Catch Distribution and Related Sea Surface Temperature For Striped Marlin *(Tetrapturus audax)* Caught off San Diego, California

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ABSTRACT

Records for 4,535 marlin landed at San Diego, California, and related sea surface temperature data were examined for the period 1963 through 1970 to determine time-space distribution and the relationship of catch and sea surface temperatures. For the period 1963 through 1970 the catch of 4,535 marlin was compared to sea surface temperature conditions relative to increased catches.

Catch distribution based on 1963 to 1967 data showed that 76.4% were caught within a 35- by 40-nautical-mile area off San Diego, with the maximum catch being made from mid-August to mid-September. Catch temperatures off southern California calculated for this area from airborne infrared sea surface temperature survey data ranged from 61° F (16.1°C) to 73° F (22.8°C); the mean catch temperature was 67.8° F (19.9°C).

Sea surface temperature conditions based on 2-week average temperature charts issued by the National Marine Fisheries Service indicate that an initial warming of water to an average temperature of 68° F (20.0°C) or above is related to an increase in catch. When average temperatures were below 68° F (20.0°C), 931 fish were caught; between 68° (20.0°C) and 70° F (21.1°C) the catch was 1,886 fish; and a further increase to 70° F (21.1°C) or above resulted in a catch of 1,718 fish.

Catch data and isotherm charts, 1963 through 1970, indicate that the continuity of the 68° F (20.0°C) and 70° F (21.1°C) isotherms from off central Baja California to off southern California is associated with improved fishing. When these isotherms were discontinuous the average catch per biweekly period was 82.0 fish; when these isotherms were continuous the average catch was 146.1 fish. The highest average catch per biweekly period (205.3 fish) was recorded when the 70° F (21.1°C) isotherm was continuous.

The striped marlin *(Tetrapturus audax)* is the object of a sport fishery in southern California waters during late summer and early fall. Sport fishing for striped marlin in these waters has been conducted since about 1903 (Howard and Ueyanagi, 1965) and striped marlin were caught commercially up to 1937. Since 1937 it has been illegal to land the species commercially in California. The early sport and commercial fishery was centered near Catalina Island and between the island and the mainland. In recent times the area off San Diego has experienced increased angling effort, and presently this area yields the largest number of sportcaught striped marlin. Most of the marlin are landed at three points in southern California: the Avalon Tuna Club, Avalon, Catalina Island; the Balboa Angling Club, Newport Beach; and the San Diego Marlin Club, San Diego. At these clubs each fish is weighed and information is recorded on a weight slip (Fig. 1).

Changes in sea surface temperature affect the distribution of many pelagic marine fishes commonly caught off southern California. During periods of high temperatures, greater numbers of the more important marine game species, such as Pacific bonito *(Sarda chiliensis)*, yellowtail *(Seriola dorsalis)*, and Pacific barracuda *(Sphyraena argentea)*, which are common to the lower west coast of Baja California, Mexico, migrate northward into higher latitides (Hubbs, 1916, 1948; Walford, 1931). Fishing success for albacore *(Thunnus alalunga)* off this area has been related to changes in sea surface temperature (Hester, 1961; Clemens and Craig, 1965). Radovich (1961, 1963) has also described the effects

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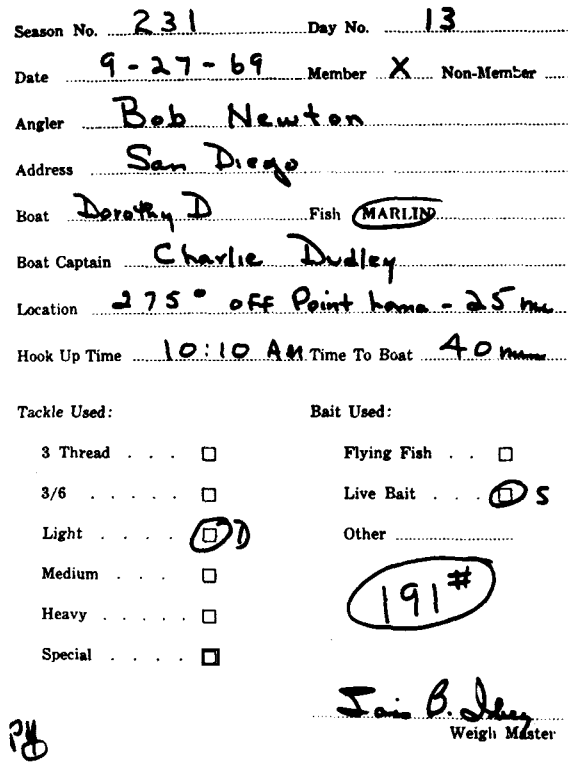
Season No. 231 Day No. 13
Date 9-27-69 Member X Non-Member
Angler Bob Newton
Address San Diego
Boat Dorothy D Fish MARLIN
Boat Captain Charlie Dudley
Location 275° off Point Loma - 25 mi.
Hook Up Time 10:10 AM Time To Boat 40 mins
Tackle Used:
3 Thread . . . □
3/6 . . . . . □
Light . . . . (D)
Medium . . . □
Heavy . . . . . □
Special . . . . □
Bait Used:
Flying Fish . . □
Live Bait . . . (D) S
Other
191#
Weigh Master

Figure 1.—Weight slip used by the San Diego Marlin Club, San Diego, California.

of water temperature on the distribution of scombrid fishes common to the water off southern California and Baja California.

There are many physical and biological factors that can affect the distribution of fishes. Temperature, salinity, turbidity, and food supply (plankton and forage species) are but a few of these factors. However, knowledge of the precise degree to which one or a combination of factors affect distribution is not known. Temperature as one of the easily measured factors has been shown in some instances to affect distribution of organisms.

Observations of sea surface temperature prior to and immediately after the start of good fishing might give us some clues as to thermal conditions that may be contributing to successful striped marlin fishing. In this paper the temporal and geographical distribution of striped marlin catches off San Diego from 1963 to 1967 are described, and the relation of surface water temperature to fishing success during the period 1963 to 1970 is examined.

Since more striped marlin were landed at the San Diego Marlin Club than at any other location, I used their catch records to determine the geographical distribution of the catch for each month of the fishing season. These records provided catch location for 3,923 fish, but the fishing effort expended in catching this amount of fish is not known. These catch distribution data and sea surface temperature data derived from airborne temperature surveys were used in the calculation of the average or mean catch temperature off San Diego for all striped marlin caught during the major months of fishing for the years 1963 through 1967.

The cooperation of the San Diego Marlin Club in allowing use of its catch records is appreciated.

CATCH DISTRIBUTION

The temporal catch distribution for the 1963 to 1967 period is shown in Table 1. Catch records indicate that August, September, and October are the months having the major catches of striped marlin. Few are caught in July, and usually the November catch is minor. Most fish are caught between mid-August and mid-October, with fishing during the first half of September yielding more catch than any other half-month period. Peak annual catches were recorded for every biweekly period, 16-31 August through 1-15 October, for the years 1963 to 1967.

Table 1.—Striped marlin catch landed at the San Diego Marlin Club during half-month periods, July-November, 1963-1967

Month	1st half	2nd half	Monthly total
July	0	31	31
August	163	841	1,004
September	1,279	612	1,891
October	450	250	700
November	297	0	297
		Total	3,923

For the months of August, September, and October, catch locations of striped marlin were plotted on a chart divided into block areas of 10-minute latitude by longitude dimension. These areas are identical to the block area system used by the California Department of Fish and Game for determining catch locations for commercial and party boat catches (Young, 1963). The total catch over the 5-yr period by block area is shown in Figure 2, and the catch for each month is shown in Figures 3-5. Figure 2 shows that the major fishing area off San Diego outlined by a dark border can be described as being within the boundaries of lat. 32°20'

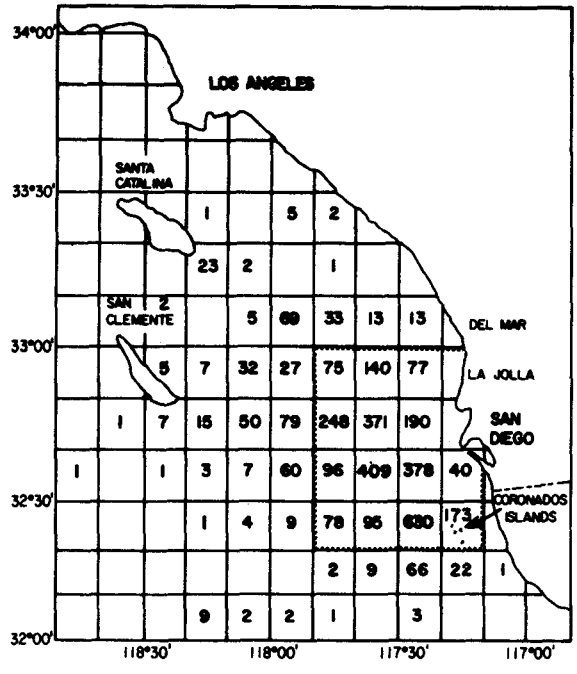

Figure 2.—Catch distribution of striped marlin landed at San Diego, California; August, September, and October 1963 through 1967.

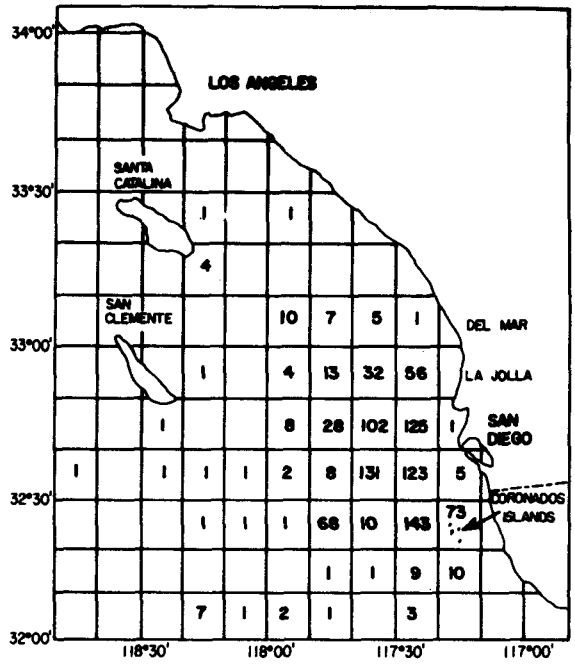

Figure 3.—Catch distribution for August 1963 through 1967.

and lat. 33°00′ N, long. 117°50′ W, and the coast from near Del Mar, California, to Rosarita Beach, Baja California, Mexico. This area accounted for 76.4% of all fish landed in these months at the San Diego Marlin Club.

CATCH AND TEMPERATURE RELATIONSHIP

Since August 1963, the National Marine Fisheries Service, Tiburon Coastal Fisheries Research Laboratory, Tiburon, California, has conducted once each month sea surface temperature survey flights off southern California in cooperation with the U.S. Coast Guard. These surveys are conducted from an aircraft using an infrared radiation thermometer (ART) to measure sea surface temperatures (Squire, 1972), and data are published in the form of isotherm charts. Comparison of 146 simultaneous sea surface temperature observations between the airborne instrument and a sea surface bucket cast showed an average difference of 0.35° F (0.2° C) (ART lower), a range of −1.9° F (1.1° C) to 1.2° F (0.7°C), and a standard deviation of 0.65° F

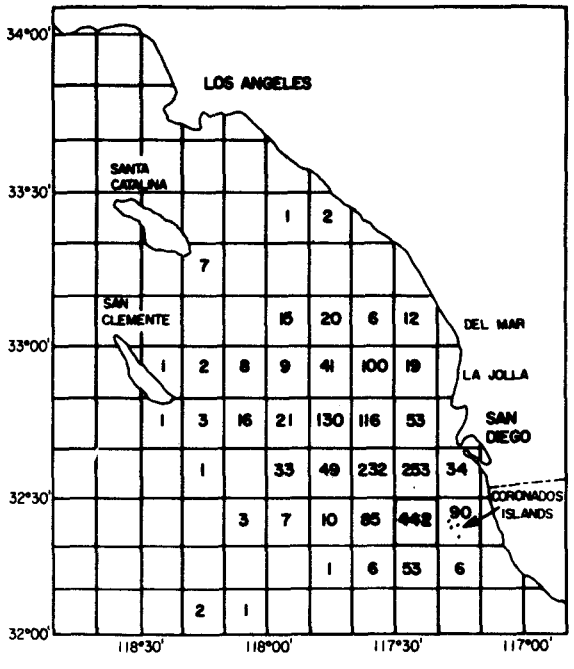

Figure 4.—Catch distribution for September 1963 through 1967.

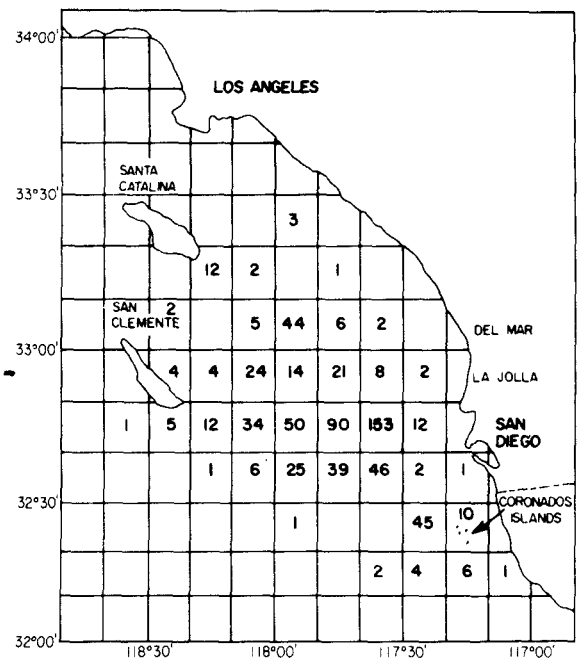

Figure 5.—Catch distribution for October 1963 through 1967.

Table 2.—Mean catch temperatures and numbers of striped marlin landed at the San Diego Marlin Club; August, September, October 1963 through 1967. Mean temperatures calculated from subjective temperature data and catch data for each 10-minute longitude by latitude block area.

Month	Year	Mean temp/month	# fish
August	1963	67.7° F (19.8°C)	605
	1964	68.0° F (20.0°C)	78
	1965	64.1° F (17.8°C)	25
	1966	71.2° F (21.8°C)	102
	1967	66.3° F (19.0°C)	194
September	1963	67.8° F (19.0°C)	717
	1964	69.3° F (20.7°C)	361
	1965	65.0° F (18.3°C)	124
	1966	67.0° F (19.4°C)	335
	1967	69.1° F (20.8°C)	354
October	1963	72.2° F (22.5°C)	73
	1964	66.5° F (19.1°C)	339
	1965	65.2° F (18.4°C)	147
	1966	69.0° F (20.8°C)	98
	1967	67.9° F (19.9°C)	43

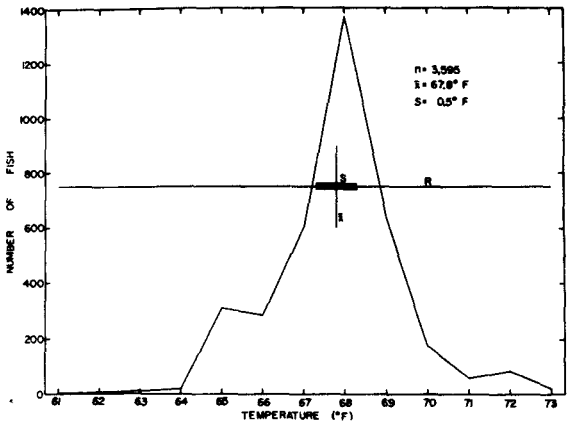

Figure 6.—Distribution of striped marlin catch by sea surface temperature showing the mean ($\bar{x}$), standard deviation (S), and range (R) of temperatures for all catches landed at the San Diego Marlin Club, California (1963-1967).

(0.36° C). From these isotherm charts a sea surface temperature value was estimated for each 10-minute block area where fish were caught as shown in Figures 3-5. Using these temperature data and the catch distribution data for the 10-minute block area, mean catch-temperature[2] figures were computed for striped marlin landed in August, September, and October for the period 1963-1967 (Table 2). Mean catch-temperatures by month for all fish landed were: August, 67.8° F (19.9° C); September, 68.0° F (20.0°C); and October, 67.3° F (19.6°C). Temperatures at which striped marlin were caught ranged from 61.0° F (16.1° C) to 73.0° F (22.8° C) with a mean overall catch temperature of 67.8° F (19.9° C) and a standard deviation of 0.5° F (0.9° C). The distribution of the catch relative to temperature for all catches is shown in Figure 6.

OBSERVATIONS OF TEMPERATURE ISOTHERMS OFF SAN DIEGO AND BAJA CALIFORNIA RELATIVE TO FISHING SUCCESS

For comparison of marlin catch to sea surface temperature for the period 1963 to 1970, temperature data for the area from southern California to off

[2] Each striped marlin had a temperature value associated with it; the mean catch-temperature was computed by summing the temperature values and dividing by the total number of entries.

the central west coast of Baja California were obtained from half-month average sea surface isotherm charts published by the National Marine Fisheries Service (U. S. Bureau of Commercial Fisheries, 1961). These isotherm charts are computed from sea surface temperatures reported by ships in the eastern Pacific. From examination of these isotherm charts temperatures off San Diego and to the south toward central Baja California were highest during the fishing seasons of 1963 and 1967, and lowest during the 1965 season (catches of 1,410, 602, and 296 respectively).

Of particular interest to fishermen is the time of the beginning of the fishing season. Early in the fishing season off San Diego during the period prior to an increase in sea surface temperature to 68° F (20.0°C) the total number of marlin caught was 115, 2.5% of the total catch of 4,535 fishes (1963-1970), whereas for the first half-month period of each year showing the 68° F (20.0° C) isotherm off San Diego. the catch totaled 824 fish, representing an increase to 18.2% of the total catch.

During the half-month periods, data show that temperatures were below 68°F (20.0° C) for 23 periods, and during this time a total of 931 fish, or an average of 40.5 fish/period, were caught. Temperatures were between 68° F (20.0° C) and 69.9° F (21.0° C) during 15 periods, and 1,886 fish were caught, resulting in an average catch of 99.2 fish/period. Temperatures of 70° F (21.0° C) or above for 14 periods resulted in a catch of 1,718 fish or an average catch of 122.7/period.

The numbers of marlin caught during the half-month periods when the 68° F (20.0° C) and 70° F (21.0° C) isotherms were continuous from off Baja California northward to off southern California were compared to the catch when these isotherms were discontinuous (Table 3). For examples of continuous and discontinuous isotherms in the area of study, see Figure 7.

Data show that during periods when the 68° F (20.0° C) or 70° F (21.1° C) average isotherms were continuous from off central Baja California northward to off southern California, a total of 2,046 fish was caught for an average catch/period of 146.1 fish, whereas a total of 1,599 fish was caught for an average catch of 82.0/period when these isotherms were discontinuous. During periods when the 70° F (21.1° C) average isotherm was continuous the largest catch per any period (570 fish) and the highest average catch rate/period (205.3 fish) was recorded.

Table 3.—Comparison of catch and catch rates during periods of continuous and discontinuous 68° (20.0°C) and 70° F (21.1°C) isotherms.

	68°F (20.0°C)	70°F (21.1°C)	Totals
Discontinuous Isotherms			
Catch	1,072	486	1,559
No. of periods	11	8	19
Av. catch/period	97.4	61.7	82.0
Continuous Isotherms			
Catch	814	1,232	2,046
No. of periods	8	6	14
Av. catch/period	101.7	205.3	146.1

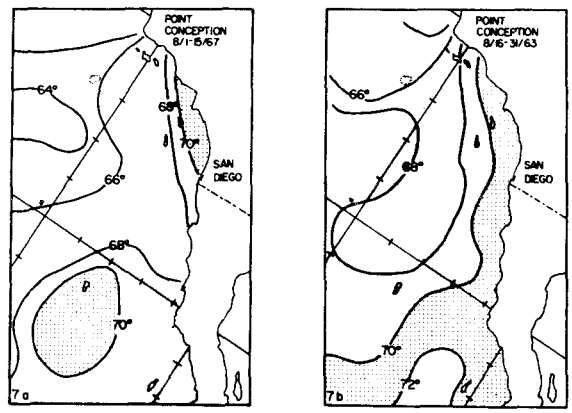

Figure 7.—Examples of discontinuous isotherms (7a) and continuous isotherms (7b) in the area of study.

From examination of the temperature structure of the waters off northern Baja California and southern California based on half-month average temperature charts it appears that 1) initial warming of the waters to an average temperature of 68° F (20.0° C) is related to an increase in catch, 2) continuity of the 68° F (20.0° C) or 70° F (21.1° C) average isotherms from off central Baja California northward to off southern California was associated with higher catches compared to catches when these isotherms were discontinuous.

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