Exploring the CTX Tanker Casualty Database

2007-12 Update

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Contents

1 Introduction

1.1 Purpose

The CTX Tanker Casualty Data Base (CDB) contains over 900 tanker casualties. Unlike just about any other worldwide tanker casualty database, it is public and freely available under the GDPL. Any can download the entire core data file from www.c4tx.org/ctx/job/cdb/xml/cdb_core.xml. It is in open XML format, so any researcher can ask any question he wants of the data. A manual is provided to aid in such efforts. The public can also access the data via the web interface. However, most people are not equipped to dissect XML and the number of different ways you can analyse the data via the web interface is necessarily very limited. Therefore, at least annually the CTX issues this summary of the current state of the data base which attempts to anticipate the questions that are most likely to be asked, or at least the more important of these questions.[1] While the CTX is not shy about making policy recommendations, these updates attempt — not always successfully — to simply present the data.

As the manual indicates, the CTX CDB can describe a casualty in great detail if the data is available. Therefore, the number of possible ways of extracting data from the database is astronomical. In these updates, we can only present the results of a miniscule portion of the possible queries. If you have a question that you would like to ask of the CDB and don't want to attempt it yourself, send an email to cdb@c4tx.org. If the query appears interesting and important, CTX will perform the analysis and publish the results on the website. CTX does not do private analyses.

When this update refers to a particular casualty in the data base, it will usually do so by putting the ship name in small caps. If you are reading the update on-line, you should be able to click on this link and go directly to the *precis* file for that casualty.

1.2 Database Limitations

The goal of the CTX CDB is to record all *major* casualties involving ocean going tankers or combination carriers carrying petroleum or ethanol. Ships with a size of less than 5000 dwt are excluded as are barges and integrated tug barges. War losses and terrorist attacks are also excluded as are casu-

[1] The CDB is constantly changing as we make corrections and additions. Researchers need to check and reference the *update* timestamp. Similarly, this update may change at any time. Please note the date on the title page in referring to this document.

alties in repair yard, during demolition, or while being towed to demolition. A casualty is *major* if any of the following are true:

- Someone was killed or seriously injured.
- Oil was spilled, either cargo or bunkers.
- The ship suffered a total loss of power for more than one hour, or a loss of power requiring tugs to be mobilized.
- The casualty involved a fire, collision or grounding.
- The casualty involved a structural failure requiring tugs to be mobilized, or cargo transferred. or the ship diverted.

The database may also contain non-major casualties of which the CTX has become aware.

The database falls far short of this goal. It currently contains less than 1000 casualties. We can be sure there are many *major* casualties we have missed. There is a systematic effort in the tanker industry to cover up problems. Crews — especially third party manager crews — often don't report problems to owners, and owners usually don't report problems to Class. And if a Classification Society becomes aware of a casualty, it is bound by contract to keep that information confidential.

The CDB is biased towards those casualties which have received publicity, and casualties occuring in countries such as the USA, UK, and Australia which make a strong effort to record these events. It is biased away from areas such as the Persian Gulf, Asia, and most importantly the high seas where even a serious casualty can go unreported.

Another extremely important bias is that we generally only have damage location data for ships that survive. Yet most oil is spilled and most crew are killed by ships that don't survive.

Finally, please note that the Killed and Volume numbers in this paper are known dead and known spill volume in cubic meters. In quite a few of our casualties, we know people were killed or oil was spilled, but we don't have a numerical estimate.

These biases should be kept in mind in interpreting the results below.

For any individual casualty, you can access the data CTX has on the website, by searching on ship name, date, or ship IMO number. The CTX welcomes corrections and additions which should be sent to cdb@c4tx.org.

1.3 Acknowledgements

The CTX Casualty Database is dedicated to two men: Norman Hooke and Richard Cahill.

Norman Hooke took on the prodigous task of documenting all maritime casualties in which a ship was lost or declared a constructive total loss between 1967 and 1996. The result, Modern Shipping Disasters, was 600 pages of small type with nothing but facts and more facts. Without Hooke's painstaking work many tanker casualties involving scores of deaths would already have been forgotten by an industry more than willing to quickly and quietly consign its dead to the deep. Without Hooke's work, the CDB would consist largely of tanker casualties which have caught the public's attention, mainly due to an oil spill on a high profile beach.

Captain Richard Cahill in his two seminal works *Collisions and their Causes* and *Strandings and their Causes* focuses on a small subset of Hooke's casualties. But for that subset he digs deep for the real cause. As the titles of the two books show, Cahill knew that collisions and groundings don't cause spills. In order to progress, we need to understand what caused the collision, what caused the grounding. And for several hundred casualties, he determined that cause despite in many cases the best efforts of owner, Class, and flag state. The CTX CDB uses Captain Cahill's definition of cause.

Needless to say, the CTX CDB borrows liberally from Hooke and Cahill. In fact, the CDB can be regarded in part as an effort to preserve a small portion of their work in a machine readable and analyzable form. The problem is we no longer have Mr. Hooke and Captain Cahill to do our work for us. We must find replacements.

The CDB owes a big debt to the Equasis organization (www.equasis.org). equasis is a ship database focussing on recording port state detentions. But, for currently and recently active ships, equasis has also taken on the very difficult task of maintaining the ship's owner, manager, class and flag history. Other than Class and flag at time of casualty, the CTX database makes no attempt to do this. If you need owner, manager stuff for a fairly recent casualty, you will probably find it by going to equasis with the ship's IMO number.[2]

Port states are big contributors to the CDB, most importantly, the USCG CGMIX and MSIS/MISLE databases, the Australian Maritime Safety, CEDRE, REMPEC, and the ACOPS summaries of UK spills. The Canadian Environmental Technology Center made a big contribution by preserving data on some 750 tanker spills between 1973 and 1997.

[2] Perhaps in the future we can automate this process.

2 Spill Causality

The CDB has some 70 initial cause codes, broken down into nine major categories.: structural failures, machinery failure, rules of the road screws up, navigation error, conninge and seamanship errors, external (to the ship), bad inerting/hotwork, cargo transfer problems. and dont know. Conspiculously missing are collision, grounding and fire. ***Collision, grounding, fire/explosion are consequences, not causes.*** Something always happened first. The key question in any casualty is not whether it involved a collision, or a grounding, or fire — many casualties involve combinations of collision, grounding and fire — but what caused these events. In the CTX database each casualty is described by a sequence of as many as seven event codes. By fiat, collision, grounding, fire can never be the first event code. Treating something like grounding as a cause is doubly irrational. It shifts regulatory focus away from preventing the grounding in the first place and towards mandating grounding-proof ships, an impossibility. Blaming a spill on grounding is like blaming the earth for an airplane crash.

Table 1 shows the breakdown by initial event for all post-1960 casualties as of the date shown. Table 1 is sorted by total known spill volume by category. But it is important we be very careful in making statements about spill volume.

The size range of tanker spills is very large. Spills as small as one-third of a liter have been recorded. The largest tanker spill so far is over 300 million liters. The spill size range is a factor of a billion. Almost all tanker spills are at the very lower end of this range. But almost all the oil that is spilled is spilled by a few spills at the top end of the range. The range is so large that even an extremely large number of small spills can't come close to matching a single very large spill. In the entire CTX CDB, the top two spills represent 10% of all known spillage over the last 50 years; the top five represent 21%; the top ten, 31%; the top 25, 50%; the top fifty, 66%; the top 100, 85%; and the top 200, 98%. The remaining 700 plus casualties represent less that 2% of the total spillage.

In short, the spill volume numbers are completely dominated by a handfull of extremely large spills. We could have a 300 million liter spill tomorrow which would totally change all but the very largest numbers in Table 1. With respect to spill volume, we must proceed with caution.

When it comes to deaths, the size range is much smaller, roughly a factor of 100. Usually the number of people we can kill in a tanker casualty is limited to the crew. The death numbers tend to be much more statistically significant than spill volumes. With these caveats in mind, let us study the

numbers by category.

Table 1: Breakdown of CTX Casualties by Initial Event

Based on CTX Casualty Data Base Version 2 as of 2007-12-09T10:33:32Z

	1960 ON			1995 0N		
Initial Event	NO.	Volume(m3)	Dead	NO.	Volume(m3)	Dead
HULL STRUCTURAL FAILURE						
Hull failure, brittle	2	14,900	0	0	0	0
Minor hull failure, crack	52	18,538	2	38	204	2
Hull failure, corrosion?	44	1,912,830	487	1	0	0
Cargo pipe failure/leak	4	1,807	5	2	7	0
Hull failure, corrosion	10	215,672	51	5	135,519	1
Probable structural failure	15	284,565	147	1	0	0
Probable corrosion failure	3	18,000	2	0	0	0
TOTAL Hull Structural	130	2,466,313	694	47	135,731.341	3
RULES OF THE ROAD						
Burdened vessel failed to manuever	6	27,689	41	1	83	0
one port2port,other stbd2strb	9	198,590	100	0	0	0
Failed to detect other vsl	2	335,890	35	0	0	0
Rogue vessel in wrong lane	2	6,638	64	0	0	0
Uncoordinated manuever	4	36,000	0	3	29,800	0
Probable uncoordinated manuever	25	146,675	13	12	6,276	1
Probable dance of death	8	290,162	156	1	9,450	0
TOTAL Rules of the Road	56	1,041,644	409	17	45,609.5	1
MACHINERY FAILURE						
Blackout	14	46,500	42	10	6,000	0
Crankcase explosion	2	2,100	0	2	2,100	0
Engine room flooding	4	67,000	0	0	0	0
Crankshaft/piston failure	5	0	0	5	0	0
Cylinder liner failure	2	0	0	2	0	0
Loss of steering	33	336,325	29	21	4,371	0
Shaft/sterntube failure	3	0	0	3	0	0
Stern tube leak	3	0	0	3	0	0
Turbocharger failure	1	0	0	1	0	0
Sea water line leak	4	146,000	0	0	0	0
Boiler failure/fire	4	3,000	10	1	0	1
Other/unknown machinery	93	128,982	4	61	1,652	0
Probable machinery failure	42	377,140	38	17	0	0
TOTAL Machinery	210	1,107,047	123	126	14,123.802	1
GUIDANCE/CONNING ERROR						
Anchor dragged	6	10,200	0	2	0	0
Hit berth	3	7,638	0	2	8	0
Conning error	9	209,711	26	4	86,707	0
Ship too deep for depth, swell	3	1,817	0	1	0	0
Engine department error	5	0	2	4	0	0
Bad seamanship, deck	3	99,600	2	1	0	2
Other Guidance error	3	2,000	0	2	0	0
Probable guidance error	28	70,681	224	15	2,289	0
TOTAL Guidance	60	401,647	254	31	89,004.522	2

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Initial Event	1960 ON NO.	Volume(m3)	Dead	1995 0N NO.	Volume(m3)	Dead
		NAVIGATION ERRORS				
Navigation error	15	260,446	7	1	0	0
Bad charts on-board	2	300	0	0	0	0
Probable nav. error	8	36,136	0	2	8,706	0
TOTAL Navigation	25	296,882	7	3	8,706	0
		BAD INERTING/HOTWORK				
No IG or IG not working	13	56,604	87	1	12,600	21
Hotwork	6	8,849	29	1	0	1
Lightning strike	4	6,980	14	0	0	0
Bad purging, gas-freeing	4	500	25	3	500	22
Probable bad inerting	20	52,646	160	4	5,000	22
TOTAL Inerting/hotwork	47	125,579	315	9	18,100	66
		CARGO TRANSFER ERROR				
Deballasting screw up	1	4	0	1	4	0
Hose break/leak	15	4,138	4	12	4,138	0
Incorrect loading	1	0	0	0	0	0
Tank over/under-pressure	4	0	0	3	0	0
Other transfer screw up	36	7,629	0	27	742	0
Unmoored by weather	15	54,378	28	10	423	0
Unmoored by wake	4	3,200	1	2	0	0
TOTAL Cargo Transfer	76	69,351	33	55	5,308.781	0
		EXTERNAL/WAR/PIRACY				
Navaid out of position, inoperative	1	5,000	0	0	0	0
Charts incorrect	4	54,476	0	1	91	0
Bad channel depth	1	4,700	0	1	4,700	0
Tug contact, other tug screw up	10	1,792	23	7	257	0
Piracy	1	14,100	51	0	0	0
Hit submerged object, not bottom	3	22,520	0	1	120	0
External Tampering	1	0	0	1	0	0
War damage	4	0	5	2	0	1
Probably external error	3	146,900	1	2	35,200	0
TOTAL External	28	249,489	80	15	40,369.2	1
		TOTAL KNOWN INITIAL EVENT				
TOTAL KNOWN	632	5,757,955	1915	303	356,953	74
		UNKNOWN INITIAL EVENT				
TOTAL Unknown	311	768,622	414	145	54,792.293	58
		TOTAL KNOWN AND UNKNOWN				
TOTAL ALL	943	6,526,578	2329	448	411,745	132

3 Hull Structural Failures

In terms of spill volume, hull structural failure is by far the most important cause of tanker casualties. Table 1 is quite emphatic in this regard.[3] It is almost as important as all the other causes combined. This is not only true of the entire post-1960 period but recently as well. The ERIKA and the PRESTIGE are only the latest in a long line of structural failures. Hull failure is also the most important cause of tankerman deaths. If all we did was eliminate hull structural failures, we would cut volume spilled and tanker casualty deaths by a half.

Table 4 lists all the Hull Structure spills greater than 1,000,000 liters in the CTX casualty database The fourth column, labeled E1, is the initial cause code. Table 2 summarizes the CDB structural failures by initial event. "Hull failure, corrosion?" means that we strongly suspect corrosion was a major factor, but we don't have proof.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Minor hull failure, crack	52	2	18,538	38	2	204
Hull failure, corrosion?	44	487	1,912,830	1	0	0
Probable structural failure	15	147	284,565	1	0	0
Hull failure, corrosion	10	51	215,672	5	1	135,519
Cargo pipe failure/leak	4	5	1,807	2	0	7
Probable corrosion failure	3	2	18,000	0	0	0
Hull failure, brittle	2	0	14,900	0	0	0
TOTAL	130	694	2,466,313	47	3	135,731

Table 2: Structural Failures by Cause. Volume in m3

[3] The CDB distinguishes between structural failures that were causes, and those that were consequences. For example, the AMOCO CADIZ lost steering, drifted aground, and then suffered a hull structural failure. This casualty is a machinery failure in Table 1.

The fifth and sixth columns, E2 and E3, are subsequent events. The possible codes are

AL	Allision, vessel hit non-vessel
AM	Near-miss allision
CA	Hit while moored, anchored or mothership
CN	Collision, own vessels moving
CM	Near-miss collision
DA	Disabled anchored
DT	Towed in and/or LOF signed
DE	Escort Tug had to be used
HL	Holed/Structural Failure
LP	Major loss of power/steering
Lp	Minor loss of power/steering
PH	Hose(s) parted after unmooring
WS	Grounding
XA	Accommodations Fire
XE	Engine Room Fire/Explosion
XP	Pump Room Fire/Explosion
XT	Cargo Tank Fire/Explosion
X_	Fire/Explosion. Cant say tank, etc
SC	Constructive Total Loss
SD	Scuttled
SK	Foundered/sank
ST	Scrapped as result of casualty

The CDB tries to differentiate between cargo tank fires and engine room fires. They are fundamentally different animals. Most engine room fires are the result of a machinery failure. For properly inerted ships, most cargo tank fires are caused by structural failures and collisions.

The seventh column, labeled L, is what CTX calls Locale. The codes are

D	At repair yard, including mooring/unmooring
T	At fixed berth, including mooring/unmooring
S	At SBM, including mooring/unmooring
L	Lightering, including mooring/unmooring lighter
H	Harbor or Harbor entrance, anything inside the Seabuoy
R	Restricted waters
O	Open water
	Dont know

The eighth column, A, is Activity at time of casualty. The codes are

A	Anchored, apparently doing nothing. Use only if none of the following
L	Loaded, including part-loaded, unmooring/mooring at load/discharge port
B	Ballast, including mooring/unmooring at load/discharge port
T	Tank Cleaning, (use instead of B if appropiate)
l	Loading, including deballasting
d	Discharging
R	Repairing
b	Bunkering, but not at load/discharge port
	dont know

The ninth column is weather. This column shows the Beaufort Force if known, or TY (Hurricane), HW (Heavy Weather), (GL) gale, GD (good), RN (rain) FG (fog), or CM (calm, not foggy). Not surprisingly, bad weather shows up in many hull failures. Most structural failures are in open waters in heavy weather. This does not mean that bad weather is a cause of structural failure. Rather the bad weather reveals that the structure is too weak. Tanker hulls are in theory designed to handle all the weather scenarios in Table 4. Either these hulls were not in fact so designed, or corrosion had weakened the structure to the point that it could not handle conditions it should have been able to.

The tenth column is the number of people killed.

Cargo leaking into segregated ballast tanks plays a crucial role in many tanker casualties. The CDB has a field, SBT?, that addresses this issue. The SBT? field is the 11th column in Table 4. The ship names for which this field is either Y or P are shown in boldface. Table 3 summarizes the importance of leakage into segregated ballast tanks in the CTX database. If you compare

	1960 On			1995 On		
SBT Leak?	No.	Killed	Volume	No.	Killed	Volume
?	68	338	675,984	30	2	76
Confirmed	20	137	878,323	8	0	115,010
Maybe	16	99	341,849	2	1	20,519
No	14	63	54,556	6	0	124
Probable	12	57	515,600	1	0	0
TOTAL	130	694	2,466,313	47	3	135,731

Table 3: Cargo Leaking into segregated ballast tanks?

these spill volumes with those in Table 1, you will find that the sum of the Confirmed and Probable categories is larger than any non-hull structure related cause. ***Hull structural failure is by far the most important***

cause of tanker casualties; and leaks into segregated ballast tanks are by far the most important cause of hull structure spills.

Table 4: Hull Structural Failures with Spillage above 1000 Kiloliters

Based on CTX Casualty Database as of 2007-12-16T17:58:50

DATE	SHIP	Kilo-liters	E1	E2	E3	L	A	WE	De-ad	B T	Brief Description
19910528	**abt summer**	305000	HF	XT	SK	O	L		5	Y	exp off Angola in perm ballast tank due to leak from cgo tank
19830805	**castillo de bellver**	296400	HF	XT	SK	O	L		3	Y	leak to port perm ballast tank, NW Capetown, fire, sank
19910411	**haven**	164700	HF	XT	SK	H	L		5	P	tank fire anch off Genoa, prob leak into SBT
19881110	odyssey	155000	H_	X_	SK	O	L	HW	27	M	fire 700M E St Johns, sank w all hands probable hull failure
19800223	**irenes serenade**	120000	HF	XT	SK	H	L		2	P	fire lowering anchor Pylos, prob cgo in FP tank
19770223	hawaiian patriot	116400	HF	XT	SK	O	L	HW	0		hull crack off Hawaii, fire, broke in two, sank
19920416	**katina p**	84700	HF	SK		O	L	HW	0	P	midships hull failure off Mozambique, sank,
19891219	**khark 5**	82300	HF	XT		O	L	HW	0	P	ballast tank leak, explosion off Morocco, loaded,
20021113	**prestige**	82000	HR	SK		O	L	10	0	Y	hull failure off NW Spain, bad corrosion in SBT
19601206	sinclair petrolore	60000	HF	X_	SK	O	L		?	M	self-unloading OBO exploded, sank off Brazil, no details
19781231	**andros patria**	58800	HF	XT	ST	O	L	HW	39	Y	50 ft crack, then explosion in 3P, off NW Spain,
19680613	world glory	53100	HF	SK		O	L	GL	24		broke in two in gale off Durban
19790108	**betelgeuse**	47000	HR	XT	ST	T	d		50	Y	bad rust in uncoated ballast tnk, no inert, explosion, 50 dead
19941021	thanassis a	41200	HF	SK		O	L	TY	16	M	broke in two in Typhoon Teresa, probably corrosion
19880422	athenian venture	40000	H_	X_	SK	O	L		29		fire off Newfoundland, broke in 2, hull failure?
19770117	irenes challenge	39500	HF	SK		O	L	HW	3		hull failure off Midway, broke in 2, no details
19691125	pacocean	34000	HF	SK		O	L	HW	3		broke in two, storm off Taiwan, Bulkpetrol Class
19991212	**erika**	33000	HR	SK		O	L	GL	0	Y	hull failure off Brittany due hvy corrosion in SBT
19720128	golden drake	32000	H_	XT	SK	O	L		2		explosion forward while loaded, sank, Bulkpetrol Class, cause?
19640301	amphialos	30000	HF	SK		O	L	HW	2		broke in two, storm off Cape Cod, Bulkpetrol Class
19691105	keo	30000	HF	SK		O	L	HW	36		broke in two, storm off Nantucket, Bulkpetrol Class
19701226	chryssi	30000	HF	SK		O	L	HW	21		broke in two quickly, sank SW Bermuda, need more info
19710327	texaco oklahoma	30000	HF	SK		O	L	11	31		split in two aft midships house, NA whole gale, overstressed?
19710706	alkis	29000	HF	DT	SK	O	L	HW	0		Hull failure in South Atl, sank under tow.
19761230	grand zenith	28700	HF	SK		O	L	HW	38		structural failure off Massachusetts, all lost, nil info
19760728	cretan star	28000	HF	SK		O	L	HW	36		hull failure, Indian Ocean, sunk with all hands

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DATE	SHIP	Kilo-liters	E1	E2	E3	L	A	WE	De-ad	B T	Brief Description
19900222	**surf city**	28000	HF	XT					2	Y	leak into ballast tank, explosion off Dubai
19940124	cosmas a	27000	H_	XT	SK	O	L	HW	10	M	broke in two S. China Sea, probable structural failure
19800307	**tanio**	24400	HF	SK		R	L	8	8	P	hull failure off Brittany, an early Erika/Prestige
19681106	spyros lemos	23500	HF	SK		O	L		5		Hull failure off Vigo, broke in two, sank/scuttled
19750404	spartan lady	21700	HF	SK		O	L	HW	1		broke in two in bad storm off New York, sank/scuttled, 1 dead
19700417	silver ocean	21000	HF	X_	SK	O	L	HW	14		fire, breaking sinking in bad weather NE Durban, need info
19910721	**kirki**	20300	HR	XT		O	L	HW	0	Y	massive corrosion, Forepeak tank fell off, Australia
19970102	nakhodka	20200	HR	WS	SK	O	L	HW	1	M	massive hull failure, Japan '20 to 50 pct corroded', sank
19660403	comet commander	20000	HF	SK		O	L	HW	11		broke in two, N Pacific, sank
19700105	sofia p	20000	HF	SK		O	L	HW	7	N	broke in two, North Pacific, sank
19701227	ragny	20000	HF	SK		O	L	HW	6		broke in two, sank off NJ, probably same storm as Chryssi
19730219	nelson	20000	HF	SK		O	L	HW	0	N	hull failure in North Atlantic, sank
19831126	pnoc basilan	19800	H_	XT	SK	O	L		6		'waves forced open a tank cover', ? fire off Luzon, sank
19721216	**bello**	18000	Hr	XT	SD	O	L		0	P	explosion W Med in No 3 tank, prob sbt, towed in, scrapped
19661015	malmohus	16000	HF			O	L	HW	?		hull damage, proceeded to Durban, day of month unk.
19901117	berge broker	15800	HC	HL		O	L		0	M	big hull rupture off Azores, very low lightweight
19790315	**kurdistan**	14900	HB	ST		O	L	GL	0	P	hull failure Cabot Str, brittle or rust perm blst tk
19790628	aviles	12000	HF	X_	SK	O	L	HW	12	N	broke in two Arabian Gulf, fire, sank,
19891004	pacificos	11800	HR	HL		O	L	10	0	M	hull failure off East Africa, prob corrosion
19761015	boehlen	11100	HF	SK		R	L	HW	28		hull failure, sank. Brittany, bad weather
19751229	**berge istra**	5000	H_	XT		O	B		38	Y	explosion in OBO double bottom Celebes Sea, 38 killed
19791029	**berge vanga**	5000	HF	XT	SK	O	B		40	P	Repeat of Berge Istra, OBO dbl bottom explosion, 40 dead
19880131	amazzone	2470	HF			O	L	HW	0	M	hull failure in storm off Brittany, one tank holed
19800909	derbyshire	2400	HF	SK		O	L	TY	44	N	DH OBO sank in typhoon, prob hatch cover collapse
19870106	stuyvesant	2380	H_			O	L		0	M	big hull crack Gulf of Alaska, need confirmation
19871004	stuyvesant	2220	HC			O	L		0	M	big hull crack Gulf of Alaska, need confirmation
19900919	algarrobo	2000	HF	SK		O	B		32	M	O/O loaded ore, sank off Chile, no message, prob dbl bot leak
19790826	cherry duke	1800	HP	XT	SK	R	B		5		tank explosion off Das Is, sank, bad rust tank lids, piping
19750908	**pacific colocotronis**	1760	H_	HL		R	L	10	0	Y	big hull crack in 3P off Holland, 70KT spill averted
19750513	**princess ann marie**	1600	H_			O	L	HW	0	P	big hole strb side midships Indian Ocean, made it to Dampier

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DATE	SHIP	Kilo-liters	E1	E2	E3	L	A	WE	De-ad	B T	Brief Description
19821226	charalambos	1160	HF	ST		O	L	HW	0	M	side plating fell off under tow, Yucatan, scrapped

4 Machinery Failures

According to Table 1, Machinery Failure is a very important cause of tanker spills, in a virtual tie with Rules of the Road screw ups for second. Machinery failure is also easily the most frequently reported cause of tanker casualties, although it is well down as a cause of deaths. Table 7 shows all machinery failure spills over 1000 liters in the CTX CDB. It includes many infamous names.

The importance of machinery failure will come as a surprise to some. Most machinery failures show up as something else in most spill databases, often a grounding, sometimes a fire, sometimes a sinking. Chapter 3 of The Tankship Tromedy goes into some detail about the many different ways machinery failures are hidden in most spill compendiums. The basic issue is confusing cause and effect. Here I will offer just one typical example.

In November 2000, the fully loaded 88,000 ton tanker WESTCHESTER had a main engine crankcase explosion in the Mississippi River. Without power, the WESTCHESTER drifted aground about 50 miles downriver from New Orleans, holed a tank, and spilled 2 million liters of her cargo. This was a high profile spill, receiving extensive media coverage. Almost all these reports decried the fact that the ship was a single hull. Not one of them, at least not any that I have come across, even noted that the ship was single screw with nil propulsion redundancy. ***This includes the official USCG investigation report.*** The Westchester spill is called a grounding in just about every database I am aware of. The Westchester indeed went aground; but that was not the cause of this casualty.

In fact, the CTX database almost certainly under-estimates the importance of machinery failure. Many of our unknown initial causes involve engine room/fire explosions. This includes the JAKOB MAERSK[4] one of the biggest spills of all time. Something happened in these engine rooms to cause the fire. It is a good bet that in most engine room fires that something was a machinery failure. Check out the SEAL ISLAND[5]

Table 5 summarizes the CDB machine failures by initial event.

[4] Ship touched bottom (maybe) mooring at Leixoes, and the engine room suddenly exploded. The owner probably knows why. Class may know why. The rest of us are in the dark. But something was wrong in that engine room. (My own guess The ship was not inerted; the fire spread to the cargo, six killed, four badly burned.

[5] Jury rigged lube-oil strainer dumped oil on hot turbo-generator when crew needed to change strainers. Crew could not take turbo-generator off line, because other generator not large enough to handle actual electric load rather than unrealistically optimistic Class Rule load. Three killed. Ship destroyed. She had just finished discharging, so nil spill, and no lessons learned.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Other/unknown machinery	93	4	128,982	61	0	1,652
Probable machinery failure	42	38	377,140	17	0	0
Loss of steering	33	29	336,325	21	0	4,371
Blackout	14	42	46,500	10	0	6,000
Crankshaft/piston failure	5	0	0	5	0	0
Engine room flooding	4	0	67,000	0	0	0
Boiler failure/fire	4	10	3,000	1	1	0
Sea water line leak	4	0	146,000	0	0	0
Shaft/sterntube failure	3	0	0	3	0	0
Stern tube leak	3	0	0	3	0	0
Crankcase explosion	2	0	2,100	2	0	2,100
Cylinder liner failure	2	0	0	2	0	0
Turbocharger failure	1	0	0	1	0	0
TOTAL	210	123	1,107,047	126	1	14,123

Table 5: Machinery Failures by Cause. Volume in m3.

Loss of steering is the most frequently reported known machinery failure in Table 5. I would not make too much of this. My own experience as a tanker operator is that loss of steering is far less frequent than engine room problems that lead to loss of power. See Tromedy, Section 3.3. Loss of steering is simply harder to hide and easier to identify.

An interesting feature of the machinery casualties is their overall frequency. Depsite the fact that we can be sure that the CDB records only a very small percentage of all machinery failures, the CDB has 209 such casualties, which is considerably larger number than any other major category. This is particularly true in the post-1995 period in which about 40% of all casualties for which we have an initial cause are machinery failures.

Thanks to the USCG Marine Incidents eXchange (CGMIX) database, it ia possible to make a rough estimate of the percentage of tanker machinery failures that the CDB is catching. About 2001/2002, the United States Coast Guard convinced American pilots that it was in their interest to report any problem on board ships which were under their control. Almost overnight the reported frequency of Losses of Power/Steering (LOP) went up by an order of magnitude or more. Table 8 shows that there are 38 complete loss of power or steering casualties in the CGMIX data for 2003 involving

tankers over 10,000 dwt. The CDB calls four of these LOP's major. These four LOP's have an event code of LP; a minor LOP is coded Lp.

According to the Maritime Administration, there were 18,503 port calls by tankers over 10,000 dwt in the USA in 2003, of which 6% were somewhere in the Mississippi River. The CTX does not have any data on how long these ships were under pilotage; but on average, it was probably less than half a day, and almost certainly less than a day. In the former case, we are talking 42 LOP's in about 25 ship-years of operation; in the latter 42 LOP's in about 50 years. This assumes conservatively that the MIX database is capturing all the LOP's under pilotage. According to these numbers, an average tanker experiences 1 to 2 LOP's per ship-year of which about 10% are major.

In 2003, about 3600 tankers over 10,000 dwt were trading. If the CGMIX numbers are correct, we would expect something like 5000 LOP's per year. In fact, the CDB has 45 machinery failures of which 38 are the CGMIX casualties. ***Outside American pilotage waters, the CDB is probably picking up less than one in a 1000 of all LOP's.*** Normally a tanker LOP will not become public unless it causes a spill or the ship is so desperate it calls for a tug and in willing to sign a Lloyds Open Form. ***In short, there is good reason that the over 10,000 dwt tanker fleet is experiencing about 10 loss of power/steering failures every day.***

The CTX feels that this level of reliability should be the focus of regulatory attention. One obvious possibility is twin screw, by which we mean two independent engine rooms and rudders. The CDB has a field called `ts` which attempts to address the question: would twin screw have helped in this casualty?[6] The coding is necessarily partially subjective, but we have tried to be conservative. Table 6 breaks down all casualties by this field. In something like 20% of our casualties, twin screw would probably have made a big difference. This percentage appears to be increasing. See The Argument for Twin Screw for a much more detailed discussion of this issue.

[6] Twin screw properly implemented not only can produce a 1000 fold improvement in reliability, but also generates a dramatic improvement in low speed maneuverability.

	1960 On			1995 On		
TS Help?e	No.	Killed	Volume	No.	Killed	Volume
No	502	1914	4,279,456	205	121	255,184
Cant say	201	263	932,699	101	11	106,276
Yes	103	10	603,884	71	0	12,466
Probably	85	81	371,894	49	0	1,830
Possibly	57	61	338,824	24	0	35,988
TOTAL	948	2329	6,526,759	450	132	411,746

Table 6: Casualties in which twin screw might have helped

Table 7: Machinery Failure Spills over 1 Kiloliter

Based on CTX Casualty Database as of 2007-12-16T17:58:50

DATE	SHIP	Kilo-liters	E1	E2	E3	L	A	WE	De-ad	Brief Description
19780316	amoco cadiz	267000	MR	LP	WS	R	L	HW	0	steering gear failure, grounded Britanny, broke up
19921203	aegean sea	87000	M_	WS	XT	H	L	9	0	could not turn ship in bad weather, grounded Coruna, fire, OBO
19830107	assimi	60200	M_	XE	SK	O	L		0	ER fire, Gulf of Oman, cause uncertain
19750110	british ambassador	56000	MW	MF	LP	O	L	HW	0	sw inlet leaked N Pacif, vlv failed ER flooded, sank under tow
19831209	pericles gc	54100	M_	XE	SK	O	L		0	ER fire east of Doha, sank
19710227	wafra	47000	MW	LP	MF	O	L		0	SW circ pump fracture, ER flooded, drifted aground SA, sunk
19760204	st peter	44300	MY	XE	LP	O	L		0	'elec fire in ER' off West Coast of Columbia, sank
19770527	caribbean sea	35200	M_	MF	LP	O	L	HW	0	ER flooded South of El Salvador, sank, cause unknown
19760218	scorpio	34900	MR	LP	WS	R	L		0	lost steering, grounded Gulf of Campeche, CTL
19720611	trader	34000	M_	MF	LP	O	L		0	Engine room flooded E Med, sank, prob machinery but need info
19821126	haralabos	31900	M_	XE	WS	H	L		0	ER fire, Red Sea, cause unknown, beached, cgo transhipped, CTL
19891229	aragon	29400	MY	LP	HL	O	L	HW	0	lost power, big spill under tow near Azores, conflicting info
19671024	giorgio fassio	25000	MF	LP	SK	O	L		0	Engine room flooded cause unknown, sank off SW Africa
19720331	giuseppe giulietti	25000	MF	LP	SK	O	L		0	ER flooded off C St Vincent, no power, sank
19810329	cavo cambanos	24300	M_	XE	SK	R	L		6	fire in generator room Tarragona, fire, sank, cause?
19940313	nassia	23500	MB	CN	X_	R	L		42	BC Shipbroker black out, no rudder, coll Bosporus, massive exp
19740723	theodoros v	23200	M_	XE	SK	O	L		9	ER explosion off Dakar, cause unknown, sank,
19700114	albacruz	23000	MW	MF	LP	O	L	HW	0	main sw piping failed, er flooded, sank loaded in N Atlantic
19680426	assimi iii	20000	M_	XE	XT	R	L		5	ER fire off Singapore, sank, nil info on initial cause
19680508	andron	20000	MW	MF	LP		L		0	ER pipe failed, ER flooded, sank off SW Africa
19700131	gezina brovig	18800	MY	LP	MF	O	L		0	piston thru crank case NW PR, broke SW main, ER flooded sank
19740926	transhuron	18600	MY	LP	WS	O	L	GD	0	A/C nipple failed, water on swbd, no power, grounded SW India
19600627	george macdonald	17000	MF	LP	SK	T	L	GD	0	massive condenser leak, ER flooded, sank
19611001	hess mariner	17000	MB	LP	MF	O	L		0	Main prop gen overspd, holed condenser, ER flood, sank
19870623	fuyoh maru	11900	MR	Lp	CN	H	L		6	collision w Vitoria in Seine 'damage to helm'
19900629	chenki	9600	MR	Lp	WS	H	L		?	lost steering Suez Canal, grounded, holed, towed to Suez

Continued on next page

DATE	SHIP	Kilo-liters	E1	E2	E3	L	A	WE	De-ad	Brief Description
19750513	epic colocotronis	6700	M_	XE	ST	O	L		0	OBO ER fire near San Juan, nil info on cause
19680307	general colocotronis	6000	MY	LP	WS	R	L		0	machinery failure cause unknown, grounded off Eleuthera
20061020	front vanguard	6000	MB	Lp	WS	H	L		0	blackout Suez, grnded, Anna PC avoiding grnded, spilled 5000T
19761227	olympic games	5880	MY	Lp	WS	H	L		0	engine failure, Delaware R, 39 ft draft, grounded
19730602	esso brussels	5000	MR	CA	ST	H	L	CM	16	rammed NY harbor by Sea Witch whose steering gear failed
19770415	universe defiance	3000	MX	LP	SD	O	B		9	Boiler room fire off West Africa, scuttled
20010329	baltic carrier	2900	MR	Lp	CN	R	L	GL	0	steering failure Baltic, collision with Tern, 6 m penetration
19770327	anson	2330	MR	LP	WS	H			0	steering gear failure Orinoco, grounded
20001128	westchester	2100	MC	LP	WS	H	L		0	crankcase exp in Miss R, grounded, 1S holed
19850928	grand eagle	1640	MY	Lp	WS	H	L	5	0	ship lost power, grounded near Marcus Hook
20020814	golden gate	1520	MY	WS	HL	H	L		0	entering Karachi, maybe mach, maybe conn, volume hi?
20060227	grigoroussa i	1300	MR	Lp	WS	H	L		0	steering gear failure Suez, hit west bank, strange fire
19760124	olympic bravery	842	MY	LP	WS	R	B	HW	4	'series of engine failures', VLCC drifted aground on Ushant
19840319	mobiloil	624	MR	LP	WS	H	L		0	steering failure in Columbia River, grounded, 150 ft damage
19760705	capetan mathios	600	MR	LP	WS	R	B		0	lost steering, grounded Bahamas Bank, some doubt story
19780321	aegis leader	586	MY	LP	WS				0	grounded off Sumatra after machinery breakdown
19760119	irenes sincerity	582	MY	LP	WS				0	'stranded after engine trouble', Baltic, nil info
19730624	conoco britannia	500	MY	Lp	WS	S	L	FG	0	lost power mooring Humber SBM, ran over own anchor
19810725	afran zenith	302	M_	LP	WS	H			0	grounding Elbe after machinery problems
19941008	seal island	238	M_	XE	HL	T	B		3	leak from temporary strainer repair, huge ER fire HOVIC
19901015	rio orinoco	200	MY	LP	DA	R	L	0	0	mach problems, anchored, dragged, grounded G of St Lawrence
19990523	parnaso	151	MR	LP	CN	O	B		0	lost steering, collision South of Cuba
19981207	tabriz	117	MY	Lp	AL	H			0	eng failure, hit jetty at Bandar Abbass
19970118	stolt spray	20	MR	Lp	CN	H	L		0	lost steering in Miss River, holed 1P, dbl hull
19990227	hyde park	16	MY	LP	CN	H	L		0	lost power in Miss R loaded w mogas, drifted 13 M, many coll.

Table 8: Loss of Power Casualties, CGMIX, 2003

Based on CTX V2 database as of 2007-12-03T17:45:15

Date	Ship	E1	E2	E3	LO	AC	Class	Flag	?	Area	Synposis
20030104	prince william	MY	Lp		H		AB	US	M	VZ	both boilers tripped due to low control air press
20030116	lepetsk	MY	Lp		H		AB	RU	P	NY	loss of power lving New York, break in TC lube oil piping
20030117	volga	MY	Lp	DT	T	L		LR	P	MR	loss of power mooring Miss R, low LO pressure
20030119	nile	MY	Lp	DA	H		AB	LR	P	NY	loss of power inbound New York, fuel control vlv
20030123	united triton	MY	Lp	DA	H	L	NV	LR	P	MR	loss of power inbound Miss R, hit anchored Clipper Faith
20030125	montana sun	MY	Lp		H		NV	LR	P	NY	loss of power inbound New York, no details
20030126	golden eagle	MY	Lp		H		LR	LR	P	NY	loss of power departing New York, no details
20030210	almudaina	MY	LP	DA	H		LR	PT	M	DR	mn eng tripped on lo lube oil pres, 1, 5 pistons leaking????
20030321	perseverance	M_	Lp		O		AB	US	Y	UE	lost power due to fuel pump failure, date probably wrong
20030326	stolt surf	MY	Lp	DT	H	L	NV	KY	M	MR	false hi temp alarm, tripped engine, towed to 12 mi anchorage
20030411	iver spring	M_	Lp	DT	T		NK	PA	M	NY	eng failed to start, claimed lo fuel temp
20030501	sichem princess	M_	Lp		H				P	NY	lost power in Newark Bay, dirt in starting air system
20030527	bow hunter	M_	Lp	DA	H	L	NV	SG	M	UE	lost bridge control of mn eng, pilot decided to stop
20030628	eagle subaru	MY	Lp	DT	T	L	NK	SG	Y	MR	lost power mooring Chalmette, Miss R, tugs handled, no details
20030704	hyde park	MY	Lp	DT	T	L	LR	GB	Y	NY	lost power lving berth, New York, no details
20030704	jo sequoia	MR	LP	CN	H	L	NV	NO	Y	GB	lost steering, hit 4 barges, grounded inbound Houston Ship Ch.
20030719	seabulk mariner	MB	Lp		H		AB	US	Y	MR	loss of power, blamed on a voltage surge???
20030720	chilbar	MB	Lp		H		AB	US	Y	MR	1 gen failed, other not big enough, blackout
20030812	east siberian s	MY	Lp	WS	H	L	LR	LR	Y	UE	loss of power leaving Charleston, grounded, no details
20030813	jo oak	MB	Lp		T		NV	NO	Y	MR	not enough gen power to run bow thruster, crew blamed
20030817	afragem	MY	Lp	DT	T				Y	GM	loss of power mooring Corpus, bad control vlv, fixed next day
20030823	sr galena bay	MK	LP				AB	US	Y	UW	connecting rod bearing failed, major LOP, West Coast USA
20030826	fandango	MY	Lp	DT	T		NV		Y	MR	loss of power lving terminal, blamed on fuse, NV tested OK
20030827	fandango	MY	Lp	DA	H		NV		Y	MR	loss of power bad cooling fan, EC power supply, long shut down
20030923	seahawk freight	MY	Lp		H		NV	MH	Y	NY	lost propulsion leaving New York, no details
20030923	eagle corona	MR	Lp	WS	H	L	NK	SG	Y	SR	mop fell onto strng gear, grounded, not holed, Neches River

Continued on next page

Date	Ship	E1	E2	E3	LO	AC	Class	Flag	?	Area	Synposis
20031013	ncc jizan	MY	Lp		H	L	NV	NO	Y	UE	starting air control problem, loss of power, Savannah River
20031026	varg	ML	LP		T				M	NY	cracked cylinder liner discvd at Bayonne terminal
20031029	cygnus voyager	MB	Lp		R		AB	BS	Y	LA	6 min loss of power, generator over-load, off El Segundo
20031106	dromeas	MY	Lp		H		LR	BS	Y	MR	loss of power, bad control air, SW Pass, Mississippi
20031109	bow fighter	MY	Lp		H		NV	NO	Y	MR	loss of power, control air sys holed, Mississippi
20031111	sea venture	MR	Lp		H	B			M	DR	rudder stuck hard right downbound Delaware R, no cause info?
20031122	perseverance	MB	Lp		O		AB	US	Y	UE	black out and loss of power, reported by MSO Miami
20031127	spectrum	MY	Lp		H		LR	GB	Y	MR	main engine governor failure, Mississippi River
20031128	bravery	MY	Lp	DA	T	B	LR	MH	Y	MR	main engine failure, lving Motiva, Mississippi River
20031205	asphalt command	MY	Lp		H	L	AB	US	Y	UE	minor loss of power inbound Savannah River, no damage
20031214	kriti art	MY	Lp		H		AB	GR	Y	MR	main engine remote control failed, Mississippi River
20031217	kriti color	MY	Lp		H				Y	NY	loss of power due to 'stuck exhaust valve' Stapelton Anch.

5 Rules of the Road Screw-Ups

Rules of the Road (ROTR) screw-ups is CTX's grab-bag term for all the ways people manage to steer one ship into another. Every casualty caused by a Rules of the Road screw-up is a collision, but not every collision is a ROTR screw up. The NASSIA[7] and BALTIC CARRIER collisions were caused by steering gear failures. The NAGASKI SPIRIT/Ocean Blessing collison in which 51 crewmen were murdered was the result of piracy.

As Table 1 shows, Rules of the Road (ROTR) screw-ups have been a very important cause of both deaths and spills.[8] The largest tanker spill of all time, the ATLANTIC EMPRESS/Aegean Captain collision, falls into this category.[9] Table 19 shows all the ROTR spills in the CTX Casualty Database with a spill volume greater than 200,000 liters. The relevant initial cause codes are

Rules of the Road Screw Up	
VB	Giveway vessel failed to manuever
VD	one port2port,other stbd2strb
Vd	probable dance of death
VL	failed to detect other vsl
VR	rogue vessel in wrong lane
VU	Uncoordinated manuever
V_	Probable uncoordinated manuever, need confirmation

The CDB database has a field called Locale which records the type of water the casualty occurred in. Table 9 breaks down the ROTR casualties by

[7] Actually the bulk carrier Shipbroker had a black out. With no electrical power, she had no steering and ran into the NASSIA in the Bosporus killing 42.

[8] The Nova/Magnum collision which spilled 82 million liters does not show up in Table 1. These two ships were shuttling oil down the Persian Gulf for the Iranians during the Iraq/Iraq War. They were running at night without any navigation lights, and reportedly maneuvering to avoid a missile attack.[**?**, page 108] CTX concluded that this was a war casualty. War casualties are not included in the CTX database.

[9] This collision appears to have been caused by horrible radar watch on both ships, abetted by illegal manning. The two ships were in and out of rain squalls at dusk. They did not adjust the anti-clutter controls on their radars correctly. Each ship apparently did not realize the other ship was there until immediately prior to impact. This is quite unusual. The officer of the watch on the Greek Flag ATLANTIC EMPRESS was the radio officer. He had no deck officer's license. This was a regular practice on-board the Empress and, according to the crew, known to the owners. Despite this flagrant violation of Greek maritime law, the Greek report says "We wish to say nothing that might be thought to be any criticism or complaint against those who were responsible for operating these two vessels."[**?**, pages 14-17] This is called Flag State control.

Locale. Not surprisingly, most ROTR casualties occur in restricted waters.

Locale	Number	Killed	Volume
Restricted waters	34	189	616,207
Open water	12	105	273,464
Harbor, river, canal	9	115	151,823
Dont know	1	0	150
TOTAL	56	409	1,041,644

Table 9: 1960 on ROTR Casualties by Locale

The CDB database has a field called Hotspot which attempts to locate the casualty by body of water. Table 10 lists the Hotspots with 2 or more ROTR casualties. The importance of the Straits of Malacca and the English Channel as tanker choke points is obvious.

Locale	Number	Killed	Volume
English Channel	10	73	69,601
Straits of Malacca	9	0	77,550
Galveston Bay	3	32	43,808
Indian Ocean	3	0	900
off Fujairah	2	0	18,800
US/Canada West Coast	2	12	50,500
Arabian Sea, G. of Oman	2	13	141,594
South China Sea	2	0	24,411
East African Coast	2	46	46,500
Bosporous, Dardanelles	2	43	114,800
TOTAL	37	219	588,464

Table 10: 1960 on ROTR Casualties by Hotspot

Table 11 summarizes the data we have on type of encounter in all ROTR casualties since 1960. "Own ship" in this context means the tanker by which the casualty is known in the CTX database.[10] Not surprisingly, the most frequent encounter type is Head-on. Many of the Head-on ROTR casualties are Dances of Death, — one ship opts for a port to port passing, the other

[10] If a collision involves two tankers, the CTX database list the casualty under the struck ship. This has no implications for guilt or innocence.

Encounter type	Number	Killed	Volume
Cant say encounter type	21	2	44,228
Confirmed Head on or near Head on	18	207	264,370
Probable head on or near head on	6	103	572,490
Crossing, other ship burdened	4	8	23,200
Crossing, own ship burdened	4	65	77,686
Over Taking	2	13	9,170
Probable crossing	1	11	50,500
TOTAL	56	409	1,041,644
Confirmed/Probable Dances of Death	15	224	447,352

Table 11: 1960 on ROTR Casualties by encounter type

goes starboard to starboard – due to an ambiguity in the Rules of the Road, when the two ships are displaced to starboard. See Tromedy, Section 3.4.

Table 12 summarizes the data we have on type of encounter in ROTR casualties since 1995.

Encounter type	Number	Killed	Volume
Cant say encounter type	12	1	1,819
Probable head on or near head on	2	0	13,990
Confirmed Head on or near Head on	1	0	0
Crossing, other ship burdened	1	0	0
Crossing, own ship burdened	1	0	29,800
TOTAL	17	1	45,609
Confirmed/Probable Dances of Death	0	0	0

Table 12: 1995 on ROTR Casualties by encounter type

Even without doing any statistical analysis, it is clear there has been real improvement here. In CTX's opinion, this is largely due to the imposition of Traffic Separation Schemes (TSS) in most restricted waters. TSS's dramatically reduce the number of head on encounters, especially head on encounters in which the ships are displaced to starboard.[11]

Table 13 breaks down the ROTR casualties by time of day. It is a little

[11] This improvement is somewhat obscured in data bases that do not differentiate between collisions and ROTR screw ups. We had some horrible collisions in the 1990's including the the Nassia and the Nagaski Spirit massacre. But these were not Rules of the Road casualties.

surprising that the preponderance of Night over Day isn't larger. And it is disgusting that we do not have a time of day for 40% of our ROTR casualties.

Time of Day	Number	Killed	Volume
NIGHT	26	261	617,818
?	22	86	325,042
DAY	8	62	98,784
TOTAL	56	409	1,041,644

Table 13: 1960 on ROTR Casualties by Time of Day

Table 14 breaks down the ROTR casualties by visibility. The CTX regards visibility less than 4 miles as Bad, and less than one mile as Very Bad. But often quantitative information is not available.

Visibility	Number	Killed	Volume
?	28	119	319,205
Good	12	61	202,161
Bad	11	209	454,328
Very Bad	5	20	65,950
TOTAL	56	409	1,041,644

Table 14: 1960 on ROTR Casualties by Visibility

Table 15 breaks down the ROTR casualties by range of detection. Y means we know the range of detection (ROD) was sufficient to avoid a collision with proper coordinated maneuvers. N means the opposite. This table combines the ROD of all ships involved in the casualty. Table 15 can be regarded as very weak support for CTX's belief that range of detection is not a key problem. But we simply don't have enough, good data to say anything meaningful on this issue from the data base itself. The same thing is true of many other fields such as initial speed.

Table 16 breaks down all the post-1960 ROTR casualties by level of communication.

Table 17 repeats this analysis for post-1995 ROTR casualties. There is some very weak evidence that the level of communication is increasing, but we simply don't have enough data to say. It is also true that, if communication is really effective, then we would not see any communicating ROTR casualties.

Range of Detection	Number
?	87
Y	8
8	4
6	3
N	3
14	1
0.3	1
22	1
1.5	1
13	1
16	1
10	1
TOTAL	112

Table 15: 1960 on ROTR Casualties by Range of Detection

TALK?	Number	Killed	Volume
?	32	165	375,358
No	20	203	660,720
Yes	4	41	5,566
TOTAL	56	409	1,041,644

Table 16: 1960 on ROTR Casualties by Level of Communication

Table 18 breaks down the ROTR casualties by Vessel Traffic System (VTS) involvement. I would not make much of this. This field is not well coded. We need a lot more information on VTS involvement, especially the "merely observed" category.

The CTX data base has a large number of other fields relating to ROTR casualties. An obvious example is initial speed. But unfortunately these fields are largely blank. Until we have more and better data, a large number of interesting questions must necessarily go unanswered. One obvious step in the right direction would be for the VTS systems to make public the data they have on the casualties that they observed.

?	13	1	15,809
No	2	0	29,800
Yes	2	0	0
TOTAL	17	1	45,609

Table 17: 1995 on ROTR Casualties by Level of Communication

VTS Status	Number	Killed	Volume
?	39	253	470,424
No VTS involvement	14	147	531,290
Talked to both ships	2	9	36,690
Talked to striker	1	0	3,240
TOTAL	56	409	1,041,644

Table 18: 1960 on ROTR Casualties by VTS Involvment

Table 19: Rules Screw-ups in the CTX Casualty Database

Based on CTX Casualty Database as of 2007-12-16T17:58:50
L=Locale, A=Activity, TOD=Time_of_Day, V=Visibility, WE=Weather, EN=Encounter Type, TK=Talk?

DATE	SHIP	Kilo liters	E1	E2	E3	E4	E5	L	A	TOD	V	WE	De-ad	E N	T K	Synopsis
19790719	atlantic empress	329000	VL	CN	SK			R	L	1905	BD	RN	26			collision w Aegean Captain off Tobago, appalling watchkeeping
19721219	sea star	141100	VD	CN	XT	SK		O	L	0400	GD	GD	12			collision Gulf Oman, one Port to Port, one stbd to stbd
19791115	independenta	111000	Vd	CN	XT	SK		R	L				43			Collision South end of Bosporus, cause?
19741109	yuyo maru 10	79500	Vd	CN	SD			H	L				34			collision w Pacific Ares in Tokyo Bay, big fire, cause?
19680228	mandoil ii	50500	V_	CN	XT	ST		O	L	1600	VB	FG	11			collision off Oregon in hvy fog, probable B encounter
19791101	burmah agate	40500	Vd	CN	XT	WS	ST	H	L	0500		GD	32			coll w Mimosa inbound Galveston Bay, 30+ dead, no detect?
19790428	gino	39000	V_	CN	SK			R	L		BD	FG	0			OBO coll w Team Castor off Ushant, fog, cause?, sank
19771216	venpet	34800	VD	CN	HL	XT		O	B	0938	BD	FG	2			coll w Venoil off S.A. classic dance of death, IG prob big aid
19971015	evoikos	29800	VU	CN	HL	ST		R	L	2054	5	CM	0			collision Spore crossing westbound lane, hugh gash, 3 tnks
19930120	maersk navigator	29400	Vd	CN	XT	HL		R	L		BD		0			collision w Sanko Honour west end of Malacca Str, cause?
19760216	nanyang	24000	V_	CN	WS	ST		O	L				0			collision in South China Sea w Staat Algoa, sank, cause?
19940330	seki	18800	VB	CN	HL			H	L	0200			0			hit while storing underway off Fujairah, 1P holed
19881010	century dawn	12000	VD	CN	HL			R	L	0442	GD	GD	0			hit by Asian Energy, bad lookout in crowded area
19720821	oswego guardian	11700	Vd	CN	SK			R	L	0500	BD	FG	44			coll w Texanita near Cape, Texanita exp, sank,cause?
19970118	bona fulmar	9450	Vd	CN	HL			R	L			FG	0			hittee off Dunkirk, OBO, 1 tank breached, 4mx3m hole
19900806	sea spirit	7770	Vd	CN	HL			R	L				0			coll nr Gibraltar w LPG carrier Hesperus whose bow destroyed
19930603	british trent	6890	VL	CN	XT	ST		R	L	0543	VB	FG	9			hitee off Ostende, port side, heavy fog, under vts
19760724	diego silang	6200	VU	CN	HL			R	L	2350	GD	GD	0			Vysotsk crossed in front, went astern, turned into Braz Faith
19701023	pacific glory	6000	VR	CN	XT	WS	SC	R	L	2023	GD	GD	13			coll w Allegro in Channel, one said overtaking, one crossing
19770813	agip venezia	5880	V_	CN	HL			O	L				0			coll w Ramses II near Sicily, cause?
19780506	eleni v	5320	V_	CN	ST			R	L	1100	VB	FG	0			'cut in two' by collision off Norfolk UK, heavy fog
19930817	lyria	5290	V_	CN	HL			O	L				0			collision with submarine off Toulon
19990115	estrella pampeana	4540	V_	CN	HL			H	L				0			collision, Rio Plata, 1P tank breached
19900329	jambur	3800	V_	CN	WS	HL		R	L				?			collision in Bosporus, 1S,1C holed dop ¿ 6m, no cause info
19941221	new world	3500	VB	CN	XT	HL		O	L				8			coll west of Gibraltar, burdened Ya Mawlaya failed to give way
19710118	oregon standard	3240	VB	CN	HL			R	L	0140	VB	FG	0			collision SF Bay, wrong frequencies, advisory VTS useless
19810128	olympic glory	3170	V_	CN	HL			H		0940	9	3	0			overtaking collision Houston Ship Channel, cause?
19740118	keytrader	2790	VD	CN	WS	HL	XT	H	L	1401	BD	FG	16			dance of death w Baune in lower Mississippi River
19751112	olympic alliance	2220	V_	CN	HL			R	L	NGHT		FG	0			coll off Dover w frigate in traffic lane
19660616	alva cape	2066	VB	XT	CN	SD		H	L	1412	GD	5	33			coll w Tex Mass, went astern, lost steerage, bow swung to port
19750213	capulonix	900	VD	CN				R	L	0028	GD	CM	0			dance of death entering Bombay

Continued on next page

DATE	SHIP	Kilo liters	E1	E2	E3	E4	E5	L	A	TOD	V	WE	De-ad	E N	T K	Synopsis
19920418	world hitachi zosen	900	V_	CN	HL	XT		O	L				1			collision w bulk carrier off Morocco, holed, fire 1S, cause?
19850321	patmos	842	Vd	CN	X_	WS	ST	R	L	0531	9	GD	3			collision S of Messina, fire, Patmos to port?
19710111	texaco caribbean	638	VR	CN	XT	SK		R	B	0311	BD	FG	51			fog, coll w rogue vessel E.C. exploded, sank, others hit wreck
19990324	min ran gong 7	543	V_	CN	HL			R					0			collision off Zhouhai, nil info
20040322	everton	494	V_	CN	HL	XT		O	L	NGHT			1			coll w fish factory in Arabian Gulf, fire port side, cause?
20021205	agate	411	V_	CN	HL			R	L	0535			0			collision E of Singapore with Tian Yu, hole P slop
19700320	otello	319	V_	CN	HL			H					0			coll near Vaxholm, some say 60-100KT spill, appears unlikely
19970803	saraband	150	V_	CN	HL								0			collision Malacca Strait, no real info
20010922	new amity	138	V_	CN	HL			H		1430			0			collision w tow in Houston Ship Channel, got bfo tank?
20010423	gudermes	84	VB	CN	HL			R	L	0429	5		0			coll English Ch w fishing vsl which had only deckhand on watch
19640703	bonifaz	Y	VD	CN	XT	SK		O	B	2212	BD	FG	25			hit by Fabiola off NW Spain fire, sank. Classic dance of death
19720506	esso chittagong	Y	VD	CN	XT	SK		R	L	2315	GD	GD	?			slow speed dance of death at Bangkok pilot station
19920503	geroi chernomorya	Y	V_	CN	HL	X_		R	L				0			collision near Skyros, aft stbd cargo tank holed, cause?
19940708	honam pearl	Y	V_	CN				R					0			coll with World Achilles in Malacca, nil info
19960216	stresa	Y	V_	CN				R	L				0			collision w roro ferry in Malacca Str, port shell, nil info
20030429	b r ambedkar	Y	V_	CN	HL			R	L				0			collision w fishing vessel off Kochi
20040526	morning express	Y	V_	CN	HL			R	L	0440			0			collision w bulk carrier, south coast of Korea, dh
19661022	arrietta s livanos	?	VB	CN	HL	MF		R	L	1544	BD	RN	0			hittee in dance of death with Anneliese off Ushant, ER flooded
19990701	new venture	?	V_	CN				R	B				0			hitter in Malacca collision w Maritime Fidelity, prob ballast
19971125	nordfarer	0	V_	CN				R	L				0			coll w Hoergh Mistral in English Ch, no cause info
20020325	british vigilance	0	VU	CN	HL			R	L	0130	GD	CM	0			collision with Stena King, no talk despite knew each other
20040522	kaminesan	0	V_	CN				R	L	2345		GD	0			coll w car carrier off Spore, communication w vts, other ship
20041024	bergitta	0	VU	CN				R	L	2218	.5	3	0			coll w MSC Eyra, 30kt closing spd, talk too late, stern swing

6 Navigation Errors

The CTX database distinguishes between navigation errors and conning errors. In a navigation error, the ship is not where she thinks she is. In a conning error, the ship knows where she is but gets into trouble anyway because someone misjudges the current or hits a berth or the like. The ARGO MERCHANT which was 24 miles off course was clearly a navigation error. The SEA EMPRESS in which the pilot misjudged the tidal set at the entrance to Milford Haven was clearly a conning error. Some spills are not so clear cut. You can argue the EXXON VALDEZ either way. The CTX rule is, if the spill almost certainly would have been avoided if the ship had had a properly functioning GPS and used it, then it is a navigation error. If it is not nearly certain that the spill would have been avoided if the ship had had GPS, then it is a conning error.[12] We called the EXXON VALDEZ a navigation error on that basis.

Table 22 shows the casualties in the CTX database which CTX has attributed to navigation errors. A fair number of the pre-Amoco Cadiz big spills were navigation errors including (TORREY CANYON, ARGO MERCHANT, ARROW). In many of those cases, the quality of the navigation was execrable. After the AMOCO CADIZ, the worst of the second tier tanker owners mostly disappeared or cleaned up their act a bit, and totally atrocious navigation errors have been reduced markedly. Table 20 summarizes our navigations errors by initial event.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Navigation error	15	7	260,446	1	0	0
Probable nav. error	8	0	36,136	2	0	8,706
Bad charts on-board	2	0	300	0	0	0
TOTAL	25	7	296,882	3	0	8,706

Table 20: Navigation Errors by Cause. Volume in m3

But even before this happened, navigation errors represented less than 7% of the volume spilled and have killed just six tankermen. Since 1990, there are only four navigation errors in the CTX casualty database and we

[12] In the case of the SEA EMPRESS and many other conning error spills, GPS/ECDIS could have alerted the pilot to the tidal set a little earlier but one cannot say with near certainty that this would have avoided the grounding.

are not absolutely sure about two of those.[13]

There should not be any. With the advent of GPS and ECDIS, spills due to navigation errors should be a thing of the past. GPS of course is the Global Positioning System. For a few hundred dollars, every ship in the world can not only know exactly where it is, but also have accurate speed and course over the ground. ECDIS, computerized chart display, eliminates plotting errors.

CTX's main concern here is crew fatigue. Table **??** breaks down our navigations errors by time of day.

	1960 On			1995 On		
TOD	No.	Killed	Volume	No.	Killed	Volume
NIGHT	12	6	89,045	2	0	476
DAY	7	1	161,350	0	0	0
?	3	0	7,757	0	0	0
0600	1	0	29,000	0	0	0
0700	1	0	1,500	0	0	0
0615	1	0	8,230	1	0	8,230
TOTAL	25	7	296,882	3	0	8,706

Table 21: Navigation Errors by Time of Day. Volume in m3

The Tromedy has allowed tanker crews to become so small that, after a load or discharge, just about everybody is dead tired.[14] One of those dead tired officers will be navigating the ship in the first couple of watches after leaving port. That's asking for trouble as the Exxon Valdez found out. A more recent example is the Nino. Shortly after part-discharging in Durban, the Nino went aground on the South African coast at 0215 local. The 2nd Officer was alone on the bridge by himself. He made a series of elementary mistakes. The ship was equipped with GPS, but he failed to check it. GPS

[13] Not all navigation errors are the crew's fault. In October, 1984, the fully loaded Aguila Azteca ran aground 8 miles northwest of Bermuda. It was broad daylight and calm weather. Visibility was good and Bermuda had been sighted. The ship's plotted position was correct. It turned out the only chart that she had of the area covered the entire Atlantic, North and South. On such a chart, Bermuda shows up as a dot and the reefs to the north of the islands not at all. The ship knew exactly where it was, but it did not know where the reefs that used to support the Bermudian economy were. Almost exactly the same thing happened to the Tifoso. These were not crew problems; they were owner problems.

[14] IMO has responded to this issue by increasing the crew's work load by mandating all sorts of paperwork.

works just as well at night as during the day; but tired humans don't.

Despite TORREY CANYON, and EXXON VALDEZ navigation errors never were that important, and should be a non-factor in the future, ***provided we enforce reasonably sized crews***.

Table 22: Lousy Navigation Casualties

Based on CTX Casualty Database as of 2007-12-16T17:58:50

DATE	SHIP	Kilo liters	E1	E2	E3	E4	L	A	TOD	Vis	We	Dead	Synopsis
19670318	torrey canyon	142300	NA	WS	SK		R	L	0850	GD	5	1	nav error, grounded Scillies, jumboized, poor Autopilot design
19890324	exxon valdez	41000	NA	WS	HL		R	L	0009	3	3	0	nav error, master not on bridge, stranded leaving Valdez
19761215	argo merchant	29000	NA	WS	SK		O	L	0600		HW	0	grnd off Nantucket, putrid nav. bad operations
19750326	tarik ibn ziyad	17400	N_	WS	HL		H		2045			0	grounding Rio, cause uncertain
19790302	messiniaki frontis	14100	NA	WS	HL		R	L	0459	GD	CM	0	grounding Crete, radar on wrong scale, no visuals
19700204	arrow	12200	NA	WS	SK		R	L	0935	5	HW	0	horrible nav, operations, grounded Nova Scotia, broke up
20001003	natuna sea	8230	N_	WS	HL		R	L	0615	GD	GD	0	grounded off Singapore, prob nav???
19660517	fina norvege	7647	NA	WS	HL		R	L				?	grounded Tunisia, Master charted bad course, mate deferred
19730318	zoe colocotronis	5970	N_	WS	HL		R	L	0255		GD	0	grnd PR, nav gear out of order, bad owner, cause?
19750106	showa maru	5290	NA	WS	HL		R	L	0540			0	VLCC grnding, narrowest part of Spore Str. 2-3m penetration
19781012	christos bitas	4290	NA	WS	SD		R	L	1634			0	grnd off Milfordhaven, probably bad navigation
19800821	texaco north dakota	2860	N_	AL	X_	HL	O	L	0430	GD		0	hit new oil platform in GOM, charts not up-to-date
19941002	cercal	1470	NA	WS	HL		H	L	1000			0	bad pilot nav , grnded entering Leixoes, 1 tank holed
19750815	globtik sun	1110	NA	AL	XT	ST	R	L	0130	GD	3	6	hit platform off Galveston, bad charts, bad plotting
19890623	world prodigy	1090	N_	WS	HL		R	L	1640	GD	3	0	grounded waiting pilot off Rhode Is. perfect conditions
19980807	ocean gurnard	476	N_	WS	HL		R	L	2100			0	another Malacca Strait grounding, guessing nav
19720722	tamano	378	NA	WS	HL		R	L	0120		GD	0	hit ledge side of channel, Casco Bay, mishandled HBL
19830120	tifoso	300	NC	WS	SD		R	B	0440		HW	0	generator problem, diverted to Bermuda, no charts, grounded
19861221	thuntank 5	161	NA	WS	HL		H	L	NGHT	BD	8	0	grounding Sweden, very bad weather, 'nav misinterpretation'
19710330	panther	110	N_	WS	SC		R	L		VB		0	stranded in very bad visibility, no pilot, CTL, spill small?
19741002	sarah c getty	0	NA	WS			R	L	1200			0	grounded full load soft sand, bad nav, no penetration
19841001	aguila azteca	0	NC	WS	ST		R	L	DAY	GD	CM	0	grounded Bermuda, chart covered N/S Atl, reef not shown
20020718	nino	0	NA	WS	HL		R	L	0215	BD	HW	0	nav equip bad, no GPS chek, grounded, ballasted down, no spill

7 Conning/Seamanship Errors

The CTX database distinguishes between navigation errors and conning errors. In a navigation error, the ship is not where she thinks she is. In a conning error, the ship knows where she is but gets into trouble anyway because someone misjudges the current or hits a berth or the like. Unfortunately, the conning error category had grown into a bit of a grab bag. It includes casualties which are the result of conning errors and casualties in which the main factor appears to be non-navigational poor seamanship on board. In the future, CTX will probably put non-navigational, non-conning bad seamanship in its own category.

Table 25 shows the conning error casualties in the CTX database. Conning errors are much more important than navigational errors, and they are not going away. The largest post-1995 spill, the Sea Empress, was a guidance error. Table 23 breaks these casualties down by initial event.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Probable guidance error	28	224	70,681	15	0	2,289
Conning error	9	26	209,711	4	0	86,707
Anchor dragged	6	0	10,200	2	0	0
Engine department error	5	2	0	4	0	0
Other Guidance error	3	0	2,000	2	0	0
Hit berth	3	0	7,638	2	0	8
Bad seamanship, deck	3	2	99,600	1	2	0
Ship too deep for depth, swell	3	0	1,817	1	0	0
TOTAL	60	254	401,647	31	2	89,004

Table 23: Conning Casualties by Initial Event

The field labeled POB (Pilot on Board) in Table 25 shows pilot status at time of casualty. Table 24 breaks down the conning casualties based on this field. Conning errors and pilotage are closely intertwined.

There is no magical technological fix for guidance errors. However, there are a couple things we can do about guidance errors.

GPS/ECDIS should help .

GPS/ECDIS should help in those gray area situations which are part conning and part navigation. The combination of knowing exactly

	1960 On			1995 On		
POB?	No.	Killed	Volume	No.	Killed	Volume
?	34	86	38,436	18	2	2,114.822
Pilot on board	20	26	247,610	12	0	86,889.7
No pilot	4	142	102,400	1	0	0
Disembarking pilot	1	0	0	0	0	
Picking up pilot	1	0	13,200	0	0	
TOTAL	60	254	401,647	31	2	0

Table 24: Connning Casualties by pilotage status

where you are and having that position immediately and correctly displayed on the ECDIS chart should alert pilots much more quickly when they are straying out of a channel. And in the case of lots of current, GPS gives the pilot better, quicker information on speed and course over the ground than he had prior to GPS.

Better low speed manueverability .

This important isssue in discussed in The Argument for Twin Screw.

Table 25: Conning/Seamanship Casualties

Based on CTX Casualty Database as of 2007-12-16T17:58:50

DATE	SHIP	Kilo liters	E1	E2	E3	POB	L	A	TOD	Vis	We	Dead	Synopsis
19930105	braer	99600	GS	LP	WS	N	R	L	0440		HW	0	pipes on deck hit vents, sw in BFO, no power, grnded Shetland
19960215	sea empress	84400	GC	WS	HL	Y	H	L	2007			0	pilot misjudged tide set Milford H, compounded by bad response
19740809	metula	62300	GC	WS	HL	Y	R	L	2218	GD		0	grounded Str of Magellan, pilot error, no place for VLCC
19750131	corinthos	42200	GC	CA	ST	Y	T	d	0029	9	CM	26	hit by E M Queeny, Marcus Hook, no IG, pilot error
19770207	borag	33900	G_	WS	SK	Y	H	L				0	grounding Keelung , pilot on board, cause?
19700505	polycommander	17600	GC	WS	HL	Y	H	L	0400			0	grounding near Vigo, pilot error?
19680303	ocean eagle	13200	G_	WS	SK	P	H	L	0700	GD	5	0	slowed for pilot, lost control, grounded in hvy swell
19780109	brazilian marina	11800	G_	WS	HL		H					0	'struck submerged rock' S. Sebastiao channel, cause?
19830928	sivand	7630	GB	AL	HL		T	L				0	hit berth at Immingham, 'negligent handling'
19711130	juliana	7200	GA	WS	HL		H	L	1650		HW	0	anchored off Niigata waiting pilot, dragged, lost
19730805	dona marika	3000	GA	WS	SC		H	L	2104		GL	0	anchor dragged in storm off Milfordhaven, why stay?
19910410	agip abruzzo	2800	G_	CA	XT	N	H		2300			142	hit by ferry Moby Prince while anchored, killer fire
19880713	nord pacific	2440	G_	AL	HL		T	L	NGHT			0	hit berth while mooring Corpus Christi
19941003	neptune aries	2380	G_	AL	HL		T	L				0	hit jetty at Cat Lai, mooring
19900728	shinoussa	2000	GY	CN	HL	Y	H	L	1440			0	pilot said stbd, helmsman went port, sunk dh barge, Galv. Bay
19970702	diamond grace	1550	GC	WS	HL	Y	H	L	1005	GD	CM	0	had to slow down in Tokyo Bay, lost steerage, grounded
19900207	american trader	1500	GD	WS	HL	Y	S	L	1620			0	grounded Huntington Beach CBM, too much draft for swell
19951117	honam sapphire	1400	G_	AL	HL		T	L				0	Hit berth mooring at Yoshon, no cause info
19720511	tien chee	1000	G_	CN	XT		R	L	0500			82	coll w Royston Grange Rio Plata due to bank effect, 82 dead
19851221	arco anchorage	904	GC	WS	HL	Y	H	L	1626	3	CM	0	ran aground anchoring Pt Angeles, pilot error
19960927	julie n	757	GC	AL	HL	Y	H					0	struck bridge Portland ME, 30m opening for 26m beam
19690430	hamilton trader	635	G_	CA	HL		H	L	DAWN			0	hit while anchored Liverpool, one tank holed
19810119	concho	317	GD	WS	HL	Y	H	L	DAY	9	CM	0	grounding New York Harbor, ship too deep for channel
19960310	mare queen	238	G_	CA	HL		T	d				0	hit by barge in Houston Ship Channel
19931009	iliad	235	G_	WS	HL		H					0	grounding leaving Pylos, 'human error'
19970807	katja	196	G_	AL	HL		T	L				0	hit quay at LeHavre, ship dh, but port bfo tank not
20021123	tasman sea	188	G_	CA	HL		R	L			FG	0	hit while anchored off Tianjin
19950205	berge banker	143	G_	CA	HL	Y	L	L	0940	GD	3	0	hit by lighter Skaubay off Galveston during mooring
20040220	genmar alexandra	83	G_	CA	HL		T	d	2000			0	hit by Bright Star discharging Mississippi River
20000315	j dennis bonney	32	G_	CA	HL	Y	L	L				0	hit by lighter while mooring, Southwest Pass
20041215	ievoli splendor	8	GB	AL	HL	Y	H	L	2100			0	hit moored barge while mooring Houston, bunker tank holed
20040729	eagle memphis	8	G_	CN	HL		H		1330		GD	0	collision w tug, both northbound??? in Miss. River

Continued on next page

DATE	SHIP	Kilo liters	E1	E2	E3	POB	L	A	TOD	Vis	We	Dead	Synopsis
19920512	aida	2	G_	WS	HL		H					0	grounded entering Cienfuegos
20010129	prince william sound	2	G_				H	L				0	'deck drain overflowed' at Port Angeles, no real info
20040802	torm mary	0.102	G_	CA	HL		H	B	0020			0	hit while bunkering Neches River
19910904	esso mersey	Y	GE	XP			T	d				2	bad pump overhaul by contractor, pump room fire, two killed
19940801	port royal	Y	G_	AL			T					0	hit dolphin, mooring at Corpus C., possible mach failure
19940921	patriot	Y	G_	AL			T					0	hit pier leaving Hong Kong terminal, no cause info
19941018	amazon venture	Y	G_	AL	HL		T	L				0	hit berth mooring at A. Theodoroi, holed 1 cargo tank
19990826	senang spirit	Y	G_	CA	HL		T					0	hit jetty at Port Fortin
20000115	kapitan rudnev	Y	G_	AL	HL							0	hit pier at Quebec
20000624	gulf star	Y	GB	CA	HL		H	L				0	hit berth with mooring Port Louis, Mauritius, dh
20041214	al samidoon	Y	G_	AL	HL	Y	H	L				0	hit Suez bank avoiding dredge, probable pilot error, holed
19770810	neil armstong	?	GS	CN		N	H	B	NGHT			?	coll w anchored Coral 1, no anchor lights, no detect
19800809	copper mountain	?	GA	WS			R				12	0	'broke moorings in hurricane', grounded Corpus Chr.
19850117	giorgione	?	GA	WS	ST		R	B			HW	0	anchor dragged in hvy weather off Sicily, grounded
19901106	star connecticut	?	GC	WS	HL	D	S	B	1944	GD	3	0	conning error lving Oahu SBM, ER flooded
20020101	willy	?	GA	WS	SC	N	R	B			HW	0	anchor dragged Plymouth, bad guard ring, eng not ready CTL
20021210	sarah glory	?	GC	CN		Y	H	B	NGHT			0	collision w HK Express forming up Suez convoy, poor VTS
20040227	aleksandr pokryshkin	?	G_	WS								?	grounded off Puerto Cortes (which one?) nil info
20040331	israa	?	G_	AL			D	R				0	hit dolphin while mooring at Jeddah shipyard
19991118	alfa britannia	0	GY				T	L	1932			0	wire parted, poor communication between pilot and Korean crew
20030130	lion	0	GE	Lp	DA	Y	H		1736			0	blackout blamed on ice in cool wtr suctions, wrong suction??
20030131	keymar	0	GA	WS			R	B			BD	0	anchored dragged in bad weather, grounded Skikda
20030416	capella voyager	0	GD	WS	HL	Y	H	L	1816			0	grnded in big swell in channel, FP holed, hvy shore pressure
20030606	genmar boss	0	GE	Lp	DA		H	L				0	lost power lded Miss R. gens triped hi temp, lo suctions open
20030704	delaware trader	0	GE	Lp	DA		H	L	0310			0	wrong fuel vlv, lost power outbound NY, anchored, hit buoy
20030827	ncc asir	0	GE	Lp	DT	Y	T		0206			0	loss or power lving terminal, cooling vlvs wrong
20041013	luzon spirit	0	GY	WS		Y	T	L				0	lines let go prematurely unmooring Frederica, grounded
20061111	fr8 venture	0	GS				O				HW	2	captain left shelter in storm w anchors unsecured, 2 crew dead

8 Inerting/Purging/Hotwork

Table 32 lists all the CDB casualties in which CTX has called the initial cause bad inerting/purging or stupid hotwork. CTX terms these IPH casualties. Every IPH casualty results in a fire or explosion. But not all fire or explosions are caused by IPH. In fact, many tank explosions are caused by structural failures or ROTR errors; most engine room fires are caused by machinery failures.

Table 26 breaks the IPH casualties down by cause. The sample size and the quality of the causal information is such that it is impossible to say anything very useful from this little table.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Probable bad inerting	20	160	52,646	4	22	5,000
No IG or IG not working	13	87	56,604	1	21	12,600
Hotwork	6	29	8,849	1	1	0
Lightning strike	4	14	6,980	0	0	0
Bad purging, gas-freeing	4	25	500	3	22	500
TOTAL	47	315	125,579	9	66	18,100

Table 26: IPH Casualties by Cause

It is important to recognize that there are many non-IPH casualties in which better inerting could have made a big difference. Perhaps the most dramatic example is the BETELGEUSE. This explosion was clearly caused by badly wasted steel. But if the ship had been properly inerted, there is a good chance that the explosion could have been avoided, or at least the number killed reduced markedly.

The CTX CDB data base design allows us analyse casualties involving a tank explosion separately from casualties in which the initial cause is thought to be an inerting/purging/hotwork problem. Table 27 breaks down all casualties involving a known tank explosion by inert gas system (IG) status at the time of the casualty. Unfortunately, the paucity of data on IG status is such that we can't make as strong a statement from this little table as we should be able to. It is amazing how often casualty investigators fail to even mention IG status. CTX is quite confident that in many of the tank explosions for which we have no info on IG status the inert gas system

was either not installed or not working properly. But even without better data, it is clear that a lot of people have been killed on un-inerted or poorly inerted tankers.

IG Status	Number	Killed	Volume
?	75	619	1,792,043
IMO IG not installed	35	544	248,790
IMO IG not operating properly	5	29	14,400
IMO IG operating properly	2	11	41,690
TOTAL	117	1203	2,096,923

Table 27: Tank explosions by IG status

The value of inerting was conclusively demonstrated by Shell in 1970. By 1975, the regulatory system should have required IG systems on all tankers, but it did not. Table 28 breaks down the post-1974 tank explosions by IG status. Once again we are sharply limited by the quality of the data with respect to IG status. But we can say that at least 62 people were killed on non-inerted tankers after 1974. The actual number is probably several hundred.

IG Status	Number	Killed	Volume
?	69	579	1,620,783
IMO IG not operating properly	5	29	14,400
IMO IG not installed	3	62	83,960
IMO IG operating properly	2	11	41,690
TOTAL	79	681	1,760,833

Table 28: Tank explosions 1975 on by IG status

By 1990, IGS had finally been mandated on just about all seagoing tankers. Table 29 breaks down our post-1995 tank explosions by IG status. Once again we are sharply limited by the failure of investigators to record IG status. But we do know that 21 crew were killed on the Bow Mariner when the IGS system was by-passed, presumably to accommodate commercial pressures.

IG Status	Number	Killed	Volume
?	18	63	6,025
IMO IG not operating properly	1	21	12,600
TOTAL	19	84	18,625

Table 29: Tank explosions 1995 on by IG status

Table 30 breaks down known tank explosions by ship activity at the time. Tank cleaning figures prominently. And we can be sure that some, perhaps many, of the explosions in which all we know is that the ship was in ballast involve tank cleaning. But loaded tank explosions are the real killer. As Table 31 shows the causation of loaded tank explosions is completely different from that of ballasted tank explosions. Tank explosions while loaded are dominated by Rules of the Road screw-ups (number killed) and structural failures (oil spilled). Tank explosions in ballast are dominated by IPH errors.

Activity	Number	Killed	Volume
Loaded	38	479	1,823,250
Ballast	34	314	64,921
Tank Cleaning	19	100	12,291
Discharging	11	101	91,220
?	8	163	34,321
Loading	5	39	70,920
Repairing	2	7	0
TOTAL	117	1203	2,096,923

Table 30: Tank explosions by Activity

Activity	Type	Number	Killed	Volume
Loaded	Rules of the Road	14	223	402,140
Loaded	Structural failure	12	72	1,260,700
Loaded	Dont Know	3	17	7,000
Loaded	Inerting/Hotwork	2	22	12,600
Loaded	Mechanical Failure	2	5	107,000
Loaded	Guidance/Seamanship	2	82	18,600
Loaded	External Factors	2	52	14,100
Loaded	Navigation Errors	1	6	1,110
Ballast	Dont Know	14	76	4,247
Ballast	Inerting/Hotwork	13	71	13,436
Ballast	Structural failure	4	89	11,800
Ballast	Rules of the Road	3	78	35,438
Tank Cleaning	Inerting/Hotwork	15	86	12,204
Tank Cleaning	Dont Know	4	14	87
Discharging	Inerting/Hotwork	4	17	40,690
Discharging	Dont Know	4	34	3,500
Discharging	Transfer Problems	2	0	30
Discharging	Structural failure	1	50	47,000
?	Inerting/Hotwork	3	17	3,490
?	Dont Know	2	0	31
?	Structural failure	2	4	28,000
?	Guidance/Seamanship	1	142	2,800
Loading	Dont Know	3	35	70,920
Loading	Transfer Problems	2	4	0
Repairing	Structural failure	1	2	0
Repairing	Inerting/Hotwork	1	5	0

Table 31: Tank explosions by Activity and Cause

Table 32: Inerting/Purging/Hotwork Screw Ups

Based on CTX Casualty Database as of 2007-12-16T17:58:50

Date	Ship	Kilo liters	E1	E2	E3	L O	A C	I G	De ad	Synopsis
19790901	chevron hawaii	32200	FG	XT	SK	T	d	N	3	exp Deer Park, lightning combined with no inerting
19661024	gulfstag	21000	F_	XP	XE	O	L	N	8	mogas in PR bilge, vent fans off, exploded, no fire pump, sank
19900609	mega borg	15800	F_	XP	HL	L	d		4	Pump room explosion while lightering, cause?
20040228	bow mariner	12600	FG	XT	SK	O	L	B	21	non-inert tank cleaning, explosion off Virginia, sank
19731105	golar patricia	5880	FG	XT	SK	O	T		1	explosion off Canaries in tank being cleaned, sank
20041115	vicuna	5000	F_	XT	HL	T	d		6	no inert?, tank explosion discharging methanol Paranagua, sank
19761217	sansinena	4760	FG	XT	SC	T	B	N	9	exp on non-inerted deck at LA, ballasting, 9 killed
19800311	maria alejandra	4660	F_	X_	SK	O	B		36	fire off Mauritania, tank cleaning?
19800403	albahaa b	4660	FH	XT	SK	O	T		6	tank fire off Tanzania while tank cleaning, very likely bad IG
19800403	mycene	4660	F_	XT	SK	O	B		1	tank fire off Sierra Leone, prob bad IG while tank cleaning?
19751028	kriti sun	3490	FL	XT	SK	S	B		0	fire Singapore SBM, lightning, just after dischg, inerted?
19810712	hakuyoh maru	3490	FL	XT	HL	T	d		6	'struck by lightning' at Genoa, probably no IGS?
19820306	golden dolphin	3490	FH	XT	SK	O			9	hot work on deck, tank explosion,
19781108	feoso sun	1000	F_	X_	SK	H	B		30	Big explosion inspecting damage after dischg, Manila Bay
19840628	perito moreno	699	FH	X_	SK	H	d		6	fire dsching Buenos Aires, broke in two, bad hotwork claimed
19840226	american eagle	582	FG	XT	SK	O	T		8	exp cleaning gasoline tank GOM, static from plastic sleeve
19850914	sinoda	582	FG	XT	SK	O	T		1	explosion while gas-freeing off Japan
19681020	sitakund	526	F_	XT	WS	R	B	N	3	tank exp in English Ch. ballast, probably pre-IG tank cleaning
20010115	p harmony	500	FP	XT	SK	R	T		9	unsafe charter forced unsafe purging, tank explosion, sank
19691006	seven skies	Y	F_	XT	SK	O	B	N	4	non-inerted tank cleaning explosion NE Singapore
19691212	marpessa	Y	FG	XT	SK	O	T	N	2	non-inerted tank cleaning explosion off Dakar, sank
19720201	v a fogg	Y	F_	XT	SK	O	T	N	39	explosion tank cleaning off Texas, part-loaded, no IG
19791213	energy determination	Y	FG	XT	SK	R	B	B	1	exp in slop tank Hormuz, inerting not working, sank
19931101	pink star	Y	F_	XT		H			0	slop tank exp anchored Falconara, hotwork?
20000130	sletreal	Y	F_	XT	SK	H	B		3	tank fire waiting to load at Cardenas
19610126	esso durham	?	F_	XT	HL	O	T	N	0	tank cleaning explosion off Gibraltar, hole in way of No 4
19670322	circe	?	FG	XT	HF	O	B	N	38	tank exp Med, possibly loose deck equip, broke in two, 38 lost
19691229	mactra	?	FG	XT		O	T	N	2	non-inerted tank cleaning explosion off Mozambique
19691230	kong haakon vii	?	FG	XT		O	T	N	0	non-inerted tank cleaning explosion off Liberia
19720514	golden jay	?	F_	XT	SK	O	B		3	tank explosion, sank in ballast, probably hotwork in bad tank
19720826	princess irene	?	FL	X_	ST	T	B		6	lightning strike at Donges, not inerted, 6 killed
19731003	texaco north dakota	?	FP	XP		O	B		3	Pump Room exp GOM, draining gasoline to P/R bilge! no vent fan

Continued on next page

DATE	SHIP	Kilo liters	E1	E2	E3	L O	A C	I G	De- ad	Synopsis
19790419	seatiger	?	FL	XT	ST	T	d	B	2	exp dsching Texas, sank, lightning, IG not being used
19790527	atlas titan	?	FG	XT	ST	T	B	B	?	put air driven pumps into cgo tank Setubal, explosion, CTL
19791220	choyo maru	?	F_	XT	SK	O	T		?	explosion off Bali, tank cleaning, broke in two, sank
19810531	monticello victory	?	F_	XE	SC	H	B		?	corroded bilge line to cgo tank left open, ER exp. Pt Arthur
19861028	omi yukon	?	FH	X_	SC	O	B		4	flush oil in bfo tank, no screen, bfo tank fire N Pacific
19880831	fiona	?	FG	XT		T	L		1	exp,static chg from stm leak, no IG, set off by tape, Long Is.
19920420	seastar	?	F_	XT		O	T		2	tank cleaning explosion in 3C SE Hong Kong
19930925	altair	?	F_	XT	SK	O	T		3	explosion during manual tank cleaning, tank not inerted
19931009	omi charger	?	FH	XT		H	B		3	hotwork anch. Galveston Bay, no proper inerting, explosion
19931031	oslo lady	?	F_	XT		D	R		5	tank exp while repairing, 1S ballast
19960730	lido	?	FP	XT		H	T		6	tnk clning exp, blamed on 'portable lamps'
19990111	athenian fidelity	?	F_	XT		O	B		5	explosion in 2C Caribbean, probable tank cleaning screwup
20010611	heng san	?	FP	XT	SK	O	T		7	tank explosion while purging Arabian Sea
20061017	quetzalcoatl	?	F_	FH	XT	T			8	tank exp during hotwork on cgo crane Mexico, prob bad ig/vent
20060408	kometik	0	FH	XT		H	B		1	hotwork in tank (why?), fire, Conception Bay, NF

9 Transfer Casualties

Table 38 shows the Transfer casualties in the CTX database. Table 33 breaks these casualties down by initial cause. The sample size is uncomfortably small; but pretty clearly we could use some improvements in the mooring system. See Tromedy, Section 3.9 for the argument for constant tension winches.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Other transfer screw up	36	0	7,629	27	0	742
Unmoored by weather	15	28	54,378	10	0	423
Hose break/leak	15	4	4,138	12	0	4,138
Tank over/under-pressure	4	0	0	3	0	0
Unmoored by wake	4	1	3,200	2	0	0
Deballasting screw up	1	0	4	1	0	4
Incorrect loading	1	0	0	0	0	0
TOTAL	76	33	69,351	55	0	5,308

Table 33: Transfer Casualties by Cause

Table 34 breaks down these casualties down by activity. The preponderance of discharging casualties is almost certainly artificial. Most load ports are in countries which, whether they are strict or lax, don't make spills public. The CTX database has no spills at Ras Tanura/Juaymah by far the largest tanker load port in terms of volume. This port loads half-a-dozen big tankers a day. Based on my experience, I'd be surprised if this port averaged less than one spill a week, almost all of them quite small.

	1960 On			1995 On		
Activity	No.	Killed	Volume	No.	Killed	Volume
Discharging	42	1	14,958	30	0	4,371
Loading	16	4	53,631	13	0	931
?	12	0	660	9	0	0
Ballast	5	28	101	2	0	6
Loaded	1	0	0	1	0	0
TOTAL	76	33	69,351	55	0	5,308

Table 34: Transfer Casualties by Activity

Table 35 breaks down our transfer casualties by Locale.

	1960 On			1995 On		
Locale	No.	Killed	Volume	No.	Killed	Volume
At fixed berth	57	5	66,873	38	0	2,926
At SBM	10	0	2,295	9	0	2,200
Harbor, river, canal	5	28	4	4	0	4
Lightering	2	0	177	2	0	177
Dont know	1	0	0	1	0	0
Open water	1	0	0	1	0	0
TOTAL	76	33	69,351	55	0	5,308

Table 35: Transfer Casualties by Locale

We have few lightering transfer casualties. This has led some to conclude that Ship to Ship (STS) transfer is not a bad thing. Most of these people have never seen what it take to bring an 80,000 ton tanker along side a VLCC at sea. And if we are comparing STS with providing off-shore SBM terminals, we need to account not only for the casualties during the offshore transfer, but also the casualties associated with the lightering tanker's delivery leg. The CDB has a field called STS status which addresses this issue. Table 36 breaks down all post-1994 casualties by STS status.

STS Status	Number	Killed	Volume
No lightering	386	127	407,524
?	32	1	3,528
Probable lighter	17	0	223
Mothership	10	0	469
Reverse lighter	4	4	0
Lighter	1	0	0
TOTAL	450	132	411,746

Table 36: All casualties 1995 on by STS Status

Most lightering is done in the Gulf of Mexico. Table 37 breaks down all post-1994 GOM casualties by STS status.[15] Once again the sample size is

[15] For the purposes of this table, we have defined the Gulf of Mexico to be Galveston Bay, Mississippi River, Sabine/Neches River, Corpus Christi, and Gulf of Mexico not otherwise specified. We have excluded LOOP.

small and the quality of the data is poor. Non-STS Casualty reports rarely indicate whether the ship was a lighter. Even so it's pretty clear that a system based on offshore SBM's would put a sizable dent in near-shore and in-shore GOM tanker casualties.

STS Status	Number	Killed	Volume
?	12	1	1,092
Mothership	9	0	247
No lightering	9	9	8
Probable lighter	7	0	38
Lighter	1	0	0
TOTAL	38	10	1,386

Table 37: Gulf of Mexico casualties 1995 on by STS Status

Table 38: Transfer Spills

Based on CTX Casualty Database as of 2007-12-16T17:58:50

Date	Ship	Kilo liters	E1	E2	E3	L O	A C	TOD	We th	Po rt	De ad	Synopsis
19801228	juan lavalleja	52700	TU	WS		T	l		HW	AZ	0	Unmoored while loading at Arzew, need confirmation
19900916	jupiter	3170	TW	PH	X_	T	d	0830		GL	1	Bay City pier failed, suction passing ship, hoses parted, exp.
19741022	universe leader	3050	TR			T	d			BY	0	valve screw-up at Bantry Bay, cargo thru seachest
19981101	giovanna	2000	TH	X_		S	d			EM	0	underwater hose leak discharging Beirut, mogas slick on fire
19851204	amazon venture	1890	TR			T	d			UE	0	'three malfunctioning valves', discharging Savannah
19771029	al rawdatain	1160	TR			T	d			GA	0	valve screw up discharging Genoa
19821108	samir	1160	TU	WS	SC	T	d		HW	WA	0	'broke moorings' discharging Mohammedia, grounded, CTL
19980608	maritza sayalero	1110	TH			T	d			CA	0	'broken hose', Carenero Bay, Ven.
19960308	bunga kesuma	906	TH			T	l			MA	0	'hose burst' while loading Bintulu, no cause?
19920717	shoko maru	374	TR			T				GB	0	2300 bbl spill at Texas City, no cause info
19990803	laura damato	294	TR			T	d			OZ	0	tampering, 2 seavlvs open, crew failed to check, Sydney
19940501	alva sea	286	TR			T				PC	0	shore vlv failed, then temp hose failed, Balboa?
19950722	jahre spray	222	TU	PH		T	d		HW	DR	0	unmoored from Eagle Point in storm, two hoses parted
19961030	once	158	TR			S	d			TH	0	spill discharging at Maptaphut SBM, no cause info
19960509	anitra	151	TR			L	d			DR	0	valve screw up at start of discharge, Delaware Bay
19930519	prime trader	127	TR			T	d	0530	4		0	valve screw up at Jacksonville
20010314	genmar hector	115	TU	PH		T	d	1500	HW	GB	0	blown off Texas City berth, broke 2 chiksans
19890302	exxon houston	95	TU	WS	HL	S	B		5	BP	0	Oahu SBM chafe chain parted, vsl later went aground
19950806	ariete	68	TH			T	d		HW	WS	0	hose break in rough seas at Conchan near Lima
20020424	front sabang	60	TR			T	d	1725		SB	0	relief valve failed dsching Saldanha Bay, need explanation
19960809	kriti sea	59	TU	PH		T	d			AT	0	unmoored in thunderstorm, Greece, hoses parted
19840627	vic bilh	30	TW	XT		T	d	1700		SR	?	unmoored by Afran Stream Pt Arthur, too fast to keep steerage
19970918	mystras	26	TR			L	d			DR	0	'possible valve misfunction', Big Stone Anchorage
19980702	theotokos	24	TH			T	d			IN	0	'hose came away' at Columbo, cause unclear
20031022	athina m	24	TH			T	d			AT	0	dsch arm disconnected at Agioi Theodoroi
19970103	tove knutsen	18	TR			S	d			HU	0	spill at Tetney SBM, no cause info, ER fire reported??
20001220	rangrid	15	TU	PH		S	d			UE	0	crew mistakenly released remote chainstopper, poor interface
20020412	petrotrym	10	TR			T	l			FL	0	'human error' at Flotta, nil cause info
19980821	palmerston	9	TR			T	d			BR	0	lube oil spill discharging Brisbane, cause?
20010522	tokachi	5	TH			S	d			TH	0	auto release coupling failure at Mahpathut SBM
19970526	plate princess	5	TD			H	B			LM	0	deballast screw-up in Lake Maracaibo
19991206	almanama	5	TU	PH		S	l		BD	BU	0	blown off Butinge SBM, hose broke

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Date	Ship	Kilo liters	E1	E2	E3	L O	A C	TOD	We th	Po rt	De ad	Synopsis
20010705	tasman	4	TR			T	l	0400		OZ	0	cgo in ballast, loading Melbourne
20041002	flying officer nirmal	4	TR			T	d			IN	0	leak from pipes discharging Vasco
19990627	arco texas	4	TU	PH		T	d	1355		PS	0	unmoored while discharging at Ferndale
19960701	provence	3	TU	WS		T	d	2245		UE	0	unmoored discharging Portsmouth NH, tide may be factor
19981129	volgograd	2	TR			T	l			TN	0	tank overflow while loading Tallinn
20010128	overseas chicago	2	TH			T	d			BP	0	coupling malfunction at Barbers Point, Hawaii
20030913	venture	2	TR			T	l			MH	0	cargo tank overflow at Milford Haven, IMO is right?
19990601	histria spirit	2	TR			T	l			BS	0	oily ballast?? at Odessa, nil info
19960205	neptune	1	TR			T	B			PS	0	bfo tank overflw bunkering Anacortes, crew left post
19890311	st lucia	0.477	TR			T	l			VZ	0	tank overflow at Valdez
20040219	irving eskimo	0.450	TU			T	d	1200	HW	UE	0	unmoored during disch by blizzard, Charlottetown
20010630	sericata	0.300	TR			T	d			BR	0	leak in IG ovbd line? at Brisbane
20010523	sericata	0.200	TR			T	d			OZ	0	screw up during manifold draining at Geelong
20030807	sirius 1	0.130	TR			T	l			MH	0	gasoline overflow loading Milford Haven
20030221	navion anglia	0.100	TR			S	l			NS	0	100 liter spill, disconnecting from Alba North SBM
20030705	zeus	0.080	TW			H	L	1750		SR	0	wake unmoored Nita M on Neches, flange busted, small spill.
20000820	loch rannoch	0.075	TR			T				SV	0	faulty cargo pump seal at Sullom Voe
20030505	ragnhild knutsen	0.003	TR			T				UK	0	Transfer spill at Finnart, but no cause data
20030727	estere	0.002	TR			T				MH	0	transfer spill at Milford Haven, no cause info
20030501	loch rannoch	0.001	TR			T				SV	0	1 liter spill at Sullom Voe, no cause info.
19600708	esso portsmouth	Y	TH	XT		T	d			MH	?	unloading arm failed Milford Haven, spill, fire, explosion
19680506	islas orcadas	Y	TH	XT	SK	T	l	0000		RP	4	ruptured hose ld gasoline La Plata, 3 ships sunk, spill?
19681212	diane	Y	TH	X_		T	d				0	fire from burst hose, while discharging
19930827	australia ocean	Y	TR			T				OZ	0	spill while 'loading fuel' at Melbourne
19940411	endeavor ii	Y	TR			T	d			SS	0	sea valve problem discharging Sao Sebastiao
19951017	kraka	Y	TH			S	l			PG	0	Leak from hose at Mena Almadhi SBM, cause?
19951209	handy sonata	Y	TH			S			HW	OZ	0	Wandoo SBM chain parted, cyclone Frank involved
19960228	san giorgio	Y	TR			T	l			CZ	0	'overflow of gasoline' loading Constanza, nil info
19960601	san sebastian	Y	TU			T	d		BD	SS	0	broke away during discharge at Sao Sebastiao
19990416	bage	Y	TU	PH		T	d			SA	0	unmoored while discharging Temadre, Brazil
20010802	s r hinchinbrook	Y	TH			T	l			VZ	0	lding arm disconnect, Valdez, ship flange too small?
20010806	genmar constantine	Y	TW	PH		T	d	0005		SR	0	unmoored by outbound eagle charlotte wake, hose parted, spill
20020513	brotas	Y	TR			T	d			ES	0	discharging Angra dos Reis, nil info
20030221	nordic blossom	Y	TR			T				MH	0	transfer spill at Milford Haven, no cause info
20030225	pacific sapphire	Y	TH	XT		O	l			GM	0	lightering hose break due to roll, small fire

Continued on next page

Date	Ship	Kilo liters	E1	E2	E3	L O	A C	TOD	We th	Po rt	De ad	Synopsis
20030603	nordic marita	Y	TR			T	d			SS	0	hydraulic failure during discharge Sao Sebastian
19800722	energy concentration	?	TL	HF	SK	T	d			RM	0	broke back dschging Rotterdam, tired CO screw up, IG worked
19801228	gogo rambler	?	TU	AL	CN	T	B		HW	WM	0	came unmoored at Oran, hit quay, other ships, no spill?
19890215	maassluis	?	TU	WS	SK	H	B	0100	HW	SK	28	'broke moorings' Skikda, hit breakwater, hvy weather
19891107	mobil petrel	?	TP	MF		T	d	1529		UK	0	tank over-pressurized, PR/ER flooded, miracle no fire
19950910	halia	?	TR			T	d			BR	0	'hose coupling failed' discharging Brisbane
20020205	kronviken	?	TP	HL						WE	0	tank overpressure, 360 t steel, no other info
20070427	bow santos	0	TP			H				GB	?	no 10 cargo tank rupture, overpressure during purge
20070620	panam atlantico	0	TP			H				GB	?	no 2 cargo tank hatch blew open, overpressure during N2 purge

10 External Factors

External Factors is a grab bag for all the casualties in which the initial cause was neither the design nor condition of the ship nor an error by the people on board. Table 39 summarizes the External factor casualties in the CDB. Charts incorrect here means the ship had the right charts on-board, properly updated; but the charts themselves were wrong.

Currently the CDB excludes war casualties, although a few gray area attacks such as the Limbourg manage to be included. CTX also has not yet focused on piracy; but we had to include the horrific, little publicized Nagasaki Spirit Ocean Blessing collision which occurred when neither ship was under the control of their crews as the result of piracy. The Nagasaki Spirit crew either was thrown overboard or killed in their liferafts after abandoning ship. Apparently, the Ocean Blessing crew locked themselves in to thwart the pirates. They were fried when both ships caught fire. Only two members of the combined crews survived this massacre.

	1960 On			1995 On		
Cause	No.	Killed	Volume	No.	Killed	Volume
Tug contact, other tug screw up	10	23	1,792	7	0	257
Charts incorrect	4	0	54,476	1	0	91
War damage	4	5	0	2	1	0
Probably external error	3	1	146,900	2	0	35,200
Hit submerged object, not bottom	3	0	22,520	1	0	120
External Tampering	1	0	0	1	0	0
Navaid out of position, inoperative	1	0	5,000	0	0	0
Bad channel depth	1	0	4,700	1	0	4,700
Piracy	1	51	14,100	0	0	0
TOTAL	28	80	249,489	15	1	40,369

Table 39: External Casualties by Cause

The sample size for this casualty category is too small to make any definitive statments. The spill volume in this category is dominated by the Urquiola, which was probably a "bad channel depth/bad chart" casualty; but, with the information we currently have, we can't say for sure. Ditto Tasman Spirit. One of the problems with this sort of casualty is that the port state, — normally one of our best sources of cause data — goes into litigant mode.

Table 40: Spills due to External Factors

Based on CTX Casualty Database as of 2007-12-16T17:58:50

DATE	SHIP	Kilo liters	E1	E2	E3	E4	E5	L	A	We	De-ad	Synopsis
19760512	urquiola	111700	E_	WS	X_	SK		H	L		1	grnd in channel to Corunna twice, 'uncharted rock'/ 2 deep
19700601	ennerdale	52200	EC	WS	SK			R	L		0	hit 'unmarked rock' in Seychelles, now dive site
20030727	tasman spirit	35200	E_	WS	ST			H	L		0	chan?pilot?mach?, guess ship too deep for Karachi channel
19791027	gunvor maersk	20000	ES	X_	SK	SC		H	L		0	'struck submerged object' Amazon, fire, sank, need more info
19920919	nagasaki spirit	14100	EP	CN	XT	ST		R	L	CM	51	coll w Ocean Blessing N end of Malacca, piracy, 51 dead
19670502	evje	5000	EB	WS	HL			R	L		?	ice removed Cook Inlet channel buoy, grounded
19970228	nissos amorgos	4700	ED	WS	HL			H	L	HW	0	ship too deep for Maracaibo Channel (maybe?)
19770722	dauntless colocotronis	2400	ES	HL	XE	SC		H	L		0	hit unmarked sunken barge, Miss R, fire, CTL
19700303	oceanic grandeur	1400	EC	WS	HL			R	L		0	hit uncharted rock Torres Str, 8 tnks holed, nil initial spill
19781230	esso bernicia	1220	EG	CA	HL			T	B		0	tug caught fire, let go, ship hit berth at Sullom Voe,
19870702	glacier bay	785	EC	WS	HL			R	L		0	struck 'uncharted rock' Cook Inlet, need to confirm
19920830	era	315	EG	CA	HL			T			0	hit by tug berthing Pt Bonython, 'rough conditions'
20000608	posavina	189	EG	CA	HL			T			0	tug punctured bunker? tank, unmooring East Boston
20041126	athos i	120	ES	HL				H	L		0	hit sunken pipe at Paulsboro, big hull leak
19960311	limar	91	EC	WS	HL			H	L		0	grounded Boston in charted 35/36 ft with 33.75 ft draft
20010523	shinoussa	50	EG	CA	HL			T	B		0	tug contact, unmooring Freeport, BS, dh but hit bfo tank
19980427	barrington	17	EG	CA	HL			H	B		0	bfo tank hit by trainee tugmaster in Brisbane River
20000430	princess pia	2	EG	CA	HL			H	L		0	tug contact, Rio Plata, why tug for loaded ship
19980924	overseas chicago	Y	EG	CA	HL			S	L		0	probable tug contact mooring Barbers Point SBM
19990308	navion clipper	Y	EG	CN	HL			O			0	contact w tug during trials in North Sea, dh
20000603	flying officer nirmal	Y	ET					T			0	robbers tampered w vlv?? Kandla, India
20021006	limburg	Y	EW	XT				R	L		1	attacked while approaching Yemen SBM to top off
19811215	oriental navigator	?	EG	X_	SC			H	B	PH	23	after discharge at Limay, tug fire spread to tanker, 24 dead
19840320	lugansk	?	EW	X_							0	struck mine off Puerto Sandino???
19890105	sagheera	?	EW	X_	SK			R	B		4	hit mine in Straits of Hormuz, sank
19970520	leonidas	?	E_	WS				R	L		0	grounded Maptaphut, probably pushing channel depth too hard
20000615	ventura	?	EW	WS	ST						0	bombed by Tamil Tigers, Ceylon, lost tow, grounded
20020119	allegiance	0	EG	HL				R	L		0	Escort tug veered into tanker, Puget Sd, tug captain at fault

11 Groundings

In the CBD, a grounding is just another event in the casualty sequence. A single casualty can include a collision, a fire, and a grounding among other events. In general, the initial event should be the real focus of our investigations, and grounding is never the initial event. But there are some interesting questions we can ask about groundings.

Perhaps the most obvious question to ask about a grounding is what caused it. Table 42 breaks down our groundings by initial event. Many people may be surprised to find that navigation error is not the dominant cause of tanker groundings.

But there are really two different kinds of groundings: powered and unpowered. The CDB has a NUC (Not Under Control) field. A Y in this field means that the ship had either lost power or steering when she went aground. Table 41 breaks down our groundings by NUC status. The powered versus unpowered numbers are roughly the same, but a lot more people have been killed in unpowered groundings. This is just another way of saying that it is what happens before the grounding that kills people. Powered groundings tend to be caused by navigation or conning errors as Table 43 indicates. Unpowered groundings tend to be preceded by a machinery failure, or a collision, and possibly a fire. See Table 44.

Table 41: Groundings by NUC status

NUC?	Number	Killed	Volume
Dont know	80	31	330,212
Unpowered	63	201	721,417
Powered	50	2	756,748
TOTAL	193	234	1,808,378

Groundings can also be divided into strandings and non-strandings, Table 45. CTX's definition of a stranding is that the ship is aground for at least one full tidal cycle. Unfortunately, the quality of the coding is such we can't say anything useful here. Obviously, we have some work to do on this field.

Table 46 what little data we have on height of penetration. We can make nothing of this. Not only do we have almost no data. But the data we do have is horribly biased. We almost never get damage location data on ships that are lost. Yet it is ships that are lost that spill almost all the oil and kill most of the people. One very weak statement we may be able to make

Table 42: Groundings by Initial Event

Cause?	Number	Killed	Volume
Dont know	87	57	315,769
Other/unknown machinery	14	4	36,350
Loss of steering	14	6	316,374
Navigation error	13	1	257,836
Probable guidance error	7	82	60,137
Probable machinery failure	6	0	119,202
Conning error	6	0	166,754
Anchor dragged	6	0	10,200
Probable nav. error	6	0	33,276
Unmoored by weather	5	28	53,958
Charts incorrect	4	0	54,476
Blackout	4	0	6,000
Probably external error	3	1	146,900
Ship too deep for depth, swell	3	0	1,817
Bad charts on-board	2	0	300
Probable uncoordinated manuever	2	0	27,800
Probable dance of death	2	35	41,342
Probable bad inerting	1	3	526
Unmoored by wake	1	1	3,170
War damage	1	0	0
one port2port,other stbd2strb	1	16	2,790
Bad channel depth	1	0	4,700
Sea water line leak	1	0	47,000
Other Guidance error	1	0	0
Bad seamanship, deck	1	0	99,600
Crankcase explosion	1	0	2,100
TOTAL	193	234	1,808,378

Table 43: Powered Groundings by Initial Event

Cause?	Number	Killed	Volume
Navigation error	13	1	257,836
Dont know	9	0	23,952
Probable nav. error	5	0	15,876
Conning error	5	0	149,154
Charts incorrect	4	0	54,476
Probable guidance error	3	0	13,437
Probably external error	3	1	146,900
Ship too deep for depth, swell	3	0	1,817
Bad charts on-board	2	0	300
Probable machinery failure	1	0	87,000
Bad channel depth	1	0	4,700
Loss of steering	1	0	1,300
TOTAL	50	2	756,748

Table 44: Unpowered Groundings by Initial Event

Cause?	Number	Killed	Volume
Other/unknown machinery	13	4	34,830
Loss of steering	12	0	315,074
Dont know	7	32	43,920
Anchor dragged	6	0	10,200
Probable machinery failure	4	0	32,202
Unmoored by weather	4	28	53,863
Blackout	4	0	6,000
Probable uncoordinated manuever	2	0	27,800
Probable dance of death	2	35	41,342
Probable guidance error	1	82	1,000
Probable bad inerting	1	3	526
Unmoored by wake	1	1	3,170
War damage	1	0	0
one port2port,other stbd2strb	1	16	2,790
Sea water line leak	1	0	47,000
Other Guidance error	1	0	0
Bad seamanship, deck	1	0	99,600
Crankcase explosion	1	0	2,100
TOTAL	63	201	721,417

Table 45: Stranding Summary

STR?	Number	Killed	Volume
Dont know	161	188	711,120
Stranded	25	40	990,850
Not Stranded	7	6	106,408
TOTAL	193	234	1,808,378

from what we have is that in a serious Powered grounding, the longitudinal extent of the damage is likely to be over 100 m.

Table 46: Height of Penetration

Ship	H.O.P. m	L.O.P. m	NUC	Spd	Strr	Dead	Volume m3
exxon valdez	4.6	160.0	N	12	Y	0	41000
showa maru	3	180	N	11.5	Y	0	5290
nino	1		N		Y	0	0
sarah c getty	None	None	N		Y	0	0
luzon spirit	None		Y			0	0

12 Collisions

In the CBD, collisions like groundings are just another event in the casualty sequence. These two consequences receive much more focus then they deserve. But there are some interesting questions we can ask about collisions. Table 47 breaks down the collisions in the CDB by initial event.

Table 47: Collisions by Initial Event

Cause?	Number	Killed	Volume
Dont know	43	67	41,826
Probable uncoordinated manuever	25	13	146,675
Probable guidance error	11	224	5,126
one port2port,other stbd2strb	9	100	198,590
Loss of steering	8	23	19,971
Probable dance of death	8	156	290,162
Tug contact, other tug screw up	7	0	572
Burdened vessel failed to manuever	6	41	27,689
Uncoordinated manuever	4	0	36,000
Other/unknown machinery	2	0	15
Unmoored by wake	2	0	30
Failed to detect other vsl	2	35	335,890
Rogue vessel in wrong lane	2	64	6,638
Conning error	2	26	42,200
Blackout	2	42	23,500
Hit berth	1	0	0
Unmoored by weather	1	0	0
Piracy	1	51	14,100
Other Guidance error	1	0	2,000
Bad seamanship, deck	1	0	0
TOTAL	138	842	1,190,987

The "probable guidance error" category is dominated by the Agip Abruzzo-Moby Prince castastrophe which killed 142. This is a warning not to read too much into the Killed column in these breakdowns since the number can be changed drastically by a single casualty. This is even more true of the volume spilled. The "failure to detect" category is completely dominated by the 329 milliion liter spill from the Atlantic Empress/Aegean Captain debacle.

Not surprisingly, most collisions have been caused by ROTR screw ups,

often a Dance of Death. But steering gear failures have been a fairly important cause.

Table 48 shows all the collisions in the database for which we have an estimate of the depth of penetration.[16] Once again the sample size is very small, but it is pretty obvious that in any major collision a 2 or 3 m double side will be penetrated. This is consistent with most other sources, and the amount of energy that must be absorbed.

It is not consistent with the Harder results in which there is a strong peak at less than 2.5% beam. The Harder results are impossible to critique both because we are not allowed to inspect the casualty data and because the numbers are inexplicably non-dimensionalized on the beam of the struck ship.[17] The Harder project arbitrarily throws out penetrations greater than 50% beam on the grounds that they represent less than 5% of their penetrations. Of course, this is by far the most important 5%.

The column labeled Impact indicates where the struck ship was hit. The longitudinal coding is B for bow, F for forward, M for midships, A aft, and T transom. P implies port side, S starboard. There is at best a weak tendency for struck ship damage to be forward. This is roughly consistent with the results reported by the Harder study,

The few impact angles we do have tend to be close to perpendicular (90 degrees). Zero is head on; and 180 is overtaking. It is a little surprising we don't have more port bow to port bow collisions.

The CTX database had the capability of recording damage length and the all important vertical extent of the damage, but currently we simply don't have enough data to make any statements here. The Harder people of course come up with detailed distributions based on whatever data they have.[18] They then take the remarkable step of simply assuming away damage below the waterline, even though this is inconsistent with their own data, and much more importantly you have assumed away the worst part of the collision damage both for ship survivability and tank spillage.

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[16] A plus sign in the DOP column means "at least". I means the hull was indented but not penetrated. It is important to note one of the worst biases in this data. If the collision is so bad that the ship is sunk, we almost never have penetration data.

[17] The Harder results show large and unexplained differences with earlier Solas numbers, similarly non-dimensionalized. Best guess is that the earlier Solas data was largely confined to casualties involving ship on ship collisions. The Harder database may include more tug contact and the like casualties. But we just don't know.

[18] One obvious question I would like to ask of the Harder database is: how many casualties do you have in which the ship was lost?

Table 48: Depth of Penetration in CTX Collisions

Struck Ship	D.O.P. m	Angle	Impact	Own Spd	Other Spd	Dead	Volume m3
eleni v	22		MS	14		0	5320
nagasaki spirit	15		MP			51	14100
british vigilance	15	135	AP	14.5	12	0	0
esso greensboro	+14	90	MP	15	15	44	7000
tekton	11		M			0	600
burmah agate	11	35	AS	1	12	32	40500
maersk navigator	+10		MP			0	29400
arctic	9	90	A			4	?
tullahoma	8	90	AP		15	1	?
keytrader	6.1	50	FS			16	2790
jambur	+6		FS			?	3800
baltic carrier	6	50	AS			0	2900
venpet	+5	150	AS	15	13.5	2	34800
esso brussels	4.6	60	MS	A	15.5	16	5000
alva cape	3.6	90	FS	4	3	33	2066
high endurance	3	20	AP			0	?
genmar kestrel	+3		AS			0	1400
kaminesan	2	10	BP			0	0
esso chittagong	1	15	FP	1	7	?	Y
eagle milwaukee	I				6	0	0
bergitta	I		TP	12	18	0	0

13 Hotspots

Table 49 summarizes all CDB casualties, regardless of cause by hotspot. Only hotspots with more than five casualties are shown. I would not make too much of this list for at least two reasons:

1. The areal extent of the hotspots varies all over the place. We have hotspots as precise as Guayanilla, and "hotspots" as large as the Indian Ocean.[19]
2. Some regions are far better reported than others. We have almost no casualties at Saudi Arabian ports, where tanker casualties are treated almost as if they were state secrets. At the other extreme, the USCG MIX database contains a large number of very minor casualties.

Nonetheless, you can see the shift away from southern Africa in Table 49. In the 1970's over 10 million BPD of oil was going around the Cape of Good Hope. Now it is often less than 1 MM BPD. Conversely, in the last ten years, we are seeing much more oil coming out of the Baltic.

Sorting the hotspots by number killed, Table 50, focuses on the more major casualties; but the ranking is clearly not statistically significant, due to the combination of small sample size and the fact that a single casualty can kill 100 or more people. A fortiori, sorting by spill volume would be just about meaningless statistically. Nonetheless, it is clear that certain areas need special attention. One possibly surprising feature of this data is that the Straits of Hormuz have been relatively free from tanker casualties.

[19] Hotspots are not mutually exclusive. Coders are instructed to use the most specific area appropriate. Therefore, if you want all casualties in the Gulf of Mexico, then you probably want Galveston Bay, Sabine/Neches River, etc as well as Gulf of Mexico not otherwise specified.

	ALL CASUALTIES 1960 On			ALL CASUALTIES 1995 On		
Hotspot	Number	Killed	Volume	Number	Killed	Volume
?	55	99	58,298	32	31	721
US/Canada East Coast	51	201	519,620	23	21	13,375
Suez Canal	36	0	20,900	24	0	7,300
East African Coast	33	162	591,873	6	0	0
Gulf of Mexico	33	120	95,024	18	8	286
English Channel	32	87	73,920	19	5	9,783
West Mediterranean	31	284	83,957	5	2	0
Mississippi River	30	16	11,017	27	0	2,227
West Coast of Africa	28	95	607,500	2	2	0
Indian Ocean	24	41	105,027	16	5	5,327
Prince William Sound	23	0	41,313	7	0	0
Straits of Malacca	22	53	157,658	10	0	38,678
United Kingdom	19	3	242,010	12	2	0
New York	18	49	8,460	13	0	207
South China Sea	18	75	181,511	4	1	411
Galveston Bay	17	38	79,478	10	0	1,099
Delaware River/Bay	17	39	55,990	10	0	525
Sabine River	15	4	30	10	2	0
Persian/Arabian Gulf	14	62	134,970	4	4	0
North Atlantic	14	52	98,490	3	0	0
Red Sea	14	7	42,982	3	1	0
West Coast of Europe	13	32	84,446	2	0	196
Australia	13	0	23,813	7	0	298
Caribbean Sea	13	32	330,845	4	0	1,261
Bay of Biscay	12	100	479,070	3	0	115,000
Kattegat, Skagerrak	12	0	3,473	11	0	2,900
North Pacific	12	80	278,190	2	0	0
West Coast, So. America	11	0	131,421	4	0	521
East Mediterranean	11	1	9,515	5	0	3,400
Bosporous, Dardanelles	11	106	149,400	5	0	0
Sullom Voe	10	0	1,224	9	0	4
Korea	10	9	13,040	7	9	500
Milford Haven	10	0	108,702	6	0	84,412
Arabian Sea, G. of Oman	10	64	215,071	4	11	611
Rio Plata	9	105	17,121	4	6	15,422
Aegean Sea	9	8	154,398	2	0	1
Strait of Messina	9	3	1,872	4	0	0
Baltic Sea	8	0	3,374	2	0	0
Lake Maracaibo	8	8	4,752	6	0	4,752
Indonesia	8	38	7,398	4	0	1,232
Puget Sound	8	5	910	6	0	6
US/Canada West Coast	7	12	55,213	2	0	113
China	7	9	19,631	6	9	19,631
Sao Sebastiao	6	3	11,800	2	0	0
North Sea	6	0	19,000	5	0	0
Japan	6	12	72,782	3	1	33,000
TOTAL	783	2114	5,406,498	373	120	363,207

Table 49: All Casualties by Hotspot

	ALL CASUALTIES 1960 On			ALL CASUALTIES 1995 On		
Hotspot	Number	Killed	Volume	Number	Killed	Volume
West Mediterranean	31	284	83,957	5	2	0
US/Canada East Coast	51	201	519,620	23	21	13,375
East African Coast	33	162	591,873	6	0	0
Gulf of Mexico	33	120	95,024	18	8	286
Bosporous, Dardanelles	11	106	149,400	5	0	0
Rio Plata	9	105	17,121	4	6	15,422
Bay of Biscay	12	100	479,070	3	0	115,000
?	55	99	58,298	32	31	721
West Coast of Africa	28	95	607,500	2	2	0
English Channel	32	87	73,920	19	5	9,783
North Pacific	12	80	278,190	2	0	0
South China Sea	18	75	181,511	4	1	411
Arabian Sea, G. of Oman	10	64	215,071	4	11	611
Persian/Arabian Gulf	14	62	134,970	4	4	0
Straits of Malacca	22	53	157,658	10	0	38,678
North Atlantic	14	52	98,490	3	0	0
Bantry Bay	2	50	50,050	0	0	0
New York	18	49	8,460	13	0	207
Indian Ocean	24	41	105,027	16	5	5,327
Delaware River/Bay	17	39	55,990	10	0	525
Galveston Bay	17	38	79,478	10	0	1,099
Indonesia	8	38	7,398	4	0	1,232
Tokyo Bay	2	34	81,050	1	0	1,550
West Coast of Europe	13	32	84,446	2	0	196
Caribbean Sea	13	32	330,845	4	0	1,261
Skikda	5	31	9,320	3	0	0
Philippines	2	29	19,800	0	0	0
Mississippi River	30	16	11,017	27	0	2,227
US/Canada West Coast	7	12	55,213	2	0	113
Japan	6	12	72,782	3	1	33,000
Genoa	4	11	169,350	0	0	0
Straits of Hormuz	3	9	0	0	0	0
Korea	10	9	13,040	7	9	500
Cuba	4	9	7,050	3	9	0
Los Angeles	5	9	6,577	2	0	0
Bombay	2	9	11,600	0	0	0
China	7	9	19,631	6	9	19,631
Aegean Sea	9	8	154,398	2	0	1
Lake Maracaibo	8	8	4,752	6	0	4,752
Red Sea	14	7	42,982	3	1	0
Oporto, Leixeos	2	6	100,270	0	0	0
Puget Sound	8	5	910	6	0	6
Malaysia	3	4	906	1	0	906
Sabine River	15	4	30	10	2	0
Sao Sebastiao	6	3	11,800	2	0	0
United Kingdom	19	3	242,010	12	2	0
Strait of Messina	9	3	1,872	4	0	0
Qingdao	3	3	5,890	0	0	0
St. Croix	4	3	239	3	0	1
TOTAL	684	2320	5,505,863	306	129	266,828

Table 50: Hotspot Casualties Sorted by Killed