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THE RESOURCES AGENCY
Department of Fish and Game

STATUS OF PACIFIC MACKEREL SPAWNING POPULATION, 1976

by

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ABSTRACT

In order to initiate a fishery for the Pacific mackerel, *Scomber japonicus*, it is required that the spawning biomass be determined to have reached 10,000 short tons. Tag and recovery data and jack mackerel, *Trachurus symmetricus*, fishery data are analyzed for evidence of an increase in Pacific mackerel population size. The present level of the spawning population of Pacific mackerel, although larger than in recent years, is determined to fall short of the 10,000 tons needed to initiate a fishery.

1/ Marine Resources Administrative Report No. 76-12, October 1976.

2/ Marine Resources Region, 350 Golden Shore, Long Beach, California 90802.

STATUS OF PACIFIC MACKEREL SPAWNING POPULATION, 1976

RECOMMENDATIONS

This report is in response to legislation requiring that the California Department of Fish and Game assess the status of the spawning population of Pacific mackerel, *Scomber japonicus*, north of Punta Eugenia, Baja California, on an annual basis. The California Legislature expressed its intent that the Pacific mackerel resource be enhanced and that a moratorium on the commercial take of this species remain in effect until the spawning population has reached 10,000 short tons.

The California Department of Fish and Game has determined that the spawning population of Pacific mackerel is below the 10,000 tons needed to open a fishery. Although a successful spawn during 1974 has increased the total biomass level, the additive effect of this year class (1974) on the spawning biomass is much less (only 77% of Pacific mackerel are mature or maturing at 2 years of age). We recommend that no commercial fishery be initiated in 1976 and that restrictions concerning incidental catches remain in force.

INTRODUCTION

For a span of 5 decades, during the twentieth century, Pacific mackerel have supported one of California's more important commercial fisheries. Blunt and Parrish (1969) summarized the landings from 1926 to 1968 and reviewed the biological knowledge, research findings, and management efforts during that period. Briefly, the cannery fishery began in the mid-1920's. Landings increased rapidly and peaked in 1935 when 73,000 tons were processed. This was followed by a steady decline in the catch, which dipped to 3,750 tons in 1953. During the next 11 years landings averaged 17,000 tons per year. After 1964 the fishery experienced a rapid decline until,

for all practical purposes, it ceased to exist at the beginning of this decade. At this time (1970) the California Legislature passed a bill establishing a moratorium on the commercial fishing of Pacific mackerel, limiting catches to only incidentally caught fish. In 1972 this legislation was renewed and included management provisions for the opening of the fishery when the spawning biomass reached 10,000 tons (Sec. 8388, 8388.3, 8388.5 and 8387 of the Fish and Game Code-Addendum 1.). This legislation mandates the California Department of Fish and Game to estimate annually the size of the Pacific mackerel spawning population.

POPULATION ESTIMATES

The absence of a commercial fishery has rendered most classical methods of stock assessment for pelagic schooling species useless. Specifically, these methods require comprehensive sampling over a number of years to provide such information as catch per unit of effort (CPUE), age composition, mortality rates, recruitment, etc. At the present low population level, with the moratorium in effect, only sporadic commercial sampling occurs when Pacific mackerel are landed incidentally with jack mackerel, *Trachurus symmetricus*. However, the data base developed on Pacific mackerel in 1975 is greatly increased over recent years because of increased effort by the Department in monitoring both commercial and sport fisheries. Sampling of commercially landed Pacific mackerel increased 25% over 1974. This sampling provides length frequency (Figure 1) and age composition data (Addendum 2). Monitoring of mackerel landings is also designed to provide data on frequency of occurrence of mixed loads and estimates of tonnage landed. In addition, the Department of Fish and Game initiated two projects in 1975 which are providing new data on the southern California sport fishery. The Southern California Independent Sportfish Project is providing an estimate of numbers of Pacific mackerel caught off private boats launched from ramps and hoists. Estimates of the number of fish

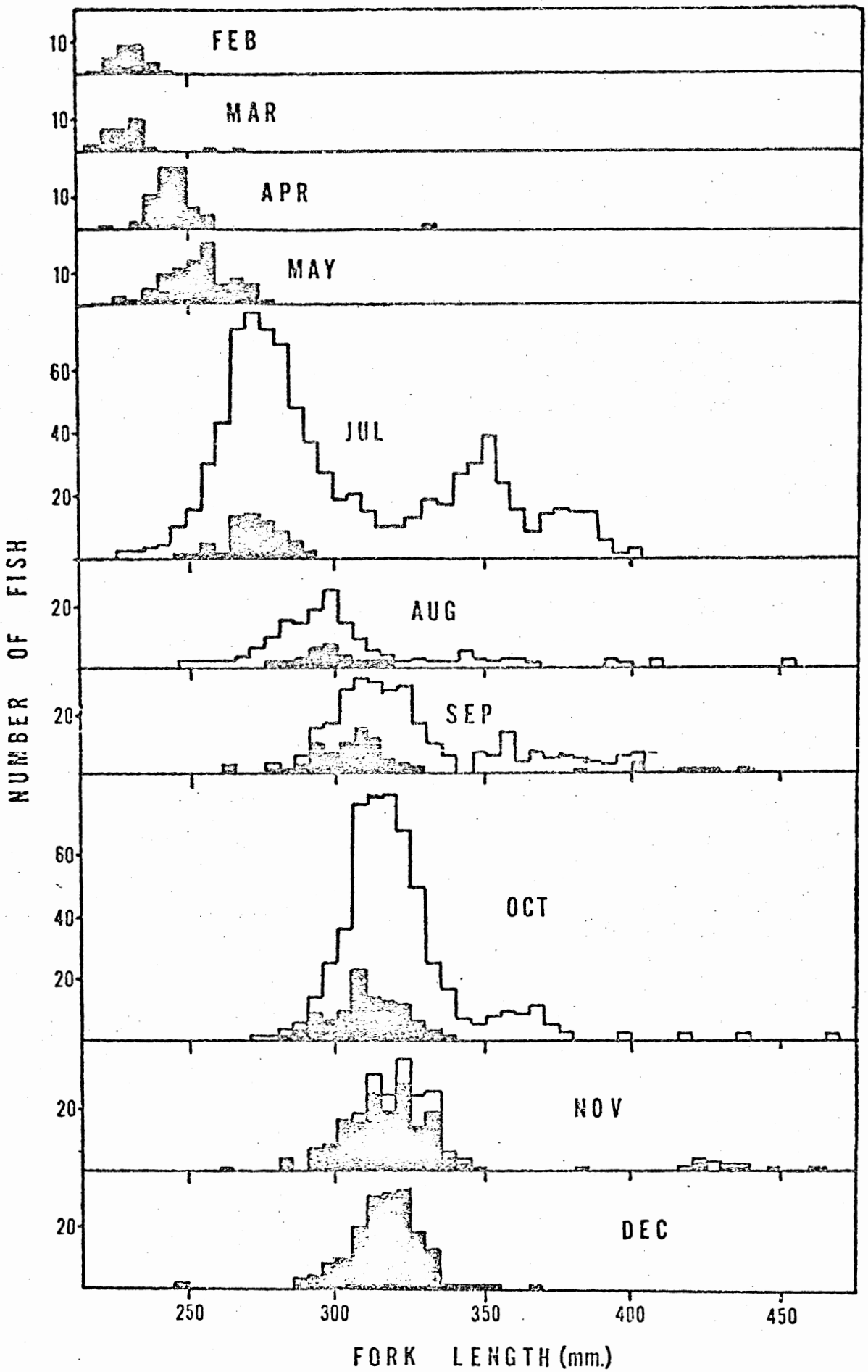

FIGURE 1. Cumulative length frequency of Pacific mackerel sampled from partyboats (clear) and commercial landings (dark) during 1975.

caught off partyboats come from partyboat logs which have been mandatory since 1947 (Figure 2). All of these data are pertinent to assessing the Pacific mackerel spawning.

Previous techniques used to estimate spawning biomass include: (1) the Murphy method (Parrish 1974; Parrish, manuscript) which provided estimates from 1931 to 1968 when a commercial fishery existed, (2) historical regression methods (Frey and Knaggs 1973; Knaggs 1974; Knaggs and Sunada 1975), and (3) tag and recovery methods (Frey and Knaggs 1973; Knaggs 1974; Knaggs and Sunada 1975). This report concerns itself with the last method and, in addition, includes an assessment which assumes that an observable and measurable relationship exists between jack mackerel and Pacific mackerel populations. The Murphy method cannot be used currently as it requires that a series of years of age composition data be available. The regression methods have proven to be unreliable in estimating spawning biomass at the low levels exhibited by the stock in recent years.

TAG AND RECOVERY DATA

Several approaches (Schnabel 1938; Schumacher and Eschmeyer 1943; and Chapman 1951) to estimating fish populations by tag and recovery data have been developed from the proportion estimation formula proposed by Petersen (1896). All of these approaches are based on the same basic assumptions. With respect to the Pacific mackerel population estimate, the more important assumptions include: (1) that tagged fish are randomly distributed throughout the population, and (2) that effort expended in obtaining tag returns is proportional to the density of the population throughout its range.

All tagging estimates require that there be some measure of numbers of fish examined for tags. For previous Pacific mackerel estimates, these numbers were generated from partyboat and fishing barge logs, and only those tags recovered on a partyboat or barge were used in calculating the

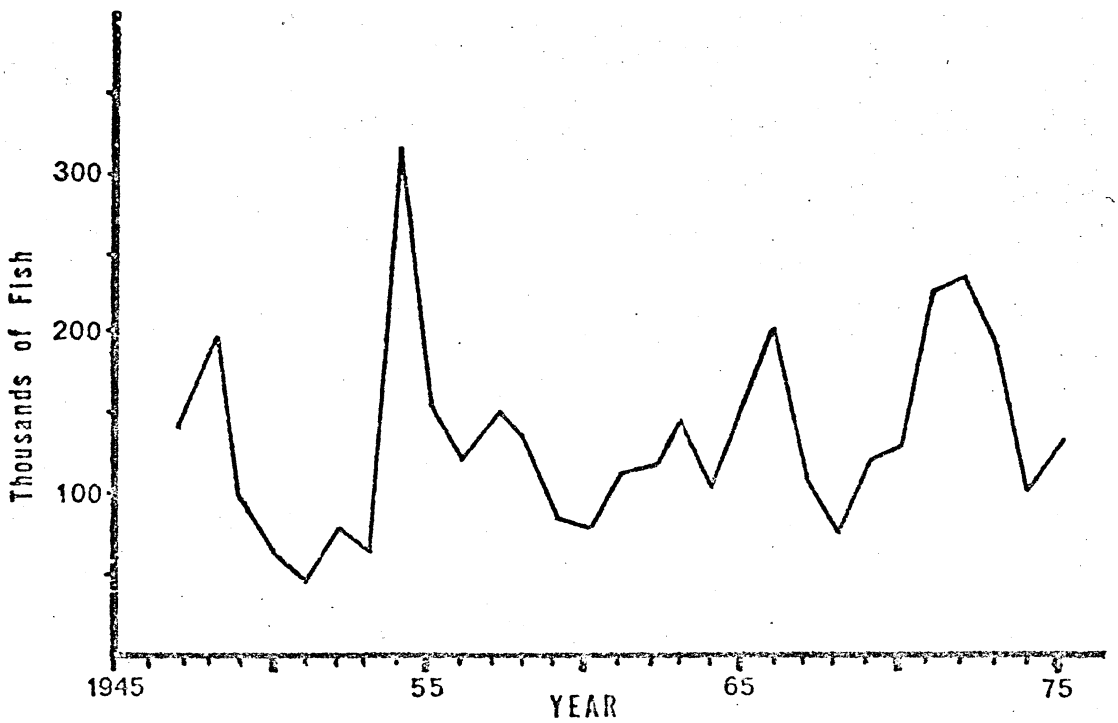

FIGURE 2. California partyboat catches of Pacific mackerel, 1947-1975.

final estimate. During 1975, the Southern California Independent Sportfish Project provided data for estimating numbers of Pacific mackerel caught by fishermen using ramp and hoist launched private boats and rental skiffs, thus increasing the data base for calculating tagging estimates. Estimates of numbers of Pacific mackerel landed by commercial fishermen are not very accurate, and only in special circumstances is it practical to use these numbers in calculating tagging estimates.

Because of the composition of the sportfishery, its patterns, and the date this report is due, tagging estimates are first calculated for the previous year (in this case, 1975) and then projected for the current year using growth, mortality, maturation and age composition data.

Several problems exist with 1975 tagging data. Relatively few Pacific mackerel were tagged and released during 1975 in time to be available to the sportfishery. For the duration of surface fishing activity of the fishery (generally June through September), there was little dispersion of tagged fish. Only one tag was recovered any appreciable distance from release sites, and there were only two areas where tags were released. This lack of randomly distributed tagged fish seriously hampers estimating the Pacific mackerel biomass over the entire range affected by the southern California sport fishery.

It was only practical to calculate biomass estimates for the two areas where tagged fish were released, the San Diego vicinity and Santa Monica Bay. Estimates of total numbers of fish for the two areas were 616,251 and 7,430,993 respectively (Addendum 3). These numbers relate to the total biomass level at the end of September 1975. The spawning biomass present by summer of 1976 can be calculated by considering 9 months mortality and converting total biomass in numbers to spawning biomass in tons by use of age composition (Addendum 2), mean weight at age, and maturation data. The calculated spawing biomasses are 170 and 2,044 tons.

An attempt was made to expand the above estimates over the entire range of the southern California sportfishery, by using CPUE data, assuming that CPUE for different areas would reflect relative density of the Pacific mackerel population in those areas. Preliminary analysis, however, indicates that neither partyboat CPUE (number of fish per angler) nor private boat CPUE (number of fish per pole hour) are adequate measures of Pacific mackerel density. In fact, each set of data shows opposite trends between San Diego and Santa Monica Bay (Figure 3).

In addition to the above estimates, it was possible to make another set of calculations based on tag and recovery data. From November 7 to December 12, 1975, the Department tagged and released 3,339 Pacific mackerel in the vicinity of Horseshoe Kelp, 4-5 miles outside the San Pedro breakwater. Tag recoveries began showing up from both Terminal Island canneries and San Pedro fish markets during the 2nd and 3rd weeks of December when purse seiners were concentrating their efforts in the vicinity of Horseshoe Kelp. During this same period, Department biologists were closely monitoring landings at canneries in an attempt to estimate numbers of Pacific mackerel landed and thus examined for tags (only landings for canning, where each fish is handled separately, were considered). Biologists, observing jack mackerel landings, estimated the percentage by weight of Pacific mackerel occurring in mixed loads. These percentages were converted to numbers using the average weight of Pacific mackerel sampled during this period and the estimated tonnage of Pacific mackerel in mixed loads. Using these data, a total biomass in the vicinity of Horseshoe Kelp in mid-December 1975 was calculated at 772 tons (Addendum 3).

JACK MACKEREL FISHERY DATA

The only means available for sampling the Pacific mackerel population for age composition on a continuing basis is by closely monitoring

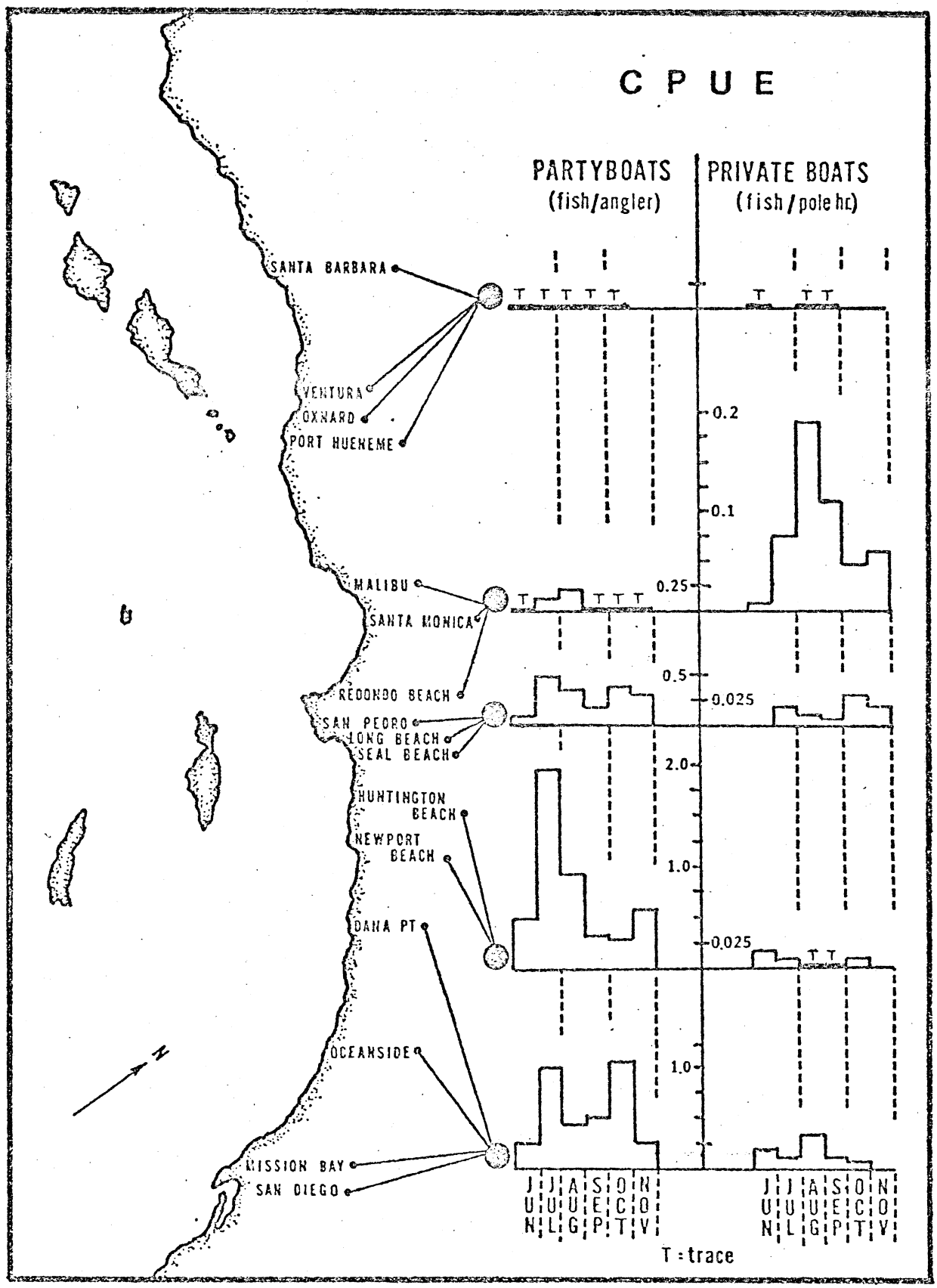

FIGURE 3. Pacific mackerel monthly catch per unit of effort (CPUE) for southern California partyboats (number of fish caught per angler) and private boats (number of fish caught per pole hour) for summer and fall of 1975.

the jack mackerel landings. Pacific mackerel, like the Pacific sardine, *Sardinops sajax caeruleus*, are known to school with jack mackerel and are found mixed in some jack mackerel landings. The California Department of Fish and Game presently employs two methods for keeping account of the landings of incidental species (primarily sardines and Pacific mackerel) which are mixed with jack mackerel landings. Klingbeil (1976) outlines these methods, discusses their limitations, and describes how the resulting data can be used in an assessment of incidental species landed.

The major assumption for an assessment of this type is that there is an observable and measurable relationship between the two species being compared. This assessment also is dependent on estimates of jack mackerel resource size and assumes that this resource has not fluctuated greatly in recent years. Knaggs (1973) indicated that the total population of jack mackerel available to roundhaul fishermen off southern California was in the range of 0.7 to 1.5 million tons. By considering the percent tonnage of Pacific mackerel landed with jack mackerel in 1975, a total biomass range of 9,762 to 20,918 tons was calculated for Pacific mackerel (Addendum 4). This range only relates to that portion of the Pacific mackerel population that is found schooling with jack mackerel off southern California and relates to a mean biomass level during 1975.

The total biomass range was updated to July 1, 1976, spawning biomass by considering the mortality ($Z = 0.5$, assuming no fishing mortality; MacCall, California Dept. Fish and Game, pers. commun.), length frequency, length-weight, age composition, and growth data (Addendum 5). The spawning biomass range calculated for July 1, 1976, is 5,289 to 11,333 tons, plus 35 to 45% of 1 year old fish (1975 year class). The impact the 1975 year class will have on the spawning biomass is undeterminable at this time.

SUMMARY AND CONCLUSIONS

Assessments of the Pacific mackerel population were made employing tag and recovery data and jack mackerel fishery data. Estimates of biomass from tag and recovery data could not be made over the entire range of the sportfishery because the tagged fish failed to disperse. Nevertheless, the estimates do indicate an increased biomass level for 1976. The number of fish estimated to be in Santa Monica Bay in September 1975, would yield a spawning biomass of 2,000 tons by the summer of 1976. This compares with estimates by Knaggs and Sunada (1975) of 600 to less than 3,000 tons of total spawning biomass in 1975. Analysis of the occurrence of Pacific mackerel mixed with jack mackerel landings resulted in an estimated spawning biomass range of 5,000 to 11,000 tons by the summer of 1976. This range seems realistic to the Department even though the validity of the assumptions regarding this estimate are questionable.

Monitoring of the commercial and sportfish catch has also produced evidence of an increase in biomass. Age composition of 1975 commercial samples and length frequencies of commercial and sport caught fish indicate a successful spawn in 1974. The resultant year class represents 70% of all fish sampled in 1975. During 1975 there was an increase in partyboat landings of Pacific mackerel and in the frequency of occurrence of Pacific mackerel in jack mackerel landings. All available data indicate an upward trend in Pacific mackerel biomass. However, if this trend is to be sustained, more successful spawnings are needed. Although the 1975 year class has appeared in landings this spring, it is too early to determine its relative size or the impact it will have on the spawning biomass.

We feel that there has been a marked increase in the spawning biomass of Pacific mackerel in the last year, but that this increase, as yet, falls short of the 10,000 tons needed to initiate a fishery.

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ADDENDUM 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.).

ADDENDUM 2

Age Composition and Length Frequency of
Pacific Mackerel Sampled from 1975 Commercial Catch.

Fork Length (mm)	Year Class								
	1974	1973	1972	1971	1970	1969	1968	Unreadable	Total
260-64	1	-	-	-	-	-	-	-	1
265-69	-	-	-	-	-	-	-	-	-
270-74	-	-	-	-	-	-	-	-	-
275-79	2	-	-	-	-	-	-	-	2
280-84	4	-	-	-	-	-	-	-	4
285-89	6	3	-	-	-	-	-	1	10
290-94	21	4	-	-	-	-	-	1	26
295-99	18	3	-	-	-	-	-	4	25
300-04	23	4	-	-	-	-	-	3	30
305-09	40	7	2	-	-	-	-	8	57
310-14	25	14	-	-	-	-	-	12	51
315-19	26	7	-	-	-	-	-	7	40
320-24	26	13	-	-	-	-	-	5	44
325-29	7	7	-	-	-	-	-	6	20
330-34	11	6	2	-	-	-	-	4	23
335-39	-	-	-	-	-	-	-	1	1
340-44	2	2	-	-	-	-	-	-	4
345-49	-	-	-	-	-	-	-	-	-
350-54	-	-	-	-	-	-	-	1	1
355-59	-	-	-	-	-	-	-	-	-
360-64	-	-	-	-	-	-	-	-	-
365-69	-	-	1	-	-	-	-	-	1
370-74	-	-	-	-	-	-	-	-	-
375-79	-	-	-	-	-	-	-	-	-
380-84	-	1	1	-	-	-	-	-	2
385-89	-	-	-	-	-	-	-	-	-
390-94	-	-	-	-	-	-	-	-	-
395-99	-	-	-	-	-	-	-	-	-
400-04	-	1	1	1	-	-	-	-	3
405-09	-	-	-	-	-	-	-	-	-
410-14	-	-	-	-	-	-	-	-	-

ADDENDUM 2-contd.

Fork length (mm)	Year Class 1974	1973	1972	1971	1970	1969	1968	Unreadable	Total
415-19	-	-	2	-	-	-	-	1	3
420-24	-	-	1	-	-	-	-	-	1
425-29	-	-	-	-	-	-	-	-	-
430-34	-	-	-	-	-	-	1	-	1
435-39	-	-	-	-	-	1	-	1	2
440-44	-	-	-	-	-	-	-	-	-
445-49	-	-	-	-	-	1	-	-	1
450-54	-	-	-	-	-	-	-	-	-
455-59	-	-	-	-	-	-	-	-	-
460-64	-	-	-	-	-	1	-	-	1
465-69	-	-	-	-	-	-	-	-	-
470-74	-	-	-	-	-	-	-	-	-
475-79	-	-	-	-	-	1	-	-	1
Totals	212	72	10	1	0	4	1	55	355
Percentage of readable otoliths	70.7	24.0			5.3				

Pacific mackerel were aged using otoliths collected from fish sampled during the period August to December 1975. Three readers read all otoliths separately without the availability of lengths. The resultant age composition (above) was collated from only those otoliths for which at least two readers agreed. Unreadable otoliths are those for which there is no agreement. The percentage of agreement between the three readers is 75.9%, 44.7%, 53.0%. The three readers are Eric H. Knaggs, John E. Fitch, and Richard A. Klingbeil.

ADDENDUM 3

Estimates of Total and Spawning Biomasses
from Tag and Recovery Data

I. Total number of Pacific mackerel calculated using tag and recovery data (Schnabel Formula) for Santa Monica Bay and San Diego vicinity at end of September 1975.

a. $N = \Sigma m(u + r)/\Sigma r$,

where: N = estimate of numbers of fish.

m = # of tagged fish available to be caught.

u = # of fish examined for tags (estimated from barge and partyboat logs and private boat sampling).

r = # of tag returns.

b. Assumptions not mentioned in text:

(1) No tagging mortality, all tagged fish are available to sportsfishermen.

(2) Values for m, u, r are developed over a 1 month period of time and each month represents one sample.

c. Data

	Santa Monica Bay			San Diego vicinity		
	m	r	u	m	r	u
July	608	3	19,258	152	2	42,621
August	605	1	27,350	200	12	18,458
September	604	1	14,729	215	6	10,003

d. Estimate

Santa Monica Bay N = 7,430,993 fish

San Diego vicinity N = 616,251 fish

II. Total Biomass (numbers) September 1975 to total biomass (numbers) July 1976.

a) Application of 9 months natural mortality (M = 0.5, assuming no fishing mortality, MacCall, California Dept. Fish and Game, pers. commun.).

$$N_t = N_o e^{-Mt}$$

where: N_t = numbers of fish on July 1, 1976.

N_o = numbers of fish on September 31, 1975.

M = natural mortality coefficient (0.5).

t = time in years = 9 months (0.75).

e = base of natural logarithms.

b) Estimate

Santa Monica Bay	San Diego vicinity
N_t = 5,107,241	N_t = 423,543

III. Total biomass (numbers) 1976 to spawning biomass (numbers) 1976.

a) Total numbers to numbers at age by using age composition of 1975 commercial landings (Addendum 2).

		Total Numbers at Age	
Year class	Percent	Santa Monica Bay	San Diego vicinity
1975	0		
1974	70.7%	3,610,819	299,445
1973	24.0%	1,255,738	101,650
1968 to 1972	5.3%	270,684	22,448

b) Total numbers at age to spawning numbers at age by using maturation at age data (Parrish, manuscript).

		Numbers Mature at Age	
Year class	Percent mature	Santa Monica Bay	San Diego vicinity
1975	35 to 45*	-	-
1974	77	2,780,331	230,573
1973	88	1,078,649	89,452
1968 to 1972	100	270,684	22,448
Spawning Biomass (numbers)	=	4,129,664	342,473

* estimated from formula (Parrish manuscript), proportion mature at age 1 = $0.54e^{(-0.0000071709)}$ (total biomass in 1,000's of lbs.).

IV. Spawning biomass (numbers) 1976 to spawning biomass (tons) 1976.

a. Mean length and mean weight at age from Knaggs and Parrish (1973).

Year class	Age	Fork length at age	Mean weight at age
1975	1	273 mm	0.56 lbs
1974	2	308 mm	0.84 lbs
1973	3	336 mm	1.13 lbs
1968 to 1972	4+	396 mm*	1.98 lbs*

* estimated from the fish of these year classes that were sampled during 1975.

b. $\frac{\text{(numbers spawning at age) (mean weight at age)}}{2000}$ =

= tons spawning at age

Year class	Age	Tons spawning at age: Santa Monica Bay	Tons spawning at age: San Diego vicinity
1975	1	-	-
1974	2	1,168	97
1973	3	609	51
1968 to 1972	4+	268	22
Spawning biomass* (tons)		2,044*	170*

* plus 35 to 45% of 1975 year class.

V. Total biomass of Pacific mackerel in vicinity of Horseshoe Kelp in mid-December 1975, from tag and recovery data (Schnabel formula).

where: m = number of tags released and available.

u = number of fish examined for tags (from estimates of tonnage of Pacific mackerel landed in mixed loads and mean weight of fish sampled).

r = number of tag returns.

	m	r	u
December 8-10	2,536	16	16,684
December 15-18	3,274	56	23,528

N = 1,660,628 fish

Average weight of fish sampled = 0.93 lbs.

Total Biomass = 772 tons

ADDENDUM 4

Calculation of Total Biomass Range of Pacific Mackerel that are Found Schooling with Jack Mackerel - 1975.

Month	Number of jack mackerel cannery landings	Tons of jack mackerel landed	No. of landings checked for incidental species	Tonnage of jack mackerel checked	Number of landings containing Pacific mackerel	*Estimation of tons of Pacific mackerel landed
January	3	131.2	2	62.5	0	-
February	52	1,226.5	43	972.5	16	3.920
March	13	200.5	7	88.2	4	.546
April	10	114.9	-	-	-	-
May	11	352.8	-	-	-	-
June	20	414.2	-	-	-	-
July	11	284.6	-	-	-	-
August	18	673.7	14	506.5	11	19.000
September	91	2,907.4	51	1,434.2	15	4.338
October	114	3,869.8	83	2,930.6	34	54.277
November	80	2,279.7	68	1,996.2	31	39.561
December	121	3,147.0	98	2,627.4	36	26.383
Totals	544	15,702.4	366	10,618.1	147	148.025

$\frac{10,618.1}{15,702.4}$ = 0.676 = fraction of tonnage landed which were checked for incidental species.

$\frac{148.025}{.676}$ = 218.972 = estimate of tons of Pacific mackerel landed assuming there was the same percentage for landings that were not checked.

$\frac{218.972}{15,702.4}$ = 0.0139 = estimate of fraction of jack mackerel catch for 1975 that consists of Pacific mackerel.

$(.7 \times 10^6)$ (0.0139) = 9,762 tons = estimate of biomass of Pacific mackerel found schooling with $.7 \times 10^6$ tons of jack mackerel.

(1.5×10^6) (0.0139) = 20,918 tons = estimate of biomass of Pacific mackerel found schooling with 1.5×10^6 tons of jack mackerel.

* Trace occurrences of Pacific mackerel were converted to tonnage by assuming that they accounted for 1/200 of the weight landed.

ADDENDUM 5

Calculation of Pacific Mackerel Spawning Biomass Range for July 1, 1976 from Total Biomass Range for 1975 (Addendum 4)

I. Biomass (tons) to biomass (numbers)

a. Total Biomass (tons) Range 1975 = 9,762 - 20,918 tons

biomass(tons)/$\bar{x}$ weight* of fish = biomass(numbers)

* Mean weight of fish sampled in partyboat catch in July 1975, calculated from length frequency (Figure 1), and Knaggs and Parrish (1973) length-weight curve. $\bar{x}$ weight = 402.59 gms = 0.887 lbs.

b. Total biomass (numbers) range 1975 = 22,011,000 - 47,166,000 fish

II. Total biomass (numbers) 1975 to total biomass (numbers) 1976.

a. Application of 1 year of natural mortality, (M = 0.5, MacCall, pers. commun.) assuming no fishing mortality.

$$N_t = N_o e^{-Mt}$$ (see Addendum 3)

b. Total biomass (numbers) range 1976 = 13,207,000 - 28,300,000 fish

III. Total biomass (numbers) 1976 to spawning biomass (numbers) 1976

a. Total numbers to numbers at age by using age composition of 1975 commercial landings (Addendum 2).

Year class	Percent	Total numbers (range) at age
1975	0	-
1974	70.7	9,337,349 to 20,008,100
1973	24.0	3,169,680 to 6,792,000
1968 to 1972	5.3	699,971 to 1,499,900

b. Total numbers at age to spawning numbers at age by using maturation at age data (Parrish, manuscript).

Year class	Percent mature	Numbers mature (range) at age
1975	35 to 45*	- -
1974	77	7,189,759 to 15,406,237
1973	88	2,789,318 to 5,976,960
1968 to 1972	100	699,971 to 1,499,900
Spawning biomass (numbers) Range	=	10,679,048 to 22,883,097

* estimated from formula (Parrish manuscript), proportion mature at age 1 = $0.54e^{(-0.000007109)}$ (total biomass in 1,000's of lbs).

IV. Spawning biomass (numbers) 1976 to spawning biomass (tons) 1976.

a. Mean length and mean weight at age from Knaggs and Parrish (1973).

Year class	Age	Fork length at age	Mean weight at age
1975	1	273 mm	0.56 lbs
1974	2	308 mm	0.84 lbs
1973	3	336 mm	1.13 lbs
1968 to 1972	4+	396 mm*	1.98 lbs*

* estimated from the fish of these year classes sampled during 1975.

b. $\frac{\text{(numbers spawning at age) (mean weight at age)}}{2000}$ = tons spawning at age.

Year class	Age	Tons spawning (range) at age
1975	1	- -
1974	2	3,020 to 6,471
1973	3	1,576 to 3,377
1968 to 1972	4+	693 to 1,485
Spawning biomass (tons)		5,289* to 11,333*

Range* July 1, 1976

* plus 35 to 45% of 1975 year class.