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Diesel Truck Traffic in Low-Income and Minority Communities Adjacent to Ports

Environmental Justice Implications of Near-Roadway Land Use Conflicts

Douglas Houston, Margaret Krudysz, and Arthur Winer

Container traffic at the Ports of Los Angeles and Long Beach, California, has tripled in the past 15 years, resulting in massive port-related heavy-duty diesel truck (HDDT) traffic on surface streets in the low-income and minority communities of Wilmington and western Long Beach adjacent to the ports. In response to the limitations of existing data on the volumes of HDDTs on surface streets, this study used direct video measurements of surface street traffic at 11 intersections and line segments in these communities to document port-related truck traffic traveling to and from intermodal facilities, truck service sites, local amenities. and regional goods movement roadways. The volumes of HDDTs often reached 400 to 600/h for several hours immediately upwind of sensitive land uses, such as schools, open-field parks, and residences. Diurnal truck traffic patterns on surface streets varied by intersection, local conditions, and passenger car commute patterns. Given the documented health and environmental consequences of HDDT emissions, the results raise serious public health concerns for the inhabitants who reside, work, attend school, or recreate in close proximity to roadways with HDDT traffic in these communities adjacent to ports. This paper discusses the environmental justice implications of truck-related land use conflicts and current planning and emission control strategies to mitigate the local air pollution impacts of increasing port-related truck traffic in these low-income, minority communities.

The health and environmental justice consequences of air pollution impacts resulting from heavy-duty diesel truck (HDDT) container transport traffic are substantial not only at regional levels but also for those urban inhabitants who reside, work, attend school, or recreate in close proximity to surface streets and freeways with HDDT traffic. A growing body of field measurements and epidemiological studies indicate that vehicle-related air pollutants and their related health impacts, including the prevalence of respiratory ailments and mortality, are highly localized within approximately 100 to 400 m downwind of major roadways (*1–6*). HDDTs are of particular concern because they emit high levels of particulate matter (PM) and oxides of nitrogen, as well as a complex mixture of gaseous air pollutants, many of which have been listed by the State of California as toxic air contaminants. Diesel exhaust PM has also been associated with approximately 70% of the known potential cancer risk from exposure to air toxics in Southern California (*7*). More than 70% of California's diesel PM pollution in 2001 was from the goods movement sector, and more than 70% of these emissions were from HDDTs (*8*).

The localized impacts of diesel truck exhaust have environmental justice implications for two Southern California communities that are adjacent to ports, the low-income and minority communities of Wilmington, in the city of Los Angeles, and the western portion of the city of Long Beach, given that large numbers of port-related container trucks travel the surface streets of these communities en route to and from intermodal transfer facilities, truck service sites, local amenities, and regional goods movement truck routes. Combined, the nearby Ports of Los Angeles and Long Beach import more than 40% of the nation's international trade cargo and are the third largest port in the world after those in Hong Kong and Singapore. Container traffic at these ports has tripled in the last 15 years and is expected to nearly triple again by 2020 (*9*). Approximately 84% of the containers are transported by HDDTs from the port complex to off-dock rail transfer facilities, to transloading facilities for repackaging for long-haul transport, or directly to regional and national destinations (*10*).

Unfortunately, relatively little quantitative information concerning the distribution of diesel truck traffic and the associated air pollution in communities adjacent to ports is available, in part because of the disparate data collection methods that have been used and the limited geographic and temporal coverage of previous studies (*11*, *12*). This paper responds to these limitations and explores the environmental justice concerns raised by the rapidly expanding HDDT goods movement infrastructure in Southern California by documenting the volumes and diurnal variations in port-related diesel truck traffic on surface streets in the communities of Wilmington and western Long Beach, which are adjacent to ports. The results provide new insight into the geographic distribution and intensity of truck traffic associated with the massive increase in goods movement and provide a refined characterization of the extent of the potential impacts on low-income and minority communities.

BACKGROUND

Near-Roadway Vehicle Pollution and Health Effects Studies

Evidence of a heightened prevalence of respiratory ailments and mortality among people who live near heavily traveled roadways is rapidly accumulating (*11*, *13*, *14*). People who live near roadways

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with high volumes of diesel vehicles are more likely to suffer from chronic respiratory ailments and reduced lung function than people who live 300 m or more away from such roadways (*1–5*). These studies generally found such health impacts within 100 to 400 m of a roadway, where vehicle-related pollutants such as ultrafine particles, black carbon, and carbon monoxide are highly concentrated. Other studies have shown that the relative concentrations of these pollutants decline by as much as 60% at about 100 m downwind, drop to near background levels at about 200 m, and are indistinguishable from background ambient concentrations at about 300 to 400 m (*6*). Roadways such as the I-710 freeway in Los Angeles, which has an average of approximately 25% HDDT traffic, mainly from the Los Angeles port system, tend to have higher concentrations of these harmful pollutants than freeways with less diesel traffic, such as I-405, which has an average of <5% HDDT traffic (*6*).

HDDT emissions are of particular concern, given that the California Air Resources Board (ARB) has declared diesel exhaust particulate to be a toxic air contaminant on the basis of the findings of more than 40 studies that showed a consistent causal relationship between long-term occupational exposures and lung cancer. Particles emitted by diesel engines vary in size: ultrafine particles, or particles less than 100 nm in diameter, are generated during combustion and at the exhaust outlet of diesel (and gasoline) vehicles; particles less than 2.5 μm in diameter, or $PM_{2.5}$ or fine PM, are products of combustion, atmospheric photochemical reactions, and the coagulation of smaller particles. Ultrafine particles are of concern because they are capable of penetrating cell walls and the blood–brain barrier and can easily be absorbed by vital organs (*15*). Heightened ambient levels of $PM_{2.5}$ have consistently been associated with increased rates of mortality and respiratory illness (*16*, *17*).

New 2007 emission controls for on-road HDDTs could greatly reduce near-roadway HDDT-related air pollution. However, given that diesel engines are quite durable and can last for 30 years, emission controls alone will not translate into substantial fleetwide reductions in the near term without large-scale truck replacement or retrofitting.

Environmental Justice and Near-Roadway Exposures

Proximity to major roadways has been used to estimate exposure because scattered regional air-monitoring stations are largely inadequate for the assessment of near-roadway air pollution and pollution monitoring is expensive and complex (*11, 18, 19*). Proximity-based analysis suggests that nonwhite children in California are about three to four times more likely to live in areas with high-density traffic than white children and that low-income children had higher potential exposures to vehicle emissions (*18*). Minority and high-poverty neighborhoods in Southern California bear more than twice the level of traffic density as the rest of the region, suggesting that these communities may be disproportionately exposed to concentrated near-roadway air pollution. Such exposures often occur in the context of structural inequalities, including racial segregation, a lack of economic opportunity, disinvestment, and declining property values (*11*).

The level of diesel exhaust at intersections and on sidewalks in freight corridors raises environmental justice concerns. Lena et al. examined truck traffic and the associated pollutant levels in Hunts Point, a major freight transportation hub in South Bronx, New York City, a community that predominately comprises low-income African- and Latin-American residents (*20*). They found that the intersection-level concentrations of elemental carbon, an important component of diesel exhaust PM, were elevated in the community and varied as a function of large truck traffic. A study of diesel exhaust particles on sidewalks in Harlem, New York City, a predominately low-income African-American and Hispanic community, by Kinney et al. indicated that variations in the sidewalk concentrations of diesel exhaust particles are related to the magnitude of local diesel sources, including heavy-duty trucks and diesel buses (*21*).

Study Area

Wilmington and western Long Beach are immediately north of the Ports of Los Angeles and Long Beach and have historically been exposed to high levels of air pollution generated by port- and refinery-related activities. They predominantly comprise minority residents and have higher poverty rates than the region as a whole. On the basis of data from the 2000 census, the population in the current study area comprised 65% Hispanic residents, whereas the proportion of Hispanic residents for Los Angeles County as a whole was 45%; only 8% of the residents were non-Hispanic white, whereas the proportion for the county was 31%. Nearly one-third (29%) of the residents had incomes in 1999 that were below the federal poverty level (versus 18% for the county), and over half (52%) of the residents had less than a high school education (versus 30% for the county).

Limitations of Available Traffic Monitoring

The traffic monitoring available in these communities is insufficient to obtain an adequate understanding of growing HDDT traffic patterns. Previous studies used traffic volume data from the Highway Performance and Monitoring System (HPMS), which is maintained by the California Department of Transportation (Caltrans), to assess the impacts of roadway traffic volumes on communities and describe the limitations of using these data to monitor traffic on surface streets (*11, 18, 19*). Previous studies assumed that residential streets have lower traffic volumes and that their exclusion did not greatly affect the results of these regional studies, but great limitations to the use of such data for the examination of near-roadway air pollution impacts remain (*12*). Moreover, although the HPMS data provide useful information on the total traffic volumes on major roadways, they do not provide detailed information on diesel truck activity.

Caltrans releases data separately for trucks in its *Annual Average Daily Truck Traffic on the California State Highway System* (*22*). These data are restricted to major freeways and, like the HPMS data, are largely based on Caltrans sampling of traffic volumes by the use of electronic counting instruments throughout the state at infrequent intervals. Only a few locations are monitored continuously.

Caltrans also maintains a dispersed network of weigh-in-motion (WIM) stations throughout the state. These provide the most comprehensive record of vehicle class at select locations on major state freeways, including vehicle class data. When they are available, WIM data help to characterize the impacts of these goods movement corridors on nearby communities, but they do not identify the impacts of the increasing container truck traffic on surface streets that serve as feeder routes to the regional goods movement infrastructure.

Local departments of transportation often use traffic monitoring to assess the need for or the impact of traffic controls or facility expansion on surface streets at a given point in time. Although some local traffic studies are conducted by in-person counters, they often include only intersections targeted for improvements and have disparate geographic and temporal coverage. In addition, local traffic studies only occasionally disaggregate trucks and buses.

Amid growing concerns over truck volumes in Wilmington, the Port of Los Angeles commissioned a study of traffic counts at key intersections in 2001 (*23*). That was the first available study based on in-person counts that distinguished total traffic from port and nonport trucks. The study monitored traffic for a single day at key intersections during the morning peak (08:00 to 09:00 h) and the evening peak (16:00 to 17:00 h) and showed substantial port-related truck traffic on surface streets. Further monitoring is needed, given the substantial growth in port container traffic since 2001, when those counts were collected, to obtain more comprehensive diurnal data for exposure modeling. Diurnal information (and not just information for peak periods) on truck traffic on surface streets is also needed, especially given the shift toward longer hours of port operation.

DATA AND METHODS

Study Area Truck Traffic Patterns

The study area is located in a major goods movement corridor north of the Ports of Los Angeles and Long Beach and stretches from the I-710 freeway eastward approximately 6 mi to the I-110 freeway on the western edge of the community of Wilmington in the city of Los Angeles (Figure 1). The study area reaches from Harry Bridges Avenue, the boundary of the Port of Los Angeles, approximately 2 mi northward and past the Pacific Coast Highway (PCH), follows Alameda Street in the northeastern direction from Wilmington into the western edge of Long Beach, and extends from Anaheim Street 3 mi northward to just south of the I-405 freeway.

Corridors for the movement of containers to and from the ports by truck are I-110 on the western edge of the port complex; Alameda Street, which transverses the study area and which connects with the I-405 freeway and downtown Los Angeles; and the I-710 freeway, which crosses the eastern portion of the study area. About 29% of the containers from the port complex travel by truck to destinations in the Los Angeles region or western United States (*10*). Approximately 14% of the containers are trucked to off-dock rail intermodal facilities near downtown Los Angeles, where they are loaded from trucks onto rail. About 29% of the containers are trucked farther inland to large warehouse complexes in Riverside and San Bernardino Counties for transloading (*10*).

About 9% of the containers are trucked to Union Pacific's near-dock rail facility, called the Intermodal Container Transfer Facility (ICTF), in the study area north of Sepulveda Boulevard. Trucks that deliver containers destined for this facility travel east–west along Sepulveda Boulevard and north–south on the Terminal Island Freeway. PCH and Anaheim Street constitute major east–west corridors for traffic traveling to I-710 and local amenities in the nearby communities of

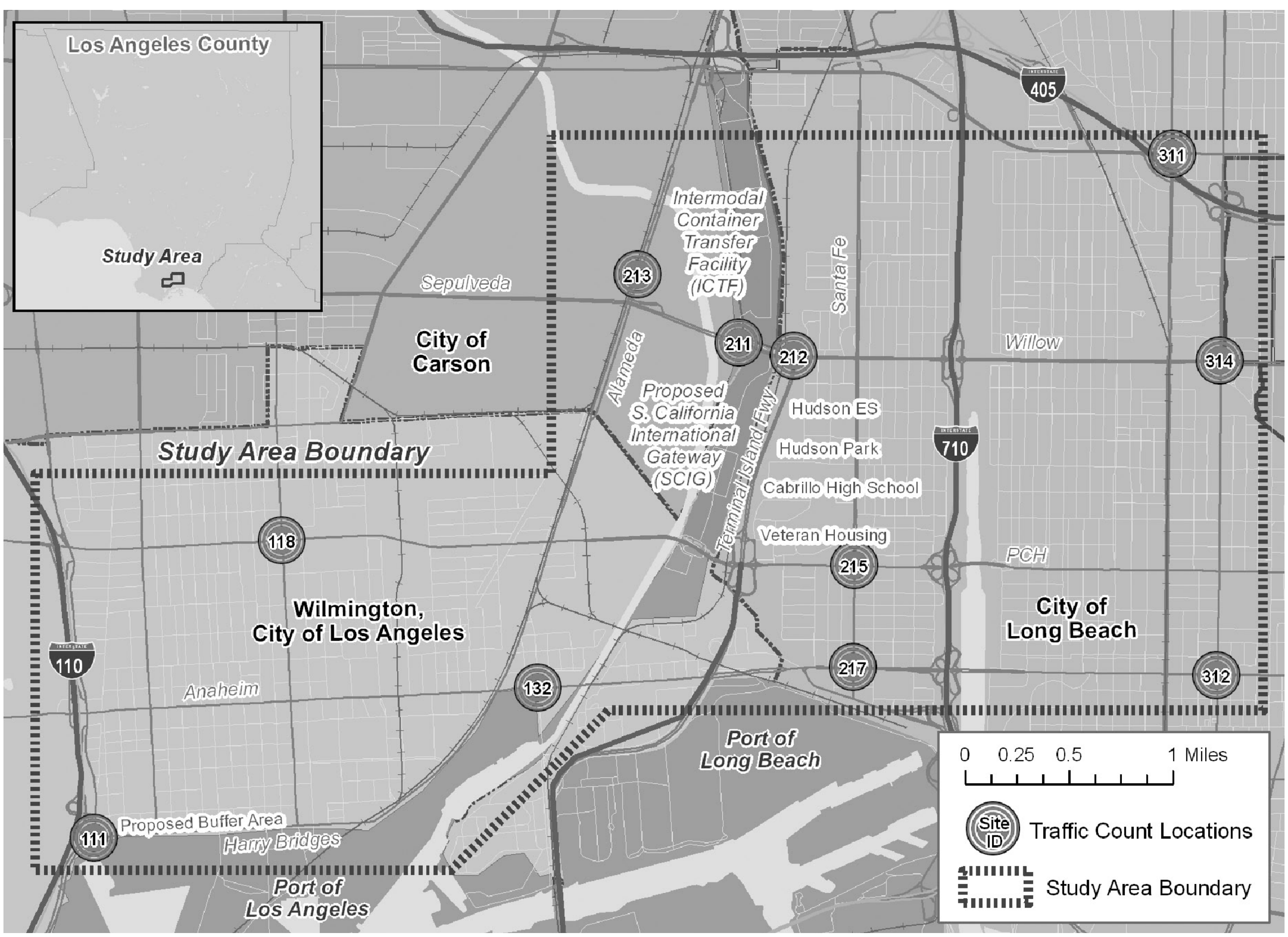

FIGURE 1 Study intersections, Wilmington and West Long Beach.

Wilmington and Long Beach. Over the course of a day, port-related trucks make multiple trips between terminals, warehouses, container storage yards, and other truck-related facilities. Substantial queuing also occurs as truckers wait for their next load or take a break.

Study Design and Traffic Counting

Intersections for monitoring were selected on the basis of previous traffic studies and input from community leaders through the Harbor Community Monitoring Study, sponsored by the California ARB. Traffic data were collected by on-site videotaping to obtain counts of traffic by vehicle class and direction for major surface street intersections to better characterize the diesel–gasoline split, determine diurnal patterns, and identify the compositions and classes of the diesel vehicles traveling on arterial streets. The traffic at 11 intersections and line segments was videotaped for 13 days between August 15, 2006, and September 19, 2006. During this sampling period, the container volumes of the port complex were the highest to that time (*24, 25*).

Videotaping coincided with the expected peaks of diesel traffic on surface streets, generally between 07:30 and 18:00 h, and was conducted on weekdays (Tuesday, Wednesday, and Thursday), with one repeat collection day on a Saturday and on an extended day, in part to assess the port's shift toward extended hours of operation. Because of limited resources, additional monitoring that could help assess the extent to which the truck volumes monitored were representative of traffic patterns on nonobserved days could not be conducted. The analysis assumes that the counts are generally representative of the traffic counts during the study period, given that, to the authors' knowledge, the traffic on the collection days was not affected by external conditions, such as accidents or adverse weather.

Traffic was videotaped at regular intervals throughout the observation period for 30-min or 1-h sampling intervals, depending on the availability of nearby amenities for the researchers. Each observation day resulted in a minimum of 5.5 h of videotaped traffic data. Electronic traffic-counting boards from Jamar Technologies Inc. were subsequently used to tabulate the videotaped traffic counts by direction and vehicle class. All video data were reduced to counts for 30-min periods for comparison across days with 30-min or 1-h sampling intervals.

The classifications distinguished passenger vehicles from vehicles that use diesel fuel. Although a small portion of passenger vehicles use diesel fuel, the discussion here assumes that passenger vehicles in California are overwhelmingly fueled with gasoline. In addition to sedans, passenger vehicles included light-duty pickups, pickups, vans, minivans, SUVs, and station wagons. Port-related diesel-fueled vehicles included HDDTs in a tractor-only configuration, tractors with a chassis bed without a container, and tractors with a chassis or a container. Non-port-related diesel-fueled vehicles included medium- and heavy-duty diesel-fueled vehicles, which could include moving vans and platform, public utility, wrecker or tow, delivery, and dump trucks, as well as five-axle noncontainer HDDTs, such as delivery trucks, gravel trucks, and tankers.

RESULTS

Intersection Port Truck Patterns

Direct measurement of the traffic at key intersections north of the Ports of Los Angeles and Long Beach demonstrated that surface streets west of the I-710 freeway are heavily affected by port-related container trucks heading eastward to I-710 and northward to major truck and intermodal facilities. The port diesel-fueled truck traffic traveling through Site 111 on the southwestern edge of the study area is heavily influenced by the operations schedule of the Trans Pacific Terminal because the intersection serves as a major entrance to the facility and connects trucks to Harry Bridges Boulevard to the east and the Figueroa Ramp to the I-110 freeway to the north (Figure 1). The average number of port-related diesels passing through this site in a 30-min period on a weekday was 184, with a maximum of 256 (Table 1). Site 132 to the west, which carries trucks that converge from multiple terminals en route to and from the I-710 freeway to the east and to and from Alameda Street to the north, had the highest numbers of port-related vehicles, with a mean of 254 and a maximum of 339 (Table 1). Those port-related diesels, which travel farther north on Alameda Street from Site 132, could pass Site 213, which serves as a north–south linkage with the I-405 freeway and downtown Los Angeles. This segment also carried a substantial number of port-related diesels and had a mean of 241 and a maximum of 308 port-related diesels in a 30-min period (Table 2).

Sites 217 and 215, on Anaheim Street and PCH, respectively, are both on the north–south street of Santa Fe Avenue and represent major east–west corridors for container trucks traveling to and from I-710 to park or queue between loads or stop for amenities. The average number of port-related diesels passing through Site 217 in a 30-min period on a weekday was 170; the maximum was 204 (Table 1). Site 215, to the north on PCH, had an average 30-min volume of port-related trucks of 148 and a maximum of 177. This lower level could partially be because Site 215 has several chain and local restaurants and a nearby high school and thus has more weekday passenger car traffic (an average of 1,437 compared with an average of 1,108 at Site 217). Higher volumes of passenger cars at Site 215 may encourage trucks to travel through Site 217, the more southern route to the I-710 freeway. The traffic at Site 215 was also monitored on a Saturday to provide a snapshot of weekend port-related truck patterns. The average 30-min volume was 69 and the maximum was 91, about half of the observed weekday volume at this site.

HDDT volumes were higher at Site 212, the northern terminus of the Terminal Island Freeway (Table 1). Trucks are prohibited from traveling east on Willow Street. Site 212 serves as a north–south linkage between Terminal Island in the port complex and the entrance to Union Pacific's intermodal ICTF west of Site 212 on Sepulveda Boulevard. Sepulveda Boulevard also links the Terminal Island Freeway and Alameda Street and provides a northern connection to the I-405 freeway and downtown Los Angeles. The segment-level monitoring of Site 211 on Sepulveda Boulevard west of Union Pacific's ICTF documented a mean port-related diesel vehicle volume of 150 per 30-min observation period and a maximum of 237, with an average volume of 28% port-related diesel trucks (Table 2).

Port-related vehicles constituted about 27% of the traffic at Site 212 on both observation days (Table 1). The average number of port-related diesels passing through Site 212 in a 30-min period on the first standard weekday of monitoring was 202, and the maximum was 307. This maximum level was sustained for the entire monitoring period (14:00 to 15:00 h), resulting in a maximum total hourly volume of port-related trucks of 600. Notably, the volume of passenger car traffic was lower at this intersection than at Sites 217 and 215. This intersection was monitored for a second weekday because of the potential impact of a longshoremen union strike on port-related truck traffic during the first sampling day. The second sampling period was extended on the second monitoring day from 5:30 to 20:00 h to better understand early morning and early evening

TABLE 1 Intersection-Level Traffic Counts (30 min), HDDT Traffic Sites

	Site 111, 8/29 Tues. 8:00–18:00 1-h Collection		Site 132, 9/6 Wed. 8:00–18:00 1-h Collection		Site 212, 8/22 Tues. 7:00–18:00 1-h Collection	
Vehicle	30-min Mean	30-min Max.	30-min Mean	30-min Max.	30-min Mean	30-min Max.
All Vehicles						
Port diesel	184	256	254	339	202	307
Nonport diesel	39	55	82	106	29	53
Passenger/clean bus	544	1,052	888	1,423	535	974
Grand total	767	1,225	1,224	1,755	765	1,160
% All Vehicles						
Port diesel	26	37	21	26	27	37
Nonport diesel	6	10	7	10	4	8
Passenger/clean bus	69	88	72	81	69	86

truck traffic patterns resulting from the shift of the nearby ICTF to an extended schedule. The average number of port-related diesels passing through Site 212 in a 30-min period on the second day was 200, with a maximum of 305, in excellent agreement with the data from the first monitoring day at this site. Again, the hourly maximum was more than 600 port trucks per hour in the period of monitoring from 14:00 to 15:00 h.

Table 3 provides summary statistics for the counts at intersections with relatively low levels of port-related diesel traffic. Site 118, which is adjacent to Banning High School in Wilmington, is dominated by passenger vehicles, which made up, on average, 96% of the intersection traffic and carried, on average, 11 port-related diesel vehicles per 30-min monitoring period. The results for Sites 311, 312, and 314, in the Long Beach neighborhoods east of the I-710 freeway, showed that the volumes of passenger vehicles at these intersections were, at times, more than 1,500 vehicles per 30-min period.

TABLE 2 Segment-Level Traffic Counts (30 min), HDDT Traffic Sites

	Segment Only		Segment Only	
	Site 211, 9/14 Thurs. 8:00–18:00 30-min Collection		Site 213, 9/20 Wed. 8:00–18:00 30-min Collection	
Vehicle	30-min Mean	30-min Max.	30-min Mean	30-min Max.
All Vehicles				
Port diesel	150	237	241	308
Nonport diesel	31	49	80	112
Passenger/clean bus	355	626	453	823
Grand total	536	871	774	1,162
% All Vehicles				
Port diesel	28	34	32	42
Nonport diesel	6	11	11	20
Passenger/clean bus	65	80	56	77

Diurnal Patterns

The results also provide new insight into the diurnal variation and intensity of container truck traffic on surface streets near port facilities. The patterns varied somewhat over the sites with higher levels of diesel traffic (Figures 2*a* and 2*b*). The sites in Figure 2*a* generally had two sustained peaks, with one in the morning and one in the afternoon. The midday reduction in HDDT traffic seemed to correspond to terminal lunch breaks (*23*).

Site 132, at the intersection of Anaheim Street and Henry Ford, had the highest intersection-level port-related peak diesel vehicle traffic observed among all sites during the periods from 14:30 to 15:00 h and 16:00 to 16:30 h, with roughly 600 or more port-related diesels per hour. Site 217 on Anaheim Street had two sustained peaks of truck traffic, with a 30-min total of about 200 port trucks. The first peak was in the morning, from about 8:30 h until at least 10:30 h; and the second was in the afternoon, from about 14:30 h until 16:00 h. This pattern resulted in an observed hourly total of nearly 400 port-related trucks in the periods from 10:00 to 11:00 h and 14:00 to 15:00 h.

Although the level of port-related trucks at Site 215, to the north on PCH, was lower overall, the level was sustained just below 150 port-related trucks per 30-min period from 8:30 to 10:30 h and then rose to more than or about 150 from 11:30 to 16:30 h (Figure 2*b*). As with Site 217, the average number of port trucks per 30-min period dropped to about 100 by 17:30 h. This afternoon decline corresponded to a substantial increase in commute-related passenger vehicle traffic. The overall volume of port-related trucks was lower on Saturday at Site 215, with the highest volumes being between 50 and 100 port trucks per hour from 9:00 to 12:00 h.

Site 212 had higher port-related truck traffic, resulting in more than 300 trucks per 30-min period in the periods from 10:00 to 11:00 h and 14:00 to 15:00 h, or more than 600 port-related trucks observed per hour (Figure 2*a*). Port-related truck volumes were more than 200 per 30-min period for nearly 8 h. The peak of more than 300 trucks from 14:00 to 15:00 h declined during the period from 16:00 to 16:30 h to between 150 to 200 port-related trucks per 30-min period. This decline corresponded to a substantial increase in commute-related passenger vehicle traffic. Monitoring of Site 212 included extended sampling (data not shown in Figure 2*a*), which documented an increase in port-related truck traffic at about 18:30 h as the commute traffic decreased to close to 250 port trucks per 30-min period and

	Site 212, 9/19 Tues. 5:30–20:00 1-h Collection		Site 215, 8/15 Tues. 8:30–18 30-min Collection		Site 215, 8/26 Sat. 7:30–18 30-min Collection		Site 217, 8/16 Wed. 7:00–18:00 1-h Collection	
	30-min Mean	30-min Max.	30-min Mean	30-min Max.	30-min Mean	30-min Max.	30-min Mean	30-min Max.
	200	305	148	177	69	91	170	204
	26	44	74	105	44	62	79	130
	541	878	1,214	1,650	1,041	1,186	858	1,282
	766	1,150	1,437	1,843	1,153	1,311	1,108	1,463
	27	44	10	13	6	8	16	23
	3	7	5	8	4	5	8	11
	70	96	84	92	90	96	77	88

which remained at between 150 and 200 trucks per 30-min period until 20:00 h. Almost 375 port-related trucks traveled through this intersection between 19:00 and 20:00 h.

Figure 2*c* profiles the diurnal port-related diesel vehicle traffic patterns for segment-level count locations. Site 213, on Alameda Street, had more than 200-related port diesel vehicles during the morning observation periods and close to 300 port-related diesel vehicles during the observation periods between 14:00 and 17:00 h. Site 211, located on the segment of Sepulveda Boulevard immediately west of the ICTF, had just less than 150 port-related diesel vehicles for most of the morning periods, and the traffic peaked in the afternoon, with nearly 250 port-related diesel vehicles from 16:30 to 17:30 h. The port-related diesel traffic at both sites declined substantially with the increase in commuter passenger vehicle traffic.

The diurnal fluctuations of port-related truck traffic on surface streets did not necessarily correspond to the diurnal patterns for goods movement freeways on the basis of the WIM data available for 2001 and 2002 for I-710 about 6 mi north of the study area during the same months as the present study. These data indicate that the volume of five-axle trucks increased from more than 150 trucks per hour at about 5:00 h to a peak of about 2,000 trucks per hour at 11:00 h and then declined after a plateau at between 12:00 and 13:00 h to the early morning levels by late evening.

DISCUSSION OF RESULTS

The results presented here raise environmental justice concerns by documenting the distribution and extent of HDDT traffic within the nonwhite and low-income communities of Wilmington and western Long Beach, adjacent to the Ports of Los Angeles and Long Beach. Traffic levels are often sustained at 400 to 600 trucks per hour for several hours during the day immediately upwind of schools; open-field parks; and residences, including affordable housing. These volumes are as high as or higher than those in Hunts Point, New York (*20*), and raise concerns about the elevated levels of diesel exhaust on nearby sidewalks and at local businesses and eating establishments. The California ARB recommends that sensitive land uses, including residences, schools, day care centers, and playgrounds, be sited at least 500 ft or farther from high-traffic roadways (*26*).

TABLE 3 Intersection-Level Traffic Counts (30 min), Low-Diesel Traffic Sites

	Site 118, 8/29 Tues. 7:30–18 30-min Collection		Site 311, 8/31 Thurs. 7:30–18 30-min Collection		Site 312, 9/7 Thurs. 7:30–18 30-min Collection		Site 314, 9/5 Thurs. 7:30–18 30-min Collection	
Vehicle	30-min Mean	30-min Max.	30-min Mean	30-min Max.	30-min Mean	30-min Max.	30-min Mean	30-min Max.
All Vehicles								
Port diesel	11	17	2	8	1	2	2	4
Nonport diesel	56	77	34	47	47	66	41	57
Passenger/clean bus	1,661	2,288	1,738	2,442	1,533	1,889	1,749	2,146
Grand total	1,728	2,344	1,774	2,458	1,580	1,911	1,792	2,185
% All Vehicles								
Port diesel	1	1	0	1	0	0	0	0
Nonport diesel	3	5	2	3	3	5	2	4
Passenger/clean bus	96	99	98	99	97	99	98	99

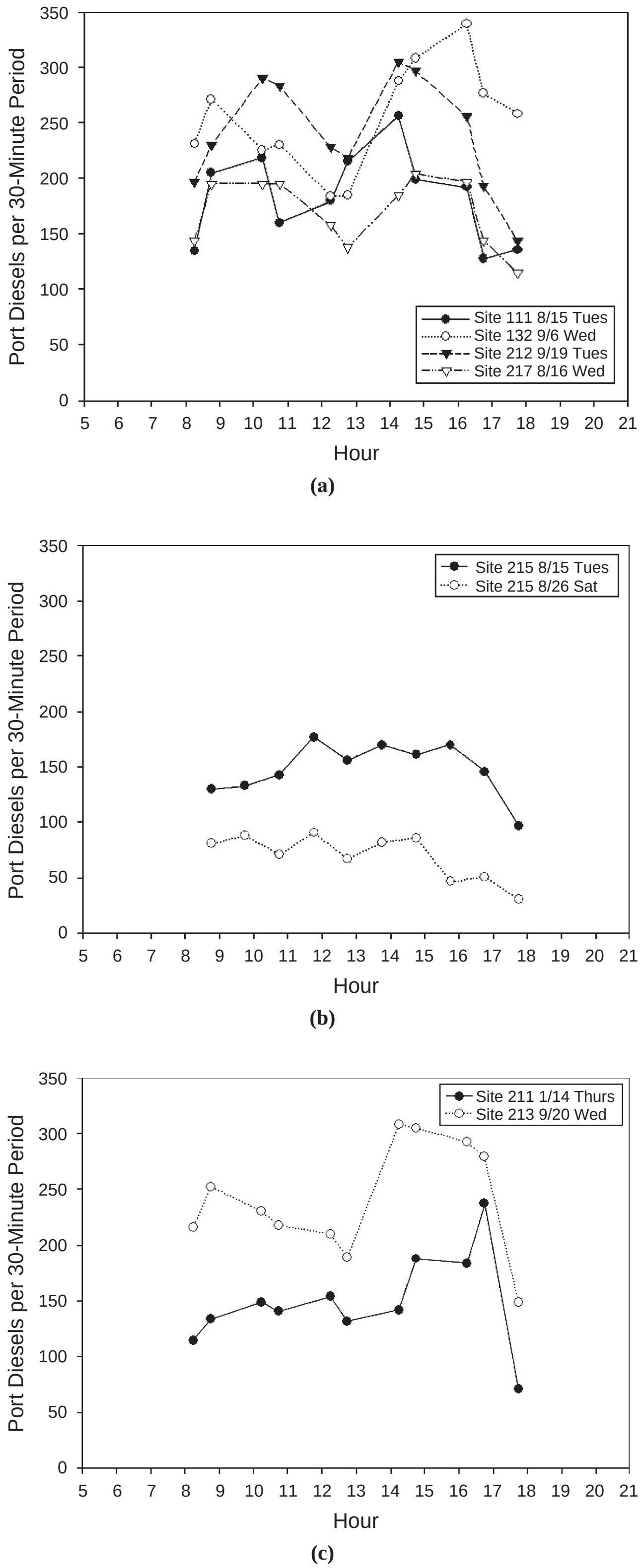

FIGURE 2 Diurnal patterns of measured port-related diesel traffic: (*a*) intersection-level counts, 1-h collection period; (*b*) intersection-level counts, 30-min collection period; and (*c*) segment-level counts, 1-h collection period.

Transportation projects implemented to improve the flow of HDDTs through adjacent communities should ensure a separation of at least 200 m, or about 650 ft, from sensitive land uses to mitigate community exposure to diesel exhaust. Further research is needed to better understand the extent to which barriers such as sound walls or landscape buffers can mediate near-roadway pollution. The planning process should incorporate community feedback from the beginning, especially during the envisioning and the development of alternatives. Early efforts to expand the I-710 freeway for increased port HDDT traffic failed because of a technical planning process that defined alternatives without the feedback of community members and elected officials of the adjacent communities. After the inclusion of their feedback, the process was refocused to consider concerns over air quality and public health more fully (*27*).

Given projected port expansion, land use conflicts are likely to result in community exposures to diesel exhaust pollution beyond those associated with regional ambient air pollution. One of the most apparent of these land use conflicts occurs alongside the Terminal Island Freeway, which carries high volumes of port HDDTs to and from Union Pacific's ICTF, in close proximity to a preschool facility, Hudson Elementary School, the recreational fields at Cabrillo Senior High School and Hudson Park, and the Villages of Cabrillo housing complex for homeless veterans. The findings of this study document that 300 to 600 port-related HDDTs pass just across a chain-link fence from these sensitive land uses for much of the day and into the night, raising serious health concerns.

Community opposition and concern over port-related emissions have stalled major port infrastructure projects for 6 years (*28*), including the expansion of near-dock rail yards. Union Pacific hopes to double the capacity of its ICTF yard, and Burlington Northern Santa Fe (BNSF) plans to construct a new 180-acre intermodal facility south of Sepulveda Boulevard and parallel to the Terminal Island Freeway, called the Southern California International Gateway (SCIG) (Figure 1). SCIG could divert as many as 1 million annual truck trips headed for the transfer facilities near downtown from the I-710 freeway by transferring containers onto rail at SCIG for transport northward via the Alameda Street corridor (*29*). Original plans for SCIG called for green alternatives for on-site machinery, including electric cranes, liquified natural gas or equivalent tractors, and low-emission switching engines. Opposition by local residents and elected officials persisted, despite these touted benefits, because SCIG would multiply the number of "dirty" HDDTs in their communities. In response, BNSF pledged in May 2007 that all HDDTs serving SCIG will meet 2007 emissions standards and will travel only on nonresidential truck routes (*30*).

Even with a "clean" HDDT fleet, some residents remain concerned that a doubling or tripling of truck traffic could worsen overall air quality and call for the expansion of the on-dock loading capacity within the main port complex. The port is currently studying the feasibility of a zero-emission mover system that would transport containers from the docks to SCIG and ICTF and eliminate substantial HDDT traffic in adjacent communities (*31*).

The extended hours of operations of the ports and truck-related facilities in the community could have substantial impacts on neighborhood truck traffic. This shift is driven by the success of the PierPASS program, which provides incentives for cargo owners to move cargo at night and on weekends by charging a traffic mitigation fee on container movements during peak hours. Many facilities, such as ICTF, have also shifted to extended schedules to accommodate related container truck traffic. In the first year after the launch of the PierPASS program in July 2005, 2.5 million truck trips were diverted from peak port periods, representing 30% to 35% of the container cargo on a typical day (*32*). Although the goal of this program is to reduce truck traffic and pollution during peak daytime hours and to alleviate port congestion, this program could extend the hours that community residents who are nearby are exposed to port truck traffic and pollution.

New federal emissions and fuel standards for on-road diesels starting with 2007 models could result in a 90% reduction of oxides of nitrogen and PM emissions in new HDDTs compared with the 2004 diesel emissions standards (*33*). Diesel engines are quite durable, however, and can last for 30 years, which limits the near-term effectiveness of the new standards. The Ports of Los Angeles and Long Beach have recognized this limitation in their joint adoption of the San Pedro Bay Ports Clean Air Action Plan in November 2006, which includes the Clean Truck Program, which will reduce air pollution from harbor trucks by 80% in 5 years by replacing or retrofitting older frequent-caller trucks to ensure that the 16,500 short-haul trucks that regularly serve the ports meet, at a minimum, the 2007 control standards by 2012 (*33*).

In early November 2007, the Harbor Commissions of both ports took the first steps toward implementing this ambitious $1.8 billion plan by adopting measures to ban in a progressive manner older, unretrofitted HDDTs from entering the port facilities, starting with the prohibition of trucks manufactured before 1989 (about 15% to 20% of the current fleet) starting in October 2008. By 2012, HDDTs not meeting 2007 standards would not be allowed to enter the port complex. In coming meetings, the Harbor Commissions will consider other key aspects of how the program will be funded and structured. Many truckers are low-income, Spanish-speaking independent owners or operators without the financial resources to acquire new emission controls and are looking to the port for assistance. Some have called for a program that would force shipping companies to hire them as employee drivers to help them cover the costs of and maintain the newer, cleaner trucks. The trucking and shipping industries have largely resisted the requirements for cleaner trucks and new labor arrangements (*28, 34*).

Although new HDDT emissions standards could result in substantial reductions in the near-roadway concentrations of diesel PM, the impacts on the community and environmental justice concerns will likely persist, given that some control technologies, which greatly lower $PM_{2.5}$ concentrations, may increase the concentrations of ultrafine particles (*35*), which are believed to be associated with heightened near-roadway health impacts. Current air quality standards are based on particle mass (particles with diameters of <2.5 µm, or $PM_{2.5}$, and particles with diameters of <10 µm, or PM_{10}); but given the information in the recent literature, which associates health effects with levels of exposure according to the numbers of ultrafine particles (those <100 nm in diameter), regulatory action is needed to research and promulgate number-based PM emissions standards, a strategy currently being explored by European regulators (*36*).

The current study focused on surface streets in communities adjacent to ports and does not provide comparative data with which the extent to which residents are disproportionately exposed to near-roadway diesel exhaust can be assessed. Previous and ongoing studies, however, suggest that nonwhite and poor communities may bear sizeable impacts from port-related HDDT traffic. About 70% of the cancer risk from exposure to outdoor toxins in Southern California is attributed to diesel particulate emissions (*7*), and race plays an explanatory role in predicting the distribution of cancer risk from exposure to outdoor toxins (*37*). The I-710 freeway carries up to 180 to 230 vehicles per minute, with approximately 25% of that traffic being HDDTs, through the largely nonwhite and low-income Gateway Cities (*6*) and imposes significant air and noise pollution problems and traffic safety and congestion issues (*27*). Recent pollution monitoring near the port indicates that the levels of NO_2, $PM_{2.5}$, ultrafine PM, and black carbon are well above the background levels (*38, 39*). The traffic counts in the present study will support air pollution line-dispersion and exposure models that examine the distribution of exposures to vehicle and HDDT emissions in these largely nonwhite, low-income communities (*40*).

Community awareness, action, and resistance have refocused unchecked port expansion toward a vision for growing green that conditions future growth on greater protections for air quality and public health. Los Angeles Harbor Commission President S. David Freeman's remarks in support of the Clean Truck Program embody this shift and sense of increased public accountability. Citing that communities adjacent to ports have been subsidizing port growth with their lungs, he said, "We absolutely have to get this plan done to justify the expansion of the port" (*34*). This remark demonstrates that concern for the impacts of HDDT emissions on the low-income and minority communities adjacent to ports has become a requirement for port growth and signals the opportunity for environmental justice advocates to take a strong stance to ensure that this concern is translated into action that not only mitigates negative impacts but enhances community health for years to come.

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