Ketchikan is based principally on Alaska cruise passenger demographic data and population projections from the U.S. Census Bureau.

4.1 Projected Cruise Passengers and Port Calls

As shown in Table 6 and Figures 4, 5 and 6 (Section 2.2), there has been a steady growth in the number of cruise ship passengers and port calls at Ketchikan over the past decade. Also of note is the trend seen in Table 7: The actual number of cruise ship passengers arriving at Ketchikan in the most recent three years is greater than the rated passenger capacity. (Capacity ratios exceeding 100% are possible because cruise ship capacity is rated on the basis of lower-berth capacity.) The significance of this is that all cruise ships are running essentially sold-out and full.

As shown in Table 6, the aggregate passenger capacity of large cruise ships calling at Ketchikan in 2001 is 640,524. Although the actual number of passengers may vary slightly from the aggregate cruise ship passenger capacity, the following analysis is based on aggregate cruise ship capacity to maintain consistency.

Figure 16 depicts five different projections of the minimum aggregate annual cruise passenger capacity calling at Ketchikan. The high estimate with growth in market penetration exceeds one million passengers beginning in 2007 and two million passengers beginning in 2041. (Note that a logarithmic scale is used for passenger capacity.) The middle estimate with growth in market penetration exceeds the one-million mark beginning in 2012. In the absence of any further growth in market penetration, the one-million passenger mark is passed in 2024, 2031 and 2051, respectively, by the high, middle, and low estimates.

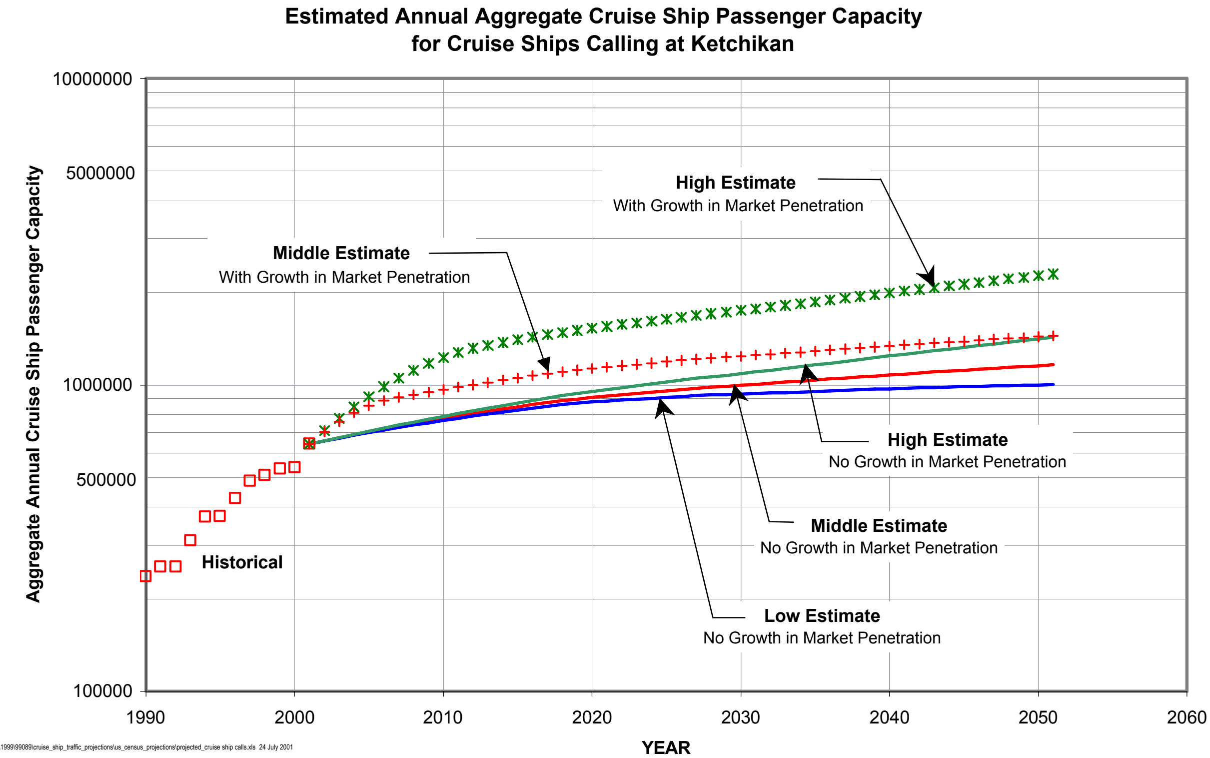


FIGURE 16
PROJECTED MINIMUM AGGREGATE ANNUAL CRUISE PASSENGER CAPACITY

Figure 17 depicts the assumptions made regarding average cruise ship passenger capacity, and shows that capacity has increased very rapidly over the decade from 1991 to 2001 (at a 7.7% effective annual compound rate). The average cruise ship passenger capacity in 2001 is 1,664 passengers (Table 6), and the largest-capacity cruise ship calling at Ketchikan in 2001 can carry 2,114 passengers (lower berth), as identified in Table 3. In 2002 a “Grand-Class” vessel (Princess Cruises) with a capacity of 2,600 passengers is scheduled to operate to Alaskan destinations. Ships with capacities of up to 3,100 passengers are now entering service (though not known to be destined for the Alaska cruise market), and even larger vessels are planned, as previously noted with reference to Tables 4 and 5.

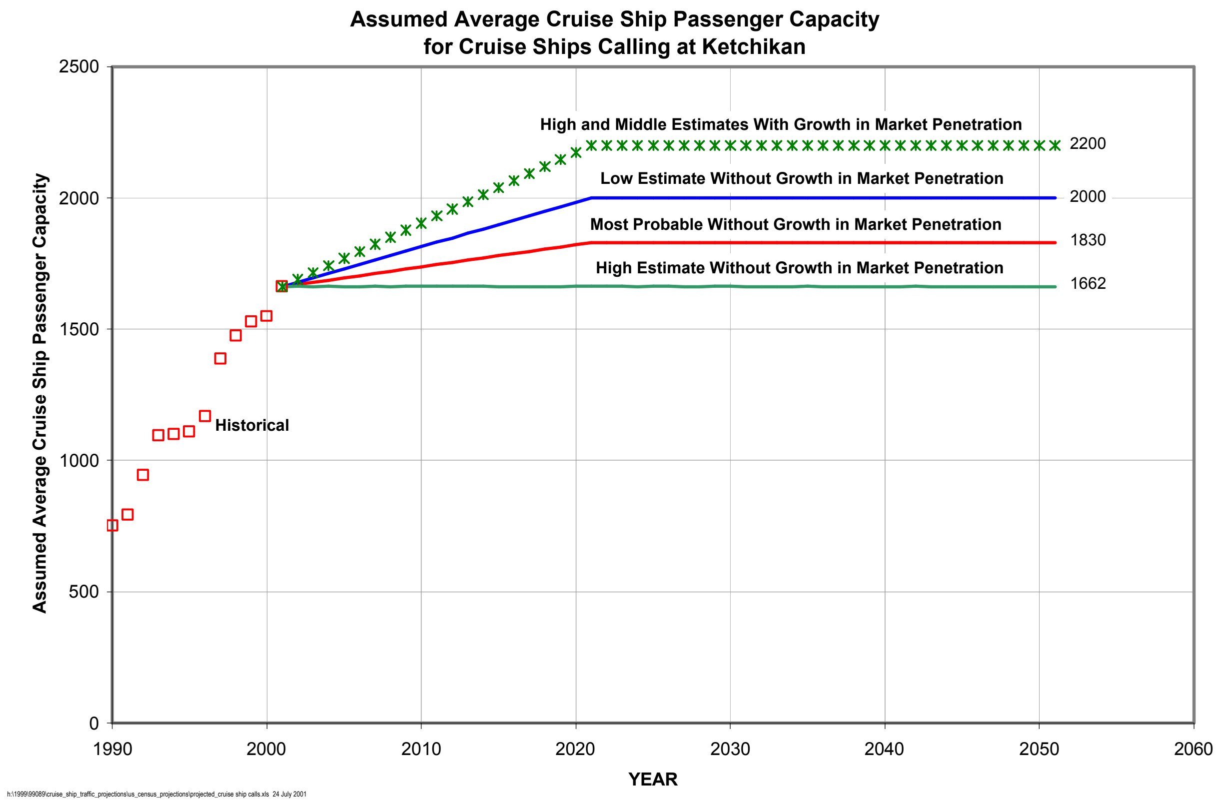


FIGURE 17
ASSUMED AVERAGE CRUISE SHIP PASSENGER CAPACITY

Because of the rapid increase of capacity, the rise of cruise ship calls at Ketchikan over the decade 1991 to 2001 was slow, from 322 to 385 (as shown in Figure 18), despite a 251% increase in passenger volume. All of the assumed trends in average cruise ship passenger capacity (shown in Figure 17) are less than what has occurred over the past decade. These assumed trends in cruise ship passenger capacity, taken together with the projected passenger demand shown in Figure 16, yield the estimated cruise ship calls shown in Figure 18.

The high-series estimate with growth in market penetration exceeds 700 large cruise ship calls annually by 2019. The middle-series estimate with growth exceeds 500 large cruise ships by 2008, and without growth achieves 500 by 2020. The high-series estimate without growth exceeds 700 calls by 2036.

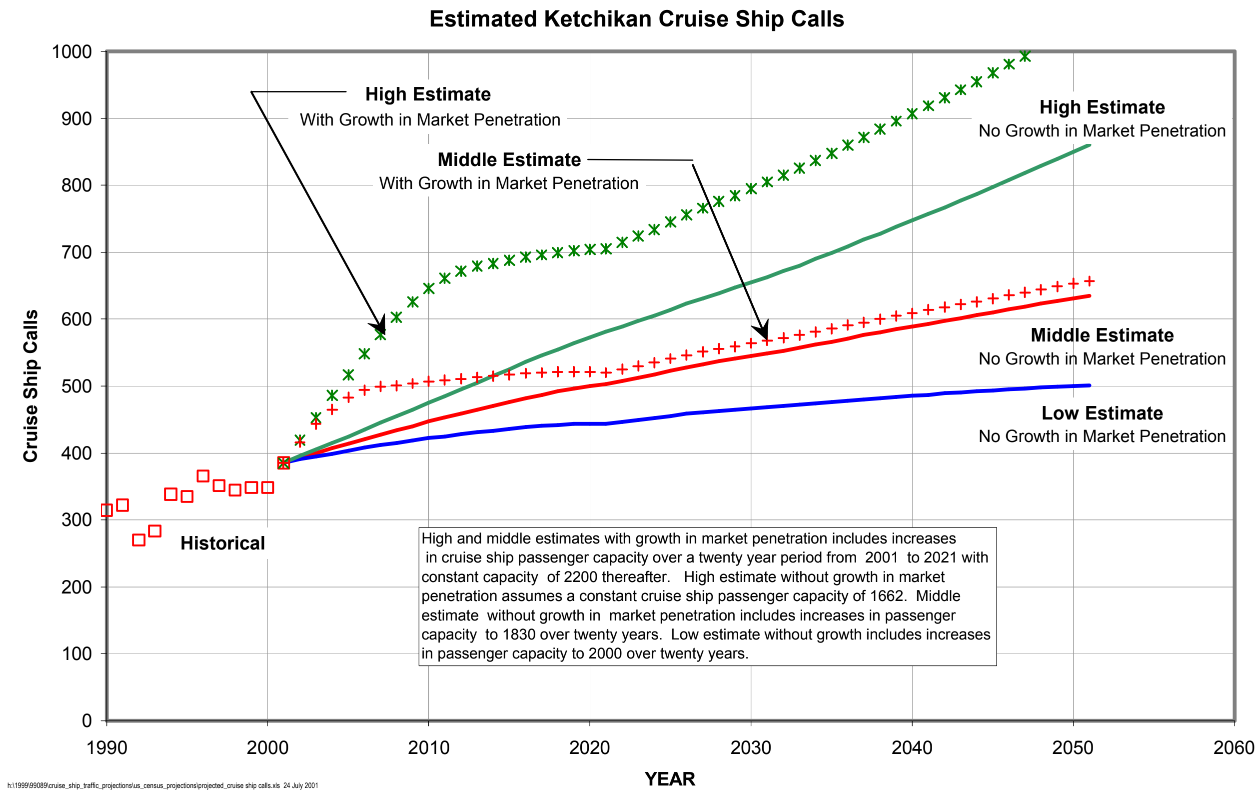


FIGURE 18
ESTIMATED KETCHIKAN CRUISE SHIP CALLS

4.2 Projected Cruise Ship Traffic Density

Table 20 presents statistics for large cruise ship calls at Ketchikan during the 2001 cruise season.

TABLE 20
2001 KETCHIKAN CRUISE SEASON – LARGE CRUISE SHIP CALL STATISTICS

Month:	*May*	*June*	*July*	*August*	*September*
Cruise Ship Calls	54	90	88	90	63
Avg. Calls per Day	1.92	3.00	2.84	2.90	2.25
Peak Calls	4	5	4	4	4

The 2001 cruise season calendar indicates that there are 34 dates on which four large cruise ships call at Ketchikan, and one occasion, 23 June, when five large cruise ships call.

Figure 19 shows the predicted trends in mid-summer average daily cruise ship calls at Ketchikan.

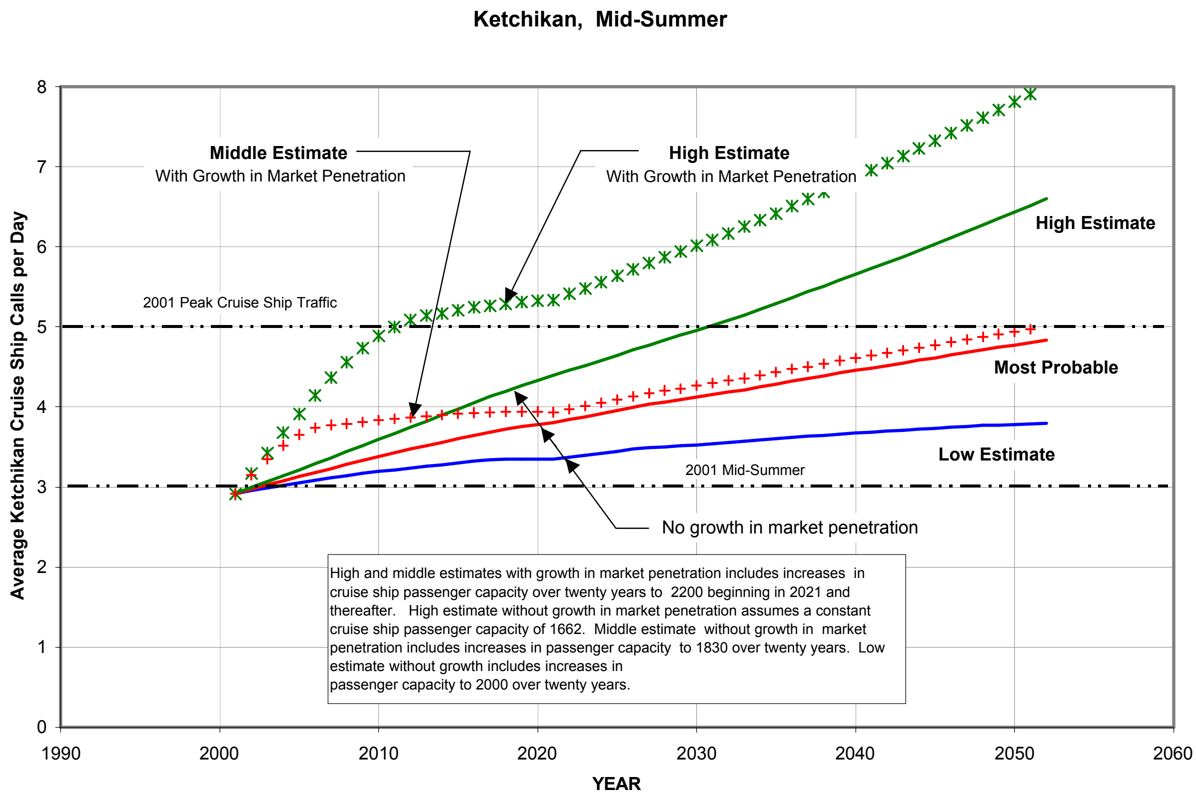


FIGURE 19
ESTIMATED AVERAGE MID-SUMMER DAILY KETCHIKAN CRUISE SHIP CALLS

4.3 Potential Limiting Factors

Factors that may potentially limit the growth in cruise ship traffic projected in Figures 16, 18 and 19 include:

- Income (i.e., income of potential cruise ship passengers)
- Tolerance of residents to growth in tourism
- Inadequate growth in destination attractions
- Competition from other markets and attractions
- Cruise ship berthing space
- Large-vessel traffic congestion in Tongass Narrows

Each of these potential limiting factors is addressed in Reference [17]. Of primary importance to this report is the last factor: the potential for large vessel traffic congestion in Tongass Narrows, including the potential adverse impacts of any bridges of low vertical clearance spanning Tongass Narrows.

4.3.1 Large-Vessel Traffic Congestion in Tongass Narrows

As described in Section 1.1, vessel operations are restricted by 33 CFR §162.240 to speeds not exceeding seven knots in the region of Tongass Narrows, bounded to the north by Tongass Narrows Buoy 9 and to the south by Tongass Narrows East Channel Regulatory marker at position 55 deg. 19' 22.0" N, 131 deg. 36' 40.5" W and Tongass Narrows West Channel Regulatory marker at position 55 deg. 19' 28.5" N, 131 deg. 39' 09.7" W.

The trackline distance from Buoy 9 to the cruise ship terminal is about 3 nautical miles (n.m.), and from Idaho Rock to the terminal, about 2.1 n.m. At 7 knots, the running time to the north is about 26 minutes, and to the south, about 18 minutes. Actual speeds may be less than 7 knots, depending on the ship, the weather, the location within the Narrows, and marine traffic in the vicinity. According to the 2001 Ketchikan cruise ship calendar, the average port stay for southbound cruise ships is 8.0 hours, and the average port stay for northbound cruise ships is 8.5 hours. Seventy-three percent of the cruise ships calling at Ketchikan in 2001 (280 of 385) are southbound and 27% are northbound.

Ketchikan and Juneau cruise ship calendars show that cruise ships rarely arrive before 6:00 a.m., and nearly always arrive no later than 1:00 p.m. Departures are almost always before 9:00 p.m. . There are 17.2 hours of daylight (sunrise to sunset) in Ketchikan at the beginning of June and 14.1 hours at the end of August.

Table 21 is an example of a daily cruise ship schedule for Ketchikan that provides 8.5 hours of port time to each vessel and ½ hour arriving and departing Ketchikan as the sole large cruise ship in Tongass Narrows. This suggests the ability of Tongass Narrows to support up to twelve cruise ship arrivals per day without large-ship congestion in Tongass Narrows.

The largest projected average daily cruise ship traffic in 2051 is eight cruise ships per day. The ability to handle twelve cruise ships per day provides a reasonable allowance for peak traffic events, as compared with average traffic. Furthermore, the capacity of Tongass Narrows could be doubled (to 24 cruise ships) without introducing two-way traffic in the narrow passages, because ships arriving from the north (and departing to the south) and ships arriving from the south (and departing to the north) use different channel segments. Thus each ship arrival and departure in Table 21 could represent two ships—one southbound and one northbound.

Other considerations affecting cruise ship scheduling at Ketchikan must be recognized, including such factors as:

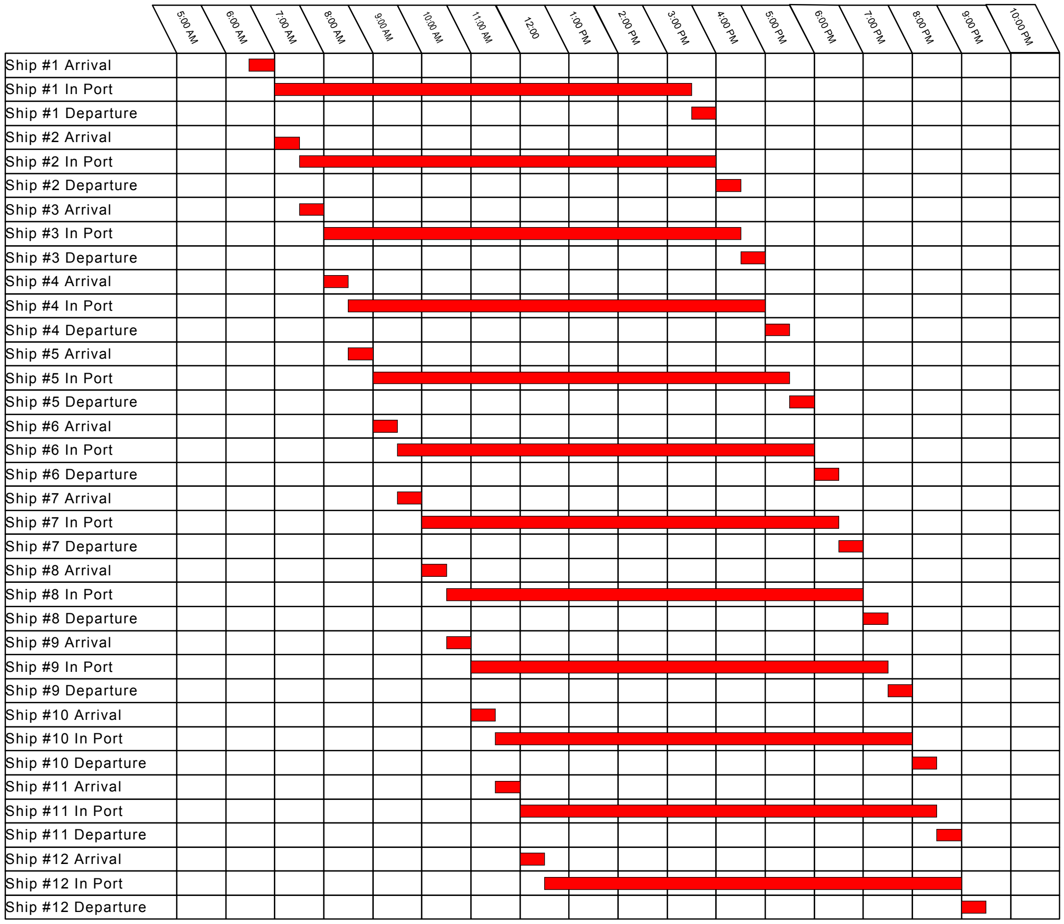
- Timing of the tide and current in Seymour Narrows
- Arrivals and departures from Vancouver, BC
- Berth availability and size relative to cruise ship size
- Arrivals and departures from other Alaska ports and destinations
- Special events in destination ports

Also, as transit time between ports and to and from Seymour Narrows depends on the cruising speed, each ship will have unique scheduling requirements. In a port such as Ketchikan, the overall scheduling problem is exacerbated by any need to coordinate arrivals and departures with other large cruise ships, though berth availability certainly already imposes such coordination (see Section 9.5 of Reference [17]).

The potential for congestion is, therefore, not as much for congestion of underway traffic in the narrow passages of Tongass Narrows as it is for harbor congestion if adequate cruise ship berthing is not available.

Section 6 addresses the potential impacts of bridges with low vertical clearances on marine navigation in Tongass Narrows and Ketchikan Harbor. Before that, in Section 5, some pertinent navigation issues are discussed.

TABLE 21
DAILY KETCHIKAN CRUISE SHIP SCHEDULE (EXAMPLE)



5—Navigation Issues

The following are specific navigation issues and concerns identified through discussions with ship pilots operating in Ketchikan, and others.

5.1 Navigation Restrictions During Construction

Legitimate concern has been expressed regarding navigation restrictions that may be imposed during a bridge (or other civil structure) construction. This question extends to both the nature of the restrictions and their timing. For instance, it would be preferable if the most severe restrictions were limited to the off-season for the cruise and tourist industry.

5.2 Bridge Structure Effect on Wind

Ship pilots have expressed concern that the introduction of a bridge structure might modify the wind patterns on Tongass Narrows.

5.3 Bridge Structure Effect on Current

Ship pilots are also concerned that the introduction of a bridge structure might modify current patterns in the waters of Tongass Narrows.

5.4 Reflection of Bow Waves by Bridge Piers

Ship pilots are concerned that the reflection of bow waves off bridge piers might cause their vessel to shear off course.

5.5 Radar Shadow of Bridges

Another concern of ship pilots is the possibility of a major bridge creating a radar shadow that would inhibit the ability to image beyond the bridge.

5.6 Ship Pilot Preferences for Bridge Alignment

Ship pilots prefer bridge alignments that cross at right angles to the shipping channel. Oblique alignments extend the duration of vessel interaction with the bridge, restrict heading and lateral position, and are visually disorienting.

5.7 Horizontal Clearance Between Bridge Piers

The magnitude of an acceptable minimum horizontal clearance has been investigated. Two authorities have been identified that have published guidelines for horizontal clearance between bridge piers. The first is AASHTO (American Association of State Highway and Transportation Officials) and the second is PIANC (Permanent International Association of Navigation Congresses).

5.7.1 AASHTO Guidelines Regarding Horizontal Clearance

The following excerpts are quoted from AASHTO Section 8, "Bridge Protection Planning Guidelines," Subsection 8.5.1, Horizontal Clearances:

- *Bridges with main spans, S, less than 2 or 3 times the design vessel length, LOA, are particularly vulnerable to vessel collision.*
- *Bridges with main spans, S, less than 2 times the channel width, C, are particularly vulnerable to collision.*
- *Piers located less than 2 or 3 times the pier width from the edge of channel, YN and YW , are particularly vulnerable to collision.*
- *The centerline of the navigable channel should coincide with the center of the main span. The maximum offset between the centerline of the channel and of the bridge should not exceed 10-15% of the main span length, S.*

The length of cruise ships transiting Tongass Narrows may equal or slightly exceed 1,000 feet. The natural channel width in the vicinity of Charcoal Point is less than 1,000 feet. Given these circumstances, only those solutions that include spans equal to the natural channel width could be construed as satisfying the AASHTO guidelines for minimized vulnerability to vessel collision.

5.7.2 PIANC Guidelines Regarding Horizontal Clearance

PIANC, headquartered in Brussels, Belgium, is an international organization concerned with technical aspects of navigation and port infrastructure, and with associated safety, economic and environmental matters. PIANC was founded in 1885 and is sponsored by 40 national governments, including the United States, which joined in 1902.

The National Commission, composed of 11 members, is the central governing body of the U.S. Section. The Chairman is the Assistant Secretary of the Army (Civil Works); the President is the Deputy Commander for Civil Works, U.S. Army Corps of Engineers; and the Secretary is employed by the U.S. Army Engineer Institute for Water Resources.

The U.S. Section has established seven committees to carry out the Association's work. The four technical committees are Environment, Shallow-Draft Waterways and Ports, Deep-Draft Waterways and Ports, and Sport and Recreation Navigation. These technical committees complement the structure of the international organization.

Reference [18], "Approach Channels – A Guide for Design," was developed by a joint working group of PIANC and IAPH (International Association of Ports and Harbors), in cooperation with IMPA (International Maritime Pilots Association) and IALA (International Association of Lighthouse Authorities).

The following is from the foreword to Reference [18]:

> *Modern design of approach channels came into existence as a separate discipline in the 1960's, particularly for the development of deepwater ports.*
>
> *The design of channel dimensions was first considered by Working Group 2 of the Permanent International Association of Navigation Congresses (PIANC) International Oil Tankers Commission (IOTC) and the report was published in 1973. The IOTC work was then reviewed some years later by Working Group 4 of the PIANC International Commission for the Reception of Large Ships (ICORELS), whose report was published in 1980. The ICORELS Report contained a detailed review, but the Commission concluded that in the state of knowledge as it then stood, its general recommendations would have to be conservative, but it left open the possibility that its recommendations might be capable of refinement as knowledge developed.*
>
> *Since the ICORELS Report, there have been considerable developments, not only in knowledge, but also in technology and analytical techniques:*
>
> - *firstly, in research as to ship behavior and in the development of guidance systems*
> - *secondly, in computer technology and in mathematical and physical modeling systems (using the research on ship behavior), enabling vessel tracking to be predicted taking account of human factors*
> - *thirdly, in experience of large ships transiting port approach channels over a number of years, including some channels which have lower width/design ship beam ratios than the ICORELS general recommendation.*
>
> *Recognizing the need for a review of the recommendations presented in previous reports, PIANC and the International Association of Ports & Harbors (IAPH) set up a joint Working Group (No. 30) and invited the participation of the International Maritime Pilots Association (IMPA) and the International Association of Lighthouse Authorities (IALA) to assess and, if necessary, update existing reports, to provide practical guidelines for the design of approach channels and fairways. Central to this work were the results collected by an earlier PIANC Working Group (No. 7) and these have been combined with recent developments in design techniques to form the basis of this report.*
>
> *Its intention is to provide practicing engineers with guidelines and data which will allow them to design a channel for a given ship or mix of ship types or, alternatively, enable assessment of the suitability of an existing channel for a proposed change in ship type or operation. The intention has been to provide practical guidelines which are readily usable and easy to understand and justify.*
>
> *In accordance with the Terms of Reference which are given in Chapter 9, a preliminary Report was prepared dealing with aspects of Concept Design, and this Report was published jointly by PIANC/IAPH in April 1995. However, the present report covers all aspects of Channel Design (Concept and Detailed Design)."*

Chapter 5 of Reference [18] describes a concept design method for channels. The method is based on a design ship (or ships) and determines, through an accumulation of factors, the minimum recommended channel width as a multiple of the design ship beam. In addition to the intrinsic maneuverability of the design ship(s) (good, moderate, or poor), the considered factors are:

a. Vessel speed (knots): classed as fast, moderate, or slow

b. Prevailing cross wind (knots)

c. Prevailing cross current (knots)

d. Prevailing longitudinal current (knots)

e. Significant wave height and wave length (meters)

f. Aids to navigation
- Excellent with shore traffic control
- Good
- Moderate with infrequent poor visibility
- Moderate with frequent poor visibility

g. Bottom surface
- Smooth and soft
- Smooth or sloping and hard
- Rough and hard

h. Depth of waterway relative to design ship draft

i. Cargo hazard level: low, medium, or high

j. Additional width for passing distance in two-way traffic

k. Additional width for bank clearance

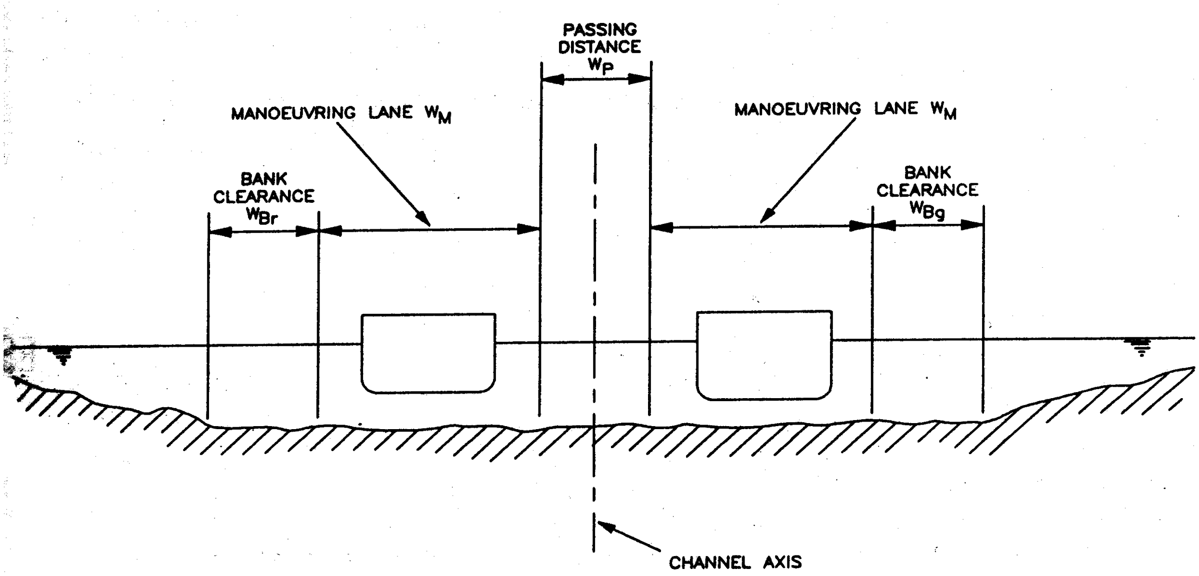


FIGURE 20
ELEMENTS OF CHANNEL WIDTH
(COPY OF FIGURE 5.11 FROM REFERENCE [18])

As stated in Chapter 5 of Reference [18]:

The bottom width w of the waterway (Figure 5.11), is given for a one-way channel by:

$$w = w_{BM} + \sum_{i=1}^{n} w_i + w_{Br} + w_{Bg}$$

and for a two-way channel by:

$$w = 2\,w_{BM} + 2\sum_{i=1}^{n} w_i + w_{Br} + w_{Bg} + \sum w_P$$

where, as shown in Figure 5.11, w_{Br} *and* w_{Bg} *are the bank clearances on the 'red' and 'green' sides of the channel,* $\Sigma\, w_P$ *is passing distance (comprising the sum of a separation distance based on ship speed and an additional distance based on traffic density) and the* w_i *are . . .*

based on factors given in Table 5.2 of Reference [18]. The factors considered in Table 5.2 of Reference [1] are synoptically described as (a) through (k) above.

The basic maneuvering width w_{BM}*, as a multiple of the beam B of the design ship, are given in . . .* [Table 22 below]. *This basic maneuvering width is that required by the design ship to sail safely in very favorable environmental operating conditions.*

TABLE 22
BASIC MANOEUVRING LANE (FROM REFERENCE [18])

Ship Maneuverability	*Good*	*Moderate*	*Poor*
Basic Maneuvering Lane, w_{BM}	1.3 B	1.5 B	1.8 B

To the basic maneuvering lane width w_{BM} *are added additional widths (to allow for the effects of wind, current, etc.) which gives the maneuvering lane* w_M.

The additional widths are given in Table 5.2 of Reference [18] and synoptically described as (a) through (k) above.

In several instances, the treatment of the factors considered in Table 5.2 of Reference [18] exhibit dependencies on other considerations such as water depth or vessel speed. Table 23 indicates these dependencies.

PIANC's concept design method has been applied to Tongass Narrows using the *Carnival Conquest* Class of cruise ships (this class includes *Carnival Conquest*, *Carnival Glory* and *Carnival Victory*) and the AMHS's largest ferry, the *M/V Columbia*, as design ships. The principal dimensions of the two ships are given in Tables 24 and 25, and the results are summarized in Tables 26 and 27.

TABLE 23
DEPENDENCIES IN TABLE 5.2 OF REFERENCE [18]

		Length	Draft	Speed	Traffic Density	Inner vs. Outer Channel	Bank Characteristics
(a)	Speed			X			
(b)	Cross Wind			X			
(c)	Cross Current			X			
(d)	Longitudinal Current			X			
(e)	Wave Height & Length	X		X			
(f)	Aids to Navigation						
(g)	Bottom Surface		X				
(h)	Depth of Waterway		X				
(i)	Cargo Hazard Level						
(j)	Two-way Traffic			X	X	X	
(k)	Bank Clearance			X		X	X

TABLE 24
PRINCIPAL DIMENSIONS OF CARNIVAL CONQUEST CLASS CRUISE SHIP (DESIGN SHIP CLASS)

Vessel	Carnival Conquest, Glory, or Victory	
Length	894.0	feet
Beam	141.7	feet
Draft	27.2	feet
Speed	7.0	knots

Note: A speed of 7 knots is used, because speed in Tongass Narrows is restricted by federal regulation to 7 knots.

TABLE 25
PRINCIPAL DIMENSIONS OF M/V COLUMBIA AMHS FERRY (DESIGN SHIP CLASS)

Vessel	M/V Columbia	
Length	418.0	feet
Beam	85.0	feet
Draft	17.6	feet
Speed	7.0	knots

Note: A speed of 7 knots is used, because speed in Tongass Narrows is restricted by federal regulation to 7 knots.

TABLE 26
MINIMUM TONGASS NARROWS CHANNEL WIDTH (FEET)
ESTIMATED USING PIANC CONCEPT DESIGN METHOD

Aids to Navigation	*Traffic*	*Wind Speed (knots)*	*Water Depth (feet)*	*Intrinsic Vessel Maneuverability (feet)*		
				Good	*Moderate*	*Poor*
Good	One-way light density	10.15	40	411	439	482
			41	326	354	397
		33	40	482	510	553
	Two-way heavy density	10.15	40	609	638	680
			41	524	553	595
		33	40	680	709	751
Moderate with Frequent Poor Visibility	One-way light density	10.15	40	468	496	538
			41	383	411	453
		33	40	538	567	609
	Two-way heavy density	10.15	40	666	694	737
			41	581	609	652
		33	40	737	765	808
Minimum				326	354	397
Maximum				737	765	808

Note: *Design ship is* Carnival Conquest *class cruise ship*

TABLE 27
MINIMUM TONGASS NARROWS CHANNEL WIDTH (FEET) AT LOW LEVEL BRIDGE
ESTIMATED USING PIANC CONCEPT DESIGN METHOD

Aids to Navigation	*Traffic*	*Wind Speed (knots)*	*Water Depth (feet)*	*Intrinsic Vessel Maneuverability (feet)*		
				Good	*Moderate*	*Poor*
Good	One-way light density	10.15	40	195.5	212.5	238.0
			41	195.5	212.5	238
		33	40	238.0	255.0	280.5
	Two-way heavy density	10.15	40	314.5	331.5	357.0
			41	314.5	331.5	357.0
		33	40	357.0	374.0	399.5
Moderate with Frequent Poor Visibility	One-way light density	10.15	40	229.5	246.5	272.0
			41	229.5	246.5	272.0
		33	40	272.0	289.0	314.5
	Two-way heavy density	10.15	40	348.5	365.5	391.0
			41	348.5	365.5	391.0
		33	40	391.0	408.0	433.5
Minimum				195.5	212.5	238.0
Maximum				391.0	408.0	433.5

Note: *Design AMHS vessel is* M/V Columbia*, the largest AMHS vessel.*

In the calculation of the estimated minimum channel widths shown in Tables 26 and 27, the following assumptions were made in all cases:

- (i) Cross current of 0.5 knots
- (ii) Longitudinal current of 3.0 knots
- (iii) Low cargo hazard
- (iv) Steep and hard bank configuration with a rough and hard bottom surface

According to the PIANC concept design method, under the most favorable of assumptions and circumstances, the minimum recommended channel width could be as little as 326 feet, while under the least favorable of assumptions and circumstances, it might be as large as 808 feet.

Restricting attention to cases with two-way traffic and moderate aids to navigation with "frequent poor visibility," the least recommended width grows to 581 feet for a vessel with good intrinsic maneuverability and to 609 feet for vessels with moderate intrinsic maneuverability. It is pertinent to present here the following evaluation on the incidence of two-way traffic in Tongass Narrows. (This assessment was submitted recently in a separate communication; see Reference [19].)

Marine pilots and cruise industry representatives have indicated that two-way traffic of large cruise ships in Tongass Narrows is rare. Furthermore, AMHS masters have indicated that it is routine to make passing arrangements by radio and that vessels will often agree that one vessel will loiter in order to avoid a two-way passage in Tongass Narrows.

To check the assumption of one-way traffic, a time-and-motion analysis of the 2001 Ketchikan cruise ship calendar was performed to identify any scheduled cruise ship port calls and departures that would seem to generate two-way traffic during the 2001 season. It was assumed that ten minutes be allowed for docking or undocking based on the arrival and departure times published in the cruise ship calendar. Once underway, 35 minutes was allowed for vessels to transit between the cruise ship dock and Peninsula Point to the north, and 25 minutes was allowed for vessels to transit between the cruise ship dock and Potter Rock to the south.

The results of an analysis of 385 large cruise ship calls at Ketchikan between May 4 and September 28, 2001 (105 northbound calls and 280 southbound calls) was that there were *no instances* of two-way traffic in Tongass Narrows north of the cruise ship dock and *five instances* of two-way traffic in Tongass Narrows south of the cruise ship dock. Those five instances are listed in Table 28, below.

TABLE 28
INCIDENCE OF TWO-WAY TRAFFIC IN TONGASS NARROWS IN 2001

Date	*Northbound*	*Southbound*	*Approximate Time*
23 June	*Bremen*	*Sun Princess* *Norwegian Wind*	6:00 to 6:30 p.m.
13 July	*Seven Seas Mariner*	*Norwegian Sky*	1:00 PM
27 July	*Seven Seas Mariner*	*Norwegian Sky*	1:00 PM
10 August	*Seven Seas Mariner*	*Norwegian Sky*	1:00 PM
7 September	*Seven Seas Mariner*	*Norwegian Sky*	1:00 PM

6—Potential Navigation Impacts of Bridges

Earlier versions of this report briefly considered the consequences of blockages of Tongass Narrows that would result from some of the identified bridge alternatives. This section addresses the potential navigation impacts that would result from the bridge alternatives that have since been selected for further evaluation under the current phase of the project:

1. Alternative C3(a) or C4: A bridge in the vicinity of Ketchikan airport, with a vertical clearance of 200 feet
2. Alternative C3(b) or D1: A bridge in the vicinity of Ketchikan airport, with a vertical clearance of 120 feet
3. Alternative F1: A dual-bridge crossing south of the cruise ship docks, with a 200-foot-high bridge over East Channel (from Revillagigedo Island to Pennock Island) and a 120-foot-high bridge over West Channel (from Pennock Island to Gravina Island)
4. Alternative F3: A dual-bridge crossing south of the cruise ship docks, traversing Pennock Island, with a 60-foot-high bridge over East Channel and a 200-foot-high bridge over West Channel.

Other potential impacts of the proposed bridges, especially the potential reduction in port calls and the economic impacts that might result, were presented recently in References [20] and [21].

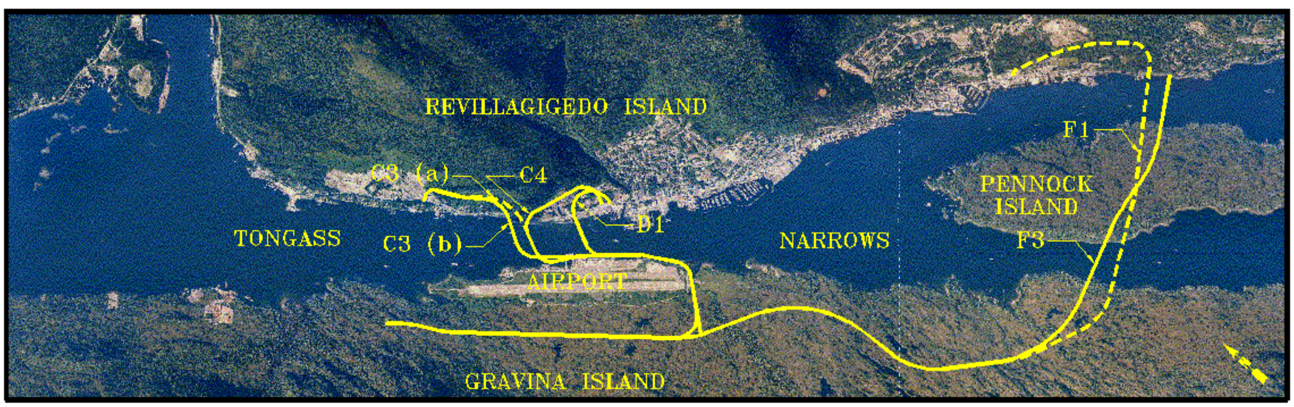


FIGURE 2OB
IDENTIFIED BRIDGE ALTERNATIVES BETWEEN REVILLAGIGEDO ISLAND AND GRAVINA ISLAND

6.1 Consideration of a 200-foot High Bridge in the Vicinity of Ketchikan Airport and of a 200-foot High Bridge over East Channel

A bridge with 185 feet of vertical clearance—one of the considered alternatives in an earlier stage of this project—might be insufficient in the future (see Reference [21] and Tables 4 and 5). On the other hand, bridges with vertical clearance that equals or exceeds that of the Lions Gate Bridge (200 feet of vertical clearance; see Table 19) would have little or no impact on navigation. This is because, as noted in

Section 2.2, nearly all of the large cruise ships calling at Ketchikan pass under the Lions Gate Bridge located at the First Narrows at Vancouver, BC.

However, it is recognized that aviation requirements and construction costs might constrain the height of bridges crossing Tongass Narrows. Acceding to aviation requirements and other factors could lead to consideration of bridges that do impede some vessel traffic. Because cruise ships are the largest vessels to ply these waters routinely, they are the vessels most likely to be affected by any such impairment.

If a 200-foot-high bridge is feasible, issues related to the horizontal clearance are likely to remain. It was shown in Section 4 that marine pilots are able to contend with horizontal clearances that are considerably less than the 550 feet clearance expected for the bridges in Alternatives C3(a) and C4. Nonetheless, concerns seemed to prevail among marine pilots based at Ketchikan about the adequacy of the horizontal clearance. These concerns were addressed further through a fast-time Monte Carlo cruise ship simulation study. The Monte-Carlo simulation study showed that the introduction of piers in the deep navigable waters of Tongass Narrows would introduce new, permanent grounding and allision (collision with a fixed object) risks and increase the imperative for the existing custom and practice of one-way traffic for large vessels operating in Tongass Narrows.

Cruise ships currently use the East Channel exclusively, and the 200-foot clearance of the East Channel Bridge would continue to allow the passage of large cruise ships. The introduction of bridge piers in the deep navigable waters of East Channel would introduce an incremental increase in grounding and allision risks at those locations. In addition, when considered with the fact that navigation of the East Channel currently involves passage through a constriction of the channel created by California and Idaho Rocks (approximate navigational clearance [width] of 477 feet), the placement of bridge piers in East Channel would add a second point of constriction in the channel by narrowing the channel width from approximately 1,100 feet to 550 feet. This second point of constriction would limit maneuvering opportunities in East Channel, and the potential for groundings and allisions at other locations within the East Channel would increase.

The navigation impacts of Alternatives C3(b), D, and F3—on cruise ship schedules and selected operating costs, in particular—are addressed in the following subsections.

6.2 Effect on Sailing Distances

Alternatives C3(a), C4, and F1 are not likely to block or inhibit large-vessel traffic, since the 200-foot vertical clearances would allow the passage of large cruise ships. The bridge alternatives, C3(b), D, and F3 are likely to either block or inhibit large-vessel traffic in Tongass Narrows. This subsection assesses the increases in sailing distances that would result from any blocking of large vessel traffic.

6.2.1 Blocking Large Vessels North of the Cruise Ship Docks

If Tongass Narrows were to be blocked to large vessels north of the Ketchikan cruise ship docks (as is expected with Alternatives C3 (b) and D), then large cruise ships arriving from the south and continuing north would have to proceed southwest through Nichols Passage and round the southern end of Gravina Island to get to Clarence Strait and continue their voyage northward (via the route shown in blue in Figure 21). And large cruise ships arriving from the north would have to round the southern end of Gravina Island into Nichols Passage and then head northeast through Nichols Passage to proceed up Tongass Narrows to Ketchikan. These alternative routes join the normal route (the normal route transits the northern portion of Tongass Narrows and is shown in red in Figure 21) at a waypoint located in the center of Clarence Strait west of Caamano Point. The distance along this normal route to this waypoint is 17.7 n.m. as shown in Figure 22, and the distance along the alternate route around the southern end of Gravina Island is 48.2 n.m. Thus the typical increase in route distance that would result from blocking Tongass Narrows north of the Ketchikan cruise ship docks is approximately 30.5 n.m.

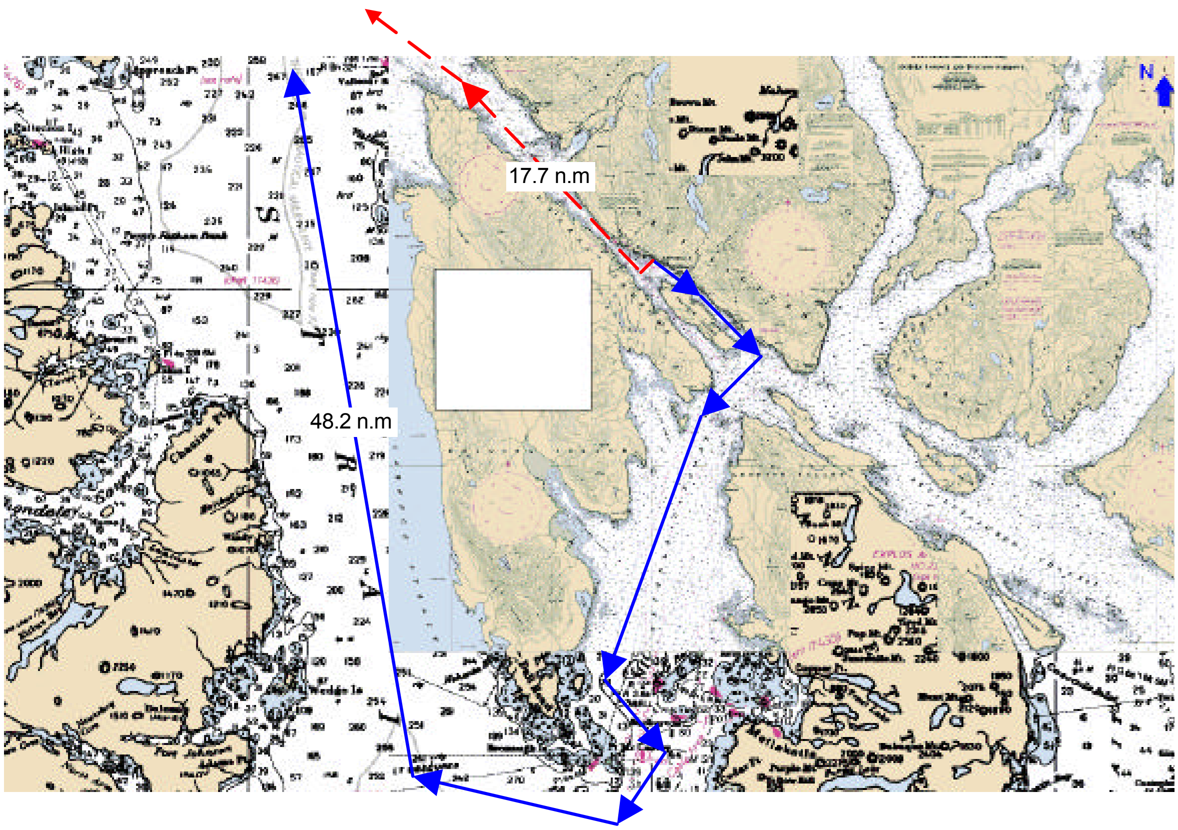


FIGURE 21
EFFECT OF BLOCKING TONGASS NARROWS NORTH OF KETCHIKAN CRUISE SHIP DOCKS
REVISED ROUTE (BLUE) AND NORMAL ROUTE (RED)

6.2.2 Blocking Large Vessels South of the Cruise Ship Docks

If Tongass Narrows were to be blocked to large vessels south of the Ketchikan cruise ship docks (as is expected with Alternative F3), then large cruise ships arriving from the north and continuing south would have to retrace their path through the northern half of Tongass Narrows and round Guard Island onto a southbound course in Clarence Strait to continue their southbound voyage (route shown in blue in Figure 22). And large cruise ships arriving from the south would have to proceed up Clarence Strait and round the Guard Islands into Tongass Narrows from the north to proceed down Tongass Narrows to Ketchikan. These alternative routes join the normal route (the normal route transits the southern portion of Tongass Narrows and is shown in red in Figure 22) at a waypoint located at the entrance to Malacca Passage near Prince Rupert. The distance along this normal route to this waypoint is 87.4 n.m., as shown in Figure 22, and the distance along the alternate route around the southern end of Gravina Island is 106.8 n.m. Thus, the typical increase in route distance that would result from blocking Tongass Narrows north of the Ketchikan cruise ship docks is approximately 19.4 n.m.

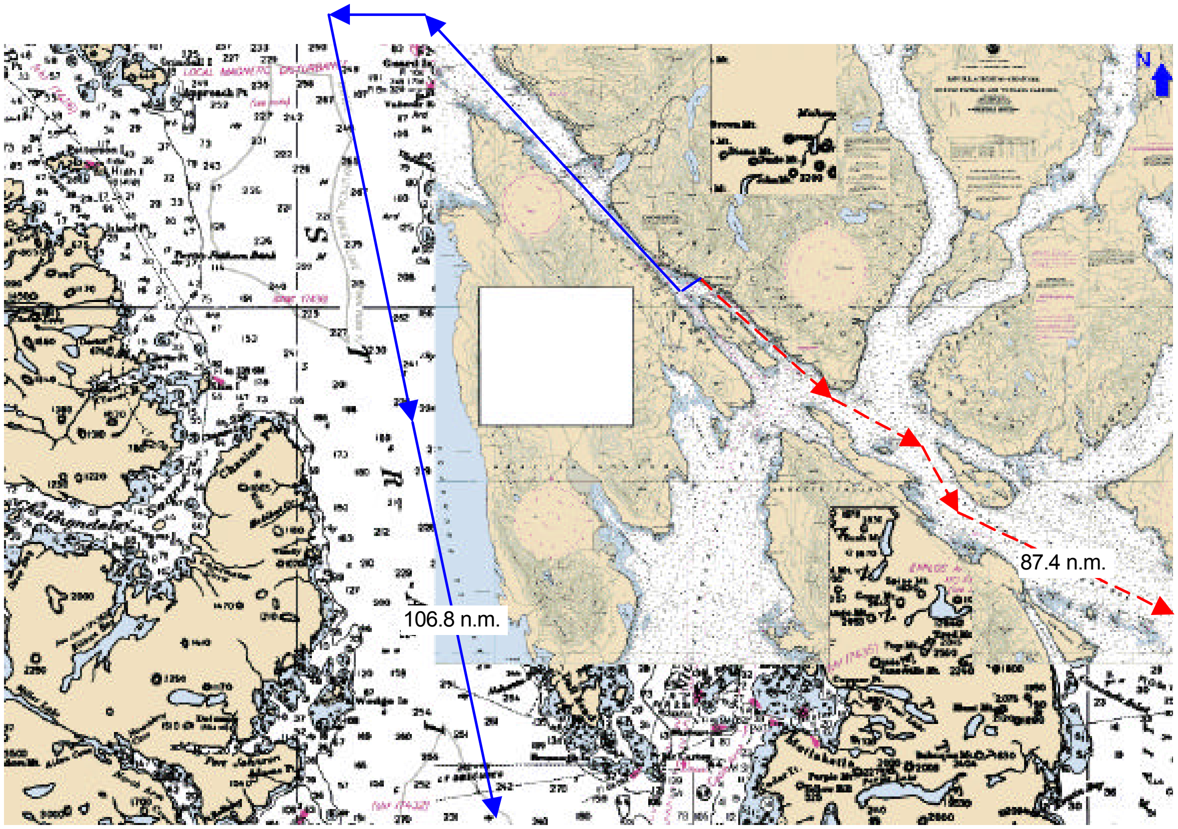


FIGURE 22
EFFECT OF BLOCKING TONGASS NARROWS SOUTH OF KETCHIKAN CRUISE SHIP DOCKS
REVISED ROUTE (BLUE) AND NORMAL ROUTE (RED)

6.2.3 Blocking East Channel to Large Vessels

If only one of the channels alongside Pennock Island is blocked to large vessels, then there would be negligible impact on the sailing distances for cruise ships calling at Ketchikan. Revision 1 of this report (February 2000) included a consideration of the blocking of West Channel to large vessels. With the current Alternative F3, however, it would be East Channel that would be blocked to large vessel traffic.

If East Channel were blocked to large vessels but West Channel were open, there would be only a negligible increase in sailing distance for cruise ships, but cruise ship operations would be made more complicated and difficult. This is discussed in Section 6.3.2.

6.3 Consequences of Blocking Large-Vessel Traffic in Tongass Narrows

This section considers the consequences of blocking large-vessel traffic in Tongass Narrows. It is pertinent to consider first some of the navigation characteristics of large cruise ships.

As shown in Table 3, the large cruise ships that have operated in southeast Alaska during the 2001 season range in length from 617 feet overall to 965 feet overall. In addition, Table 4 shows recent deliveries and ships on order among Alaska cruise operators. The overall lengths for those vessels are in the range of 781 feet to 1,020 feet. The concept design guidelines in Reference [18] give the navigational area requirements for the chosen design ship—the *Carnival Conquest* class of cruise ships, whose principal dimensions are shown in Table 24.

As described in Reference [22], modern cruise ships are typically fitted with twin propellers and twin rudders, although some older cruise ships in Alaska service have single-screw/single-rudder or twin-screw/single-rudder. In addition, many recent and planned future cruise ships are being built with bow thrusters and either high-performance rudders or azipods that enhance their maneuverability. It is anticipated that over a long time frame (perhaps twenty to thirty years), an ever-increasing number of large cruise ships will be fitted with azipods or high-performance rudder systems.

The navigational area guidelines in Reference [18] are based on the operation of single-screw/single-rudder ships. There are no navigational area data available for the modern cruise ships showing the advantages of twin-screw/twin-rudder vessels with bow thrusters. The navigational area estimates obtained from Reference [18] are expected to apply to the lowest-common-denominator cruise ships navigating unaided by tugs, without executing special maneuvers (e.g., tight turns or crabbing, which necessitate a reduction in speed), and without the differential operation of their propellers/rudders and/or bow/stern thrusters.

Section 5.3.6.5 of Reference [18] gives guidelines on berthing and swinging areas required. If a berthing maneuver involves swinging the ship through 180°, then the swinging area is sized (for a lower bound) as a circle having a diameter approximately twice the length of the ship. For the design ship (*Carnival Conquest*), the swinging area diameter is 1,788 feet. This is shown as the red circle in the chart of Ketchikan Harbor in Figure 23.

If the ship is to navigate normally, then a turning radius of four times the length is recommended for 20-degree rudder in water deeper than 1.5 times the draft (see Figure 5.8 of Reference [18]). If the design ship is 894 feet long (*Carnival Conquest*), this corresponds to a minimum turning radius of 3,576 feet, provided the water depth is at least 40 feet. Larger rudder angles will enable the ship to turn more tightly. However, it is inadvisable to have bends that require larger rudder angles, because that would give insufficient "reserve" rudder angle to counter wind, waves, or current – and would therefore compromise safety.

The width of swept track is maximum in deep water and is then about 1.8 times the beam for a 20-degree rudder angle. For the design ship, this width is 255 feet. The width of the navigable channel in the bend should be no less than that of the straight channel. Preliminary guidelines regarding channel width requirements are available from Tables 26 and 27.

The 20-degree rudder turns are shown as red arcs on the chart in Figure 23.

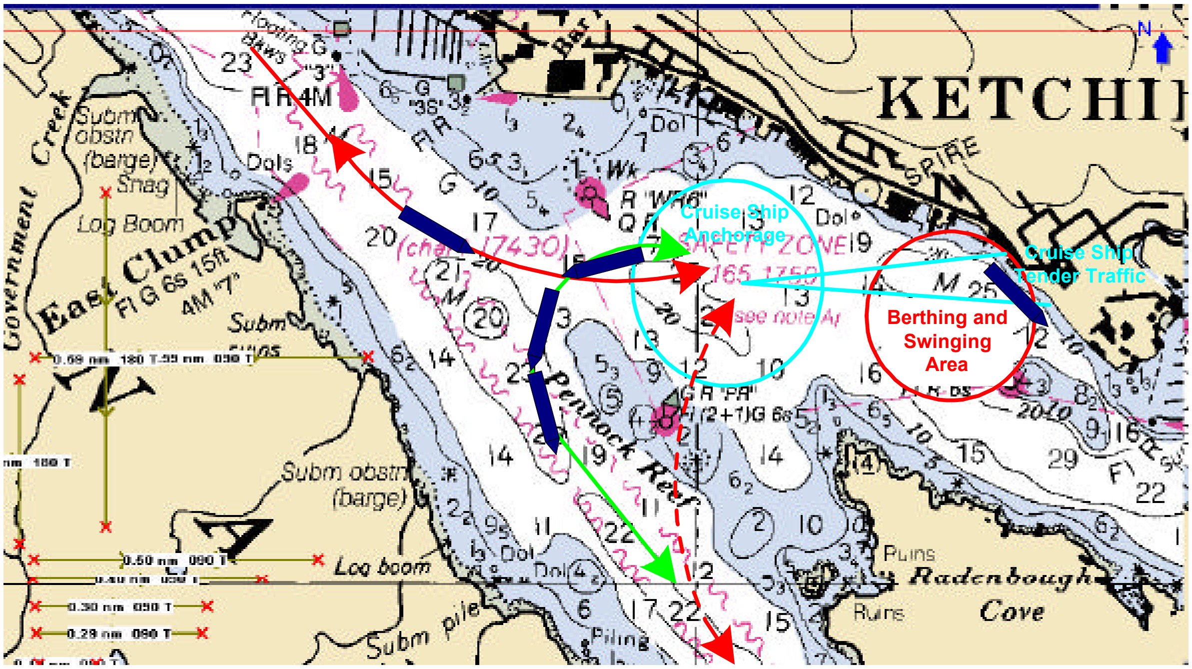


FIGURE 23
NAVIGATION CONSEQUENCES OF THE BLOCKING OF LARGE-VESSEL TRAFFIC IN TONGASS NARROWS

6.3.1 Consequences of Blocking Tongass Narrows Near Charcoal Point

This subsection considers the consequences of closing Tongass Narrows at any location north of the Ketchikan cruise ship docks, but presumably in the vicinity of Charcoal Point. Two different traffic patterns must be considered if Tongass Narrows were to be closed to large shipping north of the cruise ship docks:

- Ships arrive in Ketchikan via either East Channel or West Channel, and depart via the opposite channel.
- Large ships enter and depart Ketchikan via East Channel.

As previously noted (in Section 6.2.1), regardless of which of the two traffic patterns is adopted, closing Tongass Narrows to large ships in the vicinity of Charcoal Point would add approximately 30.5 n.m. to the running distance for ships calling at the Ketchikan cruise ship docks.

Large Shipping Uses Both East and West Channels

1. Practically, the 20-degree rudder turn plotted in Figure 23 for vessels proceeding to or from the south of the Ketchikan cruise ship docks via West Channel (red dashed arc) is infeasible because of insufficient water depth over Pennock Reef. The alternative is to proceed to the north of Pennock Reef and, after slowing down, make the necessary turn, either with tug assistance or with differential operation of the propellers and/or bow/stern thrusters (green line). Besides being a difficult maneuvering exercise, this maneuver would add time to the operations and might also require assist tugs where such assistance is currently not required. Large cruise ships currently avoid this turn around Pennock Reef. In this connection, note that the United States Coast Pilot (Reference [23]) indicates that large ships from the

south frequently take West Channel and navigate around Pennock Reef, so as to make a port landing at the Ketchikan cruise ship docks. This is contradictory to the information that has been obtained from the pilots and shipping agents, including Reference [24]. Therefore the Coast Pilot information is apparently outdated and does not reflect current practice applicable to the large cruise ships calling at Ketchikan today. For these ships, the route via West Channel and around Pennock Reef is not normal.

2. The cruise ship anchorage and the cruise ship tender traffic area are shown in Figure 23 (blue circle and blue lines). At present, only cruise ships to or from the north of the cruise ship docks pass through the anchorage. If Tongass Narrows were closed to large ships in the vicinity of Charcoal Point and ships arrived via either East or West Channel and departed via the opposite channel, then the traffic volume through the anchorage would be similar to the present circumstances, but the maneuver executed in the anchorage, including the possibility of tug assistance, would be more extreme.
3. Clearing the wreck marked by the red buoy WR6 and providing a minimum water depth of 6 fathoms in this area will open up additional maneuvering room for marine traffic. However, this is not going to make the West Channel route feasible for large cruise ships, because the difficulties mentioned in Item 1 above would still remain.
4. Given the additional time necessary to perform the turn around Pennock Reef and the approximately 30.5-n.m. additional running distance resulting from closure of Tongass Narrows to the north, a time penalty for cruise ships calling at Ketchikan might be expected. This impact on running time is estimated in Section 6.4, with an additional 15 minutes or so to perform the turn around Pennock Reef.

Large Shipping Arrives and Departs Via East Channel Only

The consequences of large shipping both arriving and departing via East Channel is to eliminate the turn around Pennock Reef and through the cruise ship anchorage in exchange for the necessity of executing an approximately 180° turn, either on arrival or upon departure, in the berthing and swinging area off the Ketchikan cruise ship dock.

1. If all large ship arrivals and departures used East Channel, it would be necessary for each ship to execute an approximately 180° turn, either on arrival or upon departure, in the berthing and swinging area off the Ketchikan cruise ship dock. The wind in the general area of this turning and swinging area is reported to be very unsteady because of deflections off Deer Mount and other adjacent ridges. While modern cruise ships outfitted with bow thrusters and azipods should have relatively little difficulty making this ~180° turn, older cruise ships lacking modern maneuvering features such as bow thrusters, azipods or high-performance rudders, might find it necessary to obtain assistance from harbor tugs where such assistance is currently not required. Additional time would be required to execute this ~180° turn.
2. The cruise ship tender traffic area is shown in Figure 23 (blue lines). Ships arriving and departing via East Channel would have to execute the ~180° turn, possibly with tug assistance, in the area that includes the cruise ship tender traffic from anchored cruise ships.
3. Clearing the wreck marked by the red buoy WR6 would do little to improve cruise ship maneuvering if both arrivals and departures were via East Channel.
4. Given the additional time necessary to perform the ~180° turn and the approximately 30.5-n.m. additional running distance resulting from closure of Tongass Narrows to the north, a time penalty for cruise ships calling at Ketchikan might be expected. This impact on running time is estimated in Section 6.4, with an additional 15 to 20 minutes or so to perform the 180° turn.

6.3.2 Consequences of Blocking of East Channel

This section considers the consequences of closing East Channel to large shipping at a location south of the Ketchikan cruise ship docks. (Note that, unlike West Channel, East Channel aligns with the Ketchikan cruise ship docks.) In many respects, the consequences are similar to those that apply in Section 6.3.1 (a) above.

1. Practically, the 20-degree rudder turn plotted in Figure 23 for vessels proceeding to or from the south of the Ketchikan cruise ship docks via the West Channel (red dashed arc) is infeasible because of insufficient water depth over Pennock Reef. The alternative is to proceed to the north of Pennock Reef and, after slowing down, make the necessary turn, either with tug assistance or with differential operation of the propellers and/or bow/stern thrusters (green line). Large cruise ships normally avoid this by taking the East Channel instead of the West Channel. In this connection, note that the United States Coast Pilot (Reference [23]) indicates that large ships from the south frequently take the West Channel and navigate around Pennock Reef, so as to make a port landing at the Ketchikan cruise ship docks. This is contradictory to the information that has been obtained from the pilots and shipping agents, including Reference [24]. The Coast Pilot information is apparently outdated and does not reflect current practice applicable to the large cruise ships calling at Ketchikan today. For these ships, the route via West Channel and around Pennock Reef is not normal. Besides being a difficult maneuvering exercise (as illustrated in Figure 24), the additional maneuvering required would add time to the operations and might also require assist tugs where such assistance is currently not required. The difficulty is heightened for the case of southbound cruise ships docked port side to at the pier. These ships must make a 180-degree turn to starboard followed by another 180-degree turn to port to get to the head of West Channel and line up with the channel orientation (see Figure 24).

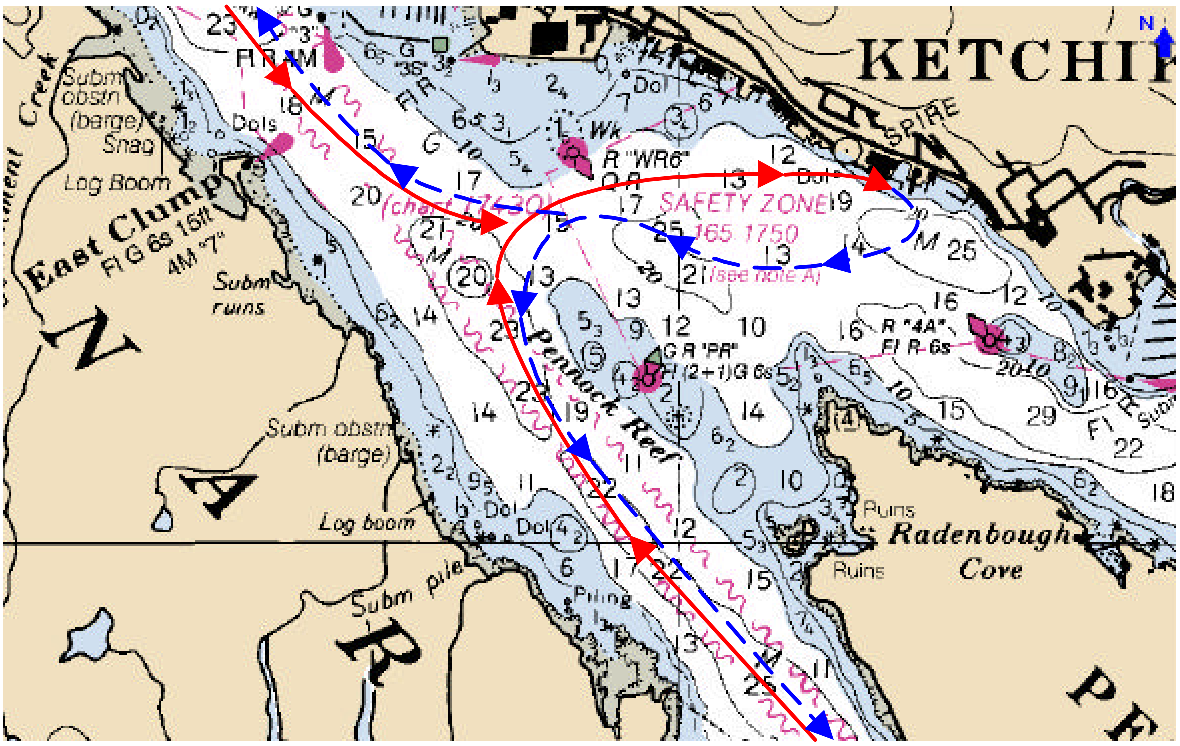


FIGURE 24
ILLUSTRATION OF CRUISE SHIP MANEUVERS IN KETCHIKAN HARBOR IF EAST CHANNEL WERE BLOCKED TO LARGE SHIPPING

1. The wind vectors in West Channel are expected to be less "confused" than they are in the general area of the cruise ship anchorage, where deflection off Deer Mount and other ridges make the winds more troublesome. It is in the area where the winds are troublesome that cruise ships using West Channel need to accomplish some complex maneuvering turns. The judgment of one cruise shipmaster is that large cruise ships should attempt the passage of West Channel only under wind conditions less than Beaufort Force 4 (11-16 knots). However, one local marine pilot does not share this degree of concern. (Shipmasters and marine pilots share responsibility in pilotage waters; accordingly, both the master and the pilot must agree on the advisability of a proposed maneuver.)
2. The cruise ship anchorage and the cruise ship tender traffic areas are shown in Figure 23 (blue circle and blue lines). At present, only cruise ships to or from the north of the cruise ship docks pass through the anchorage. If East Channel were to be closed, the vessels proceeding to the south of the Ketchikan cruise ship docks would also need to pass through the anchorage en route to West Channel. This would increase traffic through the cruise ship anchorage.
3. If East Channel were closed, vessels leaving the cruise ship docks would need to swing through 180 degrees, either with tug assistance or by operating their bow/stern thrusters. The area required for berthing and swinging is indicated in Figure 23 (red circle). Some interference with cruise ship tender traffic might be expected.
4. Clearing the wreck marked by the red buoy WR6 and providing a minimum water depth of 6 fathoms in this area would open up additional maneuvering room for marine traffic. However, this would not make the West Channel route feasible for large cruise ships, because the difficulties mentioned in Item 1 above would still remain.

The maneuver around Pennock Reef, the passage of West Channel, and the increased traffic through the anchorage and across tender traffic lanes all have adverse safety implications.

If East Channel were blocked to large vessels but open to medium-sized shipping such as Alaska ferries and barge traffic, then the natural separation of shipping that currently takes place would be adversely modified and crossing traffic patterns would develop within Ketchikan harbor. And if East Channel were blocked to both large and medium-sized shipping (as would be the case with Alternative F3), then congestion in West Channel would be exacerbated.

The operational alternative would be for cruise ship traffic to arrive and depart only through the north branch of Tongass Narrows. As previously noted (in Section 6.2.2), this would result in an increase of approximately 19.4 n.m. in the running distances for cruise ships calling at Ketchikan (the increase in running time is estimated in Section 6.4) This would alleviate the risk associated with maneuvering around Pennock Reef and that associated with the passage of West Channel, but all other impacts (including the adverse safety impacts of increased traffic through the anchorage and across tender traffic lanes) would remain.

6.4 Running Time and Other Impacts on Cruise Ships

This section addresses running time and other impacts of 120-foot high and 60-foot high bridges on large cruise ships. A 200-foot-high bridge would enable the passage of large cruise ships and would, therefore, not impact running time. The basis of this analysis is the Ketchikan and Juneau 2001 cruise ship calendar. The analysis focuses on northbound cruise ships, for which Juneau is the next port immediately following Ketchikan, and southbound ships departing Juneau, for which Ketchikan is the immediate next port of call.

The 2001 Ketchikan cruise calendar delineates 104 northbound port calls and 282 southbound port calls by large cruise ships, for a total of 386 port calls (27% northbound and 73% southbound, overall). Of these, 95 northbound calls at Ketchikan proceed next to Juneau, and 94 southbound calls arrive directly from Juneau. The sailing distance for large vessels operating between Ketchikan and Juneau (from cruise ship dock to cruise ship dock) is 300 n.m. via Tongass Narrows, Clarence Strait, Sumner Strait, around Cape Decision, thence up Chatham Strait to Frederick Sound, and thence Stephens Passage, and finally Gastineau Channel. Of this distance, approximately 4.5 n.m. are slow-sailing waters – approximately 3.5 n.m. in Tongass Narrows restricted to 7 knots, and the final nautical mile (approximately) leading to the Juneau cruise ship dock. Approximately 15 minutes must be allowed for casting off and getting under way. And, likewise, 15 minutes must be allowed for maneuvering to berth and making fast. Making these allowances, a mean transit speed can be computed for each vessel calling at Ketchikan that is either arriving from or departing to Juneau. These are summarized in the following Tables 29 and 30.

Table 29 summarizes the 2001 results for the 95 northbound vessel-trips calling at Ketchikan for which Juneau is the immediate next port of call, and Table 30 summarizes the 2001 results for the 94 southbound vessel-trips arriving at Ketchikan from Juneau. The tables give the cruise lines, vessel names, number of vessel-trips by each vessel at a given speed, total hours between ports, calculated average speed, percent of maximum cruising speed, maximum cruising speed, and maximum sea speed.

The maximum cruising speed (corresponding to full speed on the vessel pilot card) is estimated as 90% of the maximum sea speed. Where both maximum sea speed and full speed were available, this 90% relationship was determined to be a good estimator.

The maximum sea speed closely corresponds to the maximum speed capability or trials speed of the vessels. In general, ships and vessel operating companies are unwilling to schedule operations around maximum sea speed for the following reasons (and for other reasons not listed here):

- Propulsion system reliability and availability are much higher if operations above 90% are avoided.

- Operations above 90% increase fuel consumption and cost; as a rough rule-of-thumb, fuel costs increase by 37% when speed is increased from maximum cruising speed to maximum sea speed.
- Operations above 90% may result in vibrations that are objectionable to passengers.
- The power reserves available when operations are scheduled using cruising speed are necessary to offset adverse environmental conditions (wind, waves, and current).
- The speed reserves available when operations are scheduled using cruising speed may be used to overcome small time delays encountered during actual operations.

TABLE 29
TRANSIT SPEED FOR NORTHBOUND CRUISE SHIP TRAFFIC IN TONGASS NARROWS IN 2001

2001 Cruise Season Northbound							
Cruise Line	Ship	No. Trips	KTN to JUN (hours)	Average Speed (knots)	Percent Max. Cruising Speed	Max. Cruising Speed (knots)	Full Sea (knots)
Carnival	Carnival Spirit	7	16	19.89	91.70%	21.69	24.1
Celebrity	Infinity	1	15	21.32	98.73%	21.60	24.0
Celebrity	Mercury	9	17	18.64	96.31%	19.35	21.5
Crystal	Crystal Harmony	1	19	16.55	83.58%	19.80	22.0
HAL	Ryndam	9	17	18.64	94.12%	19.80	22.0
HAL	Statendam	10	17	18.64	94.12%	19.80	22.0
HAL	Veendam	1	16	19.89	97.78%	20.34	22.6
HAL	Veendam	8	17	18.64	91.62%	20.34	22.6
Princess	Dawn Princess	9	16.5	19.24	95.45%	20.16	22.4
Princess	Ocean Princess	9	16.5	19.24	95.45%	20.16	22.4
Princess	Sea Princess	9	16.5	19.24	95.45%	20.16	22.4
Princess	Sun Princess	7	16.5	19.24	95.45%	20.16	22.4
RAD	7 Seas Mariner	1	18	17.53	84.68%	20.70	23.0
RAD	7 Seas Mariner	1	16	19.89	96.08%	20.70	23.0
RAD	7 Seas Mariner	4	15	21.32	103.02%	20.70	23.0
RCI	Rhapsody/Seas	9	16	19.89	93.72%	21.22	23.6
		95	16.56	19.20	94.65%	20.29	22.54

TABLE 30
TRANSIT SPEED FOR SOUTHBOUND CRUISE SHIP TRAFFIC IN TONGASS NARROWS IN 2001

2001 Cruise Season Southbound							
Cruise Line	Ship	No. Trips	JNU to KTN (hours)	Average Speed (knots)	Percent Max. Cruising Speed	Max. Cruising Speed (knots)	Full Sea (knots)
Celebrity	Infinity	1	15	21.32	98.73%	21.60	24.0
Celebrity	Mercury	1	18	17.53	90.59%	19.35	21.5
Crystal	Crystal Harmony	2	18	17.53	88.53%	19.80	22.0
HAL	Ryndam	9	17	18.64	94.12%	19.80	22.0
HAL	Statendam	1	18	17.53	88.53%	19.80	22.0
HAL	Statendam	8	17	18.64	94.12%	19.80	22.0
HAL	Statendam	1	16	19.89	97.78%	20.34	22.6
HAL	Veendam	9	17	18.64	91.62%	20.34	22.6
NCL	Norwegian Wind	1	20	15.67	82.91%	18.90	21.0
NCL	Norwegian Wind	9	17	18.64	98.60%	18.90	21.0
Princess	Dawn Princess	9	16	19.89	98.66%	20.16	22.4
Princess	Ocean Princess	8	16	19.89	98.66%	20.16	22.4
Princess	Sea Princess	1	16.5	19.24	95.45%	20.16	22.4
Princess	Sea Princess	8	16	19.89	98.66%	20.16	22.4
Princess	Sun Princess	9	16	19.89	98.66%	20.16	22.4
RCI	Vision/Seas	17	16	19.89	98.22%	20.25	22.5
		94	16.49	19.29	96.46%	19.99	22.21

It may be observed in Table 29 that northbound cruise ships operated, on average, at 94.65% of estimated maximum cruising speed. From Table 30 it may be observed that southbound cruise ships operated at 96.46% of estimated maximum cruising speed. These percentages would be even higher were it not for a few cases where cruise ships were obviously scheduled with longer transit times. For example, one of the ten southbound trips by the *Norwegian Wind* (arriving in Ketchikan on July 14) was scheduled for a 20-hour transit, whereas the remaining nine trips were scheduled for 17-hour transits. Presumably, the additional three hours were scheduled for some special sight-seeing event (a tour up Taku Inlet, perhaps), or else the extra time was necessitated by some conflict with the cruise ship docks, either in Juneau or in Ketchikan.

In any event, it can be seen that the large cruise ships are currently operating between Ketchikan and Juneau at approximately 95% of estimated maximum cruising speed. Given that the average estimated maximum cruising speed is somewhere between 19.99 and 20.29 knots, the remaining 5% corresponds to approximately one knot (i.e., they are operating about one knot less than the estimated maximum cruising speed in 2001). On the run between Ketchikan and Juneau, this extra knot might be expected to decrease running time by about 46 minutes.

An analysis was conducted to test the degree to which running at full estimated maximum cruising speed can offset the adverse impacts of 120-foot high and 60-foot high bridges around Ketchikan. This time-and-motion analysis employed full estimated maximum cruising speed in transit and subjected it to the bridge alternatives with 120-foot high and 60-foot high spans. The first assumed a 120-foot high bridge north of the Ketchikan cruise ship docks, in the vicinity of Charcoal Point. This adds 30.5 n.m. to the sailing distance between Ketchikan and Juneau. The results of this assumption are shown in Tables 31 and 32.

TABLE 31
IMPACT ON NORTHBOUND RUNNING TIME OF A 120-FOOT HIGH BRIDGE ACROSS TONGASS NARROWS NORTH OF KETCHIKAN BRIDGE DOCKS

Tongass Narrows Blocked North of Ketchikan Cruise Ship Docks

2001 Cruise Season Northbound							
Cruise Line	Ship	No. Trips	Baseline KTN to JUN (hours)	Hours at Max Cruise (hours)	Time Lost (hours)	Max. Cruising Speed (knots)	Full Sea (knots)
Carnival	Carnival Spirit	7	16	16.17	0.17	21.69	24.1
Celebrity	Infinity	1	15	16.24	1.24	21.60	24.0
Celebrity	Mercury	9	17	17.99	0.99	19.35	21.5
Crystal	Crystal Harmony	1	19	19.00	0.00	18.26	22.0
HAL	Ryndam	9	17	17.61	0.61	19.80	22.0
HAL	Statendam	10	17	17.61	0.61	19.80	22.0
HAL	Veendam	1	16	17.17	1.17	20.34	22.6
HAL	Veendam	8	17	17.17	0.17	20.34	22.6
Princess	Dawn Princess	9	16.5	17.31	0.81	20.16	22.4
Princess	Ocean Princess	9	16.5	17.31	0.81	20.16	22.4
Princess	Sea Princess	9	16.5	17.31	0.81	20.16	22.4
Princess	Sun Princess	7	16.5	17.31	0.81	20.16	22.4
RAD	7 Seas Mariner	1	18	18.00	0.00	19.34	23.0
RAD	7 Seas Mariner	1	16	16.89	0.89	20.70	23.0
RAD	7 Seas Mariner	4	15	16.43	1.43	21.32	23.0
RCI	Rhapsody/Seas	9	16	16.50	0.50	21.22	23.6
		95	16.56	17.23	0.68	20.28	22.54

TABLE 32
IMPACT ON SOUTHBOUND RUNNING TIME, OF A 120-FOOT HIGH BRIDGE ACROSS TONGASS NARROWS NORTH OF KETCHIKAN BRIDGE DOCKS

Tongass Narrows Blocked North of Ketchikan Cruise Ship Docks

2001 Cruise Season Southbound							
Cruise Line	Ship	No. Trips	Baseline JNU to KTN (hours)	Hours at Max Cruise (hours)	Time Lost (hours)	Cruising Speed (knots)	Full Sea (knots)
Celebrity	Infinity	1	15	16.24	1.24	21.60	24.0
Celebrity	Mercury	1	18	18.00	0.00	19.34	21.5
Crystal	Crystal Harmony	2	18	18.00	0.00	19.34	22.0
HAL	Ryndam	9	17	17.61	0.61	19.80	22.0
HAL	Statendam	1	18	17.61	0.00	19.80	22.0
HAL	Statendam	8	17	17.61	0.61	19.80	22.0
HAL	Statendam	1	16	17.17	1.17	20.34	22.6
HAL	Veendam	9	17	17.17	0.17	20.34	22.6
NCL	Norwegian Wind	1	20	20.00	0.00	17.29	21.0
NCL	Norwegian Wind	9	17	18.39	1.39	18.90	21.0
Princess	Dawn Princess	9	16	17.31	1.31	20.16	22.4
Princess	Ocean Princess	8	16	17.31	1.31	20.16	22.4
Princess	Sea Princess	1	16.5	17.31	0.81	20.16	22.4
Princess	Sea Princess	8	16	17.31	1.31	20.16	22.4
Princess	Sun Princess	9	16	17.31	1.31	20.16	22.4
RCI	Vision/Seas	17	16	17.24	1.24	20.25	22.5
		94	16.49	17.48	0.99	19.96	22.21

The average time lost on northbound voyages is 0.68 hours (41 minutes), and the average time lost on southbound voyages is 0.99 hours, or essentially 60 minutes.

In addition, the cruise ships will apply more power (on average, +6,130 British horsepower [BHP]) northbound and +3,535 BHP southbound) and burn more fuel (on average, +4,594 gallons northbound and +2,712 gallons southbound). The standard deviation of additional fuel burned northbound is 2,103 gallons, with a minimum of zero and a maximum of 9,906 gallons. The standard deviation of additional fuel burned southbound is 2,750 gallons, with a minimum of 928 gallons and a maximum of 9,351 gallons.

Similar analyses apply to a 60-foot high bridge across Tongass Narrows south of the existing Ketchikan cruise ship docks. If East Channel were to be blocked to large cruise ships by a 60-foot high bridge and if the majority of large cruise ships were to shun West Channel (even though the vertical bridge clearance might admit their passage), then the large cruise ships would have to travel an additional 19.4 n.m. and they would have to execute a 180° turn that is currently not required, adding 15 to 20 minutes to their harbor maneuvers. This possibility is represented in Tables 33 and 34.

TABLE 33
IMPACT ON NORTHBOUND RUNNING TIME, OF A 60-FOOT HIGH BRIDGE ACROSS EAST CHANNEL SOUTH OF KETCHIKAN CRUISE SHIP DOCKS: DEPARTURE VIA NORTH

All Large Cruise Ships Arrive and Depart to North

2001 Cruise Season Northbound

Cruise Line	Ship	No. Trips	Baseline KTN to JUN (hours)	Hours at Max Cruise (hours)	Time Lost (hours)	Cruising Speed (knots)	Full Sea (knots)
Carnival	Carnival Spirit	7	16	16.00	0.00	21.62	24.1
Celebrity	Infinity	1	15	16.01	1.01	21.60	24.0
Celebrity	Mercury	9	17	17.71	0.71	19.35	21.5
Crystal	Crystal Harmony	1	19	19.00	0.00	17.93	22.0
HAL	Ryndam	9	17	17.34	0.34	19.80	22.0
HAL	Statendam	10	17	17.34	0.34	19.80	22.0
HAL	Veendam	1	16	16.92	0.92	20.34	22.6
HAL	Veendam	8	17	17.00	0.00	20.23	22.6
Princess	Dawn Princess	9	16.5	17.05	0.55	20.16	22.4
Princess	Ocean Princess	9	16.5	17.05	0.55	20.16	22.4
Princess	Sea Princess	9	16.5	17.05	0.55	20.16	22.4
Princess	Sun Princess	7	16.5	17.05	0.55	20.16	22.4
RAD	7 Seas Mariner	1	18	18.00	0.00	19.01	23.0
RAD	7 Seas Mariner	1	16	16.65	0.65	20.70	23.0
RAD	7 Seas Mariner	4	15	16.20	1.20	21.32	23.0
RCI	Rhapsody/Seas	9	16	16.27	0.27	21.22	23.6
		95	16.56	16.99	0.44	20.26	22.54

TABLE 34
IMPACT ON SOUTHBOUND RUNNING TIME, OF A 60-FOOT HIGH BRIDGE ACROSS EAST CHANNEL SOUTH OF KETCHIKAN CRUISE SHIP DOCKS: DEPARTURE VIA NORTH

All Large Cruise Ships Arrive and Depart to North

2001 Cruise Season Southbound

Cruise	Ship	No. Trips	Baseline JNU to KTN (hours)	Hours at Max Cruise (hours)	Time Lost (hours)	Cruising Speed (knots)	Full Sea (knots)
Celebrity	Infinity	1	15	16.01	1.01	21.60	24.0
Celebrity	Mercury	1	18	18.00	0.00	19.01	21.5
Crystal	Crystal Harmony	2	18	18.00	0.00	19.01	22.0
HAL	Ryndam	9	17	17.34	0.34	19.80	22.0
HAL	Statendam	1	18	18.00	0.00	19.01	22.0
HAL	Statendam	8	17	17.34	0.34	19.80	22.0
HAL	Statendam	1	16	16.92	0.92	20.34	22.6
HAL	Veendam	9	17	17.00	0.00	20.23	22.6
NCL	Norwegian Wind	1	20	20.00	0.00	16.96	21.0
NCL	Norwegian Wind	9	17	18.10	1.10	18.90	21.0
Princess	Dawn Princess	9	16	17.05	1.05	20.16	22.4
Princess	Ocean Princess	8	16	17.05	1.05	20.16	22.4
Princess	Sea Princess	1	16.5	17.05	0.55	20.16	22.4
Princess	Sea Princess	8	16	17.05	1.05	20.16	22.4
Princess	Sun Princess	9	16	17.05	1.05	20.16	22.4
RCI	Vision/Seas	17	16	16.99	0.99	20.25	22.5
		94	16.49	17.25	0.75	19.93	22.21

The average time lost on northbound voyages is 0.44 hours (26 minutes) and the average time lost on southbound voyages is 0.75 hours (45 minutes).

In addition, the cruise ships will apply more power (on average, +6,035 BHP northbound and +3,395 BHP southbound) and burn more fuel (on average, +4,527 gallons northbound and +2,613 gallons southbound). The standard deviation of additional fuel burned northbound is 2,013 gallons, with a minimum of zero and a maximum of 8,817 gallons. The standard deviation of additional fuel burned southbound is 2,620 gallons, with a minimum of 928 gallons and a maximum of 8,044 gallons.

Finally, assuming a 60-foot high bridge across East Channel south of the existing Ketchikan cruise ship docks and a willingness of large cruise ships to use West Channel adds approximately 1.8 n.m. to the running distance, and the cruise ships would have to execute the equivalent of two 180° turns that are currently not required, adding 30 to 40 minutes to their harbor maneuvers. This possibility is represented in Tables 35 and 36.

TABLE 35
IMPACT ON NORTHBOUND RUNNING TIME, OF A 60-FOOT HIGH BRIDGE ACROSS EAST CHANNEL SOUTH OF KETCHIKAN CRUISE SHIP DOCKS: DEPARTURE VIA WEST CHANNEL

East Channel Blocked - Large Cruise Ships Use West Channel

2001 Cruise Season Northbound							
Cruise Line	Ship	No. Trips	Baseline KTN to JUN (hours)	Hours at Max Cruise (hours)	Time Lost (hours)	Cruising Speed (knots)	Full Sea (knots)
Carnival	Carnival Spirit	7	16	16.00	0.00	20.83	24.1
Celebrity	Infinity	1	15	15.49	0.49	21.60	24.0
Celebrity	Mercury	9	17	17.09	0.09	19.35	21.5
Crystal	Crystal Harmony	1	19	19.00	0.00	17.21	22.0
HAL	Ryndam	9	17	17.00	0.00	19.46	22.0
HAL	Statendam	10	17	17.00	0.00	19.46	22.0
HAL	Veendam	1	16	16.34	0.34	20.34	22.6
HAL	Veendam	8	17	17.00	0.00	19.46	22.6
Princess	Dawn Princess	9	16.5	16.50	0.00	20.12	22.4
Princess	Ocean Princess	9	16.5	16.50	0.00	20.12	22.4
Princess	Sea Princess	9	16.5	16.50	0.00	20.12	22.4
Princess	Sun Princess	7	16.5	16.50	0.00	20.12	22.4
RAD	7 Seas Mariner	1	18	18.00	0.00	18.27	23.0
RAD	7 Seas Mariner	1	16	16.09	0.09	20.70	23.0
RAD	7 Seas Mariner	4	15	15.67	0.67	21.32	23.0
RCI	Rhapsody/Seas	9	16	16.00	0.00	20.83	23.6
		95	16.56	16.60	0.05	20.01	22.54

TABLE 36
IMPACT ON SOUTHBOUND RUNNING TIME, OF A 60-FOOT HIGH BRIDGE ACROSS EAST CHANNEL SOUTH OF KETCHIKAN CRUISE SHIP DOCKS: DEPARTURE VIA WEST CHANNEL

East Channel Blocked - Large Cruise Ships Use West Channel

2001 Cruise Season Southbound

Cruise Line	Ship	No. Trips	Baseline JNU to KTN (hours)	Hours at Max Cruise (hours)	Time Lost (hours)	Cruising Speed (knots)	Full Sea (knots)
Celebrity	Infinity	1	15	15.49	0.49	21.60	24.0
Celebrity	Mercury	1	18	18.00	0.00	18.27	21.5
Crystal	Crystal Harmony	2	18	18.00	0.00	18.27	22.0
HAL	Ryndam	9	17	17.00	0.00	19.46	22.0
HAL	Statendam	1	18	18.00	0.00	18.27	22.0
HAL	Statendam	8	17	17.00	0.00	19.46	22.0
HAL	Statendam	1	16	16.34	0.34	20.34	22.6
HAL	Veendam	9	17	17.00	0.00	19.46	22.6
NCL	Norwegian Wind	1	20	20.00	0.00	16.27	21.0
NCL	Norwegian Wind	9	17	17.46	0.46	18.90	21.0
Princess	Dawn Princess	9	16	16.47	0.47	20.16	22.4
Princess	Ocean Princess	8	16	16.47	0.47	20.16	22.4
Princess	Sea Princess	1	16.5	16.50	0.00	20.12	22.4
Princess	Sea Princess	8	16	16.47	0.47	20.16	22.4
Princess	Sun Princess	9	16	16.47	0.47	20.16	22.4
RCI	Vision/Seas	17	16	16.41	0.41	20.25	22.5
		94	16.49	16.79	0.30	19.76	22.21

The average time lost on northbound voyages is a negligible 0.05 hours (3 minutes), and the average time lost on southbound voyages is 0.30 hours (18 minutes).

In addition, the cruise ships will apply more power (on average, +4,690 BHP northbound and +2,642 BHP southbound) and burn more fuel (on average, +3,579 gallons northbound and +2,055 gallons southbound). The standard deviation of additional fuel burned northbound is 1,197 gallons, with a minimum of zero and a maximum of 5,813 gallons. The standard deviation of additional fuel burned southbound is 1,816 gallons, with a minimum of 928 gallons and a maximum of 4,519 gallons.

Regarding additional fuel consumption and assuming marine diesel fuel (some cruise ships may be burning "heavy fuel" (HFO) such as IF380), unit marine diesel fuel cost is currently probably about $1.00 per gallon.

Obviously, a similar question can be posed for vessels sailing south of Ketchikan. The critical issue is probably not scheduled arrival in Vancouver, BC, but arrival at (or departure from, northbound) Seymour Narrows. Cruise ship transits between Seymour Narrows and Ketchikan were not analyzed for two reasons: the appropriate schedule information pertaining to Seymour Narrows was not readily available, and the distance between Seymour Narrows and Ketchikan (approx. 446 n.m.) is greater than the distance between Ketchikan and Juneau (approx. 300 n.m.). Thus the Ketchikan–Juneau leg is more critical for making up time.

6.5 Other Effects of a 60-foot High Bridge over East Channel and a 200-foot High Bridge over West Channel

As described in the previous sections, Alternative F3 includes a low (60-foot vertical clearance) bridge over East Channel and a higher bridge (200-foot clearance) over West Channel south of the Ketchikan cruise ship dock. Currently, cruise ships predominantly use East Channel because it provides a nearly direct alignment to docking and berthing facilities, while West Channel requires considerable maneuvering in order to berth. This alternative would have an adverse impact on cruise ships because it would require the exclusive use of West Channel by cruise ships, which in turn would require additional maneuvering, increased sailing time (and decreased port time).

The use of West Channel also presents safety concerns for cruise ship lines and ship pilots. Discussions of these safety concerns are detailed in "Ketchikan Bridge Project, Port of Ketchikan, Alaska, Tongass Narrows, Summary Report," prepared by RTM STAR Center in Dania, Florida (see Appendix I). The RTM STAR Center study included full-mission computer generated simulation of large cruise ships maneuvering into and out of Ketchikan. The concerns presented in the report include comments from Ketchikan cruise ship pilots that West Channel with the Alternative F3 Bridge is too narrow to safely navigate large ships. The primary issue is that there is no margin for error at the bridge; e.g., a gust of wind, an engineering casualty, an error in responding to helm commands, or opposing traffic, would allow very little time (or space) to react and take sufficient evasive action. Other issues include risks associated with: a tidal current set toward Pennock Island; bank suction effects at the bridge site; maintaining vessel control in following winds and currents by increasing speed above the existing speed limit; and the need to execute a 120-degree turn around Pennock Reef, especially when the harbor has other maneuvering vessels and vessels at anchor.

Also, AMHS ferries usually use West Channel, and the high span over West Channel would allow continued use by the AMHS ferries. The AMHS ferries would not be able to transit East Channel. With cruise ships required to use the West Channel as well, marine traffic in the West Channel would increase. The current separation of AMHS traffic from cruise ship traffic by Pennock Island would cease. Furthermore, container-carrying barges would likely not be able to traverse East Channel, contributing further to marine traffic in the West Channel.

In addition, the introduction of piers in the deep navigable waters of Tongass Narrows would introduce new, permanent, grounding and allision risks. The above discussion suggests a consideration of modifications to West Channel, such as making it wider, so as to mitigate the anticipated traffic congestion and the risk of grounding.

7—Conclusions

In support of the Gravina Access Project and together with a similar effort to identify aviation requirements, this updated reconnaissance of vessel navigation requirements serves to support the process of identifying practical alternatives for improving access between Ketchikan and Gravina Island. This report, in addition to identifying the number and characteristics of vessels using Tongass Narrows, assesses some of the effects of the proposed project alternatives on marine navigation.

The report includes projections for future cruise ship traffic in Tongass Narrows and an analysis of the navigation impacts of the proposed bridge alternatives—Alternatives C3(a), C4, C3(b), D1, F1, and F3—especially on cruise ship schedule and selected operating costs.

Some of the proposed bridge alternatives—C3(b), D1, and F3—have clear potential to block or inhibit large-vessel traffic in Tongass Narrows. Either closing Tongass Narrows in the vicinity of Charcoal Point or closing East Channel to large cruise ships would require cruise ships routinely accomplishing difficult maneuvers, which might consist of turns around Pennock Reef and transiting West Channel and/or making an approximately 180° turn in the berthing and swinging area. Ships that lack modern maneuvering features such as bow thrusters, azipods or high-performance rudders might find it necessary to engage harbor assist tugs where such assistance is currently not required.

Closure of East Channel or closure of Tongass Narrows in the vicinity of Charcoal Point, with large ships making use of both East and West Channels, would increase traffic through anchorage and across tender traffic from anchored cruise ships. Any of the potential closures would increase running distances and corresponding travel time for cruise ships calling at Ketchikan.

Any of the potential channel closures to large ships could also adversely impact operations of these vessels as a result of (i) increases in maneuvering time; (ii) increases in sailing distances (for ships unwilling to use West Channel); (iii) increases in direct expenses associated with requirements for more assist tug services and/or increased fuel costs associated with efforts to increase speed to maintain schedule; and (iv) decreases in safety due to the need for more complex maneuvers in congested areas. These factors would likely result in increased costs of operations for large vessels calling at Ketchikan.

The bridge alternatives that appear to pose the least impact on vessel navigation in Tongass Narrows are Alternatives C3(a), C4, and F1. As the project progresses, a preferred alternative will be identified for evaluation in the EIS. A final design will follow approval of the EIS.

8—References

1. Waterborne Commerce Statistics Center, U..S Army Corps of Engineers, Waterborne Commerce of the United States, Part 4 – Waterways and Harbors on the Pacific Coast, Alaska and Hawaii, 1999, New Orleans; also downloadable from http://www.wrsc.usace.army.mil/ndc/wcsc.htm.
2. G.P. Wild (International) Limited, "Cruise Industry Statistical Review 1999."
3. Klugherz & Associates, "Cruise Industry Background (DRAFT)," facsimile transmission to Mark Dalton of HDR Alaska, September 3, 1999.
4. Ketchikan Cruise Ship Calendars for the years 1991 through 2001, Ketchikan Visitors Bureau.
5. Alaska Marine Highway System, "1997 Annual Traffic Volume Report," downloadable from http://ntl.bts.gov/data/97tvr.
6. Alaska Marine Highway System, "1998 Annual Traffic Volume Report," downloadable from http://ntl.bts.gov/data/98tvr.
7. Alaska Marine Highway System, "Summer 2001 Schedule," downloaded from http://www.dot.state.ak.us/external/amhs/schedres/index.html.
8. KJS Associates, Inc., et al., "Southeast Alaska Transportation Plan," prepared for the Alaska Department of Transportation and Public Facilities, March 1999; 2nd printing (incorporating errata), May 1999. Downloadable from http://www.dot.state.ak.us/external/state_wide/planning/seplan.html.
9. Southeast Region, Alaska Department of Transportation and Public Facilities, "Addendum One to the Southeast Alaska Transportation Plan," February 2001; available on line at http://www.newwavesalaska.com/addfinal22701.pdf.
10. "New Waves," Southeast Alaska Transportation News, on the Internet at http://www.newwavesalaska.com.
11. Jack Meyers, Special Project Manager, Alaska Department of Transportation and Public Facilities, private communication.
12. Tucker Gilliam, Marine Superintendent at Crowley Petroleum, Long Beach, California, private communication.
13. Norman Polmer, The Ships and Aircraft of US Fleet, 12th edition, Naval Institute Press, Annapolis, Maryland, 1983.
14. Alaska Harbor Management System, "Operations Management Report," Alaska Department of Transportation and Public Facilities, Ports and Harbors, 1994.
15. United States Coast Guard, Tongass Narrows Voluntary Waterway User Guide, Juneau, Alaska, March 1999.
16. Department of Fisheries and Oceans, Sailing Directions – British Columbia Coast (South Portion), Ottawa, Canada, Paragraph 126, Vol. 1, 15th ed., 1990.
17. The Glosten Associates, Inc., "Cruise Ship Traffic Projections," Technical Memorandum for Gravina Access Project, prepared for the Alaska Department of Transportation and Public Facilities, September 2001.

18. "Approach Channels – A Guide for Design," PTC II-30 Final Report of the Joint Working Group PIANC and IAPH in cooperation with IMPA and IALA, Supplement to Bulletin No 95, June 1997.

19. Bruce L. Hutchison, "Evaluation of the Incidence of Two-Way Traffic in Tongass Narrows," Project Memorandum to HDR, Alaska, 6 July 2001.

20. Mary Klugherz, "Interim Assessment of Cruise Industry Interviews," memorandum to Mark Dalton, HDR Alaska, 31 May 2001.

21. Mary Klugherz, "Update of Cruise Industry Interviews," memorandum to Patrick Burden, Northern Economics, 28 July 2001.

22. The Glosten Associates, Inc., "Gravina Access Project: Consequences of Various Channel Closures to Large Shipping – Technical Memorandum," prepared for the Alaska Department of Transportation and Public Facilities, February 2001.

23. United States Coast Pilot 8, Pacific Coast Alaska: Dixon Entrance to Cape Spencer, 23rd edition, 1999.

24. John Miskell (CGD13 Bridge Program Manager), "Trip Report, Tongass Narrows, Ketchikan, Alaska," prepared after transiting Tongass Narrows aboard three different cruise ships on 15 May 2000.

25. Bruce L. Hutchison, "Running Time and Other Impacts on Cruise Ships," facsimile transmission to Mark Dalton of HDR, Alaska, 27 August 2001.