

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

STATUS OF THE SPAWNING BIOMASS
OF THE PACIFIC SARDINE, 1974-75

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by

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ABSTRACT

In order to initiate a fishery for the Pacific sardine, Sardinops sajax caeruleus, it is required that the spawning biomass be determined to have reached a minimum of 20,000 short tons. Data from ichthyoplankton surveys, night-light surveys, the anchovy bait fishery and jack mackerel purse seine fishery are analyzed for evidence of an increase in the population size. The present level of the spawning population of the northern stocks of sardines is determined to be far below the 20,000 tons required to initiate a fishery.

1/ Marine Resources, Administrative Report No. 75-2,
January 1975.

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

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SUMMARY AND RECOMMENDATIONS

This is the first annual report on the status of the spawning population of the northern stock of Pacific sardines, Sardinops sajax caeruleus, as required by Section 8150.7 of the Fish and Game Code. In this section the legislature expressed its intent that the sardine resource be rehabilitated. During the process of rehabilitation, a small 1,000 short ton fishery will be allowed once the spawning population reaches 20,000 tons.

The California Department of Fish and Game has determined that the spawning population of the sardine at the beginning of 1975 is far below 20,000 tons; therefore, we recommend that no fishery be initiated in 1975 and that the restrictions concerning incidental catches remain in force.

HISTORY OF FISHERY

Fishing for the sardine on the Pacific Coast of North America began in 1889. The earliest records of landings in California are for the 1916-17 season, when less than 30,000 tons were landed. The next year a small fishery was initiated in British Columbia and total sardine landings increased slowly until 1923-24, when about 85,000 tons were landed. The tonnage doubled in the 1924-25 season and in subsequent years the fishery continued to grow with development of the British Columbia fishery and the rapid expansion of California fisheries. In 1935, sardine fishing began in Washington and Oregon and in the 1936-37 season approximately 791,000 tons were landed. The fishery remained productive over the next 8 years with landings fluctuating between 500,000 and 680,000 tons. During this same period, however, the catch per unit of effort was declining and the period 1944 to 1947 was accompanied by a sharp drop in landings. During

the subsequent 3 years, the fisheries in British Columbia, Washington and Oregon were discontinued, although California had increased its landings slightly. Disaster struck the sardine industry in 1952 and 1953, when less than 25,000 tons were landed in California during the 2-year period. By this time, a small Mexican fishery was in operation out of Ensenada, Baja California.

In retrospect, the disaster of the early 50's marked the end of an era in the history of California fishing. Sardine landings have never again reached the levels of the 1940's, although slight revivals occurred in 1954-55 and 1958-59. The fishery continued to decline after the 1958-59 season and following 1965 the reported catch has never exceeded 500 tons per year in California (Table 1).

By the early 1960's, the sardine was no longer abundant enough to be of much value to the canning and reduction industries. As fishermen and industry turned to substitute species, such as jack mackerel, Trachurus symmetricus, and northern anchovies, Engraulis mordax, fishing pressure on sardines normally would be expected to subside enough to allow the opportunity for a resurgence of the population. However, fishermen continued to take sardines when and where they could. Although their catches were seldom more than a few tons, the sardine was considered a prime bait fish by sportsmen, with dealers paying \$400 to \$500 per ton for them. Thus, when fishermen were unable to catch large amounts of less valuable pelagic species, a few tons of sardines could "make a boat's day."

In 1967, legislation was passed which sought to diminish the fishing pressure on an already badly depleted resource. It provided that no sardines may be taken or possessed on any boat, except loads or lots of fish may contain 15% or less by weight of sardines.

In 1969, the legislature provided for a 250 ton annual quota in addition

TABLE 1. Seasonal Catch in Tons of Sardines Along the Pacific Coast of United States and Canada; Each Season Includes June Through Following May

Season	Pacific Northwest			California		Total	California's % of total landings
	British Columbia	Washington	Oregon	Northern California	Southern California		
1916-17	-	-	-	7,710	19,820	27,530	100
1917-18	80	-	-	23,880	48,700	72,660	92
1918-19	3,640	-	-	36,200	39,340	79,180	95
1919-20	3,280	-	-	44,040	22,990	70,310	96
1920-21	4,400	-	-	25,190	13,260	42,850	90
1921-22	990	-	-	16,370	20,130	37,490	97
1922-23	1,020	-	-	29,320	35,790	66,130	98
1923-24	970	-	-	46,110	37,820	84,900	92
1924-25	1,370	-	-	67,870	105,150	174,390	99
1925-26	15,950	-	-	69,570	67,700	153,200	90
1926-27	48,500	-	-	85,380	66,830	200,710	76
1927-28	68,430	-	-	114,710	72,550	255,690	73
1928-29	80,510	-	-	133,810	120,670	334,990	76
1929-30	86,340	-	-	182,010	143,160	411,510	79
1930-31	75,070	-	-	146,550	38,570	260,190	71
1931-32	73,600	-	-	121,725	42,920	238,245	58
1932-33	44,350	-	-	167,023	83,667	295,040	85
1933-34	4,050	-	-	256,636	126,793	387,479	99
1934-35	43,000	-	-	411,371	183,683	638,054	93
1935-36	45,320	10	26,230	411,447	149,051	632,058	87
1936-37	44,450	6,560	14,200	583,415	142,709	791,334	92
1937-38	48,080	17,100	16,660	306,234	110,330	498,404	84
1938-39	51,770	26,480	17,020	426,084	149,203	670,557	86
1939-40	5,520	17,760	22,330	440,327	96,939	582,876	92
1940-41	28,770	810	3,160	283,790	176,794	493,324	93
1941-42	60,050	17,100	15,850	436,876	150,497	680,373	86
1942-43	65,880	580	1,950	300,283	204,378	573,071	88
1943-44	88,749	10,440	1,820	340,128	138,001	579,129	83
1944-45	59,120	20	-	373,844	181,061	614,045	90
1945-46	34,300	2,310	90	229,622	174,061	440,383	92
1946-47	3,990	6,140	3,960	34,260	199,542	247,892	94
1947-48	490	1,360	6,930	17,724	103,617	130,121	93
1948-49	-	50	5,320	47,974	135,752	189,096	97
1949-50	-	-	-	149,211	189,714	338,925	100
1950-51	-	-	-	46,426	306,662	353,088	100
1951-52	-	-	-	15,979	113,125	129,104	100
1952-53	-	-	-	49	5,662	5,711	100
1953-54	-	-	-	58	4,434	4,492	100
1954-55	-	-	-	856	67,609	68,465	100
1955-56	-	-	-	518	73,943	74,461	100
1956-57	-	-	-	63	33,580	33,643	100
1957-58	-	-	-	17	22,255	22,272	100
1958-59	-	-	-	24,701	79,270	103,971	100
1959-60	-	-	-	16,109	21,146	37,255	100
1960-61	-	-	-	2,340	26,538	28,878	100
1961-62	-	-	-	2,231	23,297	25,526	100
1962-63	-	-	-	1,211	2,961	4,172	100
1963-64	-	-	-	1,015	1,927	2,942	100
1964-65	-	-	-	308	5,795	6,103	100
1965-66	-	-	-	151	568	719	100
1966-67	-	-	-	23	321	344	100
1967-68	-	-	-	10	61	71	100
1968-69	-	-	-	-	52	52	100
1969-70	-	-	-	-	119	119	100
1970-71	-	-	-	-	190	190	100
1971-72	-	-	-	-	120	120	100
1972-73	-	-	-	-	197	197	100

to the existing incidental catch restriction. In 1973, a sardine management bill was passed by the legislature which provided for a sardine moratorium until the spawning population reaches 20,000 tons (Section 8150.7, Fish and Game Code; Addendum 1). This section stipulates that sardines taken incidentally to other fishing operations may be possessed or used for canning and reduction only.

SARDINE BIOMASS DATA

The Pacific sardine has been an extensively researched species over the years; however, it wasn't until the late 1940's, after a decline in the fishery, that research expanded in the area of population dynamics.

In 1949, the California Cooperative Sardine Research Program was formed, bringing together industry and government in what was to be one of the most comprehensive research groups of its kind. In subsequent years, many papers were published by a host of eminent scientists concerned with the population biology of the sardine.

The classical methods of dealing with the population dynamics of the sardine, which include the use of catch equations, tagging data, egg and larval surveys, and virtual population estimates, unfortunately have been rendered useless for the situation created by the present low levels of the sardine population.

The last spawning population estimate available from catch statistics and age composition data is for the 1961-62 season. Klingbeil (1974) reported a corrected virtual population of about 62,000 tons spawning biomass for this season, the last season in which more than 20,000 tons were landed. After 1965, yearly landings seldom amounted to more than 200 tons. It appears that the spawning biomass of the sardines fell below 20,000 tons spawning biomass sometime between 1962 and 1966. Since that time period, there has been no evidence of any strong recruitment. Only small numbers

of young-of-the-year sardines have been seen sporadically in bait fisheries during this period. The fact that small amounts of sardines occasionally appear in bait catches and commercial landings of jack mackerel gives reason for hope that the sardine population is holding its own (i.e., recruitment of juvenile sardines into the adult population may be sufficient enough to have stopped the population decline). There has certainly been no evidence to indicate an increase in the population.

Estimate from Ichthyoplankton Data

In 1971, the National Marine Fisheries Service stated that the spawning population of the northern stock of sardines was lower than 5,000 tons and may have been as low as 2,000 tons. These low estimates are realistic in view of the lack of any strong recruitment.

If the recruitment rate has equaled the mortality rate over the last few years, then the spawning stock of the sardine is possibly still between 2,000 to 5,000 tons. Although young-of-the-year fish have appeared in the live bait fishery in 1972, 1973, and 1974, their numbers and frequency of occurrence have been minimal and these occurrences are mainly in the San Diego area. Recruitment appears to be minimal and the population may actually have declined over the last several years. If recruitment has been negligible, then mortality may have reduced the spawning stock size to less than 1,000 tons.

Sardines in Live Bait Catches

One way to estimate spawning stock size is to compare the incidence of sardines in the live bait catch from California waters to historical population estimates of the stocks of sardines. The incidence of sardines in live bait catches is obtained from live bait fishermen's logs which are submitted on a voluntary basis. In previous years, bait fishermen sometimes

would estimate the percentage of sardines that they caught. These data were used to obtain two regression curves which, when plotted, fit the historical population estimates fairly well. From these curves, the two estimates obtained for the spawning stock size in 1973 were 6,800 tons and 150 tons. The drastic difference between these estimates is a function of both incomplete data and the present low level of the population. The fact that both of these estimates fall well below 20,000 tons is considered as positive evidence of the current low level of the population.

Sardines Associated with Jack Mackerel

One of the few remaining avenues from which to obtain current data on the sardine is the jack mackerel purse seine fishery, which is monitored on a continuing basis. Sardines are known to school with jack mackerel and therefore are found, usually in trace amounts, in some jack mackerel landings. A special attempt to sample these sardines was made in 1974 (Addendum 2). A biomass level was then calculated for that portion of the sardine population which seems to be a cohabitant of space with the jack mackerel. This is a rough measure and is dependent on the estimates of the jack mackerel resource size. Knaggs (1973) indicated that the total population of jack mackerel off southern California available to roundhaul fishermen in 1972 was in the range of 0.7 to 1.5 million tons. By considering the percent tonnage of sardines landed with jack mackerel in 1974, a sardine population estimate of between 555 to 1,190 tons was obtained (Addendum 3). This biomass range only relates to that portion of the northern stock of sardines which are found schooling with jack mackerel and assumes that the jack mackerel population has remained constant. What portion of the total sardine population this represents is unknown.

Sardine Surveys

More data indicating the low level of the sardine spawning population is provided by a recently completed sardine survey (CF&G Cruise 74A8), on which night-light stations were occupied and the presence of all species attracted to the light was recorded. Similar cruises have been conducted since 1949, and during the 1950's, sardines were commonly observed under the light. This cruise covered all areas inshore and adjacent to islands, between Point Conception and the Mexican border, where sardines have historically been known to occur. A total of 89 stations was occupied and sardines occurred at three. These three stations were all located within San Diego Bay, an area known to have a small sardine spawning population.

CONCLUSION

The present estimates of sardine spawning biomass are highly variable and by necessity have been based on incomplete and scant data. Unfortunately, both of the problems are a function of the current low level of the population. This low level appears to be far below a threshold level for estimating population size using traditional methods. Even with these thoughts in mind, all estimates are far below the 20,000 tons required to initiate a harvest, therefore, the Department of Fish and Game recommends that the restrictions concerning intentional fishing and incidental catch of sardines remain in force.

REFERENCES

- Klingbeil, Richard A. 1974. Average lunar monthly catch of sardines in California for the 1954-55 through 1961-62 seasons. Calif. Dep. Fish and Game, Mar. Resour. Tech. Rep. 26:1-43.
- Knaggs, Eric H. 1973. Status of the jack mackerel resource and its management. Calif. Dep. Fish and Game, Mar. Resour. Tech. Rep. 11:1-12.

ADDENDUM 1

Sections of California Fish and Game
Code Amended or Added by Senate Bill 192

8150.5. Sardines may not be taken or possessed on any boat, barge, or vessel except pursuant to Section 8150.7. However, loads or lots of fish may contain 15 percent or less by weight of sardines taken incidentally to other fishing operations and which are mixed with the other fish in the load or lot.

Sardines so incidentally taken may be possessed and used for canning and reduction only.

This section does not prohibit the possession and use of sardines imported into this state under a bill of lading identifying the country of origin.

Imported sardines may be used for dead bait under such regulations as the commission may prescribe.

8150.7 It is the intent of the Legislature that the sardine resource be rehabilitated. During the process of rehabilitation a small fishery shall be allowed once the spawning population has reached 20,000 tons as determined by the department during the first 60 days of each calendar year. As the spawning population increases, in excess of 20,000 tons, the seasonal quota may also be increased but at such a rate as to allow the continued increase in the spawning population. This process shall continue with the objective of maximizing the sustained harvest.

When the department determines that the estimated spawning population of northern stocks of sardines has reached 20,000 tons, it shall establish a 1,000-ton-per-season quota which may be taken under permits issued by the department.

The department shall keep records of the catch and when it appears that the 1,000-ton limit will be reached, it shall notify all permit-

holders of the date when such limit will be reached and after which no sardines may be taken, and shall notify, by certified mail, all permittees of such closure.

The department shall increase the quota beyond 1,000 tons when, consistent with the intent of this section, it determines that an increased quota is warranted.

8755. In Districts 20A and 21, purse and round haul nets may be used.

(a) Purse and round haul nets may be used, except: (1) from sunrise Saturday to sunset Sunday, in that portion of District 20 from a line extending three nautical miles east magnetically from the extreme easterly end of Santa Catalina Island southwesterly and northerly to a line extending three nautical miles southwest magnetically from the most southerly promontory of China Point and (2) at any time during the period commencing on June 1st and ending on September 10 in each year, in that portion of District 20 from a line extending three nautical miles east magnetically from the extreme easterly end of Santa Catalina Island southerly to a line extending three nautical miles southeasterly magnetically from the United States government light on the southeasterly end of Santa Catalina Island.

(b) Subdivision (a) shall not be construed as restricting the right to use the waters therein specified for anchorage of vessels at any time.

8780. As used in this chapter, the term "bait net" means a lampara or round haul type net the mesh of which is constructed of twine not exceeding Standard No. 9 medium cotton seine twine or synthetic twine of equivalent size or strength. The net shall not have rings along the lead line or any method of pursing the bottom of the net.

Bait nets may be used to take fish for bait in Districts 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 19A, 19B, 20A, 21, 118 and 118.5.

In Districts 19A and 19B bait nets may be used only to take anchovies, queenfish, white croakers, and smelt for bait only. Such nets may not be used within 750 feet of Seal Beach Pier or Belmont Pier.

No other species of fish may be taken or possessed on any boat carrying a bait net in District 19A.

ADDENDUM 2

Length Frequency of Sardines Sampled
from Jack Mackerel Landings in 1974

Standard length, mm	Months when samples were taken						Total sampled
	February	May	July	August	October	November	
185-189	-	1	-	-	3	-	4
190-194	-	3	2	-	6	3	14
195-199	-	4	5	-	5	5	19
200-204	-	13	20	-	5	6	44
205-209	-	27	44	-	6	5	82
210-214	-	33	45	1	9	7	95
215-219	-	25	46	5	19	10	105
220-224	6	12	26	5	13	3	65
225-229	5	8	8	6	6	3	36
230-234	7	2	9	9	4	1	32
235-239	4	-	1	7	-	1	13
240-244	4	-	-	9	-	1	14
245-249	-	-	-	8	-	1	9
250-254	-	-	1	2	-	-	3
255-259	-	-	-	1	-	-	1
Totals	26	128	207	53	74	49	537

ADDENDUM 3

Calculation of Biomass Range of Pacific Sardines
that are found Schooling with Jack Mackerel

Month	Number of mackerel landings	Tons of mackerel landed	Number of logs received	Tons reported on logs	Occurrence of sardines	Estimation of tons of sardines landed
January	27	592.8	9	472.5	Trace (1)	0.345
February	30	744.4	0	-	-	-
March	7	68.5	0	-	-	-
April	37	440.4	2	29.0	-	0.000
May	58	1,268.0	17	685.3	Trace (1)	0.300
June	29	117.2	2	50.3	-	0.000
July	92	2,702.6	49	1,732.0	Trace (3) 15% (1)	1.186
August	83	2,144.0	16	655.5	Trace (3)	1.048
Totals	363	8,137.9	95	3,624.6		2.879

$\frac{3,624.6}{8,137.9} = .445$ = fraction of tonnage landed for which logs were received.

$\frac{2.879}{.445} = 6.469$ = estimate of sardines landed assuming there were some for landings without logs.

$\frac{6.469}{8,137.9} = .000794$ = estimate of fraction of jack mackerel catch through August 1974 that consists of sardines.

$(.7 \times 10^6) (.000794) = 555$ tons = estimate of biomass of sardines found schooling with $.7 \times 10^6$ tons of jack mackerel.

$(1.5 \times 10^6) (.000794) = 1.190$ tons = estimate of biomass of sardines found schooling with 1.5×10^6 tons of jack mackerel.