Attachment 6

CBE, 1994.

Declaration of G. Karras

DIRTY CRUDE

The first oil industry-wide analysis of selenium discharge trends impacting San Francisco Bay

A report by
Citizens for a Better Environment (CBE)

Report No. 94-1
March, 1994

DIRTY CRUDE

The first oil industry-wide analysis of selenium discharge trends impacting San Francisco Bay

CITIZENS FOR A BETTER ENVIRONMENT

March, 1994

Author	Greg Karras, Senior Scientist
Research Guidance, Editorial Support and Analysis	Mike Belliveau, Executive Director Nora Chorover, Legal Director Julia May, Director, Clean Air Program Northern California Region Denny Larson, Campaign Director Peter Fugazzotto, Grants Administrator Michelle Ozen, San Francisco Office Manager Michael Leedie, Director, Environmental Justice Program

Citizens for a Better Environment (CBE) is a state wide public interest organization that uses technical research, policy advocacy, legal action, grassroots organizing, and public education to prevent pollution hazards and achieve healthy, sustainable urban communities.

501 Second Street, Suite 305
San Francisco, CA 94107
415/ 243-8373

122 Lincoln Blvd., Suite 201
Venice, CA 90291
310/ 450-5192

Acknowledgements

This report was made possible by the assistance of many individuals and organizations who have contributed to Citizens for a Better Environment's San Francisco Bay Protection and Petrochemical Pollution Prevention Campaigns. We are deeply grateful for your support.

The research, analysis, and production of this report were made possible by contributions from the Richard and Rhoda Goldman Fund, The Gap Foundation, the Beldon Fund, Friendship Fund, The Fred Gellert Foundation, The Lane Family Charitable Trust, Charles Stewart Mott Foundation, The Pew Charitable Trusts, Inc., Public Welfare Foundation, San Francisco Foundation, Mary A. Crocker Trust, The Environmental Careers Organization, North Shore Unitarian Universalist Society-Veatch Program, Marin Community Foundation, and Tides Foundation.

Many people lent their time and expertise to help refine the technical analyses, gather data, or answer key questions. Special thanks to Dr. Thomas Mumley, Alan Freidman, Mark Ruderman, Lila Tang, Jessica Lacy, Kim Taylor, Dr. Jeff Bailey, Dianne Kopec, Dr. Sam Luoma, and Dr. Joe Skorupa.

This research was also made possible by the members of Citizens for a Better Environment. Thank you all!

CONTENTS

Conclusions and Recommendations

1. In the first four years of the 1990s, total oil refining industry selenium discharges into San Francisco Bay *increased* by 24% as compared to 1980s levels. These discharges exceed estimates of "safe" levels for environmental health by more than 200%. Since January 1, 1987, six oil refineries discharged a total of 33,900 pounds of the toxic pollutant selenium into the Bay.

<u>Refinery selenium discharges should be reduced as soon as possible in order to protect public health and the Bay environment.</u>

2. The Unocal, Shell, and Exxon refineries cause 89% of all refinery selenium discharges into the Bay, even though they refine less than half of all the oil refined in the Bay Area.

<u>Environmental protection efforts for selenium should focus on pollution prevention for the Unocal, Shell, and Exxon oil refinery discharges.</u>

3. More than half of all refinery selenium discharges to the Bay are illegal discharges. Unocal discharges 1290 pounds-per-year (416%), Shell discharges 1260 lb/yr (162%), and Exxon discharges 160 lb/yr (46%) *more* selenium than allowed by their discharge permits.

<u>Federal permit limits that require reductions in excessive selenium discharges should be enforced against the Shell, Unocal, and Exxon refineries.</u>

4. The Unocal, Shell, and Exxon refineries violate their selenium requirements because:

- they discharge ten times more selenium for every barrel of oil refined than other Bay Area refineries that comply;
- they process crude oil with many times more selenium per barrel than other Bay Area refineries that comply;
- they process these poor quality crudes differently, causing more selenium to enter their waste waters; and
- they remove about ten time less selenium from their waste waters than at least one Bay Area refinery that complies.

Unocal, Shell, and Exxon should be required to match the discharge-per-barrel levels that are already achieved by half of the local industry through cleaner refining and waste treatment.

5. Nearly half the 48 oil fields tested in twelve States and Libya had selenium content in the range that pollutes San Francisco Bay, and these crudes are refined by other U.S. and world refineries.

Oil refinery selenium discharges should be investigated and prevented in other bays and estuaries that receive waste discharges from refineries processing high-selenium crude oil. Refineries should supply selenium data for their crude slates and effluents.

6. In-depth review of one refinery found that refining poor quality, high-selenium crude can *also* significantly increase at least ten other pollution impacts on refinery workers and neighbors.

Fence line communities, anglers, and wildlife protection advocates should work together to effect cleaner refining practices, and environmental policy makers should address the total environmental health threats posed by the more pollution-intensive refining of poor quality crude oil.

Introduction

The northern region of the San Francisco Bay is one of the major oil refining centers in western North America. Oil refineries are the predominant source of selenium inputs to the Bay. (Regional Board, 1993; Cutter and San Diego-McGlone, 1990; and EPA, 1990) The locations of all six major refineries that discharge to the Bay are roughly mapped in Figure 1.

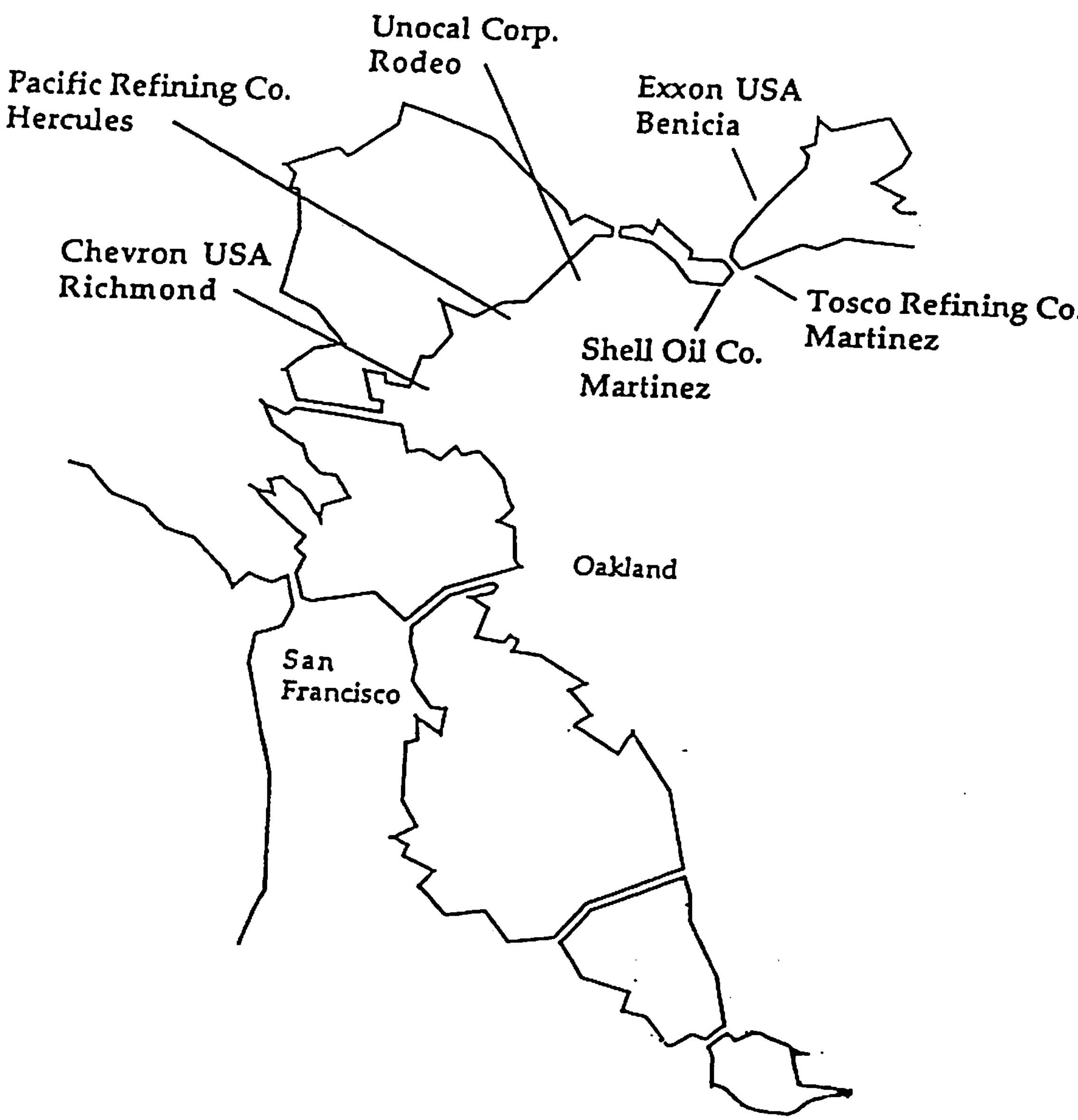
This report presents the first industry-wide analysis of selenium discharge trends in the San Francisco Bay oil refining industry.

Selenium is a chemical element similar to sulfur that is found in the earth's crust and in crude oil at various concentrations. It is an essential nutrient for some species. However, at levels that are only slightly higher than these beneficial levels, selenium can poison aquatic life, wildlife and people. Selenium is of great concern as a water pollutant because it bioaccumulates in aquatic food webs to reach high concentrations in food resources that are eaten by animals and people.

Selenium pollution threatens people and the environment throughout San Francisco Bay. (EPA, 1990; Regional Board, 1992) Since the late 1980s selenium has been found at elevated concentrations in many Bay species including clams, mussels, crustaceans, striped bass, sturgeon, diving ducks, marine mammals, the eggs of the California Clapper Rail (an endangered bird species), and other species. (Regional Board, 1992; Kopec et al., 1991, Lonzarich et al., 1991) Bay selenium approaches or exceeds levels that could cause birth defects, reproductive failures, impaired growth, and other toxic effects in some species. (Ibid.) High selenium levels in Bay harbor seals may be linked to reduced feeding success. (Kopec, 1994)

Bay selenium pollution impacts the public's fishing rights and food resources. Health warnings are in effect because of selenium hazards to people eating Bay diving ducks. (Calif. Hunting Regulations) Selenium levels in many Bay sturgeon exceed the thresholds used for these duck advisories. (DFG, 1988;

Figure 1. Locations of six major petroleum refineries discharging wastes into San Francisco Bay, California.



DFG, 1989) Anglers that fish the Bay regularly to feed themselves and their families are those most exposed to this health hazard. These people are disproportionately lower income people, and people of color. (Chin, 1993)

By focusing attention on the refining trends that cause the discharge of this important toxic pollutant, this report arms citizens with information for more democratic and responsible environmental decision making. By exposing the root causes of the problem, this report provides additional tools for citizen efforts to prevent related refinery air pollution problems in fence line communities, and selenium pollution in other bays and estuaries.

<u>Total oil refinery selenium discharges into San Francisco Bay increased in the 1990s even though they were already at dangerous levels in the 1980s</u>.

To protect people and the environment from toxicity, the selenium discharge from all six Bay Area refineries should be limited to a maximum of 1234 pounds-per-year. This estimate was made by the Regional Water Quality Control Board staff using the best scientific information available. (Regional Board, 1993) This maximum "safe" level is shown in the gray portion of the chart in Figure 2.

Total refinery selenium discharges exceeded this "safe" level by 200% to 350% every year since January 1, 1987. The tops of the black bars in Figure 2 show the total pounds of selenium discharged into the Bay by refineries each year. During this time the oil refining industry dumped an estimated 33,900 pounds of selenium into the Bay.[1]

These dangerous discharge rates increased by another 24% in the 1990s, as compared with 1890s discharge rates. The largest dischargers caused this overall discharge increase.[2]

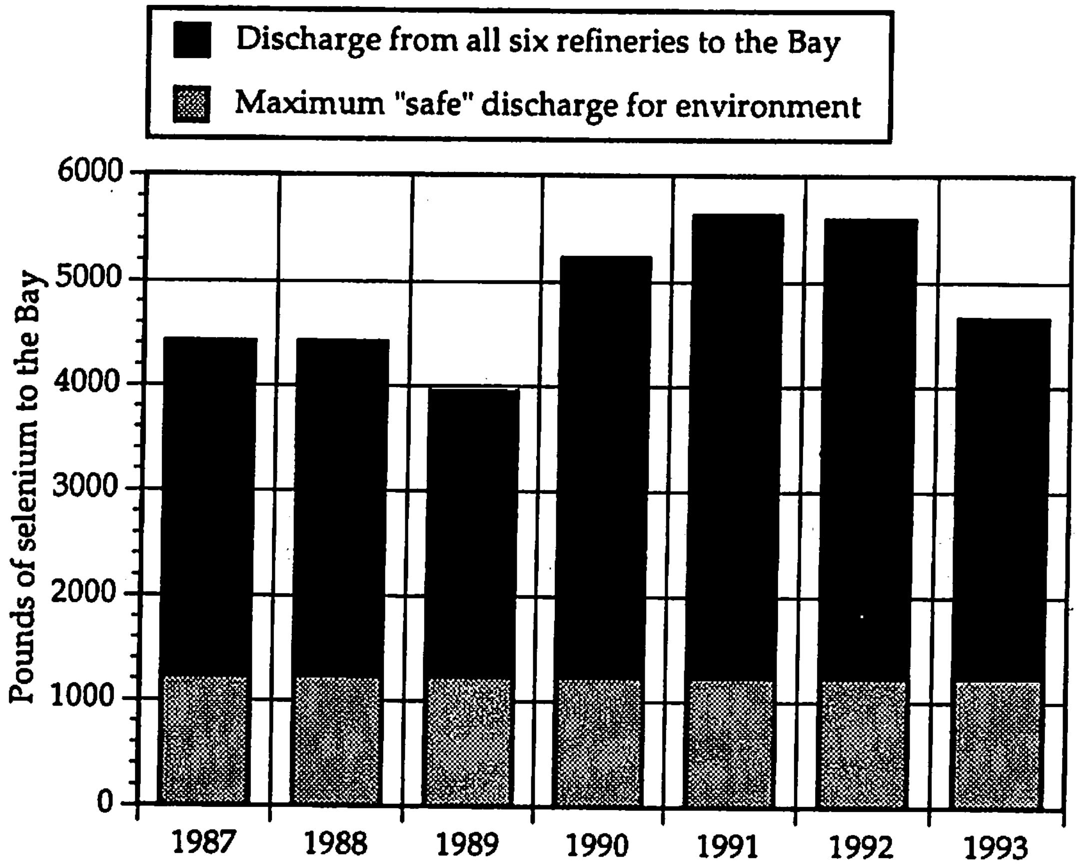
---

[1] The refinery selenium discharge data in this report were reported by the refineries themselves in self-monitoring reports to the Regional Board. Also see Regional Board (1993).

[2] Overall discharges increased because the Shell, Unocal, and Exxon refineries increased discharges more than the other refiners decreased their discharges. See Table 3 below. The apparent decrease in 1989 discharges in Figure 2 might correspond with construction on refining processes. Current refinery modification construction may also impact 1993 discharge rates.

Figure 2.

Selenium releases from six oil refineries to San Francisco Bay, already at dangerous levels in the 1980s, increased by twenty-four percent in the first four years of the 1990s.



- **Maximum "safe" discharge for environment:** 1234 lb/yr
- **Average discharge from 1987 through 1989:** 4260 lb/yr
- **Average discharge from 1990 through 1993:** 5280 lb/yr
- **Increase in total refinery discharge since 1980s:** 24 %

Maximum "safe" discharge for the environment taken from the November 1993 Regional Water Quality Control Board Staff Report for the "Mass Emissions Reduction Strategy" for selenium. Annual mass loading estimates for 1987 through 1992 from Regional Board, 1993. Estimates for 1993 from self-monitoring reports submitted by the refiners to the Regional Board.

Half the region's oil refining industry causes 89% of all refinery selenium discharges into San Francisco Bay.

The Shell Oil Co. refinery caused 2040 pounds of selenium discharge in 1993.[4] This is the biggest selenium discharge into the Bay. Shell caused 44% of all refinery selenium discharges into the Bay in 1993.

The Unocal Corp. refinery caused 1600 pounds of selenium discharge in 1993. This is the second biggest selenium discharge into the Bay. Unocal caused 34% of all refinery selenium discharges to the Bay in 1993.

The Exxon Co. USA refinery caused 510 pounds of selenium discharge in 1993. Exxon caused the third largest refinery selenium discharge and 11% of all refinery discharges in 1993.

Taken together, Shell, Unocal, and Exxon discharged 4150 pounds of selenium to the Bay in 1993. All six refineries report discharges totaling 4664 pounds of selenium into the Bay in 1993. Therefore, these three biggest discharges account for 89% of all 1993 refinery selenium discharges.

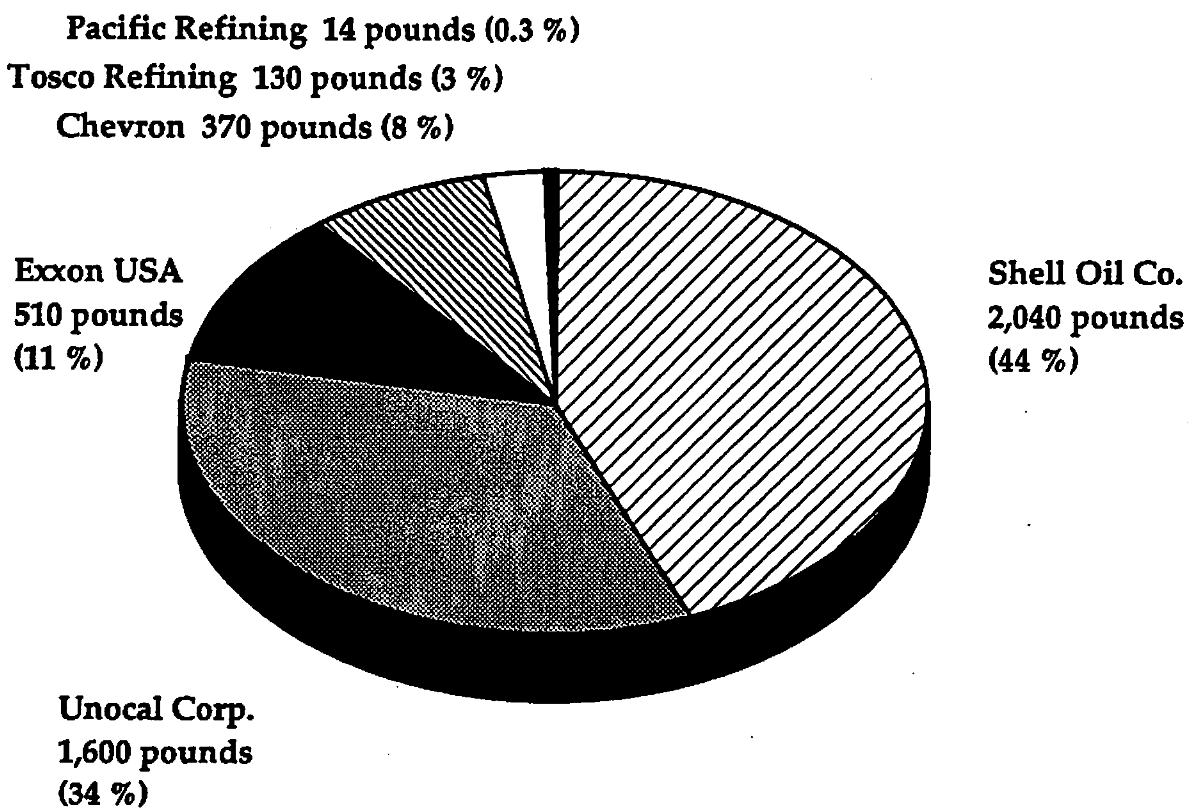
The other half of the local refining industry discharged a total of 514 pounds of selenium in 1993. Taken together, the Chevron USA, Tosco Refining, and Pacific refining Co. refineries accounted for only 11% of all refining industry selenium discharges in 1993.

[4] All 1993 discharge rates are from the refineries' calculations and data reported in self-monitoring reports.

Figure 3.

Three of the six refineries cause a disproportionately large amount of the selenium problem.

The Shell, Unocal, and Exxon refineries discharge an estimated 89% of all refinery selenium to the Bay.



Based on 1993 discharges reported by the oil companies in self-monitoring reports submitted to the Regional Water Quality Control Board.

Illegal discharges by the biggest dischargers cause more than half of all oil refinery selenium inputs to the Bay.

Under the federal Clean Water Act, National Pollutant Discharge Elimination System (NPDES) permits govern each individual refinery's waste water discharge into the Bay. The NPDES permits governing the Shell, Unocal, and Exxon discharges include effluent limits that restrict these refineries' selenium discharges.[5]

The permit limits that became effective December 12, 1993 require that the Shell refinery's annual average selenium discharge must not exceed 2.13 pounds per day, or about 778 pounds per year. However, Shell reports discharges of 2040 pounds per year. Shell discharges about 1260 lb/yr more selenium than allowed and exceeds its permit limit by 162%.

Unocal reports that its refinery discharged 1600 pounds of selenium in 1993. Its annual average permit limit of 0.85 pounds per day allows a maximum of about 310 pounds of selenium discharge per year. Unocal discharges about 1290 lb/yr more selenium than allowed, and exceeds its permit limit by 416%.

Exxon reports discharging 510 pounds of selenium to the Bay in 1993. Its annual average permit limit of 0.96 pounds per day allows a maximum of about 350 lb/yr. Exxon discharges about 160 lb/yr more selenium than allowed and exceeds its limit by 46%.

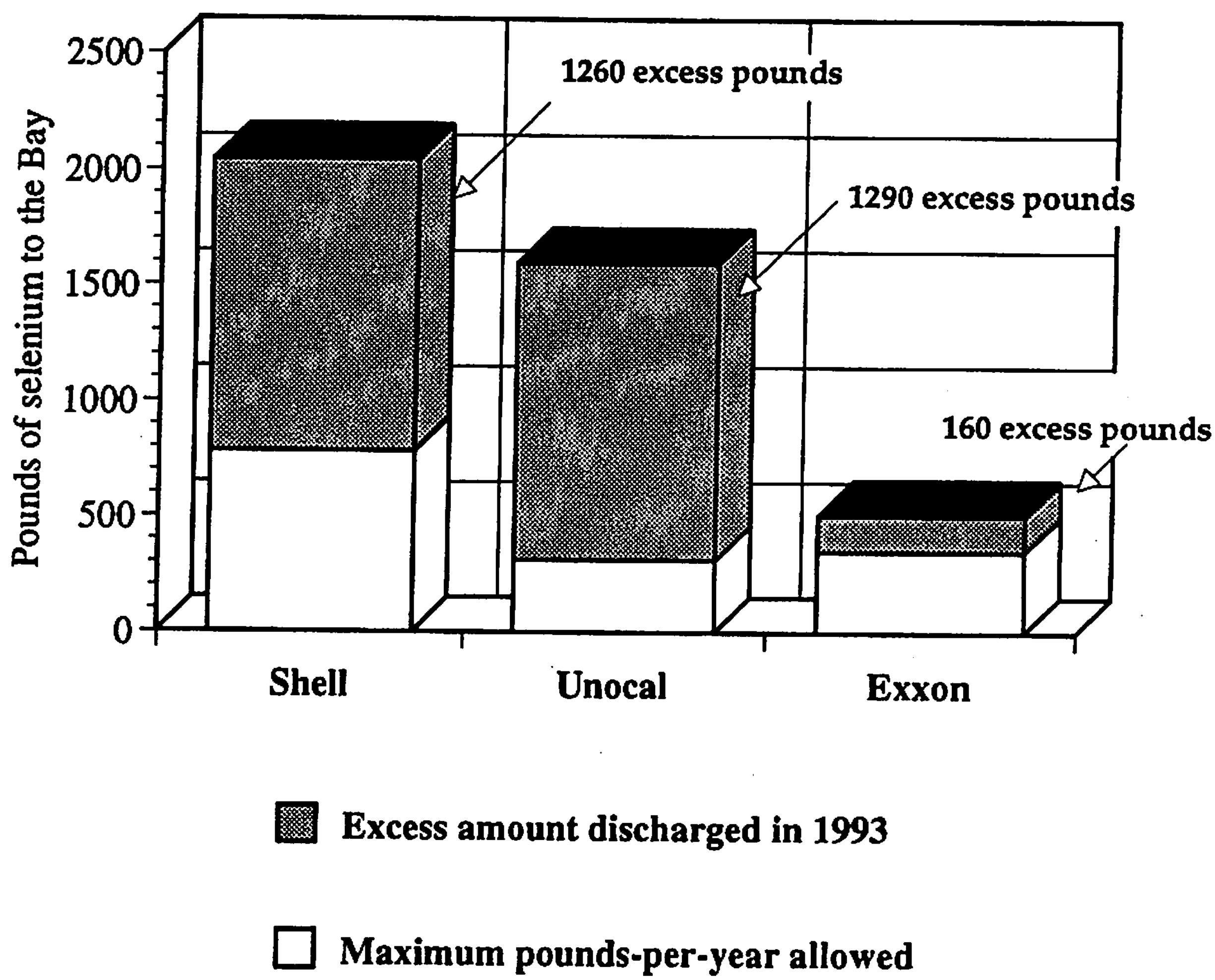
These three refineries together discharged an estimated 2710 pounds of excess selenium over and above the limits in their discharge permits. This illegal discharge alone accounts for fully 58% of all 1993 refinery selenium discharges to the Bay. Violations by the Unocal and Exxon refineries alone account for 31% of all 1993 refinery selenium discharges.

---

[5] These limits were established in Regional Water Quality Control Board Orders 91-026 and 91-099 in 1991, when the Board amended the NPDES permits of all six refineries and established "individual control strategies" required by the Clean Water Act.

Figure 4.

The Shell Oil Co., Unocal, and Exxon Co. USA refineries discharge from 46% to 416% more selenium to the Bay than allowed by the effluent limits in their discharge permits.



Based on effluent limitations for Shell (2.13 lb/d), Union (0.85 lb/d) and Exxon (0.96 lb/d) from Provision A.1 of Regional Board Order 91-099, and 1993 discharge amounts reported by the oil companies in self-monitoring reports submitted to the Regional Water Quality Control Board.

The Shell, Unocal, and Exxon refineries cause 89% of all refinery selenium discharges into the Bay because they are selenium-*dirtier* refineries, not larger refineries.

None of these three biggest dischargers are the biggest oil refiner, or even the second biggest oil refiner in the Bay area. (Chevron USA refines the most crude oil and Tosco Refining is the second biggest refiner.) In fact, Shell, Unocal, and Exxon combined refine less than half the oil refined by the local industry.[6]

When the U.S. Environmental Protection Agency analyzed oil refineries, it found that water pollution discharges can be limited to an equal amount of pollutants for each barrel of oil refined. (EPA, 1979) By looking at how much selenium a refinery discharges per barrel refined, one can see how "dirty" the refinery is in terms of selenium pollution.

For each refinery, Figure 5 shows the amount of selenium discharged to the Bay for each barrel of crude oil refined. It reveals very important trends in the refineries that cause the most selenium pollution:

- Unocal discharges almost twenty times more selenium per barrel than Chevron and nearly 100 times more than Pacific;

- Shell discharges in excess of ten times more selenium per barrel than Chevron, Tosco, or Pacific Refining; and

- Exxon discharges nearly three times as much selenium as Chevron and 13 times as much as Pacific per barrel refined.

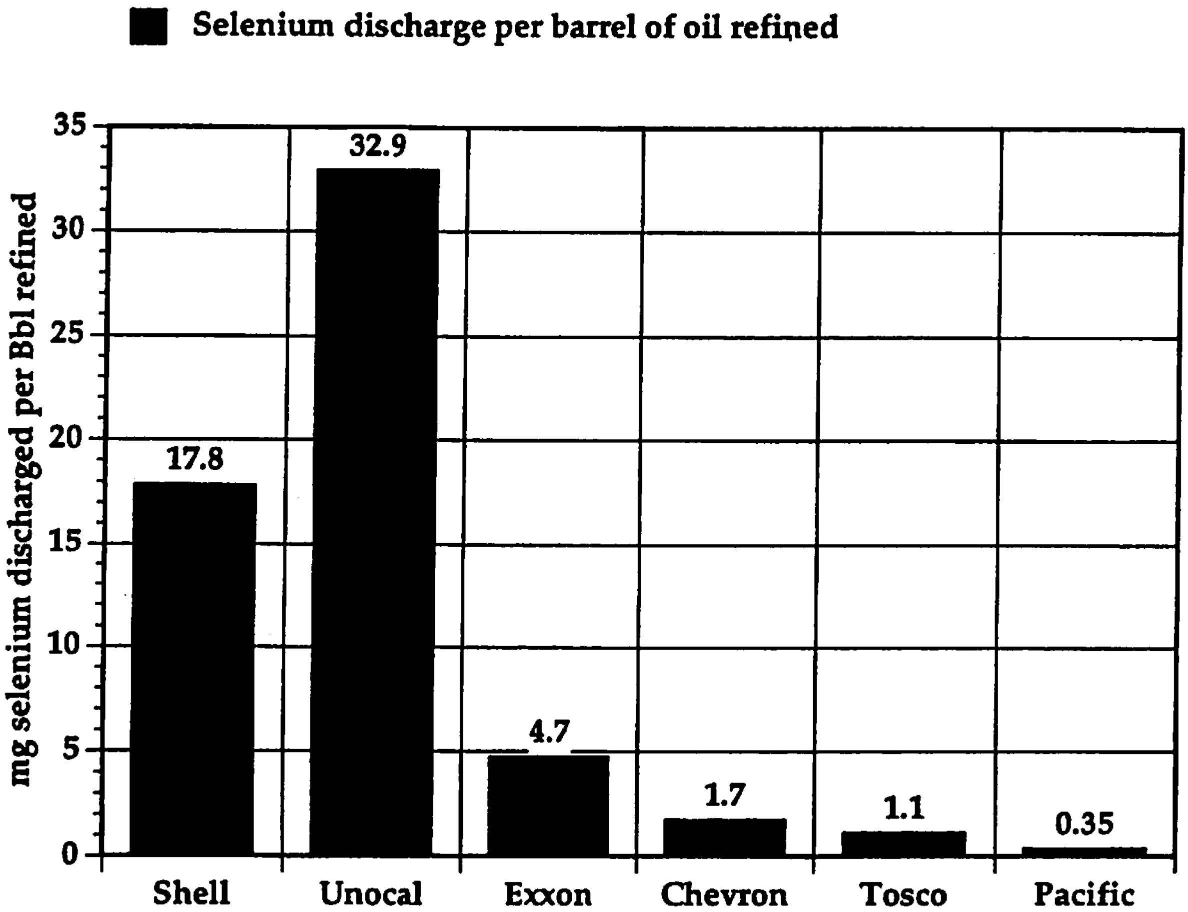
These drastically dirtier discharge rates are responsible for the vast majority of Bay selenium pollution. If Shell, Unocal and Exxon achieved Chevron's 1.7 milligram per barrel discharge rate while refining the same amounts of oil, total Bay discharges from all six refineries would fall by 80%.

---

6 The average amount of crude oil refined by each refinery is shown at the bottom of Figure 5, and in Table 3 below.

Figure 5.

For each barrel of crude oil refined, the Shell, Unocal, and Exxon refineries discharge from 3 times to nearly 100 times more selenium than other Bay area refineries.



Barrels per day:	142600	60600	135000	265000	152180	49300

Calculated by CBE from 1993 discharge estimates in self monitoring reports submitted to the Regional Water Quality Control Board; and crude throughput estimates in RWQCB Orders 92-111 (Chevron) and 89-002 (Unocal); RWQCB June 7, 1993 NPDES Factsheet (Tosco); NPDES permit applications (Exxon and Pacific); and Shell, 1992.

The biggest dischargers cause more selenium pollution because they bring more selenium in with poor quality crude oil, refine this oil in ways that move more selenium from the oil into waste water, and then take less of this selenium out of the water before dumping it into the Bay.

Refining poor quality crude oil brings more selenium into the Shell, Unocal, and Exxon refineries.

Crude oil from some oil fields can contain ten times more selenium than crude from other oil fields.[7] Shell, Unocal, and Exxon refine various amounts of high-selenium crude from California's Central Valley.[8] This brings more selenium into their refineries with every barrel of crude.

The black bars of the top chart in Figure 6 show that Shell, Unocal and Exxon bring in more selenium than Chevron. They each refine less oil than Chevron, but there are more pounds of selenium in the crude oil mixtures, or "slates" they refine.

Comparing the black and gray bars in this chart shows a simple relationship for the four largest dischargers: more pounds of selenium going into a refinery match more pounds of selenium coming out of that refinery. (Tosco does not fit this pattern because of better waste treatment. Data were not publicly available for Pacific Refining.)

The more intensive processing needed for poor quality crude puts more selenium into the refineries' waste waters.

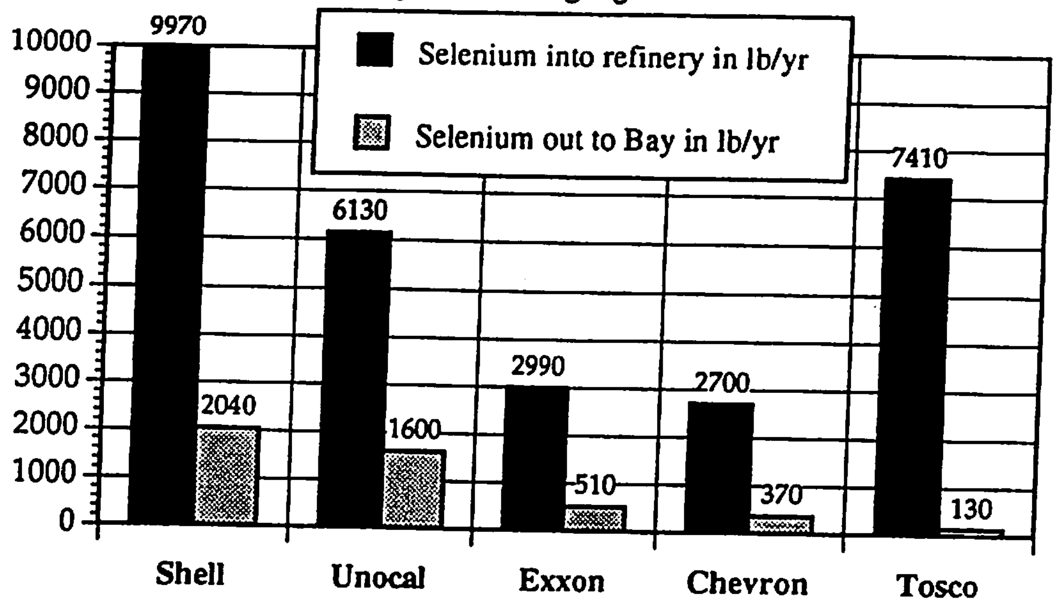
For the four biggest dischargers, the bottom chart in Figure 6 shows an almost perfect association between increasing selenium discharge rates and increasing selenium concentration in the crude slates refined. (Excluding the case of better treatment at Tosco, regression analysis at the 95% and 90% level yielded an R-squared value of .99.) Further, Unocal appears to be taking in nine times

7 Pillay et al., 1969; Shah et. al, 1970; Tosco, 1991; 1992; Chevron, 1992. See data in Table 1.
8 City of Benicia, 1993; Shell, 1992; Unocal, 1992; and Arthur D. Little, 1989.

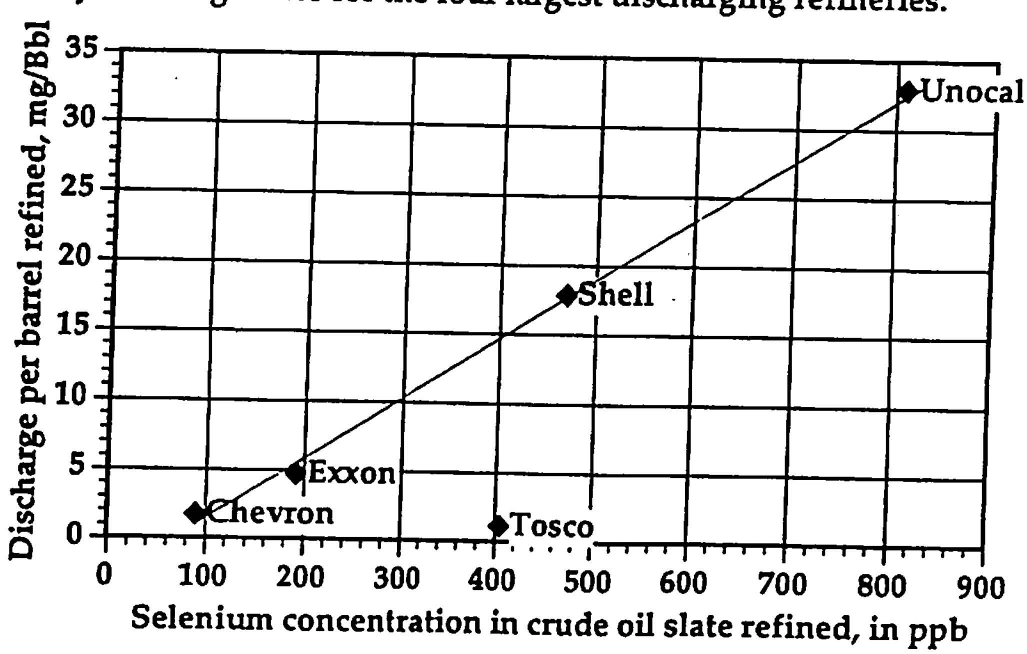
Figure 6.

The biggest selenium dischargers process higher-selenium crude oil.

More pounds of selenium in crude slates match more pounds of Bay discharge for the four largest discharging refineries.



Greater selenium concentrations in crude slates match greater Bay discharge rates for the four largest discharging refineries.



CBE analysis of discharge data from oil company self-monitoring reports, and crude throughput and selenium content data in: RWQCB Orders 92-111 and 89-002; June 7, 1993 Factsheet; NPDES permit applications; Shell, 1992; Unocal, 1992; Chevron, 1992; Tosco, 1991; 92; City of Benicia, 1993; and March 29, 1993 letter from the Regional Board to CBE.

more selenium per barrel than Chevron, but Unocal discharges twenty times more selenium per barrel refined than Chevron. At higher crude concentrations, something appears to be accelerating the movement of selenium from the oil into the waste water.[9]

High crude selenium concentrations are associated with high discharge rates because dirty crude is refined differently, and this moves more selenium from the oil into the waste water.

The high-selenium crude refined by Shell, Unocal, and Exxon also has more sulfur. The top chart in Figure 7 shows that, at relatively high selenium concentrations, California crudes with greater selenium concentrations tend to have greater sulfur content. These crudes also tend to be heavier, and higher in nitrogen and other impurities. (Purvin and Gertz, 1992)

This is important because more crude impurities means more intensive refining. Sulfur and other impurities interfere with catalysts used to speed chemical reactions in refining. The hydrotreating and other processes that remove sulfur from dirty crude also remove selenium, which ends up in waste water. These processes are the biggest internal source of selenium discharge in some refineries. (Ibid.; Chevron, 1989; and Contra Costa County, 1993)

In addition, all Bay Area refineries except Chevron and Pacific use coking processes to make a more valuable product mix from heavier, higher-selenium crudes. (Purvin and Gertz, 1992; and Regional Board, 1993b) Cokers are another major internal source of selenium discharge. (Unocal, 1992)

Data from the Shell refinery confirm that this more intensive refining puts more selenium into waste water. When Shell increased hydrotreating, coking, hydrocracking, and other processing, the bottom chart in Figure 7 shows this was closely associated with increased selenium discharges each year.[10]

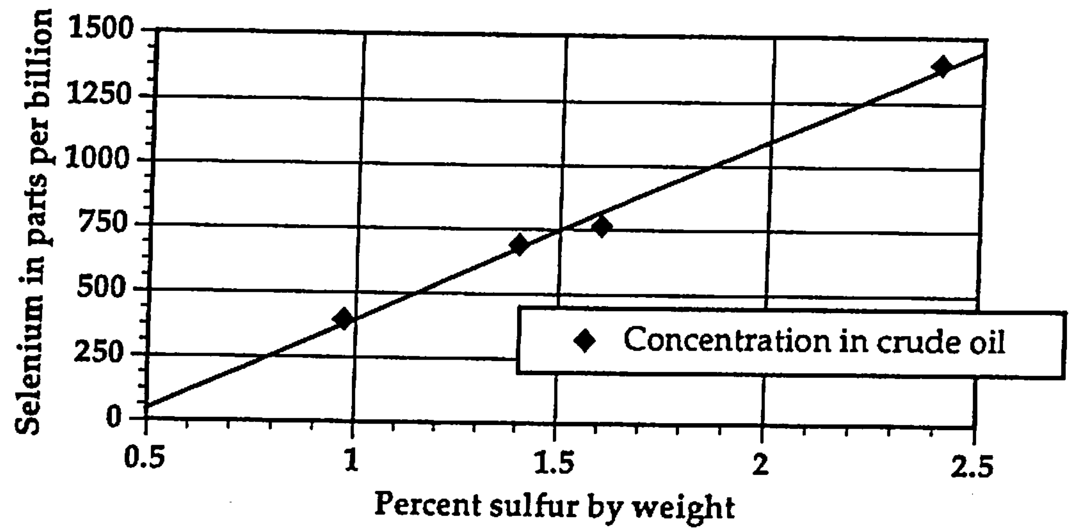
---

9 An R-squared value of .99 suggests a very strong (99%) correlation. However, this regression analysis is limited to only four data points, and though they are each annual averages of many discharge data, the crude slate data are limited to that data made public by the oil companies.
10 These increases in Bay discharge could not be explained by refining more oil. (Shell, 1992)

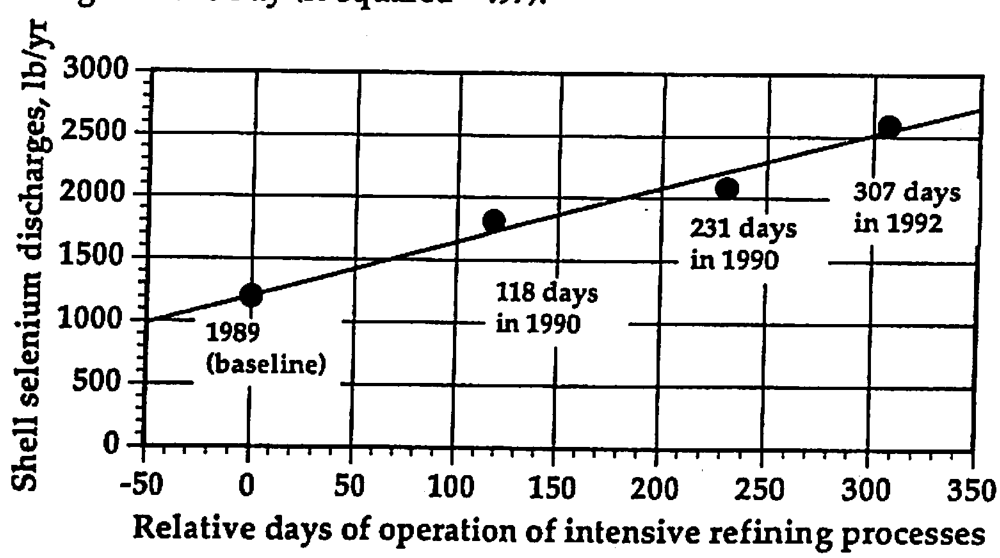
Figure 7.

High-selenium crude can require more intensive refining that moves more selenium from the oil into a refinery's waste waters.

In California crude oil, increased selenium is associated with increased sulfur (R-squared = .99). High-sulfur crude requires more intensive refining.



More intensive refining can explain 97 % of the increase in Shell's selenium discharges to the Bay (R-squared = .97).



California crude oil data from Tosco, 1991; and Shah et al., 1970. Determination of trace elements in petroleum by neutron activation analysis. Journal of Radioanalytical Chemistry 6:413-422. Shell discharges from Regional Board, 1993. Down time of major units from Shell, 1992.

Less intensive waste treatment allows more selenium to remain in waste water discharged into the Bay.

In addition to refining higher-selenium oil in ways that put more selenium into their waste water, the biggest selenium dischargers fail to take as much selenium out of their waste water as, another Bay area refinery, Tosco.

The top chart in Figure 8 shows the percentage of total selenium inputs to each refinery that 1) is discharged into the Bay, and 2) does not reach the Bay because the selenium ends up in refined products, pond bottoms, air emissions, and the like. This chart shows that Tosco discharges a significantly smaller portion of its selenium to the Bay than the other refiners.

In fact, there is an order of magnitude difference between the 20% - 26% Bay discharges from Shell and Unocal and the 2% Bay discharge from Tosco. This difference cannot be fully explained by different crude processing because Tosco refines a relatively high-selenium crude slate, as shown by the bottom chart in Figure 8. The analysis in Figure 6 suggests that Tosco discharges about 13 mg/Bbl (1600 lb/yr) less selenium than the discharge level predicted from crude slate data alone.

Tosco's discharge performance is better mainly because its waste water treatment is more effective than that of the other refineries. Tosco removes about 83% of the selenium in its waste water before discharge to the Bay through larger retention ponds than those used by other Bay Area refiners, and through its final filtration steps. (Regional Board, 1993; 93b) None of the largest selenium dischargers achieve similar treatment efficiencies. (Ibid.)

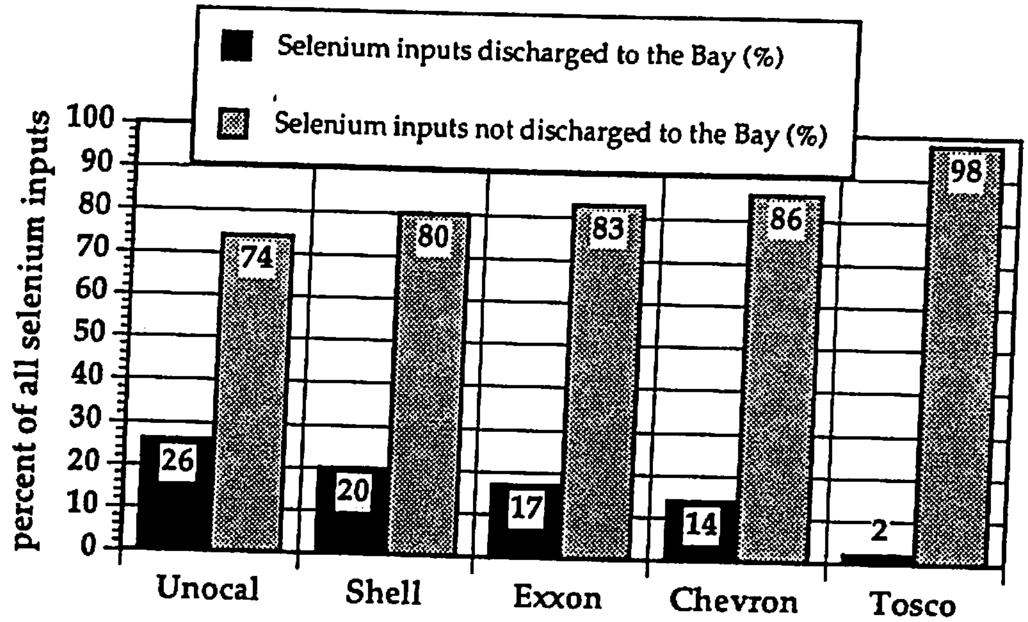
The upward-sloping line in the bottom chart further shows that the biggest dischargers put *more* of their selenium inputs into the Bay when running higher-selenium crude. This is true despite the significantly greater selenium concentrations in waste water from the three biggest dischargers[11] that should allow better, not worse, removal of the element by waste water treatment. Unocal, Shell, and Exxon failed to cancel out the impact of refining dirty crude with their existing waste water treatment.

---

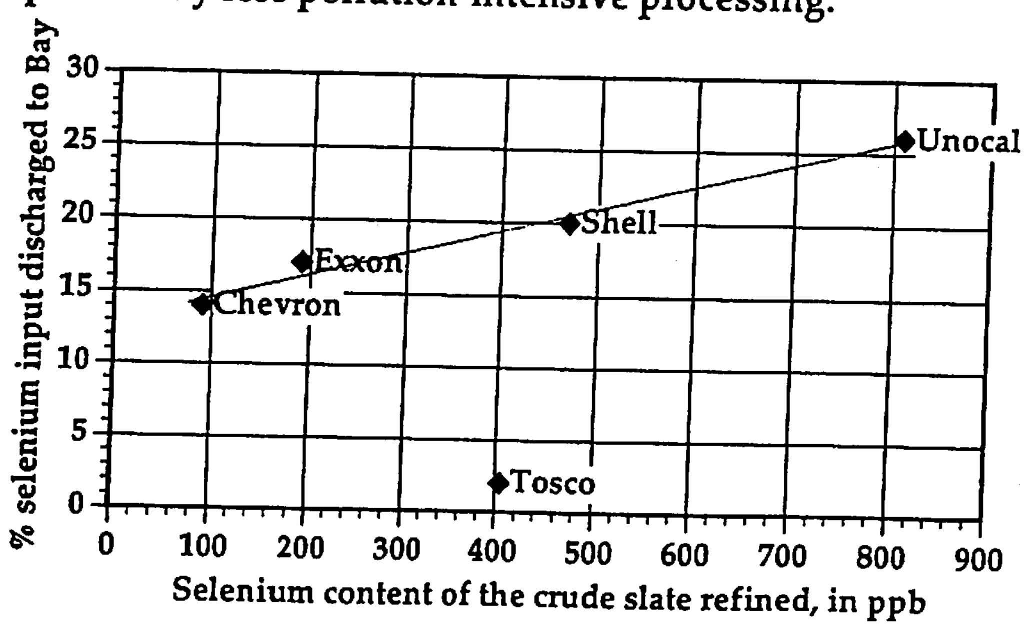
11 Unocal, Shell, Exxon, Chevron, Tosco, and Pacific effluents averaged 280, 140, 82, 19, 9, and 18 ug/l selenium, respectively, in 1993 (see Table 3 below).

Figure 8.

The biggest selenium dischargers put about ten times more of the selenium entering their refineries into the Bay than another Bay Area refinery that uses more extensive waste water treatment.



Since Tosco refines high-selenium crude oil this difference cannot be explained by less pollution-intensive processing.



CBE analysis based on selenium input rates from Figure 6, and selenium discharge rates from sef-monitoring reports. Large retention ponds allow significantly longer residence times in Tosco's treatment system relative to other refiners.

In sum, the Unocal, Shell, and Exxon refineries discharge selenium at rates on the order of ten times greater than those achieved by the other half of the local industry because they refine higher-selenium crude in selenium-dirtier ways than the largest refiner, ***and*** fail to achieve the waste treatment levels achieved by the second largest refiner.

Refinery selenium pollution may be an undiscovered problem in other bays and estuaries around the world.

Since selenium toxicity was discovered in the Kesterson National Wildlife Refuge in California's Central Valley, selenium pollution has been more intensively studied in this area than virtually anywhere in the world. Oil refinery selenium pollution of San Francisco Bay was discovered in the mid 1980s, after the Kesterson discoveries. Oil refineries may cause undetected selenium pollution in other areas as well.

Crude oil with selenium in the range that pollutes San Francisco Bay is widespread. Review of Table 1[11] reveals that selenium has been found in crudes from at least 48 different oil fields in at least twelve of the United States and in the country of Libya. Crudes from all these States and 88% of these fields have greater selenium concentrations than the crude slate now used by the Chevron refinery. Crudes from nearly half these fields in six states and in Libya have more selenium than the crude slate refined by the Exxon refinery. One Libyan crude sample had 35% greater selenium content than any San Francisco Bay refinery slate. (Shah et al., 1970) One California sample exceeded the maximum selenium concentration in any Bay refinery slate by 72%. (Ibid.)

Many other refineries run these crudes. At least 68 U.S. refineries that may run these crudes are located along coastal waters, Bays and estuaries in 13 states. (See Appendix) There is a great potential that some of these 68 plants refine widely available high-selenium crude, and discharge selenium to these waters.

---

11 The data in Table 1 are from Pillay et al., 1969; Shah et al., 1970; Arthur D. Little, 1989; Tosco, 1991; Shell, 1992; Unocal, 1992, Chevron, 1992; City of Benicia, 1993; Regional Board Order 92-111; Order 89-002; Regional Board June 7, 1993 NPDES Factsheet; NPDES permit applications; and March 29, 1993 letter from the Regional Board to CBE. The Calif. (Central Valley) and Alaska (North slope) values are averages of more than one oil field. There are from 27 to 53 fields in California's Central Valley (CCV) with 0.2% to 1.2% sulfur. (Purvin and Gertz, 1992) Selenium in crude slates from these fields and from offshore can vary (as refiners report), since they are delivered through three different pipelines. (Ibid.; and CBE, 1993)

	Table 1. Crude oil data	Se ppb	% > Chevron slate	% > Exxon slate	% > Unocal slate
1	California (sample 014)	1396	1451	627	72
2	Libya (sample 015)	1096	1118	471	35
3	** Unocal refinery crude slate	810	•	•	•
4	California (sample 010)	765	750	298	•
5	California (sample 011)	690	667	259	•
6	Calif. (Central Valley)	600	567	213	•
7	** Shell refinery crude slate	470	•	•	•
8	Mississippi (Bolton)	420	367	119	•
9	** Tosco Refinery crude slate	405	•	•	•
10	California (sample 013)	395	339	106	•
11	Texas (Panhandle)	340	278	77	•
12	Wyoming (sample 019)	321	257	67	•
13	Texas (Wasson 66)	310	244	61	•
14	Calif. (Las Cienagas)	300	233	56	•
15	Texas (Wasson 72)	270	200	41	•
16	Texas (Pewitt Ranch)	250	178	30	•
17	Texas (Darst Creek)	240	167	25	•
18	Libya (sample 016)	236	162	23	•
19	Libya (sample 017)	219	143	14	•
20	Texas (Spraberry Trend)	210	133	9	•
21	Oklahoma (Sho-Vel-Tum)	200	122	4	•
22	Arkansas (Midway)	200	122	4	•
23	Mississippi (Pool Creek)	200	122	4	•
24	Texas (Bethany)	200	122	4	•
25	** Exxon refinery crude slate	192	•	•	•
26	New Mexico (Hobbs)	190	111	•	•
27	Texas (Dune)	190	111	•	•
28	Texas (Fullerton)	180	100	•	•
29	Texas (Smyer)	170	89	•	•
30	Texas (Salt Creek)	170	89	•	•
31	Kansas (Hanston-Oppy)	160	78	•	•
32	New Mexico (Eumont)	160	78	•	•
33	California (sample 012)	151	68	•	•
34	Oklahoma (Be-Bee-Konawa)	140	56	•	•
35	Illinois (Golden Gate)	140	56	•	•
36	Texas (Sand Hills)	130	44	•	•
37	Mississippi (Dexter)	130	44	•	•
38	Texas (Yarborough and Allen)	130	44	•	•
39	Louisiana (Hackberry, E.)	130	44	•	•
40	Illinois (Sailor Springs)	120	33	•	•
41	Michigan (Buckeye, N.)	120	33	•	•
42	Calif. (Summerland)	120	33	•	•
43	Kansas (Kismet, N.)	110	22	•	•
44	Texas (Block 31)	100	11	•	•
45	** Chevron ref. crude slate	90	•	•	•
46	Calif. (Tejon, N.)	90	0	•	•
47	Alaska (North Slope)	90	0	•	•
48	Texas (Van)	80	•	•	•
49	Louisiana (Patterson)	80	•	•	•
50	Michigan (Scipio)	70	•	•	•
51	Calif. (Whittier)	70	•	•	•
52	Michigan (Peters)	60	•	•	•
53	Louisiana (sample 018)	26	•	•	•

Refining poor quality crude may increase many other toxic chemical hazards, especially for workers and refinery neighbors.

Refining poor quality crude oil into high quality products requires more intensive processing and removing more impurities. More energy and raw materials are used. More hazardous materials are produced or needed at the refinery. More "impurities" and combustion products are released from the refinery as pollutants.

For example, CBE reviewed a proposal by the Shell Oil Co. to add four hydrotreating process units, two new cokers, a related new hydrogen plant, and a related sulfur recovery/sour water system to its refinery in Martinez. (CBE, 1993) Other changes will be made in this $1 billion project, but it is these new process units that are needed to refine heavy, higher-sulfur (and high-selenium) crude oil into higher value fuels and other refined products.

Table 2 lists additional environmental impacts that could be caused by these dirty crude-related modifications. In addition to increased selenium pollution, at least eleven other potentially important environmental pollution impacts could be caused or exacerbated by the operation of these process units. Since the entire project is designed to operate at existing refining rates, these impacts can not be explained by refining greater amounts of oil.

The California Environmental Quality Act review documented in the County's Draft Environmental Impact Report found that the majority of these pollution problems will cause significant negative impacts on the environment if they are not adequately mitigated. (Contra Costa County, 1993)

Without additional controls, the Shell project would cause significant impacts from multiple chemical threats to the environment, refinery workers, refinery neighbors, and people who eat fish and other food resources from the Bay.[13] The example of the Shell analysis suggests that dirty crude refining may be threatening workers, neighbors, and aquatic resources near other refineries as well.

---

13 Shell's project was approved by Contra Costa County with a package of mitigation measures. In this specific case CBE and other citizen groups reached a settlement with Shell that we believe will greatly reduce air pollution. However, this settlement does not address the ongoing selenium violations by this refinery.

Table 2. INCREASED POLLUTION HAZARDS FORECAST FROM THE SHELL MARTINEZ REFINERY MODIFICATION (WITHOUT MITIGATION) THAT ARE CAUSED BY REFINING HIGH SELENIUM CRUDE OIL.[a]

Pollutant	Increased impact from operating modified refinery at present refining rate.	Importance of processes used for poor quality crude refining to the total refinery impact
1. Selenium	25% to 100% increase.	Cause most of the total increase.
2. Cyanide	Potential significant increase.	Cause most of any increase.
3. H2S gas	Significant increased odors.	Most of the total increase.
4. H2S gas	Acute exposure from sudden release can be fatal.	Most of the total increase in H2S in the refinery.
5. Carbon monoxide	Significant impact from increased emissions.	More than half of all new emissions.
6. Sulfur oxides (SOX)	Significant impact from increased emissions.	Half of all new emissions.
7. Fine part-icles (PM10)	Significant impact from increased emissions.	More than half of all new emissions.
8. Coke dust	Health hazards to workers and refinery neighbors.	Most or all of new emissions.
9. Hydrogen	Increased risk of explosion or fire causing other releases.	Most of the new hydrogen gas in the refinery.
10. Nitrogen oxide (NOX)	Significant impact from increased emissions.	More than 40% of new emissions.
11. VOCs	Significant impact from increased emissions.	Almost 40% of new emissions.
12. Carbon dioxide	Significant local contri-bution to global warming.	About 60% of 2 million ton-per-year increase in emissions.

[a] Summarized from CBE, 1993. For the purposes of this table, the analysis indicates the potential for multiple environmental problems from refining poor quality, high selenium crude oil: It is not intended to account for additional future treatment or control mitigation that may reduce or prevent the projected increases in discharges. In addition to CBE's analysis, the DEIR found without-mitigation significant environmental impacts for selenium, H2S, carbon monoxide, PM10, NOX, VOCs, and the overall risk of sudden chemical releases. (Contra Costa County, 1993)

Limitations of the data used in this report.

With few exceptions, the key data used in this report are summarized in Table 3.[14] Almost all the data in Table 3 are from oil industry self-reports that are limited by the accuracy and completeness of the information that is publicly released.

Data describing the average amounts of crude oil refined are from Regional Board Orders 92-111 and 89-002; the June 7, 1993 NPDES Fact Sheet for Tosco; NPDES permit applications; and Shell, 1992. Data describing the breakdown of major crude oil sources refined in each refinery's crude slate are from Shell, 1992; Unocal, 1992; Chevron, 1992; Tosco, 1992; and City of Benicia, 1993. Data on crude slate selenium concentrations are from these sources; Tosco 1991; Arthur D. Little, 1989; Shah et al., 1970; Pillay et al., 1969; Purvin and Gertz, 1992; and a March 29, 1993 letter from the Regional Board to CBE. There are few of these data.

Data describing these six refiners' waste water discharges are more numerous. Waste water flows were measured daily and selenium concentrations were measured weekly from 1-day composite samples. Selenium concentrations were reported above the analytical detection levels of the chemical analyses. Annual mass loadings were calculated using methods specified in Regional Board Order 91-099.[15] Values for 1987 through 1992 are from Regional Board staff calculations. (Regional Board, 1993.) Values for 1993 are from oil industry calculations reported in self monitoring reports submitted to the Regional Board in Oakland.

The collection of more data on selenium in refinery crude slates and waste water discharges should be an environmental monitoring priority.

This CBE analysis does not use refinery selenium loading estimates from before 1987 because less frequent selenium sampling, and different chemical analytical methods used by some or all refiners, render these earlier estimates less accurate and less comparable. Analysis of long-term trends compared averages of available 1980s and 1990s loading data. This considered all the available and comparable data, and minimizes the potential for errors caused by single-year variations. The calculations used for this comparison are presented at the bottom of Table 3.

---

14 Exceptions include the data on selenium content of crudes from different oil fields in Table 2 (From Shah et al., 1970; and Pillay et al., 1969), treatment efficiency estimates cited in the text (Regional Board, 1993; 93b), and some other data cited in the text.

15 Exxon calculates mass using the average of weekly effluent flows because the refinery sometimes stops discharge, and therefore monitoring days (when discharges occur) may be less representative of actual weekly flows and loadings in weeks when discharges are intermittent. This method was discussed with the Regional Board staff (Regional Board, 1993b).

	Table 3. Refinery data.	Shell Oil Co.	Unocal	Exxon Co. USA	Chevron USA	Tosco Refining	Pacific Refining
1	Average crude oil refined (Bbl/day)	142600	60600	135000	265000	152180	49300
2							
3	Major sources of crude slate today	CCV = 95%	CCV ~ 100%	CCV = 20%		CCV = 50%	NA
4	(Cal. Central Valley and Alaska N. Slope)	ANS = 5%		ANS = 80%	ANS ~ 100%	ANS = 35%	NA
5						NA = 15%*	NA
6							
7	Selenium content of crude slate (ppb)	470	810	192	90	405*	NA
8	Estimated specific gravity of crude slate	.98	.98	.91	.89	.94*	NA
9	(Sp. grav. of CCV = 0.98; ANS = 0.89)						
10	Mass of crude refined in Kg/Bbl	155.2	155.8	144.4	141.5	149.7*	NA
11							
12	Estimated avg. 1993 waste water discharge	4.9 MGD	2.0 MGD	2.3 MGD	6.4 MGD	4.8 MGD	0.25 MGD
13							
14	Avg. selenium concentration in effluent	140	280	82	19	9	18
15	(from 1993 weekly samples, in ug/l)						
16							
17	Selenium to Bay (weekly samples, lb/day)						
18	1993	2040	1600	510	370	130	14
19	1992	2592	1690	755	354	194	9
20	1991	2081	1927	799	576	238	13
21	1990	1808	1938	598	684	180	13
22	1989	1203	1445	482	563	244	15
23	1988	1687	1285	482	642	321	NA
24	1987	1527	1045	642	803	403	NA
25							
26	Annual average for 1987 through 1989	1470 lb/yr	1260 lb/yr	540 lb/yr	670 lb/yr	320 lb/yr	15 lb/yr
27	Annual average for 1990 through 1993	2130 lb/yr	1790 lb/yr	670 lb/yr	500 lb/yr	185 lb/yr	12 lb/yr
28	Percent change from 1980s to 1990s	+45%	+42%	+24%	-25%	-42%	-20%
29							
30	* For 15% of the Tosco crude slate, data	were not pub-	licly available	and estimates	were made by	interpolation.	

Literature cited

Arthur D. Little, 1989. Physical and Chemical Characterization of San Joaquin Valley Crude Oil. A Study Element of the Pilot and Reconnaissance Study for the Shell Oil Spill Assessment and Recovery Monitoring Environmental Effects Program. Final Report to ENTRIX, Inc. April 1989.

California Hunting Regulations. Part III (Waterfowl). State of California, Fish and Game Commission.

CBE, 1993. Technical Comments on the Shell Oil Company Clean Fuels Project Draft Environmental Impact Report. On behalf of CBE, San Francisco BayKeeper, The Bay Institute of San Francisco, and the Santa Clara Valley Chapter of the Audubon Society. June 21, 1993. Prepared by Citizens for a Better Environment (CBE), San Francisco, Calif.

Chevron USA, 1989. Control Strategy for Selenium. Submitted to the Regional Board as required by Provision D.5 of Chevron's NPDES permit.

Chevron, 1992. Response to RWQCB Request for Information Regarding the WSPA Selenium Proposal. Letter from P.S. Williams of Chevron USA to Steven R. Ritchie of the California Regional Water Quality Control Board. November 11, 1992.

Chin, 1993. Per. Com. with Wendell Chin, Field Organizer, South Bay Anglers for Environmental Rights (SAFER!) and Citizens for a Better Environment (CBE). Several communications with Greg Karras, Senior Scientist, CBE, throughout 1993.

City of Benicia, 1993. Draft Environmental Impact Report, Exxon Benicia Refinery Clean Fuels Project. City of Benicia, California, and Woodward-Clyde Consultants, Oakland, CA. September 1993. Page 2-17.

Contra Costa County, 1993. Draft Environmental Impact Report for the Shell Oil Co. Clean Fuels Project. State Clearinghouse #92093028. Contra Costa County Community Development Department, Martinez, Calif.

Cutter and San Diego-McGlone, 1990. Temporal Variability of selenium fluxes in San Francisco Bay. Hydrobiologia 129:153-176. Junk, Dordrecht, Netherlands.

DFG, 1988. Selenium Verification Study 1986-1987. California Department of Fish and Game.

DFG, 1989. Selenium Verification Study 1987-1988. California Department of Fish and Game.

EPA, 1979. Proposed Development Document for Effluent Limitations Guidelines and Standards for the Petroleum Refining Point Source Category. EPA 440/1-79/014-b, December, 1979; Settlement Agreement in NRDC v. EPA and Intervenors, Docket No. 83-1122; and EPA, 1984. Development Document for Effluent Limitations Guidelines and Standards for the Petroleum Refining Point Source Category.

EPA, 1990. Decision of the United States Environmental Protection Agency on Listings Under Section 304(l) of the Clean Water Act Regarding the State of California. USEPA Region IX, San Francisco, CA. September 28, 1990; and EPA Response to Comments and Petitions Regarding Listing Decisions for California Waters Under Section 304(l) of the Clean Water Act. USEPA Region IX, San Francisco, CA. September 5, 1990.

June 7, 1993 NPDES Fact Sheet. (Documentation of the technical basis for revisions to National Pollutant Discharge Elimination System permit that permitting agencies are required to provide to the public under the Clean Water Act.) Regional Water Quality Control Board, San Francisco Bay Region, Oakland, Calif.

Kopec et al., 1991. Pollutant Residues and Health of San Francisco Bay Harbor Seals (Phoca vitulina). Poster Session. Dianne Kopec and Steven Obrebski, Romberg Tiburon Center, San Francisco State University. Sarah G. Allen, Wildland and Resource Science, University of California, Berkeley. Lyman E Fancher, San Francisco Bird Observatory.

Kopec, 1994. Per. Com. with Diane Kopec, Romberg Tiburon Center, San Francisco State University, and San Francisco Bay Bird Observatory. Communication with Greg Karras, Senior Scientist, Citizens for a Better Environment. February 25, 1994.

Lonzarich et al., 1991. Trace element and organochlorine concentrations in California Clapper Rail eggs. University of Washington, School of Fisheries.

March 29, 1992 letter from Kim Taylor, Regional Water Quality Control Board, San Francisco Bay Region, to Greg Karras, Citizens for a Better Environment, San Francisco, Calif.

NPDES permit applications. (Pollutant discharges are prohibited without National Pollutant Discharge Elimination System (NPDES) permits. Some parts of the application forms submitted by dischargers seeking these permits are routinely supplied to the public.) California State Regional Water Quality Control Board, San Francisco Bay Region, Oakland, Calif.

National Pollutant Discharge Elimination System (NPDES) permits. These documents contain the specific legal requirements that dischargers must meet. Also see NPDES permit applications directly above. The Exxon Co. USA Benicia Refinery discharge is governed by NPDES Permit No. CA0005550; the Union Oil Co. (dba Unocal) discharge from its San Francisco Refinery in Rodeo is governed by NPDES permit No. CA0005053; the Shell Oil Co. Martinez Manufacturing Complex discharge is governed by NPDES Permit No. CA0005789; the Chevron USA Richmond Refinery discharge is governed by NPDES Permit No. CA0005134; the Tosco Corp. Avon Refinery discharge is governed by NPDES Permit No. CA0004961; and the Pacific Refining Co. discharge is governed by NPDES Permit No. CA0005096.

Pillay et al., 1969. Neutron Activation Analysis of the Selenium Content of Fossil Fuels. Nuclear Applications & Technology, November 1969. 7:478-483.

Purvin and Gertz, 1992. Submission to The Regional Water Quality Control Board, San Francisco Bay Region, Prepared on Behalf of the Shell Oil Company. By John Vautrain, Purvin and Gertz, Inc. December 1992.

Regional Board, 1991. Order 91-026 . Amending NPDES Permits for the Dischargers Cited Herein: Chevron USA Richmond Refinery, Tosco Corp. Avon Refinery, Exxon Co. USA Benicia Refinery, Shell Oil Co. Martinez Manufacturing Complex, Union Oil Co. San Francisco Refinery, and Pacific Refining Co. Adopted February 20, 1991; and Order 91-099. Amending Order No. 91-026 for the Dischargers Cited Therein. Adopted June 19, 1991.

Regional Board, 1992. Derivation of Site-specific water quality criteria for selenium. February 1992 Staff Report; October 12, 1992 Staff Report and Proposed Amendment to the Water Quality Control Plan, San Francisco Bay Region: Mass Emissions Strategy for Selenium; and Reporter's transcript of proceedings, December 16, 1992 Regional Water Quality Control Board. Proposed amendment to the Water Quality Control Plan - Hearing to Receive Testimony on the Proposed Mass Emissions Reduction Strategy for Selenium. Item No. 6. California Regional Water Quality Control Board. Oakland, CA.

Regional Board, 1993. Proposed Amendment to the Water Quality Control Plan, San Francisco Bay Region: Mass Emissions Strategy for Selenium. California Regional Water Quality Control Board. Oakland, CA. Includes June, October, and November 1993 Board staff reports and proposals.

Regional Board, 1993b. Per. Com., Lila Tang and Mark Ruderman of the Regional Water Quality Control Board, San Francisco Bay Region. Communications with Greg Karras, Senior Scientist, Citizens for a Better Environment, San Francisco, Calif. October, 1993.

Self-monitoring reports. The federal Clean Water Act and its implementing regulations set forth a discharger self-monitoring system. Dischargers are required to demonstrate compliance with the Act as a condition of being granted a discharge permit, and permitting authorities are required to assure adequate monitoring by permittees. False reports can result in potentially severe criminal penalties. Each refinery submits monthly self-monitoring reports to the California State Regional Water Quality Control Board. These documents are available for the public to review in the Board's Oakland, California offices. See especially the January 27, 1994 letter from Stephen Plesh transmitting the December 1993 Monthly Report and Annual Report for the Unocal San Francisco Refinery; January 14, 1994 letter from Michael J. Hargarten transmitting the December 1993 Monitoring Report for the Exxon Co. USA Benicia Refinery; January 14, 1994 letter from J.C. Harmon and Self Monitoring Report for the month of December, 1993 for the Shell Oil Company Martinez Manufacturing Complex; January 14, 1994 letter and monthly report for the month of December and 1993 year-end report for the Chevron USA Richmond Refinery; January 12, 1994 letter from Richard F. Hallford and Avon Refinery Waste Water Self Monitoring Report (SMR) - December 1993 for Tosco Refining; and January 10, 1994 letter from P.L. Miller and NPDES Self-Monitoring Report for December, 1993 for Pacific Refining.

Shah et al., 1970. Determination of Trace Elements in Petroleum by Neutron Activation Analysis. Journal of Radioanalytical Chemistry 6:413-422.

Shell Oil Co., 1992. Response to Regional Board request for information. Letter from J.C. Harmon of Shell to the Regional Board dated November 13, 1992. October 19, 1992.

Tosco, 1991. Selenium Removal and Source Control Study, Final Report. Submitted to the California Regional Water Quality Control Board, San Francisco Bay Region, by Tosco Refining Company, Martinez, Calif. Prepared by Brown and Caldwell. December 1991.

Tosco, 1992. Selenium Removal from Tosco's Wastewater. Letter from Richard Hallford of Tosco to the Regional Board. November 16, 1992.

Unocal, 1992. Response to RWQCB Questions on WSPA Proposal: "Removal of Selenium from Refinery Discharges." Letter from R.H. Swenson of Unocal to the Regional Board. November 23, 1992.

Appendix: Partial list of U.S. coastal oil refineries (page one of two).

State	City	Company
Alaska	Kenai	Tesoro Petroleum
	Kipnuk	Arco Alaska Inc.
	Prudhoe Bay	Arco Alaska Inc.
	Valdez	Petro Star Inc.
Washington State	Anacortes	Shell Oil Co.
	Anacortes	Texaco Refining
	Ferndale	Arco Products Co.
	Ferndale	BP Oil Corp.
	Tacoma	Sound Refining Inc.
	Tacoma	U.S. Oil and Refining
California (San Francisco Bay)	Benicia	Exxon Co. USA
	Rodeo	Union Oil of California
	Martinez	Shell Oil Co.
	Martinez	Tosco Refining Co.
	Richmond	Chevron USA Inc.
	Hercules	Pacific Refining Co.
	Oxnard	Tenby Inc.
(Los Angeles Area)	El Segundo	Chevron USA Inc.
	Long Beach	Chemoil Refining
	Los Angeles	Arco Products Co.
	Torrance	Mobil Oil Co.
	Wilmington	Huntway Refining Co.
	Wilmington	Texaco Refining
	Wilmington	Union Oil of California
	Wilmington	Ultramar Refining
Hawaii	Ewa Beach	Hawaiian Independent Refinery Inc.
	Honolulu	Chevron USA Inc.
Texas	Baytown	Exxon Co. USA
	Beaumont	Mobil Oil Co.
	Channelview	Howell Hydrocarbons & Chemicals
	Corpus Christi	Citgo Ref. & Chem.
	Corpus Christi	Coastal Refining
	Corpus Christi	Koch Refining Co.
	Corpus Christi	Southwestern Ref.
	Corpus Christi	Valero Refining Co.

Appendix: Partial list of U.S. coastal oil refineries (page two of two).

Texas (continued)	Deer Park	Shell Oil Co.
	Houston	Lyondell Petrochemicals
	Houston	Phibro Energy
	Pasadena	Crown Central
	Port Arthur	Chevron USA Inc.
	Port Arthur	Fina Oil & Chem
	Port Arthur	Star Enterprise
	Sweeney	Phillips 66 Co.
	Texas City	Amoco Oil Co.
	Texas City	Marathon Oil Co.
	Texas City	Phibro Energy
Louisiana	Baton Rouge	Exxon Co. USA
	Chalmette	Mobil Oil Co.
	Convent	Star Enterprise
	Lake Charles	Calcasien Refining
	Lake Charles	Citgo Petroleum
	Lake Charles	Gold Line Refining
	Westlake	Conoco Inc.
Mississippi	Pascagoula	Chevron USA Inc.
Alabama	Chickasaw	Coastal Mobile Refining Co.
	Saraland	LL&E Petrochemical Marketing
Georgia	Savannah	Young Refining
Virginia	Yorktown	Amoco Oil Co.
Delaware	Delaware City	Star Enterprise
Pennsylvania	Marcus Hook	BP Oil Corp.
	Marcus Hook	Sun Oil Inc.
	Philadelphia	Chevron USA Inc.
	Philadelphia	Sun Ref. and Marketing
New Jersey	Linden	Exxon Co. USA
	Paulsboro	Citgo Asphalt Co.
	Paulsboro	Mobil Oil Co.
	Perth Amboy	Chevron USA Inc.
	Westville	Coastal Eagle Pt. Oil

* Epstein and Wiener, 1994. Reinventing Refineries. A Community Guide by the Environmental Defense Fund, and Citizens for a Better Environment. Washington, D.C.