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Comparison of the Marine Wood Borer Populations in Los Angeles Harbor in 1950-1951 with the Populations in 2013-2014

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Abstract.—A 14-month study was conducted of the marine wood borers present on suspended wooden blocks replaced monthly at nine stations in Los Angeles Harbor in 2013-2014, and compared to the results of a marine borer study conducted in 1950-1951. Many environmental changes have occurred in the harbor over the past 63 years. The harbor land mass of the outer harbor has been expanded towards the breakwater, channels deepened, and the water quality improved as a result of pollution abatement. Existing pilings removed, replaced or covered with two layers of polyethylene. The isopod *Limnoria tripunctata* and the bivalve *Lyrodus pedicellatus* were the principal species. The station located in the Consolidated Slip area of the inner harbor was the site of 87 and 58 percent of the *Limnoria* and *Lyrodus*, respectively, counted during the study. Neither of these species present at this station in 1950-1951. The dissolved oxygen concentration at this station improved from a mean of 0.1 ppm in 1950-1951 to a mean of 6.7 in 2013-2014 as a result of improved environmental conditions. Larval settlement at Cerritos Channel numbered in the thousands in 1950-1951 but only 22 were counted during the 2013-2014 survey. This difference was attributed to the effect of piling covering or removal. It is recommended that existing creosoted pilings be covered or removed in the inner harbor area since this was the region of greatest occurrence of wood borers in 2013-2014.

The purpose of this study is to determine if there have been any changes in the marine wood boring animal population in Los Angeles Harbor since the study conducted in 1950-1951. The principal marine wood boring animals in Los Angeles Harbor belong to the isopod genus *Limnoria* and to the bivalve shipworm family Teredinidae. Four species have been reported from Los Angeles harbor: *Limnoria tripunctata*, *L. quadripunctata*, *Lyrodus diegensis* [= *Teredo diegensis*] and *Bankia setacea* (Menzies, et al., 1963). Two additional species of crustaceans are known to ingest wood but unknown to cause damage to wood pilings. The amphipod *Chelura terbrans*, which lives within burrows made by *Limnoria*, and the copepod *Tisbe gracilis*, which occurs on wood blocks, ingests wood under laboratory conditions. (Barnard, 1955; Barnard and Reish, 1957).

The earlier study was initiated by Robert J. Menzies who proposed to study the occurrence and biology of the wood boring isopod *Limnoria* in Los Angeles Harbor as the subject for his doctoral dissertation at the University of Southern California. He contacted Carrol Wakeman, chief testing engineer of the Port of Los Angeles, in 1949 for assistance in his proposal. Wakeman was interested and offered the assistance of a boat. Menzies' major professor, Dr. John L. Mohr, suggested that the study be expanded to include the bivalve wood borers and fouling

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organisms. Mohr then established the Southern California Marine Wood Borer Council. The members included Wakeman, Harold Schiller of Baxter Creosoted Co., and other graduate students of Mohr. The group met in the home of Mohr to plan for the study. The one-year study, of whom the author of this paper (DJR) participated, was initiated in March 1950 and terminated in March 1951. Wood blocks were suspended at three depths for a 28-day period at 15 stations in Los Angeles—Long Beach Harbors. The wood blocks were removed, fouling organisms scrapped off and preserved, replaced with clean wood blocks and the wood borers identified and counted. Additional blocks were suspended for four months in order for the pallets, the identifying systematic character, of the bivalve Family Teredinidae, to mature. Publications on the occurrence of wood borers and fouling organisms as result of this study included: Menzies (1951), Menzies, et al. 1963), Barnard (1950, 1955, 1958), Reish, (1954, 1971a). The Council ceased to exist after the completion of the study. No survey of the occurrence of wood borers in the Los Angeles—Long Beach Harbors has been conducted since 1950-1951. Therefore, the objectives of this study were to compare the occurrence of wood borers in Los Angeles Harbor and their relationship to the environmental conditions in 1950-1951 with those in 2013-2014.

Los Angeles Harbor has undergone many changes in the ensuing 63 years since the previous wood borer study and only those which influence wood borer activity are enumerated herein. The Main Channel and West Basin have been dredged to accommodate larger ships. The harbor land mass has been extended towards the breakwater by construction of Piers 300 and 400 (compare Figure 1a with Figure 1b). Pollution abatement was initiated in the late 1950s and extended into the late 1960s which resulted in an improvement of water quality (Reish, 1971b). Pilings in the harbor were primarily wood timbers which had been creosoted to prevent the infestation of wood borers. However, the isopod *Limnoria tripunctata* is capable of penetrating creosoted wood pilings (Lee and Miller, 1980). The inner harbor area was characterized in the 1950-1951 period with little or no dissolved oxygen (Menzies, et al., 1963). With the improvement of water quality (Reish, 1971b) *L. tripunctata* and to a lesser extent *Lyrodus pedicellatus* was able to infect pilings and other wood structures in the inner harbor. As a means of combating the invasion of wood borers, the harbor department covered the wood pilings with 6 mm inner wrap of polyethylene and 20-30 mm of polyvinylchloride outer wrap which killed any existing borers and fouling organisms by suffocation and excluded new infestations.

Materials and Methods

Station designations coincided, in so far as possible, with those in 1950-1951. The stations are indicated in Figure 1a for the 1950-1951 survey, Figure 1b for those sampled in 2013-2014 and described in Table 1. The study began on August 18, 2013 and terminated on October 1, 2014. Douglas fir wood was purchased from a building supply company as in 1950. The wooden blocks were smooth and without knots. A 1.5 cm diameter hole was drilled in a wood block measuring 3.5 x 15 cm. The block was attached to the rope and suspended at mid-water depth for usually a 28-day period. A rope was weighted at the end and attached to a harbor structure. The block was removed at the end of the time period and replaced with a new block. A second block was attached to the rope at selected stations and removed in approximately four months to examine the pallets to distinguish between the two bivalve teredinid species. The water temperature and dissolved oxygen concentration were measured electronically each time with a YSI 556 multi-parameter meter at a depth of three feet from the surface (Table 1). The fouling organisms were removed from the block with a paint scraper and preserved in formalin for later identification of polychaetes. Each wood block was examined on the day of recovery and the wood borers were identified under a dissecting microscope. *Limnoria*

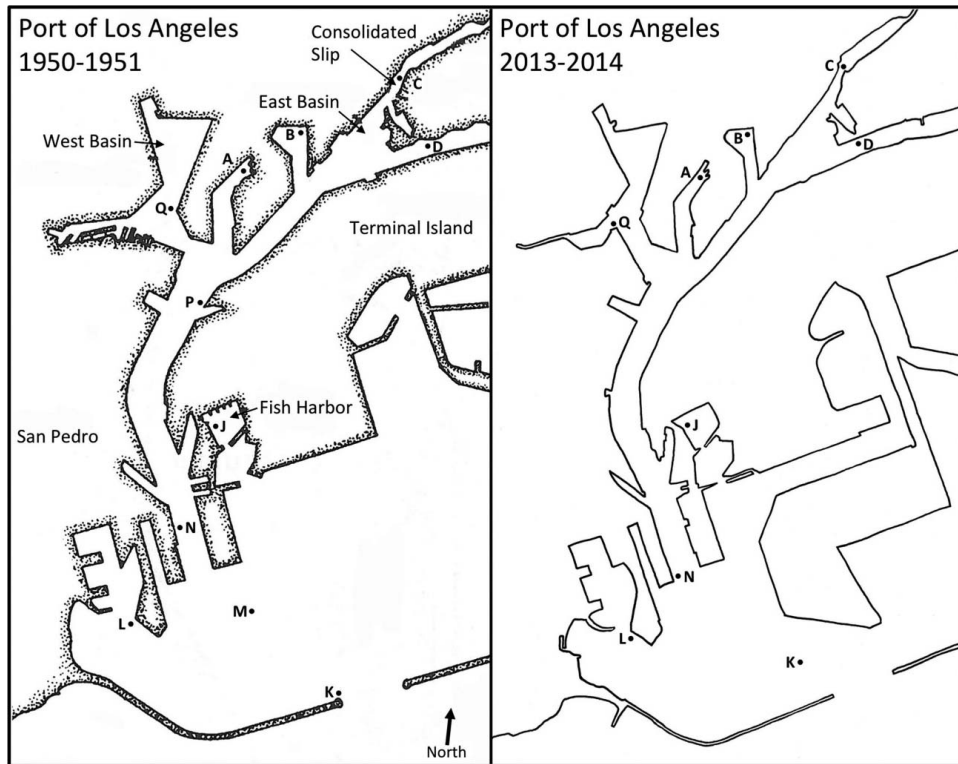


Fig. 1a. Map of Los Angeles—Long Beach Harbors showing the station locations in the Los Angeles Harbor survey conducted in 1950-1951. 1b. Map of Los Angeles Harbor showing the station locations in the 2013-2014 survey.

tripunctata is distinguished from the other species of the genus by the possession of three bumps on the telson which are visible under a dissecting microscope.

Results

Water temperatures three feet below the surface ranged from a low of 13.2°C (55.8°F) at Station K located near the harbor entrance in April 2014 to a high of 22.1°C (71.8°F) at Station C located in the Consolidated Slip area in September 2014 (Table 1). The mean temperature in Los Angeles Harbor during the 14-month study period was 17.7°C (63.8°F). The dissolved oxygen concentration ranged from a low of 5.97 ppm at Station D in Cerritos Channel to a high of 10.6 ppm at Station A located in Slip 1 in the inner harbor in December 2013. The mean dissolved oxygen concentration in Los Angeles Harbor for the 14-month study period was 7.6 ppm. Three species of wood borers were present on the test blocks: the isopod *Limnoria tripunctata*, the bivalve *Lyrodus pedicellatus* and the amphipod *Chelura terebrans*. The two colder water species *L. quadripunctata* and *Bankia setacea* present in the 1950-1951 study did not occur in the 2013-2014 study. *Limnoria* was present at all stations but Station K located near the harbor entrance. Station C located in Consolidated Slip accounted for over 87% of the *Limnoria* counted during the 14-month period (Table 2). It was present throughout the survey period at Station C with peaks in occurrence in April through July 2014 on both the monthly and quarterly exposed wood blocks. There were only 19 *Limnoria* present at nearby Station B, the second most in occurrence on the

Table 1. Environmental description, location of stations sampled in 2014-2014.

Station letter	Location	Depth* (in feet)	Water temperature °C range; mean	Dissolved oxygen ppm range; mean
A	Slip 1, Berth 160	11.3	15.3–21.2 (18.1)	6.1–8.5 (7.5)
B	Harbor Basin 5	19.9	14.2–20.4 (17.4)	6.7–8.5 (7.5)
C	Consolidated Slip	39.2	14.9–22.1 (17.7)	6.0–7.8 (6.7)
D	Cerritos Channel	32.4	15.2–20.9 (18.7)	6.6–9.0 (7.6)
J	Fish Harbor	17.9	13.6–22.6 (18.2)	6.7–9.9 (7.6)
K	Shoaling Marker A	20	13.2–21.1 (16.8)	7.3–9.1 (7.5)
L	Entrance W. Channel	31.6	11.3–21.6 (16.9)	6.6–8.6 (7.6)
N	Port Pilot station	20.3	13.4–21.2 (16.9)	7.1–8.8 (7.9)
Q	Entrance W. Basin	47	15.2–21.8 (17.8)	6.5–9.9 (8.1)

* Water depth relative to mean low water in outer Long Beach Harbor.

wood blocks. Only 11 *Limnoria* were counted from the four outer stations J, K, L and N during the 14-month study. *Lyrodus pedicellatus* was present at least once at all stations. Station C in the Consolidated Slip area accounted for 58% with a peak in September through October 2014. Nearby stations Q and B accounted for 19 and 13%, respectively. The bivalve occurred at all four outer station with largest numbers (29) observed at Station L. The amphipod *Chelura terebrans* was only found at Station C with one taken from monthly exposed wood block on October 1 and two from the longterm exposure ending in August in 2014.

Discussion

The mean water temperature at the nine stations in Los Angeles Harbor was similar in both studies with a median of 17.7°C (63.8°F) in 2013-2014 compared to 17.3°C (63.1°F) in 1950-1951. The lowest temperatures were measured in both studies at Station K; the highest temperature, 26.1°C (79°F), occurred at Station Q in the earlier study which was probably the result of shallow water at that time. The highest temperature of 22.6°C (72.7°F) was measured at Station J in Fish Harbor in 2013-2014. The dissolved oxygen concentrations were different with the range and mean of 5.97-10.6 (7.6) ppm in 2013-2014 compared to 0.0-7.7 (2.9) ppm in 1950-1951. The lack of dissolved oxygen occurred several times in the inner harbor and during fish canning season at Station J in Fish Harbor in 1950-1951. Three species of wood borers were present on the test blocks in 2013-2014: *Limnoria tripunctata*, *Lyrodus pedicellatus*, and

Table 2. Total number of wood borers present on wood blocks 2013–2014.

Station letter	Limnoria		Lyrodus	
	Monthly	Quarterly	Monthly	Quarterly
A	1	*	14	*
B	16	*	65	*
C	244 ¹		264 ¹	266
D	3	1	15	7
J	2	*	6	*
K	0	*	3	*
L	5	1	25	9
N	5	22	1	8
Q	1	*	63	*

* Quarterly wood blocks not exposed at these stations.

¹ One *Chelura terebrans* taken on October 2104 monthly block and two on the long term block August 2014.

Table 3. Comparison of the monthly total number of wood borers in 1950-1951 with 2013-2014.

Station	1950-1951 ¹		2013-2014	
	<i>Limnoria</i>	<i>Lyrodus</i>	<i>Limnoria</i>	<i>Lyrodus</i>
A	2	1	1	14
B	rare ²	rare ²	16	65
C	0	0	244	26
D	10	28,800	3	15
J	present ²	present ²	2	6
K	43	rare ⁴	0	3
L	14	18	5	25
N	328	18	5	1
Q	1	1	1	63

¹Numbers not always given in Menzies, et al., 1963.

²*L. tripunctata*, *L. quadripunctata*, and teredinids present when dissolved oxygen was high.

³All *L. quadripunctata*.

⁴*L. pedicellatus* rare in warm periods; 13 *Bankia setacea* in cold periods.

Chelura terebrans. The two colder water species *L. quadripunctata* and *Bankia setacea* were not present in 2013-2014 (Table 3). While the water temperatures were similar, the absence of these two species may be attributed to the lack of floating wood which would bring the colder water species from the north into the harbor by the prevailing California Current. Picking up floating pieces of wood was a convenient source of *Limnoria* which were used in laboratory experiments (Anderson and Reish, 1967). It was not until recent times that floating wood and debris were picked up by harbor personnel. There were three notable differences in comparing the wood borer data: (1) The near absence or lack of *Limnoria* and *Lyrodus* at the inner most harbor Stations A, B, C and Q in 1950-1951 was attributed to little or no dissolved oxygen in the water in 1950-1951, but the majority of these species occurred at these stations in 2013-2014 because of the improvement of water quality (Table 3). (2) Thousands of newly settled larvae of *Lyrodus* were noted at Station D in Cerritos Channel in 1950-1951 (Menzies, et al., 1963) but only a few were present in 2013-2014. This species has a pelagic larval stage and is capable of swimming some distance, but probably the majority came from local untreated or damaged pilings in the earlier study. These pilings had since either been removed or wrapped with polyvinylchloride to prevent infestation. (3) Station N in 1950-1951 was the primary site of *Limnoria* in 1950-1951 but not in 2013-2014 (Table 3) because all wood pilings had been wrapped. Wood borer infestation on test wooden blocks was low in the outer harbor stations and is probably now a minor problem to existing structures.

Conclusions

On the basis of the two studies conducted 63 years apart, the primary area of wood borer activity is now located in the inner harbor area especially at Station C in the Consolidated Slip and to a lesser extent in Basin 5. Three wood boring species were present in 2013-2014: *Limnoria tripunctata*, *Lyrodus pedicellatus* and *Chelura terebrans*. The colder water species *Limnoria quadripunctata* and *Bankia setacea* were not taken in 2013-2014. The covering of existing pilings with polyvinylchloride killed any existing populations by suffocation and prevented new infestations. It is recommended that either the existing pilings in Cerritos Channel be covered or removed. As a result, wood boring activity and potential damage will become minimal since new harbor construction predominately uses concrete pilings and any creosoted pilings that are added are wrapped.

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