State of California
THE RESOURCES AGENCY
Department of Fish and Game

STATUS OF PACIFIC MACKEREL SPAWNING POPULATION, 1973

Herbert W. Frey
and
Eric H. Knaggs

Marine Resources Region

FIRST ANNUAL PACIFIC MACKEREL REPORT

MARINE RESOURCES
Administrative Report No. 73-7

July 1973

STATUS OF PACIFIC MACKEREL SPAWNING POPULATION, 1973[1/]

SUMMARY AND RECOMMENDATIONS

This is the first annual report of the status of the spawning population of the Pacific mackerel as required by Section 8388.3 of the Fish and Game Code.

During 1972 and early 1973, several methods of determining population size were investigated as mechanisms for estimating the spawning population size of Pacific mackerel stocks north of Punta Eugenia, Baja California, and a method using tagging procedures proved to be the most acceptable. The estimate of the Pacific mackerel spawning population obtained by tagging procedures was 5,480 tons. This estimate agrees generally with those obtained from alternate methods in which previously computed spawning biomass estimates were correlated with partyboat catches in three different areas and the 1973 spawning biomass estimated from the resulting regression line. The estimates derived by these alternate methods are 6,970 tons, 4,730 tons, and 6,210 tons.

All estimates are below the 10,000 ton spawning population minimum and thus there is no excess by which a harvest under Section 8388.5 of the Fish and Game Code could be allowed.

INTRODUCTION

Pacific mackerel, Scomber japonicus, occur from the Gulf of Alaska southward into the Gulf of California. The species was never abundant north of Monterey Bay and in recent years has become scarce north of Point Conception.

1/ Prepared by Herbert W. Frey and Eric H. Knaggs, Marine Resources Region, 350 Golden Shore, Long Beach, California 90802.

The offshore extent of Pacific mackerel spawning populations, as deduced from larva catches is about 150 miles off southern California, 250 miles off northern Baja California, and 200 miles off central Baja California.

Pacific mackerel are capable of moving great distances. A tagging program conducted between 1935 and 1943 demonstrated that fish from as far north as Oregon and as far south as central Baja California enter the southern California fishery. Tag returns from the southernmost regions in which fish were tagged were relatively few and indicated areas south of Point Eugenia, Baja California (Figure 1), contributed little if anything to the California fishery. Results of an analysis of meristic

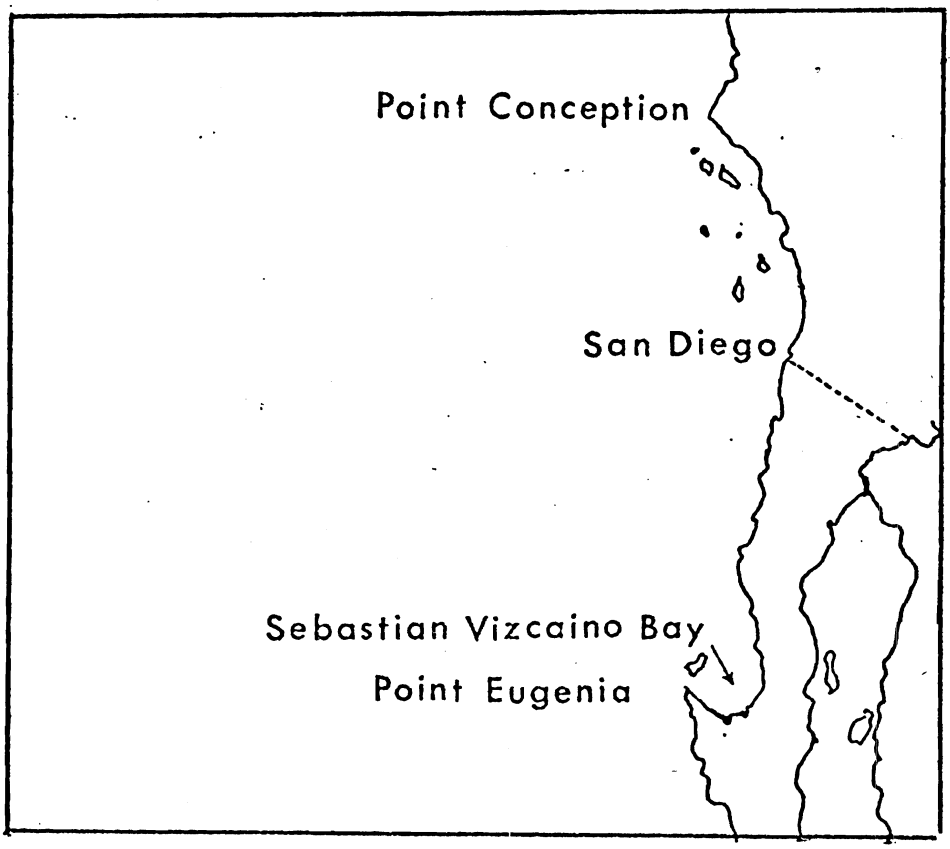

Figure 1. Major points of reference with respect to Pacific mackerel stocks off southern California and northern Baja California.

counts and body proportion measurements indicated fish from southern Baja California differ radically in many respects from fish in the northern region. Fish to the south of Point Eugenia are considered to be of a different stock; mingling little, if at all, with those to the north. As a result, Pacific mackerel north of Point Eugenia are considered as a single stock as far as management is concerned.

The Pacific mackerel for years supported one of California's most important fisheries, contributing large tonnages (Figure 2). Landings

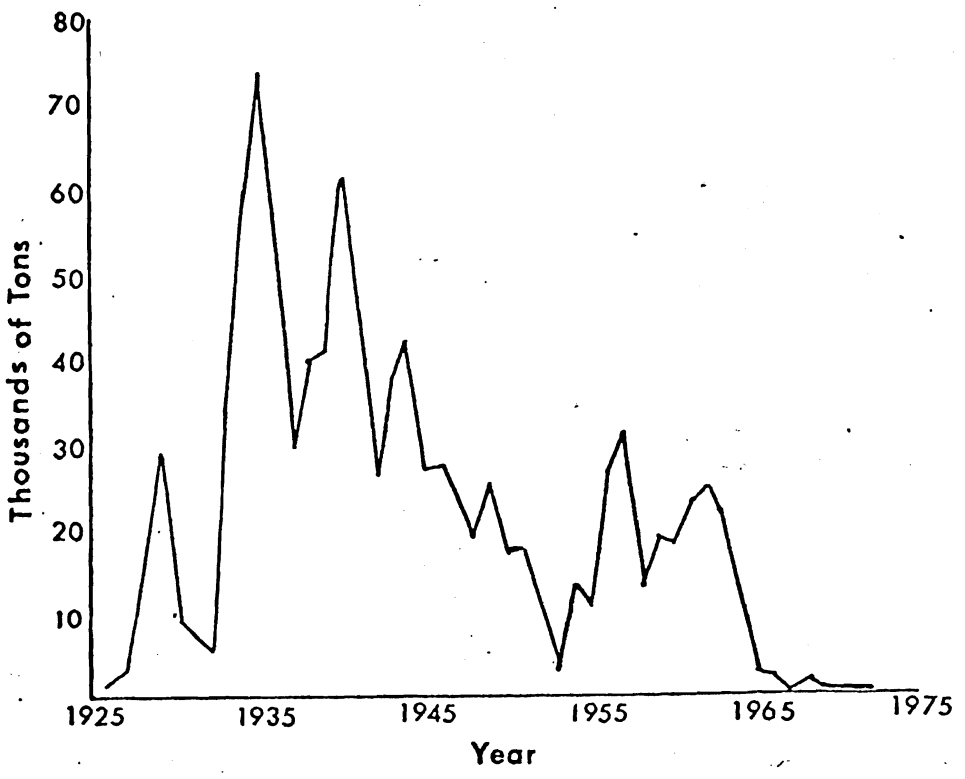

Figure 2. California commercial landings of Pacific mackerel, 1926-1972.

increased dramatically in the late 1920's, fell off in the depression years of the early 1930's and then rose to a peak of 73,214 tons in 1935. Since 1936, commercial landings declined to a low of 3,751 tons in 1953, experienced a partial recovery during the period 1956 to 1963, and have declined

since then. A moratorium placed on commercial fishing in 1970 was in effect until 1972, and since then a management law has limited the catches to only incidentally caught fish. In 1972 there were 54 tons (preliminary figure) of Pacific mackerel landed that were taken incidentally with other catches.

Pelagic fisheries off Baja California have undergone considerable development since World War II. Pacific mackerel landings remained fairly stable at 2,000 to 3,000 tons annually until 1955 when the catch rose sharply, and in 1956 Mexican landings reached 13,000 tons. Following this, landings again declined to a low level until the early and mid-1960's when large quantities of mackerel were again landed in Baja California. In 1963 over 11,000 tons of Pacific mackerel were landed, but landings had declined to only 16 tons in 1971 (Table 1). Mexican landings have been taken principally from the extreme southern end of the stock's range, in the area of Sebastian Vizcaino Bay (Figure 1), near Punta Eugenia.

Table 1. Statistical Data Pertaining to Baja California Pacific Mackerel Landings*

Year	Tons
1966	6,500
1967	1,072
1968	184
1969	289
1970	555
1971	16

*Data from Mexican Fisheries Department, Ensenada, Baja California, Mexico

Ocean sport anglers take thousands of Pacific mackerel each year. They are usually among the half-dozen species taken in greatest numbers in California's coastal waters. Partyboat landings accounted for 246,000 Pacific mackerel (an estimated 125 tons) in 1972. This partyboat fishery has been monitored by the Department of Fish and Game since 1947 (Figure 3).

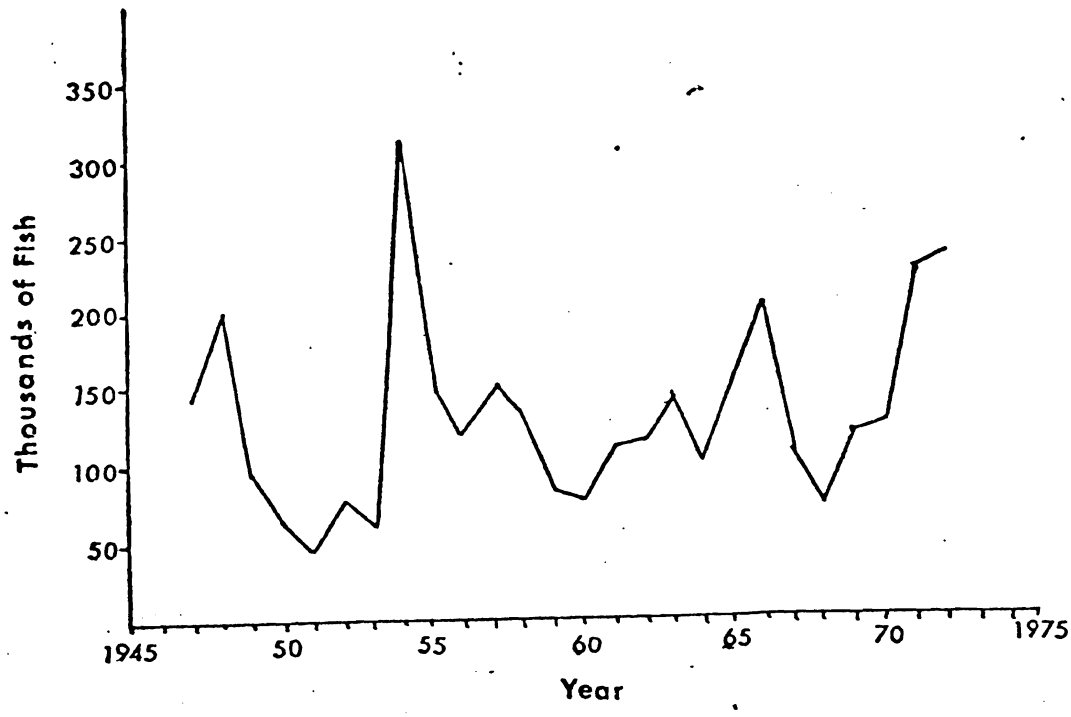

Figure 3. California partyboat catches of Pacific mackerel, 1947-1972.

POPULATION ESTIMATES

The Department of Fish and Game is required to make an annual estimate of the spawning population of Pacific mackerel to comply with Section 8388.3 of the Fish and Game Code (Addenda 1). During 1972 and early 1973, several methods of determining population size were investigated as machanisms for estimating the spawning population size of Pacific mackerel stocks north of Punta Eugenia, Baja California.

Tagging

The principle and most reliable estimate was made by using tag and recovery data (Addenda 2). This method involves the release and recovery of tagged Pacific mackerel and the utilization of age composition data from the partyboat catch to convert the total population to a spawning population estimate.

A total of 1,472 Pacific mackerel was tagged during 1972. Marked fish were recaptured not only near their points of release, but also a considerable distance from these release points (Figure 4).

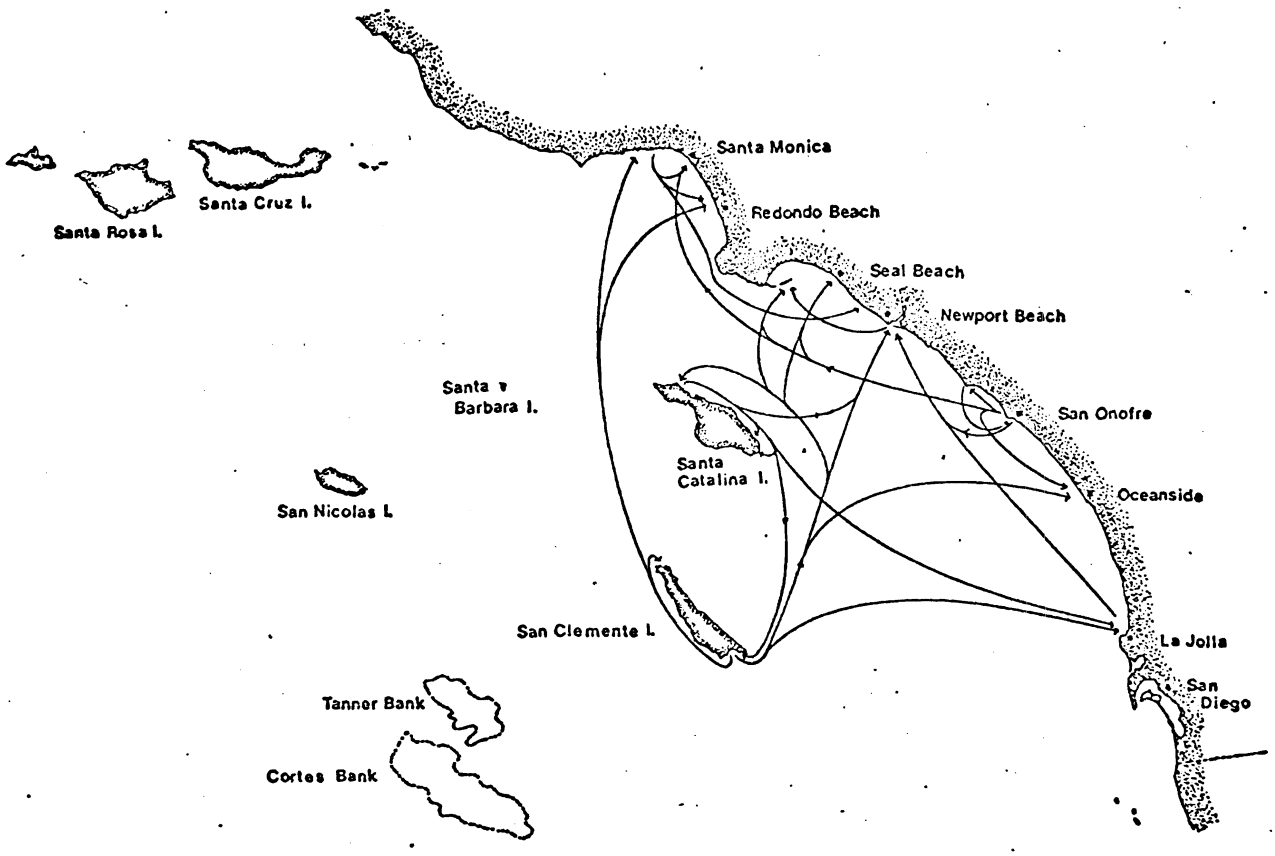

Figure 4. Movements exhibited by tagged and recaptured Pacific mackerel during 1972 and the first 5 months of 1973.

The catch data for Pacific mackerel were obtained from the mobile partyboat fleet operating in California and Mexican waters. Only tagged fish recaptured by the partyboat fleet were used to estimate the spawning population of Pacific mackerel.

The estimated size of the Pacific mackerel spawning population using tagging data is 5,480 tons.

Alternative Population Estimates

Three other sets of data were used to calculate additional estimates of Pacific mackerel spawning biomass independent of the tagging method.

The first set of data consisted of partyboat landings of Pacific mackerel captured in the waters around Santa Catalina Island correlated with corresponding estimates of spawning population determined for each year previous to 1969. These data were fitted with a trend line (Addenda 3). This statistical trend line is called a linear regression using a least squares fit. The spawning population estimate for 1973, as determined from the regression line, is 6,970 tons.

The second set of data consisted of partyboat landings of Pacific mackerel captured in the waters around the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands). These data were also correlated with previously computed spawning population estimates and fitted with a curved trend line which is called a power curve (Addenda 4). The spawning population estimate for this set of data is 4,730 tons.

The last set of data compiled from central California partyboat catches was used as an indicator of population size. These data were fitted with a

linear regression line using a least squares fit (Addenda 5). A spawning population of 6,210 tons was calculated from this set of data.

DISCUSSION

The Pacific mackerel resource stands a good chance of becoming rehabilitated in California under present management practices. While the Pacific mackerel population declined to an extremely low level during the 1960's due to a combination of poor recruitment and high fishing pressure, recruitment success in recent years gives reason for guarded optimism. Any relationship between recruitment and spawning population is obviously affected by other factors. Large variance in recruitment resulting from a given spawning population can occur because of environmental factors. These environmental factors can be adverse and may be part of the reason for good year classes failing to appear and for the present diminutive spawning stock of 5,480 tons.

The 1968 year class when first recruited appeared strong, but declined rapidly, and contributed little to the spawning population, although it was the strongest year class in many years. The 1969 year class was small, but the 1970 year class, presumably spawned by the 1968 survivors, is very strong and comprises a large portion of the present spawning population. The 1971 year class again was small, and while it is still too early to evaluate, the 1972 year class has made an early showing in incidental commercial catches and shows promise. The 1970 year class is approaching full maturity and provides for recruitment success in 1973 and 1974.

ADDENDA 1

Sections of California Fish and Game Code
Pertaining to Pacific Mackerel

8388. Except as provided in Section 8388.5, Pacific mackerel may not be taken or possessed at any time for any purpose except loads or lots of fish may contain 18 percent or less by weight of Pacific mackerel taken incidentally to other fishing operations. Such Pacific mackerel, incidentally taken, may be used for any purpose. (Amended by Stats. 1972, Ch. 608.)

8388.3. It is the intent of the Legislature that the Pacific mackerel resource be enhanced. During this process a fishery shall be allowed once the Pacific mackerel spawning population, in waters north of Punta Eugenia, Baja California, Mexico, has reached 10,000 tons as determined by the department. Such determination shall be made public in an annual report to the Legislature no later than July 31 of each year. It is also the intent that as the spawning population increases, in excess of 20,000 tons, the seasonal quota also be increased but at such a rate as to allow the continued increase in the Pacific mackerel population. This process should continue with the objective of maximizing the sustained harvest. (Added by Stats. 1972, Ch. 608.)

8388.5. Section 8388 shall remain in effect until the department determines that the estimated Pacific mackerel spawning population, in waters north of Punta Eugenia, Baja California, Mexico, exceeds 10,000 tons. When the department makes this determination, a season harvest quota equal to 20 percent of the amount of Pacific mackerel in excess of 10,000

tons spawning population, as determined by the department, shall be permitted under permits issued by the department.

When the department determines that the spawning population exceeds 20,000 tons, the harvest quota shall be increased to 30 percent of the excess over 20,000 tons.

The department shall keep records of the catch of Pacific mackerel and when it appears that the season quota will be reached, it shall notify all permit holders of the date when such limit will be reached and therefore the season closed, and shall notify, by certified mail, all permit holders of such closure. (Added by Stats. 1972, Ch. 608.)

8388.7. Subject to the provisions of Sections 8388 and 8388.5, Pacific mackerel season is from October 1 through September 30. (Added by Stats. 1972, Ch. 608.)

ADDENDA 2

Estimates of Pacific Mackerel Spawning
Biomass Using Tagging (Mark and Recapture) Methods

The total biomass was calculated using the equation:

$P = \Sigma n^2(m+u)/\Sigma nm$

where: P = biomass estimate in numbers of fish.

n = number of marked fish released into the population.

m = number of marked fish recaptured.

u = number of unmarked fish recaptured.

The values for the equation were calculated to be:

$\Sigma n^2(m+u) = 2.017618822 \times 10^{11}$

$\Sigma nm = 13061$

with the biomass estimate in numbers being:

$P = \Sigma n^2(m+u)/\Sigma nm$

$P = 2.01761882 \times 10^{11}/13061$

P = 15,447,660 fish

Conversion to pounds is accomplished by multiplying the number of fish times the average weight of fish sampled.

P = 15,447,660 fish X 1.0210 pounds

P = 15,772,060 pounds

The estimated proportion of spawning biomass (determined from age samples) to total biomass is .69444; therefore:

Spawning biomass = 15,772,060 X .69444

= 10,952,750 pounds

= 5,476 tons
(5,480)

ADDENDA 3

Estimates of Pacific Mackerel Spawning Biomass
Using Partyboat Catch from the Waters off Santa Catalina Island

The spawning biomass was calculated using a least square estimate of $\hat{a}$ and $\hat{b}$ fitted to the line $y = \hat{a}+\hat{b}x$

where: y = biomass estimate in thousands of pounds.

x = number of Pacific mackerel caught off Santa Catalina Island.

$\hat{a}$ = coefficient

$\hat{b}$ = coefficient

The coefficients $\hat{a}$ and $\hat{b}$ were calculated by using the following equations:

$$\hat{b} = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{n\Sigma x^2 - (\Sigma x)^2}$$

$$\hat{a} = \frac{\Sigma y - \hat{b}\,\Sigma x}{n}$$

A correlation coefficient was also calculated using the formula:

$$r = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

The values of the coefficients and the correlation coefficient are calculated to be:

$\hat{a} = -35224.24057$

$\hat{b} = 3.62720696$

$r = .93704902$

with the spawning biomass estimate for 1973 being:

$y = \hat{a} + \hat{b}x$

$y = -35224.24057 + 3.62720696\ (13,552)$

$y = 13,931,668$ pounds

$y = 6,966$ tons
(6,970)

ADDENDA 4

Estimates of Pacific Mackerel Spawning Biomass
Using Partyboat Catch Data from the Waters
off the Northern Channel Islands

The spawning biomass was calculated using a non-linear regression: least squares fit power curve. Data points were fitted to the formula:

$y = aX^b$

where: y = biomass estimate in thousands of pounds

X = number of Pacific mackerel caught off the northern Channel Islands

a = coefficient

b = coefficient

The coefficients a and b were calculated by using the following equations:

$$b = \frac{n \sum_{1}^{n} (\log_e x_i \log_e y_i) - (\sum_{1}^{n} \log_e x_i)(\sum_{1}^{n} \log_e y_i)}{n \sum_{1}^{n} (\log_e x_i)^2 - (\sum_{1}^{n} \log_e x_i)^2}$$

$$a = \exp\left[\frac{1}{n}\left\{\sum_{1}^{n} \log_e y_i - (\sum_{1}^{n} \log_e x_i) b\right\}\right]$$

A correlation coefficient was also calculated using the formula:

$$r = \frac{n \sum_{1}^{n} (\log_e x_i \log_e y_i) - (\sum_{1}^{n} \log_e x_i)(\sum_{1}^{n} \log_e y_i)}{\sqrt{\left[n \sum_{1}^{n} (\log_e x_i)^2 - (\sum_{1}^{n} \log_e x_i)^2\right]\left[n \sum_{1}^{n} (\log_e y_i)^2 - (\sum_{1}^{n} \log_e y_i)^2\right]}}$$

The values of the coefficients and the correlation coefficient are calculated to be:

$a = .008309748$

$b = 2.647169714$

$r = .7863828270$

with the biomass estimate for 1973 being:

$$y = aX^b$$

$$= .008309748\ (194)^{2.647169714}$$

$$= 9,457,738 \text{ pounds}$$

$$= 4,729 \text{ tons}$$
$$(4,730)$$

ADDENDA 5

Estimates of Pacific Mackerel Spawning
Using Central California Partyboat Catch
as an Indicator of Population Size

The spawning biomass was calculated using a non-linear regression: least squares fit power curve. Data points were fitted to the formula: $y = aX^b$

where: y = biomass estimate in thousands of pounds

X = number of Pacific mackerel caught off central California from partyboats

a = coefficient

b = coefficient

The coefficients a and b were calculated by using the following equations:

$$b = \frac{n \sum_{1}^{n} (\log_e x_i \log_e y_i) - (\sum_{1}^{n} \log_e x_i)(\sum_{1}^{n} \log_e y_i)}{n \sum_{1}^{n} (\log_e x_i)^2 - (\sum_{1}^{n} \log_e x_i)^2}$$

$$a = \exp\left[\frac{1}{n}\left\{\sum_{1}^{n} \log_e y_i - (\sum_{1}^{n} \log_e x_i) b\right\}\right]$$

A correlation coefficient was also calculated using the formula:

$$r = \frac{n \sum_{1}^{n} (\log_e x_i \log_e y_i) - (\sum_{1}^{n} \log_e x_i)(\sum_{1}^{n} \log_e y_i)}{\sqrt{\left[n \sum_{1}^{n} (\log_e x_i)^2 - (\sum_{1}^{n} \log_e x_i)^2\right]\left[n \sum_{1}^{n} (\log_e y_i)^2 - (\sum_{1}^{n} \log_e y_i)^2\right]}}$$

The values of the coefficients and the correlation coefficient are calculated to be:

$a = 651.9752438$

$b = .618724486$

$r = .77954374$

with the biomass estimate for 1973 being:

$$y = aX^b$$

$$= 651.9752438\ (117)^{.618724486}$$

$$= 12,412,759 \text{ pounds}$$

$$= 6,206 \text{ tons}$$
$$(6,210)$$