STATUS OF THE GENUS TILAPIA IN CALIFORNIA'S ESTUARINE AND MARINE WATERS

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Abstract. Breeding populations of Tilapia mossambica are now established in southern California marine and estuarine waters. Tilapia zillii has been collected twice in the marine environment. Survival in the marine environment, establishment of populations, geographic ranges, and the possible effect on other species are discussed.

INTRODUCTION

Tilapia mossambica and Tilapia zillii were introduced in 1973 at a number of freshwater locations in southern California (F. Hoover, Calif. Dept. of Fish and Game, Chino, Calif., pers. comm.). Several of these locations were within the Pacific slope drainage and during certain times access to the Pacific Ocean was available to these fish.

This paper is a documentation of (1) the establishment of Tilapia in California's coastal marine and estuarine waters, (2) present status of the genus Tilapia in California's coastal waters, and (3) possible consequences Tilapia may have on the marine environment.

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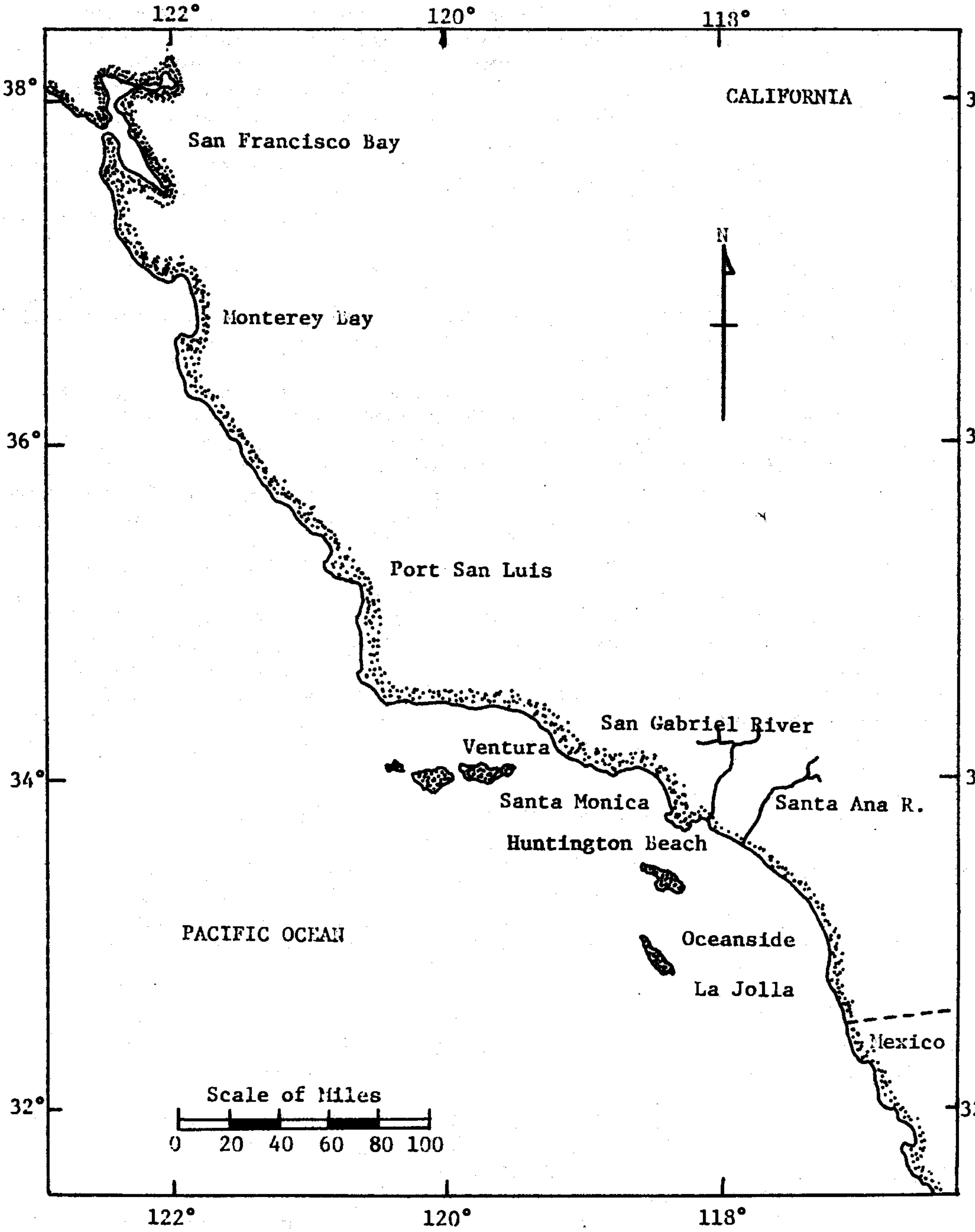
HISTORY OF ESTABLISHMENT

T. mossambica and T. zillii were introduced in 1973 into tributaries of the San Gabriel and Santa Ana Rivers in southern California (F. Hoover, Calif. Dept. of Fish and Game, Chino, Calif., pers. comm.). On August 3, 1974 the first large scale collection of T. mossambica were made in the estuarine portion of the San Gabriel River. These fish were identified and are now at

Fig. 1. Map of southern Califronia showing geographic locations.



the Natural History Museum of Los Angeles County (LACM 34065-1) fish collection. A fish kill of T. mossambica occurred in February 1975 at the upper end of the San Gabriel River tidal prism. Moyle (1976a 1976b) states that T. mossambica are established and confined to drainage ditches in the lower Colorado River Basin. A large breeding population of T. mossambica was observed in the estuarine portion of the San Gabriel River in August 1976; fish captured ranged in size from 27 mm standard length (SL) to 147 mm SL. Fish were mouth brooding and viable fry also were captured. A collection was made again in October 1976 which almost duplicated the results of the August collection.

On September 15, 1976 a breeding population of T. mossambica was located and sampled in the Los Cerritos flood control channel in Long Beach, California. This flood control channel is 1/2 mile west of the San Gabriel River. It is cement lined its entire length and collects "surface street" runoff only. Therefore, the source of these T. mossambica must be from the San Gabriel River stock. Spawning was still occurring at this location in October, while no spawning activity was observed in December, 1976 or January, 1977.

Another breeding population of T. mossambica was discovered the third week in October at Colorado Lagoon in Long Beach, California. This area is 2 1/2 miles west of the San Gabriel River. Fish were captured also in December.

Although the geographic range extensions are small, these new locations are outside of the San Gabriel River drainage and represent marine coastal areas. It should be noted that T. mossambica has been taken also on marine public fishing piers at Seal Beach and Long Beach, California.

T. zillii has been planted in over twenty ponds, lakes, and creeks in Los Angeles, Orange, and Riverside counties (Moyle 1976b). T. zillii was first captured in marine waters during a heat treatment at the Huntington Beach electric generating plant in Orange County on December 7, 1974. These fish are now in the fish collection at the Natural History Museum of Los Angeles County (LACM 36203-1). One specimen of T. zillii was captured in 1976 in upper Newport Bay.

A fish kill of Tilapia (an estimated 10 to 20 fish) occurred within tidal waters on October 9, 1974 in the East Garden Grove-Wintersberg flood control channel. This flood control channel enters Bolsa Bay near Seal Beach, California. Unfortunately identification to species was not made. Franklin Hoover with the California Department of Fish and Game checked the flood control channels in Orange County during July and August 1975 where T. mossambica and T. zillii were released. He did not find any Tilapia at this time.

PRESENT STATUS

Three breeding populations of T. mossambica are now established in California's coastal areas. The San Gabriel River location has probably been used since 1974, while the two other locations, Los Cerritos flood control channel and Colorado Lagoon, are estimated to be new and established in 1976.

At the present time, T. zillii has been collected twice in the marine environment and these collections were separated in time by two years. Therefore, T. zillii is probably not established in large breeding populations within California's marine coastal areas.

POSSIBLE CONSEQUENCES OF TILAPIA IN THE MARINE ENVIRONMENT

I believe there are three major considerations if Tilapia becomes established in marine waters: (1) probability of survival in the marine environment, (2) how far will they range, and (3) what will be the effect of *Tilapia* on other species?

Probability of Survival in the Marine Environment

There are a number of electric generating plants in southern California which use marine waters for cooling purposes. These waters are warmed in the plants and then discharged back into the marine environment. These waters would serve as a warm water reservoir for *Tilapia* to overwinter.

Low temperature survival studies on *T. mossambica* were conducted in 1965 by the California Department of Fish and Game at the Imperial Valley Warmwater Hatchery, and in 1968 and 1969 at the Chino Fish and Wildlife Base. Mortality began when the water temperature dropped to approximately 15.5°C and complete mortality occurred when it reached approximately 12.8°C. In Africa this fish is intolerant of 11°C or less in freshwater (Allanson, Bok, and van Wyh 1971).

Ultimate upper lethal temperature in freshwater was found to lie between 38.20°C and 38.25°C (Allanson and Noble 1964).

T. mossambica in Africa occurs more frequently in estuaries than in freshwater at its southerly limit of distribution (Allanson, Bok, and van Wyh 1971).

Allanson, Ernst, and Noble (1965) indicate that an increase in total dissolved solids (TDS) increases survival at low critical temperatures. Allanson, Bok, and van Wyh (1971) state that in *T. mossambica* the secondary chill coma following exposure to 11°C in freshwater is associated with decreases in plasma osmolarity, sodium and chloride ion concentrations. Fish exposed in seawater diluted to give a NaCl concentration of 5°/oo show no signs of coma nor are there decreases in osmolarity or sodium and chloride ion concentrations.

The water in the San Gabriel River tidal prism ranges from 30.8°C to 20.8°C, with most temperatures ranging from 24°C to 29°C. The 20.8°C temperature was right after a rainstorm when there was a large flow of freshwater coming down the river. These year-round temperature ranges indicate there would be no mortality to *T. mossambica* from temperatures in the lower San Gabriel River. If the warm water is coupled with the availability of year-round freshwater flows which are now entering marine waters in southern California, I think there is a high probability substantial populations may become established.

Brock (1954) found *T. mossambica* could spawn successfully in 34.8°/oo salinity. *T. mossambica* in the San Gabriel River and Los Cerritos flood control channel were spawning successfully and viable larvae were found in 34.5°/oo salinity. *T. zillii* are reported to live and reproduce in salinities between 10-45°/oo (Chervinski and Zorn 1974).

California Population Ranges

T. mossambica is adapted to the San Gabriel estuarine environment and now appears to be spreading slowly by establishing breeding populations in other marine coastal areas.

I have taken water temperature data from certain shore stations along the southern California coastline. Low lethal temperatures for increased salinities are not well documented, other than increased salinities increase the tolerance of *T. mossambica* to these low critical temperatures. Therefore, I have assumed that a total mortality would occur if temperatures fell below 12.8°C for *T. mossambica* and that a partial mortality would occur below 15.5°C. The temperature data (Table 1) indicate that a total mortality

Table 1. Number of days below 12.8°C at certain California shore stations

Year	La Jolla-Scripps Pier	Oceanside	Newport Beach Pier	Santa Monica	Ventura Marina	Port San Luis (Avila)
			longest consecutive days in parenthesis			
1963	0	1(1)	2(1)	9(3)	-	42(9)
1964	3(1)	5(5)	3(1)	18(9)	-	90(20)
1965	9(4)	12(9)	1(1)	17(5)	20(9)	45(13)
1966	1(1)	3(3)	5(4)	2(2)	26(6)	11(4)
1967	3(1)	5(3)	4(2)	2(2)	21(8)	23(11)
1968	0	3(1)	3(1)	0	16(11)	25(7)
1969	5(3)	3(3)	8(4)	4(3)	39(23)	18(5)
1970	10(9)	18(8)	9(3)	12(3)	25(12)	33(20)
1971	50(21)	51(17)	79(23)	62(17)	58(20)	124(27)
1972	35(13)	44(11)	29(16)	23(5)	44(17)	88(37)
1973	0	-	-	-	-	-
1974	18(3)	-	-	-	-	-
1975	21(6)	-	-	-	-	-
1976	0	-	-	-	-	-
			Number of Days Below 11.1°C			
1963	0	0	0	0	-	3(2)
1964	0	0	0	0	-	17(4)
1965	0	0	0	0	0	2(1)
1966	0	0	0	0	0	0
1967	0	0	0	0	0	0
1968	0	0	0	0	0	1(1)
1969	3(3)	0	0	0	1(1)	0
1970	0	0	0	0	3(2)	2(1)
1971	3(3)	1(1)	3(1)	7(7)	14(5)	25(15)
1972	0	0	0	0	5(4)	5(1)
1973	0	-	-	-	-	-
1974	0	-	-	-	-	-
1975	0	-	-	-	-	-
1976	0	-	-	-	-	-

Number of Days Below 10.0°C

All stations reported 10°C or above except Port San Luis - one day in 1964.

Table 2. Fish species and numbers captured in the San Gabriel River

1971

Species	Number	Percentage
Fundulus parvipinnis	1,122	84.0
Anchoa compressa	142	10.6
Atherinops affinis	63	4.7
Gambusia affinis	4	0.3
Dorosoma petenense	2	0.2
Paralichthys californicus	1	0.1
Leptocottus armatus	1	0.1
TOTAL	1,335	100.0

1976

Species	Number	Percentage
T. mossambica	376	94.0
Fundulus parvipinnis	10	2.5
Atherinops affinis	10	2.5
Gambusia affinis	4	1.0
TOTAL	400	100.0

Table 3. Composite fish species list for Alamitos Bay and Anaheim Bay, California

Species	Colorado Lagoon Allen (1976)	Alamitos Bay Reish (1968)	Anaheim Bay Klingbeil et al. (1975)
Mustelus californicus			x
M. henlei			x
Triakis semifasciata			x
Squatina californica			x
Platyrhinoidis triseriata			x
Rhinobatus productus		x	x
Myliobatis californica	x		x
Urolophus halleri	x	x	x
Albula vulpes	x		
Dorosoma petenense	x		x
Engraulis mordax	x		x
Anchoa compressa	x		x
A. delicatissima	x		
Porichthys myriaster		x	x
Gobiesox rhessodon		x	
Fundulus parvipinnis	x		x
Atherinops affinis	x	x	x
Leurethes tenuis	x		
Syngnathus leptorhynchus	x		x
Morone saxatilis			x
Paralabrax clathratus	x		
P. maculatofasciatus	x		x
P. nebulifer	x	x	x
Anisotermus davidsonii	x	x	
Xenistius californiensis	x		
Cynoscion nobilis			x
Genyonemus lineatus	x	x	x
Menticirrhus undulatus	x		x
Roncador stearnsii	x		x
Seriphus politus	x		x
Girella nigricans	x	x	
Cymatogaster aggregata	x	x	x
Embiotoca jacksoni	x	x	x
Hyperprosopon argenteum		x	x
Hypsurus caryi			x
Micrometrus minimus	x		
Phanerodon furcatus	x	x	x
Damalichthys vacca	x	x	x
Mugil cephalus	x		x
Gibbonsia elegans		x	
Heterostichus rostratus		x	
Xiphister mucosus		x	
Hypsoblennius gentilis			x
Sarda chiliensis	x		x
Peprilus simillimus			x
Clevelandia ios	x	x	x
Gillichthys mirabilis		x	x
Ilypnus gilberti	x		x
Quietula y-cauda	x		x
Leptocottus armatus	x	x	x
Clinocottus analis		x	
Scorpaenichthys marmoratus		x	
Citharichthys stigmaeus			x
Paralichthys californicus		x	x
Pleuronichthys verticalis			x
Paraphrys vetulus			x
Hypsopsetta guttulata	x		x
Symphurus atricauda			x
Tilapia mossambica	Oct. 1976	Sept. 1976	
Tilapia spp.			Oct. 1974

would occur in most years if it takes only a few days of low temperature to kill these fish. This temperature data also indicates that in certain years and certain areas an overwintering population could occur. In 1972, 169 consecutive days of temperatures above 15.5°C were recorded at La Jolla, 134 days in 1973, 200 days in 1974, 75 days in 1975, and 247 days in 1976. These days of higher temperatures are considered the time in which *T. mossambica* would increase its range.

T. zillii has a different temperature tolerance. Mortality studies done in freshwater on this species indicates that first mortality occurs at 11.1°C and total mortality at 7.2°C. This temperature data indicate there is little in the way of low temperatures (Table 1) to cause a complete mortality or prevent establishment anywhere in marine waters south of Port San Luis, California (Figure 1).

Tilapia's Effect on Other Species

The San Gabriel River was sampled in 1971 (Table 2) in the same area where *T. mossambica* is now established and seven species were found (letter dated 5 November 1976 from J. Parkhurst, County Sanitation Districts of Los Angeles County, California). The California killifish, *Fundulus parvipinnis*, was the most abundant fish by numbers captured. The San Gabriel River was sampled again on two occasions in 1976 and *T. mossambica* was the most abundant by numbers captured (Table 2). A total number of four species were found at this location. The electric generating plants were in operation both in 1971 and 1976, and no other modifications to the environment were made in this portion of the river.

If the reduced number of species and reduced numbers of each species is caused by *T. mossambica*; the effect of this fish on other coastal marine fishes may be large.

Three studies on either side of the San Gabriel River, from estuarine waters, show a large variety of fish (Table 3). Numbers of species captured in Anaheim Bay was 44, while in Colorado Lagoon 33 species were captured. *T. mossambica* now occur in Colorado Lagoon and Alamitos Bay, and should be added to the fishes found at these locations. *Tilapia* spp. has been captured in an extension of Anaheim Bay.

CONCLUSION

T. mossambica in California can spawn successfully in saline waters up to and including 34.5°/oo. Coastal marine water temperatures may cause mortalities of *Tilapia*; however, the large number of electric generating plants using ocean waters may create havens for overwintering populations. Effects of *Tilapia* may be dramatic on other species of marine fishes.

T. zillii would appear not to be established yet in coastal marine waters, while *T. mossambica* is slowly expanding its range.

T. mossambica appears to be one of the "milder" species in the genus *Tilapia*; therefore, I personally recommend that no other species of *Tilapia* be introduced into California's waters until we find out what effects *T. mossambica* is going to have on the marine environment.

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