The Effect of Temperature on the Distribution and Biomass of *Mytilus edulis* in the Alamitos Bay Area

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(1 Map)

INTRODUCTION

THE COSMOPOLITAN BIVALVE, *Mytilus edulis* Linnaeus, 1758 is abundant in bays and harbors in southern California. The purpose of the present study is to describe the distribution of this species with respect to water temperature in the Alamitos Bay area (Los Angeles County) where 4 large electrical power generating plants utilize bay water for cooling purposes and discharge the heated effluent into the lower San Gabriel River. The power plants increase sea water temperatures in the river up to 10° C above ambient, while other water quality parameters, such as salinity, pH, and dissolved oxygen concentration, appear not to be substantially changed.

Although *Mytilus edulis* is abundant in both Alamitos Bay and the lower San Gabriel River, its abundance appears to decrease in the warmer waters near the generating plants. The following study describes to what extent high water temperature affects the presence, size, and total biomass of *M. edulis* communities in the Alamitos Bay area.

MATERIALS AND METHODS

Alamitos Bay is a small boat harbor and marina used mainly for recreational puproses. *Mytilus edulis* forms a climax community on both floating boat docks and pilings throughout the Bay (REISH, 1964). Water is drawn from Alamitos Bay into electrical power generation plants for cooling purposes and then discharged into the adjacent San Gabriel River.

Sampling of *Mytilus edulis* took place at 3 stations within Alamitos Bay and 3 additional locations on the San Gabriel River. Samples were obtained by scraping all organisms from an area of concrete wall or piling from the high water mark vertically downward to the substratum using a putty knife 7.6 cm in width attached to a 3 m pole. The water depth at each station was 3 m (at mean sea level). Each sample was placed into a large plastic bag and returned fresh to the laboratory. The number of mussels in each sample was counted, the mussels were measured to the nearest millimeter and the wet weight of the entire sample was determined. No attempt was made to remove barnacles from the samples, so their weight is included in the results.

To determine how much of each sample was shell as opposed to animal (tissue) material, a dry weight and ash free dry weight were determined. Dry weight was determined after 24 hours at 105° C and the ash weight was taken after placing the dried sample in a furnace for 20 minutes at 600° C. The ash free dry weight was calculated by subtracting the ash weight from the dry weight and used as biomass of animal material for comparative purposes. The above procedure was used because in a dense *Mytilus edulis* community numerous shells of dead mussels are included in a sample.

To determine if any weight loss occurred due to CO_2 evolution of shell $CaCO_3$ during the furnace combustion, a pre-weighed sample of $CaCO_3$ was placed in the furnace with the mussels, and its weight change was measured along with that of the sample.

Water quality for the 2 habitats was also analyzed using the following methods: dissolved oxygen concentration was measured using a polarographic oxygen analyzer (International Biophysics Co.), salinity was determined with an American Optical Refractometer (sea water model) as total dissolved salts in parts per thousand, and water clarity was measured with a standard Secchi disc.

Water temperature was measured with an electronic telethermometer (Hydrolab, Mark IV).

RESULTS AND DISCUSSION

Dissolved oxygen concentration ranged from 8.0 to 10.3 ppm for the warm and cool stations with no apparent correlation to temperature. As waters are discharged from the generators with force, considerable turbulence and aeration probably occur and hence the warmer San Gabriel River has as much and often more dissolved oxygen as does Alamitos Bay. Salinity ranged from 32.8 to 34.0 ‰, while water clarity varied from 2.0 to 2.9m (Secchi disc), again with no consistent correlation for the 2 habitats.

In Alamitos Bay temperature measurements were taken at the collection sites and were 14.8° C on 18 February and 15.8° C on 1 April, 1971 when the study terminated.

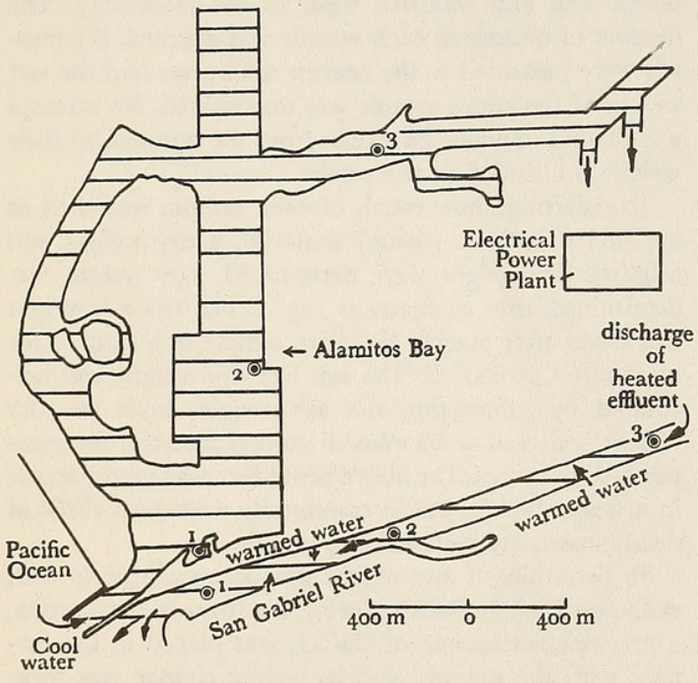

Figure 1

Alamitos Bay - San Gabriel River study site

Ambient temperature ocean water is drawn from Alamitos Bay and passed through four fossil fuel burning electrical power generating facilities and then discharged into the San Gabriel River. Three stations were located in the cooler waters of Alamitos Bay and three were located in the adjacent San Gabriel River

Water temperature in the San Gabriel River was considerably higher with a temperature gradient occurring between the generating plant outfall and the Pacific Ocean about 3.5km to the west (Figure 1). Site 1 in the San Gabriel River was located nearest to the generating plant (ca. 2km east of the ocean), with site 2 located about 1 km to the west and site 3 near the river's mouth. Temperatures taken near site 2 ranged from 22.7° C on 18 February to 25.0° C on 1 April, 1971. Undoubtedly, summer water temperatures are considerably higher than those measured in this study.

The warmer waters of the San Gabriel River appear to have a definite effect on the *Mytilus edulis* population size and biomass (Table 1).

The mean number of mussels collected in the colder Alamitos Bay waters was 321 per sample, while the mean for the San Gabriel River was 22 per sample. Shell length was not significantly different ($P < 0.05$) for the 2 habitats, but overall biomass was considerably greater in the colder habitat. The mean wet weight of Alamitos Bay samples was approximately 4 times greater than of those from the San Gabriel River, while the mean ash free weight (soft animal tissue only) was almost 10 times greater in Alamitos Bay samples (Table 1). There appeared to be no significant trend toward increased biomass of mussels in the cooler, down-stream stations.

Physical and biological environmental factors other than temperature may be responsible for the difference in numbers and biomass in these 2 habitats. However, standard water quality analyses for dissolved oxygen, salinity, and water clarity (Secchi disc) showed virtually no differences for the 2 habitats. LANDENBERGER (1967) found that *Mytilus edulis* distribution was significantly limited by sea star predation at the lower end of their vertical distribution on a pier piling. However, no sea stars were observed at any of the collection sites in the San Gabriel River, yet these predators were quite numerous in Alamitos Bay.

COE & FOX (1942) found that a related species, ***Mytilus californianus*** Conrad, 1837 which inhabits wave-exposed intertidal areas of southern California, showed a sharp decrease in growth in temperatures above 20° C. However, the mussels collected in this study were of similar size in both the warm and cool habitats, hence growth may not have been significantly affected by the warmed temperature of the San Gabriel River.

Perhaps the lower biomass of mussels in the San Gabriel River is due to the loss of both gametes and larvae by the sudden thermal shock upon transport through the power generation facilities. BARNETT (1972) reports some

Table 1

Numbers, size and weights of mussels from Alamitos Bay and the San Gabriel River

Site	Total Number of Mussels	Mean Size (mm)	Wet weight (gm)	Dry weight (gm)	Ash free dry weight (gm)
ALAMITOS BAY					
Station					
1	543	26.2	1831.0	1184.0	
2	289	32.9	2252.2	1030.7	
3a	227	47.7	2310.0	817.6	130.7
3b	*225*	*26.4*	*2348.6*	*1152.1*	*323.1*
X =	321	33.3	2185.5	1046.1	226.9
S.D. =	150.9	17.5	238.4	166.0	136.1
S.E. =	75.45	8.8	119.2	83.0	96.2
SAN GABRIEL RIVER					
Station					
1a	5	38.2	352.4	214.0	9.2
1b	8	33.2	521.0	330.0	8.3
1c	*8*	*33.7*	*449.7*	*278.9*	*3.7*
X =	7	35.0	441.3	278.9	3.7
S.D. =	2.45	2.75	85.1	66.9	2.96
S.E. =	1.42	1.59	49.2	38.7	1.71
2a	28	13.4	520.4	318.6	23.2
2b	58	25.8	616.7	350.5	40.0
2c	64	35.0	439.3	551.5	2.5
mean	50	24.73	525.5	406.87	21.9
S.D.	19.28	10.84	88.81	126.26	26.56
S.E.	11.15	6.27	51.335	73.0	15.35
3a	2	24.5	724.2	444.1	33.7
3b	3	28.3	669.4	439.6	30.6
mean	2.5	26.4	696.8	441.85	32.15
S.D.	1.96	2.69	38.75	3.18	2.2
S.E.	1.13	1.55	22.4	1.84	1.27

mortality of bivalve larvae, and CARPENTER *et al.* (1974) found mortality of copepods, upon passage through the cooling system of electrical power generation facilities. Since virtually all the water in the San Gabriel River (except during occasional heavy winter rains) passes through these power generation stations, and then flows back into the ocean there may be sufficient mortality to significantly lower the population size of *Mytilus edulis* in the San Gabriel River.

REISH (1964) found that larval settlement of *Mytilus edulis* in Alamitos Bay occurred in late winter and early spring when water temperatures would be coldest. Also, MOORE & REISH (1969) observed that mature ova of *M. edulis* were present in Alamitos Bay only in late fall and winter when water temperatures were 13 to 15° C. The almost immediate thermal shock of 25° C water, as ova or larvae are passed through the generation plants, may cause sufficient mortality to explain the small numbers of mussels in the San Gabriel River.

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