



Drinking Water Impacts from Delta Recreation

Sponsored by the
SWRCB

Non-point Source Pollution Control Program
and CALFED Drinking Water Program
with funding through Proposition 13

Contra Costa Water District
David A. Briggs
October 5, 2004
CALFED Science Conference 2004



Motivation and Background

Linkage between recreational use and contamination of water supplies is well documented from ecosystem and drinking water perspective.

- Support Contra Costa County study "*The water you play in is the water you drink*" (sponsored by CALFED and SWRCB)
 - Provide assessment of existing impacts to water quality associated with Delta recreation and use this info to help guide implementation of improvement actions.
 - Help quantify potential improvements, once implemented.
- Support on-going work to improve Delta drinking water quality
 - Complement recent efforts by California Urban Water Agencies
 - Support development of ordinances, outreach, policy, etc. by developing database and analysis framework
 - Assess and rank recreation-generated contamination to help prioritize resources



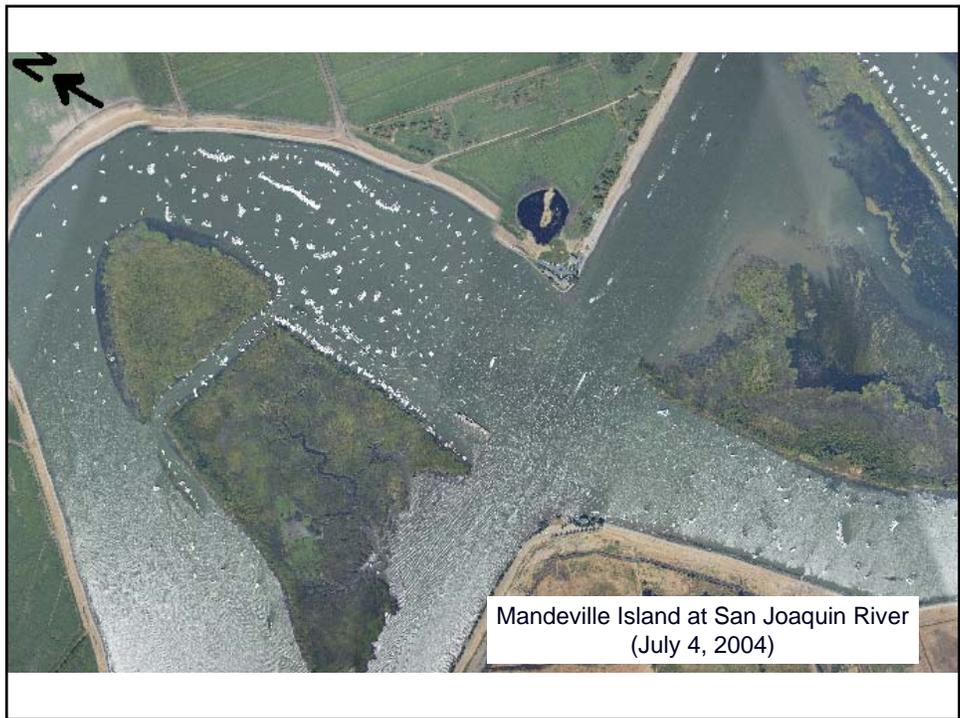
Assessment of Recreation Impacts

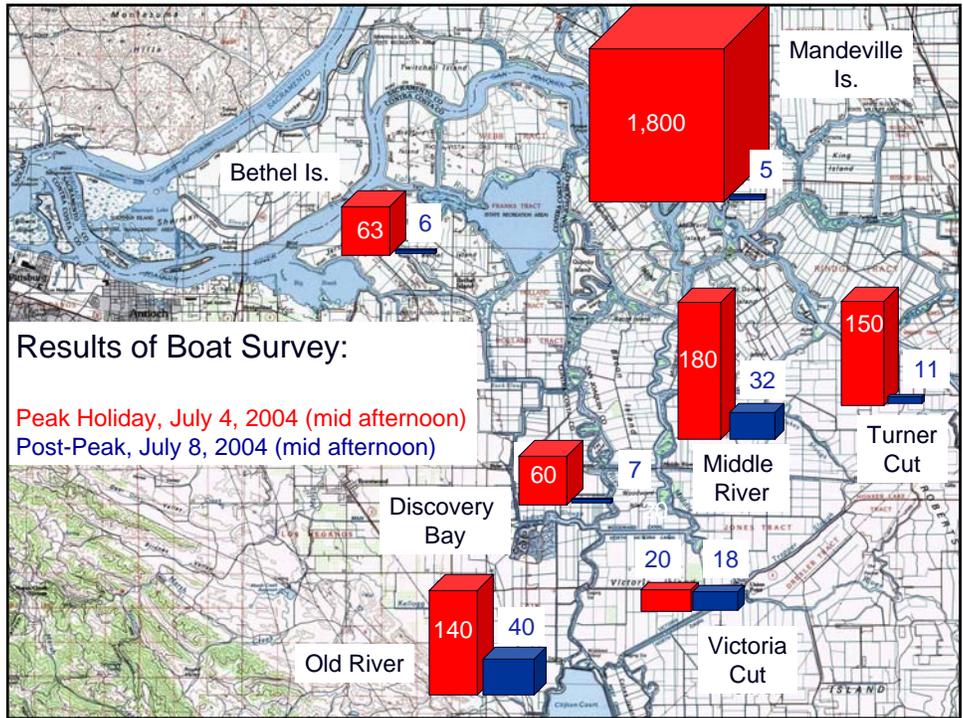
- Estimate load of fuel-related compounds (BTEX, MTBE)
 - Boating survey data (types of boats, hours of use, etc.)
 - Boat counts (use previous DWR, DBW, and other studies, aerial data, etc.)
 - Engine analysis (type of fuels used, efficiency, solubility of various compounds)
- Monitoring program
 - Estimate peak concentration of BTEX, MTBE, and pathogens in Delta
 - Compare to other beach and lake data in California
- Fate and Transport
 - Estimate residence time of compounds, timescales of decomposition, compare to timescales to travel time to drinking water uses



Delta Recreation Statistics (CA Department of Boating and Waterways, 2000)

- Number of boat trips on Delta per year: 2.13 m
 - small boats: 1.98 million
 - large boats: .15 million
- Peak use: approximately 25,000 visitors
 - approximately 8,000 small boat trips
 - approximately 600 large boat trips
- Distance traveled: 20 miles (large boats), 24 miles (small boats)
- Hours of motor use: 3-5 hours per boat, per trip (estimate)
- Boaters are concerned about water clarity (51%), perceived risks from body contact (56%), sewage (51%)





Estimate of Load Introduced into the Delta

30/06/2004

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Fuel Constituents

Percent Volume of CA Certified Fuel (2004)	
Constituent	%
MTBE	0.0
Ethanol	6.0
Benzene	0.7
Toluene	9.5
Ethylbenzene	1.4
Xylene	0.7

Source: CARB (2004)

Solubility Rates

Percent Fuel Released into Water by Engine Type				
Engine Type	MTBE	BTEX	Benzene	Toluene
Two-stroke carbureted PWC - 80 Hp	10.0%	ND	8.0%	11.0%
Two-stroke carbureted PWC - 110 Hp	8.2%	1.2%	1.1%	
Two-stroke carbureted outboard - 9.9 Hp	27.9%	11.0%	8.0%	12.3%
Two-stroke carbureted outboard - 90 Hp	11.1%	1.1%	1.1%	
Two-stroke direct-fuel injected outboard - 90 Hp	1.9%	0.3%	0.6%	
Two-stroke direct-fuel injected outboard/inboard 150 (Ficht)	0.7%	ND	0.5%	
Four-stroke direct-fuel injected PWC - 105 Hp	1.5%	0.2%	0.5%	
Four-stroke carbureted outboard - 9.9 Hp	2.0%	1.4%	1.7%	1.3%
Four-stroke carbureted outboard - 90 Hp	0.1%	0.1%	0.1%	
Four-stroke carbureted outboard/inboard - 170 Hp	0.2%	ND	0.4%	0.3%
Sources: Fiore et al (1998), CARB (2001), TRPA (1998)				

Estimation of Load

- Boater survey results (hours of use, type of engine)
- Aerial surveys and DBW surveys (number of boats and locations)
- Fuel constituents (CARB)
- Percent discharge into water and percent soluble (UNR, TRPA, other studies)

→ Estimate of load discharged into south Delta on peak recreation days

	Pre-MTBE Phase out, Unmodified 2-strokes (1990's)	Post MTBE Phase out, introduction of direct injection engines (Post 2003)
MTBE (g/day)	3,000	0
Benzene (g/day)	80	60
Toluene (g/day)	300	250

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Monitoring program (2003 – 2005)



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Field Work Acknowledgements

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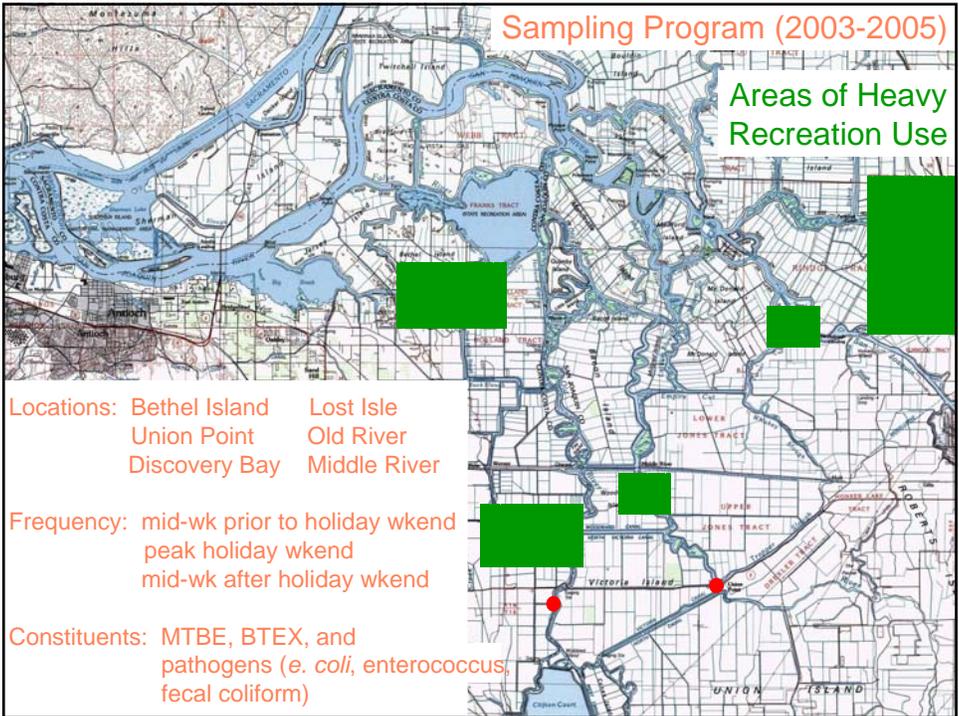
Sampling Program (2003-2005)

Areas of Heavy Recreation Use

Locations: Bethel Island Lost Isle
Union Point Old River
Discovery Bay Middle River

Frequency: mid-wk prior to holiday wkend
peak holiday wkend
mid-wk after holiday wkend

Constituents: MTBE, BTEX, and
pathogens (*e. coli*, enterococcus,
fecal coliform)



2003-2004 BTEX, MTBE Data

Maximum BTEX, MTBE Levels (all units in ug/L)				
	pre-peak	peak	post-peak	Standard
Benzene	<0.5	1.4	<0.5	1
Ethylbenzene	<0.5	0.6	<0.5	700
Xylene	0.56	4.6	<0.5	1750
Toluene	0.67	4.4	<0.5	150
MTBE	< 3.0	8.7*	1.4*	14
* value recorded in 2003, no detection during 2004				
n (sample #)	36	48	48	

2003-2004 BTEX, MTBE Data

...Comparison to other water bodies during peak usage (all units in ug/L)					
	South Delta (DWR, 2001)	South Delta (CCWD, 2003)	South Delta (CCWD, 2004)	Lake Tahoe (TRPA, 1997- 1998)	L. Echo Lake (USGS 1998)
Benzene		<0.5 - 0.7	<0.5 - 1.4	0.13 - 0.33	0.4
Ethylbenzene		<0.5 - 0.6	< 0.5	0.12 - 0.39	0.71
Xylene (total)		< 0.5 - 3.2	< 0.5 - 2.5	0.58 - 2.2	2.6
Toluene		<0.5 - 4.4	<0.5 - 2.2	0.1 - 1.9	3.5
MTBE	4.2-5.6	<3.0 - 8.7	< 3.0	0.3 - 4.2	9.8

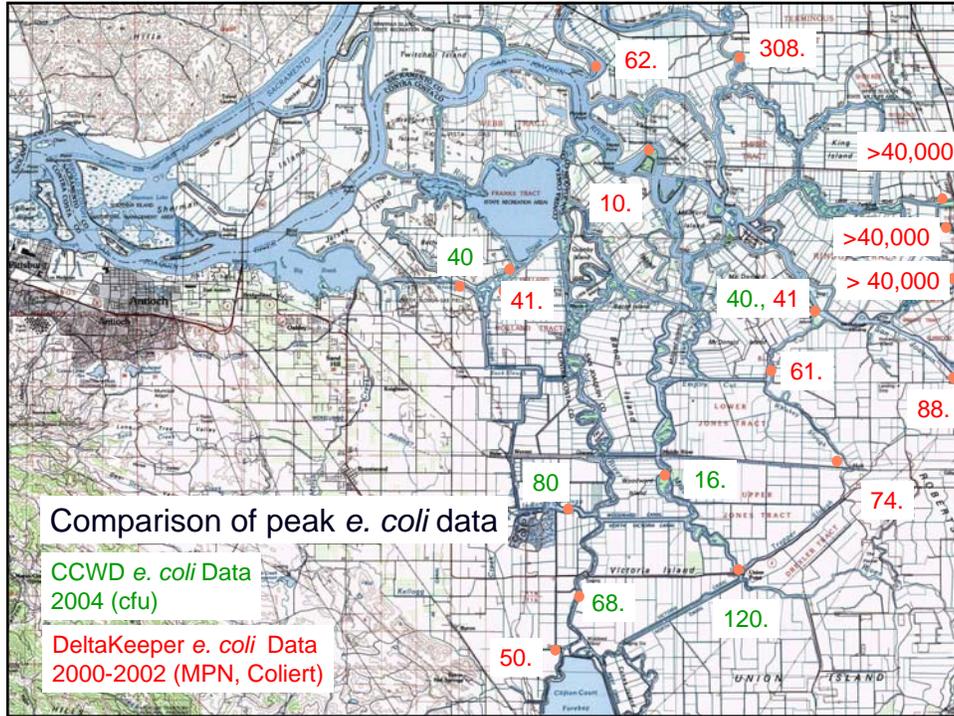
2004 Pathogen Data

Range of pathogen data (all units in cfu/100 mL)				
	pre-peak	peak	post-peak	Standard
e. coli	2 - 80	2 - 60	2 - 120	126 (235-576)*
fecal coliform	4 - 130	2 - 760	2 - 108	200 (400)*
enterococcus	2 - 140	2 - 110	2 - 78	33 (61) *
<i>n</i> (sample #)	36	36	36	
* (single sample)				

2004 Pathogen Data

...Comparison to other beach data			
	South Delta (2004)	Contra Loma Reservoir (CCWD) [cfu/100 mL]	Perris Beach (MWD) [cfu/100 mL]
e. coli	2 - 60	10 - >1600	
fecal coliform	2-760		2-1600,15
enterococcus	2-110	10-360	

...Comparison to other Delta data					
	South Delta (2004)	North Old River (1996-1999, MWQI) [MPN/100mL]	South Old River (1996-1999, MWQI) [MPN/100mL]	Lower San Joaquin (2000-2002, Delta Keeper) [MPN/100mL]	San Joaquin at Vernalis (1996-1999, MWQI) [MPN/100mL]
e. coli	2 - 60	2-344, 6 (med.)	3-531,12 (med.)	20 - > 10,000	2-3,440, 70 (med.)
fecal coliform	2-760	4-300, 14 (med.)			



Fate and Transport: Volatilization Rates $C = C_0 e^{-kt}$

Gasoline Constituent	k (1/days)	$t_{1/2}$ (days)
MTBE	0.27	2.6
Benzene	0.33	2.1
Toluene	0.32	2.2
Ethylbenzene	0.30	2.3
Xylenes	0.28	2.5

Source: Fiore et al. (1998) from lake studies

Malcolm Pirnie (1998) and other sources discuss substantially longer volatilization rates for MTBE in lake studies (i.e., months, years, ...)

Inactivation Rates

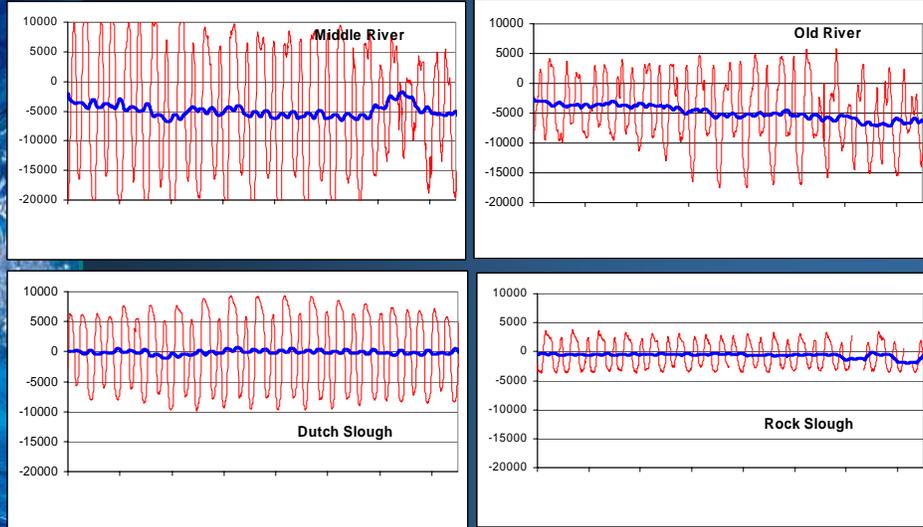
Organism	k (1/days)	$t_{1/2}$ (days)
Fecal Coliform	1	0.7
<i>Cryptosporidium</i>	0.08	8.7
Rotavirus	0.3	2.3
Poliovirus	0.58	1.2
<i>Giardia</i>	1.37	0.5

Source: Thomann and Mueller (1987), Yates et al. (1997)

Transport of Waterborne Contaminants

- Assume compounds act as passive tracers
- Use USGS UVM data and CCWD/DWR ADCP data to examine mean (residual) and instantaneous tidal flows to estimate net transport and tidal dispersion of contaminants
- DWR DSM2 particle tracking simulations also give insight into transport of contaminants.

Transport of Waterborne Contaminants



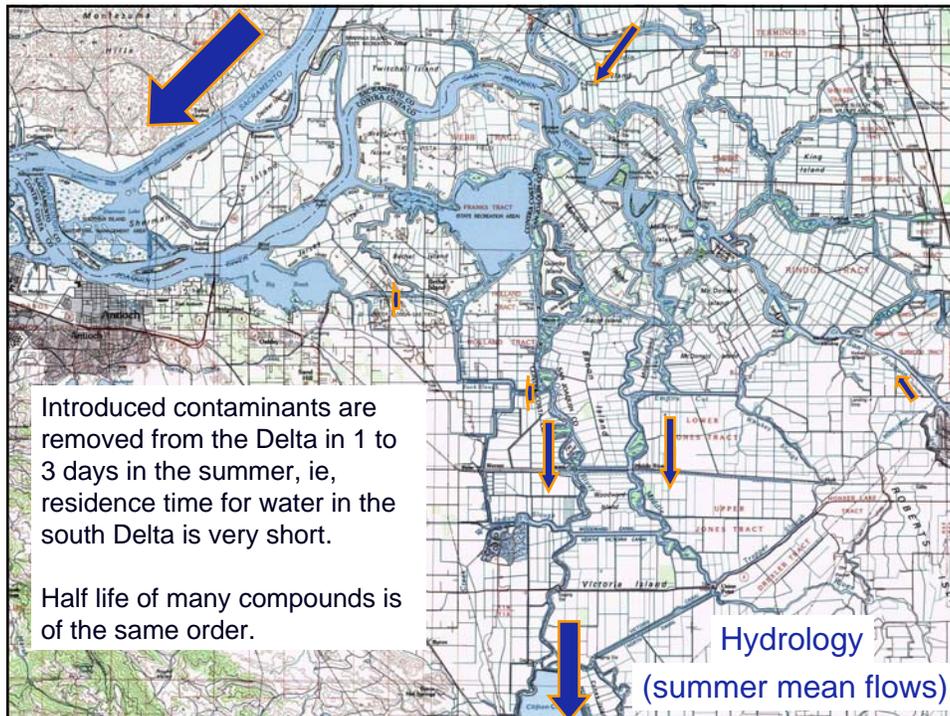
Values in cfs during between June 25, 2004 and July 10, 2004

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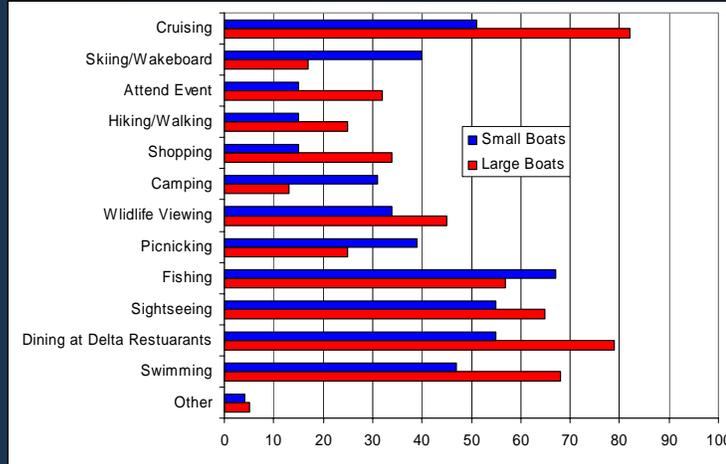


Conclusions

- Presence of BTEX compounds was detected in the south Delta in response to high use events (e.g., holiday weekends in the summer). Concentrations quickly drop following peak days.
- Pathogen load is higher in the eastern Delta due to the smaller transport flows, longer residence time in the smaller channels, and proximity to sources of pathogens (septic systems, livestock enclosures, urban runoff, municipal waste water discharges)
- Export pumping and tidal dispersion “turn over” the water in 1 – 3 days. That is, residence time of water in the south Delta is very short in the summer time. Lakes with longer residence time have a different response.
- Due to half-life of most compounds, sampling 2-3 days later will miss peaks
- Contamination of MTBE in the Delta has dropped considerably due to reformulated fuel and direct injection engines
- Contamination of BTEX compounds has likely dropped in recent years due to technological improvements. With recreational boating use estimated to grow at 1.0 – 1.5 % each year, water quality may continue to improve for the next few years.
- Water quality improvement actions should consider proximity of sources to drinking water intakes, magnitude of sources, and hydrodynamics (transport, travel time, and dispersion).



Activities by Boat Size (percent of respondents)



Source: DBW (2000)

Distribution of Boating Facilities

Distribution of Boating Facilities *	
North Zone	8%
Northwest Zone	1%
Central Zone	11%
West Zone	55%
South Zone	19%
East Zone	6%

* Includes docks, slips, parking lots, restrooms, showers, launch ramps, camp sites, fuel stations, oil collection sites, bilge pump outs

Source: DBW (2000)



Boat Ownership	Large	Small
Cabin Cruiser	62%	20%
Runabout	12%	42%
Sailboat	30%	10%
Bass Jon Boat	7%	18%
Inflatable Raft	NA	12%
Houseboat/Pontoon	14%	4%
Jet Boat	2%	10%
PWC	1%	17%
Other	19%	27%

Source: DBW (2000)

Fuel Composition

Fuel Composition		% by weight	% Soluble *
PWC 2-stroke	MTBE	0 to 14 %	8.2 -10%
	Benzene	2%	1.1 - 8.0%
	Toluene	8 - 11 %	1 (est.) - 11%
2-stroke (outboard)	MTBE	0 to 14 %	1.9 - 31%
	Benzene	2%	0.6 - 8.7%
	Toluene	8 - 11 %	12.3%
4-stroke (outboard)	MTBE	0 to 14 %	0.06 - 2.3%
	Benzene	2%	0.14 - 1.8%
	Toluene	8 - 11 %	1.3%
4-stroke (other)	MTBE	0 to 14 %	0.2%
	Benzene	2%	0.4%
	Toluene	8 - 11 %	0.3%
Source: LT WC Dec. 1998 (TRPA)			
CARB (2001), Fiore et al (1998)			
* varies with hp and type of carburation			

Boating Site Preferences

Source: DBW (2000)

need table and map

Most Popular Destinations			
Large Boats	%	Small Boats	%
Tower Park	20.1	Rio Vista	16.8
Herman's	14.8	San Joaquin River	13.4
Stockton	12.0	Franks Tract	10.4
Carquinez	10.6	Sacramento River	9.9
Discovery Bay	7.9	Tower Park	9.4
Willow Berm	7.9	Mokelumne River	8.4
Antioch	7.9	Discovery Bay	7.9
Sugar Barge	6.9	B&W Marina	5.0
Delta Marina	5.8	The Meadows	4.5
Korth's Marina	5.3	Big Break	4.5
Village West	4.8	Stockton	4.0
Outrigger Marina	4.8	Mildred Island	4.0
Oxbow Marina	4.2	Lost Isle	4.0
		Ladd's	4.0