F845
N21
c.2

F845
No. 1
c.2

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
WATER PROJECTS BRANCH

CALIFORNIA
STATE LIBRARY
OCT 23 1962
DOCUMENTS SECTION

An Historical Review of the

FISH AND WILDLIFE RESOURCES OF THE SAN FRANCISCO BAY AREA

By

JOHN E. SKINNER

WATER PROJECTS BRANCH REPORT No. 1

WILLIAM E. WARNE, Administrator
The Resources Agency

WALTER T. SHANNON, Director
Department of Fish and Game

C—043183

C-043183

16319

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
WATER PROJECTS BRANCH

An Historical Review of the

FISH AND WILDLIFE RESOURCES OF THE SAN FRANCISCO BAY AREA

By
JOHN E. SKINNER

WATER PROJECTS BRANCH REPORT No. 1

EDMUND G. BROWN
Governor

WILLIAM E. WARNE, Administrator
The Resources Agency

WALTER T. SHANNON, Director
Department of Fish and Game

June, 1962

C—043184

C-043184

TABLE OF CONTENTS

	Page
List of Figures	4
List of Tables	5
List of Appendices	7
List of Plates	8
Preface	9
Introduction	11
Purpose and Scope	13
Geography	17
Population	17
Commerce and Industry	17
Fishing Ports	18
The Fish and Wildlife Resources of the San Francisco Bay Area	21
The Commercial Fisheries	23
Early History	23
Whaling	23
Codfish Packing	23
Other Fisheries	25
The Commercial Fisheries from 1870 to 1915	27
The Commercial Fisheries from 1915 Onward	31
The Present Commercial Fish and Fisheries of the Bay Area	33
The Schooling, Pelagic, Bait and Forage Fishes	33
Pacific Herring	33
Pacific Sardine	33
Smelt	33
Northern Anchovy	35
Whitebait	35
The Flatfishes	36
The Bottom Fishes	38
Sharks, Skates and Rays	39
Saltwater Perch	40
Croakers	41
The Molluscan Fisheries	41
Abalones	42
Clams	42
Oysters	42
The Crustacean Fisheries	43
Shrimp	44
Crabs	45
Freshwater Commercial Fishes	45
Anadromous Commercial Fisheries	47
Salmon	47
Shad	47
Striped Bass	48
Economic Aspects of the Commercial Fisheries	49
Fishermen	50
Vessels	51
Marine and Commercial Fisheries References	52
Anadromous Fisheries	57
Introduction	57
King Salmon	57
The Commercial Fishery	57
Early History	57
1870 to 1915	58
1915 to Present	59
Economic Evaluation of the Salmon Commercial Fishery	60
Sport Fishery	61
The Party Boat Fishery	62
The Skiff Fishery	62
The River Fishery	62
Economic Evaluation of the Sport Fishery	63
Life History Notes	63
Time of Run	63
Size of Run	63
Spawning Conditions	63
Downstream Migration	64
Food Habits	64
Ocean Life	65
Sources of Mortality	65
Silver Salmon and Steelhead Trout	65
Silver Salmon	66
Silver Salmon Sport Fishery	66
Introduction of Silver Salmon into the Sacramento River System	66
Silver Salmon Life History Notes	66
Time of Run	67
Spawning Conditions	67
Embryology	67
Stream Life	67
Ocean Life	67
Survival	67
Sources of Mortality	68
Steelhead	68
Steelhead Sport Fishery	68
Steelhead Life History Notes	69
Time of Run	69
Composition of the Run	69
Spawning Conditions	69
Embryology	69
Stream Life	70
Ocean Life	70
Survival	70
Sources of Mortality	70

C—043185

C-043185

TABLE OF CONTENTS—Continued

	Page
Anadromous Fisheries—Continued	
Striped Bass	71
Commercial Fishery	71
Sport Fishery	72
Angling Statistics	73
Party Boat Fishery	73
Block 308, Carquinez Strait	73
Block 301, San Pablo Bay	74
Block 303, Delta	74
Block 488, North San Francisco Bay	74
Block 302, Suisun Bay	74
Block 489, South San Francisco Bay	76
General Features of the Fishery	76
Striped Bass Life History Notes	78
Time of Run	78
Spawning Conditions	78
Temperature	78
Salinity	78
Spawning Activities	78
Fecundity	78
Spawning Locations	79
Embryology	79
Postlarval Stage	79
Juveniles	80
Migrations	80
Food Habits	80
Growth	82
Age to Maturity	82
Artificial Propagation	82
Sources of Mortality	82
Sturgeon	84
Commercial Fishery	84
Sport Fishery	84
Sturgeon Life History Notes	84
American Shad	86
Commercial Fishery	86
Shad Sport Fishery	87
Shad Life History Notes	87
Time of Run	87
Spawning Conditions	87
Embryology	88
Stream Life	88
Ocean Life	88
Sources of Mortality	88
Miscellaneous Anadromous Fish	88
Comments on the Future of the Anadromous Fishes	89
Anadromous Fisheries References	90
The Molluscan Fisheries	95
The Oyster Fishery	95
Early History	95
1915 to Present	100
Oyster Culture	101
General	101
Sources of Stock	102
Conditions for Oyster Culture	102
Potential for Oyster Culture in the Bay Area	103
Production Estimates	104
Status of Bay Area Sites	104
San Pablo Bay	104
South San Francisco Bay	105
North San Francisco Bay	105
Tomales Bay	105
Bolinas Lagoon	105
Drakes Estero	105
Bodega Bay	105
Private Salt Ponds	105
The Clam Fishery	105
Early History	106
South San Francisco Bay	106
North San Francisco Bay	106
Tomales Bay	106
Bodega Bay	107
1915 to Present	107
Present Fishery	108
Sport Fishery	108
Current Clamming Localities	108
San Pablo Bay	108
South San Francisco Bay	108
North San Francisco Bay	108
Tomales Bay	108
Bodega Bay	108
Bolinas Lagoon	108
Drakes Estero	108
Halfmoon Bay	108
Special Species	108
Washington Clam	109
Littleneck Clam	109
Bent-nose Clam	109
Gaper	109
Soft-shell Clam	109
Japanese Littleneck Clam	109
Sea Mussel	109
The Abalone Fishery	110
Early History	110
The Commercial Fishery	110
The Sport Fishery	111
General Information	111
The Marine Borers	112
Molluscan Fisheries References	112

C—043186

C-043186

TABLE OF CONTENTS—Continued

	Page
The Crustacean Fisheries	115
The Crustacean Fauna	115
The Crab Fishery	118
Review of the Fishery to 1915	118
Catch Statistics from 1916 to 1958	119
The Fishery	119
Life History Notes	119
The Shrimp Fishery	121
Early History	121
Catch Statistics	122
Life History Notes	123
Other Crustaceans	123
Freshwater Crayfish	124
Crustacean Fisheries References	125
The Freshwater Fish and Fisheries of the San Francisco Bay Area	127
Historical Review	127
Angling Pressure	128
Classification of Fisheries	128
Trout Lakes	129
Trout Streams	129
Warmwater Lakes	129
Warmwater Streams	129
Miscellaneous Waters	129
Summary by County	131
Alameda County	131
Contra Costa County	131
Marin County	132
Napa County	133
San Francisco County	134
San Mateo County	134
Santa Clara County	135
Solano County	136
Sonoma County	136
Freshwater Fisheries References	137
Game Birds	139
Waterfowl	139
Historical Account	139
1915 to Present	141
Reclamation and Land Use	142
South Bay	142
North Bay	142
Waterfowl Habitat	144
Wintering Areas	144
Breeding Areas	144
Hunter Use and Economics	145
Hunter Use	145
Economic Evaluation	147
Duck Clubs	147
Sources of Mortality	147
Other Sources of Mortality	147
Waterfowl for the Future	147
Upland Game and Shore Birds	152
Quail	152
Ring-necked Pheasant	153
Other Upland Game Birds	153
Other Shore and Water Birds	153
Waterfowl, Shore and Upland Game Bird References	154
The Mammalian Resources	155
Historical Account	155
The Marine Mammals	155
The Sea Otter	155
The Fur Seals	156
The Sea Lions	156
The Cetaceans	157
The Inland Fur Bearers	157
Economic Value	157
Big Game Animals	157
Roosevelt and Tule Elk	157
Grizzly Bears	158
Black-tailed Deer	158
Pronghorn Antelope	158
Mountain Lion	158
1870 to 1915	158
1915 to present	158
The Trapping Industry	159
The Marine Mammals	160
Sea Otter	160
Fur Seals	160
Sea Lions	160
Harbor Seals	160
Rookeries and Hauling Grounds in the Bay Area	161
The Inland Furbearers	161
Mink and the River Otter	161
Muskrat	161
Beaver	162
Raccoon	162
The Lesser Furbearers	162
Small Game Animals	162
Big Game Animals	163
Mammalian Resources References	165

C—043187

C-043187

TABLE OF CONTENTS—Continued

	Page
Comments on Changes in the Fish and Wildlife Resources of the San Francisco Bay Area	167
Commercial Fisheries	167
The Schooling, Pelagic Bait and Forage Fishes	167
Flatfishes	167
Bottom Fishes	168
Sharks, Skates and Rays	168
Mollusks	168
Crustaceans	168
Freshwater Commercial Fishes	168
Anadromous Fisheries	169
King Salmon	169
Striped Bass	169
Shad	169
Waterfowl	169
Economics of the Fish and Wildlife Resources of the San Francisco Bay Area	171
Fisheries	171
Commercial Fisheries	171
Sport Fisheries	172
Salmon	172
Steelhead	172
Striped Bass	172
Freshwater Sport Fisheries	172
Saltwater Sport Fisheries	172
Hunting	173
Waterfowl	173
Hunting Values	173
Duck Club Investments	173
Other Game Species	173
Management Economics	173

LIST OF FIGURES

Figure Number		Page
1.	San Francisco 1847	12
2.	San Francisco Bay 1853	13
3.	Location Map	14
4.	California Commercial Fishing Statistical Areas	15
5.	Department of Fish and Game Administrative Regions	16
6.	Fishing Ports of San Francisco Bay Area	19
7.	Commercial Fishing Stations in San Francisco Bay 1888-1889	24
8.	Herring Spawning Areas in San Francisco Bay	26
9.	Comparative Landings of Herring for the State and San Francisco Bay Area 1916-1958	30
10.	Comparative Landings of Sardines for the State and San Francisco Bay Area 1916-1958	34
11.	Comparative Landings of Anchovies for the State and San Francisco Bay Area 1916-1958	35
12.	Comparative Landings of Pacific Sandab for the State and San Francisco Bay Area 1916-1958	36
13.	Comparative Landings of Flounders for the State and San Francisco Bay Area 1916-1958	37
14.	Comparative Landings of Halibut for the State and San Francisco Bay Area 1916-1958	38
15.	Comparative Landings of Sole for the State and San Francisco Bay Area 1916-1958	39
16.	Comparative Landings of Bottom Fishes (Combined) for the State and San Francisco Bay Area 1916-1958	40
17.	Comparative Landings of Sharks, Skates and Rays (Combined) for the State and San Francisco Bay Area 1916-1958	41
18.	Comparative Landings of Saltwater Perch for the State and San Francisco Bay Area 1916-1958	42
19.	Comparative Landings of White Sea Bass and White Croakers (Combined) for the State and San Francisco Bay Area, 1916-1958	43
20.	Comparative Landings of Oysters for the State and San Francisco Bay Area, 1916-1958	44
21.	Comparative Landings of Mollusks (Combined) for the State and San Francisco Bay Area, 1916-1958	45
22.	Comparative Landings of Shrimp for the State and San Francisco Bay Area 1916-1958	46
23.	Comparative Landings of Crabs for the State and San Francisco Bay Area 1916-1958	47
24.	Comparative Landings of Salmon for the State and San Francisco Bay Area 1916-1958	48
25.	Comparison of the Annual Value of Commercial Fishery Products for the State and San Francisco Bay Area	51
26.	Comparison of Number of State and San Francisco Bay Area Fishermen	52
27.	Comparison of State and San Francisco Bay Area Fishing Fleets	53
28.	Sacramento-San Joaquin River Commercial Salmon Landings 1864, 1957	60-61

C—043188

C-043188

LIST OF FIGURES—Continued

Figure Number		Page
29.	Surf Fishing for Striped Bass	62
30.	Fishing "Block Areas" Used in Analyzing Striped Bass Party Boat Catch Records	74
31.	Diagram of Food Chain in Bay or Estuary	75
32.	Map of Oyster Grounds 1890-1891	96
33.	Moraghan Oyster Establishment 1890	97
34.	Tonging Oysters in South San Francisco Bay 1890	98
35.	Equipment of Oyster Fishery in 1890-1891	99
36.	Culling Oysters in San Francisco Bay 1890-1891	101
37.	Pacific Oyster Seed	103
38.	Clam Digging—San Pablo Bay about 1920	107
39.	Sportsmen Searching for Abalones—Marin County	111
40.	Map of Crab Fishing Areas	120
41.	Map of Shrimp Fishing Grounds 1930	122
42.	Waterfowl on Wintering Area	140
43.	Pacific Flyway Waterfowl Migration Routes	143
44.	California Waterfowl Refuge and Management Areas	146
45a.	Pintail Duck	148
45b.	Mallard Duck	148
46.	A Waterfowl Sanctuary at Work	149
47.	Trends in the Annual Waterfowl Kill for the State and San Francisco Bay Area	150
48.	Collection of Waterfowl Killed by Oil Pollution	151
49.	Comparison of the Annual Value of Raw Furs Trapped in the State and Bay Area, 1921-22 through 1955-56	159
50.	Comparative Deer Kill of the State and San Francisco Bay Area, 1927-1960	163

LIST OF TABLES

Table Number		Page
Table 1	—Distribution of Population of San Francisco Bay Area	17
Table 2	—Exports of Fish from San Francisco in 1892 and 1893	30
Table 3	—Fishery Products of the Bay Area in 1892	31
Table 4a	—California Commercial Fishery Products—1955	32
Table 4b	—Fishery Products from California Waters Only—1955	32
Table 5	—Fishery Statistics of San Francisco County 1879-80	49
Table 6	—California Fisheries Statistics for 1880	49
Table 7	—Comparison of the Regional Fisheries of California—1892	50
Table 8	—California Fishery Statistics 1880-1908	50
Table 9	—Comparative Data on the Sacramento-San Joaquin Salmon Fishery	59
Table 10	—Poundage and Ex-Vessel Value of California Salmon Landings 1952-56	61
Table 11a	—California Central Valley Fall Run King Salmon Spawning Stock Estimates	64
Table 11b	—Spring Run King Salmon Spawning Stock Counts for San Joaquin River 1943-1950	64
Table 12	—Food of Adult King Salmon	65
Table 13	—Time and Location of Silver Salmon, Introductions into Sacramento River System 1956-1958	66
Table 14	—Salmon and Steelhead Passing Clough Dam, Counting Station, Mill Creek, Tehama County	66
Table 15	—Summary of Steelhead Census Data on Five Bay Area Streams (1954-55 Season)	68
Table 16	—Sacramento River Steelhead Runs (1953-59)	69
Table 17	—Incubation Period for Trout Eggs at Various Temperatures	70
Table 18	—Trends in California Striped Bass Angling	73
Table 19	—Composition of the Striped Bass Party Boat Fleet in 1947	76
Table 20	—Composition of Striped Bass Party Boat Fleet in 1946-1956	76
Table 21	—County of Residence of Striped Bass Anglers	77
Table 22	—Characteristics of the Striped Bass Sport Fishery	77
Table 23	—Striped Bass Angling Success by Each of Three Methods	77
Table 24	—Striped Bass Catch Locations	78
Table 25	—Food of Small Striped Bass	80
Table 26	—Food of Small Striped Bass	81
Table 27	—Food of Adult Striped Bass	81
Table 28	—Recaptures of Tagged Sturgeon	85
Table 29	—Sturgeon Reported Caught by Party Boats	85

C—043189

C-043189

LIST OF TABLES—Continued

Table Number		Page
Table 30	—American Shad Introductions into California	86
Table 31	—Anticipated Effect of the Proposed Salinity, Control Barrier on Fishlife under Two Proposals	89
Table 32	—Prevalent Molluscan Species in San Francisco Bay	95
Table 33	—Eastern Oyster Production in San Francisco Bay Prior to 1915	100
Table 34	—Surface Acreage of Selected Waters in the Bay Area	104
Table 35	—Current Oyster Allotments and Private Oyster Beds in the Bay Area	105
Table 36	—Former Clam Beds in the Bay Area	107
Table 37	—Crab Fishing Area, in Square Miles, of the California Coast	119
Table 38	—Estimated Catch of Selected Gamefish Species in San Francisco Administrative Region 3	128
Table 39	—Percentage of California Angling Licensees Reported Catching Selected Gamefish Species in San Francisco Administrative Region	128
Table 40	—Tabulation of Fishing Waters in the San Francisco Bay Area	130
Table 41	—Statistics of the Lake Merced Boat Fishery	134
Table 42	—Land Reclamation in the Bay Area	142
Table 43	—Acreage in the Bay Area Controlled by Salt Interests	142
Table 44	—Wetlands and Permanent Waters of Importance to Waterfowl	144
Table 45	—Principal Species of Ducks Wintering in the San Francisco Bay Area in Ranking Order of Abundance	144
Table 46	—Hunter Use and Waterfowl Kill on Grizzly Island Waterfowl Management Area 1950-1960	145
Table 47	—Residency of Hunters Using Grizzly Island Waterfowl Management Area 1953-54 Season	145
Table 48	—Leveed and Unleveed Marshlands Adjacent to San Pablo and Suisun Bays	152
Table 49	—Present Vegetation on Marshlands Adjacent to San Pablo and Suisun Bays	152
Table 50	—Present Use of Marshland Adjacent to San Pablo and Suisun Bays	152
Table 51	—Annual Quail Kill 1948-1958	153
Table 52	—State and Regional Jacksnipe Bag 1953-58	153
Table 53	—Mean Annual Percentage Contribution of the Bay Area to the Total State Catch of Principal Furbearers	160
Table 54	—Comparison of State and Bay Area Deer Kill, 1927-1960	164
Table 55	—Summary of Range Condition and Degree of Stocking in the Various Subunits of Deer Range (1948-49)	164
Table 56	—Range Areas, Reported Kill and Estimated Deer Hunters in the Bay Area	164
Table 57	—Number of Mountain Lions Bountied in California 1906-1955	165
Table 58	—Economics of the Bay Area Fisheries Resources	172
Table 59a	—Game Resources Economics	173
Table 59b	—Summary of Economics of Bay Area Game Resources	173
Table 60	—Summary of Economics of Fish and Wildlife Resources of the San Francisco Bay Area	174

C—043190

C-043190

LIST OF APPENDICES

		Page
A	Fishing Ports of the San Francisco Bay Area	175
B-1	Selected Common Marine Fishes of the Bay Area	176
B-2	Commercial Fish Landings of the State and the San Francisco Bay Area 1916 to 1958	177
B-3	Comparative Commercial Fishery Statistics for California and the Bay Area	194
B-4	California Landings of Selected Commercial Speices Prior to 1918	198
C-1	Selected Anadromous Fishes of the San Francisco Bay Area	200
C-2	Sacramento-San Joaquin River Commercial Salmon Catch 1864 to 1957	200
C-3	Pack of Canned Salmon from 1864 to 1919 on the Sacramento River	201
C-4	The Striped Bass Party Boat Fishery by Block and by Year (1938-1958) for Full Day Boats	201
C-5	The Striped Bass Party Boat Fishery by Block and by Year (1953-1955) for Half Day Boats	203
D	Selected Mollusks of the San Francisco Bay Area	204
E	Common Crustaceans of the San Francisco Bay Area	205
F-1	Selected Freshwater Fishes of the San Francisco Bay Area	206
F-2	Some Initial Introductions of Food and Game Fishes Occurring in the San Francisco Bay Area	207
G-1	Common Waterfowl, Upland Game and Shore Birds of the San Francisco Bay Area	208
G-2	Game Birds in the San Francisco and Los Angeles Markets in the 1895-96 Season with the Estimated Number from the Bay Area	210
G-3	Comparison of the Annual Waterfowl Inventories of the State and Bay Area Counties	211
G-4	Comparison of State and Bay Area Waterfowl Hunting Success	212
G-5	Fourteen-Year Census of Fourteen Species of Shorebirds in the South Bay (1928-1941)	213
H-1	Selected Mammals of the San Francisco Bay Area	214
H-2	Data on the Number and Value of Sea Otter Pelts	215
H-3	Annual Catch of Furbearers in the San Francisco Bay Area	216
H-4	Comparison of Bay Area and State-Wide Values of the Annual Fur Catch (1921-1956)	218
H-5	Comparison of Bay Area and State-Wide Deer Kill (1927-1960)	218
I-1	California Angling License Sales 1914-1959	219
I-2	California Hunting License Sales 1907-1960	219
I-3	California Trapping License Sales 1917-1960	220
I-4	Commercial Fishing License Sales 1909-1960	221
I-5	Reported Fishing Expenditures from 1955 Economic Survey	221
I-6	Reported Hunting Expenditures from 1955 Economic Survey	222
I-7	Capital Outlay and Management Costs Related to the Fish and Wildlife Resources of the Bay Area	222
J	A List of Federal, State and Municipal Fish and Wildlife Refuges in the San Francisco Bay Area	226

C—043191

C-043191

LIST OF PLATES

(Plates at end of report)

PLATE I	Historical location of commercial fisheries for bottom fish and rockfish, flatfish and clams.
PLATE II	Historical distribution of crab and shrimp commercial fisheries and waterfowl wintering areas.
PLATE III	Historical distribution of oyster fisheries and waterfowl breeding areas.
PLATE IV	Historical salmonid migration routes, probable distribution, and historical commercial clamming areas.
PLATE V	Location of recent commercial fisheries for herring, salmon, shad and shrimp and herring spawning areas.
PLATE VI	Present distribution of salmonid, oyster and sturgeon fishery resources and waterfowl breeding areas in the San Francisco Bay area.
PLATE VII	Present clamming and abalone fishing areas and rookeries and hauling grounds for seals and sea lions.
PLATE VIII	Location of wildlife refuges and marine salmon sportfishing areas.
PLATE IX	Commercial recoveries of marked salmon.

PREFACE

The population of the State of California is increasing at a phenomenal rate with the great mass of newcomers settling near metropolitan centers, of which the San Francisco Bay Area is the second largest in the State.

Natural corollaries of population growth are the need for greater recreational opportunity and additional food supplies, both of which may be satisfied in part by adequate supplies of clean water and fish and wildlife resources. Unfortunately, in the Bay Area, population and industrial growth have brought about tremendous decreases in fish and wildlife habitat through land reclamation, water development projects, and water pollution. Furthermore, the resources have been subjected to a relentless increase in hunting and fishing pressure. Thus, they have suffered a twofold effect—greater utilization and loss or deterioration of environment.

Water is a prime necessity of any community and its quality directly affects not only such community assets as industry, but also the area's recreational potential in the form of boating, swimming, hunting or fishing, and its esthetic values.

Water appropriation and development projects are occurring everywhere at a tremendous rate. Adequate protection of fish and wildlife in the face of such development requires ready knowledge and a wealth of background material concerning the resources, as well as an ambitious investigative program to evaluate the effects of proposed water appropriations or developmental projects on the resources. Frequently, considerable data and descriptive information exist but, all too often, these are in obscure or widely scattered places.

The present report represents the author's efforts to assemble in a single volume pertinent information regarding fish and wildlife of the San Francisco Bay Area. It has been compiled in the hope that it will prove informative and useful to those agencies which, through their primary responsibility of guiding water development and quality, also influence the destiny of the fish and wildlife resources. In addition, it is intended that the report will be of service to those agencies and individuals directly responsible for the management and protection of fish and wildlife. Finally, it is hoped that it will serve to inform the interested public of the aesthetic and economic wealth of their fish and wildlife heritage.

C—043193

C-043193

ACKNOWLEDGMENTS

Preparation of this report has spanned four years. During that period the author made repeated demands on the services and patience of colleague and clerk alike.

I am especially indebted, however, to J. C. Fraser under whose direction the project was carried out. Special thanks are due Edward Greenhood and his staff of the Department's Marine Resources Statistical Unit at Terminal Island for their assistance on the commercial fish catch statistics. The following persons, through their critical review of the manuscript have added greatly to its authenticity and reference value:

John Fitch for his earnest review of the manuscript generally and the molluscan section in particular;

Dr. Harold Orcutt and his staff for their review of the molluscan and crustacean sections;

Leo Shapovalov and Donald Fry, Jr. for their review of the salmon and steelhead portions of the manuscript;

Harold K. Chadwick for reviewing the striped bass, sturgeon and shad aspects;

George McCammon and the Region III staff, especially Willis Evans, for their review of the freshwater fisheries;

George Seymour on furbearing mammals;

Frank Kozlik on waterfowl;

Donald McLean on upland and big game;

Jack Hiehle on deer;

David C. Joseph rendered helpful advice throughout preparation of the manuscript;

Paul Johnson did the art work on the charts and graphs;

William C. Dillinger edited the entire manuscript and made many valuable suggestions for its improvement.

It is the author's fervent hope that the reader will recognize these contributions.

Assistance was also solicited and graciously granted by the following agencies: The California Department of Water Resources, State Lands Commission, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service and Napa County.

I am grateful to the many clerical workers who spent endless hours typing and proofing the manuscript and its many tables. The help of all those whom I have not mentioned because of space or oversight is also acknowledged.

Finally, I wish to express my appreciation to my wife, Marjory, and my children who on my account suffered many "lost weekends".

John E. Skinner
January 1962

C—043194

C-043194

INTRODUCTION

San Francisco Bay and the nine counties which border it comprise the San Francisco Bay Area. No other area in California can match the rich fisheries potential of this region. This potential lies in the wealth of marine life found within its bays and adjacent coastal waters, and is enhanced by a unique combination of physical and geographical features. Acting as a transition zone between the cold, productive waters of the Pacific Ocean and the nutrient-laden waters of the Sacramento and San Joaquin Rivers, San Francisco Bay provides the habitat and passageway for a variety of highly desirable aquatic organisms.

"The City," as San Francisco is frequently referred to, and many of the surrounding communities as well, owe their origin to the excellent natural harbor and bountiful resources provided by the bay.

Mission Dolores, founded in 1776 by the Spaniards was the first civilized establishment on the peninsula. The Spanish had previously selected San Jose in Santa Clara County in 1770, as the site for the first pueblo, or town, in Alta California. These settlements and later the other missions along the El Camino Real were used as collection centers for sea otter pelts as early as 1785. The padres bartered with the Indians to obtain pelts for the Mexican government.

The abundance of these valuable fur-bearing mammals first established San Francisco as a trade center. By 1800 Russian, French, American and British ships were common at the port of San Francisco in the quest for sea otter and fur seals.

Whaling became a prominent industry along the coast of California about 1840, and by 1880 San Francisco was hailed as the whaling capital of the world.

The discovery of gold, January 24, 1848, in the South Fork of the American River, at Coloma, El Dorado County, brought thousands of immigrants to "The City" on their way to the gold fields. Yerba Buena, as San Francisco was originally called, a town of 375 in August, 1847, (California Star, April, 1848) swelled to 25,000 by 1849 (Soule's Annals of San Francisco, 1849).

The new inhabitants quickly began exploiting the natural resources of their new surroundings. The local abundance of fish and shellfish presaged the future importance of this industry to the area. The first organized commercial fishery was developed between 1848 and 1850 when a colony of Italian immigrants began netting the salmon of the Sacramento and San Joaquin Rivers and seining sardines, herring and flatfishes in San Pablo and San Francisco Bays. Soon after crabs and shrimps were added to the growing fisheries.

The Bay and Delta were the natural wintering grounds for hordes of waterfowl which were shot by the millions for sport, table and market. Deer, antelope, elk and other wild game were also prominent in the markets of early San Francisco.

Thus San Francisco was immensely benefited in its formative years by a bounteous supply of fish and wildlife. Even as the wildlife resources in the immediate area declined, San Francisco continued for many years as an important shipping center for all sorts of wild game, furs, waterfowl and fishery products.

Serious inroads on all segments of the fish and wildlife resources prompted the legislature to pass a law entitled "An Act to provide for the restoration and preservation of fish in the waters of this State," which was approved April 2, 1870. The first "Commissioners of Fisheries for the State of California" were appointed as a result of this act. This body immediately obtained fish screen and ladder legislation for the protection of salmon; imported alien species of fishes from the East and Midwest; and obtained legislation curtailing the take of deer, waterfowl and shorebirds.

Major changes in the philosophy of fish and wildlife management occurred after 1870. Not only was restrictive legislation enacted, but in addition, other acts were instituted for the enhancement and protection of the environment and for the acquisition and dissemination of biological knowledge. Anti-pollution legislation, the specific designation of certain areas as wildlife refuges and sanctuaries, the establishment of a wildlife protection force, and the scientific investigation of fish and wildlife were all inaugurated.

The skyrocketing population, coupled with industrial and agricultural growth in the Bay Area resulted in a tremendous loss of wildlife. The resources were overhunted or overfished. In addition, habitat was, and continues to be, modified, vitiated or destroyed at an alarming rate.

Dams for power, flood control, irrigation and water supply diminished anadromous fish populations by cutting off spawning areas and modifying water flows below dams. Excessive water diversion has caused entire streams to dry up; unscreened diversions have taken an enormous toll of fish. Reclamation of wet lands has resulted in vast reductions of waterfowl habitat and hence lowered abundance of these birds. Hunters and trappers have eliminated several game and fur species, and reduced others almost to the point of extinction.

Fortunately, the recreational, economic and esthetic benefits of fish, wildlife and clean water are becoming increasingly apparent to the public.

C—043195

C-043195

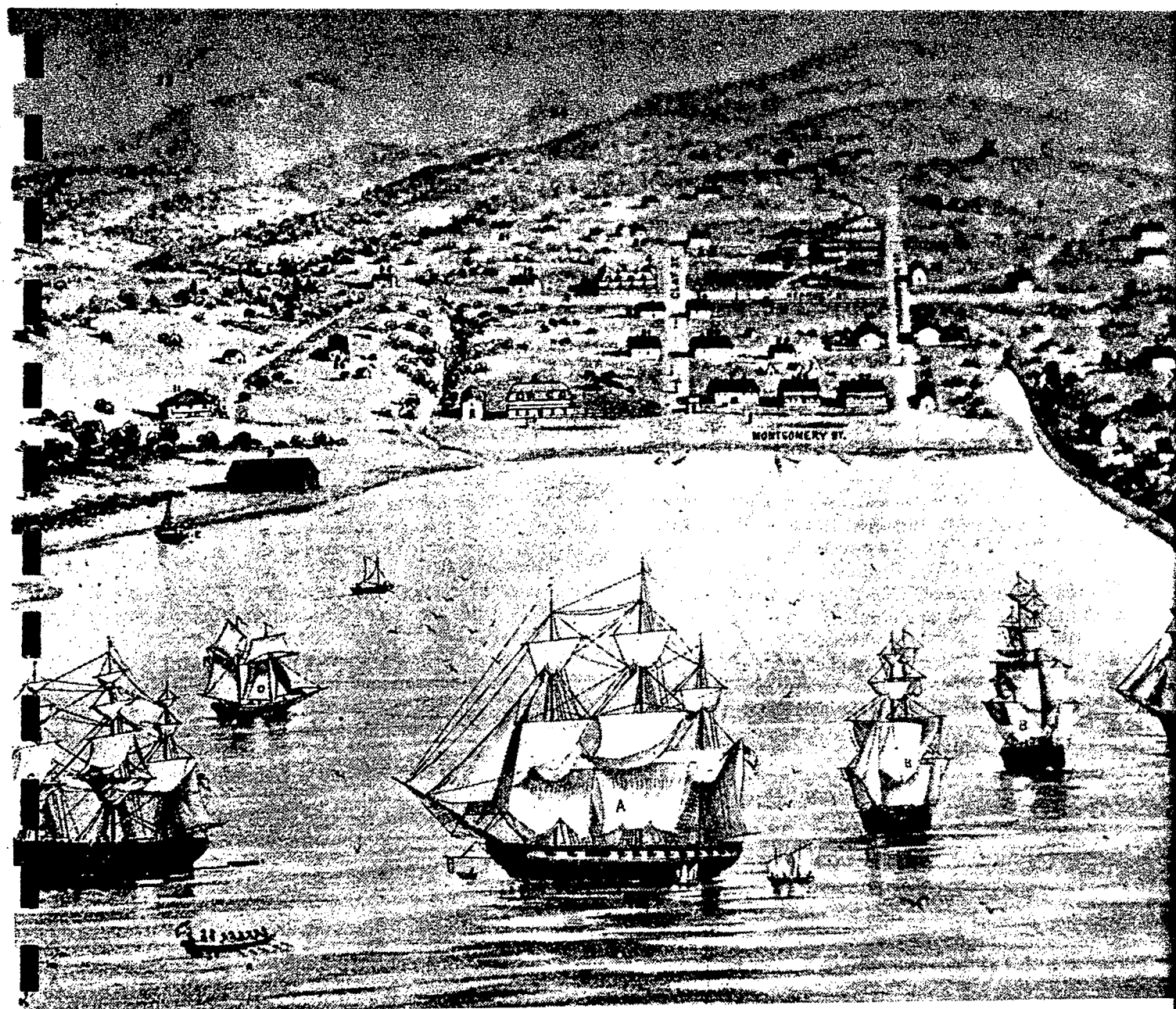


FIGURE 1. San Francisco 1847. The Ferry Building is presently located at about the same position as the ship marked "A" in the drawing. Photograph from Final Report of San Francisco Bay Marine Piling Committee, Hill and Kofoid, 1927.

Californians spent an estimated 487 million dollars in 1955 on hunting and fishing activities, according to a survey by the Department of Fish and Game. The money spent on fishing alone ($319,112,000) was more than two and a half times the total amount spent the same year on admissions to theaters and athletic events. The primary value of the 1955 commercial fish catch—that is to the State's fishermen—was 53 million dollars. At the consumer level the value would be several times this amount. No price tag can be attached to the incalculable esthetic and therapeutic benefits of fishing, hunting, and other aquatic recreation, but the benefits certainly contribute significantly to the health and well-being of our people.

The necessity of protecting, enchancing and perpetuating the resources which generate an economy of this magnitude as well as providing food, health and recreation is clearly manifest.

Many conservation measures in the form of legislation have been taken to preserve our wildlife heritage, and a large force of wildlife protection officers rigidly enforces them. Valuable contributions are being made by the technical staff through scientific research and its application to management of the resources. Although far from complete, our knowledge of life histories, food habits, population dynamics, diseases and general ecology of our wild creatures is gradually accumulating, and is well known for some species. This work must continue so that we can describe and predict the impact of man's activities on the aquatic environment.

Future methods of fostering our fish and wildlife resources must, to a large degree, deal directly with the environment of the animals by modifying or creating habitat for enhancement of the resources and by preventing environmental deterioration.

Purpose and Scope

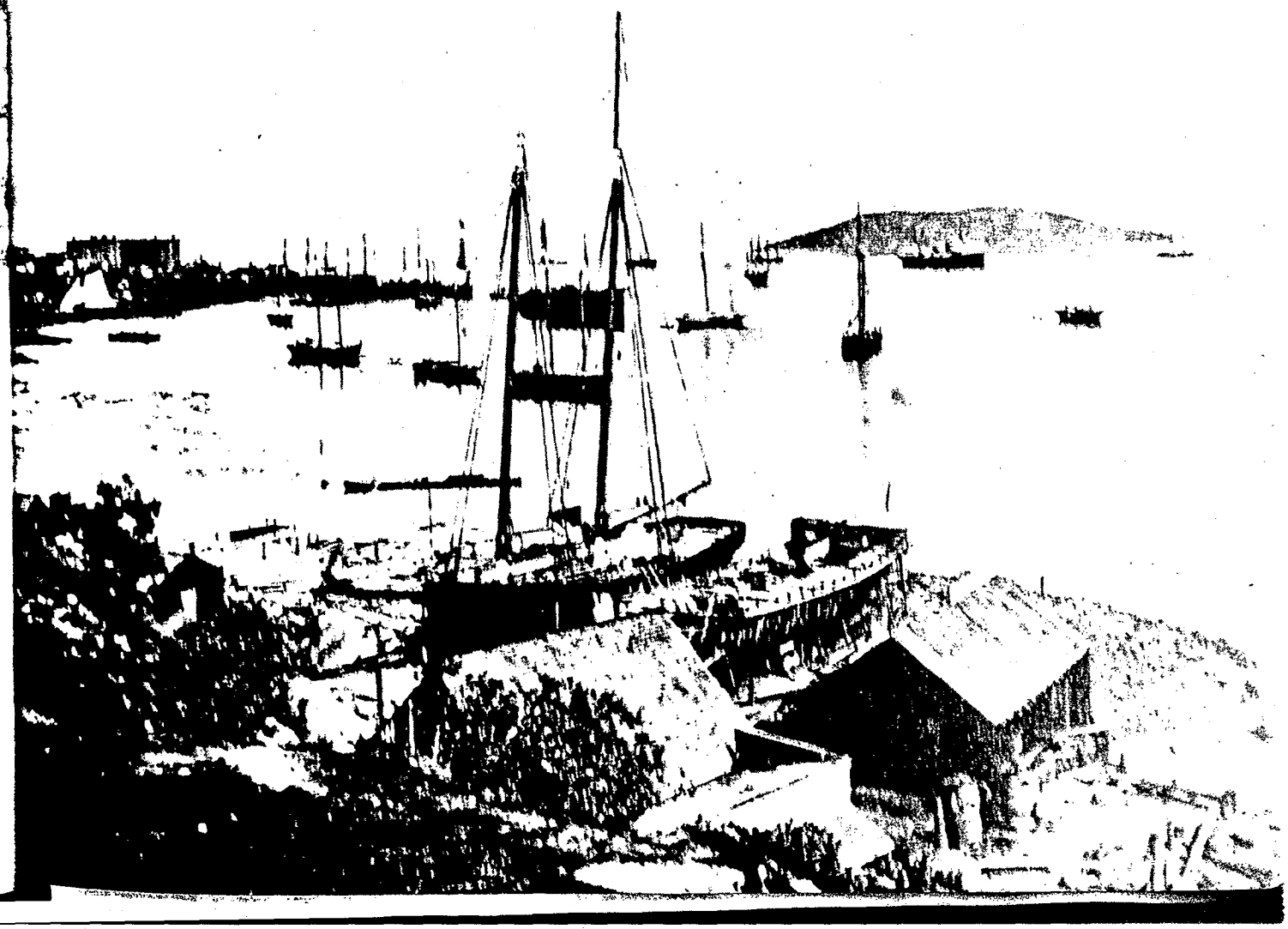
The intended purpose of this report is to provide pertinent information concerning the distribution, abundance, utilization and economic value of the more common or important fish and wildlife species in the Bay Area.

Since quantitative records concerning fish and wildlife frequently have been and still are tabulated on a county basis, the nine counties surrounding San Francisco Bay form the basic unit for presenting much of the quantitative data in this report (Figure 3). Commercial fishery data, after 1915, are based upon the statistical areas established by the Department of Fish and Game (Figure 4). The San Francisco and Sacramento areas have been combined for the purposes of this report to obtain the landings of the San Francisco Bay Area. Thus for commercial fishery purposes the region extends from Point Arena, Mendocino County, on the north to Pigeon Point, San Mateo County, on the south, and inland along the Sacramento River to the City of Sacramento.

For historical information, the early literature and records of the U. S. Bureau of Fisheries were relied upon heavily. In the absence of quantitative statistics on catches or abundance, pertinent descriptive and documentary material is presented. Beginning about 1870, both the State and Federal agencies began compiling catch statistics for a number of commercial species. Since 1915, of course, excellent records of the commercial fish landings in California have been available.

As far as the commercial fisheries are concerned, the data are adequate to show the general abundance and value of the resources since historical times. Unfortunately, similar records for waterfowl, game animals, and the freshwater fisheries are not available. Therefore, the information on these groups is necessarily restricted to whatever could be gleaned from scattered accounts in the early literature or from statements in the files and records of the Department of Fish and Game.

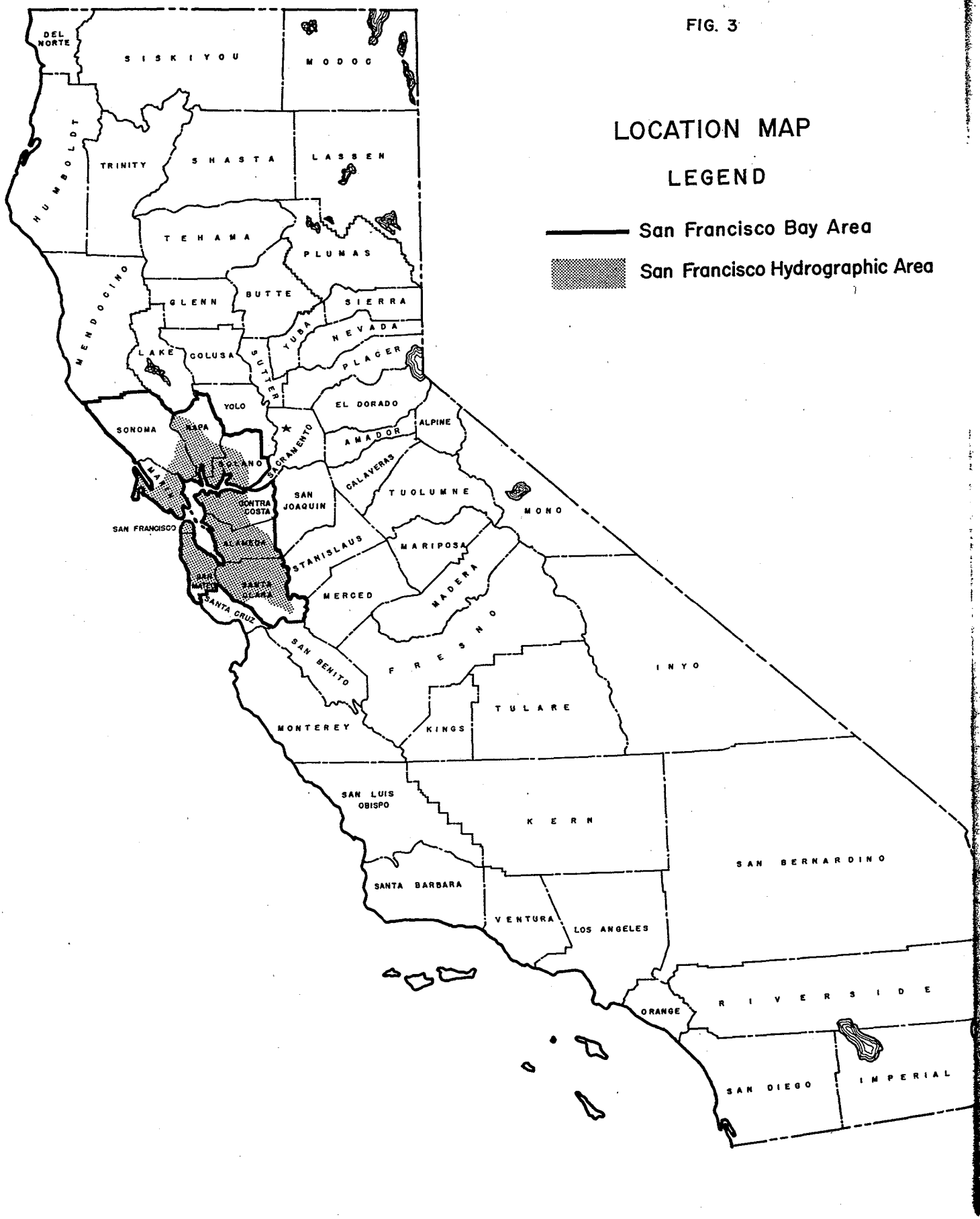
FIGURE 2. San Francisco Bay from Yerba Buena cove about 1853. Angel Island is in the background. Photograph from Final Report of San Francisco Bay Marine Piling Committee, Hill and Kofoid, 1927.



C—043197

C-043197

FIG. 3



C-043198

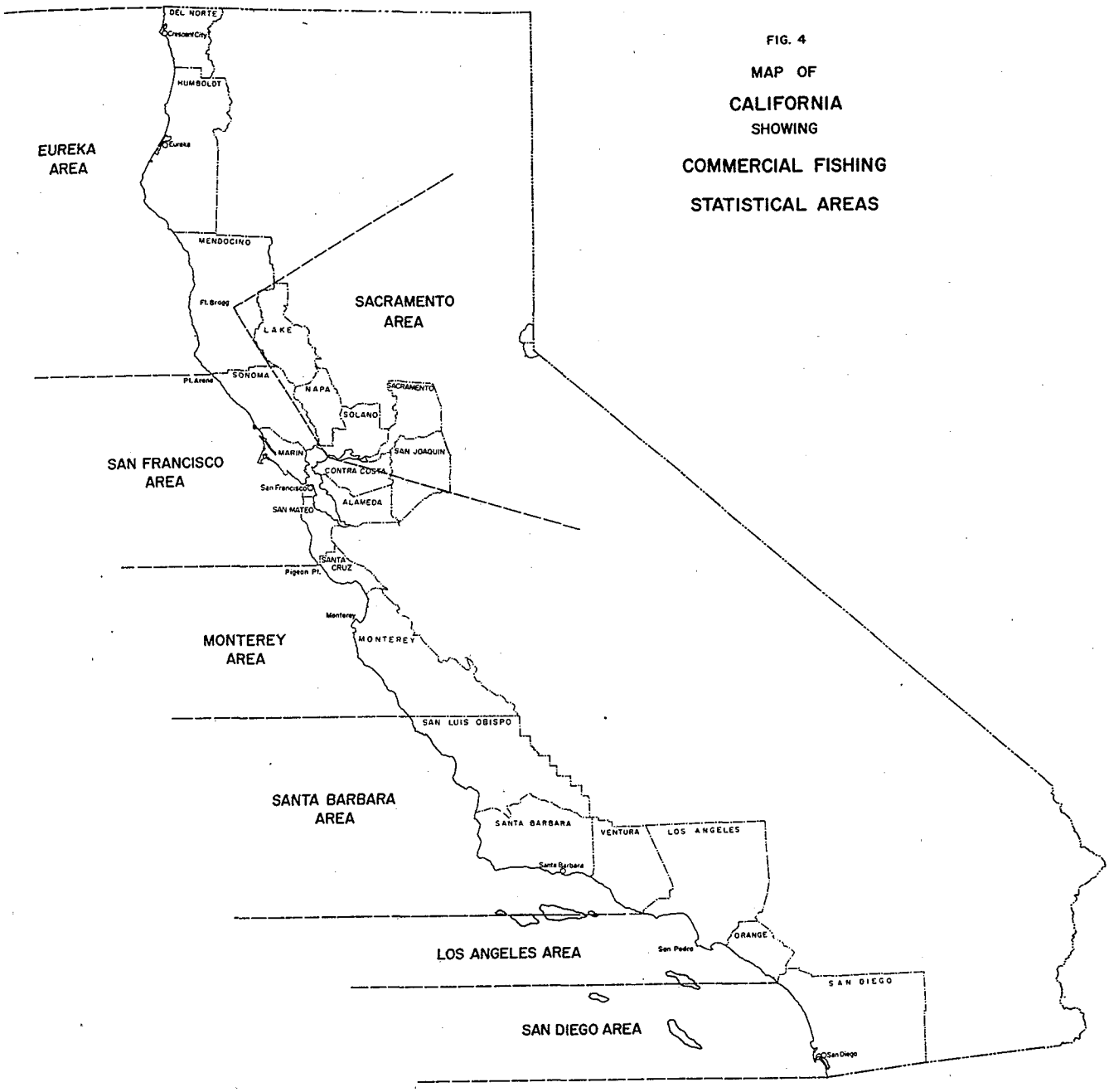


FIG. 4
MAP OF
CALIFORNIA
SHOWING
COMMERCIAL FISHING
STATISTICAL AREAS

Systematic records relating to the take of many game and fur mammals have been initiated in the last thirty or forty years. Records of the number of licensed fur trappers date from 1917, and records of their catches from about 1922. Deer kill figures first became available in 1927 when tags were required to hunt deer. Records for other game species are estimates based on postal surveys which were begun about 1948.

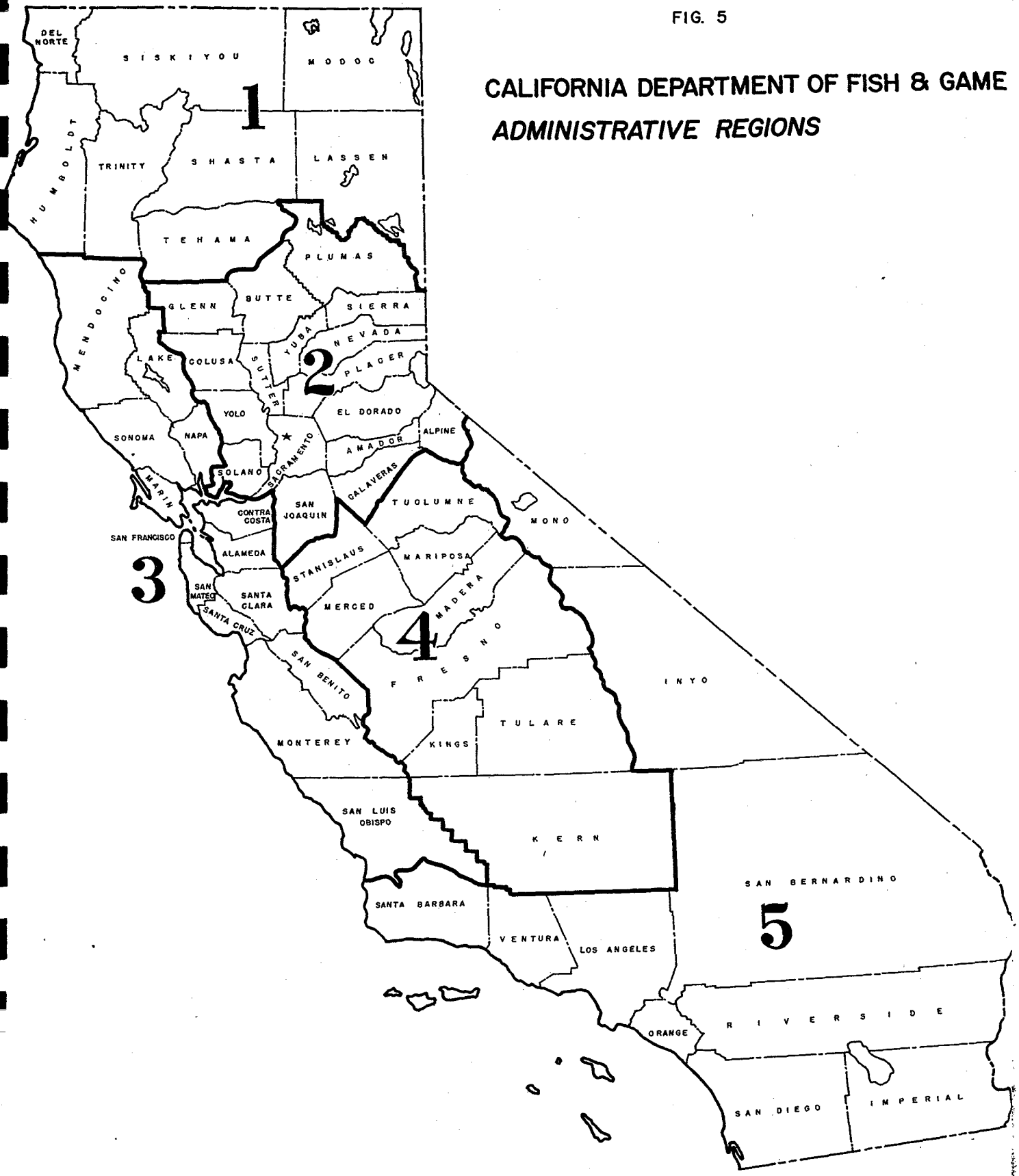
Sport catch records for a number of freshwater fish species were first obtained in 1936 through the use of postal questionnaires. This system has been continued primarily to observe trends in the fisheries. The essential features of these surveys, their validity and reliability have been discussed by Calhoun (1950).

Recipients of questionnaires are chosen by selecting a random sample of the State's licensed anglers or hunters. Although their primary function serves to indicate changes in the trends, the postal questionnaires are also useful to a limited extent in estimating the general magnitude of the catches of a few species. These surveys also yield valuable information about the locations fished and hunted and amount of time spent for various species.

In 1938 a system of party boat sport fishing records was inaugurated. In the Bay Area these are particu-

FIG. 5

CALIFORNIA DEPARTMENT OF FISH & GAME
ADMINISTRATIVE REGIONS



C-043200

larly useful in obtaining data on the catches and expenditure of effort for salmon, striped bass and sturgeon.

Quantitative data on waterfowl were first obtained in 1948. The U. S. Fish and Wildlife Service and the Department of Fish and Game cooperatively make annual inventories of migratory waterfowl wintering in the State. The Department also maintains two public shooting areas in the San Francisco Bay Area where accurate statistics on kill and hunter use are obtained.

Geography

The geographical area encompassed by this report (see Figure 3) includes all or parts of the nine Counties of Sonoma, Marin, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo and San Francisco, and is identical with the San Francisco Bay Hydrograpic Unit No. 2 shown in Department of Water Resources Bulletin No. 3. The area is comprised essentially of all basins draining into the Pacific Ocean south of Tomales Point, Marin County and north of Pescadero Point, San Mateo County.

The lineal distance along the coast is about 120 miles and the width averages about 45 miles; thus, approximately 5,400 square miles are involved.

The area lies within the Coast Range of mountains, which except for the gap at the Golden Gate, forms an unbroken barrier between the Pacific Ocean and the Central Valley of California.

The region is comprised primarily of two life zones: the "Transition Zone" generally along the west slope of the Coast Range and the "Upper Sonoran Zone" on the east. The dividing line between the two life zones roughly coincides with the edge of the coastal redwood belt.

Despite the fact that about 500 square miles, or almost ten percent of the total area is occupied by water, the region is deficient in natural lakes and permanent streams, the great bulk of the water mass being estuarine in nature. However, water development activities have resulted in the creation of a large number of freshwater storage reservoirs.

Population

The reported population of the Bay Area was 3,639,000 in 1960 or approximately 23 percent of the State's total. A long range estimate by the State Division of Highways places the 1980 population at about 8,000,000. Table 1 shows the approximate distribution of the Bay Area population by county.

TABLE 1

DISTRIBUTION OF POPULATION OF THE SAN FRANCISCO BAY AREA IN 1957

County	Incorporated Cities	Unincorporated Areas
Alameda	765,977	2,830
Contra Costa	221,409	37,800
Marin	54,917	4,790
Napa	22,557	593
San Francisco	775,357	—
San Mateo	295,603	10,268
Santa Clara	329,127	—
Sonoma	52,452	6,455
Solano	72,577	—

A considerable proportion of the population either hunts or fishes or both. In 1957, for example, more than 1,430,000 angling licenses and 666,000 hunting licenses were sold in the State. These figures represent 10.1 and 4.7 percent respectively of the State's total population. Thus, it may be assumed that the Bay Area has an estimated population of about 261,000 anglers and 122,000 hunters.

Commerce and Industry

The geographical features of the area have led to its development as one of the world's leading ports of commerce. The Bay Area, with its excellent harbor facilities and thorough accessibility by ship, has developed large industries in food products, paper, metal, petroleum and textiles. There are extensive agricultural lands producing fruit, vegetables, dairy products, grains and wine. Salt and cement products are produced in large quantities directly from the Bay.

The geographical setting has also made the area a strategic location for military bases and shipyards.

FISHING PORTS

California Fishing Ports by W. L. Scofield (1954) is a veritable history of fishing in this State. Of 273 ports listed by him, 83 are found in the Bay Area and at one time or another have been identified with some phase of the fishing industry. For each port he lists the origin of the settlement, type of fishing activity, and the general magnitude of the operation. A complete list of ports in the Bay Area counties is included in Appendix A-1 (For map, see Figure 6.) Typical of his treatment of this subject are the accounts for San Francisco and Hunter's Point which follow:

"**San Francisco:** Located on San Francisco Bay just inside the Golden Gate on the northern end of the San Francisco Peninsula. The entrance to the bay was discovered in 1769 and seven years later the Spanish established a presidio (1776) and Mission San Francisco de Asis known as Mission Dolores. The city was started (59 years after the presidio was established) by Wm. A. Richardson who had come to the cove of Yerba Buena (good herb) 13 years earlier (1822). He lived in a tent and later built the first house (1835). By 1836 there were two houses. Very soon, however, there was a thriving tent city at what is now known as downtown San Francisco. Richardson traded with Mission San Jose by a small boat and later was made captain of the port by the commandante general, Vallejo. So Yerba Buena had an early start as a trading port. The first lighthouse in the State was erected on Alcatraz Island in 1855 and by this time the port was the center of the growing fisheries of the State. It became the place where all fish of the State was shipped except the small amounts used for local consumption. It was the headquarters for the whaling ships of the Pacific Coast and became the greatest whaling rendezvous of the world in the 1880's.

"The first great fishery of the State was for salmon and it was the need for guarding the supply of this fish that led to the establishment of the original California Fish Commission (1870) which later (1878) became the Fish and Game Commission. San Francisco was the shipping point for most of the canned and mild cure salmon. Chinese fishermen developed a great sturgeon fishery in the Bay area, and they are reported as having started salmon beach seining about 1864. The bay shrimp fishery, started in 1869 by Italians was soon taken over by the Chinese and their use of staked bag nets began in 1871.

"The first cargo of Alaska cod (1864) came into San Francisco for repacking and it initated what became a thriving business in resalting and grading northern cod. By 1880 there were 16 San Francisco vessels in the cod fishery and at one time there were 20 such ships. At this time there were four salmon canneries at San Francisco. Later on, the catching of crabs in the bay by the use of baited lift ring nets became a leading fishery of the port and is still carried on in the ocean outside the bay, largely by fishermen of Italian descent. The first shipment of spiny lobsters from Santa Barbara to San Francisco occurred in 1872 and this grew into a big business.

"With completion of the transcontinental railroad in 1869, oyster spat from the Atlantic Coast was grown in the bay. By 1880 San Francisco had become the chief fishing port of the Pacific Coast and handled more fish than all the combined ports from Mexico to Puget Sound. In 1888 the amount of fresh fish handled in the port was estimated at 10 to 11 million pounds per year. In the fish trades these were big figures for those days. Small scale part-time fishing in the bay had been carried on with the establishment of the presidio. The first full-time commercial fishermen were a group of Italians who came to San Francisco in 1848 and they soon spread to other ports of the State. They used the small Mediterranean lateen sail boats from which they fished hand lines, beach seines, and gill nets, but the introduction of the Mediterranean drag or paranzella net in 1876 flooded the markets with fish and drove down the prices paid to fishermen. In the meantime Portuguese had entered the San Francisco fisheries. Many had left the Azore Islands when a pest ruined the vineyards. The State built a fishermen's wharf in 1884 at Union and Green Streets but for many years past the foot of Taylor Street and west to the foot of Leavenworth Street has been considered as the location of Fisherman's Wharf. In June, 1889, the first sardine cannery in the State opened at North Beach, San Francisco. The Chinese stuck by their sailing junks and continued to monopolize the shrimp and sturgeon fisheries. The first steam tug for trawling was introduced at San Francisco in 1885 and by 1892 steam power was replacing sail. At this time fishermen were beginning to use cracked ice but they had not yet started cleaning fish at sea.

"Through the 1880's and 1890's San Francisco was to fishermen and the general populace 'the City'. Then its glory as a fishing port began to fade. Whales became scarce and sea otter were long gone. Salmon runs had declined and the canneries had closed. Stringent laws had prohibited the taking of sturgeon. Bay shrimps could not compete with ocean prawns. Eureka crabs broke the monopoly of the San Francisco Crab

C—043202

C-043202

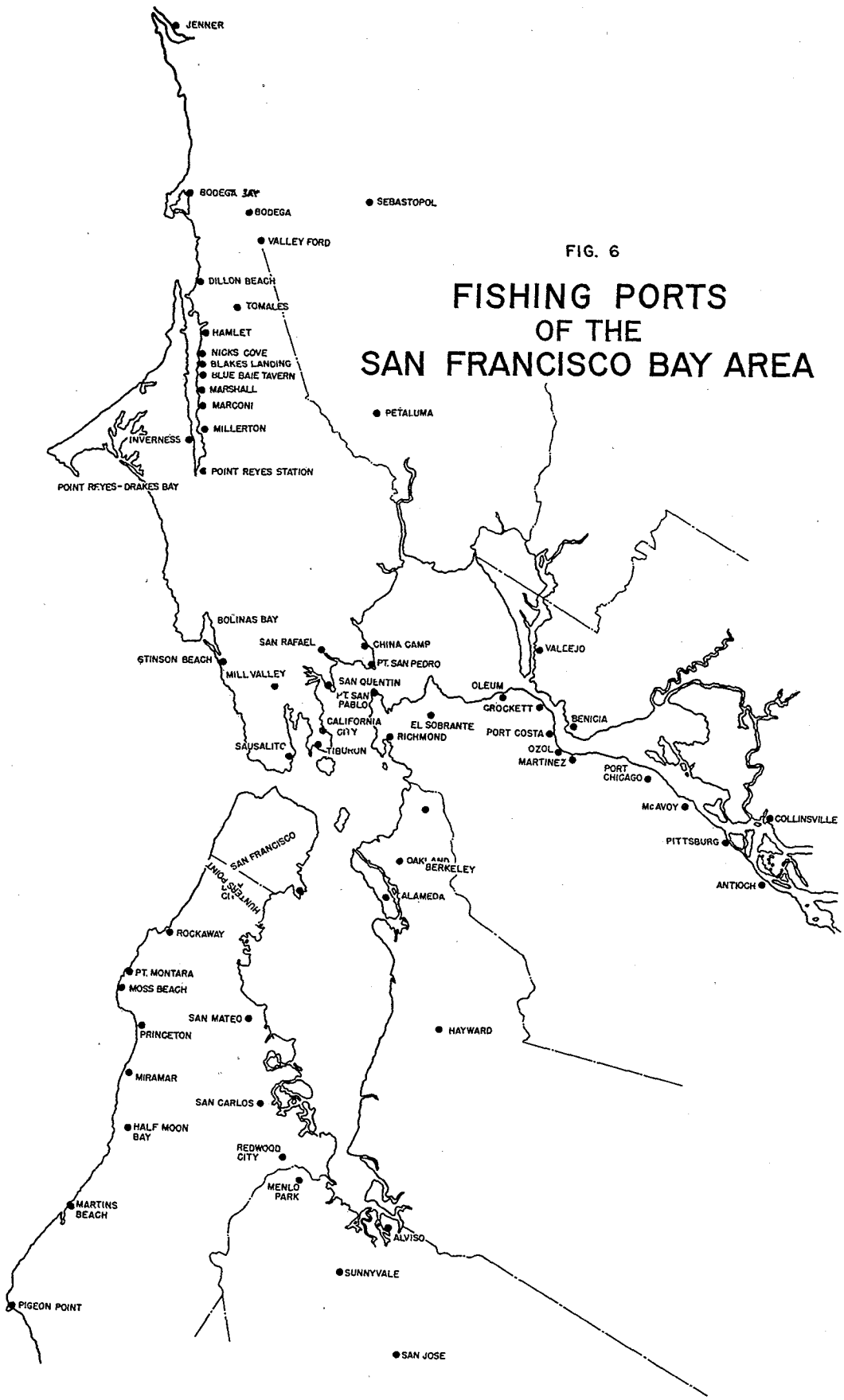


FIG. 6

FISHING PORTS OF THE SAN FRANCISCO BAY AREA

C-043203

Fishermen's Union. The fleet of trawlers transferred headquarters from San Francisco to Eureka (1935-1940). With truck transportation almost every port was a potential shipping point. There was a revival when the sardine industry boomed (1934-1946). Canneries and reduction plants mushroomed in the Bay area but that gold mine was soon worked out and most of the canneries closed their doors.

"In the last 20 years the fish deliveries at San Francisco have fluctuated from 9,000,000 pounds in 1946 and 1947 to 90,000,000 in the peak year 1941. The figures have been influenced by the deliveries during the big years of the sardine industry. The average for 20 years has been 43,000,000 pounds per year. In 1951 the leading species were albacore, crab, salmon, sole, shrimp, rockfish and lingcod.

"Sport fishing for striped bass in the delta area has had a spectacular growth in the last 15 or 20 years and several thousand sportsmen of San Francisco now indulge. They also troll for salmon in the bay area and outside the Golden Gate with shorter periods of albacore trolling 'outside the gate'. In 1952 there were in the San Francisco area 118 party boats and many more privately owned sport fishing boats."

"Hunter's Point: Located on the east side of the San Francisco Peninsula jutting into San Francisco South Bay across from Alameda and five miles south of downtown San Francisco. Since the early days of fishing in the bay, this point has been well known for its Chinese shrimp camps. Through the years, there have been three or four camps (now only two) each made up of several boat crews, living quarters, sheds for cooking and grading the catch, wooden platforms for sun drying shrimp, net tanning vats, dry racks for nets and gear storage sheds. Each had a rickety dock where boats tied up and unloaded.

"The Chinese fishing camps (sturgeon and shrimp) have had the most colorful and, to us, exotic history of all the fishing operations in the State. Power boats have replaced sailing junks but the choice places to fish and the shrimp gear used have changed little through the years. The triangular trap nets were staked to the mud bottom in a line and changed with the flow of each tide. They were ingenious and efficient. The hand woven nets were distinctly a Chinese piece of gear seen nowhere else in the State.

"Chinese families acquired the exclusive right to the best fishing grounds and for a certain consideration would farm out the fishing privilege quite contrary to our law but in accordance with a more binding Chinese precedent. Destruction of some small fish in the shrimp nets opened an opportunity for unscrupulous politicians to propose hampering legislation so that a campaign fund to kill the bill would be collected from the Chinese. The fishermen knew they were being robbed but they paid rather than fight. After all, such methods had been familiar to them and their ancestors for centuries past in Cathay.

"In 1875 it was estimated that there were 1,500 Chinese engaged in catching and drying shrimp in the San Francisco area. In 1897 there were 26 shrimp camps in the bay region but the number had been reduced to 19 by 1910 and now only the camps at Hunter's Point remain to remind us of what once was a great fishery. These camps produced a dried product for export and supplied the San Francisco markets with small but splendidly flavored shrimps. It was the custom in several San Francisco restaurants to place a heaping plate of cooked shrimps before the patron so that he could nibble while looking over the menu. Most of Hunter's Point is now reserved by the U.S. Navy."

THE FISH AND WILDLIFE RESOURCES

of the

SAN FRANCISCO BAY AREA

THE COMMERCIAL FISHERIES

EARLY HISTORY

The early development of San Francisco was due in no small way to the abundance of fish and wildlife resources so near at hand. As the fur industry waned and the gold rush began, San Francisco became the haven of a great many immigrants; many from such traditional fishing nations as Sicily, Italy, Greece, Portugal, China and Japan, who recognized the great wealth to be found in these waters.

Little is known about the Bay fisheries before the immigrants began to exploit them, although Scofield (1954), recorded the fact that Juan Batiste de Anza, who visited Carquinez Strait in 1776, had observed the Indians of the many villages along its shores using nets and fishing from rafts which they used to cross the Strait. The first Italian immigrants arrived in San Francisco in 1848 and began to seine for salmon, herring, mackerel, anchovy, smelt and "whitebait". Later, bottom fishes were taken and boats and nets were devised to fish the waters outside the Golden Gate. By 1869 the shrimp and crab resources were also being exploited.

A list of the more common marine and commercial fish species is given in Appendix B1.

Whaling

Whaling became a major industry along the California Coast about the time of American occupation, 1848-50. By 1880 San Francisco laid title to the whaling capital of the world. Shore stations established during that era still remain as fishing ports. Early literary accounts of shore whaling provide ample evidence of the abundance of these mammals along the California Coast. Col. A. S. Evans (1873) in *Sketches of Life in the Golden State* mentions that from one spot between Half Moon Bay and Pescadero, he counted not less than 15 whales. Goode (1884) quoted Scammon (1874) thus: "It has been estimated approximately, by observing men among the shore whaling parties that a thousand whales [California gray whales] passed southward daily from the 15th of December to the 1st of February for several successive seasons after shore whaling was established which occurred in 1851". In interpreting this he reduced the estimate to 30-40 thousand whales per season from 1853 to 1856. During their occurrence along the California Coast gray whales frequented shallow water and lagoons and were easily sighted and captured. By 1884 Goode reported the number passing along the coast had dwindled to less than 40.

Shore whaling started in Monterey Bay in 1851; a station existed there through the 1930's. Other stations were located along the Pacific Coast but almost all marketed their products at San Francisco. The method employed at the time was for whale boats to cruise within a 10-mile radius of the shore station and tow captured whales ashore for processing. Of the sixteen stations in California, three were located in the Bay area. These were at Bolinas Bay, Half Moon Bay, and Pigeon Point. When the latter station was abandoned in 1895 it brought to a close one of the most fabled aspects of the California fishing industry. Although shore whaling ceased, San Francisco remained the chief port on the Pacific Coast for offshore whalers.

While on the subject of whaling, it is interesting to note that a processing plant has been operating in Richmond the last few years, the only station of its kind in California.

Codfish Packing

Another interesting phase of the early fisheries of San Francisco is described by Scofield (1954): "An account of California fish canning is not complete without mentioning the picturesque codfish packing plants of San Francisco Bay. For a 75-year period (1863-1937) Alaska codfish were repacked, either hard salted, dried, brined, filleted or put up in tins at plants in the Bay Area. The Union Fish Company plant at Belvedere on Richardson Bay (Marin County) operated for three quarters of a century and the Alaska Codfish Company packed for a short period at Redwood City (San Mateo County). Schooner rigged sailing vessels out of San Francisco fished Alaskan waters by the old New England system of the mother ship dropping off dories with one or two fishermen each to handline the cod. The fish were cleaned and salted aboard the schooner and returned to San Francisco for repacking. Later the preliminary salting aboard ship was supplemented by Alaskan shore stations but mother ships out of San Francisco continued till the end of the period when the long haul from Alaska was no longer profitable.

"This salted codfish brought into the State was not recorded in our tables of fresh fish landings but the operation was a California enterprise and the Alaska trips added to our store of romantic yarns of our fisheries, including the shanghaied sailors from the San Francisco waterfront bars and the Barbary Coast."

C—043206

C-043206

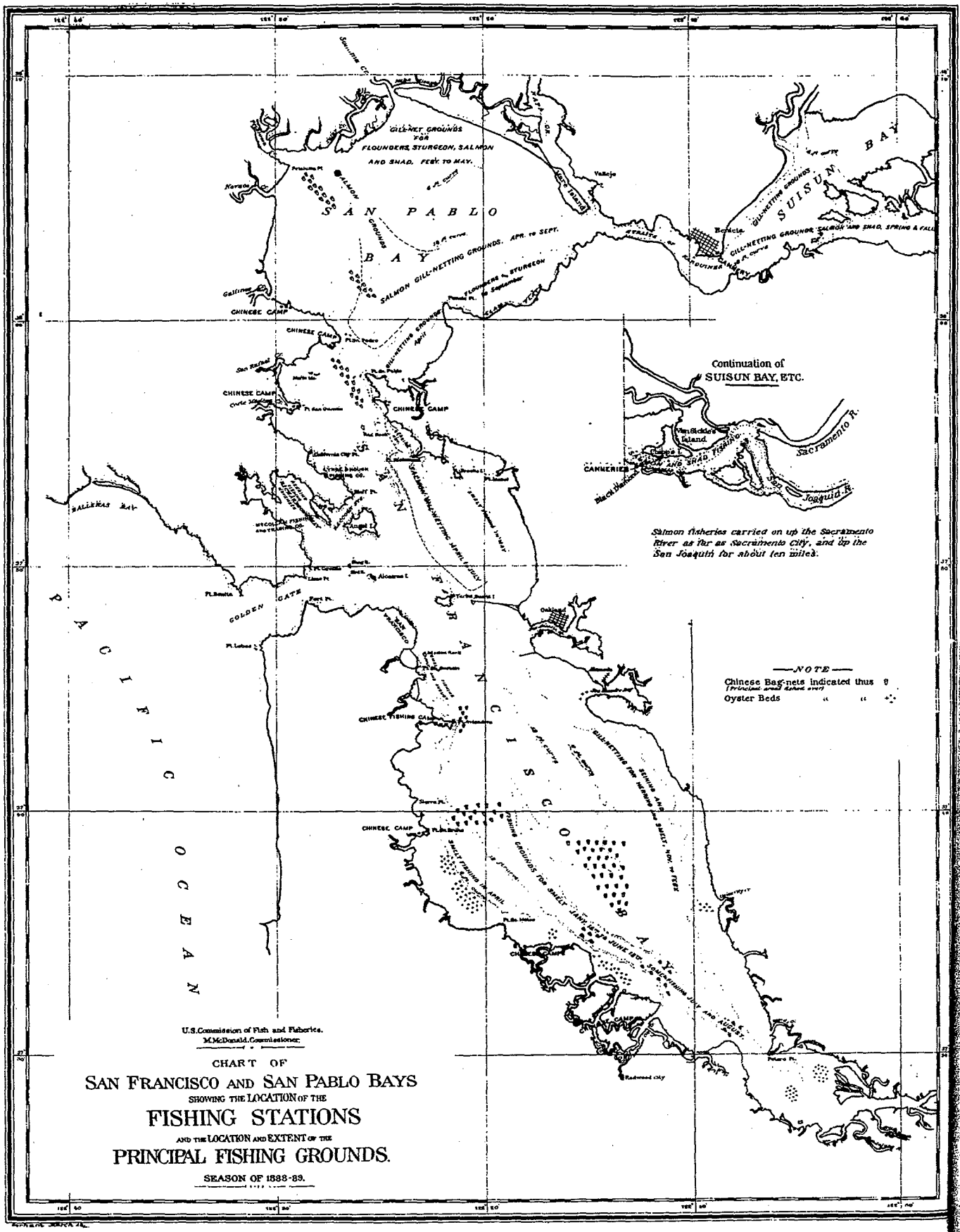


FIGURE 7. Commercial Fishing Stations in San Francisco Bay, 1888-1889.

C-043207

Other Fisheries

A description of the fisheries of the Bay Area in the year 1870 was provided by a Captain E. Wakeman who at the request of the newly appointed State Board of Fish Commissioners made a survey of the fisheries. His account is contained in the Commissioner's first biennial report (1870-71). Selected portions of his report follow:

"Since the date of my commission I have visited with the yacht 'George Steers', repeatedly, all the fishing grounds that are frequented by the Italian and Chinese fishermen in the waters of our bay. The only Chinese fishing station that I find is located a short distance north of the 'Two Sisters'. Here, on an extensive mud flat, are stakes or poles set firmly in the ground, and occupying an area of several miles in extent, from which poles are kept constantly set the nets which are taken up at each slackwater of the flood and ebb tide. From twelve (12) to fifteen (15) boats are employed having three (3) men in each boat. Shrimps are taken here and cured for the Chinese market by being boiled in large vats in salt water, then spread out on the cleanly swept ground and fried in the sun, being raked over frequently during the day. The scales or skin become separated from the meat and looks like fine sawdust. The meat and refuse is then sown up in the best quality of bags and placed on board the Chinese junk of about thirty tons and sent to San Francisco, from whence it is shipped to China. Scarcely any class of fish are taken in these nets but shrimp, and thousands of tons must find their way to China annually. Their nets are similar to those used by the Italians with this difference, viz: the middle of the net, which assumes the character of a bag, is with the Chinese, opened by untying a string, and the whole catch is dropped into the boat with ease. The net is then closed again with the string and put back into the water to remain until next slack. Three of these nets generally load a large boat, which are all of a large and commodious class.

"Saucelito (sic) Bay is constantly used by the Italians, smelt [atherinids probably comprised the bulk of the smelt catch with small quantities of true smelt,] being the principal fish, with soles, flounders, sardines, and anchovies. In some cases nothing but crabs are taken which destroy the nets and irritate the men so that they are inclined to leave them on the beach to die; but I have had, in all cases, everything that was not marketable put back into the water. In fact, crabs are the only fish that are left upon the beach, all other kinds being taken out of the nets with tin pans, the nets being in about from one to two feet of water. All that part of the catch that is desired is taken and thrown into the boat without coming in contact with the sand and dirt, and the small fish are permitted to remain in the water; nevertheless, large quantities of the young fish die from pressure or other cause arising from the fact that they have been compressed as it were among so many thousand into the contracted space of a few feet, and are unable in their most strenuous efforts to release themselves from their perilous condition.

"They are to be found in large quantities, floating upon the water, completely drowned. Still a very large number revive and swim off again. Whereas, heretofore, the custom appears to have been to dump the whole catch upon the beach and, after picking out all they wanted, the young were invariably left upon the beach, becoming, in many parts, a most intolerable nuisance to persons residing in the vicinity. A new order of things has been inaugurated this year, which is found to work to the mutual benefit of all parties concerned. Five boats are generally to be found in different parts of this bay; and fish are taken at all times of tide, both day and night. Two boats are generally employed between the bay and the Golden Gate. They cast on both shores north and south, for the same kind of fish; and also in Kashaw's Harbor, two and sometimes three boats are found both night and day, at all times of the tide. During the night fires are made upon the beach, and frequently these fires can be seen, not only on all the different beaches in Saucelito Bay and Kashaw's Harbor, but also on both sides of Raccoon Straits, giving a most picturesque and cheerful aspect during the long and gloomy nights which prevail in most parts of our harbor at this season of the year.

"These Italians are a singular and peculiar people, always sober and industrious, and like the Chinese, they pursue their avocations in silence. During the silent and tedious hours of the night some are found sleeping in close proximity to the fire, with their harness on, face down, which appears to be the universal practice among all classes of the different races of people who are accustomed to sleep upon the ground in the open air. From Raccoon Straits to the Chinese fishing station, on the north shore, are several favorite places where the nets of the Italians are cast, with various success. The same class of fish being taken from the 'Sisters' up to Petaluma, nothing but sturgeons are found until we come to Vallejo, where there is a mackerel trap fishery.

"Down on the south shore we find two (2) Italian boats on the San Pablo flats, and two more at a favorite point to the north of Sheep Island, [Brooks Island], where there is another mackerel trap fishery.

"Two boats are employed at Sheep Island. They not only cast upon the beach, but generally fish at night under sail only, pulling round and towing the nets. The same fish, smelts, flounders, sardines, anchovies, and soles, are taken here.

"Two boats are frequently employed around Goat Island [Yerba Buena Island], two at Oakland Wharf, and two at Alameda Wharf. Large quantities are taken all along the Alameda Flats, some 10 miles to the southward of Alameda, and on the west coast from Redwood Slough, all along until we come to Baybien

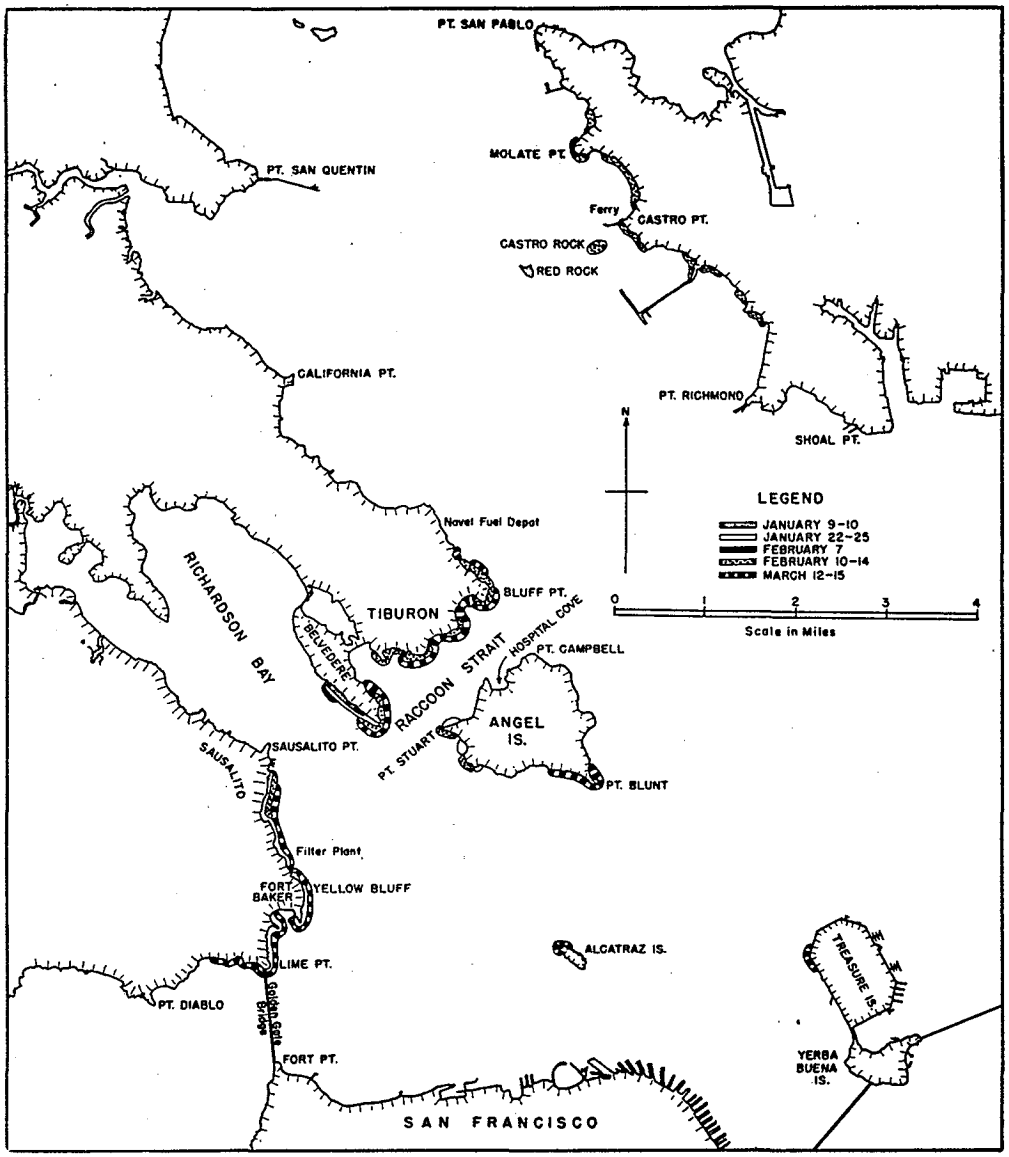


FIGURE 8. Herring spawning areas, San Francisco Bay.

[Bayview] where there is a favorite resort to repair and dry their nets and take out their boats."

Further information on the early fishery of the Bay was obtained from "Fisheries of the Pacific Coast" by David Starr Jordan in *The Fisheries and Fishery Industries of the United States* Goode, (1887). Jordan at that time stated, "The City of San Francisco is the metropolis of the Pacific fisheries and almost all the products of every sort, which are not consumed locally, come hither for use or shipment. For fishing products generally, on the Pacific Coast, the market of San Francisco is the only one of importance".

The principal methods and fishing locations at the time were: (1) By means of seines, gill nets, and hook-and-line in San Francisco Bay and neighboring shores. The great majority of San Francisco fishermen were engaged in this type of fishing. (2) Fishing with trawl lines outside and in the neighborhood of the Farallon Islands, chiefly for rockfish. (3) Paranzella (drag net) fishing, the most productive, both in the Bay and outside the Golden Gate. (4) Purse-net fishing for shrimp and small fish by the Chinese in the Bay.

About 85 boats were employed in fishing and 2 to 35 seines were in use on the Bay about 1875, mostly on the Alameda and Contra Costa side. Herring was apparently the principal species taken from the Bay itself, although smelt, flounders, "tomcod", rockfish, sturgeon, salmon and shark were reportedly caught in quantity.

Six to eight lateen rigged boats, each with 30 to 3 bunches of lines, were employed in trawl line fishing for rockfish. Smelt or sardines were used as bait.

Paranzella fishing was initiated in 1876. This type of fishing was so successful it lowered the market price

C-043209

fish greatly and caused considerable economic hardship among the seine fishermen. About six boats, each costing an estimated $1,000, were employed in this type of fishing. The nets used cost about $250 to $300 apiece. At the time, the paranzella fishing grounds were located between Pt. Reyes and an offshore point about 10 miles to the southwest.

The Chinese shrimp fishery was well developed by 1880. A colony at Bayview, in the southern part of San Francisco, consisted of 24 men, 100 seines and 11 junks. Other colonies were located along San Mateo, Santa Clara, Contra Costa, and Marin County shores.

The Italian fishermen settled at the foot of Vallejo Street, about the Vallejo Street Wharf. This had been their quarter since 1850.

About 1880, 200 men depended entirely on fishing, 300 to 400 depended chiefly on fishing, and about 1,000 were occasional fishermen. About 1,500 women and children were supported by fishermen.

Here, the first fishermen's union on the Pacific Coast was founded when the "Fishermen's Protective and Benevolent Association" was organized in 1877 and established an office on Vallejo Street.

Jordan states that 1886 was a time of depression and that the value of fishery products was poor.

Twenty years earlier, five dollars was a small price for a whole salmon; in 1862 and 1863 they commanded as much as one dollar per pound in the San Francisco markets. The salmon fishery had reached such proportions by 1863 that Hapgood and Hume established the world's first salmon cannery. It was situated on the Sacramento River at Washington [Broderick], Yolo County, across from Sacramento.

Although quantitative data were extremely meager prior to 1875, the evidence is sufficient to show that the fisheries already were well developed. Up to this time few boats ventured outside the Golden Gate, since the Bay itself provided a plentiful supply of all kinds of fish.

The earliest net fishing for salmon occurred about 1850, soon after the Italian fishermen arrived. They also initiated the shrimp fishery in 1869, the use of the paranzella in 1876, and are responsible for a number of other innovations. The steam engine, introduced into the fishing fleet in 1885, made fishing outside the Golden Gate more reliable.

The California State Board of Fish Commissioners, the U.S. Bureau of the Census, and the U.S. Commissioner of Fish and Fisheries began recording catch statistics on the fisheries of the Bay Area about 1875. These are given in a subsequent part of this report concerned with the economic aspects of the commercial fisheries.

Another fortunate contingency was the presence of such great naturalists as Ayres, Jordan, Gilbert, Gill, Evermann, and others who studied the ichthyological fauna in detail. These men identified and classified the fishes of the Bay Area and took particular note of those entering the San Francisco markets. They provided knowledge on the relative abundance and distribution of many species.

The South Bay apparently was the most productive area in the region. Prodigious quantities of the native oyster and other shellfish were found there. The literature indicates this was the major area for smelt and contributed substantially to the shrimp catch. Smelt were taken chiefly on the East side of the bay off Alameda from November to February.

Mussel production reached 3,000,000 pounds or more according to Wilcox (1893) but many of these (probably common littleneck clams) were taken in Tomales Bay.

Apparently the shark fishery, although not particularly exploited, was also centered in the South Bay.

Crabs were first taken on the San Francisco side of the Bay and in Richardson Bay. Catch data are not available to show the amount. These grounds and those along the Marin County shoreline were rapidly depleted and the fishery moved outside the Golden Gate.

According to Collins (1892) 35-40 boats were engaged in the herring fishery which centered in Richardson Bay between October and March.

The North Bay, including San Pablo Bay, was the primary shrimping grounds. Several Italians initiated the fishery in 1869 but the shrimp net introduced in 1871 by the Chinese was so successful it promptly put the Italians out of business. The maximum number of shrimp camps set up is not positively known but at least 26 were located around the bay in 1897, according to Scofield (1919).

Sturgeon were taken chiefly in the shallow flats on the north side of San Pablo Bay, in the bend west of Pinole Point and in the bay from Pinole Point to Point San Pablo, Collins states.

Flounders were taken all over the bay, but principally in San Pablo Bay according to Collins.

THE COMMERCIAL FISHERIES FROM 1870 TO 1915

The fisheries resources of the Bay Area came under especially heavy exploitation between 1870 and 1915. The existing resources were prosecuted severely, new species of fish and shellfish were imported to increase production, and the fishing fleet extended operations into the offshore waters.

The newly appointed Commissioners, eager to augment the native fauna, imported a variety of exotic species from the East Coast of the United States, some of which were spectacularly successful and contributed greatly to the commercial catch. Striped bass, shad, eastern oyster and softshell clams were the most noteworthy from the commercial point of view.

One of the most promising ventures was the culture of eastern oysters. They were imported about 1870,

grew favorably and by 1900 oysters alone had expanded to a million dollar a year industry. The industry originally was restricted to San Francisco Bay but later was carried on in Tomales Bay also. The success of the initial oyster introduction gave impetus to the industry which eventually became the single most valuable fishery in the state. Landings are reported to have exceeded fifteen million pounds in 1892.

Clams and mussels also figured prominently in shellfish production during this period. From the few thousand pounds gathered by the Chinese on the mudflats of the South Bay about 1865, the annual clam production surpassed two and a half million pounds. The eastern softshell clam was accidentally introduced with oysters about 1870 and became very abundant. The market for this shellfish grew until by 1889 more than a million and a half pounds a year were being taken from San Pablo Bay and South San Francisco Bay.

By 1892 crab landings rose to an estimated 2,750,000 pounds while the shrimp catch surpassed five million pounds.

The quantity of fisheries products from the Bay itself began to decline before 1900. This probably was due in the main to overfishing, but there is little question but what pollution, siltation and ship wastes hastened the decline and prevented recovery. The shellfish fisheries were particularly vulnerable and the companies engaging in this industry simply had to abandon their beds. Some idea of the extent of pollution in the Bay is provided by Mr. W. N. Lockington, who at the time, was studying the fishes of this Coast. Mr. Lockington in the Biennial Report of the State Board of Fish Commissioners for 1878-79 wrote the following: "Already the fishery carried on in the Bay of San Francisco is much less productive than it was in the early days of the American occupation; species that were abundant fail to attain their full dimensions. Nor is over-fishing the sole cause of this. The constant hurrying to and fro of the numerous ferry-boats and other steamers, indispensable to our comfort, tends to drive away the timid finny tribes, whilst the ashes and cinders let fall injure the character of the bottom.

"But the injury from this source is small compared with that inflicted by the constant fouling of the waters and consequent destruction of life by the foetid inpourings of our sewers . . . into the waters to pollute them for the destruction of creatures of which human beings are largely dependent for the means of life. As the supply in San Francisco Bay has become limited the scene of wholesale destruction is now shifted to Tomales Bay whence a very large proportion of our fish is now brought".

The position of the Bay Area in the State's fisheries at that time is described in the following account from the thirteenth biennial report of the State Board of Fish Commissioners (1893-94).

"At and about San Francisco are located the most extensive fisheries to be found on the coast. Captain J. W. Collins, of the U. S. Commission of Fish and Fisheries, has said: 'As a whole, San Francisco and vicinity may be considered one of the leading fishing centers of the United States, and its possibilities for development in that direction are believed to be very great.

" 'The geographical features of San Francisco are particularly favorable to the development of the fisheries. A review of San Francisco fisheries, however, is naturally made to include the adjacent counties of Alameda, San Mateo, Santa Clara, Contra Costa, Solano, Sonoma, Marin, Sacramento, Tehama, and Shasta. The headquarters of the fishing industry in most of these counties is in San Francisco.

" 'The marine fisheries of this region are so important as to exceed in value of combined products the value of fish taken at all similar fisheries on the Pacific Coast. In addition to the large local fisheries, San Francisco is also extensively interested in the whale, fur-seal and cod fisheries, the products of which reach a very considerable value.

" 'The extent and importance of the shore or local fishing-grounds of San Francisco may best be appreciated when it is considered that the entire area included within San Francisco, San Pablo, and Suisun bays, constitutes good fishing-grounds. Extensive fisheries are also maintained outside the heads, from Pigeon Point to Point Reyes, and as far west as the Farallon Islands; also in Tomales Bay, the Sacramento and San Joaquin Rivers, and numerous tributary sloughs. These waters contain many species of fish, crustaceans, mollusks, and so forth, and afford the fisherman some kind of a catch for every month in the year. So extensive is the supply of fish from all sources that in the matter of the market prices there is never any cause for complaint from the consumers.

" 'San Francisco is the chief fishing center of this entire region, although salmon fishermen work from nearly every town of any size on the Sacramento River. By far the greater number of men, however, make their headquarters in San Francisco, going from there to the various fishing-grounds and then returning in time to market their catch in a fresh condition.

" 'Several Chinese camps are located at different points on San Francisco and San Pablo bays. The Chinese are principally engaged in catching shrimp which are dried and then exported to China and the Hawaiian Islands.

" 'Until a few years ago there were several large stations devoted to the curing of cod. The business was then quite extensive, but of late years it has been

C—043211

C-043211

permitted, for various reasons, to decline, until now the station at California City is the only one in operation. The decrease in the value of the product commenced prior to 1888, and has continued ever since.

" 'San Francisco is the headquarters of the Pacific whaling fleet, and of many vessels engaged in sealing operations. Space does not permit of an extensive outline of these fisheries, which fact is to be regretted, as there is much of interest that might be written.

" 'Besides the sloops used for carrying oysters to market, and salmon to the canneries, and the steam tugs employed for outside fishing, nearly all of the fishing craft used are small boats, the greater number being feluccas. The regular salmon boat is in use on the Sacramento River.

" 'On account of the great variety of fish caught, and the character of the different fishing-grounds, nearly all kinds of gear are used. The large paranzella nets are hauled upon the banks off Point Reyes by steam tugs, and take the greater proportion of flounders and soles. Many of the fishermen use troll lines and trawls the greater part of the year in fishing outside the heads for cod [probably lingcod and sablefish] and rockfish. Gill-nets are operated wherever the fish happen to be temporarily abundant. The salmon, smelt, herring, and shad, as well as several other varieties, are taken in this manner.

" 'Smelts and sardines are also taken with seines, and in the upper Sacramento gill-nets are used as seines in taking the salmon. The sturgeon are taken on sturgeon lines to which are attached large hooks. Hoop nets are used in taking the crabs.

" 'While many of the varieties are taken in all parts of San Francisco and San Pablo bays, some points furnish much better fishing for some varieties than others. Smelt are found in the greatest abundance in the southern portions of San Francisco Bay. The salmon are chiefly taken in the Sacramento River and adjacent sloughs, and in Suisun Bay, although good catches are sometimes made in San Pablo Bay. A favorite locality for flounders is in the northern part of San Pablo Bay. The principal catch of sturgeon is made in Suisun Bay, although these fish are also found in San Francisco and San Pablo bays, and in the lower Sacramento River. Shad are found in these localities where salmon are taken. Striped bass, carp, and catfish are most abundant in the San Joaquin River and adjacent sloughs.

" 'Naturally the San Francisco market is at all times well supplied with fish. It is true of this market, as of all others on the coast, that for lack of proper handling when caught, the fish, by the time they are offered for sale, are far from being fresh as they should be. No ice is used, and very rarely are the fish cleaned before being sent to the market. This results from the great plentitude of fish, and from the fact that fishermen are able to market their catch within such short distance of the place of capture.

" 'Flounders, rock-fish, perch, carp, and sturgeon are found in the market at all seasons. Salmon and smelt are also found throughout the year; the former, however, being more plentiful during the summer months, and the latter during the winter. Shad are very abundant from October to June, and only about one-third as many are taken as could be were these fish in greater demand. Sardines and mackerel are very abundant during the summer. Many fish are sent from San Francisco to the markets of the interior, and the exports of dried and canned fish amount to many thousand pounds a year. The large majority of the men engaged in the fishing in this region are natives of the countries of Southern Europe, and almost the entire number are foreigners.

" 'It would be much more satisfactory had we the figures at hand to make a comparison of the different branches of the fisheries of this region, but unfortunately, in compiling the data no division has been made prior to 1892.

" 'There were 4,430 men engaged in the fishery industry in this territory in 1892, an increase of 171 since 1888. In 1888, there were 1,023 vessels and boats used, and in 1892, the number had decreased to 900. There was an investment of $2,541,730 in 1888, and although the amount invested in the whaling fleet had fallen off nearly a million dollars in 1892, there was a decrease of but $206,897 in the total investment. In 1892 the value of the product was $2,793,535, a decrease of $1,402,329, on account of the decline in the whale and seal fisheries. This still leaves, however, the extremely large valuation of $2,793,535 to be credited to this region, which is justly considered one of the finest in the world, not only because of the large variety of fish at hand, but moreover, because of its magnificent possibilities.

" 'Aside from the benefits our people derive directly from the food fisheries, it must be remembered that we are so situated as to be able to send the products of this industry to foreign lands, and thus add a considerable amount to the income afforded by domestic trade. Until the establishment of the new steamship lines from northern points a few years ago, a considerable portion of the output from British Columbia and the Columbia River was shipped to foreign countries from San Francisco. These shipments have not only ceased since steamers commenced running from Oregon, Washington, and British Columbia, but more than this, because of favorable transportation rates, some of the dried and shellfish products of San Francisco fisheries have been sent north for export, instead of being shipped, as formerly, direct from San Francisco. The following table shows a decided decrease of exports in 1893, because the low prices for canned salmon in England and the British Provinces made it advantageous for the dealers to place their season's pack on the home market:' "

TABLE 2

EXPORTS OF FISH FROM SAN FRANCISCO IN 1892 AND 1893

Species	1892	1893
Codfish [1]	$26,681.00	$21,412.00
Dried fish	34,439.00	27,043.00
Salmon, canned	1,810,567.00	621,336.00
Salmon, in barrels	46,986.00	44,157.00
Other canned fish	10,715.00	9,828.00
Oysters	9,655.00	7,432.00
Other shell-fish	226,063.00	188,532.00
Totals	$2,165,106.00	$919,740.00

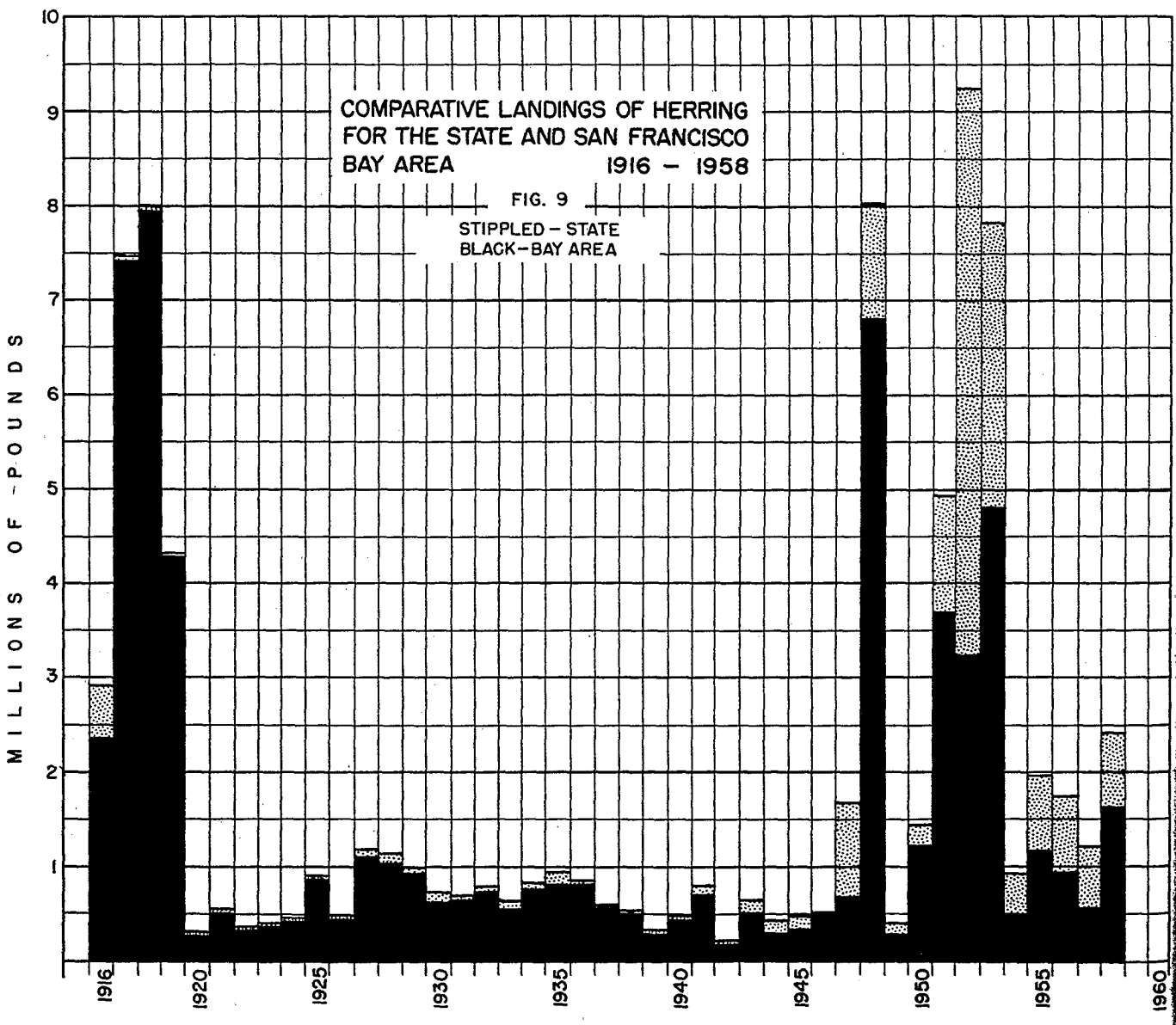
[1] Most likely Alaskan cod.

Between 1870 and 1915 the fisheries of the Bay proper reached maximum production. Practically every species fished commercially was taken in record quantities.

By 1890 the shad catch had to be curtailed to keep from glutting the market. The salmon catch twice reached more than ten million pounds and for a 27-year period averaged over six million pounds. Oyster production was reported to have reached more than 15 million pounds; and shrimp five to ten million pounds consistently, until 1911 when legislative action restricted Chinese shrimping activities.

Fresh fish, of course, were the mainstay of the industry and during this period the quantities landed increased each year. The bottom or trawl fisheries for sole, flounders, and similar species continued to expand with improved techniques, and extension of the fishing grounds outside the Golden Gate.

In 1892, the Bay Area accounted for 93 percent of the State's commercial fishery products, 94 percent of the fisheries investments and 80 percent of the men employed in fishing. Before this the Bay Area was re-



C-043213

sponsible for an even larger proportion of the State's fishery statistics. The products marketed in the Bay Area in 1892 are shown in Table 3. The data are from the thirteenth biennial report of the State Board of Fish Commissioners (1893-94).

In 1908 the Bay fisheries, excluding the ocean, contributed 42 percent of the total California catch and 64 percent of the total value. As a matter of fact, the Sacramento River fisheries alone accounted for 32 percent of the quantity (salmon, shad, striped bass, and catfish) and 38 percent of the value of all the shore and boat fisheries. Salmon, of which 79 percent was taken from the Sacramento River, was the most valuable fishery, followed by oysters and striped bass.

In Appendix B4 are presented data on landings of the more important commercial species in the Bay prior to 1918.

TABLE 3

FISHERY PRODUCTS OF THE BAY AREA IN 1892

Species	Pounds	Species	Pounds
Cod [1]	2,274,565	Shad	491,394
Sardines	703,130	Salmon	3,484,049
Sturgeon	718,017	Flounders	3,557,113
Smelt	1,506,103	Crabs	2,750,000
Herring	4,376,887	Shrimp and Prawns	5,315,075
Rockfish	644,372	Clams and Mussels	2,654,800

[1] It is not clear whether the cod listed here are Alaskan cod or sablefish and lingcod and other closely related species from Bay Area waters but it is presumed to be the former.

THE COMMERCIAL FISHERIES FROM 1915 ONWARD

While scattered records of the commercial fish catch date back to 1872, it was not until 1915 that regular, detailed statistics of the California commercial catch were kept. In 1909 legislation was enacted authorizing the licensing of commercial fishermen. Prior to this however, the State on March 21, 1887 enacted legislation requiring the licensing of fishing boats. In 1911 another law required wholesale dealers to obtain licenses and record their transactions. These records were required to be kept by the dealers and available for inspection by fish and game deputies.

Another legislative change in 1915 compelled wholesale dealers to submit monthly statements showing the transactions of the preceding month. This system was altered in 1917 when legislation was enacted which required the wholesale dealer to record all fish transactions in duplicate. These records were to specify the weight in pounds by variety and the price per pound, in addition to the information previously required.

The only essential change since that time came two years later in 1919 when records of transactions were ordered to be made out in triplicate on forms issued by the State. The triplicate copy was pink and the statistical system became popularly known as the "pink ticket" system. Since 1950 these records have been made out in quadruplicate.

Through this system the State is able to collect, compile, and statistically evaluate commercial fish landings. The records have proven invaluable in assessing the value of the resources and in detecting the changing status of individual fisheries. They are also useful in comparing the various fisheries of the state.

Statistics have been compiled individually since 1916 for each of seven statistical areas into which the State is divided for this purpose.

In this section of the report, the data on commercial fisheries were derived almost exclusively from the statistical reports of the Department of Fish and Game.

The State's commercial fisheries have changed radically since the turn of the century. San Francisco was the major port until shortly after 1900. Then the tuna fishery came into prominence followed closely by the sardine fishery. The largest stocks of both were in southern and offshore waters. Immense tonnages were landed at Los Angeles and San Diego and these ports consequently surpassed San Francisco in both landings and value of catch. The sardine and squid fisheries bolstered the Monterey Area into a position ahead of San Francisco and in recent years the landings in the Santa Barbara Area have also exceeded those at San Francisco. The Eureka Area is now approximately on an equal level with the San Francisco Area and only the Sacramento Area is less important.

The Sacramento Area includes those ports of landing upstream from the Carquinez Bridge. These were the major salmon, striped bass and shad areas. Practically all commercial fish caught or landed within the Sacramento Area, however, is within the general area encompassed by this report. Therefore, all Sacramento landings have been included in the Bay Area (Pt. Arena to Pigeon Pt.) tabulations in this report. It is emphasized that in tabulating and reporting landings of the San Francisco Bay Area, the landings of both the Sacramento and San Francisco statistical areas (Figure 4) have been combined; thus, when reviewing the landings of the San Francisco Bay Area in the text or tabulations in Appendix B2 it is to be observed that they will be greater than those listed for San Francisco in the "Commercial Fish Catch" bulletins of the Department of Fish and Game. Furthermore, shipments into the State have been omitted since 1950. Landings after 1950 also exclude catches made north and south of the California borders. Formerly, both the Sacramento and San Joaquin Rivers were open to commercial fishing but the largest share of the catch appears to have been made in the lower portions within Bay Area counties.

The annual landings for each major species have been tabulated individually for the Bay Area and for the entire State from 1916 through 1958, and are listed in Appendix B2 along with the percentage contributed by the Bay Area to each group. The species have been

C—043214

C-043214

grouped into categories on the basis of similarity of habitat, taxonomy or commercial use.

There have been several notable omissions, namely tuna, mackerel, squid, and several lesser varieties. Only species taken in California waters are included. Tuna have been omitted since almost all of it, except albacore, is caught in foreign waters or on the high seas. Albacore is the only tuna taken off San Francisco. Mackerel are taken along the California Coast in large quantities, but since they have not been landed at San Francisco for many years they have not been included in the report.

Squid are principally taken offshore from, and landed at, Monterey. The lesser varieties are too numerous to treat individually, and collectively contribute less than one half of one percent of the total landings.

Sardines have been included in the tabulations since they were formerly taken in good quantity in the Bay Area. The fishery is now in poor condition with most of the current catch being taken off Southern California.

The landings of 1955 illustrate the present status of the San Francisco fisheries in relation to the rest of the State. In that year a total of 710,713,523 pounds of fishery products entered California. About one-half was taken within California waters or directly off the California Coast. The rest was taken either north or south of the border, or was shipped into the State via common carrier. Of the quantity taken from California waters, 7.7 percent was landed in the Bay Area. The breakdown according to types of products is shown in Tables 4-a and 4-b.

Salmon, flatfish and albacore are the most important local fishes at the present time. In 1955 they comprised over two-thirds of the Bay Area fish catch. San Francisco generally ranks first or second in the production of crustaceans. Almost four and a half million pounds of crab and over a million pounds of shrimp were landed here in 1955. The combined landings of both accounted for 64 percent of the State's total.

Although oysters and clams at one time were the most important fishery products of the Bay Area, they are now relatively minor as compared to the rest of the State. Excluding the squid catch of over 14 million pounds, the Bay Area contributed a little more than six percent of the entire shellfish landings in 1955.

TABLE 4-a

CALIFORNIA COMMERCIAL FISHERY PRODUCTS—1955

	Poundage	Percentage of Total Poundage
California and off-shore waters	343,806,895	48.4
Other Waters	259,310,225	36.5
Shipments into the State	107,596,403	15.1
TOTAL	710,713,523	100.0

TABLE 4-b

FISHERY PRODUCTS FROM CALIFORNIA AND OFF-SHORE WATERS ONLY—1955

	State landings	Bay Area landings	Bay Area landings as percentage of State-wide landings
Crustaceans	8,546,252	5,479,975	64.1
Mollusks [1]	6,053,265	374,701	6.2
Fin-fish	314,935,410	20,381,241	6.5
TOTALS	343,806,895	26,235,917	7.7

[1] Squid excluded from both mollusks and totals.

CHRONOLOGICAL TABULATION OF LEGISLATION AND OTHER ACTIVITIES WHICH HAVE INFLUENCED THE FISHING INDUSTRY OF THE BAY AREA [1]

1848—A colony of full-time Italian fishermen arrived in San Francisco.

1852—First California salmon law. Weirs or obstructions prohibited and closed season established.

1863—First vessel load of Alaska codfish arrived in San Francisco.

1863 or 1864—First Pacific Coast fish cannery (across from Sacramento).

1870—California State Board of Fish Commissioners created.

1870—Eastern oysters introduced.

1870—Softshell clam introduced.

1871—Shad introduced.

1872—Carp introduced.

1874—Catfish introduced.

1876—First paranzella trawl in the State (San Francisco Bay).

1877—Founding of "Fishermens Protective and Benevolent Association" (San Francisco).

1878—California Fish and Game Commission created.

1879—Striped bass introduced.

1881—Law against pound or set nets and weirs enacted.

1885—Steam engine introduced.

1887—Commercial fishing boats licensed.

1889—First West Coast sardine cannery—San Francisco Bay [Wilcox, (1895), states 1890 was date established].

1894—Purse seine introduced.

1895—Law prohibited sturgeon setlines.

1898—Mild curing of salmon begun.

1901—Possession of sturgeon prohibited.

1909—Licensing of Commercial Fishermen.

1911—Shrimp fishing restricted.

1911—Licensing of wholesale dealers and requiring of record of transactions.

1915—Drying of abalone prohibited.

1915—Systematic records of commercial landings initiated.

1935—Sale of striped bass prohibited.

1951—Most of the Delta area closed to netting.

1953—Sale of catfish prohibited.

1957—Use of gill and trammel nets in San Francisco Bay and the Delta prohibited.

[1] Mostly after Scofield (1954).

THE PRESENT COMMERCIAL FISH AND FISHERIES OF THE BAY AREA

The Schooling, Pelagic, Bait and Forage Fishes

Under this heading are sardines, anchovies, herring, smelt and whitebait. These are the most abundant fish species in the oceans and collectively are the most important food fish the world over. Here in California they are also the basis of an important subsidiary industry in which waste and fish are reduced to meal, oil and fertilizer. Before whole fish can be reduced however, processors must meet specified pack requirements for the food market.

They are extremely important as forage for other species of fish. In San Francisco Bay, smelt and whitebait are present the year around where they are utilized heavily by striped bass, salmon and other species of fish. All are or were found within San Francisco Bay.

Pacific herring. The Pacific herring *(Clupea pallasi)* is a schooling fish and is distributed from Alaska to Mexico. Landings have varied from less than 300,000 pounds to more than 9,000,000 pounds a year. The average has probably been close to 2,000,000 pounds.

It is one of the more important market species at San Francisco, where the heaviest landings in the State are made. They are taken during the winter months from December to April as the large schools enter San Francisco and Tomales bays to spawn. These bays are probably the most important herring spawning areas along the California coast, although spawning also occurs in Drakes Bay and Bodega Bay. According to Scofield (1918) spawning takes place among rocks and seaweed below low tide mark. Later work by Miller and Schmidtke (1956) indicates that Pacific herring spawn primarily in the intertidal zone, with occasional spawning extending down through the intertidal zone to a depth of at least six fathoms below mid-tide level.

Pacific sardine. Sardines *(Sardinops caerulea)* were found in the Bay originally, but have not been reported from there in many years. Collins (1892), wrote: "At the time of completing this report (1890) sardines are reported so abundant in San Francisco Bay that they literally obstruct the passage of boats through the water." A fishery for them existed at San Francisco before 1900 but it wasn't until later that their value for reduction purposes was realized, and that a food product capable of competing with other species was developed. The first concerted effort toward expanding the sardine market outside the Bay Area came with the establishment of the Golden Gate Packing Company of San Francisco in 1890, the first sardine cannery on the West Coast. Anchovies were also used for canning purposes. By 1915, the sardine fishery was the largest single fishery in the State in terms of poundage landed.

The fishery is generally concentrated from Monterey south, but for about a 20-year period beginning in 1930, San Francisco also became a prominent port. The fishery reached its peak between 1934 and 1944 when state-wide landings exceeded 800 million pounds each year and three times went over the billion pound mark. The reduction ship landings are not included in these totals. The most productive year was 1941 when the staggering total of 1,262,480,393 pounds was taken. The peak year for the Bay Area was 1939 when over 491 million pounds were taken from local waters. Sardines led all other fisheries in both tonnage and value of landings until 1946.

The combined landings of the Sacramento and San Francisco areas contributed over 200 millions pounds of sardines a year from 1936 through 1944. The entire fishery began to decline after the 1944 season and landings reached an all time low of about 9.5 million pounds in 1953. Northern stocks disappeared entirely and sardines have not been landed in commercial quantities at San Francisco since 1951.

During the sardine boom there were 132 canning and reduction plants in the State of which 49 were located in the Bay Area. Scofield (1954) gives the number and location of plants in 1950 as follows:

Pittsburg	[1]	Port Costa	[1]
Benicia	2	Petaluma	[1]
Richmond	21	San Jose	1
San Francisco	15	Princeton	1
McNears Point	3	Half Moon Bay	1
Martinez	3	Bodega	1
Port Chicago	[1]		
		Total	49

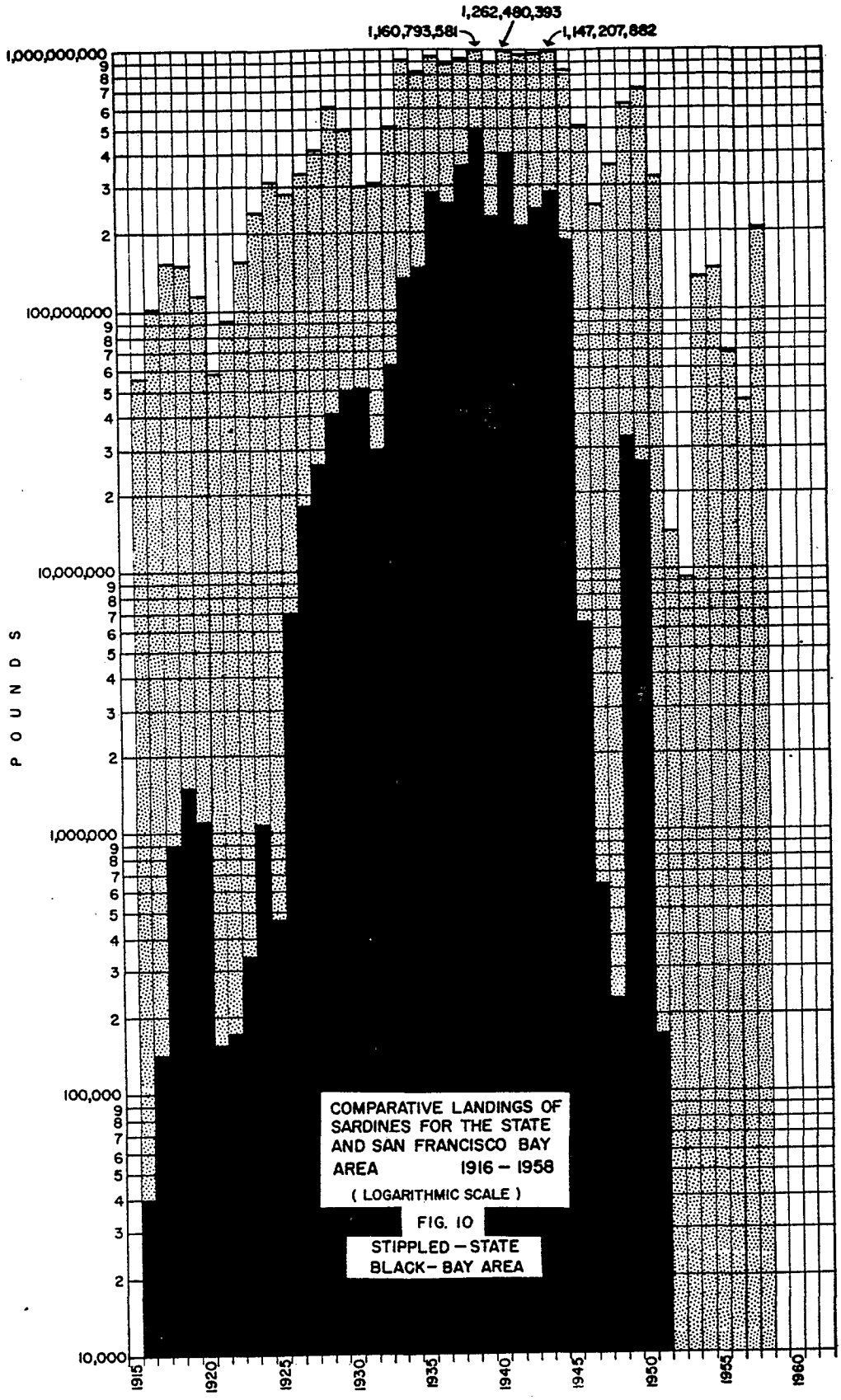
[1] The absence of a number indicates plants which existed but were not operating in 1950.

The Pacific sardine is a typical schooling pelagic fish and is found from Alaska south into the Gulf of California. Since 1950, however, the only California stocks have been off Southern California. During the peak years of the fishery they were very abundant off San Francisco, apparently reflecting favorable oceanic conditions.

Although they were formerly found in San Francisco Bay, their appearance there was probably seasonal and incidental, since they are offshore spawners.

Smelt. Smelt, like herring, have always been taken in the Bay Area but the catch has never been of much significance. It has varied in the region from 100,000 to over 2,000,000 pounds a year, but probably averages close to 400,000 pounds annually. The state-wide catch is usually just about double the catch of the San Francisco Area.

The bulk of the fish which enter the commercial catch as "smelt" belong to the silverside family, *Atherinidae*. The catch is made up largely of jacksmelt *(Atherinopsis californiensis)* and topsmelt *(Atherinops affinis,)* although surf smelt *(Allosmerus elongatus)*, a



COMPARATIVE LANDINGS OF SARDINES FOR THE STATE AND SAN FRANCISCO BAY AREA 1916 – 1958
(LOGARITHMIC SCALE)

FIG. 10

STIPPLED – STATE
BLACK – BAY AREA

true member of the family Osmeridae, is usually included. The former two comprise 80 percent of the catch.

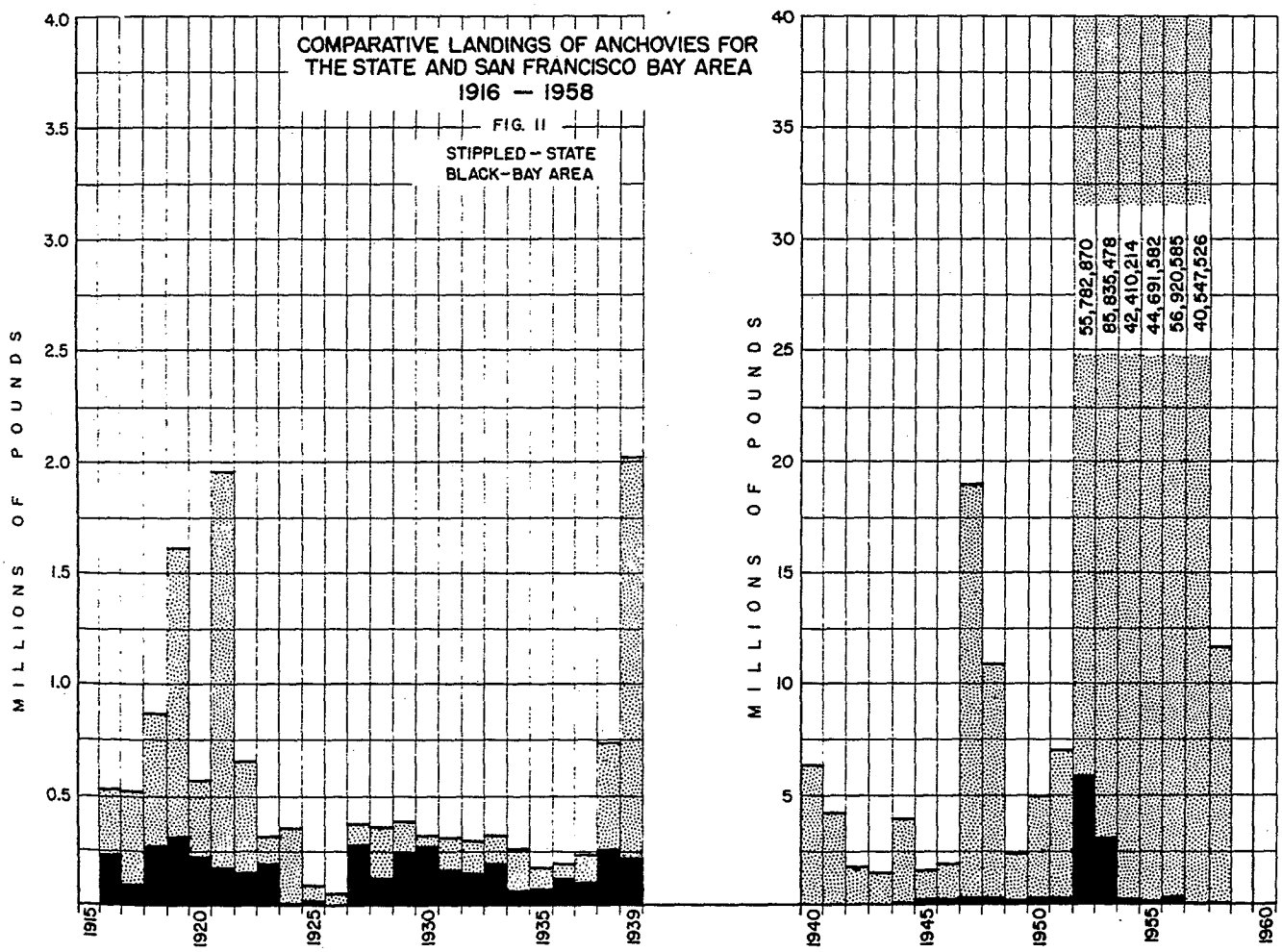
Smelt are sold almost entirely in the fresh fish market, with a small amount entering the bait trade. Jacksmelt and topsmelt usually swim in "loose" schools and quite often occur together. They are usually found within a few miles off shore along the coast and are particularly common in San Francisco Bay.

Northern Anchovy. Anchovies *(Engraulis mordax)* have been found in great abundance all along the California Coast. Heavy concentrations are found off Central California between Point Reyes and Monterey. The stocks shift and are reduced at times under heavy exploitation and are therefore found at different areas along the coast at different times. Anchovies are a mainstay of the "dead bait" industry. They have also been used in the reduction industry to a considerable extent. With the decline of sardines and mackerel this species was exploited to fill the void in the canning industry. The 1953 production of almost 86 million pounds is the largest in the history of the fishery. Top production for the Bay Area occurred in 1952 when almost 6 million pounds were taken. Generally, the local catch averages 300,000 to 400,000 pounds annually.

Anchovies are also a pelagic, schooling species. Their distribution according to Roedel (1948) is from British Columbia to Cape San Lucas, Lower California. They are abundant in San Francisco Bay during the spring of the year and spawn there in fair numbers. They are principally inshore spawners along selected areas of the coast. Anchovies are not uniformly distributed throughout their range, but are concentrated in particular localities, one of which is the area from Point Reyes to Monterey, including San Francisco Bay.

It is interesting to note that a subspecies of the northern anchovy *(Engraulis mordax nanus)* is restricted to San Francisco Bay.

Whitebait. Whitebait includes a group of miscellaneous small fishes found in bays and inshore areas. They are of limited commercial value, the entire catch seldom exceeding 200,000 pounds per year.



C-043218

The whitebait catch in California is composed primarily of true smelts, *Spirinchus starksi* and *Hypomesus pretiosus*. Catches are landed chiefly at Eureka and San Francisco. At the latter port, another species, *Spirinchus thaleichthys*, is represented in the whitebait catch.

In the early years the collective landings of this entire group each year exceeded all others. In the last 43 years the Bay Area has contributed about 10 percent of the total landings in the State although during peak years, 1935-1945, it was closer to 25 percent and in 1939 exceeded 42 percent.

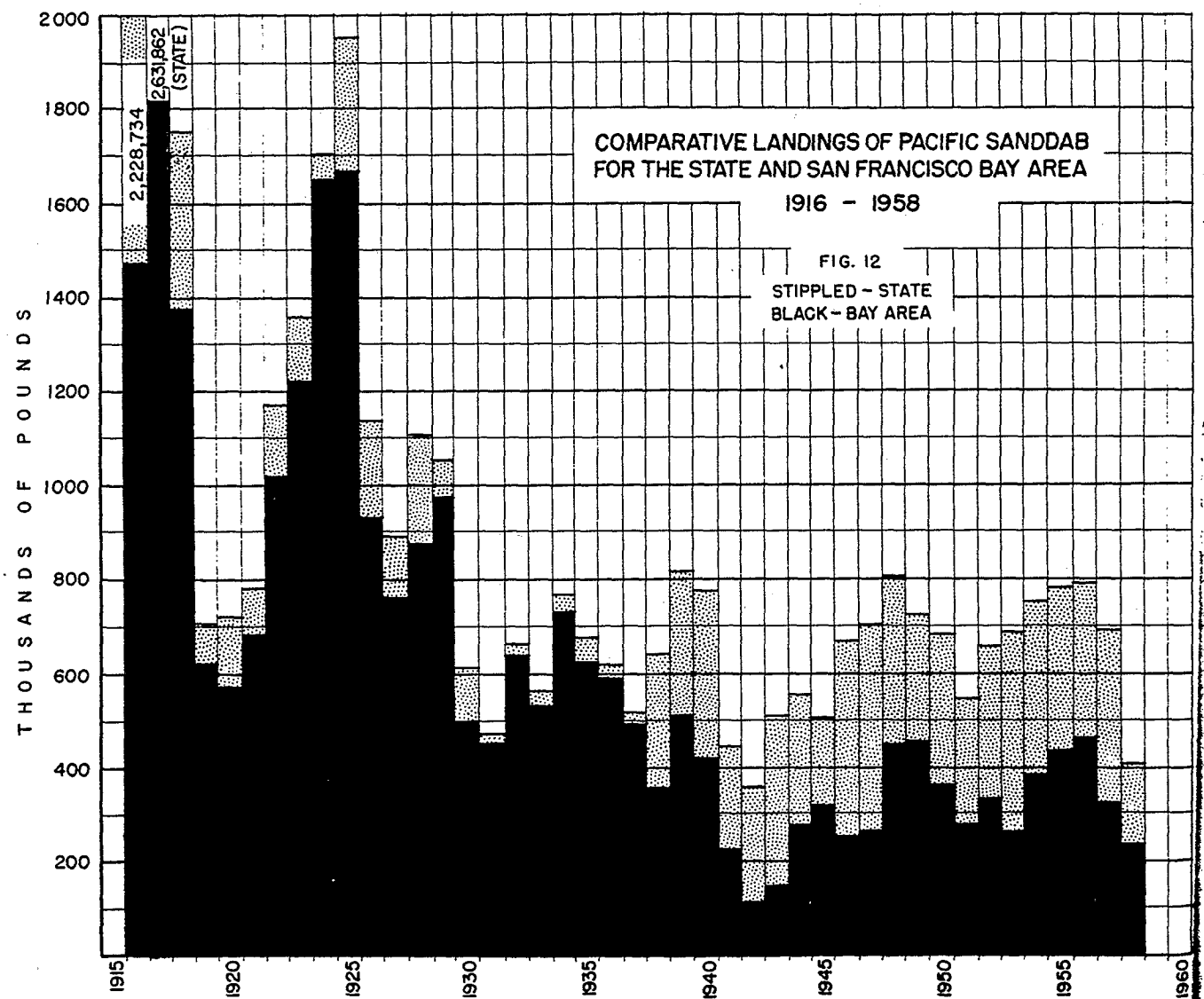
Some of these species are found in both fresh and salt water throughout the year. Others spawn in fresh water in the spring but are found principally in the Bay during the rest of the year. Water quality in the Bay would therefore affect them. The polluted condition of the South Bay is probably among the chief reasons these fish have not been seen there in their former numbers.

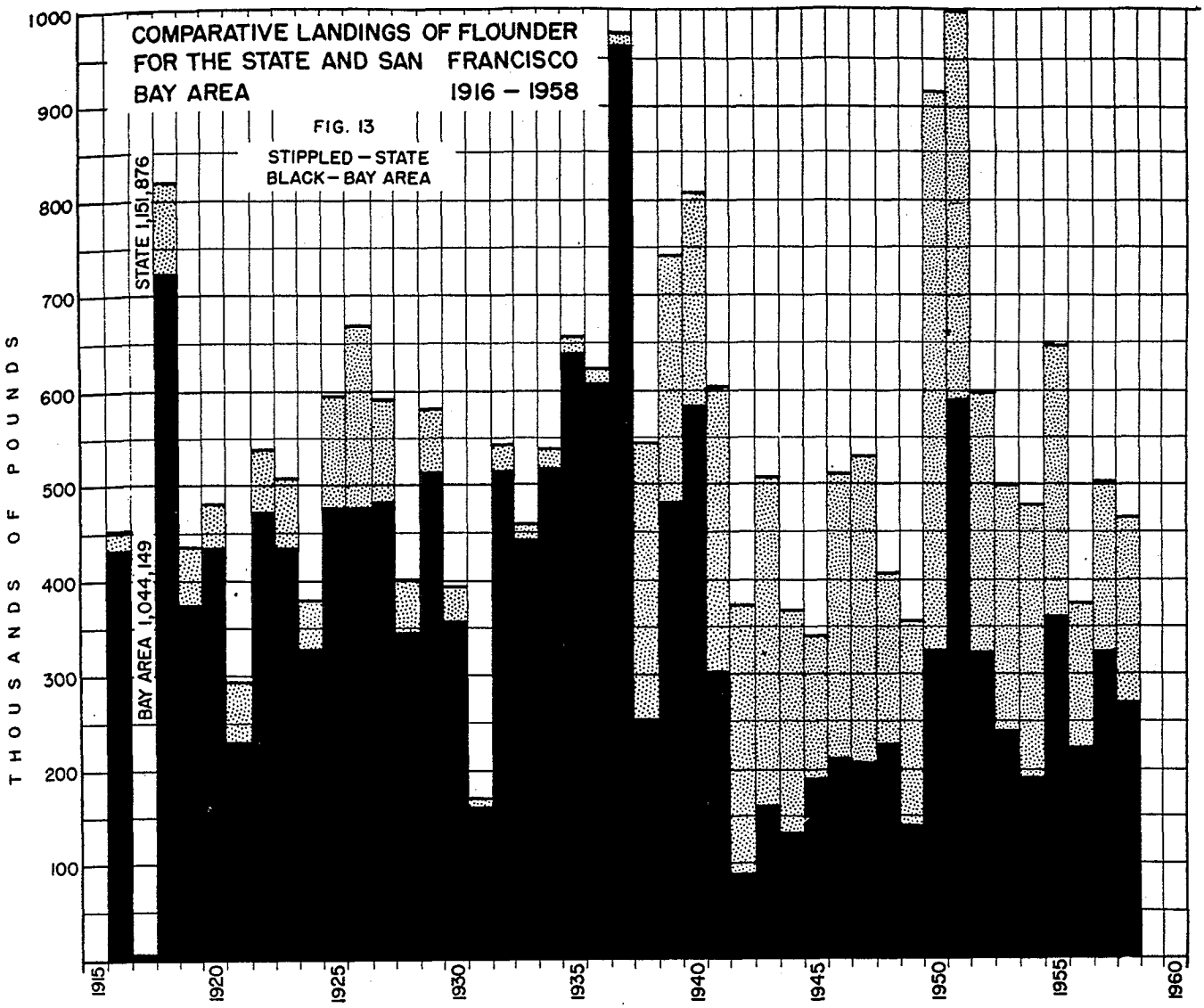
The Flatfishes

Sole, halibut, flounder, turbot, sanddab and similar fishes are included in this category. The important commercial species belong either to the right-eyed flounder family, *Pleuromectidae*, or the left-eyed flounder family, *Bothidae*. They live on the bottom and in the adult stage have both eyes on the upper side of the head.

They are taken in immense quantities all along the California coast but the fishery was centered at San Francisco until recently. Flatfish were first taken from San Francisco and San Pablo bays. The latter still has a good population of starry flounders. After the introduction of the paranzella and later the steamer, trawl fishing for the flatfishes expanded to areas outside the Golden Gate.

Flatfish have always been a principal constituent of the freshfish market. Landings have gradually increased under steady demand. In the Bay Area, the





catch hit a peak of more than 12 million pounds in 1929 and remained at or near 10 million pounds until 1938, at which time the fleet switched to the more lucrative soupfin shark fishery. The slack in the San Francisco catch was quickly taken up by the Eureka fleet primarily, but also by other areas to fill the market demand.

Toward the end of World War II, a filleting process was developed which vastly expanded the flatfish market. The state-wide catch peaked at almost 27 million pounds in 1950 and has exceeded 17 million pounds every year since.

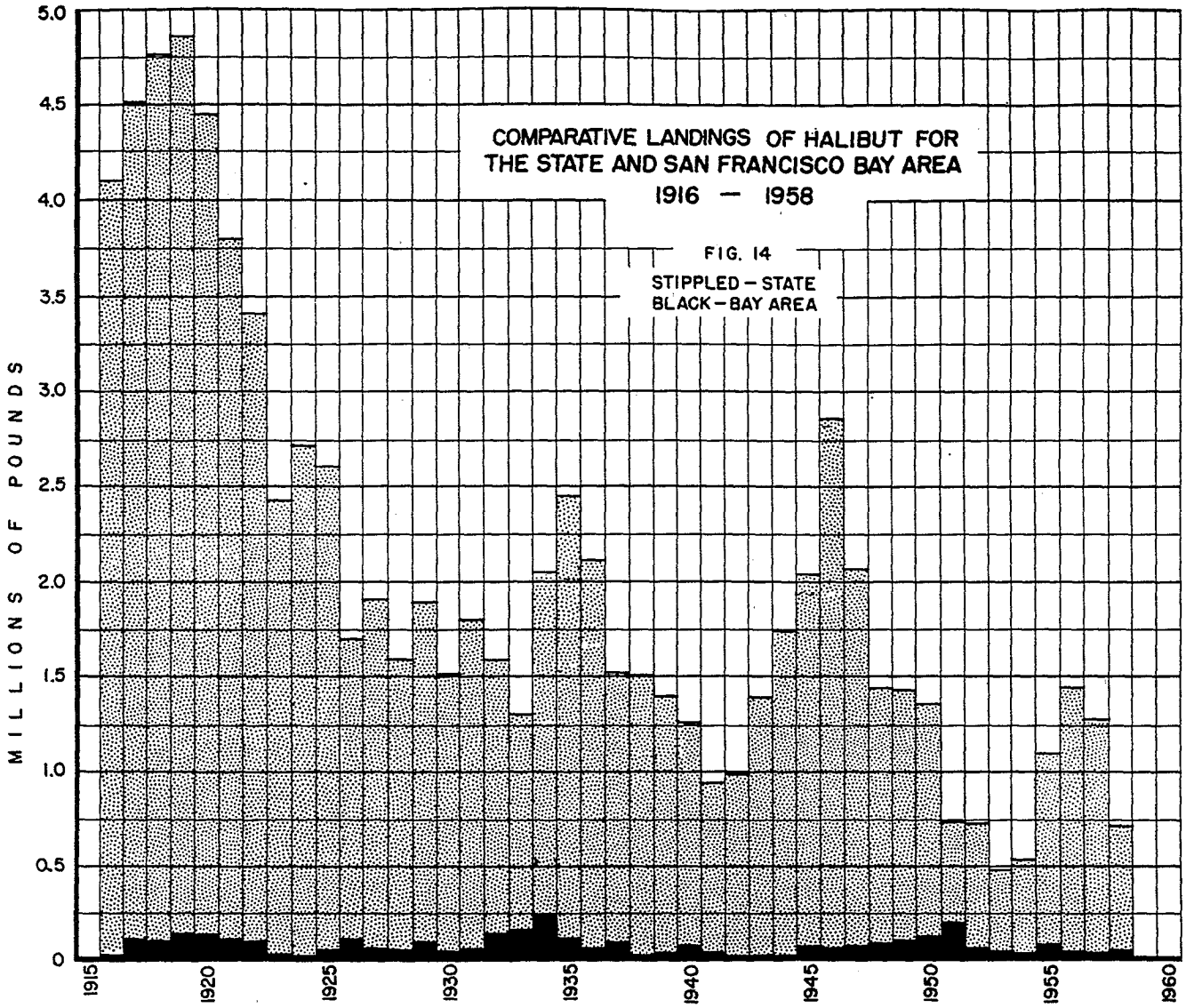
The San Francisco catch has not yet returned to former levels but fluctuates between four and seven million pounds a year. The principal species of flatfish landed at San Francisco is English sole *(Parophrys vetulus)*. Since 1955, separate records have been maintained for each species of sole landed and the records indicate 1.5 to 2.5 million pounds of English sole each year in the San Francisco landings.

Between 1915 and 1938, San Francisco produced 60 to 85 percent of the total flatfish catch. When the fleet shifted to the short-lived shark fishery, it dropped to about 35 percent. In spite of increased catches by the San Francisco fleet, greater landings elsewhere have caused the proportion contributed by this area to drop to about 30 percent of the state-wide catch. Figures 12-15 illustrate the comparative catches of sanddab, flounders, halibut and sole.

Unfortunately, the overall importance of San Francisco Bay to the flatfish fishery is not well known. Research in the Bay has been limited since being closed to most types of commercial fishing. It is known, however, that tremendous numbers of immature flounders, sole, and sanddabs are present. The relationship between the immature fish in the Bay and the

C—043220

C-043220



adults both in the Bay and on the offshore fishing grounds is not clear, but it has been suspected that the Bay might possibly be a spawning and nursery ground for them. On the other hand the flatfish of the Bay may represent a discrete population exhibiting little exchange with ocean stocks. The presence of large numbers of these young fish is sufficient to carefully consider any factor which might adversely affect their abundance in the Bay. Dependence of flounders and menhaden on tidal marshes has been well documented by researchers on the Atlantic Coast.

Hagerman (1952) points out that young Dover sole *(Microstomus pacificus)* are restricted to comparatively shallow water while the largest specimens do not invade these nursery grounds. According to him, Dover sole gradually move into deeper water with increasing age.

The starry flounder *(Platichthys stellatus)*, is the most common species found in San Pablo Bay and is common in Suisun Bay. The mudflats of San Pablo were reported to have been excellent fishing grounds for flounders prior to 1900.

The starry flounder also contributes to the sport fishery in local waters.

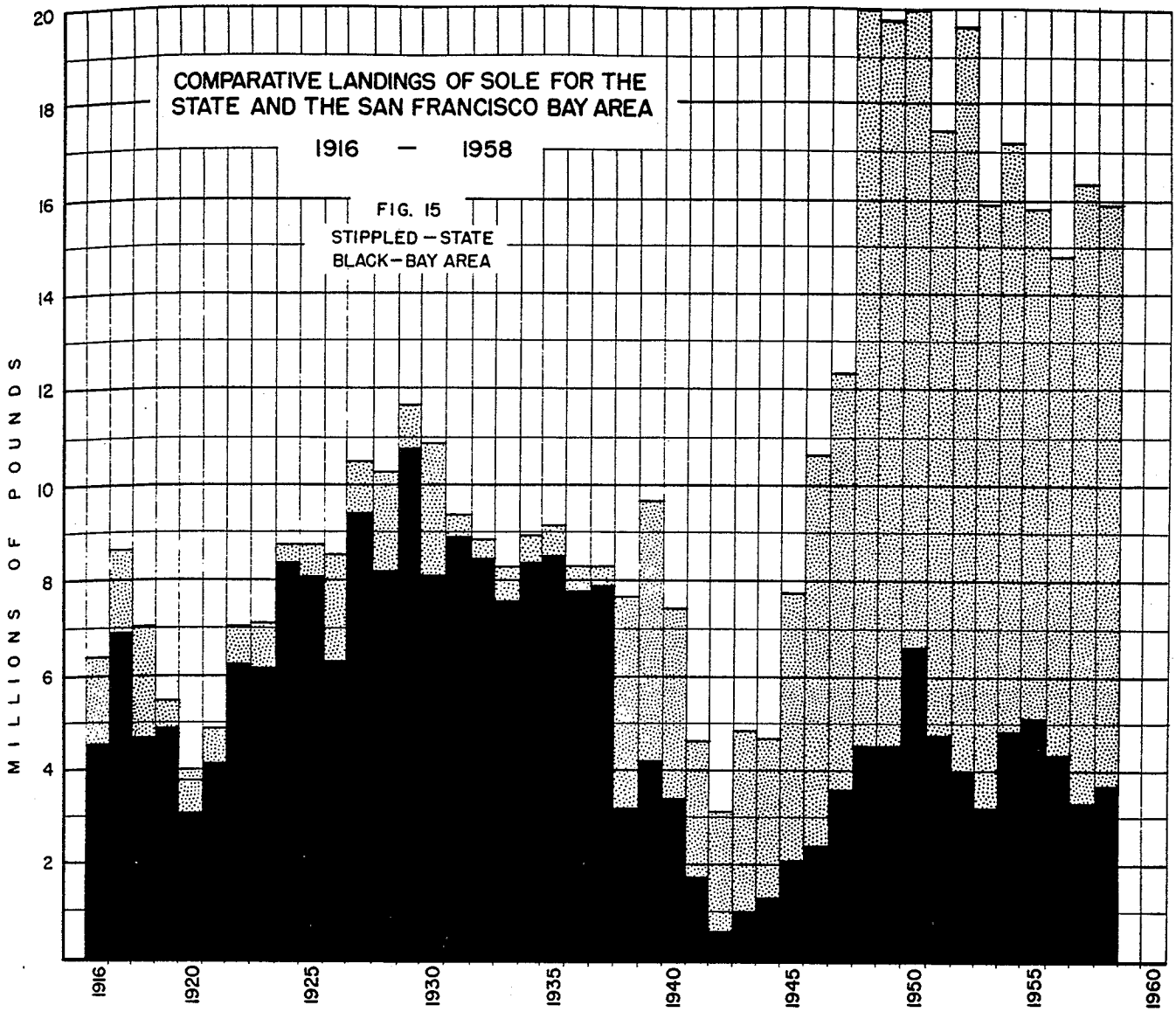
The Bottom Fishes

This is a heterogeneous group of fishes which are caught principally by the offshore trawl fleet. Particular species like rockfish, lingcod and cabezon are also sought by anglers whose catch, at times, may exceed the commercial catch.

Rockfish, sablefish and lingcod, followed by hake, are the most important commercial species in the group. Rockfish comprises the bulk of the catch, averaging between 70 and 80 percent of the total. The catch is made chiefly off Northern and Central California.

C—043221

C-043221



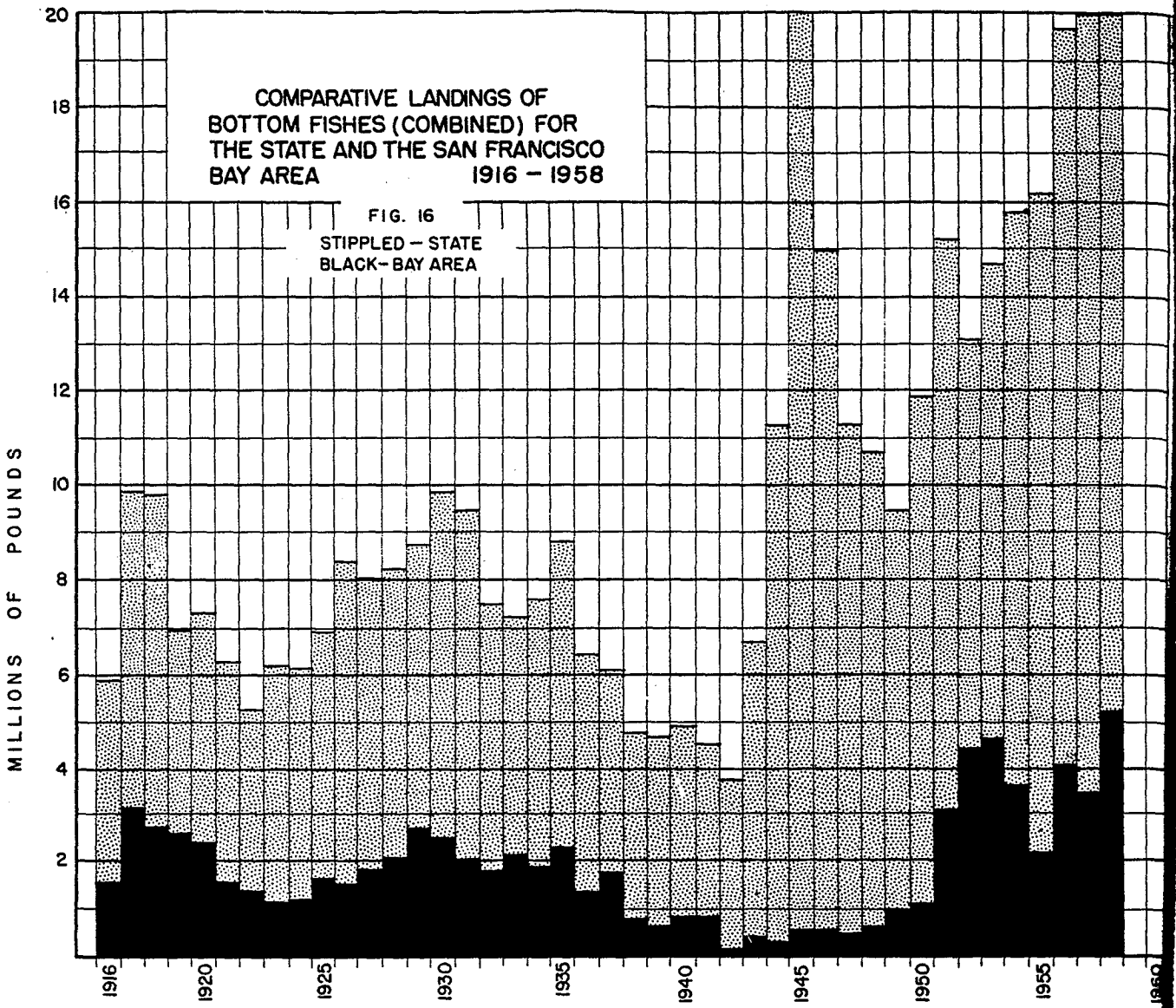
Except for the 1940's, San Francisco generally contributed about 25 percent of the state-wide catch. The total catch, except for 1918, did not exceed 10 million pounds until 1944 when the balloon trawl was introduced. Since then the catch has been less than 10 million pounds only twice and in 1958 reached almost 21.5 million pounds.

Rockfish are not only the chief constituent of the bottom fish commercial catch, but usually are also the leading ocean sportfish in terms of numbers caught. For example, rockfish led the marine sportfish catch six of the seven years from 1952-58. In 1956, party boat operators alone reported more than 2 million rockfish taken by anglers on their boats. All of the members of the genus *Sebastodes* caught along the California Coast are called rockfish. They are similar to the basses in appearance. Rockfish formerly were the most important species in the fresh fish market; now most of the catch is marketed as frozen fillets. In processing rockfish there is a loss of about two-thirds from the round weight. The waste is used in the manufacture of meal, much of which is marketed as mink food.

Rockfish are generally found from shoreline to a depth of 2,000 feet or more although by far the greatest number are in less than 750 feet of water. They apparently were taken in fair numbers in San Francisco Bay prior to 1900. Figure 16 depicts the Bay Area and state-wide catches.

Sharks, Skates, and Rays

Catches of these species have remained rather constant since 1916 except for the eleven year period 1938-48. The discovery of the exceptionally rich source of vitamin A in soupfin shark livers is the reason for the increased catch of shark during those years. Prior to 1938 the catch was rather stable at a little under one million pounds annually. Thereafter it increased and



reached a maximum of more than 9 million pounds in 1940. The production of synthetic vitamin A brought about a diminishment of the fishery which by 1950 returned to its previous level.

While the fishery lasted it was a lucrative attraction to the State's fishermen. The prices paid for soupfin shark resulted in a general shift to shark fishing and the desertion of other types.

Until 1941 San Francisco regularly produced about 50 percent of the catch of sharks and skates, but declined after this to its present level of about 20 percent. Catches are depicted in Figure 17.

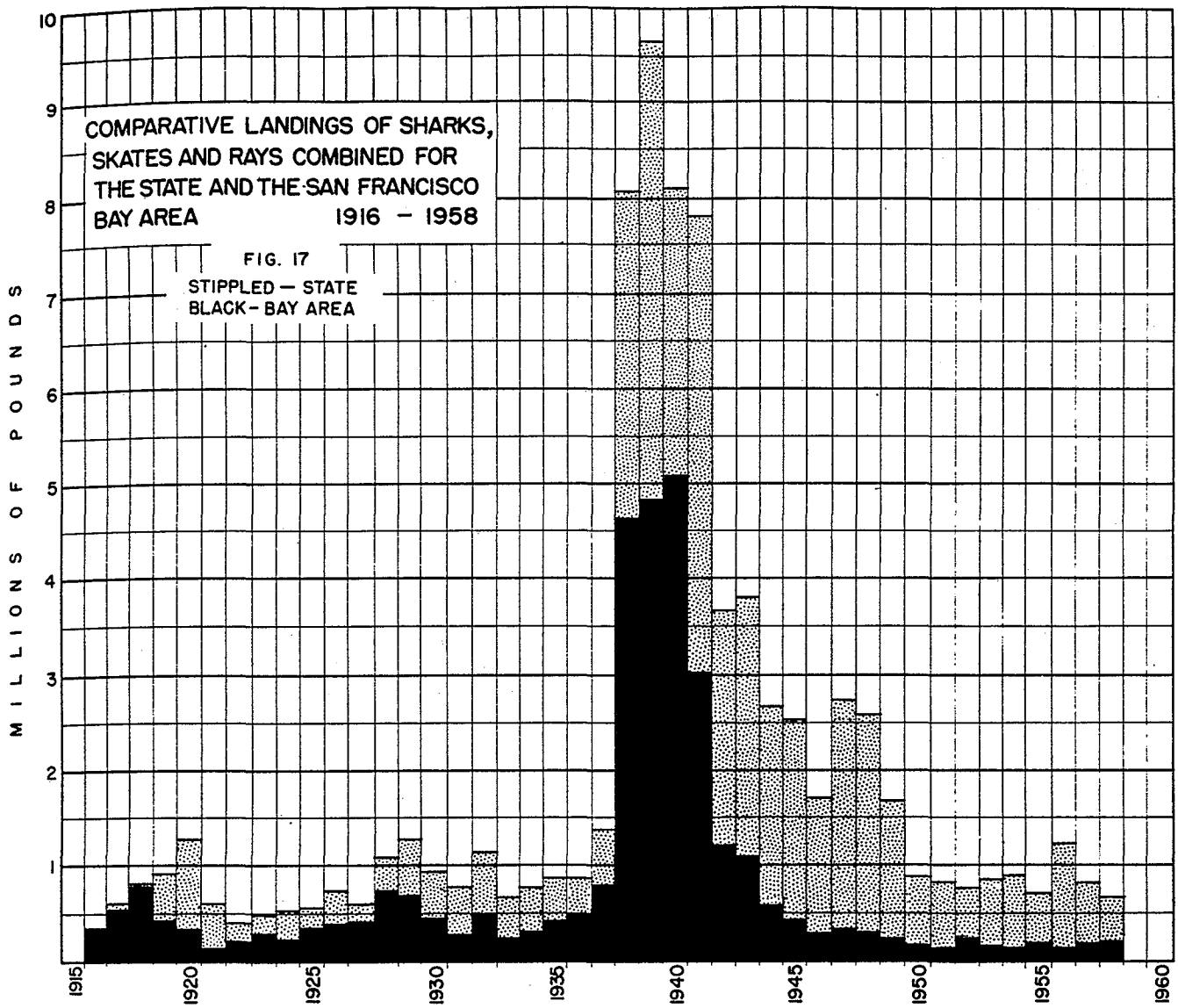
The common dogfish of San Francisco Bay is also an excellent source of vitamin A and these were taken in good quantities during the boom in the shark fishery.

Saltwater Perch

A great many species are included under this heading. Most are members of the family *Embiotocidae* and are found along beaches, wharves and pilings. They are relatively unimportant in the commercial catch, but are an extremely integral part of the marine sportfish catch. Several millions are taken annually by anglers who fish for them from rocks, sandy beaches, wharves and piers. This group provides one of the less expensive forms of fishing, and this is reflected in the number of anglers who fish for them. This is true, particularly, near the metropolitan areas of San Francisco and Los Angeles, where they are an easily accessible source of angling for a large number of persons.

The commercial take seldom exceeds 300,000 pounds a year, of which the Bay Area generally accounts for 25 to 40 percent (see Figure 18).

In any consideration of water quality in the Bay Area this group should be given particular consideration. They are usually found near shore, and since



most pollution originates at or near the shoreline this group is one of the first to be affected.

Croakers

The only croakers of any commercial importance in the Bay Area are the white seabass and white croaker. Even these, however, are insignificant in relation to the other fisheries. The catch landed at San Francisco seldom exceeds five percent and since 1948 has been less than one percent of the State total (see Figure 19). The landings at San Francisco have been less than 50,000 pounds a year since 1930. The maximum since 1915 was just over 150,000 pounds in 1926.

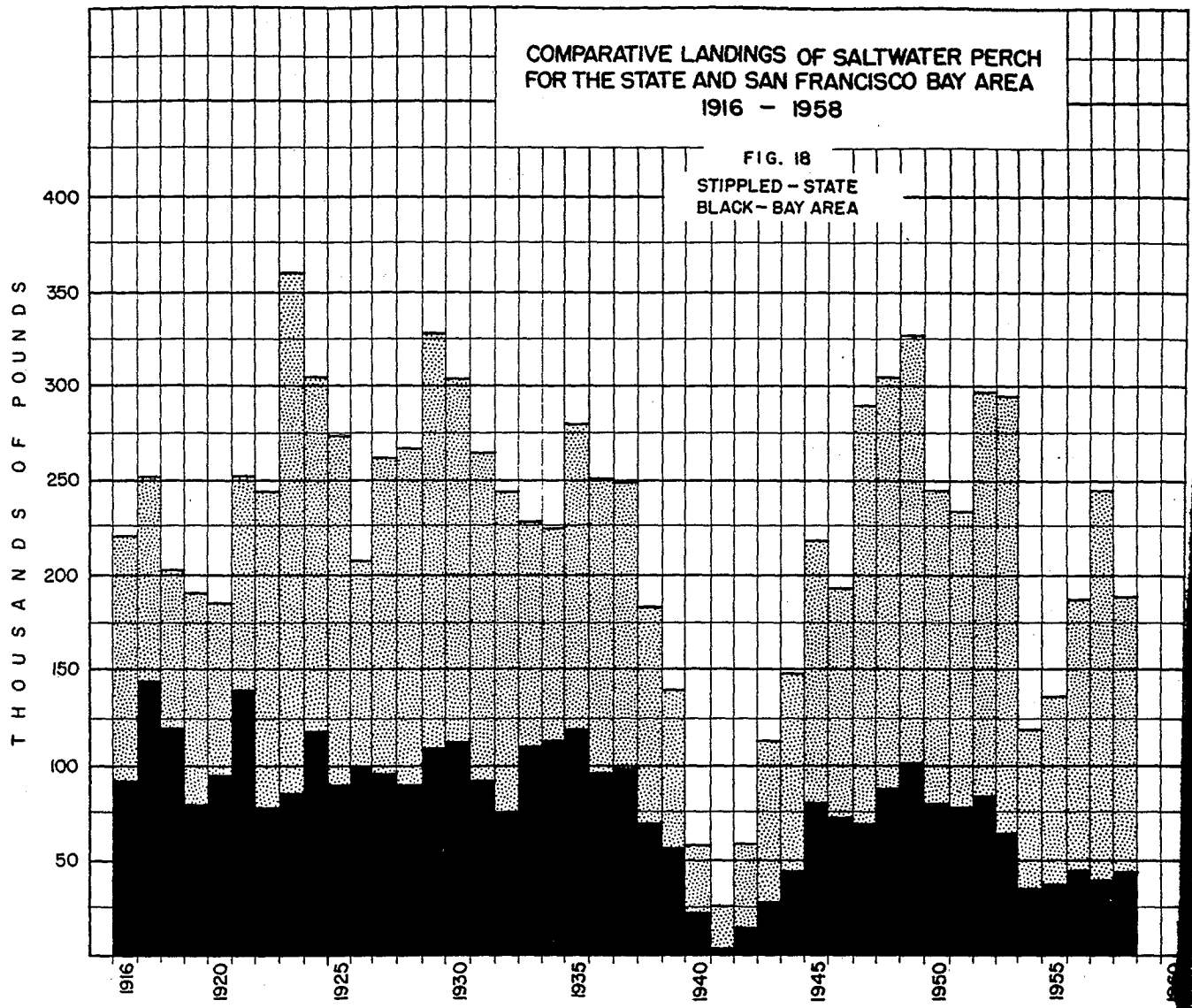
White seabass are a prime sport fish in Southern California waters where they are fairly common, but ordinarily they are not abundant enough to be important in the Bay Area sport fishery. In 1957 because of unusually warm ocean water temperatures they appeared off San Francisco in good numbers and were caught by sport fishermen.

The Molluscan Fisheries

Abalone, octopi, oysters and clams are included in this category. Squid are also mollusks but the fishery for them is restricted almost exclusively to Monterey and they have therefore been omitted from this report.

Formerly, the Bay Area was one of the chief areas in the State for clams and oysters, of which there are several important species of each. These fisheries have declined steadily since 1900. Whereas almost all of the oysters and clams once came from San Francisco and Tomales bays, very few are now taken from these areas. The supply of oysters has shifted to Humboldt and Morro bays. Clams are no longer taken in good commercial quantities anywhere in the State.

In reviewing the tabulations (Appendix B-2) and Figure 21 it should be noted that increased abalone



landings elsewhere in the State, as well as the reduced oyster and clam landings, have brought about the reduction in the proportion of mollusks contributed by the Bay Area to the state-wide total. Octopi have never been of much significance in the California landings.

Mollusks are discussed in detail in another section of this report.

Abalones. The waters immediately off San Francisco are not particularly productive of abalones and landings in this area have been curtailed by restrictive legislation. The major share comes from the Santa Barbara Area. The state-wide landings have been on the order of two to four million pounds a year since 1924. There is a good sport fishery for them both north and south of the Golden Gate, especially along the Marin County coast.

Clams. For a while the Bay Area was the principal source of clams (excluding Pismo clams) in the State. However, the supply in the Bay diminished and late clams and mussels were quarantined for public healt reasons. Softshell clams have not been recorded in th San Francisco commercial fishery landings since 194

Oysters. Oysters in the past were one of the pri cipal fishery products of San Francisco Bay, whic according to early records produced 2 to 15 millio pounds annually for many years.

The landings steadily decreased after 1915, reachi a half million pounds about 1934.

The Pacific oyster was introduced from Japan abo 1930 and new oyster beds were established in are outside San Francisco. State-wide landings then i creased until World War II when seed oyster shi ments from Japan were halted.

The areas to which the oyster industry has shift are chiefly Humboldt and Morro bays. A few beds located in Tomales Bay and Drakes Estero and vari

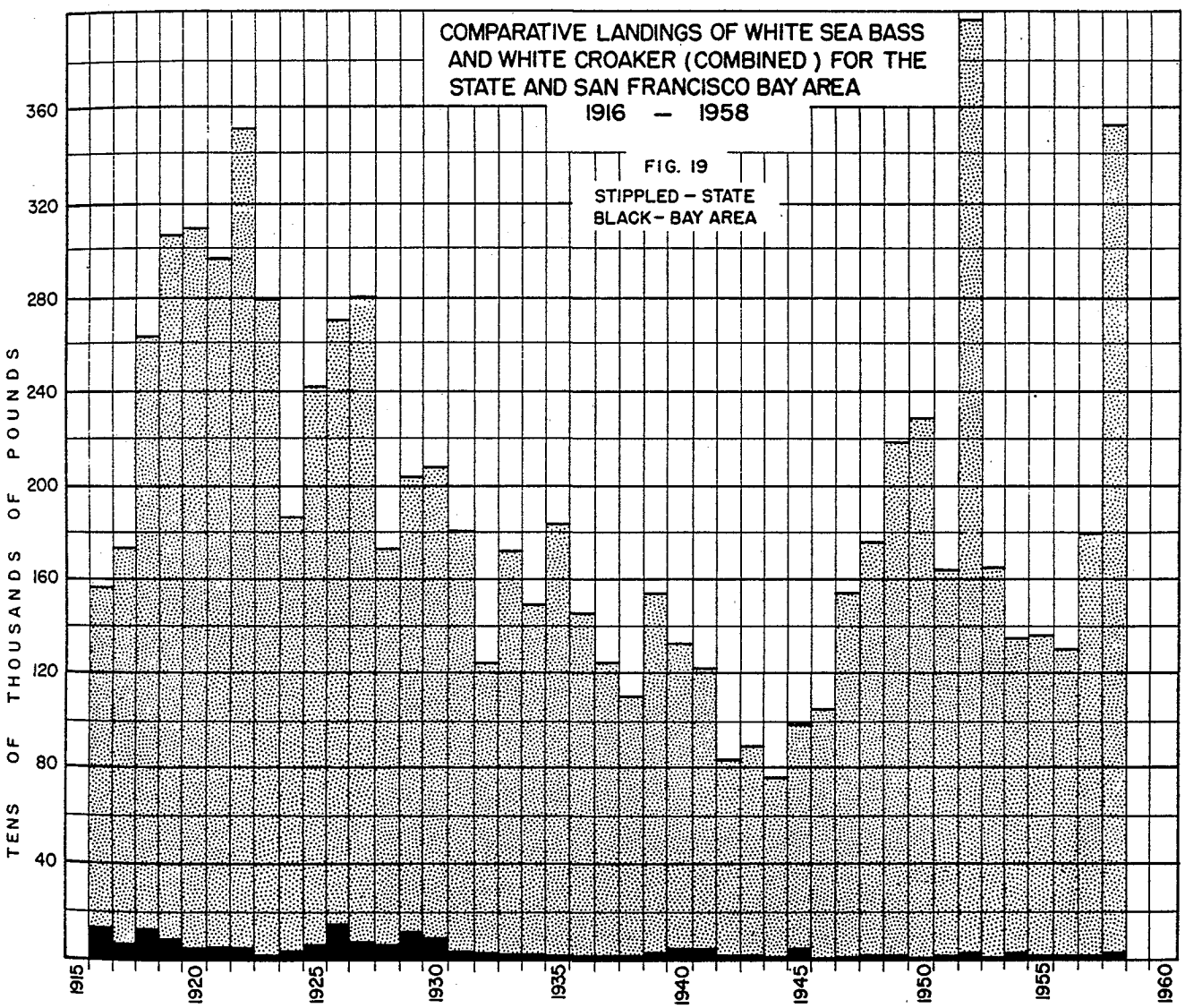
persons are experimenting in San Francisco Bay, but oyster culture in the Bay Area is now at a very low point. Annual production for the Bay Area now averages 500,000 pounds a year.

It has only been since 1954 that oyster culture has been carried on intensively outside the Bay Area, whereas before this time the state-wide landings were almost entirely from this area. Pacific oyster production in Humboldt and Morro bays rose from less than one-half million pounds in 1954 to over eleven million pounds in 1957. Oyster landings are shown in Figure 20.

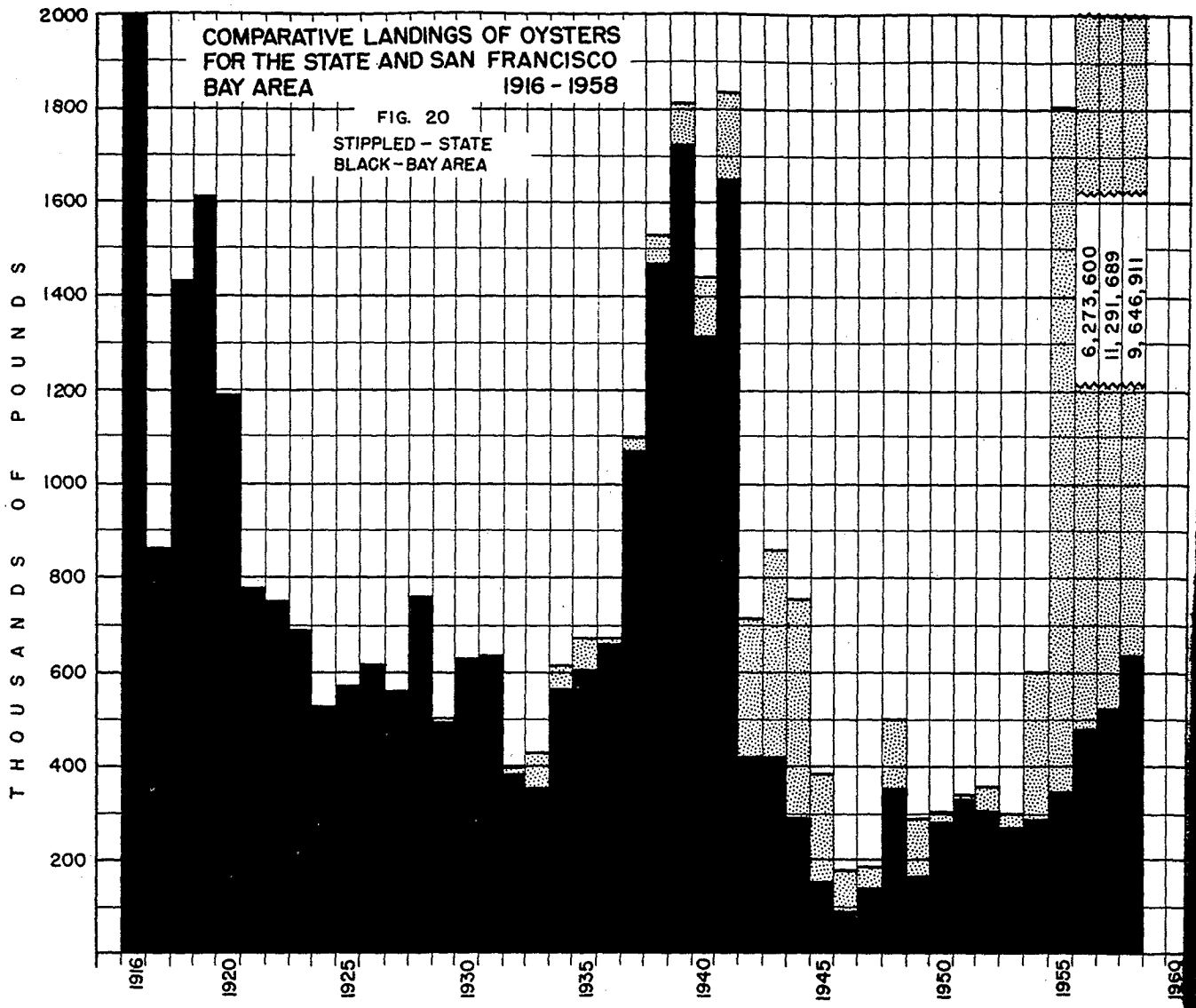
For the entire molluscan category, the total landings for the State have varied between two and five million pounds a year since 1916 until the last two years. The San Francisco Area, up to 1920 accounted for over 60 percent of the total landings. From then until 1946 the Bay Area contribution varied a great deal, but generally remained between 20 and 40 percent of the total in spite of the large abalone production of other areas. After World War II abalone landings elsewhere continued to increase while oyster production in the Bay Area decreased, and as a result, the San Francisco mollusk landings have comprised less than 10 percent of the state-wide total since 1946. The general trend can be observed in Figure 21.

The Crustacean Fisheries

The crustaceans include shrimp, prawn, crabs, and lobsters. Only shrimp and crab are taken in commercial quantities at San Francisco. These two fisheries were prominent here long before 1900 and San Francisco has been the state's chief source of them. The importance of the area can be observed in Figures 22 and 23. Until 1944 more than 70 percent of the total landings were made here. Since then, the Eureka crab fishery has enlarged greatly and new shrimp beds



C-043226



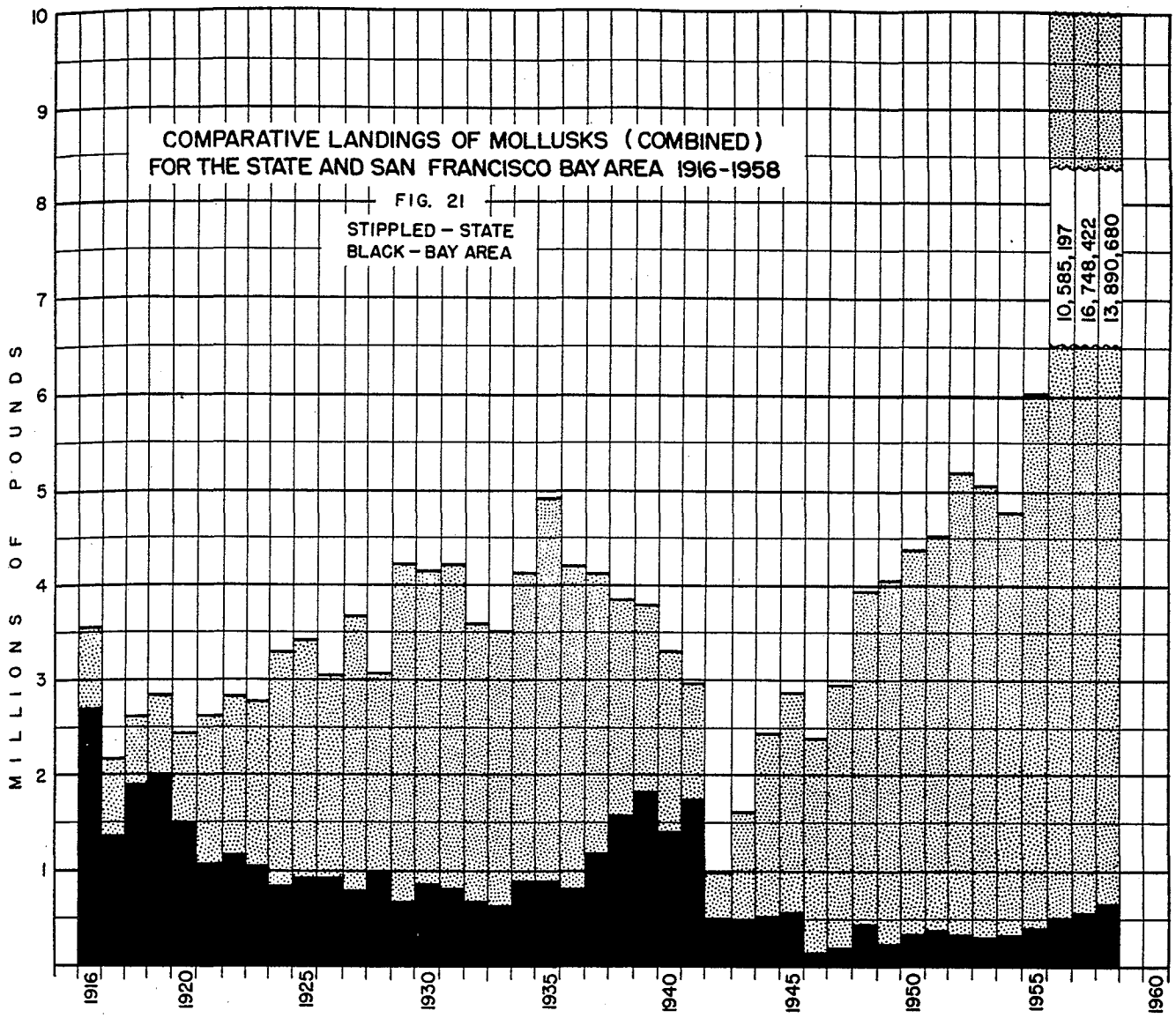
have been exploited in other areas along the coast. As a result the relative contribution of the Bay Area to the state-wide total has decreased even though the local landings have generally increased.

Shrimp. The Bay shrimp fishery has no counterpart in the United States. These tiny crustaceans were taken in tremendous quantities by the Chinese between 1870 and 1915. The fishery was located in both North and South San Francisco Bay and in San Pablo Bay. Legislative restrictions reduced the take briefly after 1910 but within a short while the landings increased to an average of almost 2 million pounds a year until 1940. Since then, they have been less than a million pounds a year. Apparently, the cost of the labor involved in processing them is prohibitive and the annual production therefore does not reflect accurately the market demand or their abundance. Another factor is legislation which limits the amount which may be dried. The foreign Chinese market was the largest buyer of dried bay shrimps and curtailed trade with that country has undoubtedly been a factor in the reduced landings.

Virtually all shrimps landed in California came from San Francisco Bay until 1952, when new beds of ocean shrimps and prawns in offshore waters were discovered outside the Bay by Department of Fish and Game marine biologists. The exploitation of those beds, plus the reduced catch of bay shrimps has decreased the relative contribution of the San Francisco Bay Area to the state-wide total.

Shrimp landings are summarized in Figure 22.

Since there has been a lack of research and commercial effort in exploiting bay shrimps it is difficult to ascertain their present abundance or distribution in the Bay. It seems extremely unlikely however, that they are present in their former abundance when five or more million pounds a year were taken by the Chinese



Shrimp are a major forage item for the young of many fish species.

Crabs. Crab landings at San Francisco have fluctuated between one and eight million pounds in the last 25 years, the average being about three million. (See Figure 23.) The larger landings have been made in the more recent years. The state-wide totals paralleled the San Francisco catch very closely until 1946 when the poundage landed at Eureka began to equal and then exceed that at San Francisco. The crab fishery is one of the most important in the region. Most of the crabs are taken on sandy bottom in the shallow water off the Golden Gate. Originally they were taken in San Francisco Bay, but the fishery had moved outside before 1900.

Freshwater Commercial Fishes

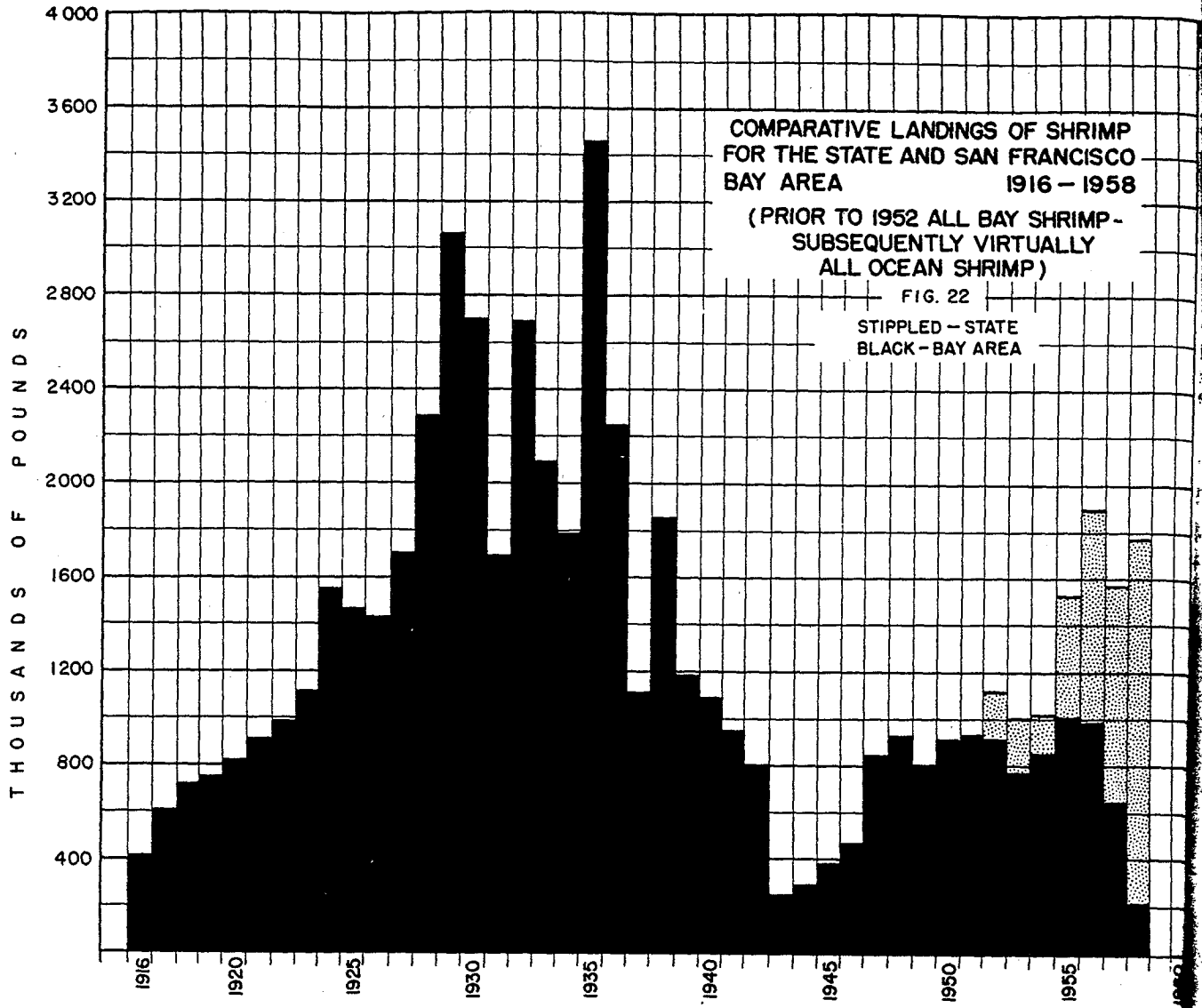
This category contains catfish and several species of so-called roughfish. The latter are non-game fish, and include carp, hardhead, sucker, splittail and Sacramento blackfish chiefly.

In the early days, Sacramento perch were a major constituent of the freshwater fisheries. Collins 1892 reports: "Sacramento perch (*Archoplites interruptus*) is known only by the name of 'perch.' It is taken in great numbers from October to March in the lower reaches of the Sacramento and San Joaquin Rivers and is shipped to San Francisco where it sells at from 4 to 8 cents per pound." The 1888 landings of 432,000 pounds appear to be the largest on record; however, it is not clear whether the landings under "perch" included the freshwater viviparous perch *(Hysterocarpus traskii)* or not.

With the exception of a few years, the State's entire freshwater commercial fish catch has been landed at Pittsburg and San Francisco. The catch for the most part was made by Pittsburg fishermen in Suisun, Honker and Grizzly Bays, with some effort by com-

C—043228

C-043228



mercial seiners in the inland lakes in various parts of the State.

At least four species of catfish were introduced into California waters in the 19th century; two, the white catfish and the brown bullhead, were extremely successful. Of the brown or common bullhead *(Ictalurus nebulosus)*, Evermann and Clark (1931) related: "During 1900, shipments were even made to the native home of the catfish, Missouri and Mississippi River points. They supplied the markets of Chicago, Salt Lake, Denver, Portland, and other middle and eastern points."

The white catfish *(Ictalurus catus)*, introduced the same year as the brown bullhead, was the leading commercial catfish for many years past and probably comprised in large part the shipments referred to by Evermann and Clark. The most productive year noted by the present author was 1908 when 1,069,000 pounds were recorded. In more recent times, the 1929 catch of 1,012,318 pounds is the largest. Generally, the catch ranged from 200,000 to 700,000 pounds. Most of the catfish were taken in the rivers and sloughs of Solano, Contra Costa, Sacramento and San Joaquin counties until removed from the commerical category in 1952.

The total annual landings of freshwater commercial fishes exceeded one million pounds only nine times since 1916.

Since the Sacramento-San Joaquin gill net fishery has been abolished, future freshwater fish landings will be limited. Carp may be taken by traps under special permit. Sacramento blackfish are also taken in certain areas under permit.

Catfish are an important sportfish in the Sacramento-San Joaquin Delta and carp are taken in fair numbers by some anglers.

C—043229

C-043229

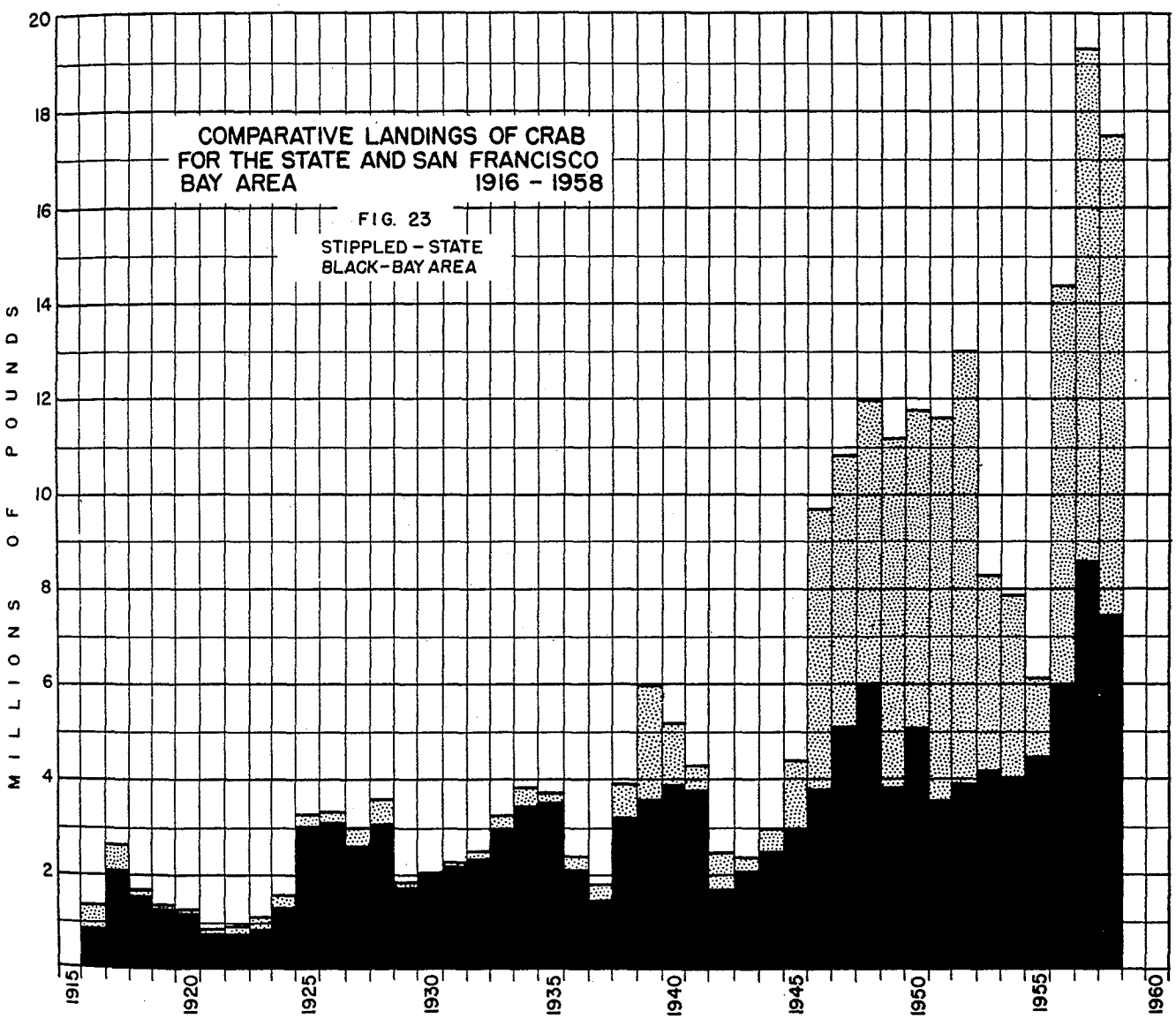
Anadromous Commercial Fisheries

Salmon, shad, and striped bass are the principal anadromous species which have been fished commercially in this State. All three reach their peak abundance in the Bay Area and the rivers of the Central Valley. These species generally spend part of their life in fresh water and part in the ocean.

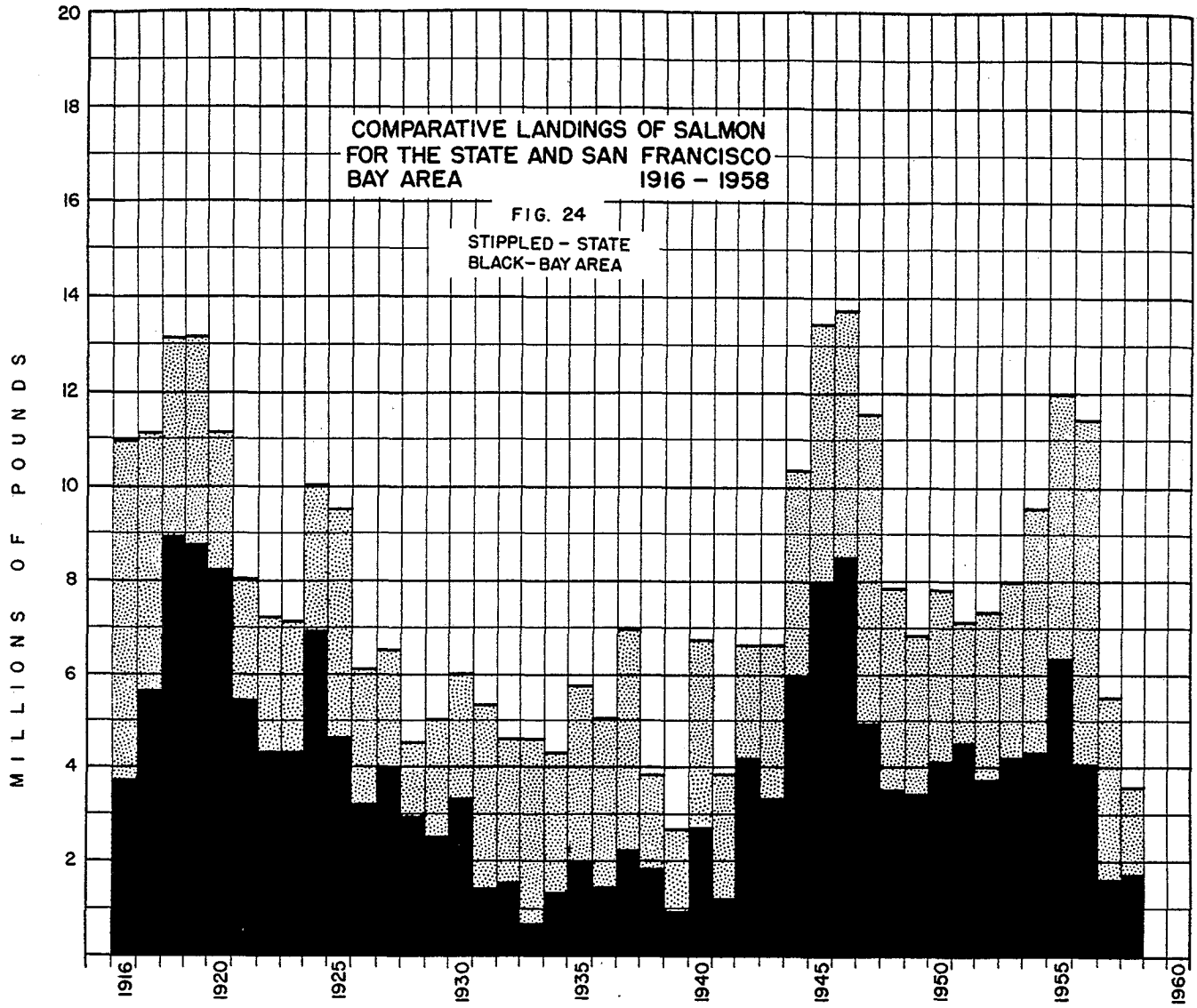
Salmon. Salmon generally is considered to be the most valuable individual species in the Bay Area. Prior to 1900, almost the entire catch came from inside the Golden Gate. Now they are taken in the ocean from Monterey northward by the ocean troll fleet. Legislative action in 1957 eliminated commercial salmon fishing inside the Golden Gate.

The landings in the region have varied from less than a million pounds to almost nine million pounds a year since 1916. The average would probably be close to four. Before the turn of the century even greater quantities were taken. The annual landings at San Francisco have represented about 50 percent of the state-wide total since 1915. (See Figure 24.)

Shad. Shad were important in the San Francisco landings for a short while after their introduction into Bay waters from the East Coast in 1871. However, they soon became so abundant as to glut the market. They have never been as popular here as on the Atlantic coast. The landings accordingly have been limited. They are taken principally for their roe. The fishing fleet at Pittsburg has been the main one to exploit them. A few stray fish are taken elsewhere, but virtually 100 percent of the landings have been in the Bay Area. The record catch of over 5 million pounds



C-043230



was made in 1917. The average was between one and two million pounds a year, but the fishery could have sustained perhaps two to three times that much. Legislative action banning the use of gill nets in what was the principal shad fishing area all but eliminated the commercial fishery after 1957.

Striped Bass. Striped Bass were introduced into Carquinez Strait in 1879 from New Jersey. By 1890 a few were being taken commercially and the species was highly favored in the San Francisco market. They commanded a good price and supported a fair fishery until legislative action in 1935 prohibited the commercial take. Like shad, almost all were taken and landed in San Francisco, Pittsburg and other ports in the Bay Area.

Between 1916 and 1935 the landings averaged 600 to 700 thousand pounds a year and twice exceeded a million pounds. The peak commercial catch, reported at 1,776,000 pounds, occurred in 1908.

Striped bass have been popular with sportsmen since their introduction. The total take by anglers each year is in the neighborhood of 600,000 to 1,200,000 fish, or two to four million pounds.

The combined landings of these three species at San Francisco have varied considerably with salmon, of course, being the most influential. Since 1916 the least amount recorded was 1,333,641 pounds in 1941, and the highest better than 12 million pounds in 1918. The average is just under 6 million pounds a year.

The annual state-wide landings have fluctuated with the Bay Area catch, the low of just under 4 million pounds coming in 1941, and the high of over 17 million occurring in 1917. The state-wide average is between seven and nine million pounds. The percentage

of the state-wide total contributed by the Bay Area is generally upwards of 50 percent annually. Only six times since 1916 has it been less than 45 percent, while it has been greater than 60 percent in 21 different years.

ECONOMIC ASPECTS OF THE COMMERCIAL FISHERIES

It is extremely unfortunate that during the great growth of California's fishing industry, between 1900 and 1930, statistics on the value of the catch, number of employees, vessels and capital investment were not given greater consideration. During this transition period there were tremendous changes in the regional status of the resources, physical property, transportation and harbor facilities.

Although the total volume of products landed at San Francisco increased, it did not keep pace with the growth in other areas. Several factors are chiefly accountable for this. The first was the exploitation of the tuna and sardine fisheries. The tuna catch, which is made principally on the high seas, is landed almost entirely at Southern California ports and it alone accounts for almost fifty percent of the fishery products presently landed in California.

Sardine landings, which increased steadily for forty years after 1900, likewise were concentrated south of the Bay Area. The San Francisco fleet fished them only during the relatively short period they were found in abundance off the coast of the Bay counties.

Associated with these developments, of course, was the location of the manufacturing and processing plants of the fishing industry in the southern part of the State.

A second factor was the development of local fishery resources all along the coast, which before 1900 had scarcely been exploited. The trawl and salmon troll fisheries are of particular note. The Eureka Area developed its important crab resources, and in the last few years has seen the establishment of an extensive oyster fishery.

Since the San Francisco fisheries already were well developed by 1900, production increases have had to come chiefly through advances in techniques and the extension of fishing grounds. The fishery potential of the region also was diminished somewhat when San Francisco Bay became unsuitable for the valuable shellfish industry which had once thrived there.

Finally, the development of harbors, handling and transportation facilities all along the coast has greatly reduced the tonnage of fishery products landed at San Francisco.

Despite the paucity of quantitative data before 1930, an attempt is made to show the comparative economic relationships between the fisheries of the State as a whole and those of the San Francisco Bay Area. (See Figure 25.)

The earliest comprehensive statistics to show the value of the Bay fisheries, are those of Jordan (1887) for the years 1879-80 which are presented in Table 5.

TABLE 5

FISHERY STATISTICS OF SAN FRANCISCO COUNTY 1879-80

Item	Products Poundage	Value of Products	Fishery Statistics Item	Value
Fresh Fish	5,500,000	$220,000	391 Men	
Shrimp	250,000	12,500	90 Boats	$11,000
Abalone	150,000	9,500	Other Gear	15,000
Abalone Shells	950,000	23,750	Misc.	550
	6,850,000	$265,750		$26,550

For Alameda, Marin, and Sonoma Counties he estimated the fisheries products at $72,400, bringing the Bay Area total to $338,150 for the 1879-80 fiscal year. These figures are minimal however, since they do not include Solano and Contra Costa counties, the most important salmon areas.

For the entire State, Jordan gave the following statistics for the year 1880 (Table 6):

TABLE 6

CALIFORNIA FISHERIES STATISTICS FOR THE YEAR 1880

Products	Quantity	Value to Fishermen
Sea Otter Skins	75	$3,750
Seal Skins	2,000	10,000
Whalebone	61,000 lbs.	122,000
Whale Oil	153,685 gal.	79,650
Fresh Fish	24,577,920 lbs.	1,145,006
Crab and Shrimp	2,500,000 lbs.	66,358
Mollusks	—	128,250
Salt	60,400,000 lbs.	302,000
Other	—	3,700
Total		$1,860,714

MANPOWER

Fishermen	2,089
Shoremen	1,005
Total Men	3,094

GEAR AND ASSETS

Item	Number	Value
Vessels	49	$535,350
Boats	853	94,485
Other Gear and Apparatus	—	205,840
Cash Capital and Shore Property	—	307,000
Total Assets		$1,139,675

Statistical information for the Bay Area for 1892 indicates that the Bay fisheries were still by far the most important both in the quantity and value of prod-

ucts. The cash capital and investments also exceeded those of any other area in the State. This is clearly shown in Table 7, the data for which were obtained from the Thirteenth Biennial Report of the State Board of Fish Commissioners. The county-by-county tabulation has been retained to show the relative magnitude of the individual regional fisheries of the State at that time. The Bay Area maintained the status indicated in Table 7 until shortly after 1900 when the sardine and tuna fisheries came into prominence.

The statistics in Table 8 were compiled from the biennial reports of the State Board of Fish Commissioners, U. S. Fisheries Bulletins, Reports of the U. S. Commissioner of Fish and Fisheries and the U. S. Department of Commerce and Labor census reports. Incomplete as they are, they indicate the general magnitude of California's fisheries between 1880 and 1915. The salmon fishery was extremely important in boosting fisheries values for this period.

Catch statistics published by the Department of Fish and Game show that by 1916 landings at other ports exceeded those at San Francisco. Whether or not the volume was sufficient to offset the greater value of the salmon, crab, and oyster fisheries of the Bay is questionable. Certainly by 1920, however, the port of Los Angeles had replaced San Francisco as the fishing center of California. Eventually the San Diego and Santa Barbara Areas also surpassed San Francisco both in landings and value of catch.

Until recently the Bay Area was always the principal source of products for the fresh fish market. The Eureka Area has now forged into the lead in terms of landings, but San Francisco remains the primary center for the sale and distribution of fresh fish.

TABLE 7

A COMPARISON OF THE REGIONAL FISHERIES OF CALIFORNIA IN 1892 [1]

Source	Value of Products	Total Investment	Fishermen and Shoremen
San Diego	$47,538	$41,067	92
Orange	3,025	750	12
Los Angeles	49,541	49,261	234
Ventura	1,960	885	4
Santa Barbara	—	10,315	—
San Luis Obispo	8,487	5,615	38
Monterey	61,000	32,145	121
Santa Cruz	14,168	10,000	60
Placer Nevada (1893)	4,700	2,250	30
Humboldt	47,038	18,010	320
Del Norte	5,988	31,900	118
Totals	$193,904	$202,198	1,079
San Francisco Bay Counties	$2,793,535	$2,334,853	4,430
Grand Totals	$2,987,439	$2,537,051	5,509
San Francisco Bay Area as Percentage of Total	93.5	92.0	80.4

[1] After Wilcox (1895).

TABLE 8

CALIFORNIA FISHERY STATISTICS 1880-1908

Year	Men Employed	Boats and Vessels	Capital and Investments	Products (Pounds)	Value of Products
1880	3,094	902	$1,403,487	—	$1,193,555
1888	5,338	1,448	2,684,210	—	4,463,369
1889	4,684	—	2,081,950	53,505,055	2,465,317
1890	—	—	—	53,330,194	2,592,826
1891	—	—	—	52,483,906	3,031,430
1892	5,509	1,391	2,537,031	57,838,466	2,987,439
1895	4,770	—	2,612,298	—	1,786,479
1899	3,974	—	2,774,493	—	2,551,451
1904	4,406	—	1,489,000	—	2,523,000
1908	4,100	—	1,568,000	—	1,970,000

In Appendix B-3 are listed the available data on the Bay Area and state-wide commercial fishery statistics. From 1926 to 1939 some accuracy was lost in the interpretation and transfer of values from a graph, (Fish Bulletin No. 49, pp. 137-8). Between 1926 and 1938 the Bay Area comprised about 20 percent of the total value of the commercial fishery products of California. The value of the local products varied from less than one to slightly more than two million dollars while that of the entire California fleet fluctuated between three million and nine and one-half million dollars.

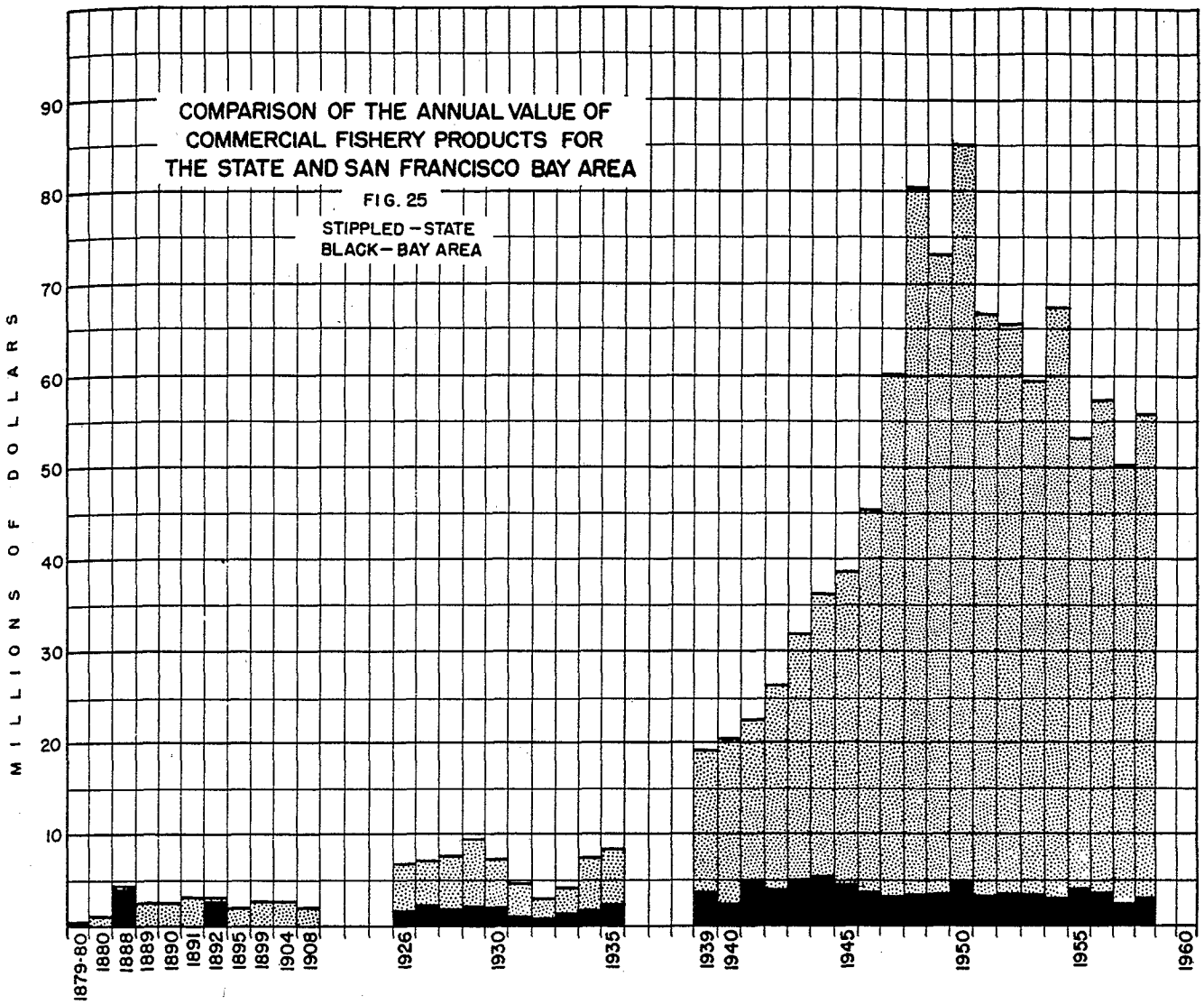
Since 1938 the value of the San Francisco landings has increased but slightly, whereas the State total now exceeds 50 milion dollars annually. Maximum value of the Bay Area catch was a little over 5 million dollars in 1944 as compared to 85 million dollars recorded for the State in 1950.

The value of the Bay Area catch remained in excess of ten percent of the State total until the end of World War II. Since the war it has consistently averaged about five percent.

The effect of the tuna landings on the value of California's fisheries is readily apparent when it is realized that in 1954, for example, tuna represented $52,708,774 or 78.2 percent of the $67,402,524 value of California's fishery products. The remaining 21.8 percent was made up largely of local fishery products. The $2,830,993 value attributable to the San Francisco Area comprised only 4.2 percent of the above total. However, excluding tuna, the value of the Bay Area catch represented 19.3 percent of the $14,681,189 value of local fishery products.

Fishermen

The number of fishermen employed in the Bay Area fisheries has changed considerably because of technical advances and basic changes in the methods of fishing. Early in the history of the Bay Area fish-



ery there were more than 4,000 fishermen fishing by means of seines, traps and numerous small boats.

Restrictive legislation gradually reduced the fishing area within San Francisco Bay, curtailed or prohibited certain types of fishing, and has recently resulted in a virtually complete commercial closure of all waters inside the Golden Gate. Men engaged in fishing operations thus affected were eventually forced into other areas or out of fishing altogether.

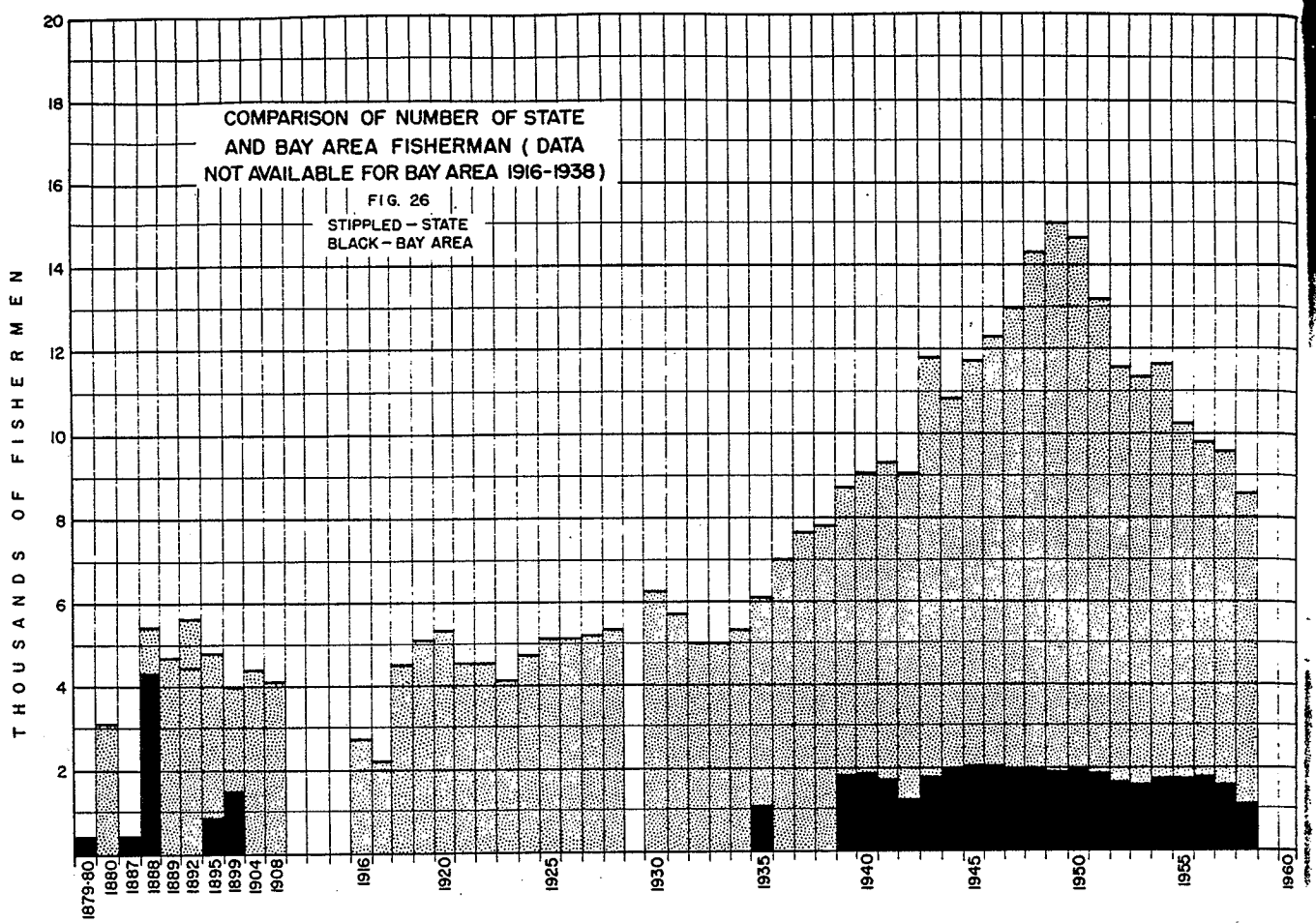
Nevertheless, the Bay Area supported between 15 and 20 percent of the State's commercial fishermen between 1935 and 1957. Prior to 1935 only statistics on the total number of licensed fishermen in the State were available. The total number of fishermen and proportion employed in the San Francisco fishery is given in Appendix B-3. (See also Figure 26)

Vessels

The boats employed in the fisheries of the State as well as those of the Bay Area are also included in Appendix B-3 and are shown graphically in Figure 27. Only scattered data were available prior to 1934. As in the other commercial aspects, most of the California fleet operated out of San Francisco before 1900. Following the pattern of the landings, the largest concentration of boats later accumulated at the southern ports. In 1929 about 33 percent of the fleet was working out of San Francisco. From then until 1946, the end of World War II, the local fleet was between 25 and 30 percent of the total, and since 1946 has been quite stationary at about 20 percent, or roughly a thousand boats as compared to 5,000 for the whole State.

C—043234

C-043234



MARINE AND COMMERCIAL FISHERIES REFERENCES

Arora, Harbans Lall
1951. An Investigation of the California Sand Dab, *Citharichthys sordidus* (Girard).
California Fish and Game, Vol. 37, No. 1, pp. 3-42

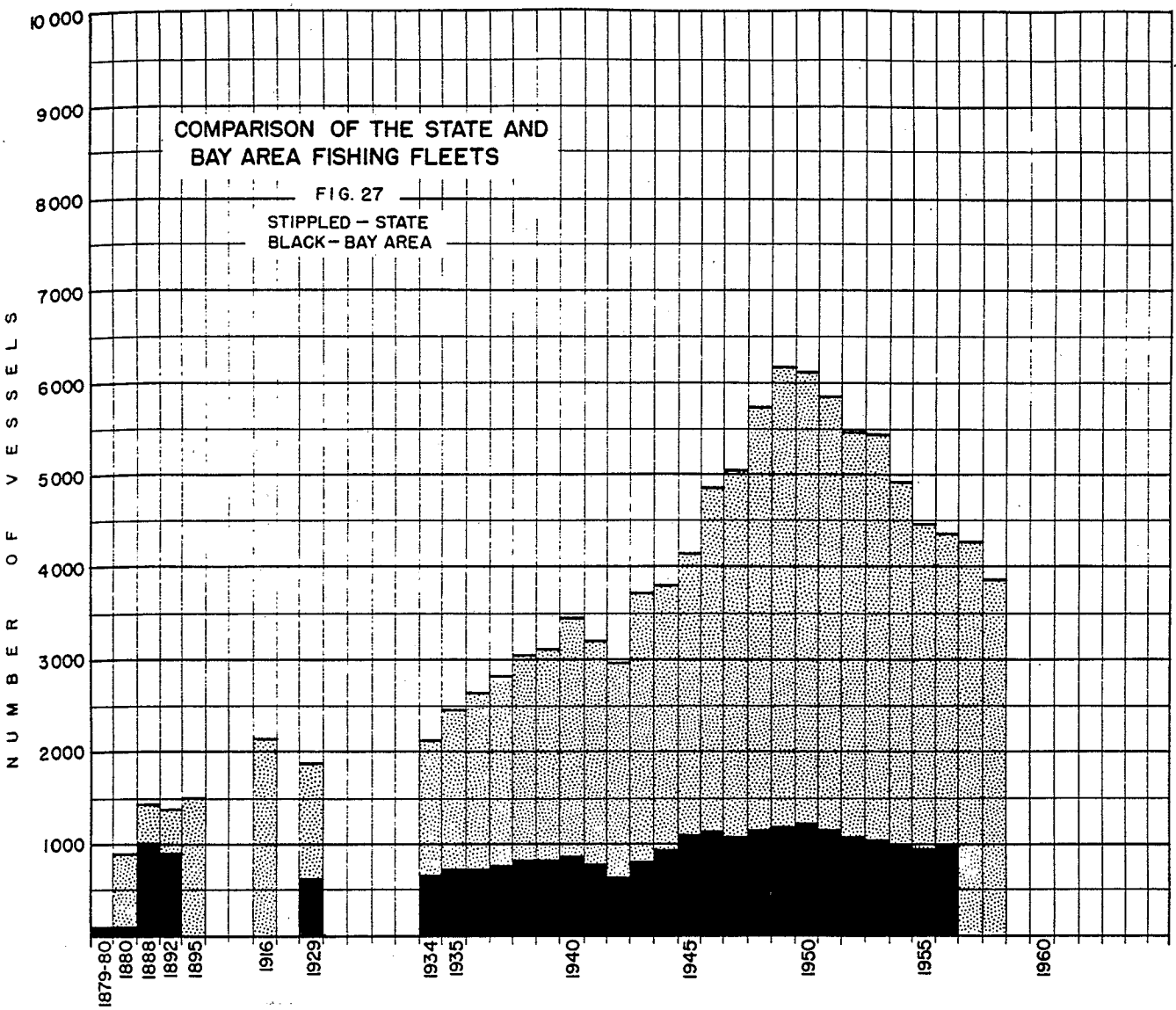
Bonnot, Paul
1932. The California Shrimp Industry
California Department of Fish and Game, Fish Bulletin No. 38.

California Department of Fish and Game
1930. Fishing Areas Along the California Coast for the Sardine (*Sardina caerulea*)
California Department of Fish and Game, Fish Bulletin No. 25.

California Department of Fish and Game
Commercial Fish Catch of California for the Years 1915-1929
California Fish and Game, Vol. 2, No. 2, pp. 102-103; No. 3, pp. 166-167
Ibid: Vol. 4, No. 1, pp. 52-53; No. 2, pp. 100-101; No. 3, pp. 156-157, Vol. 5, No. 1, pp. 44-45; No. 2, pp. 100-101; No. 3, pp. 164-165; No. 4, pp. 208-209.
Vol. 6, No. 1, pp. 40-41; No. 2, pp. 90-91; No. 3, pp. 136-138; No. 4, pp. 184-185.
Vol. 7, No. 1, pp. 70-71; No. 2, pp. 130-131; No. 3, pp. 188-189; No. 4, pp. 272-273.
Vol. 8, No. 1, pp. 58-59; No. 2, pp. 138-139; No. 3, pp. 194-195; No. 4, pp. 244-245.
Vol. 9, No. 1, pp. 38-39; No. 2, pp. 80-81; No. 3, pp. 126-127; No. 4, pp. 178-179.
Vol. 10, No. 1, pp. 48-49; No. 2, pp. 100-101, No. 3, pp. 154-155; No. 4, pp. 204-205.
Vol. 11, No. 1, pp. 46-47; No. 2, pp. 94-95; No. 3, pp. 146-147; No. 4, pp. 192-193.
Vol. 12, No. 1, pp. 50-51; No. 2, pp. 114-115; No. 3, pp. 158-159; No. 4, pp. 214-215.
Vol. 13, No. 1, pp. 74-75; No. 2, pp. 160-161; No. 3, pp. 229-231; No. 4, pp. 302-303.
Vol. 14, No. 1, pp. 102-103; No. 2, pp. 188-189; No. 3, pp. 260-263; No. 4, pp. 328-329.
Vol. 15, No. 1, pp. 94-95; No. 2, pp. 190-191; No. 3, pp. 298-299; No. 4, pp. 358-359.

California Department of Fish and Game
The Commercial Fish Catch of California for the Years 1926-1954
Fish Bulletins Numbers 15, 20, 30, 44, 49, 57, 58, 59, 63, 67, 74, 80, 86, 89, 95, 102, 105

California Department of Fish and Game
Report on Fresh and Canned Fishery Products for the Years 1920-1926



California Fish and Game Commission
Biennial Reports for the years 1920-1922; pp. 128-136.
Ibid: 1922-23; pp. 101-109
1924-1926; pp. 114-124

California Department of Fish and Game
Report on Fresh and Canned Fishery Products
California Department of Fish and Game, Fishery Circulars Numbers 1-33

California Fish and Game Commission
Biennial Reports for years 1870-71 through 1916

Carpelan, Lars H.
1955. Tolerance of the San Francisco Top Smelt to Conditions in Salt-Producing Ponds Bordering San Francisco Bay
California Fish and Game, Vol. 41, No. 4, pp. 279-284.

Clark, Frances N.
1929. The Life History of the California Jack Smelt, *Atherinopsis californiensis*, California Department of Fish and Game, Fish Bulletin No. 16

1937. Fishing Localities for the California Sardine, *Sardinops caerulea*, California Department of Fish and Game, Fish Bulletin No. 48

1953. California Marine and Fresh Water Sport Fishing Intensity in 1951.
California Fish and Game, Vol. 39, No. 1, pp. 115-125.

Clark, Frances N. and Julius B. Phillips
1952. Northern Anchovy (*Engraulis mordax mordax*) in the California Fishery
California Fish and Game, Vol. 38, No. 2, pp. 189-207.

Clark, G. H.
1929. Sacramento-San Joaquin Salmon (*Oncorhynchus tschawytscha*) Fishery
California Department of Fish and Game, Fish Bulletin No. 17.

1931. The California Halibut, (*Paralichtys californicus*) and an Analysis of the Boat Catches.
California Department of Fish and Game, Fish Bulletin No. 32.

1933. Fluctuations in the Abundance of Striped Bass (*Roccus lineatus*) in California.
California Department of Fish and Game, Fish Bulletin No. 39.

1935. San Francisco Trawl Fishery
California Fish and Game, vol. 21, no. 1, pp. 22-37

1936. The California Trawl Fishery and its Conservation
California Fish and Game, Vol. 22, No. 1, pp. 13-26

Clemens, Harold B.
1953. Catch Localities for Pacific Albacore Landed in California, 1951-1953.
California Department of Fish and Game, Fish Bulletin No. 100.

Collins, J. W.
1892. Report on the Fisheries of the Pacific Coast of the United States in: Report of the U. S. Comm. of Fish and Fisheries for 1888, part II; The Fisheries of California, pp. 21-175.

Croker, Richard S.
1933. The California Mackerel Fishery
California Department of Fish and Game, Fish Bulletin No. 40.

Fiedler, R. H.
1930. Review of the Fisheries of California. U. S. Department of Commerce, Bureau of Fisheries Document No. 1087, pp. 341-369.

Fitch, John E.
1953. Common Marine Bivalves of California
California Department of Fish and Game, Fish Bulletin No. 90.
1953. Extensions to Known Geographical Distributions of Some Marine Fishes on the Pacific Coast
California Fish and Game, Vol. 39, No. 4, pp. 539-551.

Goode, G. Brown
1884. California Gray Whale
In: Natural History of Useful Aquatic Animals; The Fisheries and Fishery Industries of the United States. U. S. Commission of Fish and Fisheries Section I, Part I, pp. 31-32.

Hagerman, Frederick B.
1952. The Biology of the Dover Sole, *Microstomus pacificus*, (Lockington).
California Department of Fish and Game, Fish Bulletin No. 85.

Herald, Earl S.
1951. Relative Abundance of Sharks and Bat Stingrays in San Francisco Bay
California Fish and Game, Vol. 37, No. 3, pp. 315-329.

Israel, Hugh R.
1936. A Contribution Toward the Life Histories of Two California Shrimps, *Crago franciscorum*, (Stimpson), and *Crago nigricauda*, (Stimpson).
California Department of Fish and Game, Fish Bulletin No. 46.

Jordan, David Starr
1887. Fisheries of the Pacific Coast.
In: The Fisheries and Fishery Industries of the United States; by George Brown Goode; U. S. Commission of Fish and Fisheries, Section 2, pp. 591-630.

Jordan, David Starr and Charles H. Gilbert
1887. The Salmon Fisheries of California and of Oregon South of the Columbia River. In: The Fisheries and Fishery Industries of the United States. Section V, Vol. 1, pp. 731-739.

McMynn, R. G., and W. S. Hoar
1953. Effects of salinity on the development of the Pacific Herring, Canad. Jour. Zoology 31, p. 417.

Miller, Daniel J.
1959. A Field Guide to Some Common Ocean Sport Fishes of California
Part 1 and Part 2
California Department of Fish and Game

Miller, Daniel J. and John Schmidtke
1956. Report on the Distribution and Abundance of Pacific Herring (*Clupea pallasi*) Along the Coast of Central and Southern California. California Fish and Game, Vol. 42, No. 3, pp. 163-187.

O'Connel, Charles P.
1953. The Life History of the Cabezon *Scorpoenichthys marmoratus* (Ayres)
California Department of Fish and Game, Fish Bulletin No. 93.

Orcutt, Harold George
1950. The Life History of the Starry Flounder, *Platichthys stellatus* (Pallas).
California Department of Fish and Game, Fish Bulletin No. 78.

Phillips, Julius B. and John Radovich
1952. Surveys Through 1951 of the Distribution and Abundance of Young Sardines (*Sardinops caerulea*).
California Department of Fish and Game, Fish Bulletin No. 87.

Ripley, William Ellis
1946. The Soupfin Shark and the Fishery.
In: The Biology of the Soupfin, *Galeorhinus zyopterus*, and Biochemical Studies of the Liver.
California Department of Fish and Game, Fish Bulletin No. 64.

Roedel, Phil M. and William Ellis Ripley
1950. California Sharks and Rays.
California Department of Fish and Game, Fish Bulletin No. 75.

Roedel, Phil M.
1948. Common Marine Fishes of California
California Department of Fish and Game, Fish Bulletin No. 68.
1953. Common Ocean Fishes of the California Coast.
California Department of Fish and Game, Fish Bulletin No. 91.

Scofield, Eugene C.
1931. The Striped Bass of California (*Roccus lineatus*).
California Department of Fish and Game, Fish Bulletin No. 29.

Scofield, Norman B.
1918. The Herring and the Development of the Herring Industry in California
California Fish and Game, Vol. 4, No. 2, pp. 65-70

Scofield, W. L.
1948. Trawling Gear in California
California Department of Fish and Game, Fish Bulletin No. 72.
1952. The Tomales Bay Herring Fishery
California Fish and Game, Vol. 38, No. 4, pp. 499-50
1954. California Fishing Ports.
California Department of Fish and Game, Fish Bulletin No. 96.

Shapovalov, Leo and Alan C. Taft
1954. The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*).
California Department of Fish and Game, Fish Bulletin No. 98.

Skogsberg, Tage
1939. The Fishes of the Family Sciaenidae (Croakers) of California.
California Department of Fish and Game, Fish Bulletin No. 54.

Squire, James L., Jr.
1956. Development of the Pacific Coast Ocean Shrimp Fishery
Commercial Fisheries Review, Vol. 18, No. 9, pp. 1-

C—043237

C-043237

Starks, Edwin C.
1921. A Key to the Families of Marine Fishes of the West Coast
California Department of Fish and Game, Fish Bulletin No. 5.
1922. A History of California Shore Whaling.
California Department of Fish and Game, Fish Bulletin No. 6.

Tarp, Fred Harald
1952. A Revision of the Family Embiotocidae (The Surf Perches).
California Department of Fish and Game, Fish Bulletin No. 88.

Thompson, Will F., Oscar Elton Sette, Elmer Higgins and W. L. Scofield
1926. The California Sardine. Calif. Dept. Fish and Game, Fish Bulletin No. 11.

Townsend, Charles H.
1893. Report of Observations Respecting the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States. Report of U. S. Commission of Fish and Fisheries for 1889 to 1891. Appendices pp. 343-372.

U. S. Department of Commerce
1911. Fisheries of the United States.
Special Report, U. S. Gov. Printing Office

Wales, Joseph H.
1952. Life History of the Blue Rockfish, (*Sebastodes mystinus*).
California Fish and Game, Vol. 38, No. 4, pp. 485-498.

Walford, Lionel A.
1931. Handbook of Common Commercial and Game Fishes of California.
California Department of Fish and Game, Fish Bulletin No. 28.
1935. The Sharks and Rays of California.
California Department of Fish and Game, Fish Bulletin No. 45.

Whitehead, S. S.
1930. Analysis of Boat Catches of White Sea Bass (*Cynoscion nobilis*) at San Pedro, California.
California Department of Fish and Game, Fish Bulletin No. 21.

Wilcox, William A.
1893. The Fisheries of the Pacific Coast.
Report of the U. S. Commissioner of Fish and Fisheries.
1895. Fisheries of the Pacific Coast.
Report of U. S. Commission of Fish and Fisheries for 1893. Appendices pp. 139-304.
1901. Notes on the Fisheries of the Pacific Coast.
Report of U. S. Commissioner of Fish and Fisheries, pp. 501-574.

C—043238

C-043238

ANADROMOUS FISHERIES

INTRODUCTION

The anadromous fishes of the Bay Area include such favored species as king and silver salmon, steelhead trout, sturgeon, striped bass and American shad. With the exception of shad and striped bass, all are native species. Several other anadromous species are found in the Bay (Appendix C-1), although they are rare or of minor importance to the sport or commercial fisheries.

The general distribution of steelhead trout (*Salmo gairdnerii*), commonly called steelhead, is in the coastal streams of the Pacific Coast of North America, from the United States-Mexico boundary or possibly even Baja California northward to and including Alaska, according to Shapovalov and Taft (1954). The general distribution of silver salmon (*Oncorhynchus kisutch*) is from some of the streams entering Monterey Bay, California, to the Amur River in Asia, according to Shapovalov and Taft. In California both species become increasingly common from south to north.

Steelhead are common to both the Sacramento and Klamath River systems. Silver salmon are native to the Klamath River but not the Sacramento River.

Silver salmon enter the commercial catch through the offshore troll fleet, but in the San Francisco Area are a minor constituent of the salmon fishery.

The king or chinook salmon (*Oncorhynchus tshawytscha*) fishery in California has always been centered in the Bay Area. Originally most of the State's catch was made inside the Golden Gate, principally by the gill net fishery. After 1900, the ocean troll catch increased rapidly and by 1915 surpassed the river gill net catch.

Within the Bay, the principal method of taking king salmon was, from the earliest days, by means of gill or trammel nets.

The fishing area was modified greatly by legislative action, and finally in 1957, was closed altogether to most types of commercial fishing. Since then, the entire commercial salmon catch has come from the ocean.

The striped bass (*Roccus saxatilis*) fishery is almost exclusively confined to the Bay Area. Prior to the removal of this fish from the roster of commercial species in 1935, the same men, using essentially the same boats and gear employed in the salmon fishery, also fished for striped bass. The fishing area and legislative restrictions of this fishery closely parallel those of the salmon fishery.

As in the case of the striped bass, almost 100 percent of the shad (*Alosa sapidissima*) catch was made in the Bay Area. The fishery was pretty much restricted to the river between Carquinez Strait and Rio Vista, until 1951 when the upstream limit for commercial fishing was moved down-river to Stake Point near Pittsburg. The same fleet and essentially the same methods as described for salmon and striped bass was employed for shad. Legislation in this fishery closely paralleled that for the striped bass and salmon fisheries.

KING SALMON

The Commercial Fishery

Early History. Indians along the river apparently were actively engaged in fishing for king salmon when Juan Batiste de Anza first sighted Carquinez Strait in 1776. The Indians are said to have used nets and fished for them from rafts. The interior Indians were also known to rely heavily upon them for food. Crude weirs, spears and frequently clubs or bare hands were used to capture them.

Later on (1850), Italian immigrants began to fish for them in the Sacramento and San Joaquin Rivers and San Pablo Bay. During the gold rush and the railroad building era they were an important item of food wherever they were found. Eventually commercial salmon fishing extended for a considerable distance up the Sacramento River and into many of its tributaries.

Early accounts by Livingston Stone, the famous fish culturist of the U. S. Fish Commission, testify to the great abundance of king salmon in the upper reaches of the Sacramento in the early years. For many years he operated Baird Hatchery on the McCloud River, taking eggs for the purpose of introducing king salmon elsewhere in the United States.

During the 1850's salmon fishing and processing became a lucrative business. Quick to grasp the great potential of the salmon resource three men, George W. and William Hume and A. S. Hapgood initiated one of the most profitable enterprises on the West Coast. William Hume had arrived in Sacramento in 1850 from the East Coast and talked his brother, George, into coming West in 1855. On a return trip to the East Coast in 1863 George induced his boyhood friend and schoolmate, A. S. Hapgood, a tinner, to come to Sacramento.

Hapgood arrived in Sacramento on March 24, 1864 and he and the Hume brothers immediately set about their task. By late summer or early fall a crude but nonetheless functional canning operation under the name of Hapgood, Hume and Company was established. This was the first cannery on the West Coast and the first salmon cannery in the world. Their can-

C—043239

C-043239

nery was built on a floating scow in the town of Washington (Broderick) on the Sacramento River across from the city of Sacramento.

The first season's operation was not entirely successful since only half of the 4,000 cases canned were merchantable. Each case contained four dozen one-pound cans. The young industry also received a temporary set-back when skeptical Americans would have nothing to do with the product. After considerable searching they found a ready market for canned salmon in Australia and later South America. Poor salmon runs in 1864, 1865 and 1866 forced them to look elsewhere to enlarge their business. As a result they established the first cannery on the Columbia River near Eagle Cliff in 1866. But by 1883 there were 21 canneries in California, most of them in the Bay Area.

Our first quantitive records concerning salmon catches in those early years are largely from cannery records.

Shortly after the gold rush many rivers became badly silted, which all but destroyed their use for salmon. Railroad construction crews did similar damage by dynamiting along the Sacramento River and its important spawning tributaries. Often, streams were made impassable to salmon as a result of the rocks and debris permitted to enter them. Lumbering was also responsible for silting and blocking many of the smaller spawning tributaries.

The salmon runs of the Sacramento and San Joaquin river system have fluctuated a great deal since records were first kept. Peak runs have occurred at intervals of 8 to 30 years followed by poor catches midway between the peaks.

Water development projects have made serious inroads on the salmon populations of California, particularly in the Central Valley. Dams were built on streams tributary to the San Joaquin River prior to 1900. In the last 25 years a large number of public and private projects and the gigantic Central Valley Project have been built on the major rivers in the Central Valley. These projects have unquestionably had a great influence on king salmon and other anadromous species by preventing access to spawning areas above the dams, and by reducing the flow of water below the dams or changing the general regime of the streams.

In the early years silver salmon and steelhead runs, also, were adversely affected by saw mills, flour mills and water supply reservoirs on the coastal streams.

It is beyond the scope of this report to provide but a small portion of the available information on the king salmon of the Sacramento-San Joaquin system. Several excellent publications are listed in the references which describe the life history and fishery for this species.

Although the fishery for king salmon is centered in the Bay Area, few kings actually spawn in any of the local streams. They generally enter the larger rivers along the coast north of San Francisco. By far the greatest proportion however, has always passed through the Golden Gate to ascend the Sacramento and San Joaquin rivers on the way to ancestral spawning grounds in these rivers and their tributaries.

There were three principal methods employed in commercially fishing salmon before 1870. The most profitable, drift gill netting, was introduced shortly after 1850 by the Italians. Fyke net fishing was employed also at this time and according to Jordan and Gilbert (1887) in 1852 and 1853, fishermen commonly caught 700 to 800 pounds a day in their fyke nets at Rio Vista. Sweep seines were used but no mention is made of the success encountered.

The gold rush and inflationary conditions led to a rapid expansion of the fishery. Jordan states that between 1850 and 1860 salmon frequently brought a dollar a pound and that five dollars was a small price for a whole salmon. Complete data are lacking on the amount of salmon caught and canned before 1870 but during 1864 and 1865 two thousand cases (48 one-pound cans each) were canned each year. Little else about the fishery is available until 1872.

1870 to 1915. By 1870 the king salmon runs began to decline and the newly formed (1870) State Board of Fish Commissioners expressed concern for the fishery. Hydraulic gold mining activities had all but destroyed the American, Feather, and Yuba Rivers, according to their reports. Even so, the catch about 1874-1875 was 4 to 5 million pounds, worth $500,000 a year.

The U. S. Fish Commission sent Mr. Livingston Stone to California in 1872 to procure salmon eggs for the East Coast. He arrived in August of that year and immediately set up operations on the McCloud River. Thus began salmon fish cultural operations in California. It is from Stone's annual reports that much of our early knowledge of Sacramento king salmon was obtained.

Because of the decline in the fishery the California Commission contracted with the U. S. Commission to supply eggs for propagation purposes to stock the Sacramento River. Shortly thereafter, the commercial salmon catch began to increase and by 1880 had reached almost 11 million pounds. At the time, the increase was attributed chiefly to fish cultural operations by the early pioneers, thus lending great impetus to this phase of fishery management. Since 1872 many millions of fry have been released into the river and this activity still continues today. Shebley (1922) summarized fish distribution activities in California through 1921. His article also gives an account of the history of fish cultural operations in this State.

Jordan and Gilbert (1887) provide an idea of the fishery of their time in the following paragraph:

"Since 1866 salmon fishing has fallen off very fast at Collinsville and Black Diamond [Pittsburg]. In the

year 1880 there were about 225 boats engaged in salmon fishing on the Lower Sacramento, each boat with a crew of two men. A good outfit for salmon fishing is worth $700 to $1,000. The salmon caught are either shipped to the San Francisco markets, sold to the canneries, or salted and smoked."

They reported 500 men and 230 boats engaged in the salmon industry of Marin and Contra Costa counties.

Salmon catch data for the Sacramento-San Joaquin gill net fishery for the years 1864-1957 are given in Appendix C-2 and are shown graphically in Figure 28. The annual landings in the early years are for the commercial catch and do not include the portion consumed locally, which was estimated by the California Fish Commissioners at about 20 to 25 percent of the total. Neither do the landings include salmon taken above the City of Sacramento.

During the 1880's the salmon catch remained above six million pounds. In 1883 the Commissioners estimated there were 1200 boats engaged in salmon fishing (two men per boat) and 21 canneries operating. By 1886 they estimated there were 3,000 men fishing for salmon. These reports are in conflict with Clark's (1929) data (Table 9), but neither report clearly indicates the extent of the area under consideration or the size of boats.

The Fish Commissioners' report for the years 1883-84 points out the loss of the McCloud River spawning grounds due to railroad construction activities, and the subsequent abandonment of Baird Hatchery. They also expressed deep concern over the fact that dams had been placed on the Stanislaus, Tuolumne and San Joaquin rivers and tributaries of the Sacramento River.

Another problem besetting them was the large number of smaller water diversions on anadromous fish streams. In their eleventh biennial report the Commissioners advocated a law to require that all such diversions be screened to prevent the loss of juvenile downstream migrant salmon.

The catch of 1891 (1,957,354) pounds) was the lowest on record at that time. The landings picked up, however, and again went over 10 million pounds in 1910, 30 years after the previous peak.

Between 1874 and 1914 the mean annual catch for the 27 years recorded was 6,146,203 pounds.

The salmon canning industry hit its peak in 1882 but lingered on until 1919 when the industry was abolished by legislative action. The salmon pack from 1864 to 1919 is given in Appendix C-3.

1915 to Present. Another decline occurred in the Sacramento-San Joaquin gill-net salmon fishery between 1915 and 1939, after which the landings soared upward to a peak of 6,463,245 pounds in 1946, only to recede again. The period from 1926 through 1943 was the most dismal in the history of the fishery, averaging just over a million pounds a year. Only once was more than 2 million pounds taken during that period, the low being 397,572 pounds in 1934. However, in 1957 only 321,824 pounds were taken by the gill-net fishery, the lowest catch ever recorded.

TABLE 9

COMPARATIVE DATA ON THE SACRAMENTO-SAN JOAQUIN SALMON FISHERY [1]

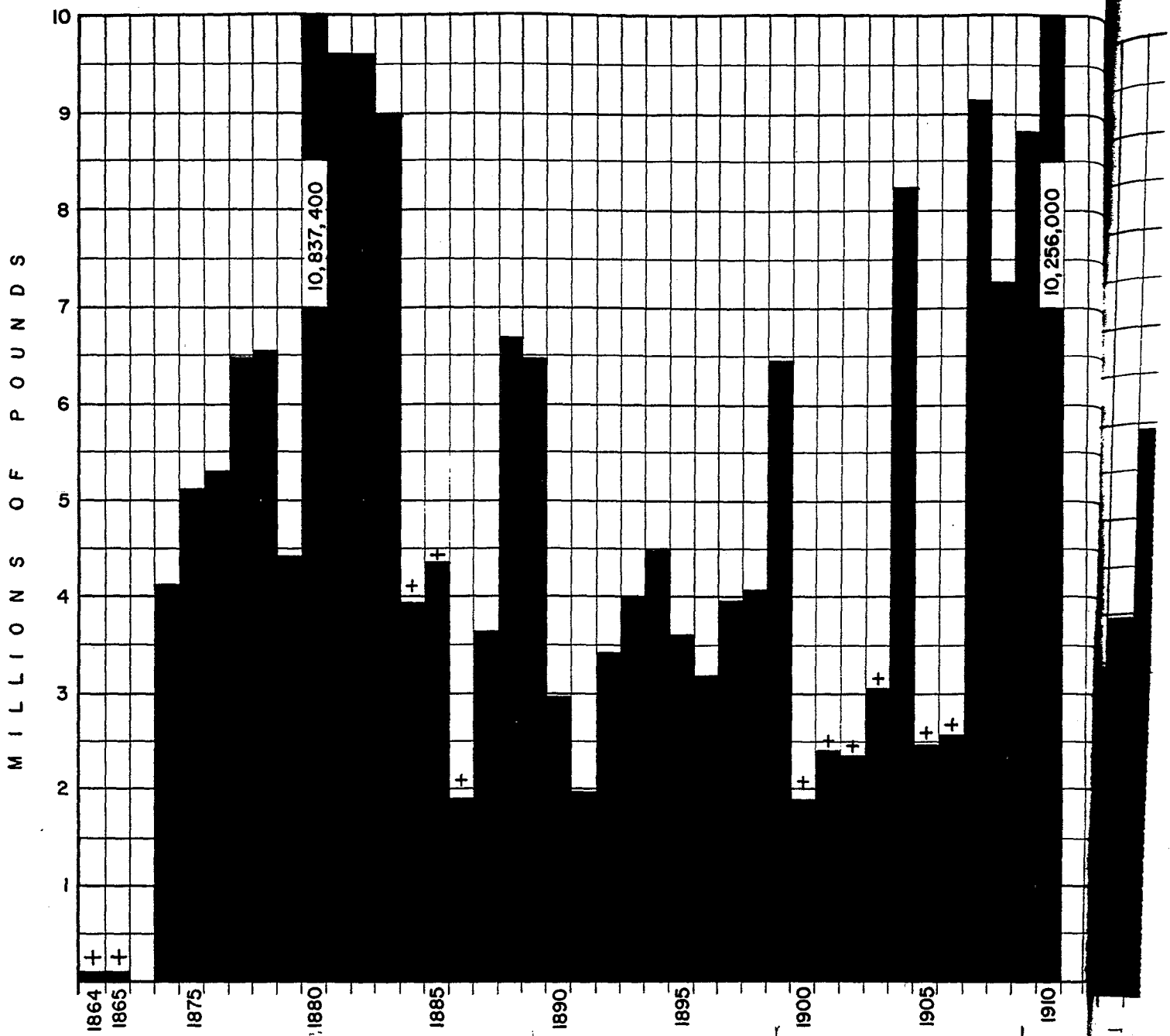
Year	Number fishermen	Number boats	Number gill nets	Number seines	Catch in pounds
1872	200	100	100	10	4,000,000
1880	500	230	200	—	10,000,000
1889	796	467	474	24	6,471,000
1899	907	459	478	20	6,458,000
1909	1.490	842	750	26	8,796,000
1916	990	525	495	25	3,450,000
1924	748	435	430	—	2,640,000
1927	574	307	307	—	917,000
1938	250 (est.)	149	200 (est.)	—	1,668,376
1955	225 (est.)	134	175 (est.)	—	2,273,809

[1] Data mostly after Clark, 1929.

The 44-year mean catch for the 1915-1958 period is 1,984,931 pounds, or more than 4 million pounds a year less than the 1870-1914 period. One of the principal factors, of course, which accounts for much of the difference is the large increase in the ocean troll fleet. Sacramento-San Joaquin salmon are taken in the ocean by the trollers before they return to these rivers as spawners, thus reducing the number available to the gill-net fishery. The tabulations in Appendix B-2 show the state-wide salmon landings of 1916-20, 1924-25, 1944-47 and 1954-56 to equal or exceed those of any other period in the history of the fishery. (See also Figure 24). However, the extremely poor catches at the state-wide level between 1926 and 1943 and again in 1957 and 1958, despite greatly increased effort, are evidence of an over-all decline in the salmon fishery. Another important consideration affecting the gill-net fishery is restrictive legislation in the Delta and river fishery, which reduced fishing seasons and modified the fishing area.

The Central Valley Project, and other similar water development projects must also be considered, in that power, flood control, irrigation and other water use and conservation projects have reduced or eliminated flows below dams, cut off spawning areas, diverted fish into irrigation canals, and changed the general regime of streams. The influence of such projects is illustrated by the Friant Dam project on the San Joaquin River, where the lack of adequate releases from it and other dams and weirs below it have eliminated a former major spring salmon fishery. Although actual data are not on hand, there has been a substantial reduction in salmon spawning areas as a result of water projects.

Fortunately, in most instances arrangements have been made with project sponsors for the protection of the resource or compensation in the case of losses. Hatcheries have been built to replace lost spawning areas, screens installed to prevent losses at diversions, or flows maintained for the preservation of fish life.



One other factor must also be considered in speculating upon the decrease of salmon runs; namely, the effects of industrialization and urbanization. Chronic sewage and waste discharges into the streams and bays are usually adverse to natural conditions. Many pollutants of industrial nature are toxic to fish life in small quantities.

The degraded condition of the Bay was common knowledge even before 1900; since then the industrial and population growth of the Bay Area has been manyfold and so has the volume of the wastes.

It is beyond the realm of this report to go into detail on any of the above factors to determine which has been the most injurious to the Sacramento-San Joaquin king salmon runs, but all must be considered.

Economic Evaluation of the Salmon Commercial Fishery. On the basis of salmon landings between 1952 and 1956, it is possible to assign a value of sorts to the king salmon resource which each year passes in and out of the Bay.

Research by the Marine Resources Branch of the Department of Fish and Game indicates that about 70 percent of all California salmon landings originate from stocks of the Central Valley. Since the annual state-wide value (1952-56) averaged $2,716,367, the proportion attributable to the Central Valley is therefore approximately 2 million dollars a year (see Table 10). Many fish of Central Valley origin are also caught off Washington, Oregon, and British Columbia, thus creating wealth in those areas.

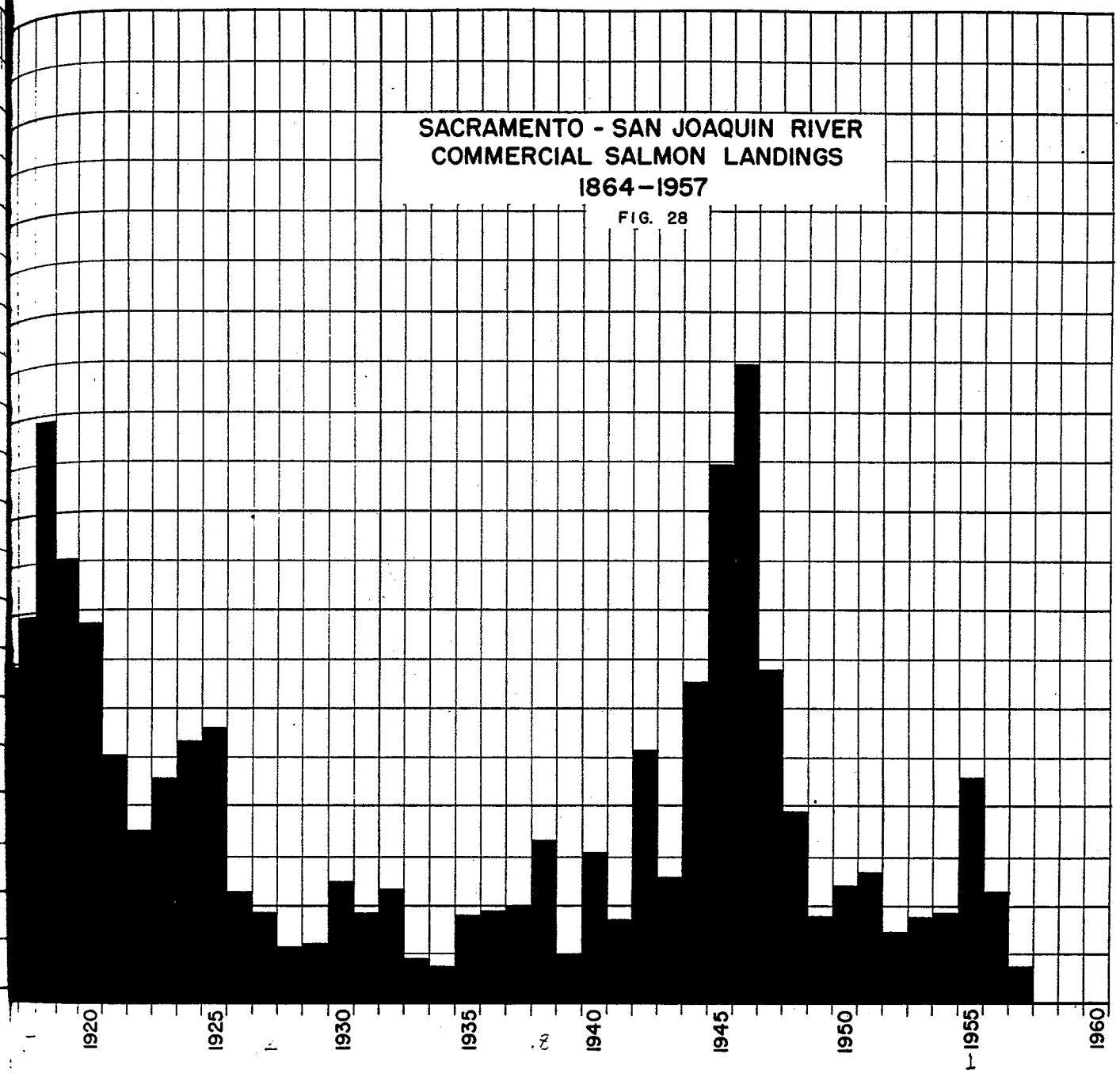


TABLE 10

POUNDAGE AND EX-VESSEL VALUE OF CALIFORNIA SALMON LANDINGS 1952-56 [1]

Year	Total Landings	Total Value	Proportion Assessable to Central Valley (70%)
1952	7,275,026	$1,802,883	$1,262,018
1953	8,006,000	1,927,849	1,349,494
1954	9,498,624	2,834,313	1,984,019
1955	11,977,697	3,593,309	2,515,316
1956	11,411,609	3,423,471	2,396,437
5 Year Averages	9,633,813	2,716,367	1,901,457

[1] At the time of printing final figures for 1955 and 1956 were not available; however, they did not differ appreciably from those given.

Sport Fishery

Trolling is the principal method by which sport fishermen take king salmon. Most of the fishing takes place outside the Golden Gate, although occasionally good catches may be had in the Bay. Data on sport fisheries is of recent origin, and practically nothing in the way of quantitative data exists for the period before 1940.

Anglers have taken salmon in the ocean for many years but on a relatively small scale. Within the last 15 years, however, the sport salmon troll fishery has expanded tremendously. A large fleet of party and

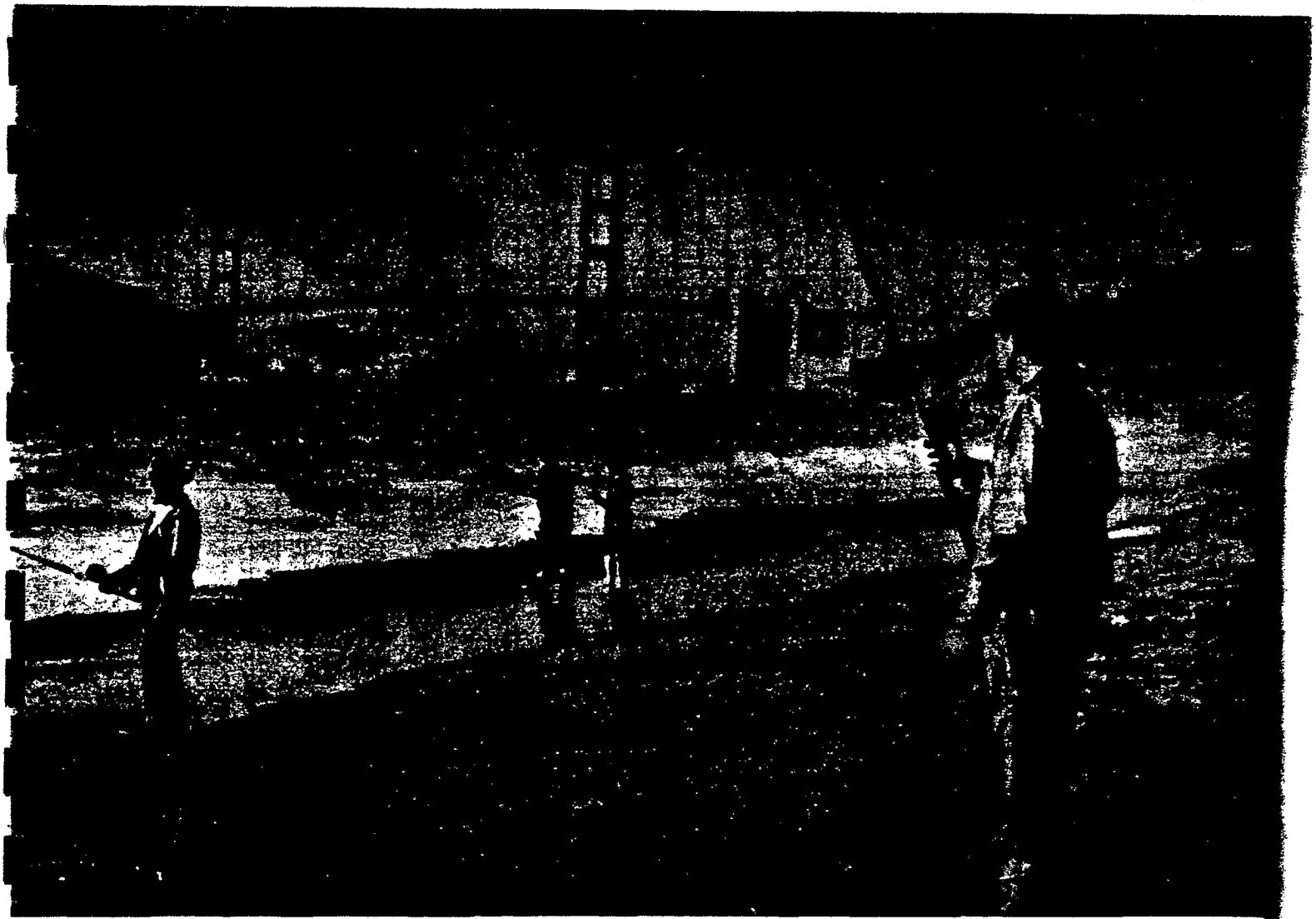


FIGURE 29. Surf fishing in the shadow of the Golden Gate. D. F. & G. photo by Kramer Adams.

charter boats operate out of Berkeley, San Francisco and Sausalito. Party boats are also available at Princeton by the Sea, Bodega Bay, Tomales Bay and other ports.

McCully (1957) summarized results of an intensive survey which has been conducted since 1954 under a Federal Aid To Fish Restoration Program, and which was designed to obtain a measure of the ocean salmon sport fishery.

The Party Boat Fishery. A total statewide catch by party boat anglers of 154,600 fish in 1955 and 128,500 in 1956 was reported by McCully. Of those totals 75.3 and 60.5 percent respectively were taken by boats operating out of Bay Area ports. The season at that time ran from February to November with the catch peaking in July.

For 1955 he reported a total of 132,200 angler days and for 1956 a total of 129,200 angler days spent fishing from salmon party boats. Thus, about 130,000 anglers per year fish for salmon from Bay Area party boats. As might be expected the effort and catch are proportional. Bay Area boats accounted for 73.5 and 60.8 percent respectively of the angler days recorded.

The amount of money paid in fares for party boat services was estimated at just about one million dollars a year for 1955 and 1956. The percentage attributable to the Bay Area would be 73.5 and 60.8 percent respectively for these years.

The Skiff Fishery. McCully's report also contains data on the skiff or small boat fishery. Bodega Bay and Tomales Bay are the chief areas supporting this type of fishery. He reported an estimated 3,600 skiff days and 7,000 angler days produced 1,896 salmon at Bodega Bay in 1956. In Tomales Bay 942 salmon were taken with effort estimated at 1,381 skiff days and 2,953 angler days. His estimates, however, are for abbreviated periods and are not an estimate of the total effort or catch of this fishery.

The amount invested in skiffs, motors and trailers along the Coast was estimated at one million dollars, of which about 20 percent can be charged to the Bay Area.

The River Fishery. Sport fishing inside the Golden Gate is excellent on occasion, but is not dependable from year to year. Salmon are rarely taken between San Pablo Bay and Sacramento on sporting tackle although anglers have reported a few from the Rio

Vista area. The river sport fishery becomes increasingly important north of Sacramento and reaches its greatest development near Los Molinos, Tehama County.

A considerable amount of work has been conducted on angler characteristics, angler success, length of angler day, etc., but no reliable estimates are available concerning the total number of anglers which participate in this activity or the number of fish taken annually. There are three different periods during the year that salmon are available: fall, winter, and spring. Steelhead are available to anglers during the fall and winter, while salmon support the fall, winter and spring fisheries.

Economic Evaluation of the Sport Fishery. The economic importance of salmon angling in this state is quite surprising. Pelgen (1955a) estimated that anglers in 1953 spent in excess of 10 million dollars, on the basis of a reported daily expenditure of 16 dollars per day. Since the Sacramento-San Joaquin system produces about 70 percent of all California-caught salmon, it can be inferred that this fishery is responsible for 70 percent of the total or seven million dollars a year. Pelgen (1955b) therefore assigned a value of 7 million dollars annually to this fishery; but it is the belief of this writer that salmon angling in coastal streams is responsible for a greater proportion of the annual expenditure of 10 million dollars and accordingly only 50 percent or five million dollars has been assigned to the salmon sport fishery originating in the Central Valley in this report.

Life History Notes

King salmon have been one of the most abundant, economically important, and desirable of all California fishes. It is not surprising therefore, that this species would be the first to come under scientific investigation. The first steps toward obtaining factual data on the life history of this species were made by Livingston Stone. In 1897 N. B. Scofield was directed by the State Fish Commission to conduct the initial scientific investigation into the life history and habits of king salmon. Rutter (1902) continued this work under the auspices of the U. S. Fish Commission.

Since then many separate investigations have revealed a tremendous amount of information on spawning habits, migrations, growth, food habits, maturity, fecundity, catch composition and other facets of the king salmon story, though much still remains to be learned.

The original work with salmon (1853-1900) was principally taxonomic. Stone and his successors in their fish cultural activities made observations on abundance, fecundity, time and place of spawning. Scofield and later workers solved many of the other problems in the complex life history of this species.

Time of Run. King salmon adults ascend the Sacramento-San Joaquin system and spawn in gravelly areas supplied with an abundance of clean, fresh, running water. On their way to the spawning areas in the Central Valley they must enter the Golden Gate and pass through the Delta. By far the major proportion now ascend the Sacramento River, although variable runs occur in tributaries of the San Joaquin River every year. Salmon may be present within the Bay at all times of the year, but there are three well-defined runs. The largest is the fall run which begins about the first of August, and peaks near late September. It trails off about the first of November, when it coincides with the beginning of the winter run, which is generally a small run lasting until February. The spring run begins sometime in February, usually peaks in May and ceases about June.

The largest proportion of the fall run spawn in the Sacramento River and its tributaries. The Tuolumne and Stanislaus rivers are particularly notable fall run streams in the San Joaquin system.

Winter run fish appear to ascend only the Sacramento and a few of its tributaries.

The spring run formerly consisted of fish which spawned chiefly in the San Joaquin system, but since the loss of adequate flows in the San Joaquin River, the Sacramento River system now supports the bulk of spring-run salmon.

The McCloud River, a tributary to the Sacramento, was an especially noted spring-run stream.

Usually, fall run salmon proceed directly to the spawning beds, spawn and die. Winter-run fish spawn from May through June or July, while spring run fish lay over in the cool deeper waters of the river during the summer and spawn in the fall. A portion of the spring run, however, spawns in the Sacramento River in May and June.

Size of Run. The size of the king salmon run in the Sacramento-San Joaquin system has been estimated by the U. S. Fish and Wildlife Service and Department of Fish and Game survey crews for a number of years. Estimates were based on counts of dead spawners, aerial surveys, redd counts and tag recoveries. Since 1951 estimates have been based chiefly on surveys made by crews which count dead spawners and estimate the proportion uncounted. Estimates for the Central Valley are presented in Table 11-a. Table 11-b lists the counts for the San Joaquin River.

Two large hatcheries are maintained to propagate Sacramento king salmon. The U. S. Fish and Wildlife Service operates Coleman Fisheries Station on Battle Creek, below Redding, and the California Department of Fish and Game operates Nimbus Hatchery on the American River east of Sacramento. Both installations were built by the Federal Government to compensate for spawning areas lost as a result of water development projects.

Spawning Conditions. Warner and Slater (1955) did extensive work on water and gravel conditions at the time of spawning. Based upon their observations,

they formulated a table of standards for estimating the amount of spawning area available, using gravel size, water velocity, and stream depth as criteria. Generally speaking, the best spawning areas contained up to 50 percent small gravel (1 inch to 3 inches), 30 percent or more medium gravel (3 to 6 inches), and lesser amounts of larger and smaller sized gravel or sand. Water velocities appeared best between 1.5 and 2.5 feet per second. The most favored stream depth was between 10 and 24 inches.

TABLE 11a

CENTRAL VALLEY FALL RUN KING SALMON SPAWNING STOCK ESTIMATES 1940-1959 [1]

Year	Sacramento Valley	San Joaquin Valley	Total Central Valley
1940	---	131,000+	---
1941	---	42,000	---
1944	---	130,000+	---
1951	---	---	---
1952	338,000	---	---
1953	513,000	84,000	597,000
1954	412,000	75,000	487,000
1955	369,000	31,000	400,000
1956	153,000	12,000	165,000
1957	102,000	15,000	117,000
1958	237,000	46,000	283,000
1959	421,000	52,000	473,000

[1] After Fry (1961) and based on aerial surveys, redd counts, tag recoveries, actual counts, and spawning survey estimates by U. S. Fish and Wildlife Service and California Department of Fish and Game.

TABLE 11b

SPRING RUN KING SALMON SPAWNING STOCK COUNTS SAN JOAQUIN RIVER 1943-1950 [1]

Year	Number Salmon
1943	35,000
1944	5,000
1945	56,000
1946	30,000
1947	6,000
1948	2,000
1949	(no count)
1950	(no fish)

[1] Except for 1943, based on actual counts; however, at times estimates were required for fish jumping the dam and bypassing counting station.

The females choose the site, and dig the nests, or redds, as they are called. After having scooped out a large depression in the gravel, the female discharges a number of eggs which are simultaneously fertilized by the milt of an accompanying male. The female then covers the eggs with gravel from the upstream end of the pit, thus enlisting the aid of the stream current. Later, the same process is repeated until the entire complement of eggs (about 5,000) is exhausted. The entire spawning process may require a week or more. The redds may be 10 feet or more in diameter and be built a foot or two above the stream bottom.

All Pacific Coast salmon die after spawning.

Rounsefell (1957) reported that Sacramento River female king salmon averaged over 7,000 eggs as compared to 3,700 for fish of the same species in the Klamath River. McGregor (1922) reported over 5,000 eggs per female for Sacramento king salmon.

The incubation rate is influenced greatly by water temperature. In general, hatching occurs in 45 to 55 days at 50° F. but under natural conditions the incubation period may vary from five to ten weeks. Immediately after fertilization the eggs are hardy but by the sixth day (at 50° F.) and for two weeks thereafter they are extremely sensitive. During the incubation period the developing embryo requires a well aerated supply of fresh water. According to Tarzwell (1958) the dissolved oxygen content should be in excess of 6 parts per million. Silt or sawdust are very damaging in that they quickly settle over or filter through the redds and cause suffocation of the embryonic fish.

The fry emerge from the egg and subsist on the yolk sac for about 6 weeks, after which they begin feeding. Their emergence from the gravel is approximately three months after fertilization of the eggs.

Downstream Migration. Most king salmon fry begin their seaward migration shortly after their emergence from the gravel but a few do not make the journey until the following year. They generally drift downstream tail first and, according to Rutter (1902), travel chiefly at night, averaging about ten miles a day. They are about four to five months old when they reach the ocean.

During their stream life temperatures should not exceed 70 degrees and the dissolved oxygen should be in excess of five parts per million.

Salmon fingerlings on their seaward migration are most abundant in the Bay Area between February and July. Rutter indicates it takes about two months for salmon to reach Benicia from Battle Creek, a tributary of the Sacramento River. They apparently remain in the brackish water of the Bay until they become acclimated to salt water.

Food Habits. During the downstream trip the small salmon subsist on various insects, crustaceans and other small invertebrates. By the time they reached Benicia, Rutter found that copepods were the principal item in the diet. It is quite probable, however, that a large proportion of their diet while in the Bay also consists of the small neomysid shrimps (*Neomysis mercedis*), aquatic isopods, and polychaete worms which abound in those waters. Unfortunately this has been a neglected phase in the life history of this species. The amount of factual data on their feeding habits in the Bay and Delta is meager.

Merkel (1957) made a study of the food habits of adult king salmon in the vicinity of San Francisco. During a one-year period (October 1954 to October 1955) he examined the contents of 1,004 sport-caught salmon. Excluding all items identified as bait, he found

the items in Table 12 to be the principal constituents in the diet of king salmon.

TABLE 12

FOOD OF ADULT KING SALMON

Item	*Percentage of Total Volume*
Northern Anchovy	29.1
Rockfishes	22.5
Euphausiids	14.9
Pacific herring	12.7
Squid	9.3
Other Fishes	7.3
Crab Megalops	4.0

From August to November (season closed to fishing November 15 to February 11) anchovies were the major item. They probably continue to be the most important item until herring arrive in November or December. Herring are the principal item from at least February to April when euphausiids, squid and crab megalops predominate. Rockfishes become important in May and are the most frequent item in June and July when anchovies again begin to occur.

Within San Francisco Bay northern anchovies were the most common item observed; however, as a rule salmon taken in the Bay are maturing and Merkel found that most salmon had ceased feeding.

Ocean Life. After the juvenile salmon enter the ocean, their movements are not well known, but marked Sacramento River fish have been taken south of Monterey and north to British Columbia. One marking experiment, for example, indicated a majority of those released in the Sacramento River were later caught off Washington and Oregon.

King salmon are voracious feeders and grow exceedingly fast while in the ocean. By the time they mature three to seven years later, they may weigh in excess of 70 pounds. The average weight upon returning is 20 pounds, although 50 pound fish are not uncommon. Kings are the largest of all salmon, with indviduals of over 100 pounds having been caught.

Most king salmon mature at three or four years; however, grilse, that is, fish which mature after one growing season in the ocean, are not uncommon. After maturing in the ocean salmon return to their native streams to spawn and die. The amount of straying is remarkably low.

Sources of Mortality. While in the ocean king salmon themselves are prey for other species of fish. They are also subjected to an intense troll fishery by both sport and commercial fishermen. Upon entering the Sacramento-San Joaquin system, they formerly were subjected to the highly efficient gill net fishery in Carquinez Strait and Suisun Bay. Legislation enacted in the spring of 1957 and effective September 27 of that year eliminated the latter source of exploitation.

The young fish before entering the ocean must also cope with numerous hazards. In the first place the alevins and fry are prey for many other species of fish. Secondly, they are vulnerable to a great many water diversions all along the Sacramento and San Joaquin Rivers and the Bay until they finally pass out of the Golden Gate.

Pollution is still another hazard and adults as well as the young are susceptible. Warren (1949) reported the kill of a considerable number of adult salmon from sewage pollution while the fish were on their spawning migration in the Tuolumne and San Joaquin rivers.

The young may find themselves in a particularly precarious postion with respect to pollution in the Bay Area because of the tidal prism; they may be flushed back and forth through several tidal cycles before escaping from contaminated areas.

SILVER SALMON AND STEELHEAD TROUT

In the Bay Area both silver salmon and steelhead are important primarily for their contribution to the sport fishery. Steelhead are, or were, found in a number of tributaries to San Francisco Bay including the Sacramento River system, and in the principal tributaries of Tomales Bay as well as most coastal streams. With a few exceptions silver salmon were restricted to coastal streams in the Bay Area. They are not native to the Sacramento River but were introduced there in 1956.

Since 1927 it has not been permissible to take steelhead commercially. Silver salmon have formed a very minor part of the ocean salmon catch in the Bay Area and were unknown to the Sacramento-San Joaquin gill net fishery until 1957 when returns of the 1956 experimental stocking by the California Department of Fish and Game contributed substantially to an otherwise poor salmon catch.

When Captain Wakeman, under hire of the State Board of Fish Commissioners, in 1870 surveyed the fisheries of the Bay Area, his survey included the coastal streams from Spanishtown on Pilarcitos Creek to Pescadero. He described the wretched conditions of the streams due to the logging, saw mills and flour mills located on them. The inference from his description is that the streams had once been very productive of silver salmon and steelhead trout but at the time of his survey were greatly degraded. The fish taken were sold locally rather than being shipped to San Francisco.

Wakeman points out that trout and salmon from these streams brought 75 cents per pound in 1870. He claims that a wagon load of these "beautiful" fish weighing 2 to 30 pounds each were taken daily from Pescadero Creek between October and March. Apparently San Gregorio Creek also produced fish in commercial quantities at that time.

C-043247

SILVER SALMON

Silver Salmon Sport Fishery

Silver salmon ascend most coastal streams and support a seasonal fishery in the winter. They are taken by anglers both in the streams and in the lagoons at the stream mouths. Pescadero and Papermill Creeks are probably the most notable streams in the area. Actual data on the number of anglers who engage in silver salmon fishing, or on their catch, are not available.

The sport troll fishery in the ocean takes a fair number of silvers, but the proportion is quite small as compared to king salmon. The year 1957 was an exception in that king salmon catches were poor while silver salmon were much more abundant than usual.

Veteran anglers feel the silver is a gamer fish than the king when taken on rod and reel.

Introduction of Silver Salmon into the Sacramento River System. Preliminary results of the experimental introduction of silver salmon into the Sacramento Valley have been impressive. The initial stocking took place in March of 1956 when 43,025 yearling silvers were released in Mill Creek, Tehama County, by the California Department of Fish and Game. The time and location of these and subsequent releases are show in Table 13:

TABLE 13

TIME AND LOCATION OF SILVER SALMON INTRODUCTIONS TO SACRAMENTO RIVER SYSTEM, 1956-1958

Date	*Location*	*Number of Fingerlings*
March 19, 21, 22, 1956	Mill Creek at Child's Meadow	24,150 (total)
March 20, 1956	Mill Creek at Ward Dam	6,300
March 23, 1956	Mill Creek at Clough Dam	12,757
February 14-19, 1957	Mill Creek at Child's Meadow	28,340 (total)
March 20-21, 1957	Mill Creek at Clough Dam	12,575
April 17-29, 1958	Mill Creek at Ward Dam	38,003 (total)
April 15, 1958	Mill Creek at Child's Meadow	10,797
December 15, 17, 1958 [1]	Sacramento River at Ball's Ferry	21,418 (total)
December 16, 1958 [1]	Chico Creek Ponderosa Way	4,624
December 17, 1958 [1]	Deer Creek at Highway 99E	9,489

[1] These were fish raised at Coleman National Fish Hatchery of the U.S. Fish and Wildlife Service from eggs taken from returning adult silver salmon of the 1956 and 1957 plants.

The first recorded adult fish to be taken by angling was in August 1956. In 1957 silvers were caught by commercial fishermen in the Delta. The first naturally spawned silvers were observed by Departmental personnel in Mill Creek in the winter and spring of 1958 when 49 fish averaging one to four inches were taken in traps.

In December of 1956 three of the fish stocked the previous March strayed into the American River on their return from the ocean and were taken at Nimbus Hatchery. Silver salmon have since appeared in the Feather and Mokelumne rivers also.

The following gives an indication of the early success of the introduction (Data from Quarterly Reports of F7R Sacramento-San Joaquin Salmon and Steelhead Study).

For the 1957-58 season (July 1, 1957-June 30, 1958) fishery personnel actually counted 1,523 returning adult silver salmon in the upper Sacramento River. Through tagging operations it was estimated that the total run consisted of approximately 4,180 two-year-old fish of the 1957 plants and 2,240 three-year-old fish from the original 1956 release. The estimated catch by anglers, extended on a basis of 41 tag returns, was 312 fish.

During the 1958-59 season the run was estimated at 5,600 three-year-old fish and 6,000 two-year-old fish.

Table 14 gives the numbers of each species passing the Clough Dam counting station on Mill Creek, Tehama County, during the period September 28-October 31, 1957.

TABLE 14

SALMON AND STEELHEAD PASSING THE CLOUGH DAM COUNTING STATION, MILL CREEK, TEHAMA COUNTY (SEPTEMBER 28-OCTOBER 31, 1957)

Species	Number	Percentage of Total
King Salmon	465	16.6
Silver Salmon	1,506	53.7
Steelhead Trout	833	29.7
	2,804	100.0

Silver Salmon Life History Notes

In the Bay Area, silver salmon occur in most of the creeks directly tributary to the Pacific Ocean and at least a few streams tributary to San Francisco Bay. Perhaps the most notable streams in this region in which silver salmon now occur are Pescadero, San Gregorio, Gazos, and Papermill creeks.

Silver salmon have been the subject of a number of investigations in California, but have been overlooked to some extent in favor of the larger and more valuable king salmon.

Shapovalov and Taft (1954) made an exhaustive study of the life history of this species, and their work includes the findings of other investigators as well. Most of the ensuing information on this species is based upon their work. Their studies were conducted from 1932 to 1942, principally on Waddell Creek, Santa Cruz County. This is a typical coastal stream just south of Pescadero, except that at the time of the study it had been relatively untouched by logging or other human activities for many years. It was also closed to fishing.

Time of Run. Silver salmon begin to appear in the streams about November and may continue till March; the bulk of the runs, however, occur from the last of November to the first of February.

The run is comprised of both grilse and adults that have spent two or more growing seasons in the ocean, the latter being the most common. Silvers, like all salmon, normally spend at least one growing season in the ocean before maturing. Males predominate in the early portion of the run, females in the latter.

The upstream migration takes place during the daytime. There is a correlation between the general time of the spawning runs and periods of rainfall. They will ascend on both rising and falling stream levels but cease movement during peak floods.

Spawning Conditions. The spawning conditions and the act of spawning are similar to those already described for king salmon. The female, as in all salmon and trout, chooses the redd site, usually near the head of a riffle, in medium or small gravel. The location insures a good supply of oxygenated water. The female digs the nest, which is generally just a little larger in diameter than the length of the fish. Several males may accompany her, but usually only one becomes the mate. She moves into the depression, deposits a number of eggs which are simultaneously fertilized by the male, and then covers them. The same procedure is repeated at several sites until all of the eggs are extruded. Spawning may take a week or more. Shapovalov and Taft believe that at least 97 percent of the eggs spawned lodge in the pit and are properly buried.

The adults die after their first spawning. Death is a result of physiological changes independent of the rigors of the spawning or migration.

Embryology. The incubation period varies from 38 days at an average temperature of 51.3° F. to 48 days at 48° F. In Waddell Creek, the usual period ran from 35 to 50 days. Colder water of course extends the incubation period.

As in the case of other species, silt has a deleterious effect on the eggs. Shapovalov and Taft believe that silt is the principal factor determining the percentage of silver salmon that survive to emerge from the gravel. Under favorable conditions they estimate 65 to 85 percent of the eggs deposited result in fry.

Stream Life. The young fish, as soon as they are able, move to shallow gravelly areas near the sides of the stream, where they tend to congregate. Here they feed avidly and grow rapidly. Later they separate, move into deeper water and change their diet.

A marked decrease in the number of small silver salmon occurs shortly after the peak of emergence. This, according to Shapovalov and Taft, is caused chiefly by predatory fishes, at least in relatively untouched, and unfished, streams such as Waddell Creek.

Silvers, unlike most kings, normally remain in the stream for one growing season before going to sea. About July or August they move into deeper pools and apparently cease or diminish their feeding activities, since the rate of growth becomes perceptibly slower. These changes in habit are attributed to increasing stream temperatures. Growth continues to be slight until the following spring. About late March or April they begin their seaward migration and reach the ocean by June. They usually move down in small schools during the twilight and night hours.

During their life in the stream (first year of life) young silvers feed principally on insects, crustaceans and other small invertebrates. During their early ocean life marine invertebrates are the major item in the diet but as the fish grow they become progressively more piscivorous.

The fry grow rapidly after emerging from the gravel and attain a length of about three inches by July or August. By the time they reach the ocean the following spring, they are about six inches long.

Ocean Life. The movements and behavior of silver salmon in the ocean are not well known. It is believed the young fish at first remain close to the shore. But recoveries of marked and tagged fish indicate they move offshore from their native streams within a few months. They are thought to remain within the limits of the continental shelf during their life in the ocean. Various populations probably mix in the ocean. Observation of the sport and commercial catches indicates mass movements occur.

Homing, as in other salmons, has been established, but straying is common and may exceed fifteen percent. Shapavalov and Taft theorize that the amount of straying is determined at the time of the downstream migration; the larger the number and smaller the size when they move down the greater will be the amount of straying.

Growth in the ocean is rapid. Grilse returning after one year average about 16 inches, while the average size of both sexes after two years in the ocean is 25 or 26 inches.

Survival. The over-all survival from egg to maturity varied from 0.02 to 0.3 percent during six seasons at Waddell Creek, with a mean of 0.13.

Survival from the time of the downstream migration to the time of return to the stream was found to average 2.3 percent. From time of egg deposition to the time the fish began their downstream migration survival averaged 1.35 percent.

Survival from the time they moved to the ocean until the time they returned showed considerable variation. Survival during four seasons varied from 0.98 to 7.72 percent, averaging 4.95 percent.

Deformities and disease among natural populations in their normal environment is uncommon.

C—043248—001

C-043249

Sources of Mortality. Stream life was shown to be the most hazardous phase in the life history of this species. Predatory fish were believed to be the greatest factor affecting them during this period in Waddell Creek. Since they spend a full year in the stream before migrating to the ocean, they are susceptible to other hazards, namely poor logging practices, pollution, drying streams and other natural phenomena.

Timbering and milling practices between 1850 and 1900 virtually ruined a number of fine coastal streams in Santa Cruz and San Mateo counties insofar as their use by salmon and steelhead was concerned. Nevertheless, the runs have shown gradual recovery with the abandonment of the mills and eventual regrowth of the logged-over areas.

Current logging and dairy and winery pollution are the present threats to silver salmon and steelhead in the Bay Area streams. Since their introduction into the Sacramento-San Joaquin system they are also threatened by the factors previously described for king salmon.

Since silver salmon ascend even the smallest streams their complete distribution in the Bay Area is not known, but they may be expected in most coastal streams with adequate spawning gravel and a good fall and winter supply of water.

STEELHEAD

Steelhead Sport Fishery

In the minds of many anglers steelhead fishing transcends all other forms of angling. These beautiful sea-run trout are one of the gamest of all sport fishes. Skill and patience are required of the successful angler, but these are rewarded manyfold each time one of these fish is encountered.

The best known steelhead fishing streams in the State are north of Tomales Bay, but excellent catches are also made on occasion in Bay Area streams.

While steelhead are native to the Sacramento River, the sport fishery for them developed largely after Shasta Dam was built. It is not known whether the change in the regime of the river has resulted in better conditions and hence more fish, or whether the controlled flows have simply made them more available to anglers. Both factors are probably involved. At any rate, the number of anglers and the importance of this fishery between the cities of Sacramento and Redding has increased greatly since 1950.

In the Bay Area during the 1954-55 winter season, wildlife protection officers of the San Francisco Region (III) of the Department of Fish and Game censused the main steelhead streams of the San Francisco Region. Five of the streams included in their census are within the area encompassed by this report. Pertinent data on the results of their check on these streams are given in Table 15.

TABLE 15

SUMMARY OF STEELHEAD CENSUS ON FIVE BAY AREA STREAMS (1954-55 SEASON)

	Census Data			Estimated Totals for Period		
Name of Stream	Days Censused	Angler Days	Angler Hours	Angler Days	Steelhead Catch	Catch per Angler Day
Walker Creek	32	471	1,481	1,518	576	0.38
Papermill Creek	53	841	2,948	2,163	388	0.18
Napa River	38	762	2,188	1,508	371	0.28
San Gregorio Creek[1]	8	82	218	188	51	0.27
Pescadero Creek	24	415	1,292	2,281	249	0.11
Totals				7,658	1,635	
Russian River[2]	25	600	2,172	15,301	8,369	0.55
San Lorenzo River[3]	25	308	567	11,255	5,913	0.48

[1] For January only
[2] For December only
[3] For January and February only

The same data for the Russian and San Lorenzo rivers are presented for comparative purposes. These rivers are north and south of the Bay counties respectively and are considered good steelhead streams.

The data attest to the persistent efforts of anglers in spite of seemingly poor results. The seven thousand plus angler days here recorded for these five streams are but a fraction of the total effort spent on steelhead angling in the Bay Area streams.

Angling for the adult fish does not constitute the entire sport fishery. Juvenile steelhead in the streams and lagoons also support a large amount of angling. The effort expended for the young fish may exceed that for adults. When caught in these locations juvenile steelhead are often confused with resident rainbow trout which are common in most streams. Angling for stream fish is possible over a much longer period of the year than for the adults, which run during the winter months and early spring.

The Sacramento River supports a steelhead fishery of fair quality. Between 1953 and 1959 the Department made annual counts of fish trapped near Fremont Weir on the Sacramento River and conducted creel censuses farther upstream. From six years of trapping, tagging, and census data, the run was calculated to average about 20,500 fish annually. Anglers took from 20 to 38 percent of the run each year. Detailed data for 1953-54 through 1958-59 are presented in Table 16.

Pelgen (1955) found that it cost the average angler 18 dollars per day to fish for steelhead. Since an estimated 58,300 days were spent steelhead angling in the Sacramento-San Joaquin system in 1953, he assigned an annual value of over one million dollars to the steelhead fishery of this system.

Juvenile steelhead are released into the Sacramento River each year from Coleman National Fish Hatchery on Battle Creek. The numbers released since 1953 and their effect on the runs is shown in Table 16. These stocked steelhead have comprised a variable percentage of the annual steelhead runs in the Sacramento River, but generally it is on the order of 15 percent.

Steelhead Life History Notes

The life history of this species is somewhat similar to that of the silver salmon, but there is a major biological difference between the two species. Steelhead are a sea-running form of the common rainbow trout. The steelhead, a trout, may spawn several times whereas all salmon die after their first spawning.

The variable life history of the steelhead is summarized in this quote from Shapovalov and Taft (1954), "Unlike silver salmon, steelhead migrate to sea at various ages and over a long period within a season, spend varying amounts of time in the ocean and return over a fairly long period within a season, are capable of spawning more than once, sometimes spawning before their first journey to sea, and may even remain in fresh water for their entire lives."

Time of Run. Steelhead inhabit many of the same streams as silver salmon. Their migrations occur over a longer period, and in the Sacramento River, for instance, may take place at nearly all months of the year. The majority, however, enter the streams in winter or spring.

According to Shapovalov and Taft they can be divided into two general groups, determined by the time of the spawning runs. The spring run fish enter while quite green but do not spawn until the following spring. The fall run is comprised of fish which spawn the spring following their entry into the river. Spring runs do not occur in most California streams. In coastal streams the height of the run takes place between January and March, while at the Fremont Weir location above Sacramento on the Sacramento River, the run peaks about the middle of September.

Their ascension, in relation to such variables as water flow, time of day, and storms, is similar to that described for silver salmon.

Composition of the Run. The upstream migrants at Waddell Creek were largely (82 percent) first spawners, although second spawners comprised 15 percent, third spawners 2.1 percent, and fourth spawners 0.1 percent of the run. The most common category making the spawning run were fish which had spent two years of stream life and one year in the ocean (29.8 percent). Next were those with two years stream life and two years of ocean life recorded on their scales (26.5 percent) and, in descending order, three years of stream life and one year of ocean life (10.5 percent), and two years of stream life and one of ocean life including a previous spawning (8.1 percent). The above four groups comprised 75 percent of the run. There were other life history categories in each year's run but none exceeded 5 percent. Steelhead over seven years of age were not observed.

Survival after spawning is higher among females than males. The greater physical exertion of serving more than one female and the fact that in so doing they are subjected to the danger of being stranded by lowering flows and the closing of the bar at the stream mouth was given as the probable reason.

As in the case of silver salmon, males predominate in the early part of the run, females in the latter.

Spawning Conditions. The choice of site and other factors associated with spawning are similar to silver salmon. Needham and Taft (1934) gave an account of steelhead spawning. They found that 550 to 1,300 eggs were deposited in each nest site and that it required 6 to 7 pits to complete spawning. They estimated the completed redd to be 12 feet long and 5 feet wide. Sites are so chosen that the redds are rarely affected by falling stream levels.

About 97.5 percent of the eggs were successfully buried in the redds. Egg loss due to use of redds by subsequent spawners may be severe in individual redds but is believed to be negligible overall.

The number of eggs varies with the size of the female. The average in coastal streams is perhaps close to 5,000, although the range is from 3,000 to 12,000. The percentage fertilized is consistently high.

After spawning the survivors descend to the sea between April and June. Spent fish typically do not feed in fresh water, but once they return to the ocean, feeding and growth is resumed.

Embryology. In essence, the embryology of the steelhead is similar to that of the other trouts and salmon. The incubation period may vary between spe-

TABLE 16

SACRAMENTO RIVER STEELHEAD RUNS (1953-59) [1]

Season	Estimated Number of Upstream Adults in Run[2]	Number of Hatchery Reared Steelhead in Run	Computed Angler Catch[2]	Percentage of Run Caught by Anglers	Computed Number of Hatchery Reared Steelhead in Catch	Juvenile Steelhead Planted
1953-54	14,400	400 (2.8%)	3,030	21.0	80	151,848
1954-55	28,400	2,320 (8.2%)	9,830	34.6	810	177,259
1955-56	28,320	5,220 (18.4%)	8,840	31.2	1,630	270,543
1956-57	18,380	3,200 (17.4%)	6,960	37.8	1,210	227,113
1957-58	19,410	2,880 (14.8%)	5,280	27.2	780	151,401
1958-59	14,340	940 (6.6%)	5,520	38.5	360	282,588[3]

[1] Data provided by Richard Hallock, Biologist, California Department of Fish and Game, under the Federal Aid to Fish Restoration Program.
[2] Fish over 12.5 inches in length only.
[3] These were unmarked fish since study had been terminated.

cies and between different batches of eggs of the same species. Wales (1941) made a very careful study of the development of steelhead eggs and found that they hatch in about 30 days at 51° F. He formulated a table showing the stage of development at various temperatures and time periods based on his work. He found that his values for rainbow trout were almost identical to those worked out by Embody (1934). Since most of these species are represented in the Bay Area and are somewhat comparable to salmon, Embody's data (modified) are shown in Table 17.

TABLE 17

INCUBATION PERIOD FOR TROUT EGGS AT VARIOUS TEMPERATURES

Water Temperature	Incubation Time in Days: Rainbow Trout	Brown Trout	Brook Trout	Lake Trout
35° F.	–	156	144	162
40° F.	80	100	103	108
45° F.	48	64	68	72
50° F.	31	41	44	49
55° F.	24	–	35	–
60° F.	19	–	–	–

Mortality of young steelhead while imbedded in the gravel is due principally to silt. Under favorable conditions perhaps 80 to 90 percent of the eggs deposited hatch. At the time of hatching the young fish are about 0.7 inch in length and weigh about 270 fish to the ounce. About 4 to 8 weeks after hatching the young emerge from the gravel and at that time are just slightly under an inch in length and weigh about 180 per ounce.

Stream Life. Post-emergence behavior and mortality is similar to that described for silver salmon. In late summer, however, their habits differ from silver salmon in that instead of choosing pool sites they move into somewhat swifter water. Their growth rate at this time slows but not as markedly as evidenced in silver salmon. Growth remains negligible until the following spring.

The behavior of young steelhead is extremely variable. Most young go to sea during the spring or summer following emergence, but a secondary migration usually occurs in the fall. Other fish may move downstream at any time or not at all. Some may even remain in the lagoon for a year before entering the ocean.

Ocean Life. Steelhead life in the ocean remains much of a mystery, even more so than salmon. They apparently do not wander as far out to sea or as far from the home stream as salmon. For some unknown reason they are only rarely taken by commercial or sport trollers although a few have been taken in Monterey Bay and near Fort Bragg. Those which have been caught in the ocean were taken from piers or boats within a half mile or so of shore.

"Homing" is well supported by the data of Shapovalov and Taft. During nine seasons only 1.9 percent of the fish marked in Waddell Creek strayed to neighboring Scott Creek while the percentage straying from Scott to Waddell Creek was but 2.9 percent.

Survival. Overall survival was found to vary from 0.017 to 0.028 percent for Waddell Creek steelhead. Survival of the various life history categories is given by Shapovalov and Taft but the number and variability of these groups is such that a simple discussion is not possible.

Deformities and diseases among wild populations are not well understood but they are probably not prevalent. Furunculosis (a fungus) was noted at Waddell Creek in the 1933-34 season, however. Freshwater copepods (*Salminocola californionsis*), an external parasite, were detected on many individuals but their presence was not believed serious. Mr. Joseph Wales, trout disease expert formerly of the Department of Fish and Game, has described many of the parasites and diseases of steelhead and rainbow trout in California in a number of publications.

In the stream the food of steelhead consists principally of aquatic and terrestrial insects and other small invertebrates. The smaller fish in saltwater depend on marine invertebrates, while those in brackish water, especially lagoons, feed on the crustaceans common in those waters. The larger fish are chiefly piscivorous.

Growth is similar to silver salmon and the adults achieve approximately the same length as silvers in the same life history categories. Males tend to reach a larger size than females among fish spending two years at sea. The opposite occurs among fish spending one year at sea. Steelhead may attain a weight of 30 pounds or more, but the average adult taken in the sport fishery probably weighs less than five pounds.

Sources of Mortality. Predators are probably the most serious hazard to young steelhead in many coastal streams and this probably applies to the runs in the Sacramento River as well. In addition poor logging practices, pollution, and drying streams also take their toll of fish. Outside of the metropolitan area, siltation and winery and dairy wastes are perhaps the major pollution threats on Bay Area coastal streams.

The hazards of Sacramento River steelhead closely parallel those of king salmon.

The statements made previously concerning the conditions of silver salmon streams before 1900 apply here also.

Steelhead in the Bay Area are known to inhabit a number of tributaries of streams which empty into San Francisco Bay. Snyder (1905) found steelhead in San Francisquito, Madera, San Antonio, Stevens, Campbell, Guadalupe, Coyote, Arroyo Hondo, Smith and Isabel Creeks. In a later paper (1916) he recorded them from Papermill, Olema and Walker creeks, all tributary to Tomales Bay. These records, of course, do not include

the many small spawning tributaries of the larger streams where steelhead might be expected.

Unlike king salmon, which all pass through San Francisco Bay to the Sacramento River, steelhead also ascend the tributaries to San Francisco Bay previously mentioned, and are therefore found in all parts of the Bay itself, where they are most common during late summer and early fall.

STRIPED BASS

Commercial Fishery

Striped bass (*Roccus saxatilis*) were introduced into California in 1879 by Livingston Stone at the suggestion of Mr. S. R. Throckmorton of the California State Board of Fish Commissioners. Stone obtained 132 fish from 1½ to 3 inches in length and 30 medium-sized specimens from the Navesink River in New Jersey. These were brought out by rail and deposited in Carquinez Strait at Martinez in July of 1879. An estimated 25 fish died enroute and several others were discarded, so the number released is not exactly known, but is usually quoted at 132. A second plant of 300 fish obtained from the Shrewsbury River, New Jersey, was undertaken by Mr. J. G. Woodbury of the California Fish Commission and Mr. Emmet L. Marks of New York. These fish were placed in Suisun Bay off Army Point, near Benicia.

Therein lies one of the most remarkably successful attempts ever made to establish a species in new waters. Conditions must have been ideal because those planted made phenomenal growth and the species increased at a prolific rate. A few were reported taken in 1880, and several more appeared in the San Francisco markets between 1880 and 1884. A fish weighing 17 pounds was taken in 1883 and another of 18½ pounds was offered for sale in 1884. By 1888 several thousand were displayed in the markets and the commercial fishermen began to direct their efforts toward them. Eleven years later (1899), a mere twenty years after the introduction, the commercial catch as recorded by the U. S. Bureau of Fisheries was 1,234,000 pounds.

As late as 1888, striped bass sold for as much as a dollar per pound in the San Francisco market. However, by 1890 due to increasing abundance the price had dropped to 18 cents per pound and, according to Smith (1895), between 1889 and 1892 the average price received by the fishermen fell from 25 to 11½ cents. In 1893 and 1894 the price was further reduced to about 3½ cents. Quoting Smith: "On June 21, 1894, the day following the large catch on the Berkeley Flats in San Francisco Bay the wholesale price in San Francisco was 3½ cents and the retail price 7½ cents a pound." (The report by Smith incidentally is one of the best we have on the early introduction and distribution of striped bass in this state.)

The State Board of Fish Commissioners in 1910 stated: "From the commercial standpoint the striped bass stands next in value to the salmon as a food fish in this state. It is also one of the most highly prized of the game fishes, being eagerly sought after by thousands of anglers throughout the State."

Again quoting Smith: "In referring to their abundance, mention is made of the presence of a numerous body of fish on the Berkeley Flats in San Francisco Bay, in June, 1894, and in the San Joaquin River in December, 1893.

"An idea of the abundance of this species may be gained from the following statement by Mr. Babcock, [California Fish Commission]: 'On June 19, 1894, the fishermen struck a school of striped bass on the Berkeley Flats in San Francisco Bay; on June 20 one boat caught 1,500 fish and the other boats made large hauls. These fish weighed on an average 6 pounds apiece.'

"It is doubtful if in recent years at any point on the Atlantic Coast so large a catch of striped bass—9,000 pounds—has been taken by one boat in one day's fishing."

The bass distributed themselves widely, very shortly after being introduced. Within a few years they were found as far upstream as Sacramento and Stockton. Less than a year after being placed in Suisun Bay a specimen was taken in Monterey Bay. They appeared in the Russian River by 1890 and in Tomales Bay at about the same time. By 1893 one was taken at Santa Cruz, and the following year two were seined at Redondo Beach, Los Angeles County.

Small populations of striped bass became established on the Russian and Salinas Rivers as well as Elkhorn Slough near Monterey Bay. In Oregon, stripers are found in Coos Bay and the Umpqua River. However, in spite of a considerable coastwise dispersion, the overwhelming center of abundance of the striped bass has been and remains in San Francisco Bay and the Delta Area.

The principal commercial fishing grounds for striped bass were located on the San Joaquin River in the Delta country and the majority of the catch was taken in gill and trammel nets. River landings reached a peak between October and February, with the maximum catches made in December. In San Francisco Bay itself landings were most abundant during the summer.

Records of commercial landings are available for most, but not all, years between 1889 and 1915. However, between 1899 and 1915 it is evident that the catch regularly exceeded one million pounds (Appendix B-4). After 1915, regulations became progressively more restrictive and the annual commercial catch dropped below a million pounds (Appendix B-2). The species was completely removed from the commercial category in 1935.

Several reports have been written about this species in California. Scofield (1931) described the life history,

fishery and commercial catch. Craig (1928 and 1930) analyzed the commercial catch records and discussed the status of the fishery. Clark (1933) continued this work and came to the same general conclusion, namely that the supply was at the time capable of supporting the existing fishing pressure. Both cautioned, however, against neglecting the effects of the rapidly growing sport fishery.

Sport Fishery

Smith (*op. cit.*) points out that few anglers were fortunate enough to catch striped bass before 1895. Shortly thereafter, however, the anglers began to take them with increasing success. A number of striped bass clubs were formed and the sport fishery expanded from year to year.

Since 1935 the fishery has been reserved exclusively for sportsmen. Calhoun (see references) has done extensive work on this species including migrations, spawning, population dynamics, and their relationship to major water projects. Skinner (1955 unpublished data) analyzed the sport catch records dating from 1936, and other available data and came to the conclusion that a decline had occurred in the fishery between 1944 and 1954.

The striped bass fishery is one of the most valuable in the state, both in terms of the recreation and sport it provides and the economic wealth it generates. Only trout rank higher in the number of days spent by anglers (Skinner 1955). The trout fishery, however, is statewide, whereas the bass fishery is concentrated in San Francisco Bay and the Delta.

The number of anglers participating in the fishery now exceeds 200,000 a year. They expend on the order of 2 million days and 18 million dollars a year on this activity (Pelgen, 1955). The catch is estimated at a million or more fish per year with an aggregate weight close to four million pounds.

There is a year-round season which provides ample opportunity to fish and assures an open season within all parts of its range.

The fish are taken by a variety of angling methods in an area extending from the beaches outside the Golden Gate up the Sacramento River to Red Bluff and up the San Joaquin River to Mendota. The upstream limits of its range were formerly more important fishing areas than they now are. Most of the fishery recently has been confined to the area below Sacramento on the Sacramento River and below Stockton on the San Joaquin River.

Fishing from an anchored boat has been the most popular method. Bait used includes fresh or frozen sardines, anchovies, clam, squid and live or dead sculpins. Usually these baits are fished on or near the bottom.

Trolling has been practiced on a limited scale in selected areas, the most renowned being Carquinez Strait. This type of fishing is most rewarding in the summer, when in Carquinez Strait upwards of a hundred of boats may be seen plying the water. A number of party boats operate all summer for the purpose of taking anglers trolling.

Since the summer of 1957 fishing in the Bay near Alcatraz and vicinity has been extremely rewarding and appears to involve a new development in the fishery. The boats use heavy tackle and weights up to 3 pounds to fish deep. Salmon party boats were the first to locate and fish the area, and word of the excellent catches of striped bass soon brought the regular striped bass party boats on the scene. In 1957, during the two months of July and August, 8,726 striped bass weighing 98,245 pounds were taken in 5,301 angler days. The party boat records from which these data are derived are not a full measure of the effort or catch, however, since a great many private boats which are not required to report also fished the area.

Scofield (1926) pointed out the favored "old fishing grounds" for striped bass. These included San Antonio Slough near Petaluma, Oakland Estuary, San Leandro Bay and Petaluma Creek at Schultze's Slough. Other noted areas were Cache Slough and its tributaries. Sausalito, Petaluma, Napa, Rodeo, Crockett, and Cuttings Wharf on the Napa River were favorite striped bass resort sites. Baker's Beach, San Francisco, provided excellent surf casting.

Most of these are still good "bass grounds" but virtually the entire South Bay including the aforementioned Oakland Estuary and San Leandro Bay have been abandoned as bass fishing areas. The principal explanation for the absence of bass in the South Bay appears to be the polluted conditions which prevail there.

Similarly, the Napa River has lost much of its once famous reputation because of pollution. Scofield (*op. cit.*) emphasizes the conditions there by quoting an ardent Napa River angler, Mr. W. P. West, ". . . pollution from garages [oil] and tanneries has ruined fishing of all kinds in the vicinity of Napa except when the rains have purified the river; then it is possible to catch fish in town for a few weeks out of the year, whereas formerly they could be taken nearly the year around.

"During the fall of 1924 fish died in the Napa River within a radius of six miles from the city of Napa. The stench from the thousands of dead fish floating on the water became so bad that it was necessary to chemicalize the carcasses.

"Years ago bass were so numerous in the lower reaches of Napa's sloughs that a man rowing a boat would strike a fish every few minutes with his oars. In recent years bass fishing in these sloughs has been largely abandoned because almost every slough that formerly afforded good fishing has been leveed off."

Angling Statistics. The Department of Fish and Game has given particular attention to this species because of the intense interest expressed by sportsmen regarding it, the recreation it provides and its economic importance.

Through periodic postal card surveys it has been possible to observe the trends in the fishery. Catch figures thus obtained are exaggerated but the long term trends are considered fair indices of the status of the fishery. Calhoun (1950) discussed the methods, validity and reliability of them.

The catch figures obtained from these surveys are shown in Table 18 along with the number of successful anglers and the proportion of the state's total which they represent.

Since 1943 there has been a general reduction in the total catch in spite of a doubling in the number of successful anglers. The mean annual catch per angler is now about one-third its former level.

Party Boat Fishery. Another method of observing angling conditions in this fishery has been by an analysis of daily logs maintained by operators of striped bass party boats. These men are required by law to complete a form, supplied by the Department, consisting of the number of anglers carried, number and aggregate weight of the catch and location and time fished.

These records are subject to some error but they provide the most reliable data available on the trends in the fishery. Calhoun (1949) discussed their usefulness, reliability and the party boat fishery in some detail. The data provided in Appendix C-4 are taken from his report for the years prior to 1949. Data on subsequent years were provided by personnel engaged in the "Study of Sturgeon and Striped Bass", another of the State's Federal Aid to Fish Restoration programs.

For statistical purposes and record keeping the Bay and Delta area is divided into so-called "Block Areas" each with a designated code number. The specific location of each block is shown in Figure 30. Without describing them in detail the blocks are as follows:

Block Number	Location
301	*San Pablo Bay*
302	*Suisun Bay Area*
303	*The Delta*
308	*Carquinez Strait*
488	*North San Francisco Bay*
489	*South San Francisco Bay*

Block 308, Carquinez Strait: This area normally accounts for from one-quarter to one-half of all party boat trips recorded each year. Angler success has been much better here than any other block. Block 301 (San Pablo Bay) on occasion has supported a greater number of boat trips but Block 308 must be considered the most important party boat area year in and year out. Fishing in Block 308 is negligible from December through April, becomes increasingly good as the summer and fall progresses and peaks during the months of October and November. Fishing effort and success coincides with the upstream migration of adult fish in the fall.

TABLE 18

TRENDS IN CALIFORNIA STRIPED BASS ANGLING

Year	Total Catch	Successful Anglers	Percentage of all Angling Licensees	Mean Annual Catch Per Angler	Median Annual Catch Per Angler
1936	2,110,000	84,400	28	25	–
1937	2,040,000	81,900	26	25	–
1938	1,940,000	92,800	27	21	–
1939	1,880,000	89,000	24	21	12
1941	1,940,000	106,000	23	18	10
1942	1,680,000	88,200	20	19	–
1943	1,680,000	75,000	17	22	9
1944	1,420,000	–	–	–	–
1946	1,380,000	113,000	15	12	6
1948	1,650,000	161,000	17	10	5
1949	1,750,000	165,000	17	11	5
1951	1,490,000	144,000	14	10	5
1953	1,590,000	166,000	14	10	6
1954	1,440,000	158,000	13	9	5
1955	1,270,000	163,000	–	8	–
1956	1,000,000	127,000	9	8	5
1957	1,890,000	230,000	16.0	8	5

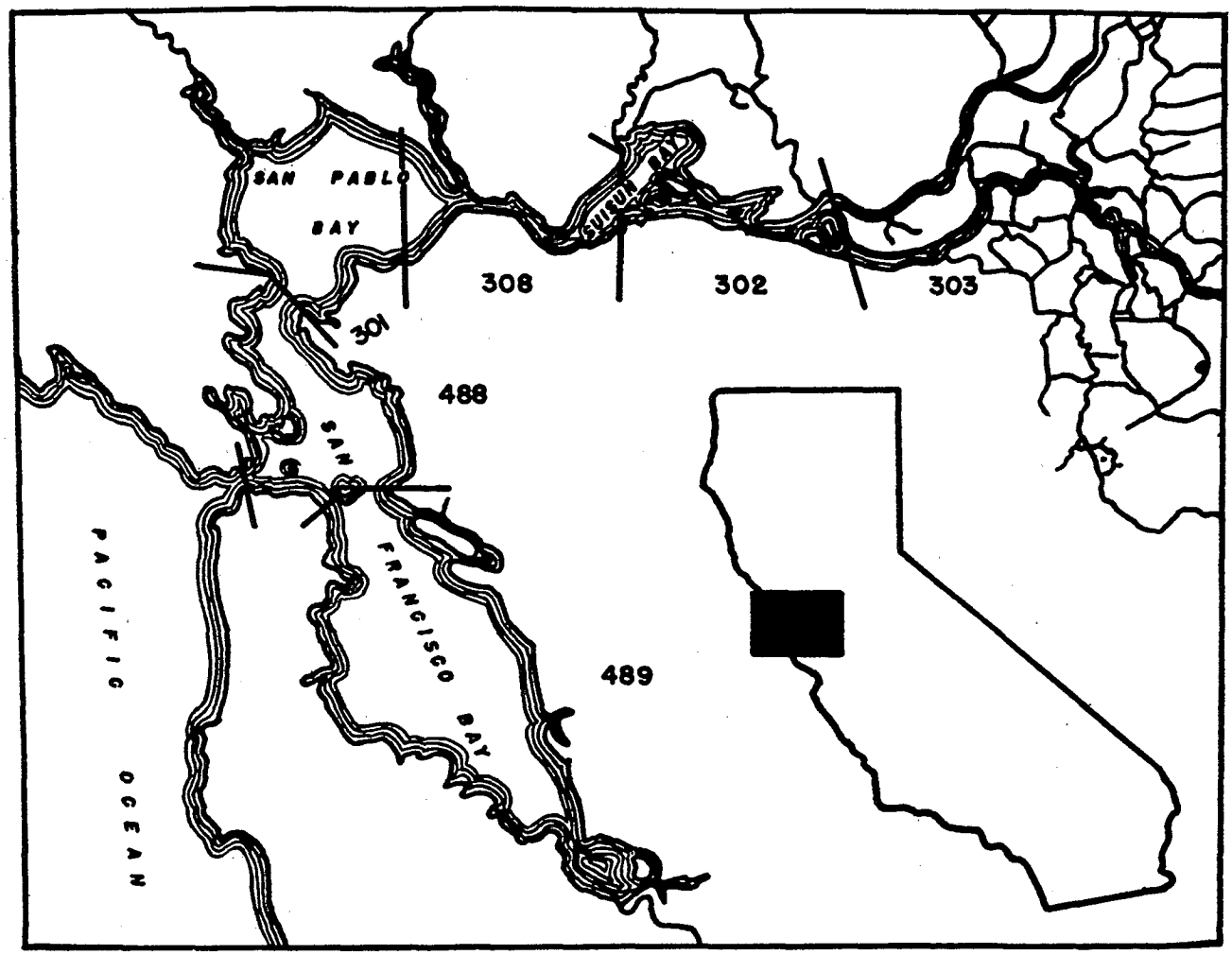


FIGURE 30. Block areas used in analysis of striped bass party boat records.

[1] There has been a recent revision in designating "Block Areas."

Block 301, San Pablo Bay: Party boat angling in San Pablo Bay has fluctuated widely, at times exceeding Block 308, but at other times only accounting for a small percentage of the boat days reported (only 10 percent in 1947 as compared to 40 percent in 1943.) The seasonal activity here parallels that of Block 308, and in addition supports a fair spring and light summer fishery for the smaller non-migratory bass.

Block 303, Delta: The Delta ranks about third in terms of boat trips recorded. In recent years it has exceeded Block 301. The party boat fleet moves up into this area during the fall and winter to follow the run of adult fish. Fishing is usually excellent in November, moderate from December to April or May, (presumably because of the feeding habits of the fish and not abundance), picks up for a short period in late spring, and then drops off as the fish move back down toward the Bay. Fish taken in this area are generally large, weighing between 5 and 15 pounds with fish up to 40 pounds being not uncommon.

Block 488, North San Francisco Bay: The North Bay has been good on occasion but is highly variable. In 1944 this block accounted for 23 percent of all party boat days, in 1948 a mere one percent. The best fishing location is in the vicinity of Alcatraz and farther north. Fishing is best during the summer months and almost at a standstill from September to April. Success in this block was very poor from World War II until 1957, when the deepwater troll fishery previously described began to operate.

Block 302, Suisun Bay: Suisun Bay and the area upstream to approximately Antioch forms Block 302. It is less important than the previous four but on occasion has yielded excellent catches of striped bass. Prior to 1945 about 10 percent of the boat days were spent in this area, since then less than five percent. The best fishing coincides with the fall run. Small fish are characteristic of Suisun Bay, and it is frequently referred to as the "kindergarten" by people familiar with fishing here. Record analysis depends upon a sample of at least 30 reports per month, and for many

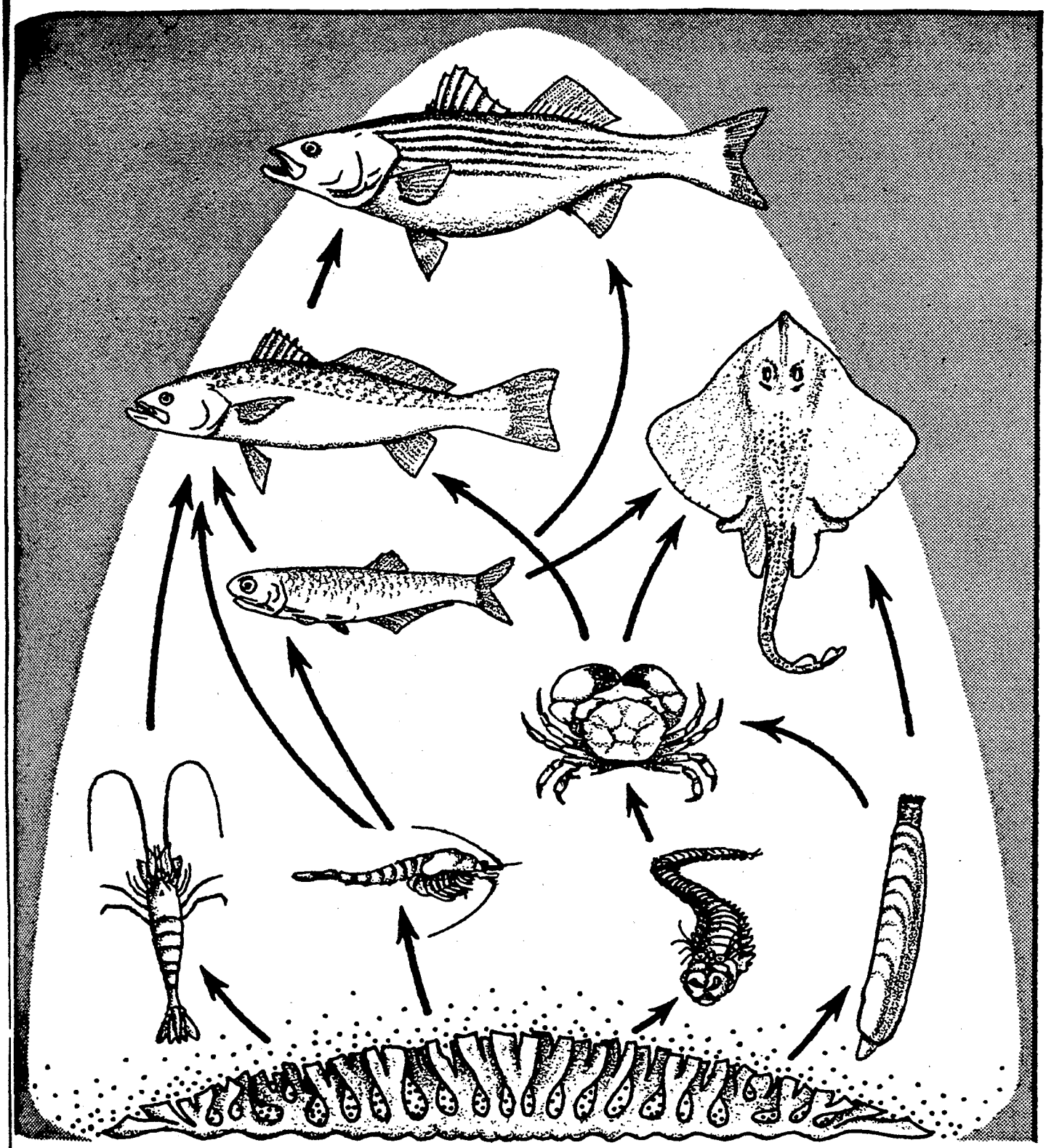


FIGURE 31. Pictorial diagram of typical food chain in an estuary or bay. Credit courtesy University of Delaware.

months and even for a few complete years this block did not provide sufficient party boat records. It is possible, therefore, that angling quality in this block could have been good but because of small fish the operators preferred to take their clientele to other areas.

Block 489, South San Francisco Bay: This area is now relatively unimportant to the party boat fleet. Two locations, Hunters Point and Mission Rock, are responsible for most of the records in this block. Fishing in this block has been fair in only three years since 1938. Between 1943 and 1946 less than one percent of all party boat days were spent here. The area was somewhat restricted during World War II, which partially explains the lowered use during this period. However, even several years after the war it continued to be devoid of party boats. The fish which are taken are large, giving the area some appeal. The fishery is a summer one when it does exist.

In addition to these areas operators may take their clientele directly to the ocean on the rare occasions striped bass are hitting there. In 1956, for instance, 1,257 anglers caught 442 fish in the ocean from party boats.

The party boat fishery is a small but important component of the overall striped bass fishery. The amount of effort from this source is perhaps on the order of 5 to 10 percent of the total. For the 11 year period, 1938-1949, party boats were responsible for an average of just over 13,500 angler days per year including half day trips.

Because of the knowledge, experience and skill of the operators, party boat anglers are somewhat more successful than the general angling public. The operator knows when and where to find the fish and will travel some distance to assure his party of good fishing.

Regardless of this fact there has been a decided reduction in the daily success of party boat anglers since 1944. The reduction is approximately of the same magnitude as that previously discussed for the postal survey. In Block 308 for instance, party boat angler success diminished from 3.8 fish per angler per day in 1938 to 2.0 fish in 1954, a 50 percent decrease.

Harold K. Chadwick of the Department of Fish and Game in the course of the striped bass study made an estimate of the amount of money anglers spent for party boat fares, based on the number of anglers using these facilities and the average fare. His estimate for 1957 was between $97,000 and $110,000 per year.

The number of party boats engaged in the fishery varies from year to year and has been decreasing over the past few years. Not all boats are operated the year-around. Individual boats may vary from large well equipped vessels down to the smallest inboard cruiser. Calhoun's data on the composition of the fleet for the year 1947 is given in Table 19. Mr. Chadwick has furnished data on the fleet for the years 1946-1956, shown in Table 20.

TABLE 19

COMPOSITION OF THE STRIPED BASS PARTY BOAT FLEET IN 1947

Type of Operator	Number of Operators	Average Number of Days of Operation During the Year
Professional (Main source of income)	31	105
Non-Professional (Some degree of permanence)	11	38
Others	56	16
	98	159

TABLE 20

COMPOSITION OF STRIPED BASS PARTY BOAT FLEET 1946-1956

Year	Class I Boats [1]	Total Boats in All Classes
1946	30	127
1947	31	98
1948	21	124
1949	37	161
1950	17	147
1951	18	125
1952	17	133
1953	15	156
1954	12	139
1955	11	102
1956	10	123
1957	11	114
1958	12	129

[1] From 1946 through 1952 the Class I Operator was considered professional if he operated throughout the greater part of the year as a main source of income. From 1953 on the Class I Operator is defined as one who reports on 100 or more days during the year.

General Features of the Fishery. The writer while in charge of the striped bass investigation conducted a survey of known striped bass anglers to obtain qualitative data on the striped bass sport fishery. Questionnaires were mailed to all anglers who in the regular postal survey had declared they fished for striped bass in 1955. Approximately 50 percent of the more than 400 contacted responded.

Angler Characteristics: Sixty-eight percent of the respondents claimed residence in the Bay Area counties and another 20 percent resided in Sacramento and San Joaquin counties. Alameda and Contra Costa counties alone accounted for 18.6 and 18.1 percent respectively or 36.7 percent of the total.

These figures indicate that 88 percent or about 176,000 of California's estimated 200,000 anglers who fish for striped bass reside in those counties immediately adjacent to the Bay and Delta. Twenty-four of California's 58 counties were represented by at least one striped bass angler. These data are summarized in Table 21.

Anglers were asked to record the number of years they had fished for striped bass in California. It was interesting to note that 40 percent of the respondents reported having fished 10 years or more, indicating many striped bass anglers have had considerable experience. The mode, however, was one year.

TABLE 21

COUNTY OF RESIDENCE OF STRIPED BASS ANGLERS

County	*Percentage Residing in County(ies)*	
Alameda	18.6	
Contra Costa	18.1	
Marin	3.8	
Napa	1.0	
San Francisco	7.1	
San Mateo	6.2	
Santa Clara	8.1	
Solano	4.3	
Sonoma	1.0	
Subtotal (Bay Counties)		68.1
Sacramento	12.9	
San Joaquin	7.1	
Subtotal		20.0
All Others (13 counties)	11.9	11.9
Total		100.0

In order to obtain some insight about the number of trips made by striped bass anglers each year, the fishermen were asked to record the number of times they went fishing. The mode was three and the mean ten trips. These data agree well with the postal survey results of 1953. Forty-four percent of the respondents went fishing 5 days or less, 26 percent 6 to 10 days and 30 percent fished more than 10 days.

Characteristics of the Fishery: Another objective of the survey was to determine the approximate distribution of angler effort by the several methods of fishing—party boats, private boats and from shore.

In this respect, 110 (40 percent of respondents) reported fishing 715 days from shore, bank, pier or bridge, accounting for 35.8 percent of the effort and 25.1 percent of the catch. Party boat anglers (10 percent of respondents) reported 7.7 percent of the total effort, and 10.6 percent of the catch. The small boat fishery, private and rented skiffs, accounted for 56.5 percent of all effort in 1955, and 64.3 percent of the catch. These data are summarized in Table 22.

It is interesting to compare the success of anglers engaging in each of these three methods of fishing. Shore fishermen averaged 3.9 fish per year for 6.5 trips and a mean catch per day of 0.59 fish. Skiff anglers caught 7.8 fish while averaging 8.2 days per year and a mean catch per day of 0.96 fish. Party boat anglers, presumably reflecting the skill of the operator, averaged 1.16 fish per day. These figures are given in Table 23. Success as reported by these anglers is in the direction and within the general magnitude one might expect. As a matter of fact, the success of the party boat anglers in 1955, as determined by the actual records, is identical to the results reported in this survey.

TABLE 22

CHARACTERISTICS OF THE STRIPED BASS SPORT FISHERY

	Respondents		Days Reported		Fish Caught	
Type of Fishing	No.	%	No.	%	No.	%
Shore, bank, pier or bridge	109	39.9	715	35.8	423	25.1
Party and Charter Boats	27	9.9	154	7.7	179	10.6
Skiffs and Rowboats	137	50.2	1,127	56.5	1,085	64.3
Totals	273	100.0	1,996	100.0	1,687	100.0

TABLE 23

STRIPED BASS ANGLING SUCCESS BY EACH OF THREE METHODS

	Number of Reports		Mean Catch Per	Mean Days Fished Per	Mean Catch Per
Method of Fishing	Catch	Days	Year	Year	Day
Shore, bank, pier or bridge	109	110	3.90	6.50	0.59
Skiffs and Rowboats	139	138	7.80	8.17	0.96
Party and Charter boats	27	27	6.62	5.70	1.16

Catch Localities: The recipients of questionnaires were also asked to indicate the locations in which they caught their fish. In tabulating these returns the Bay and Delta were divided into 19 sub-areas and the catches were assigned to those areas in which the fish were reported caught by respondents. San Pablo Bay accounted for almost twice (20 percent of the total) the catch of any other location. The combined catch of all Bay Area locations was 43 percent of the total as compared to 57 percent in the Delta. Next to San Pablo Bay, Suisun Bay and the Napa River were most important in the Bay catch. Considering its size and location, the South Bay was negligible as compared to other locations, yielding less than one percent of the total catch. The catches in each area and their respective percentages of the total are given in Table 24.

The San Joaquin portion of the Delta contributed almost twice as many fish as the Sacramento, 36.7 percent as opposed to 20.3 percent. Surf fishing along the beaches outside the Golden Gate has been good at times in the past, but this fishery is very sporadic. A few fish are taken by this method every year, but the number is usually only a small portion of the total. The data in Table 24, for instance, indicate only one percent of the fish were taken in the ocean in 1955.

Due to the vagaries of sampling the results of the survey cannot be considered conclusive; however, in the light our present knowledge about the fishery, they appear reasonable enough to place a fair degree of confidence in them. Other factors including regulations, migrations, weather conditions, etc. would also affect the results to some extent from year to year.

TABLE 24

STRIPED BASS CATCH LOCATIONS

Location	Number Fish Reported	Percentage of Total
1. Ocean	15	0.94
2. South San Francisco Bay	12	0.75
3. North San Francisco Bay	38	2.39
4. San Pablo Bay	321	20.19
5. Petaluma Creek and tributaries	2	0.13
6. Napa River and tributaries	95	5.97
7. Carquinez Strait	58	3.65
8. Montezuma and Suisun sloughs and tributaries	18	1.13
9. Suisun Bay up to Sherman Island	125	7.88
Total for Bay Area	684	43.00
10. Sherman Island Lake	78	4.91
11. Sacramento River to Cache Slough	77	4.84
12. Sacramento River above Cache Slough	168	10.57
Total for Sacramento River System	323	20.30
13. Big Break	21	1.32
14. Frank's Tract	168	10.57
15. Old River system	80	5.03
16. Middle River system	41	2.58
17. San Joaquin River up to Potato Slough	178	11.19
18. San Joaquin River above Potato Slough	49	3.08
19. Mokelumne River	46	2.89
Total for San Joaquin River system	583	36.70
Total for Delta	906	57.00
Grand Total	1,590	99.99

Striped Bass Life History Notes

Striped bass is a relatively long lived species and the population therefore is made up of fish of many ages, as compared to salmon, for instance, which generally have a 3 to 5 year life cycle. Stripers may live as long as 20 years or more.

Time of Run. The adults begin to enter Carquinez Strait from the Bay and ocean about August; the run usually peaks in October, and tapers off rather abruptly. They spread out over the entire Delta for the winter season. Angling is excellent during October and November throughout the Delta and as far north as the Feather River. With decreasing water temperatures, angling drops off to a very low point in January and February.

Spawning Conditions. About March or April the fish become active again to provide a short period of good angling. Potential spawners move up into the fresh water of the sloughs and rivers of the Delta system and begin to spawn in March or April. Spawning usually reaches a peak in May depending on water temperatures, and continues through most of June.

Temperature: Water temperature appears to exert an important influence on the time at which striped bass spawn. Raney (1952) summarizing the data of several investigators lists temperatures from 54° F. to 71° F. as being the known range at which they have been observed spawning. Scofield, working with this species here in California, found sperm viable at a temperature ranging from freezing to 90° F. He found the sperm most active at 68° F., sluggish below 42° F. and died at 100-110° F. Spermatazoa were found to remain active after 24 hours between 54 and 68 degrees in a 0.05 percent salt solution. He found that the sperm were active for about 3 minutes in water, after which time their swimming motion ceased.

In the Delta, spawning generally does not begin until temperatures reach 59° or 60° F. The optimum temperature appears to be 64 to 68 degrees.

Salinity: Spawning occurs in essentially fresh water. Larval bass and eggs are found in brackish water, but evidence has not yet been uncovered to show that spawning actually takes place in brackish water. Woodhull (1947) states that in the area which he observed them spawning (San Joaquin River), the salinity (in terms of chlorides) varied from 1 to 7 parts of chlorine per 100,000 of water.

Spawning Activities. Several authors have described the activities involved in the spawning process. Woodhull (*op. cit.*) observed them on the San Joaquin River in the vicinity of Venice Island. According to his description innumerable groups of fish gathered at the surface of the water for a distance of 3 miles along the river on a flood tide. The fish began to roll over on their sides at a 45 degree angle near the surface and splashed about with their caudal fins. This activity continued for several hours. During the process he used a plankton net to collect eggs not yet water hardened to corroborate the fact that the fish were spawning. Morgan and Gerlach (1950) observed a similar situation in the Coos River, Oregon.

Fecundity. Several investigators have estimated the egg production of female striped bass. The number is correlated with the size of the fish and in general, it may be said that this species is extremely prolific. This phase of their life history has not been specifically explored for California striped bass, therefore, the data presented are from observations elsewhere. Merriman (1941) found that the number of eggs ranged from 11,000 to 1,215,000 with the majority of fish yielding 180,000 to 700,000 each. Jackson and Tiller (1952) found the number to vary from 68,000 in a 4 year old fish weighing 4.4 pounds to 4,536,000 in a 14 year old fish weighing 35 pounds. Morgan and Gerlach (*op. cit.*) found that Coos Bay striped bass produced about 1 million eggs when they reached 10 pounds and that this figure reached almost 5 million for fish weighing between 30 and 50 pounds.

Spawning Locations. In California a few striped bass spawn in the larger coastal rivers, the Russian River particularly, and formerly the Salinas River. A few apparently persist in Elkhorn Slough, which enters Monterey Bay, and spawn there also. The major tributaries to San Francisco Bay are the principal spawning grounds, however, particularly those above Antioch and Collinsville.

Strong currents appear to be absolutely necessary for the development of striped bass eggs. They have not been found in stagnant water, nor have the adults been observed spawning under lacustrine conditions. The tidal action in the Delta seems to be particularly favored.

Since 1946, a considerable amount of effort has been expended to determine spawning locations. Sampling with plankton nets for eggs has indicated the San Joaquin River below Stockton and many of the sloughs in that portion of the Delta to be the major spawning area.

Eggs were found in greatest abundance in an area extending upstream from the Antioch Bridge to Venice Island and Salmon Slough. The Old River and Middle River systems are perhaps the next most important followed by the Sacramento River system, the San Joaquin River above Salmon Slough and the Mokelumne River. These can be considered the most important year after year, but conditions from year to year may change the sequence. In wet years, for example, spawning may occur below Pittsburg.

Striped bass were formerly reported to spawn in the Napa River. A special trip to collect eggs there during 1957 was unsuccessful, although large, ripe fish were known to be present in the river just previous to the sampling period.

Embryology. The eggs of this species are small (16 to the inch) and transparent at the time of expulsion, but they enlarge to about twice this size upon water hardening. They are very similar to shad eggs, and because both species spawn in the same places and at the same time, the two are easily confused. Striped bass eggs, however, can usually be differentiated by a relatively large oil globule which is not so apparent in shad eggs. Once the eggs are spawned, they are left to drift freely with the currents: Because of the oil globule, they are only slightly heavier than water and are kept suspended by the slightest current. The eggs develop while thus suspended. On the San Joaquin side of the Delta, they are flushed back and forth by the currents and their movement downstream is somewhat restricted. The opposite situation exists in the Sacramento River. Eggs spawned as far up as the Feather River or beyond are moved down into the Delta rather rapidly until they reach the Rio Vista area where they come under the oscillating influence of the tides.

The incubation period is influenced by temperature, higher temperatures being conducive to faster hatching. The known range has varied from 74 hours at 58° F. to 30 hours at 72° F. Hatching occurs in about 48 hours at 67° F. In our waters the temperature is usually in the vicinity of 62 to 68 degrees and the normal incubation period from 48 to 60 hours.

The larvae at hatching are about 0.1-0.2 inch (3-5mm.) in length. They subsist on the yolk material for the first 200 hours while being carried by currents. If they encounter still water, the larvae may settle to the bottom and die. According to Pearson (1938), if food is not available by the time they reach 6mm. (about 0.25 inches), they soon begin to die. This is perhaps the most critical stage in the life history of this species. At this small size they are almost completely at the mercy of the tides and predators.

Postlarval Stage. A great deal of work has been done in the Bay and Delta in sampling the abundance and distribution of small fry. Calhoun and Woodhull (1948), Calhoun, Woodhull and Johnson (1950), Calhoun (1953), Skinner (1955), Hatton (1940), Hatton and Clark (1942), and Erkkila et al. (1950), have all investigated the subject, chiefly because of the presence of millions of these small fish in the vicinity of large industrial and irrigation diversions and sewage and industrial waste discharges; Skinner and later Chadwick (unpublished data) have continued the work.

Surveys have been conducted almost annually since 1946 to obtain a measure of the distribution and abundance of bass fry over the Bay and Delta Area where they are widely distributed. Calhoun (1953) in conjunction with personnel from the U. S. Fish and Wildlife Service divided the entire area into 67 different sections, sampled each to obtain the density of fry per thousand cubic feet of water strained, and projected the result to the approximate volume of water within each section. They derived an estimate of 35 million fry during mid-July of 1951 and a second estimate of 20 million for late July.

Fry were found in greatest abundance in Honker, Grizzly and Suisun bays and in the main channels of the Sacramento and San Joaquin rivers in the Delta. particularly heavy concentrations were found in Honker Bay and in the San Joaquin River between Pittsburg and Antioch.

The surveys since 1951 have not been as extensive as in that year, but they indicate that a similar distributional pattern has prevailed each year since. Between 1953 and 1956 the surveys were conducted under identical conditions to obtain continuity for year-to-year comparisons of fry abundance. Five stations were selected and sampled on minus tides, when the fry reached a mean length of one inch in the vicinity of Antioch.

It appears that reproduction was exceptionally good in 1953 and 1954 with progressively poorer years in 1955 and 1956. Unfortunately, statistical procedures have revealed certain discrepancies in the sampling

methods which limit the usefulness of past surveys as indices of abundance. A new approach is being employed which it is hoped will yield more useful data.

Experimental data indicate the fry are usually located nearer the surface than the bottom, although a recent series of tests designed to determine their vertical distribution, showed the reverse to be true on at least one occasion. Chadwick (unpublished data) conducted tests in the summer of 1957 which showed that the smaller fish are found in greater numbers near the shoreline than in mid-channel. As they approach two inches in length, they are found more evenly dispersed throughout the channel. Evidently, even fry less than an inch in length have some control over their movements despite rapid tidal currents. His findings agree with observations made by the writer in 1954 and 1955 while engaged in this work.

Juveniles. By early summer young fish are scattered throughout all parts of the Delta and at least as far downstream as San Pablo Bay. Apparently, all fry are not carried into the Delta because they can be found far up the Sacramento and San Joaquin Rivers in the late summer and fall. It seems rather improbable that they return upstream after having once gone down. Juvenile fish have been seined all along the Sacramento and San Joaquin rivers and at least as far down as Point Wilson in San Pablo Bay.

During seining operations during the fall (October) of 1956 and 1957, throughout the Bay and Delta, fish with mean lengths ranging from 2.9 to 4.0 inches were taken. The overall average is probably about 3.5 inches. There does not appear to be any perceptible difference of growth pattern in any particular part of the area covered. Growth ceases, or at least is greatly diminished from October until the following March.

Juvenile fish apparently remain principally in the Delta for two to three years before moving into San Francisco Bay or the ocean. During this period they tend to be gregarious, moving about in scattered schools.

Fish up to 16 inches may be found anywhere throughout most of the year, but certain areas seem to be more favorable than others. Such juveniles are almost always present in San Pablo Bay in the vicinity of Mare Island, the Napa River, Suisun Bay, and in a number of localities in the Delta.

Raney (1952) states: "During the first and second years they remain in small schools or feeding groups, but it has been observed that they exist in large schools by the end of the second summer."

The age at which they first begin their annual migrations between fresh and salt water has not been positively established on the West Coast. Most fish, it is thought, undertake them in the third year though many unquestionably begin in the second and others probably wait until their fourth year or later. Inherent differences between fishes, and sexual differences, are likely factors influencing the age at which they move into salt water. The proportion of adults making these annual excursions is not known; however, since large fish are very scarce in the Delta during the summer, it may be concluded that the great majority are involved.

Migrations. Clark (1934 and 1936) and Calhoun (1952) are responsible for most of our present knowledge on striped bass migrations in California. Both have conducted tagging experiments showing the migratory patterns. A third study, by Chadwick, was underway at the writing of this report.

Clark reported the results of tagging 1,544 bass, mostly small ones (mean length 11 inches), and found that they did not move in a well defined migration but more or less diffused out of the tagging area.

Calhoun's work was with legal sized fish (then 12 inches and over), of which he tagged more than 4,000. He found that unlike the smaller fish, the adults did undertake well defined seasonal migrations. Recoveries of tagged fish by sportsmen and gill net fishermen showed that the adults move upstream into San Pablo Bay and Carquinez Strait in the fall, then into the Delta in the winter, spread out and ascend the tributary rivers in the spring, and move down to the Bay again by early summer.

Their movement to and in the ocean is not yet understood, although a fair number appear to enter the ocean each year. Occasionally, good catches are made by surf casters off San Francisco beaches. Although stripers are seldom taken off shore, the party boat fleet made good catches of striped bass in the ocean during 1956. On the Atlantic Coast extensive north-south ocean migrations are made, presumably for feeding purposes. This phenomenon has not been observed to occur here.

Food Habits. Scofield (1911) found that fish up to four inches, in Napa Creek, relied on marine worms (50 percent) crustaceans (48 percent) and small fish (2 percent). The items are listed in Table 25.

Hatton (1940), in a collection of 76 fish ranging from one to six inches in length taken at Martinez, found that 69.4 percent of all stomachs contained crustaceans. The percentage of stomachs containing each item found is shown in Table 26.

TABLE 25

FOOD OF SMALL STRIPED BASS [1]

Items	Percentage of Total Number
Neomysis *(Neomysis mercedis)*	30
Young shrimp (*Crago* sp.)	15
Gammarus (scuds)	1
Marine Isopods *(Synidotea laticauda)*	1
Crab	1
Marine Worms *(Nereis)*	45
Marine worms (Not identified)	5
Small fish (Not identified)	2

[1] After Scofield (1911).

TABLE 26

FOOD OF SMALL STRIPED BASS [1]

Items	Percentage of Stomachs Containing Item
Isopods (*Synidotea laticauda*)	32.0
Amphipods (*Corophium spinicorne*)	40.0
Shrimps (*Crago* sp.)	5.3
Crab [remains]	1.3
Total for Crustaceans	69.4
Fish [remains]	10.6
Empty	25.3

[1] After Hatton (1940).

Hatton points out that the items were found during September and November while the water at Martinez was brackish.

Under freshwater conditions in this area, during the spring, the amphipods and isopods disappear, and the small fish were found to be feeding almost exclusively on a species of Mysidacea (*Neomysis mercedis*).

The writer has on several occasions while checking the stomachs of young-of-the-year bass (2 to 4 inches) from the San Joaquin River and Suisun Bay during the summer also found that mysid shrimp (*Neomysis mercedis*) was by far the major item in the diet. Some of the stomachs examined were simply packed with them. Each spring and summer the River and Delta abound with these small crustaceans.

Messrs. Fisk and McCammon of the Department, who have studied the food habits of the white catfish in the Delta, observed that amphipods (*Corophium spinicorne*) were the most important organism utilized by catfish. Hatton's work seems to confirm the importance of it in the diet of small bass. Unfortunately, data are meager on feeding habits of small bass from the time they begin to feed until they are through the first year.

On the East Coast, freshwater shrimp (*Gammarus*), and Dipterid (*chironomid*) larvae were found to be major food items.

Striped bass become piscivorous at least by the time they reach 6 inches and perhaps earlier. Their diet from this size on is extremely varied, and appears to depend upon the forage available. The larger fish appear to have a proportionately larger percentage of fish in the diet but even the largest specimens were found to contain crustaceans.

Bay shrimp (*Crago* sp.) appears to be one of the most common items, along with *Neomysis mercedis* and the small forage fishes found in the Bay, such as smelt, herring and anchovy. Hatton (op cit) examined 224 stomachs of adult bass taken near Pittsburg between March 13 and May 4, 1939 and found 56.6 percent to be empty (during the spawning season). His findings are summarized in Table 27.

TABLE 27

FOOD OF ADULT STRIPED BASS

Item	Percentage of Stomachs Containing Item
Striped Bass	2.67
Clupeoids [1]	4.01
Osmerids [2]	4.90
Split-tails	3.57
Lamphreys	0.89
Atherinids [2]	0.40
Catfish or sculpins	1.34
Unidentifiable fish remains	18.74
Shrimp	11.20
Crab	1.78
Plant Material (tules)	2.23
Unrecognizable material	3.57
Empty	56.60

[1] Herring and shad.
[2] These are commonly called smelt or whitebait.

Johnson and Calhoun (1952) examined 387 stomachs of adult bass collected during a period of a year. All fish were over 12 inches in length. One group of 229 was collected between San Rafael and Martinez during the summer and fall, while the other lot of 158 was taken from the Delta portion of the San Joaquin River between Antioch and the mouth of Middle River between November 1947 and June 1948.

Shrimp (*Crago* sp.) were the most numerous item and comprised the largest volume of all organisms found in the summer group. It occurred in 35 percent of all stomachs examined and formed 53 percent of the volume of all foods. Anchovies, the next most important item, occurred in 11 percent of the stomachs and comprised 39 percent of the food volume Isopods, crabs, mysid shrimp, and other fish were also found but none occurred more than six times or formed more than 2 percent of the total volume. Of this group of fish 28 percent of the stomachs examined were empty.

Their winter sample, the one from the Delta, contained 66 individual fish (42 percent of the sample) with empty stomachs. Neomysid shrimp occurred in more stomachs than any other item and formed, surprisingly enough for large fish, 20 percent of the total volume. Small fish, however, were the most frequent item and accounted for the greatest volume (64 percent). Bay shrimp (*Crago* sp.) accounted for 13 percent of the volume.

Shapovalov (1936) examined the stomachs of 47 striped bass taken from the mouth of Waddell Creek, Santa Cruz County. He found a large variety of items, with crustaceans predominating in the small bass, and other fish being the principal food of the larger bass.

Bass are obviously omnivorous feeders; quoting Scofield (1931): "Practically every marine form common

to the San Francisco Bay region has been found in their stomachs. Their food includes fishes, such as small Pacific herring, smelt, anchovies, split-tails, striped bass, shad, gobies, carp and perch; crustaceans and mollusks—crabs, shrimps, periwinkles, clams; and various other forms such as worms, copepods and vellella."

From the available data, it may be concluded that the very young fish at first depend on the microcrustacea, diatoms and other minute invertebrates. From one to four inches they depend heavily on larger crustaceans, *Neomysis mercedis*, *Crago* sp., aquatic isopods, amphipods, and marine worms. During succeeding years their diet becomes largely piscivorous, although crustaceans continue to be important.

Growth. The growth rate and relationship between age, length and weight was first worked out by Scofield (1931) for California striped bass. Robinson (1960) recently completed another study of the subject to determine if any appreciable change had occurred over the intervening 30 years. Both studies show a rapid gain in length for the first 4 years of life after which the rate becomes progressively less. Robinson, however, found that growth both in length and weight was more rapid than shown by Scofield, the difference being about 10 percent greater length and 25 percent greater weight by the end of the 7th or 8th years of life. Difficulty in aging specimens after their 7th year of life precluded accurate interpretations beyond this age without a great deal of careful study. Stripers reach a length of about 32 inches and a weight of 14 pounds by their 9th year of life. The maximum length attained in California may exceed 50 inches while the maximum weight may exceed 60 pounds (a 63 pound striped bass has been recorded). Fish attaining the above dimensions are most likely 20 years of age or over. Stripers gain weight at a relatively constant rate after their fifth year of life; the gain may be in excess of 2 pounds per year.

Age to Maturity. Scofield (*op. cit.*) made a careful study of maturing bass and came to the conclusion that 35 percent of the females mature by their fourth year, 87 percent by the fifth year, 98 percent spawn in their sixth year and 100 percent thereafter. Males mature earlier, many spawning while only 2 years old and most by the time they are three. Morgan and Gerlach (1950) reported mature male fish at one year of age. Males may be scarcely more than 10 inches in length by the time they mature. Females, on the other hand, are generally more than 18 inches long.

Artificial Propagation. In California, between 1907 and 1910, a brief attempt was made to propagate this species artificially. A small hatchery was built on Bouldin Island and operations were carried on for several seasons but the difficulties encountered, particularly the inability to collect ripe spawn, resulted in the abandonment of operations.

On the Atlantic Coast there still exists a hatchery at Weldon, North Carolina for this purpose.

Striped bass are extremely prolific and attempts to propagate them artificially are unwarranted. So many fry are produced through natural propagation that almost any contribution from artificial sources would be superfluous. Once established in an area any decline in the population is most likely the result of environmental factors rather than insufficient natural propagation.

Sources of Mortality. This phase of the life history of striped bass requires more investigation. Information simply is not available concerning the ages at which various types of mortality occur. Several earlier attempts to obtain data on angler harvest were attempted, but these met with difficulties.

An unknown proportion of the eggs deposited by the female are not fertilized. Losses occur while the eggs and larvae develop in their hazardous position of drifting in the river or tidal currents. Predation, sudden changes in temperature, pollution, and a number of other factors must also take a tremendous toll of eggs and larvae. As the yolk material is used up the larval fish must begin to fend for themselves, and it is at this stage that perhaps the greatest losses occur. Those which survive are continually subjected to predation, diversions and pollution, each of which could account for significant losses. Predation is everywhere apparent, but losses to pollution and water diversions occur at specific locations.

Losses at diversions are similar to those previously described for king salmon and need not be repeated here, except to say that the magnitude of striped bass losses at diversions far exceeds those of any other species in the Bay and Delta area. Some idea of the numbers involved can be obtained from recent tests at two major water diversions in the Delta.

The Contra Costa Steam Plant of the Pacific Gas and Electric Company located near Antioch requires 868 cubic feet of water per second for cooling purposes at peak capacity. Screening small fish from this amount of water presented a formidable problem but one which was eventually overcome by research and cooperation between the Pacific Gas and Electric Company and the Department of Fish and Game. This plant alone, it was estimated, could conceivably affect 10 percent of the annual striped bass fry population which, it will be recalled, was estimated at 35 million fish in 1951. Fortunately, salvage operations have greatly reduced the numbers of small fish destroyed at the installation.

Similarly, but on a more gigantic scale, the Tracy Pumping Plant of the Central Valley Project draws water from Old River and pumps it into the Delta-Mendota Canal for irrigation purposes in the San Joaquin Valley. A very conservative estimate of fry under the influence of this large diversion (designed to draw 4,600 cfs at peak periods) would be 10 to 15

percent of the population each year. Research by the Bureau of Reclamation and the Fish and Wildlife Service in cooperation with the Department, resulted in a revolutionary new type of salvage facility termed the "louver facility". Up to 98 percent of fish one inch or more in length have been successfully deflected from the diversion by it. From March through August of 1957, the completed structure bypassed over 1,750,000 striped bass, 217,800 salmon and steelhead, 1,187,000 catfish, and 261,800 miscellaneous fish.

Pollution affects fish in several ways: the most obvious, of course, is the direct lethal action of toxic substances which results in mass kills but which is seldom detected. Small fish under the influence of tidal currents are carried in the vicinity of toxic discharges which they might otherwise avoid. Even the adults are sometimes caught in particularly toxic discharges as in the case of the Stauffer Chemical Company fish kill in San Francisco Bay in May of 1957 and the Napa River die-off of several years ago.

Usually, however, polluting substances destroy the bottom fauna or food organisms upon which fish depend, or set up a barrier in the form of odors, acidity, temperature or some other condition which is detected by the fish and which they avoid. The latter two are not sources of mortality but they restrict the habitat and result in loss to the fishery.

Predation undoubtedly causes large losses among striped bass under 12 inches in length. After this, however, they themselves are predators and are pretty well removed from the forage class.

Old age, diseases, and parasites also take their toll of fish. Little work has been done concerning the former two. The author has observed striped bass completely riddled with the larval form of a cestode of the order *Trypanorhynca*. It is thought to be of the genus *Gymnorhynchus*. Striped bass are the intermediate host of this parasite which has as its definitive host certain sharks, skates and rays. Another common parasite observed was the nematode *Contracaecum*, of undetermined species.

Scofield (1929) reported injuries to striped bass from lampreys, presumably the Pacific lamprey (*Entosphenus tridentatus*). The author has observed a large number of striped bass with lamprey scars, and in a few instances with fairly fresh wounds. The effects of predation by lampreys cannot be assessed at this time without considerable conjecture; nevertheless, it is thought that lampreys are not a particularly important source of mortality.

Commercial exploitation was prohibited by law in 1935 largely eliminating this source of mortality. However, studies by the writer (Skinner, 1957) from 1954 to 1957 showed that a considerable number of striped bass were destroyed incidental to commercial shad and salmon netting operations. At a minimal estimate, 22,000 fish weighing about 250,000 pounds were destroyed in netting operations during the fall of 1955 and the spring of 1956. The total poundage destroyed each year by this method could easily have amounted to 500,000 pounds. By law, fish taken by the netters had to be returned to the water upon removal from the nets whether dead or alive. Legislation in 1957 prohibited all gill and trammel netting within the Golden Gate, thus eliminating such losses in the future.

Prior to 1935 striped bass were taken commercially. The amount taken each year is described in an earlier section of this report.

The next and probably the greatest single source of mortality among legal size fish is incurred from angling. Tagging studies aimed at measuring the exploitation from this source have not been wholly successful. Clark's tagging study (1934 and 1936) was not intended for this purpose primarily and certain deficiencies in it do not permit application of the results to the fishery in general. He recovered about 10 percent of the fish he tagged within one year of the date of release.

A very intensive tagging program conducted by Alex Calhoun of the Department of Fish and Game was specifically designed to measure the proportion of the population caught by anglers. It soon became apparent, however, that the commercial gill net fishery in the Delta and Suisun Bay region was seriously interfering with the study. The gill netters removed the tagged fish before the anglers had the opportunity to catch them and furthermore, the placement of tags on the fish was found to increase the chances of a fish being captured by the gill nets. Other adverse factors included the reluctance of sport and commercial fishermen to return tags from captured fish. Because of these conditions only the roughest sort of estimate was possible regarding the proportion taken by anglers. The writer made a brief study of tag returns from the above program and concluded that the proportion exploited by both sources, anglers and gill nets, was in excess of 25 percent of the legal population annually. Chadwick, (unpublished data) in a later review estimated a minimal annual rate of exploitation of 10 percent. Anglers, of course, were presumed to catch the greater share by quite a large margin.

Chadwick (unpublished data) initiated another tagging program in the spring of 1958 after removal of the gill net fishery. Preliminary analysis of the first three years of tag returns indicate angling mortality on the order of 20 to 30 percent annually on the population over 16 inches in length.

In spite of all the factors acting against it, the natural survival of this species is obviously high. The frequency with which individuals in excess of 30 or 40 pounds (over 15 years of age) are encountered lead to the conclusion that natural mortality is low.

STURGEON

Two species of sturgeon are common in San Francisco Bay; the white (*Acipenser transmontanus*) and the green (*Acipenser medirostris*). Little has been recorded about the early history of the green sturgeon except that it was considered definitely inferior to the white and was actually claimed by some to be poisonous. Most early accounts refer to white sturgeon, which incidentally, also was considered a nuisance by commercial fishermen who destroyed them at every opportunity because they inflicted heavy damage to their nets. Until 1870 or thereabouts only the Chinese, who extricated the gelatinous notochord from the backbone, found them of value. Up to that time white sturgeon were abundant.

The westward movement brought Easterners with appetites for sturgeon and caviar to the Pacific Coast. About the same time sturgeon were becoming scarce on the Atlantic seaboard. These factors served to bring about a complete reversal in demand for the species and by 1901 when the legislature temporarily abolished the fishery, white sturgeon were claimed to be on the verge of extinction.

Commercial Fishery

Relatively speaking, the commercial sturgeon fishery was short-lived. Fishing was principally by "Chinese" trawl lines, long lines suspended several feet above the bottom from which large barbless hooks were "dropped". Gill and trammel nets were also successful gear for capturing them; but such catches, more often than not, were made incidental to fishing for other species.

The earliest records concerning the catch date from about 1875. Catch data are almost exclusively from the annual reports of the U. S. Commissioner of Fisheries. Unfortunately, the statistics for one year often contradicted those of preceding years, making a definitive determination virtually impossible. Nevertheless, statistics for those years for which catch data are available are given in Appendix B-4. Where contradictory data were encountered, the latest was used on the assumption that such data were based on more complete and detailed reports.

Jordan (1887) reported a catch of 1,658,000 pounds for the year 1885, the largest catch on record. The annual catch from 1875-1892 apparently averaged just under 500,000 pounds, while those between 1892 and 1901 were on the order of 100,000 to 200,000 pounds. The fishery was abolished between 1901 and 1910, reopened for two years and then closed until 1916. In 1917 the fishery was again abolished by the legislature and the taking or possession of sturgeon was completely prohibited until 1954.

Sport Fishery

Sturgeon made an encouraging recovery under their 35 years of complete protection, and Department research personnel working on the Bay fisheries in 1953 advocated the opening of a year-round angling season for them. The Fish and Game Commission subsequently adopted an open season in April, 1954. At the outset a considerable amount of effort was expended for sturgeon, judging from party boat records, the numerous inquiries received by the Department of Fish and Game, and the extensive newspaper coverage in 1954 and 1955.

Angling is centered in San Pablo Bay, which supports the largest sturgeon population in the State. During the first year of the open season many were taken by the party boat fleet and occasional catches were made by individual anglers. It was charged that party boat anglers were "snagging" most of the sturgeon they took, and as a result this method was declared illegal.

Anglers have not yet found a successful method of taking sturgeon by hook and line other than snagging. It is hoped that eventually a specific bait or method will be developed. Today most catches are made incidental to striped bass angling.

In order to keep watch on the fishery, the Department initiated a tagging program to measure the catch (Pycha 1956). In this study 994 white sturgeon and 25 green sturgeon were tagged in San Pablo Bay between August and December 1954. Some idea of the numbers taken by sportsmen can be obtained from Table 28 which contains data on recaptured tagged fish. Anglers returned tags from two percent of 888 legal-size tagged white sturgeon (over 40 inches) within the first year after tagging. The combined catch of anglers and commercial gill net fishermen (who caught the sturgeon incidental to other fish) was 5.3 percent; however, since sturgeon could not be possessed legally by commercial fishermen, it is not possible to assess the significance of the commercial returns. As Table 29 indicates, the sturgeon catch from party boats dropped rapidly after adoption of the anti-snagging regulation.

Chadwick (1959), estimates that the actual harvest by anglers in the first year after tagging was two to ten percent.

Sturgeon Life History Notes

Sturgeon are the largest of all freshwater fishes. The white sturgeon, common to the Sacramento and Columbia River drainages of the Pacific Coast, are the largest in North America and are exceeded in size only by those of the genus *Huso* of Eurasia.

The weight of an individual white sturgeon taken from the Columbia River, Oregon, was reported to

be in excess of 1800 pounds. Here in California specimens of three hundred pounds and over were common before 1900, but when they came under severe exploitation the average size decreased rapidly. Under periodic protection from 1900 to 1917 and then complete protection until 1954 they made a surprising recovery. In August of 1955 a 462 pound female was found enmeshed in a Department salmon trap in the Sacramento River near Fremont Weir, and one weighing 277 pounds was taken by an angler in Suisun Bay.

TABLE 28

RECAPTURES OF TAGGED STURGEON

	By Anglers	By Commercial Fishermen	Totals
0-365 days at large	19	33	52
366-730 days at large	6	2	8
Over 730 days at large	2	0	2
Totals	27	35	62

TABLE 29

STURGEON REPORTED CAUGHT BY PARTY BOATS 1954-1957

April 1, 1954-March 31, 1955 (40 inch size limit)	191
April 1, 1955-March 31, 1956 (40 inch size limit)	70
April 1, 1956-March 31, 1957 (50 inch size limit)	12
April 1, 1957-October 1, 1957 (50 inch size limit)	2
Total	275

Green sturgeon rarely exceed 350 pounds and in the Bay Area the average weight is probably less than 100 pounds.

White sturgeon are an anadromous species, ascending the larger rivers north of Monterey to spawn in freshwater. Green sturgeon on the other hand apparently prefer salt or brackish water. The writer, while engaged in a study of sturgeon and striped bass observed numerous white sturgeon above the confluence of the Sacramento and San Joaquin Rivers. They are especially plentiful above that point in the winter.

During an investigation of the gill net fishery (1954-57), many green sturgeon were caught in the nets in Suisun Bay and Carquinez Strait. The general upstream limit of this species was observed to be at about the Middle Grounds in Suisun Bay. However, two green sturgeon were taken by departmental personnel at Collinsville, some 15 miles above the Middle Grounds. Both species appear to be most abundant in San Pablo Bay during the fall.

Concentrations of white sturgeon can easily be located by observing the fish jump out of the water. They rise out in a forward leap and come down in a resounding splash. No explanation has been given for this peculiar behavior but it may be associated with feeding. Herring and anchovies enter the Bay in the fall and sturgeon might be feeding on schools of these fish at the surface.

White sturgeon appear to make a general migration out of the Bay into the upstream waters in the spring but data are lacking to support this point. Spawning is said to occur in May and June, although this has not been demonstrated in California. Bajkov (1954) and Dr. Vadim Vladykov (personal communication) of Canada believe that spawning occurs on rocky bottom in deep holes supplied with swift currents. This agrees with reports on the spawning of rock sturgeon (*Acipenser fulvescens*), in Southern Michigan streams. Adult sturgeon are known to have occurred in the Pit River in the Sacramento system and were observed at the face of Mendota Dam on the San Joaquin River in 1947.

White sturgeon are extremely prolific. The number of eggs is correlated with size. Individual females may contain as many as 5 million eggs. The 462 pound female taken in the Sacramento River in August 1955 was estimated by the author to contain 4,700,000 ripe eggs. Bajkov (1949) states that a closely related species in Russia contained 665,000 at 25 years, 1,978,000 at 40 years, and 4,100,000 at 50 years. The eggs are adhesive and attach to the substrate in the area where spawning occurs.

Nothing is known of the embryology of white sturgeon to this writer's knowledge. The Russians, however, have done extensive work in this field, and have published on the embryology of several closely related species.

The adults do not die after spawning and research has thus far failed to reveal whether individuals spawn annually or at longer intervals. The latter seems most probable. Three distinct phases of ova formation were observed by the writer in the 462 pound female noted above. Ripe, loose, black eggs constituted the bulk. In addition, cream colored eggs somewhat less than half the size of the ripe ones in an intermediate stage of development were still firmly attached to the ovarian tissue. These eggs appeared to be a year or so from maturity. The third size appeared as minute follicles imbedded in the walls of the ovaries.

The youngest individuals taken in the Sacramento-San Joaquin system have been recovered at the Tracy Pumping Plant of the Central Valley Project and at the Pacific Gas and Electric Company's Contra Costa Steam Plant. Individuals as small as 5 and 6 inches have occurred at these installations. They are thought to be downstream migrants which were spawned farther up in the river systems.

Fish between 18 and 30 inches are common in the Delta and Bay Area. Those under 18 inches are perhaps most numerous in the Delta. No information is available to indicate the age at which they first move into the ocean.

C—043266

C-043267

Pycha (1956), estimated the adult population (over 40 inches) in the Bay to number about 11,000 fish. In the gill net investigation mentioned previously an estimated 17,900 sturgeons, chiefly under 36 inches, were caught by commercial fishermen in Carquinez Strait and Suisun Bay between September 1955 and June 1956.

White sturgeon live for many years. The oldest encountered in the present investigation was the 462-pound female trapped near Fremont Weir; its age was determined at 45 to 47 years by examination of the annuli in a pectoral fin ray. Since this species is known to attain a much larger size, the age attained also must be proportionately greater. Individuals aged 100 years or more probably existed before development of the fishery. Canadian authorities have placed the age of a sturgeon from Ontario (a different species) at 152 years.

The age at which white sturgeon attain sexual maturity is not definitely known, but it is tentatively believed to be between 15 and 20 years for females. At that time they are about 40 to 60 inches in length. Males mature somewhat earlier.

Sturgeon are bottom feeders primarily. Their mouth is ventrally located and the fish moves along the bottom sucking up mud and debris, sifting out the organisms upon which it feeds. They are therefore largely dependent upon the bottom fauna. Known items in the diet (observed by the writer) include small shore crabs, immature market crabs, clams, bay shrimp, and neomysid shrimp. Sturgeon over 20 inches definitely eat other fish. Several specimens caught in the Sacramento River were gorged with smelt (*Sprinichus thaleicthys*) and (*Hypomesus olidus*). A 19 inch carp was removed from the stomach of one large adult. Concentrations of anchovies and herring during the fall and winter in the Bay are thought to provide excellent forage, but this has not yet been proven.

From the 1954 tagging study some useful data are available concerning their migrations. Most of the tagged fish caught by anglers were taken in San Pablo Bay, the tagging site. A small number of returns came from fish caught during the winter and spring upstream from the tagging site. However, rather than indicating a definite movement in that direction, those returns are thought to be a reflection of angling effort.

One tagged white sturgeon was recaptured at the mouth of the Columbia River on August 26, 1955. This migration represents a minimum distance of 600 miles in 294 days. Three tagged green sturgeon have also been taken off the Oregon Coast, two at the mouth of the Columbia River; one on December 4, 1955 and the other on August 20, 1958. The third was caught in Winchester Bay on September 1, 1957. These returns strongly suggest an interchange of both species between the Columbia and Sacramento River systems.

AMERICAN SHAD

The American shad (*Alosa sapidissima*) appears to have been the first exotic species introduced into this State. They were first stocked in the Sacramento River near Tehama, California on June 27, 1871 by Mr. Seth Green, famous fish culturist of the U. S. Fish Commission. There were about 10,000 fry in the first stocking. Livingston Stone in 1873 brought out another 35,000 and between 1876 and 1881 several subsequent plants totaling 784,000 fry were made by the U. S. Fish Commission (Table 30).

TABLE 30

AMERICAN SHAD INTRODUCTIONS INTO CALIFORNIA

Year	Number	Source	Location Stocked
1871[1]	10,000	Albany, N. Y.	Sacramento R., Tehama, Teh. Co.
1873[2]	35,000	—	Sacramento R., Tehama, Teh. Co.
1876	99,000	—	Sacramento R., Tehama, Teh. Co.
1877	110,000	—	Sacramento R., Tehama, Teh. Co.
1878	115,000	—	Sacramento R., Tehama, Teh. Co.
1880	240,000	—	Sacramento R., Tehama, Teh. Co.
1881	220,000	—	Sacramento R., Tehama, Teh. Co.
Total	834,000		

[1] Introduced by Seth Green on June 27, 1871. Out of 15,000 at start of trip, an estimated 10,000 survived.
[2] Introduced by Livingston Stone on July 2, 1873.

After the original introduction, shad appeared at various points along the coast from San Diego to Alaska. The only stable populations in California, however, have been those in the Salinas and Russian Rivers and, of course, the Bay and Delta. In Oregon they have been taken in substantial numbers in the Umpqua and Coos rivers. Records have been maintained for the Umpqua River fishery since 1923 and show the catch to average about 400,000 pounds annually.

Commercial Fishery

Nidever (1916) reported that shad first appeared in numbers in the San Francisco markets in 1879. In 1886 the State Board of Fish Commissioners estimated a million mature fish were taken. Shortly after their introduction curious customers paid $10.00 to $15.00 per fish and many brought $1.00 to $1.50 per pound. By 1880 the price was down to 20 to 25 cents and still later (1888) only 5 cents per pound was obtainable during the height of the run. In 1894 the price declined to 2 cents per pound. This condition prevailed until at least 1916. Even at this price many fish could not be disposed of.

Between 1870 and 1915 data are limited, but apparently the catch rarely exceeded a million pounds before 1900 (Appendix B-4). After 1900 the catch regularly ran over a million pounds. The all-time record catch of 5,675,509 pounds was made in 1917. Landings

fluctuated between one and two million pounds (Appendix B-2) from 1918 to 1945 after which a million pounds was exceeded but once.

The catch figures are not a strict measure of the abundance of shad, however. This species simply does not have the reputation on this coast that is so apparent along the Atlantic. Its delicacy makes shipping difficult, thus further reducing its marketability.

Shad have an excellent flavor, are good fresh or canned, and extremely good smoked. Unfortunately, there is an absence of skilled boners in this area and the market has suffered as a result.

The eggs, or roe, of the female are the most valued part of these fish in California. In recent years females brought 6 to 8 cents per pound while male or "buck" shad rarely exceeded 1 cent per pound.

Almost 100 percent of the state's catch was made in the Bay Area, until the fishery was eliminated under 1957 legislation.

Shad Sport Fishery

In spite of the fact that shad have been exceedingly abundant in the Sacramento and its tributaries, there had never been much of a sport fishery for them until 1950. Since then, the fishery has grown immensely. Derbies are now annual occasions on the Sacramento, American and Feather rivers. When shad are present, usually from March through July, sportsmen descend on these streams in great numbers. Shad take flies avidly and have proved to be one of our gamest freshwater fishes. They put up a spectacular fight on light tackle. The fishery can be expected to expand greatly in the future.

Another popular method of taking shad is the so-called "bump net" fishery in which long handled dip nets of chicken wire mesh are used. The net is held in the water from a slow moving boat and when the characteristic bump is felt, the net is quickly raised to catch the fish. This method of fishing is conducted in the Delta at night during April, May and June. The Mokelumne and Sacramento rivers are particularly popular spots. One livery operator in the Delta specializing in this type of accommodation estimated that 2,500 anglers operating out of his establishment caught 30,000 shad by this method in 1954.

Thus far no work has been specifically directed at determining the proportions of the fishery or the amount of time and money sportsmen spend in pursuit of shad, but even in its present state of development the economic value of the sport fishery probably exceeded that of the commercial fishery.

Shad are not caught in bay waters by sportsmen because no suitable methods have as yet been developed. They are, however, taken in the Russian River, where the sport fishery is well developed, and in a few of the other larger coastal streams.

Shad Life History Notes

There has not been a specific life history investigation of this species in California, but a number of workers have observed different facets and from these a general picture can be constructed. East Coast workers (Mansuetti and Kolb, 1953) have written an extensive volume covering the shad of both coasts. The life histories are similar and some of the ensuing details, although taken from their report, apply to the shad on this coast as well.

Time of Run. Shad begin to enter the Bay as early as February, but the run does not assume major proportions until late March or early April. Males predominate during the early phase of the run and females the latter. Smaller unripe females also seem to precede the larger ripe females. A steady increase in the degree of ripeness is noted in both males and females as the season progresses.

Fish making up the spawning runs vary from three to five years of age with occasional fish either younger or older. The bulk is probably composed of three year old males and four year old females.

They ascend most of the rivers of the Sacramento-San Joaquin system until limited by impassable barriers. They do not use fish ladders to any appreciable extent. Talbot (1953) believes that shad can be successfully passed at locks and other types of ladders and fishways. Collins (1951) described the successful passage of shad over a dam at Lawrence, Massachusetts. Both agree that under proper hydraulic conditions shad can be successfully passed.

Sampling has revealed that the greatest proportion of shad ascend the Sacramento rather than the San Joaquin River.

Spawning Conditions. Spawning occurs above tide-water, generally in streams with a good current. Although they are reported to spawn at the mouths of creeks, the writer believes most spawning (at least in the Sacramento River system) occurs in the main channels and not necessarily near the confluence of the tributaries.

Spawning may take place at temperatures as low as 50° F., but the general range is between 55° and 75° F. The optimum range is probably 62°-68° F.

The eggs are fertilized by the male as the female expels them, and are left to drift in the currents. No nest is built nor parental care exercised. Shad eggs have been recovered at all depths in the river where they are held aloft by the currents and gradually drift downstream.

Many shad die after spawning, dead fish being common in the Sacramento River at the height of the spawning period. The cause is presumed to be the result of the rigors of spawning and the long migration preceding it. It is possible, however, that the conditions which prevail in the river at that time are at least partially responsible.

Lehman (1953) studied the fecundity of this species and found that egg production is correlated with age, length and weight. He found that production of Hudson River shad varied from 116,000 to 4,680,000 eggs per fish. This is much greater than has been previously reported by other investigators.

Embryology. The incubation rate has been established for this species under experimental conditions and found to vary from 6 days at 57° F. to 3 days at 74° F. Under natural conditions in California rivers, hatching probably occurs in 4 to 6 days.

Stream Life. The young fish gradually move downstream after hatching, but may remain in certain freshwater localities for extended periods of time. They are abundant in the lower Sacramento and San Joaquin Rivers (near Rio Vista and Antioch, respectively) during the late summer and fall, and are prevalent throughout the entire Delta as late as the month of October. Most of the young fish move into brackish water the fall and winter following hatching, but a few appear to remain until the following year.

Bi-weekly seine samples taken over a period of a year near Antioch on the San Joaquin River indicate the young reach an average length of about 3 to 4 inches by October. Seine samples throughout the Delta in two consecutive years (1956 and 1957) indicate some variation in the average length of fish at different locations but most were between the values given. Mansuetti and Kolb state that they may attain a length of 6 or 7 inches in 7 months under favorable conditions on the East Coast.

Their food habits on our coast have not been studied in detail although several shad examined at the California State Fisheries Laboratory contained anchovies and euphausiids. The diet is probably similar to that of Atlantic Coast shad in consisting principally of small shrimp, copepods and aquatic worms. Insects may be important to the juvenile fish in freshwater.

Ocean Life. Virtually nothing is known about shad once they reach San Pablo Bay. A few fish have been taken incidentally by commercial fishermen near Monterey, but they do not appear regularly in any type of gear or at any location. Well defined north-south ocean migrations occur on the Atlantic Coast but such has not been observed here.

By the time they return to spawn, the males average three pounds and the females almost four pounds. Six to eight pound fish are quite rare.

Sources of Mortality. Young fish are subjected to the same hazards as downstream migrant salmon and steelhead in the Sacramento system. These hazards include diversions, predators, irrigation pumps and pollution. The larvae particularly, may suffer exceptional mortality since they are pelagic and vulnerable to the many plankton feeding fishes in these river systems.

Shad are most abundant in the Bay Area during late fall and winter. The young probably prefer the shoreline as they move downstream and hence would be vulnerable to diversions and polluted areas along the river banks.

The Tracy Pumping Plant and the Pacific Gas and Electric Company's Contra Costa Steam Plant have been particularly troublesome diversions in the past.

Shad are an extremely delicate fish and the slightest physical injury usually results in death. The effects of various pollutants on shad are not known, but it may be inferred that this species is more susceptible to toxic or deleterious substances than many other species.

MISCELLANEOUS ANADROMOUS FISHES

In addition to the anadromous species already discussed there are a few others which either pass through the Bay Area to spawn in the freshwater tributaries or spend most of their life in the Bay except to spawn in freshwater.

The Pacific lamprey (*Entosphenus tridentatus*) can be observed each spring, mostly during the period April to June, as they attempt to pass over the dams of Central Valley streams. They spawn in the smaller tributaries of the rivers they ascend. Like salmon, the adults die after spawning.

Just what role this parasite plays in the overall picture of our fishery resources has not been determined. It is not caught commercially and is generally disdained by all who come in contact with it. Lampreys are eaten by several species of fish, but so far as is known they are not an important forage species. It might be mentioned here, however, that lampreys are used as bait in the commercial sturgeon fishery on the Columbia River.

These parasites attach themselves to the host fish by means of their mouth, which is so modified as to form a very effective suction disk. Once attached they rasp through the skin and flesh of the victim and suck out the body fluids.

Lampreys are used as food to some extent, particularly by the Indians of several coastal streams.

Freshwater smelt (*Hypomesus olidus*) and Sacramento smelt (*Spirinchus thaleichthys*) are common in the Delta from late winter to early summer. They spawn in many of the same areas as striped bass and shad but do not ascend the rivers much above tidewater. Their most important contribution is as forage for food and game fishes, particularly striped bass. They seldom exceed 5 inches in length and are extremely delicate. They travel in large schools which are followed and preyed upon by larger carnivorous fish.

Other anadromous fish which are rare or occasionally stray into the Bay are the pink, chum and red salmon.

COMMENTS ON THE FUTURE OF THE ANADROMOUS FISHES

The continued maintenance of our anadromous fish resources is one of the gravest problems facing fishery managers. Dams and other barriers reduce stream flows, destroy and block spawning grounds and prevent the upstream passage of fish. They may also hinder the downstream migrants even where successful methods have been employed to pass the adults upstream over the dam. Industrial and agricultural diversions are responsible for the loss of enormous numbers of the small downstream migrants. Poor logging and mining practices destroy spawning areas or form barriers to the ascent of fish. In some instances poor logging practices have destroyed entire small watersheds through erosion and destruction of the stream bottoms and the upsetting of the temperature regimes to such an extent as to cause severe reductions in fish populations and fish food organisms.

In California, generally, dams appear to be the most serious factor in diminishing salmon runs. Untold miles of spawning tributaries have either been inundated or cut off by impassable barriers. Shasta Dam alone on the Sacramento River eliminated approximately 50 percent of the available spawning area of this river system. Fortunately, the flow and temperature regime below the dam is favorable to salmon. Friant dam eliminated about 36 percent of the spawning area of the Upper San Joaquin River. Folsom Dam on the American River also eliminated valuable spawning areas. The latter loss was at least partially compensated for by Nimbus Hatchery with its capacity of 30 million eggs annually (Equivalent to 6,000 female spawners). Similarly, Coleman Fisheries Station on Battle Creek near Redding has made up in part for the loss of spawning areas above Shasta Dam. No such provision was made at Friant Dam.

At the present time the principal spawning areas on the Feather River are still accessible. A ladder on Sutter-Butte Dam enables fish to negotiate this obstruction. The gigantic dam being constructed by the State above Oroville, however, will eliminate more spawning area and result in controlled flows below the dam. State agencies are cooperating to bring about the greatest protection of the river's salmon resource.

As the California Water Plan progresses, even greater curtailments in spawning areas are inevitable. On the Sacramento River the proposed Iron Canyon Dam, if built, will cut off an area used by 94 percent of the present salmon runs in this river system. This estimate is based on annual counts of salmon spawners (Hallock 1957).

Perhaps the greatest potential blow to all anadromous species, and a number of other species as well, are the salt water barriers being considered for the Bay Area. A number of plans for such barriers have been suggested, all of which would have major repercussions on the anadromous fisheries resources of the Sacramento-San Joaquin River systems.

At the present time the only one under serious consideration is the modified Biemond Plan which, incidentally, is also the most favorable from a fisheries point of view. Fisheries personnel under contract to the Department of Water Resources are now evaluating the effect of this plan on the fisheries resources. Information already has been published for other salt water barrier plans including that of the Junction Point Barrier, which it is believed would affect the resources on about the same order of magnitude as the Biemond Plan. Fisk (1957) has estimated the effects of the Biemond Salinity Control Barrier Plan on fish life. (Table 31)

These reductions are expected to occur even though several types of fish salvage facilities will be employed.

The "California Water Plan" embodies over 200 major dams throughout the State, many of which would affect anadromous fish. The Delta area, as one of the focal points in the plan, would see the construction of more and greater diversions and pumping facilities.

All of these facts impressively point out that many adverse developments from water manipulation projects, as far as anadromous fish are concerned, can be expected for some time to come.

Projects such as those outlined are not the only source of concern. More urban and industrial development, particularly in the Bay Area and along the Sacramento and San Joaquin rivers, must also be anticipated. This will result in a greater volume of waste which must be adequately treated if pollution problems are not to be intensified.

Fortunately, significant advances have been made in abating domestic sewage pollution in and around the

TABLE 31

ANTICIPATED EFFECT OF THE PROPOSED BIEMOND SALINITY CONTROL BARRIER ON FISH LIFE UNDER TWO PROPOSALS

Species	River System	Anticipated Population Loss or Gain in Percentage Single Screen [1]	Three Screen [2]
King Salmon	Sacramento	−12.0	−3.4
King Salmon	San Joaquin	−18.0	−4.3
King Salmon	Mokelumne	−24.0	−24.0
Silver Salmon	Sacramento	−14.0	−3.4
Steelhead Trout	Sacramento	−9.0	−1.2
Striped Bass	Sacramento-San Joaquin	−15.0	−15.0
Shad	Sacramento-San Joaquin	−25.0	−25.0
White Sturgeon	Sacramento-San Joaquin	−5.0	−5.0
Catfish	Sacramento-San Joaquin	−25.0	−25.0
Panfish (Black bass, Sunfish, etc.)	Sacramento-San Joaquin	+25.0	+25.0

[1] Under this plan there would be a single large fish screen at the Delta Pumping Plant.

[2] In addition to the fish screen at the pumping plant, screens are proposed at Walnut Grove on the Sacramento River and Paradise Cut on the San Joaquin River.

Bay Area. A number of communities still discharge raw sewage into these waters but contemplate treatment facilities in the near future; thus, the outlook for eliminating this type of pollution is good.

Industrial pollution is not generally as obvious to detect as domestic wastes. The bottom fauna may be destroyed by the deposition of petroleum substances, pulp fibers, or other waste materials. Oxygen depletion may occur directly through the dumping of organic substances of high oxygen demand into the water or indirectly by release of substances which encourage excessive algae and plankton growths which seriously deplete the available oxygen each night. Many waste products have physical or chemical characteristics which are readily detected and avoided by fish, leaving areas thus contaminated devoid of fish life, even though no actual fish kills occur.

It would appear that insofar as pollution is concerned in the Bay Area, the prospects for the future are encouraging. Strengthening of the pollution control laws in 1957, and increased public awareness have made much progress possible.

The rehabilitation of large segments of the Bay is highly desirable, not only for the benefit of anadromous fishes, but for the molluscan fisheries as well, and the many species of forage fishes.

There seems to be little reason to doubt that areas presently devoid of aquatic life would again become populated with fish if they were cleaned up. Some assurance of this is the reappearance of striped bass the past few years on the Berkeley "flats", an area which in the past has been completely devoid of them.

The Department of Fish and Game is making a strenuous effort to protect the fisheries resources in the case of water projects and is finding water developers increasingly cooperative and cognizant of the problem. Nevertheless, losses of magnitude are bound to occur. Artificial propagation is only a partial answer in most cases to losses of spawning areas. Additional solutions must be found. Fish losses at diversions remain a serious problem although the recent development of louver and vertical drum screens may offer an opportunity to overcome losses at some major diversions.

ANADROMOUS FISHERIES REFERENCES

Bailey, Elton D.
1954 Time Pattern of 1953-54 Migration of Salmon and Steelhead Into the Upper Sacramento River. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report No. 54-9.

Bajkov, Alexander D.
1949 A Preliminary Report on the Columbia River Sturgeon Fish Commission Research Briefs. Fish Commission of Oregon, Vol. 2, No. 2, pp. 3-10.

Black, V. S.
1951 Changes in body chloride, density and water content of chum (Oncorhyncus Keta) and Coho (O. Kisutch) salmon fry when transferred from fresh water to sea water, Jour. of Fisheries Research Board of Canada 8, p. 164.

Calhoun, A. J.
1949 California Striped Bass Catch Records From the Party Boat Fishery; 1938-1948. California Fish and Game, Vol. 35, No. 4, pp. 211-253.
1950 California Angling Catch Records from Postal Card Surveys: 1936-1948 With an Evaluation of Postal Card Non-response. California Fish and Game, Vol. 36, No. 3, pp. 177-233.
1951 California State-Wide Angling Catch Estimates for 1949. California Fish and Game, Vol. 37, No. 1, pp. 69-75.
1952 Annual Migrations of California Striped Bass. California Fish and Game, Vol. 38, No. 3, pp. 391-403.
1953a. State-Wide California Angling Estimates for 1951. California Fish and Game, Vol. 39, No. 1, pp. 103-113.
1953b. Distribution of Striped Bass Fry in Relation to Major Water Diversions. California Fish and Game, Vol. 39, No. 3, pp. 279-299.
1957 Striped Bass Fishing Map (Revised by John E. Skinner). California Department of Fish and Game.

Calhoun, A. J., and John E. Skinner
1954 Field Tests of Stainless Steel and Tentalum Wire with Disk Tags on Striped Bass. California Fish and Game, Vol. 40, No. 3, pp. 323-328.

Calhoun, A. J., and C. A. Woodhull
1948 Progress Report on Studies of Striped Bass Reproduction in Relation to the Central Valley Project. California Fish and Game, Vol. 34, No. 4, pp. 171-187.
1950 Striped Bass Reproduction in the Sacramento River System in 1948. California Fish and Game, Vol. 36, No. 2, pp. 135-145.

Cating, James P.
1953 Determining Age of Atlantic Shad From Their Scales. U. S. Department of Interior Fish and Wildlife Service, Fishery Bulletin No. 85, Vol. 54, pp. 187-199.

Chadwick, Harold K.
1959 California Sturgeon Tagging Studies. California Fish and Game, Vol. 45, No. 4, pp. 297-301.

Clark, G. H.
1929 Sacramento-San Joaquin Salmon (*Oncorhynchus tshawytscha*) Fishery of California. California Fish and Game, Fish Bulletin No. 17.
1932 The Striped Bass Supply of California, Past and Present California Fish and Game, Vol. 18, No. 4, pp. 297-298.
1933 Fluctuations in the Abundance of Striped Bass (*Roccus lineatus*) in California. California Department of Fish and Game, Fish Bulletin No. 39.
1934 Tagging of Striped Bass. California Fish and Game, Vol. 20, No. 1, pp. 14-19.
1936 A Second Report on Striped Bass Tagging. California Fish and Game, Vol. 22, No. 4, pp. 272-283.
1938 Weight and Age Determination of Striped Bass. California Fish and Game, Vol. 24, No. 2, pp. 176-177.

Cole, Charles E.
1930 Angling for Striped Bass. California Fish and Game, Vol. 16, No. 4, pp. 286-290.

Collins, Gerald B.
1951 A Fishway That Shad Ascend. U. S. Department of Interior, Fish and Wildlife Service. Special Scientific Report: Fisheries No. 65, 17 pp. illustrated.

Cope, Oliver B. and Leo F. Erkkila
1952 Weekday Angling Pressure in the Sacramento-San Joaquin Delta, 1948-1949. California Fish and Game, Vol. 38, No. 1, pp. 73-84.

Craig, J. A.
1928 The Striped Bass Supply of California. California Fish and Game, Vol. 14, No. 4, pp. 265-272.
1930 An Analysis of the Catch Statistics of the Striped Bass (*Roccus lineatus*) Fishery of California. California Department of Fish and Game, Fish Bulletin No. 24.

Dymond, J. R. and V. D. Vladykov
1934 The Distribution and Relationship of the Salmonid Fishes of North America and North Asia. Proceedings, Fifth Pacific Science Congress, 1933, pp. 3741-3750.

Embody, G. C.
1934 Relation of temperature to the incubation periods of four species of trout. Trans. Amer. Fish Soc. Vol. 64, pp. 281-292.

Fry, Donald H. Jr.
1961 King Salmon Spawning Stocks of the California Central Valley, 1940-1959. California Fish and Game, Vol. 47, No. 1, pp. 55-71.

Fry, Donald H. Jr. and E. P. Hughes
1952 Sampling Program for Recovery of Marked King and Silver Salmon. California Fish and Game, Vol. 38, No. 4, pp. 535-540.

Gangmark, Harold A. and Robert D. Broad
1955 Experimental Hatching of King Salmon in Mill Creek, A Tributary of the Sacramento River. California Fish and Game, Vol. 41, No. 3, pp. 233-242.
1956 Further Observations on Stream Survival of King Salmon Spawn. California Fish and Game, Vol. 42, No. 1, pp. 37-49.

Gharrett, John T.
1950 The Umpqua River Shad Fishery. Oregon Fish Commission; Research Briefs Vol. 3, No. 1, pp. 3-13.

Hagen, William, Jr.
1953 Pacific Salmon Hatchery Propagation and Its Role in Fishery Management. U. S. Department of Interior, Fish and Wildlife Service, Circular 24 U. S. Government Printing Office.

Hallock, R. J. and W. F. Van Woert
1957 1956 Fall-Run King Salmon, (*Oncorhynchus tshawytscha*) Population Estimates for the Sacramento River and Tributaries North of Hamilton City. California Fish and Game, Inland Fisheries Branch, Administrative Report No. 57-14, 9 pp.

Hallock, Richard J.
1957 Monthly Reports for Investigations Project F-7-R; Sacramento-San Joaquin River Salmon and Steelhead Study. California Fish and Game, Inland Fisheries Branch.

Hallock, Richard J., D. H. Fry, Jr., and Don A. LaFaunce
1957 The Use of Wire Fyke Traps to Estimate the Runs of Adult Salmon and Steelhead in the Sacramento River. California Fish and Game, Vol. 43, No. 4, page 271-298.

Hanson, Harry A., Osgood R. Smith, and Paul R. Needham.
1940 An Investigation of Fish-Salvage Problems in Relation to Shasta Dam. U. S. Dept. of Interior, Fish and Wildlife Service, Special Scientific Report No. 10.

Hatton, S. Ross
1940. Progress Report on the Central Valley Fisheries Investigations, 1939. California Fish and Game, Vol. 26, No. 4, pp. 334-373.

Hedgepeth, Joel W.
1941 Livingston Stone and Fish Culture in California. California Fish and Game, Vol. 27, No. 3, pp. 126-148.

Hughes, Elden P.
1955 1954 Annual Salmon Progress Report. California Fish and Game, Unpublished Report. 5 pp. typed.

Hume, R. D.
1893 Salmon of the Pacific. Reprinted in Washington Department of Fisheries 68th Annual Report for year 1958, pp. 117-140.

Jackson, H. W. and R. E. Tiller
1952 Preliminary observations on spawning potential in striped bass (*Roccus saxatilis*). Maryland Dept. Res. and Ed., Pub. 93, pp. 1-6.

Johnson, W. C., and A. J. Calhoun
1952 Food Habits of California Striped Bass. California Fish and Game, Vol. 38, No. 4, pp. 531-533.

Jordan, David Starr, and C. H. Gilbert
1887 The Sacramento River Salmon Fishery In: The Fisheries and Fishery Industries of the United States by G. B. Goode, et al. Section 5, History and Methods of the Fisheries, Vol. 1, U. S. Government Printing Office, Washington, D. C.

Kerr, James E.
1953 Studies on Fish Preservation at the Contra Costa Stream Plant of the Pacific Gas and Electric Company. California Fish and Game, Fish Bulletin No. 92.

Lehman, B. A.
1953 Fecundity of Hudson River Shad. U. S. Fish and Wildlife Service Research Report (33); pp. 1-8.

Mansuetti, Romeo and Hazen Kolb
1953 A Historical Review of the Shad Fisheries of North America. Department of Research and Education, State of Maryland Board of Natural Resources, Publication 97, 293 pp.

McCully, Howard
1957 Quarterly Narrative Report for Investigations Projects. Report of Progress (April 1, 1957 to June 30, 1957). Project F 12-R-3, California Department of Fish and Game, Marine Fisheries Branch.

McGregor, E. A.
1922 Observations on the egg yield of Klamath River king salmon. California Fish and Game, Vol. 8, No. 3, pp. 160-164.
1923 Notes on the egg yield of Sacramento River king salmon. California Fish and Game, Vol. 9, No. 4. pp. 134-138.

Merkel, Terence J.
1957 Food Habits of the King Salmon (*Oncorhynchus tshawytscha*) (Walbaum), in the Vicinity of San Francisco, California. California Fish and Game, Vol. 43, No. 4, pp. 249-269.

Merriman, Daniel
1941 Studies on the Striped Bass (*Roccus saxatilis*) of the Atlantic Coast. U. S. Department of Interior, Fish and Wildlife Service, Fishery Bulletin No. 35.

Moffett, J. W.
1949 The First Four Years of King Salmon Maintenance Below Shasta Dam, Sacramento River, California. California Fish and Game, Vol. 35, No. 2, pp. 77-102.

Morgan, Alfred R. and Arthur R. Gerlach
1950 Striped Bass Studies on Coos Bay, Oregon in 1949 and 1950. Oregon Fish Commission, Contribution No. 14.

Needham, Paul R. and A. C. Taft
1934 Observations on the spawning of steelhead trout. Trans. Amer. Fish Soc. Vol. 64, pp. 332-338.

Nidever, H. B.
1916 Shad in California. Calif. Fish and Game, Vol. 2, No. 2, pp. 59-64.

Pearson, John C.
1938 The Life History of the Striped Bass or Rockfish, (*Roccus saxatilis*) (Walbaum). U. S. Department of Commerce Bureau of Fisheries, Vol. XLIX, Bulletin No. 28.

Pelgen, David E.
1955a. Economic Value of Striped Bass, Salmon and Steelhead Sport Fishing in California. California Fish and Game, Vol. 41, No. 1, pp. 5-17.
1955b. Fish and Wildlife
Appendix C of Report to the Water Project Authority of the State of California on Feasibility of Construction by the State of Barriers in the San Francisco Bay system, California Department of Public Works.

Phillips, J. B.
1931 Netting Operations on an Irrigation Canal. California Fish and Game, Vol. 17, No. 1, pp. 45-52.

Pycha, Richard L.
1956 Progress Report on White Sturgeon Studies. California Fish and Game, Vol. 42, No. 1, pp. 23-35.

Raney, Edward C., Ernest F. Tresselt, Edgar H. Hollis, V. D. Vladykov and D. H. Wallace
1952 The Striped Bass (*Roccus saxatilis*). Bulletin of the Bingham Oceanographic Collection, Vol. 14, Article 1.

Rich, Willis H.
1920 Early History and Seaward Migration of Chinook Salmon in the Columbia and Sacramento Rivers. Bulletin of U. S. Bureau of Fisheries, Vol. 37, Document No. 887.

Robertson, O. H.
1957 Survival of Precociously Mature King Salmon (*Oncorhynchus tshawytscha*) (juv.) After Spawning. California Fish and Game, Vol. 43, No. 2, pp. 119-129.

Robinson, John B.
1960 The Age and Growth of Striped Bass (*Roccus saxatilis*) in California. California Fish and Game, Vol. 46, No. 3, pp. 279-290.

Roundsfell, George A.
1957 Fecundity of North American Salmonidae. U. S. Department of Interior, Fish and Wildlife Service. Fishery Bulletin No. 122.

Rutter, Cloudsley
1902 Studies in the Natural History of the Sacramento Salmon—17th Biennial Report of the California State Board of Fish Commissioners for the year 1901-1902.
1904 Natural History of the Quinnat Salmon. A Report of Investigations in the Sacramento River, 1896-1901 Bulletin of U. S. Fish Commission, Vol. 22 for 1902, pp. 65-141.

Scofield, Eugene C.
1928 Striped Bass Studies. California Fish and Game, Vol. 14, No. 1, pp. 29-37.
1931 The Striped Bass of California (*Roccus lineatus*). California Department of Fish and Game, Fish Bulletin No. 29.
1932 A Simple Method of Age Determination of Striped Bass. California Fish and Game, Vol. 18, No. 2, pp. 168-170.

Scofield, N. B.
1910 Notes on striped bass in California. Biennial Report, Calif. Board of Fish and Game Commissioners for 1909-1910, pp. 104-109.

Scofield, N. B. and H. C. Bryant
1926 The Striped Bass in California. California Fish and Game, Vol. 12, No. 2, pp. 55-74.

Scofield, Norman Bishop
1929 Lampreys Injure Striped Bass. California Fish and Game, Vol. 15, No. 1, pp. 73.

Shapovalov, Leo
1936 Food of the Striped Bass. California Fish and Game, Vol. 22, No. 4, pp. 261-270.
1937 Trout and Salmon Marking in California. California Fish and Game, Vol. 23, No. 3, pp. 205-207.
1953 An Evaluation of Steelhead and Salmon Management in California. California Department of Fish and Game, Inland Fisheries Branch Administrative Report 53-4.
1954 An Analysis of the Effect of An Extended Angling Season on California Steelhead Runs. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report No. 54-2.

Shapovalov, Leo and A. C. Taft
1954 The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*). California Department of Fish and Game, Fish Bulletin No. 98.

Shaw, Paul
1946 Oxygen Consumption of Trout and Salmon. California Fish and Game, Vol. 32, No. 1, pp. 3-12.

Shebley, W. H.
1922 A History of Fish Cultural Operations in California. California Fish and Game, Vol. 8, No. 2, pp. 61-99.

Skinner, John E.
1955a. California State-Wide Angling Estimates for 1953. California Fish and Game, Vol. 41, No. 1, pp. 19-32.
1955b. Observations on the Shad Gill Net Fishery in 1954. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report 55-3.
1957a. Incidental losses of Striped Bass in the Sacramento River Gill Net Fisheries for Shad and Salmon. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report 57-2.
1957b. Status of the Striped Bass—Sturgeon Study and Suggestions for its Future. California Department of Fish Fish and Game, Inland Fisheries Branch, Administrative Report No. 57-11.

Smith, Hugh M.
1895 The Striped Bass History and Results of Introduction. U. S. Fish Commission Bulletin, Vol. 15, pp. 449-458.

Snyder, John Otterbein
1905 Notes on the Fishes of the Streams Flowing into San Francisco Bay, California. Appendix to the Report of the Commissioner of Fisheries to the Secretary of Commerce and Labor for the Year Ending June 30, 1904.
1916 The Fishes of the Streams Tributary to Tomales Bay, California. Bulletin of the U. S. Bureau of Fisheries, Vol. 34, 1914, Document 825.

Stone, Livingston
1897 The Salmons of the Pacific Coast. In: A Manual of Fish Culture, Based on the Methods of the United State's Commission of Fish and Fisheries. United States Commission of Fish and Fisheries, Report of 1897, pp. 7-26.

Taft, A. C. and Leo Shapovalov
1938 Homing Instinct and Straying Among Steelhead Trout (*Salmo gairdnarii*) and Silver Salmon (*Oncorhynchus kisutch*). California Fish and Game, Vol. 24, No. 2, pp. 118-125.

Talbot, G. B.
1953 Passage of Shad at the Bonneville Fisheries. U. S. Department of Interior, Fish and Wildlife Service, Special Scientific Report: Fisheries No. 94, 30 pp. illustrated.

Tarzwell, Clarence M.
1958 Dissolved Oxygen Requirements of Fishes In: Oxygen Relationships in Streams. U. S. Department of Health, Education and Welfare Technical Report W58-2, pp. 15-19.

Taylor, Clyde C.
1951 A Survey of Former Shad Streams in Maine. U. S. Department of Interior, Fish and Wildlife Service, Special Scientific Report: Fisheries No. 66, 29 pp.

Van Woert, William
1955 The Pattern of Migration of Salmon and Steelhead Into the Upper Sacramento River During the 1954-55 Season. California Fish and Game, Inland Fisheries Branch; Administrative Report No. 55-17.
1957 Time Pattern Migration of Adult Salmon and Steelhead Into the Upper Sacramento River During the 1956-57 Season and Length-Weight Relationship of Sacramento River Steelhead. California Fish and Game, Inland Fisheries Branch Administrative Report No. 57-19.

Van Cleve, Richard
1945 A Preliminary Report on the Fishery Resources of California in Relation to the Central Valley Project. California Fish and Game, Vol. 31, No. 2, pp. 35-52.

Wales, J. H.
1941 Development of Steelhead Trout Eggs. California Fish and Game, Vol. 27, No. 4, pp. 250-260.

Wales, J. E., E. W. Murphey and John Handley
1950 Perforated Plate Fish Screens. California Fish and Game, Vol. 36, No. 4, pp. 392-403.

Warner, George
1954 The Relationship between Flow and Available Salmon Spawning Gravel on the American River, Below Nimbus Dam. Report to California Department of Fish and Game Marine Fisheries Branch.

Warren, Charles E.
1949 The Extent and Effect of Pollution Resulting from the Modesto Sewage Farm Levee Break. California Department of Fish and Game Inland Fisheries Branch Administrative Report pp. 49-32.

Wilimovsky, Norman J. and Warren O. Freihofer
1957 Guide to Literature on Systematic Biology of Pacific Salmon. U. S. Department of Interior, Fish and Wildlife Service, Special Scientific Report: Fisheries No. 209.

Woodhull, Chester
1947 Spawning Habits of the Striped Bass (*Roccus saxatilis*) in California Waters. California Fish and Game, Vol. 33, No. 2, pp. 97-101.

THE MOLLUSCAN FISHERIES

The San Francisco Bay Area undoubtedly possesses the greatest potential of any area in the State for shellfish culture. Ironically, however, clam and oyster fisheries which at one time flourished and were the most valuable in the State, have waned until at the present time clams rarely are taken commercially and oyster culture has largely been abandoned in favor of other more suitable areas.

Packard (1918) described the molluscans in the most detailed investigation ever made of the bottom fauna of San Francisco Bay. His work was part of the U. S. Fish Commission's investigation undertaken during the presence of the U. S. Fisheries Steamer "Albatross" on the Pacific Coast in 1912 and 1913.

The ensuing material (from Packard) will serve to show the relative distribution as well as the more common species of mollusks in the Bay Area:

"The fauna from San Francisco Bay comprises 81 species and varieties, 43 of which are pelecypods, 31 gastropods, and 7 chitons.

"Fifty-nine percent of the species listed below were taken exclusively within San Francisco Bay. This percentage would be somewhat decreased had collections been made along the littoral outside the Golden Gate. Nevertheless the relatively small percentage of forms common to the two contiguous regions is noteworthy. A number of the forms listed below were rarely taken. Such species obviously have little significance in such a study. Therefore, it has seemed advantageous to prepare a list of the more common species.

"The more common or prevalent species may arbitrarily be defined as those that were taken at one-fourth or more of the stations of any given group of stations, as suggested by Sumner et al. (1913, p. 69). In Table [32] the prevalent species for the different divisions of San Francisco Bay are given."

Appendix D contains a list of selected mollusks of the San Francisco Bay Area.

THE OYSTER FISHERY

Early History

Historically, the native oyster (*Ostrea lurida*), was present in the Bay in prodigious quantities and clams and mussels were plentiful. Townsend (1893) one of the foremost experts of the time on oyster culture, who was sent by the U. S. Fish Commission to make a survey of the oyster fisheries on this coast, reported the following: "There are extensive deposits of this species [native oyster] in the shallow water all along the western part of the Bay, and their dead shells washed ashore by the high seas that accompany the strong winds of the winter season, have formed a white glistening beach that extends from San Mateo for a dozen or more miles southward. So abundant are they that this constantly increasing deposit of shells covers everything along shore and forms bars extending into the Bay.

"Schooners frequently carry away loads of them for the making of garden walks and for other purposes to which oyster shells are adapted. The supply is unfailing."

TABLE 32

PREVALENT MOLLUSCAN SPECIES IN SAN FRANCISCO BAY—1912-1913 [1]

	Species	San Pablo Bay	South San Francisco Bay	North San Francisco Bay	Entire Bay (quantitative) hauls
Cordium corbis	[*Clinocordium nuttalli*] [2]	–	x	x	x
Macoma balthica	[*Macoma inconspicua*]	x	–	–	–
Macoma inquinata	[*Macoma irus*]	–	–	x	x
Macoma nasuta		x	x	x	x
Mya arenaria		x	x	–	–
Mya californica	[*Cryptomya california*]	x	x	x	x
Mytilus edulis		x	–	x	x
Ostrea lurida		–	x	x	x
Protothaca staminea		–	–	x	–
Schizothaerus nuttalli		–	–	x	–
Thais lamellosa		–	–	x	x
Zirfea gabbi	[*Zirfea pilsbryi*]	–	–	x	x

[1] After Packard (1918).
[2] Scientific names in brackets differ from original publication to conform with the latest taxonomic works.

Current testimony to the existence of these tremendous deposits is found in the recent book *San Francisco Bay* by Harold Gilliam, Doubleday and Company, New York: "The Bay is one of the few places in the world where cement is made from shells and possibly the only place where the shells and the mud exist naturally in almost exactly the right proportions for cement making.

"For more than a quarter of a century this [cement] plant has been fed by the remains of the Bay's ancient oyster populations and it is estimated that the Bay floor is covered with enough shells to continue the operation another 50 years."

Bonnot (1935), who was assigned to the State's oyster investigations in the 1930's, gave the following brief history of the oyster industry from 1870 onward:

"An historical account of the oyster industry of California must deal almost entirely with exotic species. The native oyster has been utilized commercially since the days of the Spaniards but no worthwhile attempt at any form of culture was ever made. The natives were merely taken from the natural beds until the introduction of other and larger species thrust them into the background.

"In recent years the sale of oysters in California has been confined to eastern oysters (*Ostrea virginica*)

C—043275

C-043276

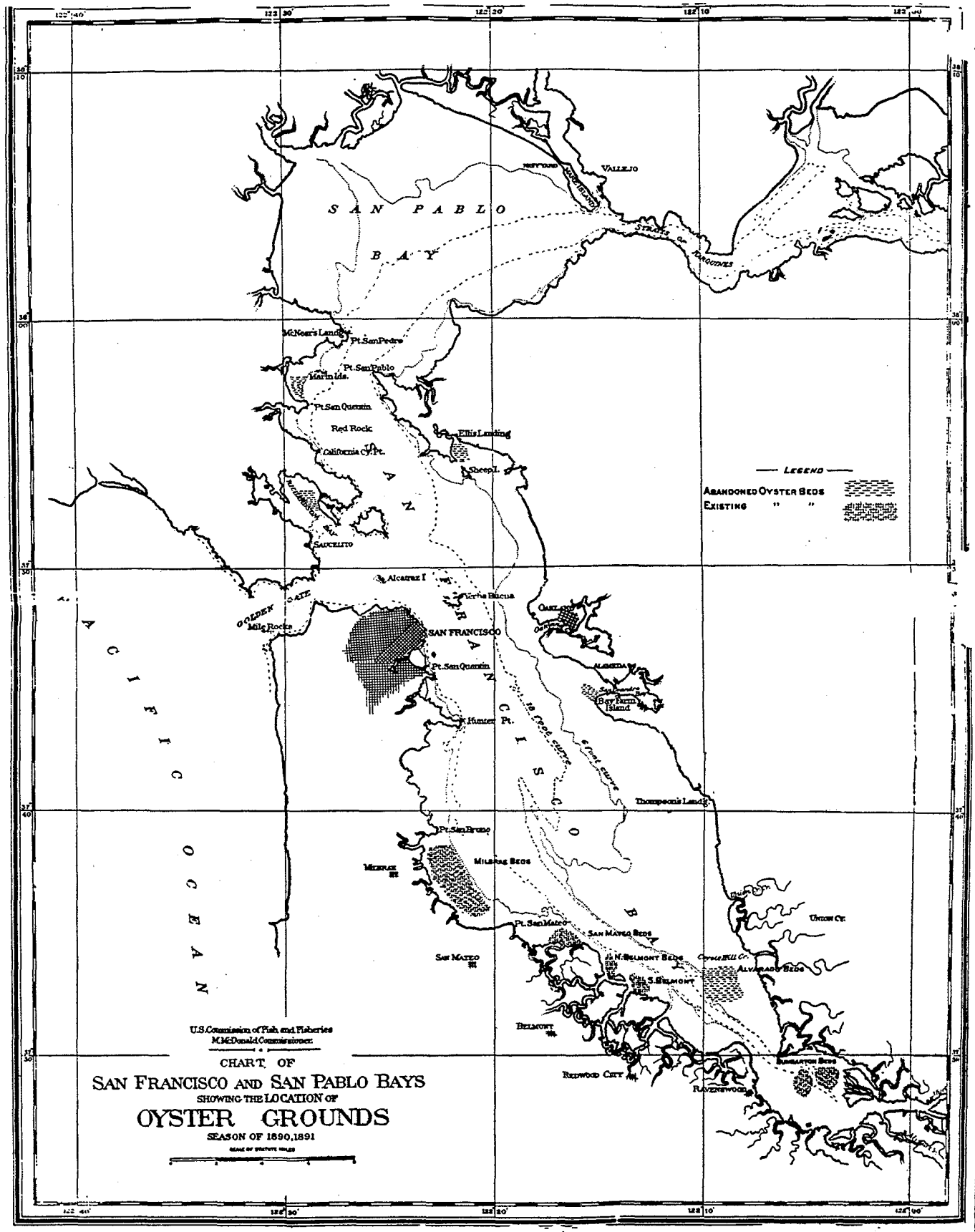


FIGURE 32. Map of Oyster Grounds, 1890-1891.

C—043276

C-043277

[now *Crassostrea virginica*], shipped market-size and held in San Francisco or Tomales bays, and to Olympia oysters [*Ostrea lurida*] shipped from the state of Washington. There is no particular reason why the California native oyster could not compete favorably with Olympias except that in both California and Washington the old-time oysterman, until very recently, clung to the trial and error method of culture, and natural conditions in the State of Washington have been such that these methods were effective there.

"The first introduction of a foreign oyster on a commercial scale was in 1868 when the Mexican Oyster Company started importing Mexican oysters [*Ostrea irridescens* or *chilensis*] to San Francisco from Altata and Acapulco. The oysters were shipped by steamer and sold at the dock for 25 cents each. A notice was posted several days in advance of the steamer's arrival. This business was not very profitable as many of the oysters died during the trip and in 1870, when the eastern oysters began to be shipped to San Francisco on the newly completed transcontinental railroad, the Mexican company went out of business. Mexican oysters were again imported during 1897-99 by Eli Gordon, of San Francisco but the conditions arising from the Spanish-American War caused him to discontinue the business.

"During 1870 [according to Collins (1892) this oyster shipment came West in 1869] A. Booth [and Company] of Chicago shipped three carloads of eastern oysters to San Francisco. Most of these were sold at once and those remaining were laid out in the bay. Booth sold out to the Morgan Oyster Company in 1871 and passed from the picture.

"The first oyster beds were located at Sausalito, Point San Quentin, Sheep Island [Brooks Island], Oakland Creek and Alameda Creek. These beds were soon abandoned and by 1875 all the beds were located in South San Francisco Bay. In 1872 Corville and Company laid out a bed just south of Point San Bruno. After operating here for several years they sold to Swanberg and West who worked the ground until 1885 when it was absorbed by the Morgan Oyster Company. In 1884 Doane and Company established a bed at North Belmont and the next year sold it to Morgan Oyster Company. In 1877 M. B. Moraghan made a start in the oyster business and controlled several beds, the most important being at Coyote Point, near the Morgan Oyster Company bed. By 1885 we find only two companies engaged in the oyster business; Moraghan with two or three beds and the Morgan Oyster Company controlling six. The Morgan Oyster Company beds at this time were located at Dumbarton, San Bruno, Millbrae, Alvarado, North Belmont, and South Belmont. The Alvarado station was abandoned in 1890 as it was too exposed to strong winds and heavy seas.

FIGURE 33. Moraghan Oyster Establishment 1890. Note the enclosed bed and thickness of the oysters which are exposed at low tide. Photo credit. Report U.S. Commission of Fish and Fisheries for 1889-1891.

FIGURE 34. Tonging oysters in South San Francisco Bay 1890. Photo credit. Report U.S. Commission of Fish and Fisheries 1889-1891.

"Moraghan dropped out some time later and the Morgan Oyster Company controlled the oyster business until 1921 when they went out of business and the Consolidated Oyster Company took over their interests. The Consolidated Oyster Company is still carrying on, maintaining until 1929 the old Millbrae bed which was started by Morgan Oyster Company in 1874, and now operating a bed at Oyster Point.

"The first oysters shipped by Booth in 1870 were market size. This was found to be unprofitable as the expense of shipping adult oysters was excessive.

"Morgan Oyster Company started the practice of shipping eastern oyster seed and planting them in San Francisco Bay, and this method was successfully maintained until about 1900. The prevailing opinion at the time was that the eastern oyster would not spawn or set seed in San Francisco bay because of the low temperature. However, no concerted effort was made to catch any eastern seed oysters, and as a matter of fact eastern seed oysters did set seed in small quantities on the eastern side of the bay. During the 90's an average of 100 carloads of 90 barrels each of seed oysters were shipped to San Francisco yearly.

"About 1900 some unknown factor or factors caused a radical change in the southern end of San Francisco Bay which acted unfavorably on the oyster beds. The eastern seed planted there took much longer to reach a fair size and they were thin, watery and unfit for market. As the old-time oystermen knew little of the biological side of their business and ran it by a trial and error method, their only recourse was to look about for other bedding grounds. They decided to try Humboldt Bay.

"Humboldt Bay had been tested for eastern oysters by the U. S. Bureau of Fisheries, which in 1896 planted 25 barrels of 3 and 4 year old easterns from Princess Bay and East River, New York. The returns of this plant were negative. About 1910, three men—Louis Hegburg, Ivan Berggren and Olaf Thoresen—established small beds of natives in the northern end of the bay and carried on the business on a small scale. They sold their holdings to the Morgan Oyster Company in 1911 and that company immediately shipped in larger quantities of eastern oysters only to find that the local conditions were unfavorable as the U. S. Bureau of Fisheries had already demonstrated. By 1912 they had lost $90,000 on the venture and abandoned their holdings in the bay.

"In 1911 while the Morgan Company were taking out their oysters as fast as the market conditions allowed, Mr. Louis Eaton, now a member of the Consolidated Oyster Company, planted 250,000 adult oysters in south Humboldt Bay, where conditions are a little different from those prevailing in the northern end of the boy. However, comparatively few of these

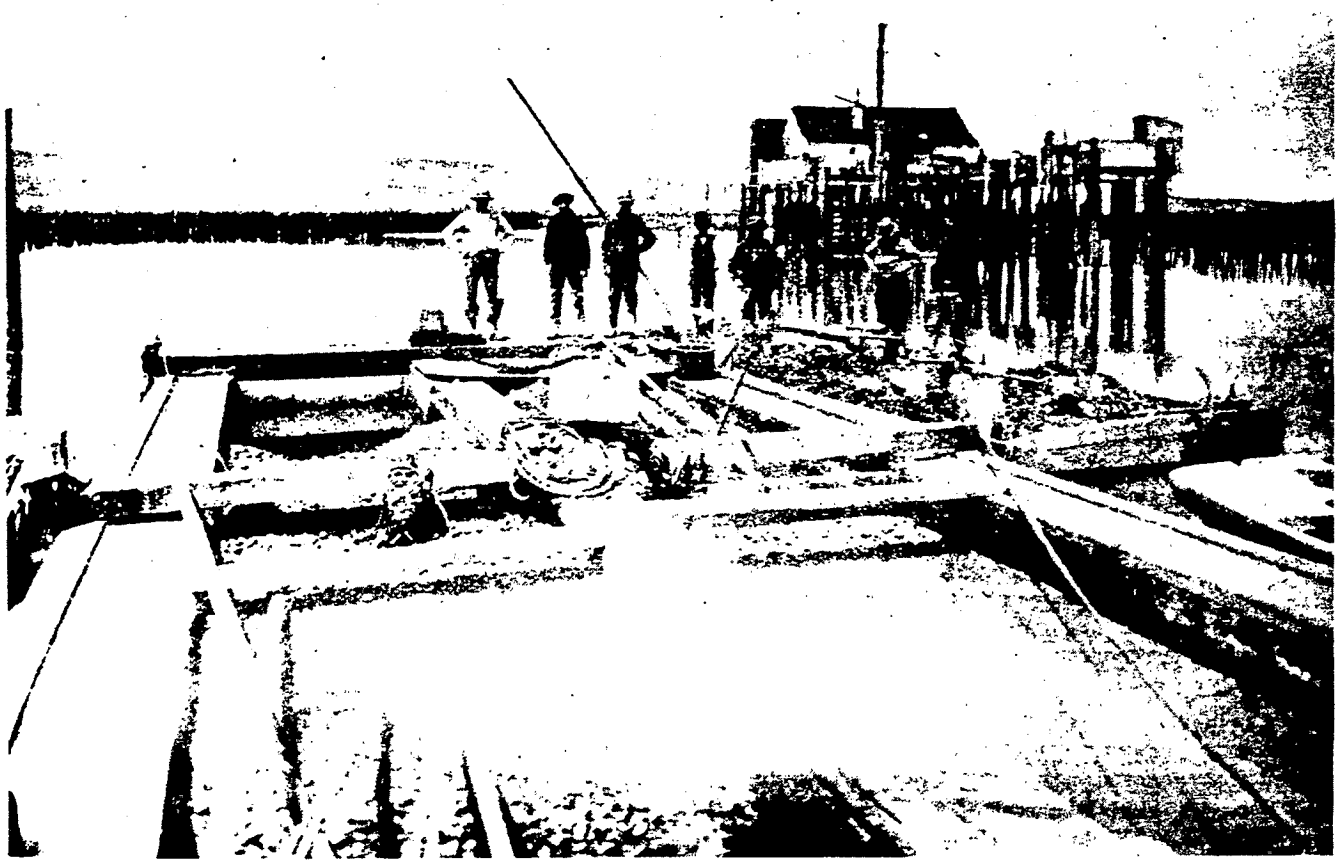
oysters were ever recovered. Humboldt Bay was given up by the oystermen and no attempt was made to do anything more there until 1932.

"Oyster planting in Tomales Bay started at about the same time as that in San Francisco Bay. At Millerton, on the eastern side of the bay, 17 carloads of eastern oysters were laid out by Weinard and Terry, in 1875. They simply held them there and sold as the market permitted until all were disposed of. Easterns were again planted in 1907 by Eli Gordon, who staked several small beds. Gordon later sold his holding to J. McNab and G. Smith, who in turn sold to the Pacific Coast Oyster Company, which still owns the beds and holds eastern and Olympia oysters there. The Consolidated Oyster Company put in a small bed at Blakes Landing in 1917 which is now abandoned."

Townsend (1893) mentions that the beds in Oakland and Alameda Creeks were abandoned because of sewage and traffic on the bay. At the time, he reported the Dumbarton beds as being the best in the Bay. According to him the Moraghan beds occupied 1,100 acres. Those of the Morgan Oyster Company, according to a biennial report of the State Board of Fish Commissioners, were estimated at 1,500 to 2,000 acres at that time.

It is interesting to note the value of oyster lands during this period. The information is from Townsend's report. "These lands [the tidelands of San Francisco Bay], surveyed and sold by the State at $1.25 per acre, have gradually passed into the hands of the larger oyster companies. This is especially true of the extensive flats in the southern part of the Bay, most

FIGURE 35. Large double float with scows, tongs, baskets and other features of the oyster fishery of 1890. M. B. Moraghan Establishment. Photo credit. Report U.S. Commission of Fish and Fisheries, 1890-1891.



available for the present system of laying out oysters. . . . The Tide Land and Water Front Company of San Francisco are proprietors of the tidelands to a considerable extent and offer them for sale at the uniform price of $25 per acre."

Quoting Mr. Moraghan of the oyster company by that name, Townsend continues, "The price depends upon the location, the kind of bottom, whether mud, shell, or sand, etc., and more than all, upon the improvement or amount of labor bestowed on the land. We have some beds that are worth fully $1,000 per acre to us, as we have been improving and working upon them for the past ten years in bringing them to their present condition. Unimproved tide land, such as is used in the Californian method of bedding oysters, is very cheap, being worth $10 per acre, and such lands can be had adjacent to the best inclosed beds for $20 per acre."

The oyster industry thrived and became the single most valuable fishery in the state during the 1890's. At this time the importing of seed oysters from the East Coast and their culture in San Francisco Bay was a million dollar a year business. The State Board of Fish Commissioners reported in the 17th Biennial Report for the years 1901 and 1902 that between 1887 and 1900 more than 11,000 tons of eastern yearling seed oysters had been brought to San Francisco Bay for further growth. Wilcox (1895) provides the following data on the amount of seed oysters shipped to San Francisco:

	Pounds
1887	1,562,000
1888	1,128,000
1889	1,007,000
1890	1,559,000
1891	3,273,000
1892	2,123,000
1893	1,607,000
1894	1,332,000
1895	1,680,000

Fortunately, records are available showing the quantity of oysters grown during a few of those early years. These are given in Table 33. Appendix B-4 shows oyster landings prior to 1918. The data were obtained from reports of the U. S. Commissioner of Fish and Fisheries, U. S. Department of Commerce and the biennial reports of the California State Board of Fish Commissioners. The oyster production figures prior to 1915 are confusing because of frequent contradictions in the early reports. As shown in Table 33, two sets of figures are available for most years, thus making it almost impossible to determine which is correct. While such discrepancies may exist, the amounts are of similar magnitude and it must be assumed therefore that the yield was on the general order of the figures cited.

TABLE 33

EASTERN OYSTER PRODUCTION IN SAN FRANCISCO BAY PRIOR TO 1915

Year	Quantity (pounds)	Value
1880	750,000	—
1888[1]	9,100,100[2]	—
1889	12,369,000-10,500,000[2]	$571,525
1890	12,829,500-10,592,750[2]	592,137
1891	13,387,800-11,069,100[2]	618,455
1892	15,098,700-12,505,150[2]	698,257
1895	14,975,682	—
1899	2,940,000-28,800,000[3]	—
1904	1,320,000	—
1908	729,000	—

[1] Includes 910,000 pounds native oysters.

[2] Poundage estimated from bushels, using 70 pounds per bushel.

[3] It is thought a typographical error is involved in this estimate, in which case the estimate would be 2,880,000 pounds and thus be in agreement with the other estimate for the same year.

1915 to Present

The oyster fishery was relatively short-lived. By 1908 production underwent a decrease of about 95 percent from the reported landings of 1892, and continued at less than a million pounds through 1936. The only explanation offered for the decline was the polluted condition of the Bay. The choicest locations in the Bay were heavily contaminated, resulting in oysters of poor quality.

Little was done to revive the fishery until the 1930's. Bonnot (1935) made a survey of all the potential oyster areas of the State. Regarding San Francisco Bay, he states:

"In some places development is affected by some unknown factors and the full grown oyster is not marketable."

"Recent ventures have not proved to be marked successes and it is probable that other areas will be used in the future."

"Portions of San Francisco Bay are free from sewage but great areas are contaminated and must be avoided. In clean areas where oysters develop to commercial size, some effort may be made to improve natural conditions, but no great amount of time or energy should be spent in San Francisco Bay until sanitary conditions improve."

Unfortunately, San Francisco Bay was not the only oyster ground thus condemned by pollution. Alamitos and San Diego bays, Anaheim Slough, and the Tia Juana River Estuary were all discounted as oyster growing locations because of one type of pollution or the other. Oil was the principal polluting agent at the time in the southern locations, except for San Diego Bay which received large quantities of raw domestic sewage.

The Department (then Division) of Fish and Game, and the U. S. Bureau of Fisheries entered into a co-

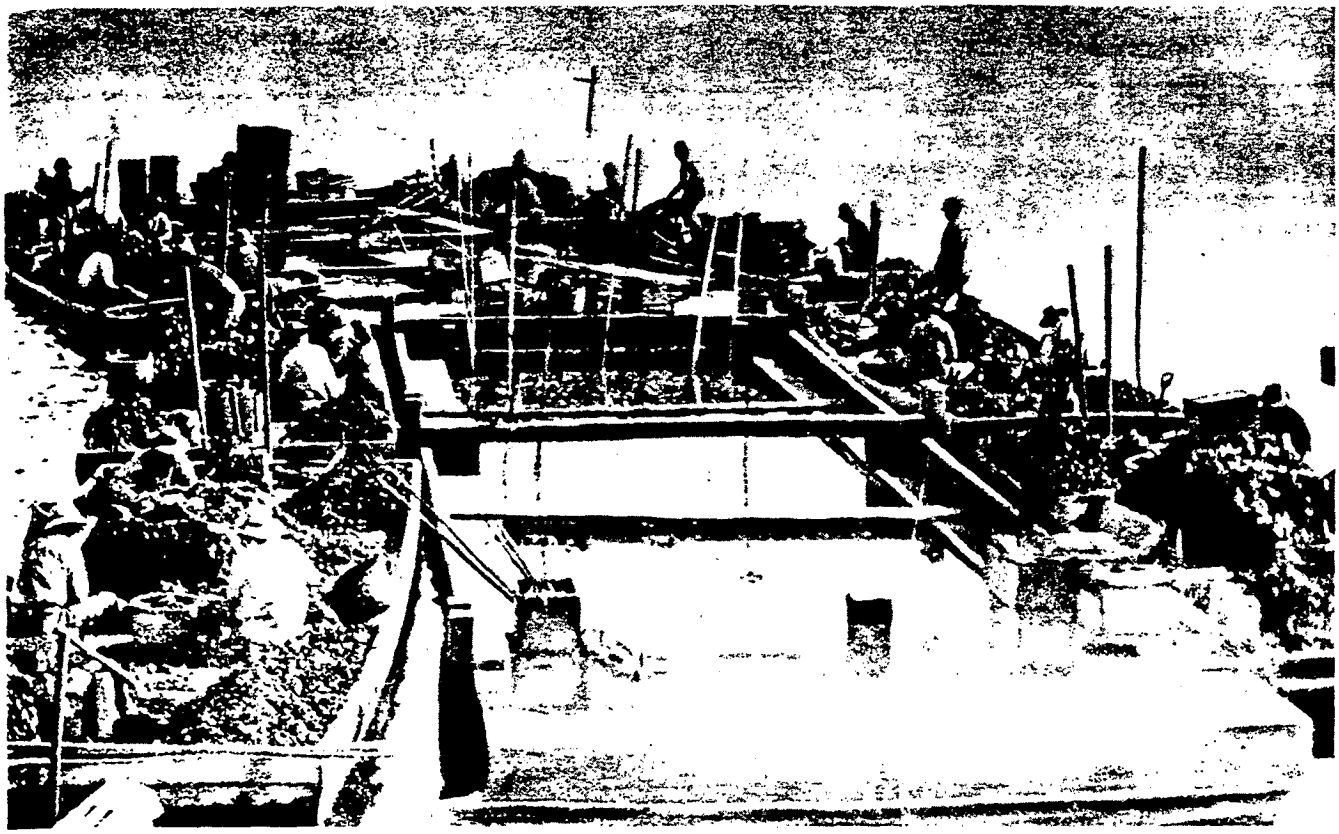


FIGURE 36. Culling oysters 1889-1891 Morgan Oyster Company, Millbrae. Photo credit. Report U.S. Commission of Fish and Fisheries, 1889-1891.

operative program in the 1930's to promote the development of the oyster potential on this coast. The program, which involved a series of surveys and research, provided much of the present knowledge about oyster culture in this State.

The program successfully stimulated the interest of private companies. The Pacific oyster *(Crassostrea gigas)* was imported from Japan in 1931 and beds were established in Drakes, Tomales, and Morro bays. Special efforts were directed toward the cultivation of the native oyster in Humboldt Bay in an attempt to offer a product which would compete with the Olympia or Willapa Bay oyster, which is the same species, grown in Washington.

The results of the program were positive and the state-wide oyster landings began to increase. San Francisco Bay, however, continued to decline as an oyster ground. Only one oyster company persisted on the Bay as late as 1937. The San Francisco Area, nevertheless, up to this time, remained the State's leading oyster producer chiefly because of new beds in Bodega Lagoon, Tomales Bay and Drakes Estero. By 1941 total production in the State reached almost 2 million pounds, mostly Pacific oysters. At this point the war interfered with the importation of seed oysters from Japan and the landings steadily decreased to 272,000 pounds by 1946.

At the cessation of hostilities oyster culture was resumed and imports were again made from Japan. Production gained momentum, until by 1956 over 6 million pounds of oysters were harvested in the State.

Humboldt and Morro bays are now the leading oyster grounds, the former being the largest producer. Of the 6 million pounds harvested in 1956, the San Francisco Area contributed slightly more than 6 percent. Landings for both the Bay Area and those of the entire State are given in Appendix B-2 from 1916 through 1958. Figure 20 compares the State and Bay Area Landings.

There does not exist an oyster sport fishery, as such, in California, although a small quantity of native oysters are taken by sportsmen. The other species have not yet distributed themselves and therefore are found only on cultivated beds.

Oyster Culture

General. Oyster culture necessarily varies, according to the species grown and local conditions. Outside of these variables, there are basic differences in cultural and harvesting techniques. In California, in the past, only the crudest methods have been employed. The practice generally has been to import seed oysters and

lay them out on the beds to grow to proper marketing size, or to import market-size oysters and merely hold them for sale. Until the last few years, harvesting has been done by hand almost exclusively.

There have been great strides in oyster culture in the last fifty years, in Europe and Japan particularly. The techniques which have been developed offer great promise for the local fisheries should they be adopted. With the knowledge that the Bay is proven oyster ground, it would seem worth while to explore the possibilities in this direction.

Sources of Stock. Present knowledge dictates the importation of seed oyster for cultural purposes, since temperature conditions do not appear satisfactory on our coast for natural reproduction. It should be reiterated however that no special effort has been made to collect the spat of imported varieties. Townsend (1893), who examined the Bay to determine the extent of natural reproduction, and Bonnot (1935) found evidence that led them to believe that eastern oysters did successfully reproduce here. Therefore, the possibility of locally produced stock of either Pacific or eastern oysters is not to be altogether precluded. Furthermore, the extremely prolific native oyster would be a readily available source of stock, if a marketable product could be produced.

There is some advantage, however, to importing seed oyster rather than using locally spawned stock. Where natural reproduction occurs, spat usually become crowded on the available cultch and requires culling. This expensive process would be negated in the case of seed imports, which it might be added, have been easily obtained except for war years.

According to Dr. Harold Orcutt, shellfish expert of the Department of Fish and Game, Pacific oysters appear to be best suited for cultural purposes in the Bay, although the eastern oyster has been successfully grown in the past. The Pacific oyster attains a large size and is preferred for commercial outlets, while the eastern is reported as being the tastier and preferred for domestic use and as a special purpose oyster.

Under favorable conditions about 20 to 25 cases of seed oysters (16,000 to 50,000 per case) are laid out per acre. This amount when harvested should yield 20 to 40 gallons of shucked oysters (approximately 100 oysters per gallon).

Conditions for Oyster Culture. The primary consideration in oyster culture of course, is water quality. The need for sanitary conditions is imperative both from cultural and public health viewpoints. At the present time, for instance, public health agencies have prohibited the sale or culture of oysters for human consumption in many sections of the Bay. Good water quality is also necessary for proper growth and conditioning of a marketable product. Under adverse conditions oysters become flaccid and unacceptable to the consumer.

Water conditions and of course the availability of good clean cultch determine to a large extent the success of natural reproduction. Moore (1897) states, "The most desirable water for oyster culture is that which contains an abundance of minute living particles with a minimum of suspended inorganic matter. Such waters must be free from slime or sediment. Any substance which forms a film on spat collectors is detrimental to oyster culture." If collectors are used, precautions should be taken to see that they are set out at the proper time. They must be set out when the spat are abundant, and remain sufficiently long to assure a good quantity of larvae. But they must not be exposed so long beforehand as to acquire a film to which the spat cannot attach.

The tidal prism is apparently a requirement during all phases of oyster culture. The constant oscillation of tidal waters is necessary to disseminate the reproductive products and larvae in areas where natural reproduction occurs, to oxygenate the water, and continually renew the supply of food organisms. Tidal action also scours and cleans the spat collectors or cultch and prevents the settling of sediment and subsequent smothering of the young oysters.

Since oysters become sedentary after the larvae set, they are highly susceptible to the vagaries of weather, pollution, predation and any of the sources of exploitation to which they are exposed.

The diet of oysters consists of the great diversity of microscopic and planktonic organisms common to their environment, among which bacteria, diatoms, protozoa, microcrustacea and algae are the most important. A stream of water is constantly pumped through the mantle cavity, from which these minute organisms are strained. This same stream of water also serves the respiratory processes, bringing oxygen and carrying away carbon dioxide. "An adult eastern oyster will pump from two to seven gallons of water per hour and if not exposed at low tide will feed more than 22 hours out of every 24." Fitch (1953).

Another consideration in cultural operations is the prevention of depredation by other organisms. In the Bay Area oysters have a number of natural enemies. Chief among these are bat rays, sharks, several varieties of fish, and oyster drills. Of the latter, two species were accidentally introduced with oyster shipments. *Urosalpinx cinerea* and *Ocinebra japonica*, eastern and Japanese oyster drills respectively, are introduced species while *Thais lamellosa* is a native species. Starfish are one of the greatest threats in some areas, but do not present a problem locally.

Good success was formerly obtained with stake or wire fencing to exclude sharks and bat rays and this method could be employed again. Depredations by bat rays have been particularly serious. Fortunately, other

FIGURE 37. Freshly set out Pacific oyster seed on shell. D. F & G. photo by H. G. Orcutt, Jan. 11, 1956.

fish are not a serious problem; they would be almost impossible to exclude.

Oyster drills would undoubtedly cause the greatest losses unless special precautions were taken to protect against them. Presently each shipment of imported oysters is inspected and infested lots are not permitted to be planted. The predations of the drill and starfish both have been largely disposed of in some areas (foreign countries) by the adoption of modern cultural techniques in which the oysters are grown in racks or trays suspended above the bottom. Since both pests are strictly bottom forms, they are thus excluded.

Potential for Oyster Culture in the Bay Area. Knowing most of the esturine waters of the Bay Area are capable of producing oysters and being supplied with quantitative data from previous production records, it is not too difficult to imagine that an oyster fishery of exceptional proportions could be developed here.

There is an unfailing market for oysters and they usually command an excellent price. The quantity grown in California in past years fell far short of the demand and much of the supply had to be shipped in from areas to the north.

Since the end of World War II and the resumption of trade with Japan, Pacific seed oysters have again been imported and highly successful fisheries have been developed in Humboldt and Morro bays and to a lesser extent in the smaller bays in the San Francisco Area. These, however, do not satisfy the present market demand. The apparent solution would seem to lie in an expansion of the industry and; as a matter of fact oyster growers have already shown renewed interest in some of the local oyster lands for the purpose of establishing commercial beds. Some lands have already been allotted to oyster concerns by the Fish and Game Commission for cultural purposes.

These allotments are made to qualified interests who agree to develop the lands for oyster production purposes. A small charge is made for the lease of the lands which the operator is required to develop at a specified rate. No allotments can be made on good natural clam beds.

The major drawback to expansion of the industry in the Bay appears to be water quality. Quoting from the 44th biennial report (1954-56) of the Department of Fish and Game: "Many thousands of acres of the largest bays—San Diego, San Francisco, San Pablo and large portions of Humboldt Bay—cannot be certified by the Department of Public Health for oyster production because of the possibility of contamination by sewage.

"This boom in shellfish production is now limited to areas presently in production and no further expansion is possible under present physical conditions.

"The oyster industry in San Francisco Bay was at its height around the turn of the century. It reached a [secondary] peak of over 1.5 million pounds annually by 1911, then faded away because of polluted conditions of much otherwise usable area."

Production Estimates. Some idea of the oyster-producing capacity of San Francisco Bay and the adjacent waters can be obtained from previous production records. Recalling the landings during the 1890's, it was seen that 10 to 15 million pounds were produced annually on a few thousand acres of beds. It is conceivable therefore, that a several fold increase in production could occur simply through a proportionate increase in area put under oyster culture. Reference to Table 34, which gives the surface acreage of the principal bodies of water in the Bay Area, indicates roughly 190,000 surface acres (inclusive of restricted areas) with some degree of potential as oyster grounds.

TABLE 34

SURFACE ACREAGE OF SELECTED WATERS IN THE BAY AREA

Location	Acreage	Potential Oyster Grounds [1]
South Bay	141,100	100,000
North Bay	40,300	5,000
San Pablo Bay	71,400	70,000
Subtotal	252,800	175,000
Carquinez Strait	4,500	
Suisun Bay	17,600	
Upper Suisun Bay	7,800	
Subtotal	29,900	
Tomales Bay	9,600 (est.)	9,600
Bodega Bay	700 (est.)	700
Bolinas Bay	500 (est.)	500
Drakes Estero	3,000 (est.)	3,000
Subtotal	13,800	13,800
Grand Total	296,500	188,800

[1] These figures are rough estimates based on the depth and type of bottom. No attempt has been made to exclude public clamming (or restricted) areas in the estimates.

Data from 1890 to 1900 provide a rough estimate of the yield per acre for that period. The available evidence indicates that 3,000 to 4,000 acres were used to produce 10 to 15 million pounds of oysters. The yield therefore, could have varied from 2,500 to 5,000 pounds per acre. At the latter rate 10,000 acres of good oyster ground could produce 50 million pounds per year. Even at the lower rate, which incidentally, seems the most reasonable considering the techniques employed, there appears to be sufficient bottom land to produce twice this amount.

As further evidence of the oyster potential some examples of the result of modern methods of oyster culture, as practiced in Japan, France, Denmark and Holland particularly, might be cited. The techniques employed are much advanced over those now in practice in this state and this country generally.

Dr. Coste revolutionized oyster culture in the Bay of Arcachon, France (Smith and Chapin, 1954) and his techniques have been widely adopted elsewhere. Spat are collected on pieces of tile or other suitable substance, which has been coated with lime and sand, and which has been set out at the proper time. The development and abundance of larvae are observed closely to assure that the collectors are not set out too far in advance. After the spat have been collected, they are broken off and placed in wire covered trays which are suspended on legs above the bottom of the Bay. Finally the oysters are moved to "claires" or fattening beds to complete their growth.

In this manner about 500 million edible oysters a year are produced in the 37,000 acre Bay of Arcachon, for an approximate yield of 13,500 oysters per acre.

Intensive culture in Japan and Holland has resulted in the production of about 6,000 pounds per acre. Production in Holland has been increased from ½ to 2 million oysters per year under natural conditions to 30 to 40 million superior oysters under culture.

Status of Bay Area Sites. A very brief description and statement of the present status of Bay Area oyster sites and the potential of various waters in the Bay Area for oyster culture follows. Table 35 provides information on present oyster allotments and private beds.

San Pablo Bay: Pollution appears to be less severe here than in any other part of San Francisco Bay. Most of the Bay appears physically suitable for growing oysters. No portion is too deep, and the bottom appears to be generally satisfactory. The concern of Clayton McNeil had an allotment of 3,000 acres in this Bay for oyster cultural purposes, but abandoned it after a small initial plant proved unsuccessful. The

TABLE 35

CURRENT OYSTER ALLOTMENTS AND PRIVATE OYSTER BEDS IN THE BAY AREA

Location	Ownership	Acreage	Name of Concern
San Pablo Bay	State Allotment #60	3,000	Clayton McNeil
Tomales Bay	State Allotment #1	387	Coast Oyster Company
Tomales Bay	State Allotment #52	88	Coast Oyster Company
Tomales Bay	State Allotment #34	120	Henry Jensen
Tomales Bay	Private	5*	Spenger
Tomales Bay	Private	10*	Tomales Bay Oyster Co.
Drakes Estero	State Allotment #2	1,165	Coast Oyster Company
Bolinas Lagoon	State Allotment #57	240	Coast Oyster Company
Total Acreage		5,015	

* Estimated.

Coast Oyster Company has also expressed an interest in San Pablo Bay.

Several factors appear to be affecting the development of San Pablo Bay for oyster purposes. Apparently there are few interests willing to invest the capital required to establish the industry on unproven ground, and furthermore, certain areas are restricted by the Department of Public Health. Industrial pollution is serious in some areas.

South San Francisco Bay: At the present time no oyster operations are conducted in the South Bay due to the public health quarantine. The Department of Fish and Game is experimenting with small plants in the vicinity of Palo Alto to observe the growth and condition of oysters planted in this area. The entire South Bay is potentially valuable oyster ground, perhaps the finest in the State. It is proven ground and the only serious factors limiting its use are pollution and public health restrictions.

North San Francisco Bay: Oysters are not grown here at the present time. The North Bay does not appear to have the potential of either the South Bay or San Pablo Bay. Some areas are rather deep for oyster purposes. However, portions with mud bottoms, and the smaller coves and bays along each side, are possibilities. Richardson's Bay, for example, was used as an oyster ground before 1900.

Tomales Bay: This bay has extensive shallow areas well suited to oyster culture. The east side of the bay is most suited to the purpose. The Tomales Bay Oyster Company and the Spenger Oyster Company are currently growing oysters here on private beds. A total of 595 acres has also been allotted by the Fish and Game Commission to oyster interests. This Bay produces fine oysters and the potential is good. A large portion of this Bay, being one of the most productive clam areas in the State, has been set aside as a public clamming area and cannot be alloted for other purposes. Extensive development is also limited because most of the adjacent land is in private ownership.

Bolinas Lagoon: This is another excellent shellfish area. Clamming is superior, but oyster culture has been limited. The Coast Oyster Company has a 240 acre allotment here and has spent two years in developing it. Although operations are still in the exploratory stage, it appears to be a promising producer. The rest of the Lagoon is set aside as a public clamming area.

Drakes Estero: Past experience has shown this site to be a good oyster producer. Formerly, the entire area (about 3,000 acres) was in oyster allotments. At the present time 1,165 acres along the shoreline are reserved for this purpose. The rest has been set aside as a State public clamming area. The Coast Oyster Company is active here and the oysters produced are of excellent quality, entering the trade as half shell and for other specific purposes requiring a first class product. This area can be expected to be developed to the fullest possible extent in the future.

Bodega Bay: Bodega Bay is rather small (about 700 acres) and oyster potential is limited. The only suitable area lies in the south end of the bay where beds formerly existed. It is chiefly a clamming area.

Private Salt Ponds. The use of small acreages of privately owned tidal bottom lands or salt water ponds has not been investigated in California to the writer's knowledge. On the Atlantic Coast, however, some experimental work is being done along these lines, with commercial oyster culture in mind. The U. S. Bureau of Commercial Fisheries has reported the successful setting and growth of eastern oysters in salinities varying from 15 to 27 parts per thousand.

THE CLAM FISHERY

Much of the foregoing enthusiasm about the possibilities of oyster culture in the Bay could appropriately be applied to clams as well. However, there is little doubt that where private enterprise is concerned, efforts at clam culture would be secondary in view of the more lucrative oyster.

Bonnot (1940b) and, more recently, Fitch (1953) have described the common marine bivalves of California. Fitch, in addition, gives a brief but informative account of their habits and habitat, anatomy, locomotion, feeding, growth, reproduction, maturity and ecological relationships.

Introduced species have sustained the clam market in the Bay Area.

Early History

The original shellfish fauna of the Bay Area was extensive, but few species could be considered of good commercial value as food products.

The more important species were the Washington, gaper, Pismo, common littleneck (formerly called rock cockles) and bent-nose clams, and sea mussels.

The most common edible species of the Bay was the bent-nose clam (*Macoma nasuta*). According to Fisher (1916) Chinese shrimp fishermen dug large quantities of them in the South Bay for the market prior to 1876. This is also the most common species found in Indian shell mounds.

The sea mussel *(Mytilus californianus)* was widespread and abundant and was in moderate demand.

Most of the common little neck clams (*Protothaca staminea*) in San Francisco markets came from Tomales Bay, where they were very abundant.

Gaper (*Schizothaerus nuttalli*) and Washington (*Saxidomus nuttalli*) clams are fairly abundant and certainly must have entered the market in some quantity, although records specifically referring to them were not located.

Pismo clams (*Tivela stultorum*) are rare in the Bay Area and probably did not contribute substantially to the early markets.

The soft-shell clam *(Mya arenaria)* is believed to have been accidentally introduced with the first oyster importations in 1869 or 1870. At any rate it soon displaced the native species in the Bay and became widely distributed over the entire region. It is an excellent food clam and formed the bulk of the clam trade in San Francisco. The mud flats of San Pablo Bay and the South Bay were particularly favorable locations.

The common bay mussel (*Mytilus edulis*) is not a native species, but is thought to have reached our coast from Europe by way of sailing vessels several hundred years ago. It contributed substantially to the shellfish catch in past years. In Europe it is cultivated extensively as a food mollusk.

The ribbed horsemussel *(Arcuatuta demissa)* is another apparently accidental introduction. It was first detected in 1894. It is not a major species.

The Japanese littleneck clam (*Tapes semidecussata*) was first detected about 1931 and is believed to have been introduced with shipments of the Pacific oyster from Japan. This small clam rapidly became disseminated along the coast from San Francisco northward. They are particularly abundant in San Francisco Bay and the Delta.

Reports of the U. S. Commissioner of Fish and Fisheries indicate that between one and three million pounds of clams and mussels were taken regularly each year from 1880 to 1900. The soft-shell clam of course was the principal species but bay mussels were also taken in fair quantities. For example, Wilcox (1895) reported 487,995 pounds of mussels for 1895 and in a later report (1901) listed the mussel landings for 1899 at 364,076 pounds. Landings prior to 1918 are given in Appendix B-4.

Bonnot (1932) provides a brief summary of some commercial clamming operations in the Bay Area from their inception to 1932:

South San Francisco Bay.

"*South City (near Fuller Paint Works)*: a fenced bed of about 25 acres. The bed was staked in 1890 and has been maintained ever since by a family named Maitzer. It is in fine shape at present [1932].

"*Western Pipe and Steel Plant*: This bed was fenced in 1890 by John Connell and was worked by him and later by his son. It was destroyed in 1920 by the shipyard which was built there.

"*Bayview*: A staked bed of 50 acres laid out in 1890 by Connell. It was worked until 1930, when it was abandoned due to industrial wastes which are dumped into the bay. This condition has been steadily increasing as more and more factories locate on that part of the bay.

"*Bayshore*: This bed was staked in 1925 by Connell. It was an enclosed bay of about 10 acres. It was destroyed in 1931. Connell's lease ran out and the city took over the cove and is now filling it up with refuse from the incinerator.

"*San Leandro Bay*: This bed is not fenced. It is quite large. A good many clams are dug for the market from this bed by Chinese."

North San Francisco Bay.

"All the beds from Sixteenth Street, Oakland, to Cosy Cove with the exception of Quong Sang's bed at Albany are merely open flats where any one can dig clams.

"*Albany:* This bed is enclosed by a very modern square-meshed wire fence on redwood posts. The fence encloses about 100 acres and there is a small house where a couple of Chinese live who act as keepers and diggers.

"*Martinez and Napa River*: I have not seen these beds. They are reported to be good. Digging on them started this year [1932]. The reports I have received all claim that clam beds so far up the river are due to the lack of fresh water and the consequent upriver push of salt water.

"*Tiburon*: There are three small beds here, all staked and owned by John Connell, who owned the beds about South City. The beds will cover about 8 acres of bottom."

Tomales Bay. "There is only one staked bed in Tomales. It is the largest fenced bed in the vicinity. The area enclosed is about 300 acres. It belongs to the Pacific Oyster Company and was originally intended for oysters. It is at present under lease to the Hop

Lung Clam Company. Although there are soft shell clams all over Tomales Bay, they can only be found in paying quantities inside this fence."

Bodega Bay. "The whole bottom of Bodega Bay is good clam ground and six or seven species are taken in commercial quantities, including the soft shell. A great many of the clams of all species are used by the local fishermen for bait. None of the bottom is fenced."

TABLE 36

FORMER CLAM BEDS IN THE BAY AREA [1]

Location	Fenced or Unfenced	Acres	Started	Destroyed	Owner
South City	yes	25	1890	....	Maitzner
South City	yes	25	1890	1920	Connell
Bayview	yes	50	1890	1930	Connell
Bayshore	yes	10	1925	1931	Connell
San Leandro Bay	no	100	....	....	Public
Sixteenth Street Oakland	no	150	....	....	Public
Brooks Island	no	50	....	....	Public
Sobrante	no	100	....	....	Public
Wine Haven	no	100	....	....	Public
Cozy Cove	no	40	....	....	Public
Albany	yes	100	1928	....	Quong Sang
Tiburon	yes	3	1930	....	Connell
Tiburon	yes	2	1930	....	Connell
Strawberry Point	yes	3	1930	....	Connell
Tomales Bay	yes	300	1910	....	Pacific Coast Oyster Company
		1,058			

[1] Data from Bonnot 1932.

1915 to Present

With the initiation of the record system in 1915, accurate information on clam landings became available. But the resource had degenerated greatly by then.

Soft-shell clams remained the most important market species in the Bay and as a matter of fact comprised almost the entire catch in Area after 1915. Annual soft-shell landings are shown in Appendix B-2. They were on the order of about 100,000 to 300,000 pounds between 1916 and 1935. The species continued to decrease until they eventually dropped completely out of the commercial picture in 1949. There have been no landings reported since that time. Bay Area landings constituted virtually the entire state-wide total of soft-shell clams.

Pismo and razor clams have been omitted from this discussion since both are rare in the Bay Area. Pismo's were the most important commercial species in the State for a number of years immediately preceding 1920 but, due to pollution and excessive digging, landings dropped below those of soft-shell clams. In California, Pismo clams are found chiefly along the coast of San Luis Obispo County.

For the sake of convenience all clams and mussels other than soft-shell clams have been arbitrarily classified as miscellaneous clams in Appendix B-2. The combined landings of all species in this category rarely

FIGURE 38. Orientals digging soft-shell clams on flats of San Pablo Bay at Pinole about 1920. D. F. & G. photo presumably by F. W. Weymouth.

exceeded 100,000 pounds per year in the Bay Area between 1916 and 1935. During this period the Bay Area landings comprised about one-half of the state-wide total. In 1936 only 7,000 pounds were recorded from the San Francisco Area. Less than 500 pounds have entered the commercial catch in the last 17 years.

State-wide landings of miscellaneous clams underwent a sharp decline between 1936 and 1943 to a low of 898 pounds in the latter year.

One of the reasons for decreased clam landings throughout the State is the labor required to dig them. Populations exploited by the general public have become sparse and it simply does not pay to dig them commercially. Furthermore, the State has reserved for the public some of the better clamming locations, and these may not be exploited commercially.

The Present Fishery

Sport Fishery. Some of the finest natural clam beds in the State are found in the Bay Area, where each year throngs of people flock to the beaches to dig them. The resource affords recreational opportunity and at the same time provides a good many people with a tasty seafood treat they might not otherwise enjoy.

Unfortunately, data on the number of diggers or the effort and money thus expended each year are unknown.

Current Clamming Localities. Several investigators have surveyed the California shellfish resources. Among these might be mentioned Heath (1916), and Weymouth (1920). Dr. Harold Orcutt of the Department of Fish and Game made observations of the clam resources, incidental to a recent oyster survey.

A brief summary of the principal locations and the more important species found in each follows:

San Pablo Bay: Formerly, this bay produced the greatest share of soft-shell clams marketed in San Francisco. They have not been exploited recently, largely because of the public health problem. Recent observations by Orcutt indicate they are still present in good numbers. The bent-nose and Japanese littleneck clams are also present. Data are not available regarding the status of the littleneck in San Pablo Bay, but they may be assumed to be there in good quantity. The Chinese operated soft-shell clam beds at Pinole until recently. Weymouth (*op. cit.*) reported that a single digger could obtain between 60 and 100 pounds on one tide here.

South San Francisco Bay: As in San Pablo Bay, the chief species here is the soft-shell clam. Originally the bent-nose was very abundant but was displaced by the imported soft-shell. The Japanese littleneck has presumably become well established here also. Washington and gaper clams are present but not abundant. Other species are found in limited quantities.

Domestic and industrial pollution have resulted in the complete loss of the South Bay clam fishery. The last so called "farm" operated near Bayshore. Weymouth in his report stated that many localities of San Francisco Bay were unsafe sources of food mollusks.

North San Francisco Bay: Except in the shallow tidal flats and bays such as Richardson Bay, clams are not particularly abundant. Clam habitat here is limited. The species present are essentially the same as in the South Bay, although more of the marine forms are found here than in the South Bay or San Pablo Bay. The bay mussel is found in good numbers attached to rocks, piles, shell, and similar substrate.

Tomales Bay: According to Weymouth the common littleneck clam reached its greatest abundance in Tomales Bay from where the major share for the San Francisco market was obtained. Soft-shell clams are fairly abundant and were dug commercially until recently. This is one of the better clamming areas and sport clammers take large numbers of Washington and gaper clams as well as the other species. A large area of this bay between Tom's Point and Sand Point is reserved as a public clamming ground.

Bodega Bay: Virtually all of this Bay may be considered good clam grounds. The principal species found here are the Washington and soft-shell clams and the gaper. It is an excellent sport clamming area.

Bolinas Lagoon: The accessability of this bay makes it a popular sport clamming area. It is a good producer of gaper, Washington and littleneck clams.

Drakes Estero: At the present time this is one of the very finest clamming areas in the State. Clams are abundant and of fine size and quality. The principal species are Washington, gaper and soft-shell clams. Being surrounded by private land, the Estero is rather difficult of access and this is perhaps largely responsible for the present clamming quality.

Halfmoon Bay: Clams are not overly abundant here. Among the species taken are Pismo and Washington clams.

Most of the species just described are usually found in sheltered bays or coves. In contrast to them, many shellfish are found along the outer coast attached to the rocks of exposed reefs, as for instance the sea mussel (*Mytilus californianus*) and some of the boring clams which are so situated that they are constantly lashed by the full force of the surf. Others like the Pismo, razor and white sand clam are found burrowed in the sand along the ocean beaches.

Special Species. Several species deserve special mention because of their importance to sport diggers, or to the commercial industry, or because of their abundance. Insofar as possible, information is provided on the location of the better known beds.

Washington Clam: The Washington is one of the more important species to sport clam diggers and is especially esteemed as a food mollusk. According to Weymouth "The localities in which they are most markedly abundant are: Humboldt Bay, Crescent City Beach, Bodega Bay, Wilson's Creek, Tomales Bay, Bolinas Bay, and Drakes Estero." Morro Bay is an equally important source of Washington clams. "In Bodega Bay the beds lie in the middle ground exposed by the tides, and along the western shore. In Tomales Bay the beds are neither extensive nor utilized commercially. In Bolinas Bay they are nearly gone, due, it is said, to the deposition of sand. Judging from the fact that at one time the Indians came annually to camp at Tomales Bay in order to gather the Washington clam, they must have been far more abundant then, than at the time [1919] of the survey."

"It is improbable that any further development of an industry based on this clam is to be expected. It is less hardy and of slower growth than *Mya* [soft-shell] and hence less able to withstand excessive fishing."

The shells of this species were formerly used as money among the coast Indians. A heavy valve without discolorations was worth about fifty cents around 1900.

Littleneck Clam: In California the common littleneck clam reaches its greatest abundance in bays such as Humboldt, Bodega and especially Tomales, according to Weymouth. At the time of his survey [1919] he stated that in Bodega Bay it was of sufficient importance to warrant digging commercially for shipment to the San Francisco markets. They are most abundant on the northwestern side of Bodega Bay.

Good beds in Tomales Bay are located on the gravel and boulder beaches.

Quoting Weymouth, "On the northern side of the Bay the best beds are between Marshals and Arroyo San Antonio; on the southern side they lay opposite these and for two miles towards the head of the Bay from Inverness . . ."

Bent-nose Clam: This species is of particular interest because it is the most common and widely distributed species in the State. It is a hardy species, common to sheltered bays and sloughs. It tolerates a great range of water and bottom conditions, but is not common on sand or gravel beaches or in situations where it is exposed to the surf. Weymouth states "It is a hardy species, flourishing under conditions speedily fatal to many other forms."

Although the bent-nose has been used as a food mollusk, they are generally overlooked by most clammers. These are the most common shells found in the Indian shell mounds, indicating they were an important food item to the Indians.

Gaper: With the exception of the geoduck, this is the largest species of clam in California. It may reach a length of eight inches and weigh up to four pounds. They are found in a variety of habitats, except in areas of low salinity, and are fairly abundant at a good many locations along the California coast. In the Bay Area, particularly good locations include Bodega Bay, where they are found on the middle tidelands near the channels; Tomales Bay, between Sand Point and Tom's Point and in association with littleneck clams on the beaches; in Drake's Estero they are found along the eastern spit. Beds are also located along the coast between Bodega and Tomales Bay. The gaper is one of the most important species taken by clammers. It is not particularly favored as a food item in comparison to some of the other species; nevertheless, diggers exploit the available beds fully.

Soft-Shell Clam: The soft-shell is one of the better known food clams. It is widely distributed in all favorable estuaries, bays, and river mouths north of San Francisco. San Francisco Bay, however, is the center of abundance because of the large expanse of favorable habitat. It prefers sheltered bays free from heavy wave action.

Important beds in the Bay area, other than in the Bay itself, are located in Bodega Bay along the eastern shore and the northern end of the western shore, and in Tomales Bay, near the head of the Bay and along the northeastern shore. Beds of lesser importance are found in Drakes Estero and the Estero del Americano.

The beds in Bodega and Tomales Bay offer fair results to sport diggers but would not withstand commercial exploitation. Drake's Estero, being encompassed by private land, is not easily accessible to sport diggers.

The soft-shell clam offers the greatest possibility for cultivation, here as on the Atlantic Coast. The species is hardy, fast growing, and tolerant of variable salinity. San Francisco Bay with its extensive mud flats could support a fair industry were it not for polluted conditions. At the present time, the cost of labor and the initial capital required to fence out predacious sharks and stingrays, are additional factors discouraging clam culture.

Japanese Littleneck Clam: Special mention should be made of this clam because it has become abundantly distributed in San Francisco Bay. It will tolerate very low salinity and a variety of bottoms. It attains a length of about 3 inches and is reported to be an excellent food clam. They are eagerly dug by Bay Area clam enthusiasts.

Sea Mussel: The California sea mussel is taken in fair quantities by clammers. Since it is the species most commonly associated with mussel poisoning, it deserves brief mention in this connection.

During the summer months, June to September, the tiny dinoflagellate *Gonyaulax* becomes very abundant in the ocean and forms a substantial part of the diet of clams and mussels. Contaminated shell fish become

~~[illegible] losses~~

89. barriers

toxic and if eaten by man may cause serious illness or may even be fatal. The poison causes paralysis, first of the extremities, and then the respiratory muscles. Death, if it occurs is usually due to respiratory failure. The Department of Public Health issues warnings at the appropriate time each year. Sport clam diggers should watch for and heed these warnings.

THE ABALONE FISHERY

Abalones are large gastropods, distant relatives of land snails, which inhabit the rocky beaches of the outer coast from high tide to considerable depths. They are found on rocks, to which they cling with great tenacity by means of their broad muscular foot. They belong to the genus *Haliotis*.

Early History

The coastal Indians of California utilized abalones for food and prized their beautiful nacre shells; pieces of which were used as money. At the time the Spaniards were seeking the valuable sea otter, they found the Indians willing to barter two pelts for a single shell.

The white man at first neglected this resource and left it to the Chinese, who took them in tremendous quantities between 1864 and 1915. Although some were consumed locally, the bulk was dried and shipped to the Orient. Californians became aroused about 1900 and obtained legislation in 1913 which prohibited the drying and exportation of abalones. After these legislative restrictions, the Chinese passed out of the abalone industry, but by then Southern California beds were pretty well depleted.

The Japanese entered the abalone fishery about 1900 and worked the waters off Monterey and San Luis Obispo counties principally. The introduction of the diving suit by them made it possible to fish in the deeper unexploited waters. They monopolized the fishery until World War II.

The abundance of abalone shells led to a short-lived but prosperous industry in the late 1800's. It is from these mollusks that much of the supply of nacre or mother-of-pearl was obtained for the manufacture of souvenirs, curios, jewelry and buttons. The industry faded shortly after 1915. During the "seventies" an abalone shell was worth about twice as much as the meat.

The first abalone cannery was established at Cayucos in 1905. By 1917 the number had grown to five but was reduced to three in 1921. The last cannery was abandoned in 1931.

Caucasians entered the fishery seriously about 1930, confining their efforts to Morro Boy and vicinity. Since 1930 abalones have been sold chiefly as a sliced frozen product with a limited amount reaching local markets in the fresh state. They are generally considered a luxury item.

Although abalones are found all along the coast they are not equally abundant in all areas. Red abalones, one of the most important commercial species, are taken in greatest quantities off San Luis Obispo County. North of Point Lobos, Monterey County, abalones in general become decreasingly abundant.

Current regulations require commercial interests to fish in depths of 20 feet or more and at least 150 feet offshore, reserving the shallower waters for sport purposes.

The Commercial Fishery

The paucity of data prior to 1915 does not permit proper evaluation of the early fishery. In 1879, 787,600 pounds of abalone worth $38,880 were recorded. In the same year 3,383,500 pounds of shell brought $88,825. The 2,600,000 pounds recorded for 1888 was the largest quantity noted by the author.

Catch records since 1916 are complete and are listed in Appendix B-2. Landings at San Francisco have been very erratic, with little or none recorded from the years 1918 to 1934 and again between 1937 and 1942. In the intervening years the largest quantity recorded was 33,667 pounds in 1936. Since 1943 the landings have been highly variable. In 1945 for instance, 390,310 pounds were taken, the modern high for the Area, yet in 1947 none were recorded. The landings generally range from 10,000 to 40,000 pounds.

Changing legislation is partially responsible for the erratic nature of the San Francisco landings. The coast was closed all along the Bay Area counties in some years, open in other years, and for the past several years only the area south of Point Lobos, San Francisco County, including the Farallones, has been open. Abalones are not abundant enough to sustain a major commercial fishery north of Monterey County.

The state-wide landings reached a million pounds shortly after 1915, and up until World War II averaged about 2 million pounds annually. The war and absence of divers brought about the lowest catch ever recorded (164,462 pounds) in 1942. By 1945 landings were again well over 2 million pounds and since 1950 have repeatedly exceeded 4 million pounds of which 1.5 to 2.1 million pounds are pink abalones from Southern California. Average catch for the State during the 1916-55 period was 2,430,000 pounds.

The contribution of the Bay Area to the State-wide abalone catch is minor.

FIGURE 39. Sportsmen searching for abalones along Marin County shoreline. Photo courtesy Marin County Sportsmen's Association.

The Sport Fishery

Abalones are sought intensively by many people in the Bay Area. There is a long open season each year and on a series of minus tides scores of people can be found searching the rocks for them. Most of the easily accessible locations have been pretty well depleted, but fair quantities still exist in the relatively inaccessible areas north of the Golden Gate.

Particularly popular areas along the Bay Area coast include Pillar Point, Montara, and the Marin County coast. In some localities north of Stinson Beach abalone fishing is excellent for the fortunate few who are able to gain access.

General Information

There have been many technical and popular reports written on abalones. Edwards (1913) gave a brief account of the fishery of that time and some historical information. Croker (1931), treated the same subjects but more extensively. Thompson (1920), described the abalones of Northern California and their distributions. Bonnot (1948), in more detail described seven of the eight species, listed their distribution, and also touched briefly on their life history.

Of the eight species found in California four are represented in the ocean off Bay Area counties. The red abalone (*Haliotis rufescens*) is the principal species in both the sport and commercial fisheries. The black abalone (*Haliotis cracherodii*) may be fairly common in some locations, while the green (*Haliotis wallalensis*) and the Japanese (*Haliotis kamtschatkana*) abalones must be considered scarce.

Abalones occupy the intertidal zone from high water to a depth of about 300 feet, though maximum concentrations are found in depths of 25 to 40 feet. Cox (1958) in his investigation disclosed that abalones are particularly sedentary. Tagged animals have been found in the same areas in which they were released two to three years previous. They do not appear to move from one depth to another, although short lateral movements (parallel to shoreline) may occur. None released in water over 20 feet deep have ever been recovered in shallower water.

Spawning takes place in the spring and summer. There is a free floating stage which is estimated to last from 8 to 10 days before the spat drop to the bottom to assume the adult characteristics. Young abalone are found on the underside of rocks and in dark crevices.

C—043292

C-043293

It is thought they are light sensitive. The shell does not cover the mantle until they are about 4 inches in diameter, a condition which would expose them to numerous predators were they not to seek secluded locations. Growth occurs chiefly in the winter. Once they reach about 4 inches they come out into the open. Any form of confinement or artificial restraint is usually lethal in a short time.

Abalones are unable to tolerate polluted conditions. An experiment involving the exchange of unhealthy abalones in the vicinity of a sewage discharge (Los Angeles County) with healthy ones from an uncontaminated area was conducted recently by the Department of Fish and Game. As might be expected, the healthy ones, when placed near the waste discharge became diseased, while the unhealthy ones recuperated in the uncontaminated area.

THE MARINE BORERS

Brief mention might also be accorded the marine borers, which in the past have caused immense economic losses through their destruction of wharves, pilings, docks and wooden ships.

Three species are known to occur in San Francisco Bay. The most destructive has been *Teredo navalis*, a species suspected of being accidentally introduced about 1913. *Teredo diegensis* has been detected, but at only one locality prior to 1927, when the San Francisco Bay Marine Piling Committee made its final report. Another species, *Bankia setacea*, is also very destructive of wooden marine structures.

The general extent and abundance of these pests and the destruction and subsequent economic losses caused by them is covered in detail in the above mentioned report. (Hill and Kofoid, 1927)

MOLLUSCAN FISHERIES REFERENCES

Amemiya, I
1926 Notes on experiments on early development stages of the Portuguese, American and English native oysters, with special reference to the effect of varying salinity, Jour. Mar. Biol. Assoc. 14, 1, p. 161.

Anonymous
1947 Recommended procedure for the bacteriological examination of shellfish and shellfish waters, Amer. Jour. of Public Health 37.

Anonymous
1957 Report cites reasons why north coast waters cannot support commercial abalone fishery. Outdoor California, Vol. 18, No. 5.

Bonnot, Paul
1930 Abalones in California. California Fish and Game, Vol. 16, No. 1, p. 15-23.
1932 Soft Shell Clam Beds in the Vicinity of San Francisco Bay. California Fish and Game, Vol. 18, No. 1, pp. 64-66.
1935 The California Oyster Industry. California Fish and Game, Vol. 21, No. 1, pp. 65, 80.
1937a. Report on the California Oyster Industry for 1936. California Fish and Game, Vol. 23, No. 2, pp. 163-173.
1937b. Setting and Survival of Spat of the Olympia Oyster (*Ostrea lurida*), on Upper and Lower Horizontal Surfaces. California Fish and Game, Vol. 23, No. 3, pp. 224-228.
1938 Report on the California Oyster Industry for 1937. California Fish and Game, Vol. 24, No. 2, pp. 191-195.
1940a. California Abalone. California Fish and Game, Vol. 26, No. 3, pp. 200-211.
1940b. The Edible Bivalves of California. California Fish and Game, Vol. 26, No. 3, pp. 212-239.
1948 The Abalones of California. California Fish and Game, Vol. 34, No. 4, pp. 141-169.
1949a. Clams. In: The Commercial Fish Catch of California for the Year 1947 with a Historical Review, 1916-1947. California Department of Fish and Game, Fish Bulletin No. 74, pp. 161-164.
1949b. Oysters. In: The Commercial Fish Catch of California for the Year 1947 with a Historical Review, 1916-1947. California Department of Fish and Game, Fish Bulletin No. 74, pp. 167-170.

Butler, P. A.
1948 Effect of fresh water on oyster spawning. Atlantic Fisherman 29, 6, p. 49; Water Pollution Abs. 22, May (1949).

California Department of Fish and Game
1956 Oysters. Forty-fourth Biennial Report, pp. 51-52.

California State Board of Fish Commissioners
Biennial Report for the years 1893-94, pp. 11, 89, 92-108.
Ibid: - for the years 1901-02, pp. 25-26.
for the years 1903-04, p. 44.
for the years 1905-06, p. 56.

Carriker, Melbourne Romaine
1955 Critical Review of Biology and Control of Oyster Drills *Urosalpinx and Eupleura*. U. S. Dept. of Interior, Fish and Wildlife Service Special Scientific Report—Fisheries No. 148.

Churchill, E. P., Jr.
1919 The oyster and the oyster industry of the Atlantic and Gulf Coasts. U. S. Bur. of Fisheries, Annual Rept. Appendix 8, Doc. No. 890.

Churchill, E. P., Jr., and S. Lewis
1923-24 Food and feeding in freshwater mussels. U. S. Bur. of Fisheries Bull. 39, p. 439.

Clark, A. E.
1933 Oyster spawning in Bideford River in 1933. Annual Report Biol. Bd., Canada, p. 18.

Clark, Frances N.
1932 The present status of the Pismo clam (*Tivela stultorum*). California Fish and Game, Vol. 18, No. 2, pp. 170-180.

Coker, R. E., A. F. Shira, H. W. Clark, and A. D. Howard
1919 Natural history and propagation of fresh-water mussels. U. S. Bur. of Fisheries, Bull. 37, p. 79.

Collins, J. W.
1892 Report on the Fisheries of the Pacific Coast of the United States. Report of the U.S. Comm. of Fish and Fisheries for 1888, part II. The fisheries of California, pp. 21-175.

C—043293

C-043294

Cox, Keith W.
1955 California Abalone, Report of Investigation presented to California Assembly Interim Committee on Fish and Game.
1958 Notes on the California Abalone Fishery, Proceeding of the National Shellfisheries Association. Vol. 48, 1958, pp. 103-109.

Croker, Richard S.
1931 Abalones. In: The Commercial Fish Catch of California for the Year 1929. California Division of Fish and Game, Fish Bulletin No. 30, pp. 58-72.

Davis, H. C.
1953 On food and feeding of larvae of the American Oyster, *Crossostrea virginica*. Biol. Bull. 104, p. 334.

Dean, Bashford
1892 The phsyical and biological characteristics of the natural oyster grounds of South Carolina. U. S. Fish. Comm. Bull. 10, p. 335.

Edmondson, Charles H.
1922 Shellfish Resources of the Northwest Coast of the United States. U. S. Department of Commerce, Bureau of Fisheries, Bureau of Fisheries Document No. 920.

Edwards, Charles Lincoln
1913 The Abalone Industry in California. California Division of Fish and Game, Fish Bulletin No. 1, pp. 5-15.

Ellis, M. M.
1931 Some factors affecting the replacement of the commercial fresh-water mussels. U. S. Bur. Fisheries, Fishery Cir. 7.

Fielder, R. H.
1936 The Story of Oysters. U. S. Department of Commerce, Bureau of Fisheries, Fishery Circular No. 21.

Fisher, John P.
1916 Clams in San Francisco Bay
California Fish and Game, Vol. 2, No. 4, pp. 209-210.

Fitch, John E.
1953 Common Marine Bivalves of California
California Department of Fish and Game, Fish Bulletin No. 90.

Galtsoff, P. S., H. F. Prytherch, and H. C. McMillin
1930 An Experimental Study in Production and Collection of Seed Oysters, U.S. Department of Commerce, Bureau of Fisheries, Fisheries Document No. 1088.

Heath, Harold
1913 Investigation of the Clams of California
California Division of Fish and Game, Fish Bulletin No. 1.
1916 California Clams
California Fish and Game, Vol. 2, No. 4, pp. 175-178.

Hill, C. L. and C. A. Kofoid, Editors in Chief
1927 *Marine Borers and their Relation to Marine Construction of the Pacific Coast, Final Report of the San Francisco Bay Marine Piling Committee*
San Francisco Bay Marine Piling Committee, San Francisco.

Kellogg, James L.
1905 Conditions governing existence and growth of the soft clam, U.S. Comm. Fish and Fisheries Report 194.

Korringa, P.
1952 Recent advances in oyster biology, I. Quarterly review of Biology 27, p. 266.

Loosanoff, B. L. and F. D. Tommers
1947 Effect of low pH upon rate of water pumping of oysters, Anatomical Record, 99; 4, pp. 112-113.

Lunz, G. R., Jr.
1938 Effects of flooding of the Santee River in April 1936, on oysters in the Cape Romain Area of South Carolina. Part II, U.S. Engineer's Office, Charleston, S. C.

McMillin, H. C. and Paul Bonnot
1931 Oyster Culture in California
California Fish and Game, Vol. 17, No. 3, pp. 246-251.
1932 Oyster Pests in California
California Fish and Game, Vol. 18, No. 2, pp. 147-148.

Medcof, J. G., and A. W. H. Needler
1941 The influence of temperature and salinity on the conditions of oysters, Jour. Fish Res. Rd. Canada 5, No. 3, p. 253.

Mitchell, P. H.
1914 The oxygen requirements of shellfish, Bull. U.S. Bur. of Fisheries 32, p. 207.

Moore, H. F.
1897 Oysters and Methods of Oyster Culture with Notes on Clam Culture, U.S. Commission of Fish and Fisheries, Government Printing Office, Washington, D. C.

Oliveira, L. P. H., de
1924 Annotated Bibliography of oysters, Rept. U.S. Comm. Fish. Doc. 966.

Orcutt, H. G.
1956 Oysters
Outdoor California, Vol. 17, No. 5
California Department of Fish and Game.

Packard, E. L.
1918 The Molluscan Fauna from San Francisco Bay
University of California Publications in Zoology, Vol. 14, No. 2, University of California Press, Berkeley.

Phillips, J. B.
1934 Octopi of California
California Fish and Game, Vol. 20, No. 1, pp. 20-29.

Rankin, Edward P.
1918 The Mussels of the Pacific Coast
California Fish and Game, Vol. 4, No. 3, pp. 113-117.

Scofield, N. B.
1930 Conservation Laws Provide Ample Protection for Abalones
California Fish and Game, Vol. 16, No. 1, pp. 13-15.

Smith, F. G. W. and H. Chapin
1954 The Sun, the Sea and Tomorrow, Charles Scribner's Sons, New York, New York.

Sommer, H., K. F. Myer, W. F. Whedon, and C. A. Kofoid
1936 Mussel poisoning, 2d Inst. Congr. Microb.; Water Pollution Abs. 9, November (1936).

Tartar, Vance
Washington Oysters
State of Washington, Department of Fisheries, 5 pp. mimeo.

Thompson, Will F.
1920 The Abalones of Northern California
California Fish and Game, Vol. 6, No. 2, pp. 45-50.

Townsend, Charles H.
1893 Report of Observations Respecting the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States, U.S. Commission of Fish and Fisheries Report 1889-91.
U.S. Government Printing Office, Washington, D. C.

Tressler, D. K.
1923 The California Abalone Industry
Marine Prods. of Comm. The Chemical Catalog Company, N. Y., pp. 615-618.

Truitt, R. V.
1946 Maryland oyster situation, Maryland Tidewater News, September 1946.

Weymouth, Frank W.
1919 A Case of Destruction of Pismo Clams by Oil California Fish and Game, Vol. 5, No. 4, pp. 174-175.

1920 The Edible Clams, Mussels and Scallops of California California Division of Fish and Game, Fish Bulletin No. 4.

Wilcox, William A.
1895 Fisheries of the Pacific Coast Report of U.S. Commission of Fish and Fisheries for 1893. Appendices pp. 139, 304.

1901 Notes on the Fisheries of the Pacific Coast Report of U.S. Commissioner of Fish and Fisheries, pp. 501-574.

THE CRUSTACEAN FISHERIES

THE CRUSTACEAN FAUNA

The crustacean fauna of San Francisco Bay and the coastal waters off the Bay counties is rich and varied in terms of species present, but only a few occur in marketable quantities. Crabs have been a major constituent of the San Francisco fishery since 1870 at least. Except for a period between 1911 and 1920, when the fishery was curtailed by legislative restrictions, shrimp were a mainstay of the San Francisco fishing industry until 1939. Since that time shrimp have assumed a rather minor role. Crab landings on the other hand have more than doubled since 1945.

Recent knowledge concerning the crustaceans of the Bay Area has resulted from life history investigations of particular species or as incidental information arising out of some other specific study such as a pollution investigation. Thus, there have been no recent comprehensive undertakings to determine species composition or distribution. Schmitt's (1921) monograph on the marine decapod crustacea of the Bay Area remains the outstanding authority.

The more common crustaceans of the Bay Area are listed in Appendix E.

Schmitt's account, which includes data on species composition in regard to geographical location, bottom type, and depth of water is sufficiently applicable at the present time to be excerpted here. Minor changes have been made to condense the excerpt, and scientific names have been changed to conform to the latest taxonomic works:

". . . with respect to their local distribution the survey species belong to three groups: (1) those taken only outside [the Golden Gate]; (2) those taken only in the Bay; and (3) those taken both in the Bay and outside.

"1. The species taken only outside are sixteen (35%) in number, as follows:

Pandalus jordani	*Paguristes bakeri*
Spirontocaris gracilis	*Holopagurus pilosus*
Crago alaskensis elongata	*Pagurus ochotensis*
Crago communis	*Pylopagurus minimus*
Crago alba	*Acantholithodes hispidus*
Crago resima	*Randallia ornata*
Crago spinosissima	*Oregonia gracilis*
Eupagurus turgidus	*Pinnixa occidentalis*

"All these are bottom dwellers, and almost without exception all returns for each were from depths of about 30 fathoms or more. Of the species taken at the regular series of stations, specimens of three only were found in shoaler water: *Crago alaskensis elongata* . . . *Eupagurus turgidus* . . . and *Pagurus ochotensis*. On the other hand, all but two, *Crago alba* and *Pylopagurus*, . . . ranged into 40 or more fathoms of water. Seven, *Pandalus jordani, Crago alaskensis elongata, C. communis, C. resima, C. spinosissima, Eupagurus turgidus* and *Pinnixa occidentalis*, were even taken in 60 to 68 fathoms in the deepest haul made . . . The only species recorded from more than one outside station and not taken at the deepest is *Pagurus ochotensis*.

"In nearly every case the bottom was composed of fine, more or less greenish sand, which at one station . . . was marked by 'refuse and garbage' and at only one other . . . replaced by a 'very coarse variegated sand, with a small proportion of fine sand.' At this last, of the six species recorded from it, *Pandalus jordani, Crago alaskensis elongata, C. alba, Pagurus ochotensis, Pylopagurus minimus* and *Paguristes bakeri*, two, the third and fifth, were found elsewhere.

"So far as shown by the hydrographic observations made outside, none of the outside species was obtained from water having a salinity less than 33.9 (bottom reading), . . . the highest salinity recorded was 34.3 (bottom) . . . the corresponding (bottom) temperatures ranged from 9.3 degrees . . . to 11.1 degrees C . . . .

"Owing to the lack of any very definite data regarding their occurrence, *Acantholithodes hispidus, Randallia ornata*, and *Oregonia gracilis* are not included in the above discussion.

"2. Of the twenty-three (50%) species taken only in the bay, seven are represented only in the shore collections . . . .

"Two of these seven are burrowing forms, which, though not found in company, were taken only from sandy beaches:

Emerita analoga was dug out of the beach skirting the Presidio, west of Fort Point, and brought up in the seine both at Fort Baker and on Angel Island.

Upogebia pugettensis was obtained both at Sausalito and at Tiburon; at the latter place by means of the seine.

The other five are all primarily inhabitants of rocky beaches:

Oedignathus inermis, at Point Bonito.

Petrolisthes cinctipes, at Sausalito, and along the Richmond shore.

Pagurus samuelis, along the Richmond shore.

Pachygrapsus crassipes, on the Presidio shore near Fort Point, at Point Bonita, at Sausalito, and on Red Rock.

Hemigrapsus nudus, on the Presidio shore near Fort Point, at Point Bonita, at Sausalito, north of the Key Route Pier, along the Richmond shore, and Red Rock.

C—043296

C-043297

"The other sixteen Bay species grouped on the basis of their distribution within the Bay, arrange themselves as follows:

a. Ten, restricted to the middle Bay:

Pandalus danae	*Crago munitella*
Spirontocaris franciscana	*Pugettia productus*
Spirontocaris paludicola	*Cancer antennarius*
Spirontocaris brevirostris	*Pinnixa littoralis*
Spirontocaris taylori	*Scleroplax granulata*

b. One, found only in the middle and lower Bay: *Cancer productus*

c. Five, common to all three divisions of the Bay:

Callianassa gigas	*Pinnixa schmitti*
Pagurus hirsutiusculus	*Hemigrapsus oregonensis*
Pinnixa franciscana	

"Excepting the first, third, and ninth, seven of the 10 species found only in the middle Bay, inclusive of shore stations, are restricted wholly to that portion lying west of a line drawn across the head of Raccoon Strait, and from Blunt Point on Angel Island to the nearest point on the San Francisco shore.

"This limitation of range seems to be closely correlated with the character of the bottom, which within that area is more or less hard, rocky, gravelly, or sandy with very little if any admixture of mud, exclusive, of course, of the muddy portion of Richardson's Bay, where only two hauls of the boat dredge were made and none of the strictly middle Bay species was found.

"In addition to being found only on a rocky substratum, *Pugettia productus* was always in patches of kelp, or in their immediate vicinity. At Point Bonita, Sausalito, and east of Fort Point, *Spirontocaris taylori*, another 'hard bottom' species, was also taken only at localities characterized by an abundant growth of algae along both shores of Golden Gate and in bunches of seaweed stripped from the piles of the Sausalito Ferry Building. So far as our observations go, the only other middle Bay species, excepting *Spirontocaris paludicola* mentioned below, the distribution of which may be similarly conditioned, is *Spirontocaris brevirostris* for although taken near the head of Raccoon Strait on a bottom characterized simply as 'stones,' it was also taken at the south side of Golden Gate in company with *Spirontocaris taylori*.

"Though no doubt exercising a considerable influence on the distribution of the Bay species, the effect of temperature and salinity on these bottom dwelling forms is much more difficult of demonstration and probably less important, at least within this section, than that exerted by the character of bottom. Of the species found exclusively in the Bay only three were taken with the tow-net, *Callianassa gigas*, *Cancer antennarius* and *Hemigrapsus oregonensis*, respectively two, three, and one specimen each, the latter obviously an accident.

"Of the three middle Bay species, *Pandalus danae*, *Spirontocaris paludicola*, and *Pinnixa littoralis*, not wholly restricted to the portion lying west of the line drawn above, the third was found only in the predominantly muddy eastern portion of the middle Bay; the first, *Pandalus danae*, was returned but once from a 'variegated mud . . . sand and fine gravel' bottom in this eastern portion, as compared with thirty-two specimens from a principally coarse sand, gravel, and stone bottom in the western portion of the middle Bay; while the second, *Spirontocaris paludicola*, was taken but twice in the middle Bay, once in its western portion, in the eel grass along the northern shore of Angel Island, and once in its eastern portion, from the algal growth in tide pools north of the Standard Oil pier, Richmond.

"In lacking a straining apparatus 'for removing fine particles of foreign matter from its respiratory stream of water,' *Cancer productus* is ill adapted for life on more or less muddy or purely sand bottoms, and although recorded from the lower Bay and the easterly sections of the middle Bay, it was taken most frequently and abundantly in the western middle Bay, as is to be expected. Here twenty-two specimens were taken at ten stations, all on primarily gravel or rock bottoms, as compared with twelve at seven stations in the easterly parts of the middle and lower Bay, of which several had more or less hard bottoms, composed largely of shells, shell fragments, or clinkers. Aside from the scarcity of favorable bottom, it is possible that the great fluctuations of salinity obtaining in the upper Bay may tend to exclude *Cancer productus* from that division.

"As the bottom of the greater part of the Bay is predominantly muddy, it is to be expected that the five Bay species listed as occurring in all three divisions will show some preference for bottoms of that character.

"*Callianassa gigas*, in view of its burrowing habits, would naturally be restricted to the softer bottoms, and it is not surprising that no specimens of this species were taken in the western middle Bay. In the eastern middle Bay it was dredged at nine stations, in the lower Bay at five, and in the upper at three.

"*Pagurus hirsutiusculus*, although only taken in the course of shore collecting, from rocky shores around the middle Bay, was dredged from more or less shelly bottoms in the predominantly muddy sections of the Bay; once in the upper Bay, four times in the lower Bay and seven in the eastern middle Bay. Of the other six stations at which this species was taken, four were on the more or less hard sandy or rocky bottom of the western middle Bay, and two in the eel grass patches around Angel Island, one in the western, the other in the eastern middle Bay.

"*Pinnixa franciscana* and *P. schmitti* have practically the same range within the Bay, in fact, coincide at three stations. In nearly every case the bottom from which they were dredged was a more or less sandy mud, accompanied in at least two instances by numerous worm tubes, the probable habitat of both species.

With the exception of *P. franciscana* taken from a bottom of 'soft mud, with numerous worm tubes,' off Belvedere Point, in Richardson's Bay, neither species was found in the western middle Bay.

"*Hemigrapsus oregonensis*, as is well known, shows a marked preference for muddy bottoms, being especially abundant on mud flats at low tide though taken at times in more or less rocky situations in company with *Hemigrapsus nudus*. In the predominantly muddy lower Bay an average of sixteen and eight-tenth specimens per haul was taken at each of sixteen stations, while in the middle and upper Bay only one and five-tenths specimens were returned from each of the two hauls made in both of those divisions.

"3. Seven (15%) of the survey species were found both in the Bay and outside:

Spirontocaris cristata	*Crago franciscorum*
Crago nigricauda	*Cancer magister*
Crago nigromaculata	*Cancer gracilis*
Crago stylirostris	

"These seven are really Bay species which range outside as far as the environmental conditions correspond in general to those obtaining in the portions of the Bay in which they range inside. With the exception of *Spirontocaris cristata* and *Cancer gracilis* none of these species was taken outside the 30 fathoms line nor, so far as our records indicate, in water of (bottom) salinity exceeding 34.0. Comprising, on the other hand, nearly two-thirds (63%) of the eleven species taken at more than ten stations, and all of the five taken at about one-fourth of the dredging stations, they should be, and in fact are, fairly well distributed throughout the Bay. *Crago nigromaculata* is the only one of them failing of record in the upper Bay.

"*Spirontocaris cristata* was taken only three times outside, two specimens at each of two stations, and one at a third, in 8½ to 9 fathoms (bottom not characterized), in 9½ to 11¾ fathoms (bottom, 'coarse sand and gravel'), and 29 to 36 fathoms (bottom, 'refuse and garbage'). In the upper bay, however, *Spirontocaris cristata* was taken at two stations, . . . in the middle Bay at thirty-three [stations] . . . and in the lower Bay at twenty-five [stations] . . . . The lower Bay with its predominantly muddy bottom seemed to be the more favored habitat of this species. Here fourteen and four-tenths specimens per dredge haul were returned as compared with two and two-tenths for the middle Bay and two for the upper Bay. The average per catch with tow-net was, lower Bay, four and eight-tenths, middle bay, three and five-tenths, and upper Bay, one.

"*Cancer gracilis*, the only other species found in the Bay which ranged beyond the 30 fathom line, was taken but twice outside, one specimen in 8 to 9 fathoms, on a bottom of 'fine, dark, very clean sand,' and two specimens in 39 to 40 fathoms on 'very fine dark green sand.' Although taken in the Bay at but one upper, eight middle and three lower Bay stations, its distribution was very closely related to that of the preceding species, *Spirontocaris cristata*, coinciding with it at five of the stations from which it was recorded and very nearly at the other nine. Similarly, too, the greater number of specimens per haul was in favor of the stations made on more or less muddy bottoms.

"*Crago nigromaculata* though lacking in the upper Bay, in common with other fairly well distributed Bay species, seemed to a certain extent also to prefer more or less muddy bottoms. Of the nineteen stations returning it only two were located on the harder bottom of the western middle Bay, and only three on sandy bottoms outside.

"*Crago stylirostris*, however, although exceeding the range of *Crago nigromaculata* both within and outside the Bay, in direct contrast to that species was found most frequently as well as most abundantly on more or less hard, sand or sandy bottoms. In the western middle Bay *Crago stylirostris* was taken at twenty-eight dredging stations, in the eastern middle Bay at seven, and in the upper and lower bay at only two each. Outside it was returned at eight stations from fine, grey, or coarse sand and pebble bottom. At the more or less muddy eastern middle, upper, and lower Bay stations less than eleven specimens per haul were obtained, with one exception at which thirty-three were taken. But of the outside and western middle Bay stations thirty returned more than twelve specimens each; of these eight returned more than thirty-three, and five more than fifty specimens.

"*Crago nigricauda* and *Crago franciscorum* are the two most widely distributed decapods in the Bay and outside within the 30 fathom line. Both were taken abundantly in all three divisions of the Bay, and the latter was also abundant outside. More or less muddy bottoms returned the greater number of specimens per haul, though otherwise their distribution seemed little affected by the character of the bottom. Of the two *Crago nigricauda* is apparently more of a 'bottom dweller,' for even though taken at seven more dredging stations it appeared only about half as often (69 out of 137 times) in the catches of the tow-net.

"*C. franciscorum* was the only decapod found in Suisun Bay, as well as Napa Creek, and probably, therefore, can endure water of a lower salinity than any other species listed in connection with the survey.

"*Cancer magister*, in spite of the fact that it is adapted primarily for living on sandy bottoms, was found well distributed throughout the region covered by the survey though not so abundantly as either of the preceding species. Within the Bay it was actually taken more often on more or less muddy bottoms, but with very few exceptions all the specimens were very much undersized. Together with *Crago nigricauda* and

C. franciscorum this species is one of the only three that were taken at more than three stations in the upper Bay, and together with these two and *Hemigrapsus oregonensis* is one of the only four taken at any of the upper Bay stations lying north of Pinole Point.

"In general, *salinity* seems to be the controlling factor in the separation of the strictly outside species from those found in or 'in and out' of the Bay, and *character of bottom* that in the distribution of species within the Bay. Though so important geographically, the effect of temperature on the local distribution of species is not at all evident. Depth, likewise, apparently exerts little or no influence on the distribution of the survey species: certain species were taken only beyond the 30 fathom line and others only in the course of shore collecting, but the relation of the former to the salinity outside, and the latter to their substratum is too intimate to permit any other explanation. That only four decapods are known to occur in the upper Bay north of Pinole Point is probably due to the low salinity there obtaining, for although the annual range of temperature in this division is considerable it is almost equally great in the more populous but much more saline lower Bay."

THE CRAB FISHERY

Review of the Fishery to 1915

The market crab (*Cancer magister*), or dungeness crab as it is called north of California, has been a leading San Francisco fishery product since at least 1870. At first they were found in good quantity along the south side of the Golden Gate and on the Marin County side of the Bay. One of the earliest references to crabs, encountered by the author, is in the 1871 report to the State Board of Fish Commissioners of the previously named Captain Wakeman.

He stated: "In some cases nothing but crabs are taken which destroy the nets and irritate the men so that they are inclined to leave them lie on the beach to die; . . ." Weymouth (1916) quoting from an 1880 report states: "They are taken in immense numbers [in the Bay] in seines, together with many shoal water species of fish, yet the supply seems to be undiminished. Three or four good-sized crabs sell in the market at retail for 25 cents."

This condition did not persist; for shortly thereafter, the crab fleet was forced to move outside the Golden Gate to maintain the fishery. The crabs within the Bay were small and inadequate in number. Weymouth, at the time of his report stated: "No crabs could be taken by shore-hauled seines in the locality mentioned [south side of Golden Gate], and very few of marketable size by any method in any part of the Bay; profitable fishing is confined to the bar three or four miles outside the Golden Gate. One good crab sells for 25 cents in the market on rare occasions, but more commonly for 30 or 35 cents."

Apparently there was real cause for concern over the condition of the fishery about 1895 because the legislature enacted a law prohibiting the taking of female crabs. In 1903 a closed season was established and a six-inch size limit imposed, which in 1911 was increased to seven inches.

The catch according to the available statistics exceeded a million pounds regularly after 1880; the maximum reported was 3,676,680 pounds in 1899 (Wilcox, 1901).

In 1913 the "Crab Fisherman's Protective Association" was formed. This organization supplied the local trade and each year arbitrated with the dealers to prearrange a price agreement for the season. A law passed in 1917 at the request of the north state residents, forbade the export of Eureka crabs south of Mendocino. This combination of circumstances served to uphold crab prices locally and practically restricted the fishery to the Bay Area in spite of the fact that excellent crab grounds extended all along the coast from Monterey Bay northward. The San Francisco monopoly was further abetted by the Association's regulation forbidding the shipment of crabs outside San Francisco.

The San Francisco crab fishery continued to flourish but several circumstances came about which broke the Association's hold and resulted in greatly increased landings from other areas of the coast. In 1938, a "picked" crab meat and canning industry was established. In the same year a court decision ruled that crabs taken outside designated Fish and Game Districts or the three mile limit (Northern California) could be shipped into the San Francisco area. The final obstacle to "opening up" the Eureka fishery was removed in 1941 when the legislature repealed the 1917 law which forbade the export of Northern California crabs south of Mendocino County.

Weymouth *(op. cit.)* in discussing the fishery of 1916 stated that about 60,000 dozen crabs were taken annually. These were brought to market in sacks containing two dozen crabs each, which were sorted into large (averaging 24 lbs. per dozen) and medium (averaging 20 lbs. per dozen) sizes. The fishermen obtained $1.25 to $2.25 per dozen and the consumer was charged 25 to 35 cents per crab. About 200 boats were engaged in crab fishing at San Francisco and Sausalito, 35 at Monterey and few along the north coast. The value of the boats and nets was placed at $200,000. The crabs had a wholesale value of $120,000.

According to Phillips (1935), the San Francisco-Sausalito fleet held consistently at 200 to 250 boats from 1918 onward. However, for a brief period around 1921 an apparent scarcity of crabs led to a reduction in the number of boats and fishermen.

Catch Statistics from 1916 to 1958

Commercial catch records from 1916 through 1958 are presented in Appendix B-2 and appear graphically in Figure 23. Landings previous to 1918 appear in Appendix B-4. Between 1916 and 1945 the catch fluctuated between 70,000 and 3,800,000 pounds. Until 1945 the Bay Area regularly accounted for 90 percent of the total state-wide catch. The catch exceeded five million pounds six of the eleven years between 1947 and 1958. The peak year occurred in 1957 when 8,559,-912 pounds were taken.

Since 1946, landings in the Eureka region have generally equalled or exceeded the San Francisco catch. The state-wide catch of 19,269,615 pounds in 1957 is the largest in the history of the fishery. Figures 22 and 23 graphically depict the comparative catch of crustaceans (crab and shrimp) of the State and the Bay Area.

The Fishery

In California, crabs have been taken by several methods: first by seines, then crab hoop-nets, gill and trammel nets, and most recently by crab pots or traps. Out of San Francisco the hoop net was used almost exclusively until the development of the crab pot. The setting and hauling of hoop nets required great skill on the part of the operator since it was necessary to set them from a moving boat in a running tide. Unless the hauling action was fast and clean the crabs were able to escape. Bait losses also occurred. The crab pot can be set and left without entailing these difficulties, for once inside the trap few crabs are able to relocate the funnel through which they entered.

Clark and Bonnot (1940) delved into some detail in evaluating the relative densities of crab populations along the California coast, estimating the fishable areas in square miles. They concluded that approximately 400 square miles of good crabbing grounds exist from shoreline to the 30 fathom contour between Point Reyes and Pescadero Point of which the San Francisco crab fleet was utilizing only 240 square miles. From Point Reyes to the Oregon line they calculated 1,430 square miles of crab bottom inside the 30 fathom contour. Their data for other areas and depths are given in Table 37. See also Figure 40 for map of crab fishing areas.

Life History Notes

Because large numbers of immature market crabs are continually present in the Bay and just outside the Golden Gate it seems appropriate to give a brief resume of the habits and life history of *Cancer magister*. However, two other species, *Cancer productus* and *Cancer antennarius*, usually referred to as rock crabs, reach marketable size and are occasionally included in the commerical landings.

The market crab is usually found on shallow sandy bottoms. Although occasionally found on rocky or shale substrate and in depths to 90 fathoms they have

TABLE 37

CRAB FISHING AREA IN SQUARE MILES OF THE CALIFORNIA COAST [1]

Coastal Area	Shore to 30 Fathoms	Shore to 100 Fathoms	3-Mile Limit to 100 Fathom Line
Oregon line to Cape Mendocino	560	1,200	720
Cape Mendocino to Pt. Arena	160	480	110
Pt. Arena to Pt. Reyes	160	800	560
Pt. Reyes to Pescadero Pt.	400	1,200	960
Pescadero Pt. to Pt. Pinos	150	400	240
Totals	1,430	4,080	2,590

[1] After G. H. Clark and Paul Bonnot (1940).

a decided preference for water between 4 and 15 fathoms. Because of their burrowing habits, the substrate must be loose. When in their burrows only their stalked eyes and antennules are exposed. Their respiratory mechanism is modified in such a manner as to strain the course sand particles and the usual amount of sediment found in their environment from the current of water which they maintain. This mechanism is inadequate in very silty water or in muddy bottoms. If continually exposed to the latter conditions, they are usually of poor quality. Other species, interestingly enough, are adapted to mud bottoms while still others, as for instance the rock crabs, are adapted to gravelly or rocky bottoms. Any fine organic wastes would have much the same effect as muddy or silty water on the market crab.

The antennules are sense organs by which crabs are able to detect the slightest odors. Research has shown that even blinded animals are able to detect and locate food rapidly. They are primarily carnivorous, feeding on fish, shrimp, small crabs, clams, other animals and apparently, some carrion.

Throughout their life, crabs, like other crustaceans, periodically shed their carapace, or shell. This process is known as molting and is necessary for growth increment to occur. Molting occurs frequently in young crabs but generally only once a year in adults. While in the "soft" stage the crab remains buried for the few days it requires the new shell to calcify; body tissues swell with water and greatly increase the bulk of the crab over its original size so that upon hardening there is adequate room for additional growth. Once this occurs growth is limited until the next molt. New appendages may be regenerated during the molting process. Unlike the blue crab (*Callinectes sapidus*) of the East Coast, the market crab is not edible during the "soft" phase, or for a month or more afterward.

Mating takes place in late spring or early summer, but the eggs are not laid until the fall months. After

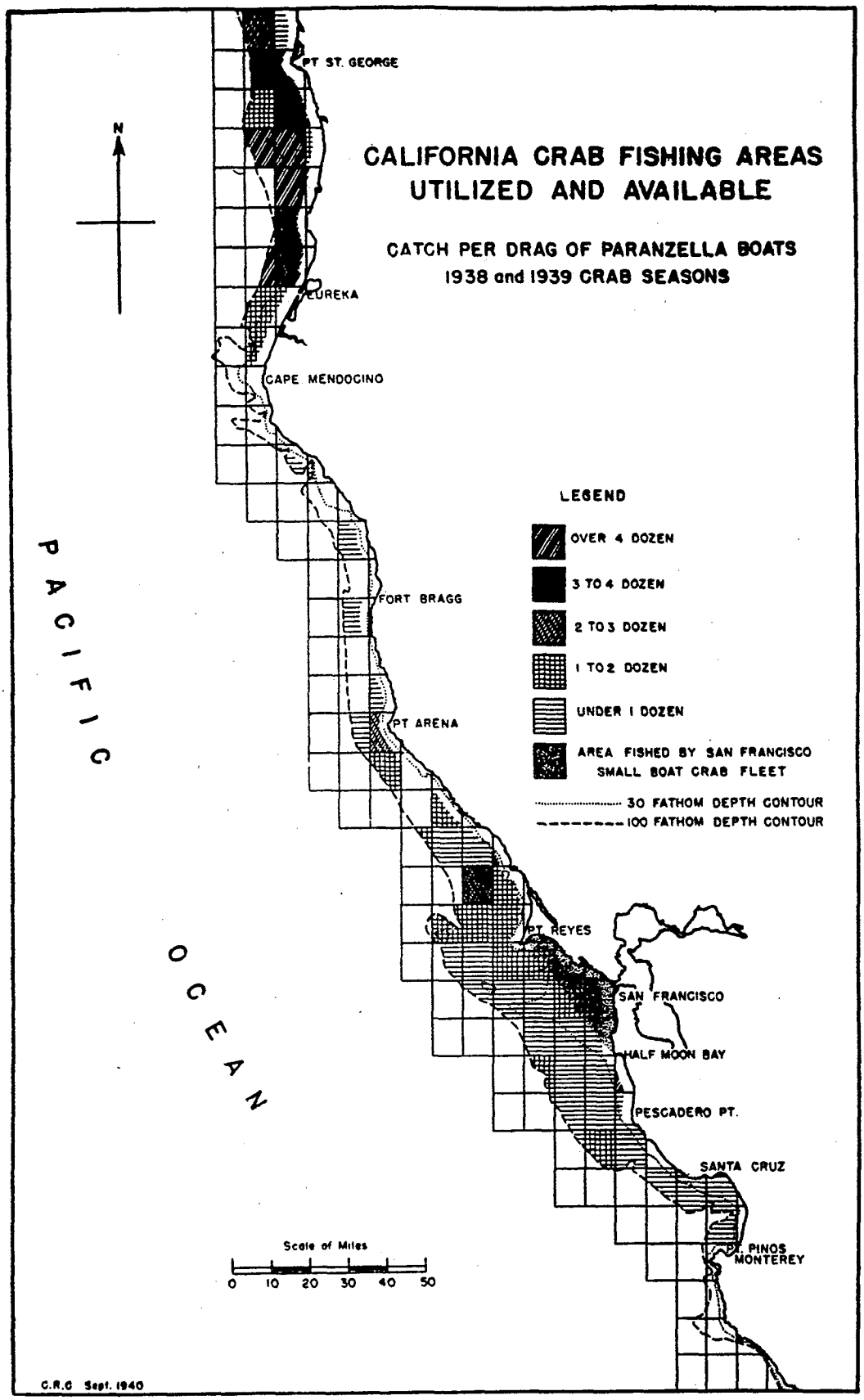


FIGURE 40. Map of Crab Fishing Areas.

extruding the eggs the female carries them under the abdomen and on appendages to which they are attached by a fine adhesive thread. Here they are constantly aerated by the movement of the appendages and protected by the broad tail flap. A single female may lay in excess of 2,500,000 eggs. Hatching occurs in late winter or early spring.

Newly hatched larvae are at first free-swimming shrimp-like creatures. During the first few months of life they grow rapidly and change in form. Tremendous numbers of the megalops, or larvae, are consumed by fish such as salmon. They are positively phototropic, and immense swarms of the tiny creatures may appear inshore during May or June in particularly favorable reproductive years. The young settle to the bottom in early summer by which time they have assumed the appearance of the adult, just about one year from the time mating occurred.

At the end of the first year after becoming a bottom dweller they attain about 1.5 inches in width; at the end of two years, 4 inches. By this time most are sexually mature. After maturity is reached the males grow more rapidly than females and may attain 9 inches or more in width, while females seldom exceed 6.5 inches. The males generally reach the legal commercial size of 7 inches between the fourth and fifth year.

Immature market crabs are found in abundance the year around in San Francisco and San Pablo bays. They seasonally migrate toward the freshwater inlets of the bays in tremendous numbers with the summer intrusion of saltwater. They formerly were found as far upstream as Pittsburg but since controlled freshwater flows from upstream dams have been maintained, their upstream limit has been restricted to the vicinity of Carquinez Strait. Freshwater is quickly fatal to crabs.

There is a worthwhile need to investigate the maturity of these small crabs to find out if growth to normal size occurs, to determine if they undertake seaward migrations, and in general to determine the relationship between them and the adult crabs offshore. Adults of commercial size are infrequently observed, however, this is partly due to the lack of concerted effort to find them.

THE SHRIMP FISHERY

Early History

The first commercial shrimp enterprise in California was begun by Italian seine fishermen in San Francisco Bay in 1869. Their catch was small and was disposed of in local fresh fish markets. In 1871 the Chinese entered the fishery and employed the shrimp net, a tide-operated type of gear traditionally used in China. This net was extremely efficient in comparison to seines and the Chinese promptly put the Italian fishermen and their fleet of 8 boats out of business.

Scofield (1954) estimated that in 1875 there were 1,500 Chinese engaged in shrimp fishing. The State Board of Fish Commissioners in their 19th biennial report (1905-06) reported there were 50 boats in the fishery in 1885-86. By 1898 the number was reduced to 33. The principal fishing grounds as of 1888-89 are shown in Figure 7.

The local demand for bay shrimp not being great, the bulk was dried and exported to China.

Chinese shrimp camps were established at various locations around San Francisco Bay. There was also one at Tomales Bay, but it was abandoned during the 1890's. In 1897 there were 26 camps around San Francisco Bay. The number was further reduced to 19 by 1910. Of these, three were located in the cove just north of South San Francisco, five at Hunter's Point, four near Red Rock and seven near Point San Pedro, Marin County. Since each camp had its own junk, there were also 19 boats in the fishery.

The fishing grounds at this time were located off Alameda County east of Point San Bruno, and south of the Alameda mole; south of Hunter's Point; north of Red Rock; and south of Point San Pedro and eastward to Contra Costa County. Five of the camps at Point San Pedro fished on the "Petaluma flats" off Marin County.

According to Scofield (1919) there were 1,000 shrimp nets in operation throughout the Bay in 1910.

All did not go well in the shrimp fishery however. The earliest signs of trouble appeared in 1871 when Captain Wakeman in his report to the Fish Commissioners remarked on the young fish taken in the shrimp nets. By 1885 the sentiment of the local citizenry was turned against the destructive method of fishing employed by the Chinese. Tremendous quantities of juvenile commercial fish were destroyed and the feeling at the time was that the shrimp were also being depleted. By 1901 there was sufficient support to bring about legislation which imposed a closed season during the months of May, June, July and August. The Chinese fought this law all the way through the United States Supreme Court without success.

In 1905 they were successful in getting the closed season repealed but lost to legislation which prohibited the export of dried shrimp. This resulted in the loss of the foreign Chinese market and effectively curtailed fishing activities. In 1909 they were again curtailed by a closed season during the months of June, July and August, and in 1911 the shrimp net was prohibited. The severity of these restrictions and the apparently depleted condition of the beds made it virtually impossible to obtain shrimp in commercial quantities by any of the permissible methods.

The Frank Spenger Company introduced the shrimp trawl in 1914. In 1915 the legislature legalized the use of Chinese shrimp nets in the South Bay where the loss of fishlife was minimal. The law prohibiting the exportation of dried shrimps was repealed in 1919 but another law made it illegal to dry any more than one-

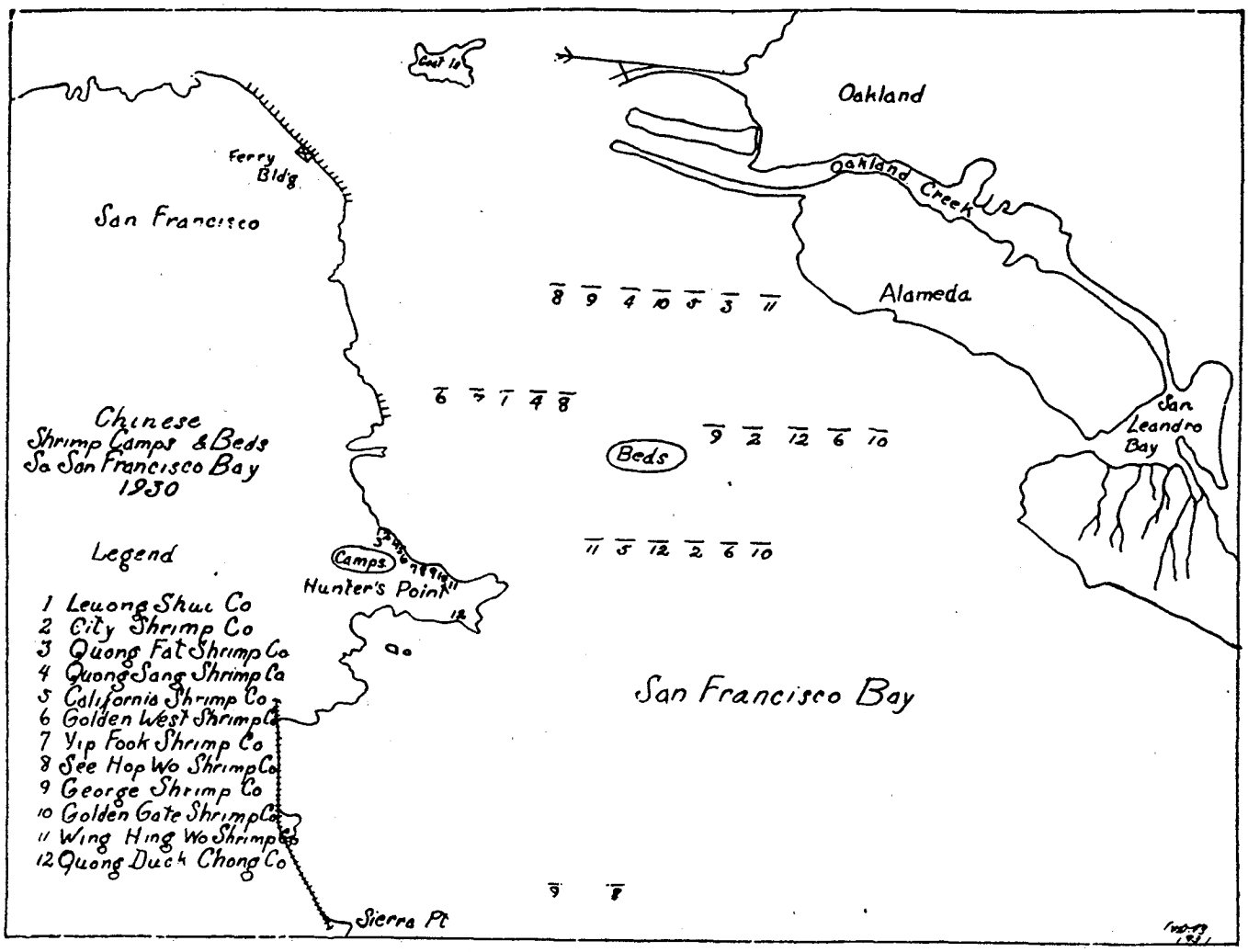


FIGURE 41

half of any one catch. With these changes the shrimp fishery made a good recovery.

As time passed the number of camps was reduced but essentially the same system and methods of fishing have prevailed up to the present time. As of 1930, the camps varied from a two-man outfit operating 20 nets to an eight-man camp fishing 50 nets. Shrimp nets were lawful only in the South Bay, while the trawls operated in the North Bay. Bonnot (1932) listed the organizations operating in each part of the Bay in 1930 and the numbers of boats and nets belonging to each. These totaled 12 companies, 504 nets, 16 boats and 53 men in the South Bay, and 2 companies, 38 nets, 19 boats, and 19 men in the North Bay. The main shrimping ground in the South Bay was located northeast of Hunter's Point, where at least 23 beds were worked. (See Figure 41 for map.)

By-products of the shrimp industry included shrimp meal, composed of the ground shells and wastes, fertilizer and animal feeds.

Catch Statistics

Three species of bay shrimp are represented in the catch: *Crago franciscorum*, *Crago nigricauda* and *Crago macronigricauda*, the former constituting the bulk of the landings. At times, however, *C. nigricauda* may comprise 50 percent or more of the catch in certain localities. *C. macronigricauda* is a comparatively minor species.

As was the case of the other fisheries, data on the amount and value of landings are quite limited and conflicting prior to 1915. Captain Wakeman in his report to the Fish Commissioners in 1871 stated that thousands of tons of shrimp were sent to China. Jordan (1887) estimated the catch at 250,000 pounds for the 1879-80 season; however, there is evidence to indicate that perhaps two or more million pounds per year were taken in the late 70's. From 1882 to 1892 the catch apparently leveled off at about 5 million pounds, according to reports of the U. S. Com-

missioner of Fish and Fisheries and the State Board of Fish Commissioners. For the period 1892-1915, data were found for only two years, 1899 and 1908, when 4,047,186 and 979,000 pounds respectively were landed (Appendix B-4). Scofield (1910 and 1919) stated that shrimp nets were taking 10 million pounds a year, including small fish which he estimated to vary from 20 to 50 percent of the individual catches. Assuming an average of 35 percent for fish, this would mean that the annual shrimp landings from 1895 to 1910 were on the order of 6,500,000 pounds. The legislative problems previously discussed resulted in a tremendous reduction in the catch thereafter.

Accurate records of the yearly shrimp landings are known from 1915 onward. They are recorded in Appendix B-2 and Figure 22. With the removal of restrictions, the catch increased at a rate of 100,000 to 200,000 pounds per year between 1916 and 1924 from an initial 400,000 pounds in 1916 to more than 1,500,000 pounds in 1924. The catch went over 3 million pounds in 1929. From 1930 to 1936 the catch fluctuated about the 2 million pound level, after which it gradually decreased. Shrimp dropped below the million pound mark in 1941 and did not exceed that amount until 1952. Throughout this period the Bay Area produced almost the entire shrimp catch.

Research in the Bay has been limited, thus there is very little recent scientific information concerning such commercial species as shrimp. Nevertheless, since there is scarcely any shrimp fishing in the South Bay at the present time, it may be concluded that these beds are less productive than those in the North Bay. The beds off Hunter's Point for instance are not utilized at all. The main fishery is now located in the vicinity of San Rafael. While it seems reasonable to assume that the shrimp population is below former levels of abundance, it also appears that the resource could withstand greater exploitation than it currently receives.

It is difficult to speculate upon the potential or present status of the bay shrimp resources. Definite knowledge of the abundance and distribution of shrimp in the Bay is lacking. Commercial interests apparently cannot expand operations profitably because of the high cost of labor involved in processing. Present operators restrict their activities to known beds and only remove those amounts which return a reasonable profit. Consumers apparently have not expressed sufficient demand for bay shrimps at the present price level to warrant an expansion of the fishery. If in the future cheaper processing techniques are brought into the trade, as for instance shrimp peelers, there may be a consequent reduction in costs and an enlarged market which would, of course, call for an expansion of the industry.

Life History Notes

Knowledge concerning the life and habits of bay shrimps is extremely meager. A study is now in progress by the California Academy of Science, but heretofore the only investigation of consequence was that of Israel (1936).

Except for chronological differences the habits and life histories of the three species of bay shrimps are essentially the same. According to Israel the breeding season for *Crago franciscorum* extends from December through May or June but some oviferous (egg bearing) females have been found in some locality at all seasons of the year. The females carry the eggs on the abdomen or appendages as in the case of crabs. The "Petaluma Flats" in particular show a large percentage of oviferous females the year-around. In the North Bay off San Quentin egg-bearing females were taken principally from August to December, and off Southampton chiefly during April to June. In the South Bay oviferous females are found in the spring.

Each species moves toward the ocean as the spawning season approaches, the eggs being hatched in highly saline water. Newly hatched free-swimming larvae are planktonic. As they metamorphose they gradually assume the appearance of shrimp. The post larval stage is reached at a length of about 7 millimeters (about ⅜ inch) after which they settle to the bottom. Once this stage is attained the tiny shrimp move toward shallower water of reduced salinity. They are found in greatest quantity at depths of less than 15 feet on shell or mud bottom, the latter being preferred. As they grow, they gradually move into deeper water so that there is a distinct graduation to progressively larger shrimp with increasing water depths.

The females which grow faster than males may attain a 25 percent larger size. All three species mature at or near the end of their first year at which time they are about two inches in length.

Crago nigrocauda breeds chiefly from April through September as opposed to the December-May period of *C. franciscorum.*

C. franciscorum is presumably the most tolerant of freshwater, since Israel found it far up into the Delta (15 miles below Stockton), while the extreme upper limit for *C. nigricauda* was found to be Suisun Bay, and then only in the fall with the intrusion of saltwater. Furthermore, from San Quentin, where both species are well represented, *C. nigricauda* becomes most abundant toward the ocean while *C. franciscorum* becomes most abundant toward the inland or freshwater parts of the Bay.

OTHER CRUSTACEANS

The foregoing discussion was concerned chiefly with the commercially important varieties of crustacea in the San Francisco Bay Area. There are others which

enter the commercial fishery in minor proportions, and a great many which serve in an important capacity as forage for the food and game fishes of the Bay.

As a result of explorations by marine biologists of the Department of Fish and Game, in 1952 an ocean shrimp resource was uncovered. The discovery of beds of *Pandalus jordani*, *P. danae*, *P. platyceros* and *P. hypsinotus* in several areas along the coast has opened up a major new ocean shrimp and prawn industry. However, only a minor part of the catch is taken and landed within the Bay Area because they are not abundant enough locally to support a firm commercial fishery.

The small crustacean (*Neomysis mercedis*), not considered in the above discussion, is seasonally present in tremendous quantities for a considerable distance into the Delta. It is a major constituent in the diet of small striped bass.

The small shore crab (*Hemigrapsus oregonensis*) is an important forage item in the diet of white sturgeon and presumably for many other species as well.

It is only logical that a large proportion of the crab and shrimp-like crustaceans constitute staple dietary items of the food and game fishes of the Bay.

A rather interesting industry, involving the collection, drying and packaging of brine shrimp (*Artemia salina*) has developed in the Bay Area in association with the salt industry. These tiny creatures are exceptionally tolerant of high salinity, and do well in the saltwater evaporation ponds. The eggs are easily shipped since they are resistant to freezing and desiccation. The shrimp are hatched and used as tropical fish food by aquarists.

Freshwater Crayfish

Freshwater crayfishes of the sloughs, creeks and rivers throughout the region are preferred forage for large and smallmouth black bass, particularly the latter, and are known to be utilized by rainbow, steelhead and brown trout. There are several native and introduced species.

Procambarus clarkii was imported from the Midwest at least as early as 1925 and this crayfish is now pretty well distributed throughout the freshwater environs of the Bay Area. It is mechanically destructive to dikes and levee but furnishes valuable forage for many of our freshwater species of fish.

The native *Pacifastacus klamathensis* and *Pacifastacus leniusculus* have been exploited for the commercial market as "ecrevisse." The latter species was brought into California specifically for culinary purposes and as biological material.

Pacifastacus nigrescens was reported from the Bay Area many years ago, but not recently.

Bonnot (1930) states that crayfish have not figured extensively in a commercial capacity because of the lack of a market and their relative scarcity. When they were in demand, San Francisco was the largest outlet on the Pacific Coast. The principal sources of supply were reported to be Coyote Creek near San Jose and the Russian River. Currently, excellent catches of large crayfish (*P. leniusculus*) are made in the Delta.

CRUSTACEAN FISHERIES REFERENCES

Bonnot, Paul
1930 Crayfish
California Fish and Game, Vol. 16, No. 3, Pp. 212-216
1932 The California Shrimp Industry
California Fish and Game, Fish Bulletin No. 38

California State Board of Fish Commissioners
Biennial Report for the years 1893-94, P. 89
Ibid 1901-02, Pp. 22-24, 26
1903-04, Pp. 38-40
1905-06, Pp. 52-56
1909-10, Pp. 42-44
1914-16, Pp. 91-92

Chute, George Roger
1929 The Crab Fishery of Monterey Bay, California
California Fish and Game, Vol. 15, No. 1, Pp. 28-33

Clark, G. H. and Paul Bonnot
1940 The Utilization of the California Crab Resource
California Fish and Game, Vol. 26, No. 4, Pp. 374-380

Cleaver, Fred
1947 Life History and Habits of the Commercial Crab, *Cancer magister*
State of Washington Department of Fisheries, 4 Pp. mimeographed

Israel, Hugh R.
1936 A contribution toward the Life Histories of Two California Shrimps, *Crago franciscorum* (Stimpson) and *Crago nigricauda* (Stimpson)
California Department of Fish and Game, Fish Bulletin No. 46

Kimsey, J. Bruce and Leonard O. Fisk
1954 Crayfish in California
California Fish and Game, Inland Fisheries Branch Information Leaflet No. 1, 4 Pp. illustrated

Light, S. F.
1957 Intertidal Invertebrates of the Central California Coast (Revised)
University of California Press, Berkeley and Los Angeles, 466 Pp. XIV, illustrated.

Phillips, J. B.
1935 The Crab Fishery of California
California Fish and Game, Vol. 21, No. 1, Pp. 38-60
1939 The Market Crab of California and its Close Relatives
California Fish and Game, Vol. 25, No. 1, Pp. 18-29

Raymont, J. E. G.
1955 The Fauna of an Intertidal Mudflat
Papers in Marine Biology and Oceanography. Supplement to Vol. 3 of Deep Sea Research Pp. 178-203

Ricketts, E. and Jack Calvin (Revised by Joel Hedgepeth)
1952 Between Pacific Tides
Stanford University Press, 502 Pp. Illustrated XIII

Riegel, J. A.
1959 The Systematics and Distribution of Crayfish in California, California Fish and Game, Vol. 45, No. 1, Pp. 29-50

Schmitt, Waldo L.
1921 The Marine Decapod Crustacea of California
University of California Publications in Zoology, Vol. 23, 470 Pp.

Scofield, N. B.
1919 Shrimp Fisheries of California
California Fish and Game, Vol. 5, No. 1, Pp. 1-12

Weymouth, Frank W.
1916 Contributions to the Life History of the Pacific Coast Edible Crab
California Fish and Game, Vol. 2, No. 1, Pp. 22-27
1919 Note on the Habits and Use of the Small Sand Crab (*Emerita analoga*)
California Fish and Game, Vol. 5, No. 4, Pp. 179-180
1920 The Pacific Edible Crab and its Near Relatives
California Fish and Game, Vol. 6, No. 1, Pp. 7-10

Wilcox, William A.
1901 Notes on the Fisheries of the Pacific Coast
U. S. Commission of Fish and Fisheries Report for 1899

Wilson, Robert C.
1948 A Review of the Southern California Spiny Lobster Fishery
California Fish and Game, Vol. 34, No. 2, Pp. 71-80

THE FRESHWATER FISH AND FISHERIES OF THE SAN FRANCISCO BAY AREA

HISTORICAL REVIEW

The freshwater fish fauna of the San Francisco Bay Area is quite varied and supports a large angling population. This was not always so, however; the area originally was deficient in natural lakes and warmwater streams and the many varieties of so-called warmwater or spiny-rayed gamefish. The only native warmwater gamefish found here was the Sacramento perch (*Archoplites interruptus*).

Salmonids on the other hand inhabited virtually every stream. Native populations of rainbow trout (*Salmo gairdneri*) were found in most streams with a year-around supply of cool water. Silver salmon and steelhead also favored the cooler waters and utilized many of the intermittent streams for spawning.

Salmonids as a group have always been particularly favored both for food and sport and even in the early days of San Francisco were heavily exploited by anglers. Besides angling they were taken by spears, traps, weirs, explosives and any other available means.

As the population of the Bay Area increased between 1850 and 1890, the local redwood forests were timbered off and public water supplies were developed. Coastal streams suffered from pollution by sawdust, grist, and siltation. The streams were obstructed by log jams and were dammed to form water supply reservoirs and to harness their energy for the operation of sawmills and flour mills. Records of the Fish and Game Commission relating to this early period indicate the local salmonid fisheries suffered a severe setback.

It is of passing interest to note that the first hatchery and fish cultural station in California was established on the grounds of the University of California at Berkeley in 1869. The station, operated by "The California Acclimatization Society", and operated under the supervision of Mr. J. G. Woodbury, sold the fish to the State Fish Commission.

Immediately after the legislature established the State Board of Fish Commissioners (1870) this body set about to import prominent gamefish species of the East and Midwest. The black basses, panfishes (green sunfish, bluegills, etc.) catfishes, perches, and eastern brook and brown trout were among the freshwater varieties introduced. Most of them did extremely well in their new environment. As a matter of fact, the introduced species now sustain virtually all warmwater angling in the Bay Area. The more common freshwater fish species are listed in Appendix F-1. Initial introductions of selected species now occurring in the Bay Area are given in Appendix F-2.

About 1884 the State Board of Fish Commissioners was concerned about the vanishing Sacramento perch. The species was disappearing at an alarming rate, presumably because of overfishing and reclamation. More recently, the introduction of alien species also has been blamed for the perch scarcity.

Sacramento perch and several non-game varieties found their way into the San Francisco commercial trade to some extent before 1870. They were obtained by seining in the Delta, in the lower reaches of the rivers tributary to the Delta, and in Clear Lake, Lake County.

The largemouth and smallmouth basses (*Micropterus salmoides* and *Micropterus dolomieui*) respectively, both highly esteemed as food and gamefish in the East and Midwest, were among the first varieties brought to California. They were brought out by Livingston Stone in 1874 and stocked in Alameda Creek and the Napa River. By 1890, most of the suitable lakes and streams in the Bay Area were well stocked with them.

The white catfish (*Ictalurus catus*) and brown bullhead (*Ictalurus nebulosus*) were introduced by Stone in 1874. Panfish and crappies were first introduced between 1890 and 1891 into Southern California and made their way to Bay Area waters through later transplantations.

White catfish and brown bullheads increased at such a prolific rate that they supported a substantial commercial fishery from the turn of the century until 1953 when the fishery was abolished by the legislature. Most of the catch, though landed at Pittsburg, was made in the Delta. Special fyke nets were employed.

Other freshwater species entering the commercial catch included carp (*Cyprinus carpio*), which were first introduced from Europe in 1872, and the native hardhead (*Mylopharodon conocephalus*), squawfish (*Ptchocheilus grandis*), splittail (*Pogonichthys macrolepidotus*), and Sacramento blackfish, (*Orthodon microlepidotus*). For the most part the latter species were taken incidental to shad and salmon by the Pittsburg fleet and landed at either Pittsburg or San Francisco. The Department of Fish and Game issues special permits to commercial operators to fish for some of these

C—043307

C-043308

species in certain inland waters infested with them. The quantity taken each year through 1958 is shown in Appendix B-2 under the heading "Commercial Freshwater Fisheries". Catfish landings are shown under the same heading. The fishery was discussed briefly in the commercial fisheries section of this report.

Lack of data makes it impossible to evaluate the freshwater sport fisheries of the past. Sport fishery surveys and censuses are of recent origin, and even these encompass but a small proportion of the fisheries.

ANGLING PRESSURE

General information concerning angling in the region, as compared to the state as a whole, is available from postal card surveys: Calhoun (1953), Skinner (1955) and Ryan (1959). It was estimated on the basis of these surveys that approximately 30 percent of the State's angling population resided in the Department of Fish and Game's Administrative Region 3, a considerably larger area than that encompassed by this report. (See Figure 3 and Figure 5.)

The catch of trout, river salmon and steelhead in this Region is on the order of ten, nine and seventeen percent, respectively, of the state-wide totals for these species. Black bass, catfish and panfish each represent 20 to 25 percent of the state-wide totals as judged from the postal surveys. The catch by species and percentage contributed to the state-wide catch of each is shown for Region 3 in Table 38, for five different years between 1951 and 1957. The percentage of anglers catching the above species in Region 3 is shown in Table 39. Table 38 gives an indication of the species contribution to the state-wide totals, while the latter indicates angler preference and the relative proportion of anglers fishing for selected species in Region 3 as compared with the rest of the State. The number of anglers residing in the region was estimated at 307,000 and 323,000 in 1951 and 1953, respectively. This represented 29.7 and 27.0 percent of all licensed anglers in those years.

CLASSIFICATION OF FISHERIES

In general, the warmwater fisheries have been expanded through construction of water storage reservoirs, while stream habitat, supporting salmon, steelhead, and resident trout has decreased because of water development.

The continued growth of the Bay Area has resulted in a steady increase in storage reservoirs for municipal and industrial water supply and irrigation purposes until there are now more than 50 of them distributed throughout the nine Bay Area counties. As a consequence, there has been a steady increase in lacustrine habitat and fisheries. Most reservoirs are best suited to warmwater species, but a few, those too cool or fluctuating to support a good warmwater population, are often managed as trout lakes. Regardless of the type of fishery, all are potentially valuable recreational areas. Unfortunately many of the reservoirs used for domestic water supply are not open to the public for fishing or recreation.

Warmwater species, once stocked in a suitable environment, are usually able to maintain themselves, thus rarely necessitating restocking. Frequently, the fish become too abundant for the available food supply causing stunted fish. Such fish, though only a few inches in length, are capable of reproducing, thus further aggravating the situation. Lakes in which this condition occurs are sometimes chemically treated to eradicate the stunted population and are then restocked with a new or different broodstock combination.

Lakes which become infested with carp and other undesirable species which compete with game species are similarly treated and restocked.

The Department of Fish and Game maintains an active program of stocking catchable-size, (7-inch), or, in some cases, subcatchable-size or fingerling trout,

TABLE 38

ESTIMATED CATCH OF SELECTED GAMEFISH SPECIES BY ANGLING IN SAN FRANCISCO ADMINISTRATIVE REGION [1]

	Trout	Black Bass	Catfish	Panfish	River Salmon	Steelhead	Striped Bass
1951	1,767,000 (9.9)[2]	170,000 (13.5)	709,000 (16.5)				770,000 (52.0)
1953	1,840,000 (8.8)	540,000 (24.6)	920,000 (14.9)		15,000 (7.4)	34,000 (12.9)	730,000 (54.5)
1954	993,000 (3.7)	486,000 (20.8)	1,713,000 (25.9)	1,648,000 (15.0)	14,000 (7.0)	75,000 (18.3)	747,000 (65.9)
1956	1,983,000 (7.4)	326,000 (12.7)	1,511,000 (22.8)	2,319,000 (22.2)	18,000 (8.7)	64,000 (17.8)	406,000 (46.5)
1957	4,562,000 (14.6)	681,000 (28.5)	3,020,000 (36.3)	2,768,000 (34.4)	25,000 (12.8)	110,000 (20.5)	1,087,000 (60.1)

[1] Data from postal survey estimates, Calhoun (1953), Skinner (1955) and Ryan (1959).
[2] The figures in parentheses are percentages of statewide totals of each species for the year cited.

TABLE 39

PERCENTAGE OF ALL CALIFORNIA ANGLING LICENSEES REPORTED HAVING CAUGHT SELECTED SPECIES IN THE SAN FRANCISCO ADMINISTRATIVE REGION 3

	1951	1953
Trout	10.8	9.3
Blackbasses	19.7	21.6
Catfish	22.9	16.2
Panfish	16.3	22.3
Striped Bass	47.6	48.7
River Salmon	–	17.3
Steelhead	–	32.6

in streams and reservoirs suited to this type of management. In 1957, for instance, the scheduled allotment for the Bay Area included 381,000 catchable-size rainbow trout, 1,400,000 subcatchables, and 50,000 eastern brook trout fingerlings.

Usually trout streams near population centers are subjected to heavy angling pressure and are stocked regularly, provided the habitat is satisfactory and the return to the creel is reasonable. Numerous streams, too remote to be fished heavily, are stocked infrequently or not at all. Although such streams individually support relatively minor trout or steelhead populations, it is possible that they collectively shoulder much of the trout and steelhead angling pressure in the region. Their individual and minor character, however, makes them difficult or impractical to census and evaluate.

In a previous section of the report, it was shown that juvenile silver salmon and steelhead contribute substantially to angling in the Bay Area. Anglers frequently confuse these species with resident trout.

Many streams and lakes are not conducive to natural reproduction of game species, but nevertheless are valuable to the angling public. Thus, cool or fluctuating water-supply reservoirs which will not provide a satisfactory warmwater fishery can be stocked with trout and provide excellent angling, even though such habitat is not suitable for natural trout propagation because most trout require the cool running water of streams for spawning. Trout populations in heavily fished streams often cannot maintain sufficient levels of abundance through natural propagation and require supplemental stocks of fish.

Many of the freshwater lakes and streams of the Bay Area are located on, or flow through tracts of private land. Since most of them have not been open to the angling public, there has been little occasion to survey or stock them. Many of these streams support populations of resident trout and are spawning tributaries for steelhead.

As a means of outlining the freshwater fisheries of the San Francisco Bay Area, a county-by-county tabulation of the more important waters in each is provided.

In general, the freshwater fisheries fall into the five arbitrary categories listed in Table 40, and described below.

Trout Lakes: *These are in most cases water-storage reservoirs or other suitable impoundments under Department of Fish and Game management for trout stocking. A policy of the Fish and Game Commission provides that catchable-size trout be stocked only in those waters where a reasonably high (about 50 percent) percentage return of stocked fish may be expected. Normally, the suggested return can only be met under very intense angling pressures. Natural trout propagation in these lakes is generally lacking. There are a number of water supply reservoirs in the Bay Area with excellent potential as trout lakes and recreational areas, which are not now open to the public.*

Trout Streams: *This category includes most of the cooler freshwater streams capable of sustaining wild or catchable trout. Many are heavily stocked with catchable rainbow trout and thus provide an easily accessible source of angling near the metropolitan areas. Many of these streams support resident populations of rainbow trout, steelhead, silver salmon, and frequently brown trout. Most streams in this category are utilized in some capacity by silver salmon, steelhead, or trout for natural propagation. Smaller tributaries of an intermittent character may require fish salvage operations by Fish and Game crews when they dry up.*

Warmwater Lakes: *Reservoirs which seasonally become too warm for trout may support excellent populations of black bass, crappie, panfish or catfish, if a minimum pool is provided. There are a number of these in the Bay counties, especially in Santa Clara, Napa and Solano counties. These lakes may support heavy annual fishing pressure. After an initial stocking, they are normally maintained through natural propagation. Many impoundments suitable for warmwater fishing are public water supplies not open to angling at this time.*

Warmwater Streams: *Streams under this heading usually get too warm in the summer and fall to sustain most trout, although brown trout may occur in some of them. The fish population may consist of any combination of small-mouth black bass, crappie, catfish, panfish, and roughfish. Angling pressure on these waters is usually light to moderate.*

Miscellaneous Waters: *The waters in this category are highly variable and generally without a specific management program. They may contain either salmonid, warmwater or brackish water species. In some cases, there may be a minor seasonal fishery for trout or steelhead, in others, perhaps, a sparsely utilized population of warmwater fishes. Angling pressure may vary greatly.*

Three distinct habitat zones are usually evident in the larger tributaries of the Bay. These zones are ostensibly the result of variable salinity and temperature conditions.

Headwaters of the streams are usually pure and cold since they are fed primarily by winter runoff or springs. Such waters are especially suitable for trout and other salmonids. At medium and low elevations, air temperatures are usually much higher and stream flows modified to the extent that the water becomes progressively warmer as it flows downstream.

At some point the stream usually becomes more suitable for warmwater fishes than salmonids. Near the mouth, which is very near sea level, the water becomes brackish to saline and the species which inhabit it are either marine or unique to brackish conditions. Brack-

TABLE 40

TABULATION OF FISHING WATERS IN THE SAN FRANCISCO BAY AREA

County	Trout Lakes	Trout Streams	Warmwater Lakes	Warmwater Streams	Miscellaneous
Alameda	None	San Lorenzo Creek Alameda Creek Arroyo Mocho Creek Arroyo las Positas San Leandro Creek Arroyo del Valle Arroyo de la Laguna	Temescal Lake Calaveras Reservoir Lake Chabot San Leandro Reservoir	San Lorenzo Creek Alameda Creek Calaveras Creek	Calaveras Creek Lake Merritt
Contra Costa	None	Inadequate data to specifically isolate trout streams	San Pablo Reservoir[1] Martinez Reservoir[1] LaFayette Reservoir[1] Mallard Reservoir[1]	Castro Creek San Pablo Creek Walnut Creek	Castro Creek Pinole Creek San Pablo Creek San Ramon Creek Tassajara Creek LaFayette Creek Pacheco Creek Walnut Creek Alamo Creek Pine Creek Sycamore Creek Bear Creek
Marin	Alpine Lake Phoenix Lake Lagunitas Lake Bon Tempe Lake Rodeo Lagoon Kent Lake	Olema Creek Pine Gulch Creek Papermill (Lagunitas) Creek Arroyo Nicasio San Antonio	Novato Reservoir	Novato Creek	Novato Creek Rush Creek Gallinas Creek Crystal Lake Bass Lake Pelican Lake Abbott's Lagoon
Napa	None	Dry Creek Redwood Creek Conn Creek	Conn Valley Lake (Lake Hennessey) Rector Reservoir[1] Curry Lake[1] Milliken Reservoir[1]	Napa River Conn Creek	Leoma Lakes Soda Creek Moore Creek Mill Creek Napa River Napa Slough
San Francisco	Lake Merced	None	Stowe Lake	None	None
San Mateo	Pilarcitos Lake Higgins Creek Reservoir Upper Bean Hollow Lake	San Pedro Creek Tunitas Creek Denniston Creek Purissima Creek Gazos Creek San Gregorio Creek Butano Creek Pescadero Creek San Francisquito Creek	San Andreas Lake[1] Crystal Springs Reservoir Searsville Lake Lake Lucerne[1] Lower Bean Hollow Lake	San Francisquito Creek	Alpine Creek ElCorte de Madera Creek Deer Creek Frenchman's Creek LaHondo Creek Lobitas Creek Mindego Creek Pomponio Creek
Santa Clara	Stevens Creek Reservoir Austrian Reservoir[1] Lexington Reservoir Almaden Reservoir Guadalupe Reservoir	Arroyo Hondo Creek San Francisquito Creek	Felt Lake (Private) Calaveras Reservoir Calero Reservoir LeRoy Anderson Reservoir Coyote Reservoir	San Francisquito Creek Guadalupe River Coyote Creek Stevens Creek Los Gatos Creek	Guadalupe River Coyote Creek Stevens Creek Arroyo Bayo Packwood Creek Los Gatos Creek Williams Reservoir
Solano	None	Suisun Creek	Pine Lake (Private) Lake Herman[1] Lake Chabot Lake Madigan Lake Frey	Suisun Creek Ledgewood Creek Montezuma Slough	Ledgewood Creek Green Valley Creek Sulphur Springs Creek Montezuma Slough
Sonoma	None	None	Petaluma Reservoir[1]	Petaluma Creek Sonoma Creek	Petaluma Creek Sonoma Creek Tolay Creek Napa Slough Calabazas Creek Carriger Creek Adobe Creek

[1] Currently closed to public fishing.

ish portions of creeks and sloughs are frequented by striped bass, are permanent habitat for cottids, gobies, smelt and other forage species, and some are highways for anadromous species.

All listed waters contain forage and non-gamefish of one sort or another, some of which provide limited angling. It should be realized, of course, that some waters do not fit any of the above classifications while others might possibly fit into two or more.

SUMMARY BY COUNTY

Alameda County

Trout Lakes.

There are no trout lakes in the portion of Alameda County discussed in this report.

Trout Streams.

San Lorenzo Creek: This is a steelhead stream which is tributary to San Francisco Bay. It has the usual estuarine fauna near its mouth and trout in the headwaters. The creek has been modified greatly by man and is scheduled for further development. There is some question as to the effect of a recent channelization project on the steelhead runs. Angling pressure has not been investigated recently.

Alameda Creek: During the 1930's, this creek accommodated a steelhead run of fair quality. At the present time, it is managed as a catchable trout stream about 35,000 being planted there in 1957. Angling pressure is generally moderate.

Arroyo Mocho Creek: Like many other streams in the Region, Arroyo Mocho Creek has a small annual run of steelhead and a fairly good resident population of rainbow and brown trout. According to survey records of the 1940's, it received moderate angling pressure and produced nice catches of trout.

Arroyo las Positas, San Leandro Creek, Arroyo del Valle, Arroyo de la Laguna: These creeks contain resident trout populations and may accommodate steelhead. They have not been surveyed as to their present or potential fisheries value and are not under any specific management program.

Warmwater Lakes.

Temescal Lake: This small lake contains the usual warmwater assemblage of largemouth black bass, panfish, catfish and forage fishes. It was chemically treated in 1951 to remove roughfish. The lake receives heavy local use particularly by juveniles.

Calaveras Reservoir: Formerly this lake was characterized by a good annual run of rainbow trout from Arroyo Hondo Creek. Beginning about 1940, they began to disappear. The reason for the disappearance was thought to be the methods employed to control algae. The lake now contains a typical warmwater assemblage of fish, about which little is known. Since it is a water supply reservoir, it is currently closed to public fishing.

Lake Chabot, San Leandro Reservoir: These are water supply reservoirs of the East Bay Municipal Utility District, which is currently studying the possibility of opening some of its reservoirs to public fishing. They contain warmwater species of fish but are closed to public fishing at the present time.

Warmwater Streams.

There are no streams in the portion of Alameda County discussed in this report which could be referred to as typical warmwater streams. Warmwater species of fish, nevertheless, inhabit portions of the following: *San Lorenzo, Alameda, San Leandro,* and *Calaveras creeks.*

Miscellaneous Waters.

Calaveras Creek: Below Calaveras Reservoir there are mixed populations of trout and warmwater species. Angler use has not been investigated.

Lake Merritt: Situated within the city of Oakland, this tidal basin was designated a waterfowl sanctuary in 1869, reportedly the first in the United States. The fish population is limited to brackish water forms; namely, flounder, smelt, gobies, striped bass and sticklebacks. Children account for light to moderate fishing use of the lake. The lake would appear to be a recreational asset which has not been developed to its fullest potential.

Contra Costa County

Trout Lakes.

There are no trout lakes in the portion of Contra Costa County discussed in this report.

Trout Streams.

The streams in Contra Costa County have not been adequately investigated to permit the separate listing of trout streams. Most of the streams in the county are intermittent but nevertheless contain local trout populations. However, since data are not available to specifically isolate trout streams, they are included in the miscellaneous classification.

Warmwater Lakes.

San Pablo Reservoir: This water supply reservoir supports a population of warmwater fishes, and, in addition, is reported to contain striped bass. Its fisheries value is potential, since it is presently closed to the public.

Martinez, La Fayette, Mallard reservoirs: None of these reservoirs have been investigated to the writer's knowledge, but it is safe to say they contain warmwater fish populations. They are presently closed to the public and, therefore, must be considered as potential fisheries.

Warmwater Streams.

Castro, Pinole, San Pablo, Pacheco, and Walnut Creeks: The part of Contra Costa County encom-

passed by this report does not contain any typical warmwater streams. However, the lower drainages of these waters accommodate a variety of warmwater species.

Miscellaneous Waters.

Castro, Pinole, San Pablo, San Ramon, Tassajara, La Fayette, Pacheco, Walnut, Alamo, Pine, Sycamore, and Bear creeks: These are for the most part small intermittent creeks about which little information is available. Most contain natural trout populations and several have small runs of steelhead. Several have mixed populations of warmwater, game and forage fishes. Lack of data does not permit more detailed description.

Marin County

Trout Lakes.

Alpine Lake: This lake is managed by the Department of Fish and Game as a catchable trout water. Pre-season plants of about 10,000 fish are made each year. It is a large lake with inadequate angling pressure to warrant heavier stocking. However, in 1957, it also received 100,000 sub-catchable trout for experimental purposes. After heavy initial pressure at the beginning of the trout season, use becomes moderate to light. It is a potentially valuable reservoir, capable of heavier angling pressure.

Phoenix Lake: This is another catchable trout lake managed by the Department of Fish and Game. About 25,000 rainbow trout were stocked here in 1957. Plants are made throughout the season. Angling pressure is heavy even though there is a lack of facilities. Warmwater, gamefish, forage and roughfish inhabit and maintain themselves in the reservoir, but conditions are marginal for the gamefish.

Lagunitas Lake: This also is a catchable trout lake under State management. It receives about 30,000 fish each year of which an estimated 70 percent are caught by anglers. As the results indicate, it receives intense angling pressure. Like Phoenix Lake, it is marginal for warmwater species of which several kinds are present.

Bon Tempe Lake: Like the preceding three, this is a catchable trout lake managed by the State. In 1957, it received 15,000 catchable trout and an experimental plant of 50,000 sub-catchables. Angling is heavy initially but fades as the season progresses.

Rodeo Lagoon: This lagoon only recently was put under State management for catchable trout. About 5,000 fish were stocked in 1957. Recreational use is somewhat restricted since the lake is on a military reservation.

Kent Lake: This is a water supply reservoir under State management. It was allotted 100,000 sub-catchable trout in 1957. Like a number of the others, it receives heavy angling pressure at the beginning of trout season but progressively less thereafter. The lake has the normal assemblage of warmwater species but it is marginal for them.

Trout Streams.

Olema Creek: Natural populations of steelhead, silver salmon and resident rainbow trout are present in this stream. Its overall contribution to the Bay Area must be considered minor, but it is important to local anglers. In the past, dairy pollution was of sufficient severity to warrant an investigation by the Department of Fish and Game which resulted in action by the Regional Water Pollution Control Board. Fish passage structures are present in the creek.

Pine Gulch Creek: A small annual run of steelhead and a resident population of rainbow trout, about which little are known, occur in this stream. These populations maintain themselves without the aid of stocking. Angling pressure has not been measured.

Papermill (Lagunitas) Creek: This is one of the best steelhead and silver salmon streams in the Bay Area. Rainbow trout are also present. The natural spawning areas have been greatly reduced by numerous diversion dams. Angling is heavy during the winter when the steelhead run is on but overall use is moderate. Dairy pollution was severe at one time and still poses a threat to fishlife. Action was taken to clean up this problem at the same time as on Olema Creek.

Arroyo Nicasio: Self-sustaining populations of steelhead and resident rainbow trout occur in this stream. Angling pressure is moderate to low. Water development has been a problem on this stream. However, the developing agencies have been required to provide facilities for mitigation of damages to the resources.

San Antonio Creek: A natural population of rainbow trout and some steelhead are present in San Antonio Creek. Water development is also a problem on this stream. Angling pressure has not been measured but is presumably low.

Warmwater Lakes.

Novato Reservoir: This is a new reservoir being managed for largemouth black bass, bluegill and other warmwater species. The potential appears to be good, but it has not been fully evaluated yet as to its capability of sustaining a good natural population of warmwater fishes. Angling pressure is moderate.

Warmwater Streams.

Well defined warmwater streams do not exist in Marin County, although warmwater species occur in portions of Novato and Gallinas creeks.

Miscellaneous Waters.

Novato Creek: Near the mouth this is a typical brackish water slough which supports a striped bass fishery of fair quality and good waterfowl hunting. Above tidal influence, the fish population is negligible.

Hunting and fishing account for moderate use of the lower part of the creek. Domestic sewage is a constant threat to fish and wildlife. In 1953, a rather large kill of striped bass and carp occurred here.

Rush, Gallinas creeks: These are typical miscellaneous streams lacking survey data and without definite management programs.

Crystal, Bass, Pelican lakes: These are private lakes which have not been surveyed by the Department of Fish and Game.

Abbott's Lagoon: This is a private lagoon about which little is known except that striped bass have been reported from it.

Napa County

Trout Lakes.

There are no specifically managed trout lakes in the portion of Napa County covered by this report.

Trout Streams.

Dry Creek: A steelhead run and a resident population of rainbow trout occur in this creek. It is one of the best spawning tributaries for steelhead in the whole Napa River system. Angling use is minor and largely dependent upon the steelhead run. There are two low irrigation and domestic water diversion dams on the stream, each with a fish ladder.

Redwood (Napa) Creek: This is another tributary of the Napa River similar to Dry Creek. Although resident trout are present, the principal value of the stream is its use as a steelhead spawning tributary. The stream is intermittent in the lower reaches, but pools near the headwaters are maintained by springs where juvenile steelhead exist during the summer.

Conn Creek: Conn Creek is managed by the Department of Fish and Game primarily as a catchable trout stream, but a small self-propagating run of steelhead enters each year. During 1957, 11,000 trout were stocked here. Angling is generally moderate. A loose-rock dam which was put across the creek to form a small reservoir is stocked and reserved for the use of children.

Warmwater Lakes.

Conn Valley Lake, (Lake Hennessey): A water supply reservoir formerly managed for catchable trout, this lake now supports an assemblage of warmwater fishes including largemouth black bass, bluegills, green sunfish and crappie. It receives heavy angling pressure, is well policed, and is provided with a boat launching ramp and sanitary facilities. The fish population is self-sustaining. The lake is provided with rough-fish control structures at the inlets. Some trout are still taken; apparently they reproduce near the mouths of the tributaries.

Rector Reservoir: This is a water supply reservoir now closed to the public. The fishery was formerly managed by the State for catchable trout and rescued steelhead. It still contains a residual population of trout and roughfish.

Curry Lake, Milliken Reservoir: Like Rector Reservoir, these waters are closed to the public. They contain populations of warmwater fishes.

Warmwater Streams.

Conn Creek, Napa River, Napa Slough, Soda Creek: There are no well defined warmwater streams in the portion of Napa County discussed in this report. However, warmwater species do occur in the above named streams.

Miscellaneous Waters.

Leoma Lakes: These are a series of privately owned lakes which are used for domestic fish breeding purposes.

Soda Creek: Minor steelhead and resident rainbow trout populations maintain themselves in this creek but little is known about them. Angling pressure occurs during a short period each spring. Its value as a steelhead spawning tributary has not been investigated. There are water diversions on the stream but no fish facilities.

Moore, Mill Creeks: Both of these are small creeks which have not been surveyed and which do not have specific management programs.

Napa River: Although this river is classified miscellaneous, it is important to fishlife as well as the anglers who use it. The estuarine portion of the river to some distance above the city of Napa has furnished excellent striped bass angling. Above Napa, catfish, other warmwater species and resident trout are present. Steelhead pass up the river to spawning tributaries.

Below the city of Napa, the river was at one time one of the most favored striped bass fishing areas and a number of resorts were built to accommodate the fishery. It still receives moderate to heavy angling pressure. When the steelhead fishery was censused during the 1954-55 season, it was estimated that 1,508 angler days were spent here during January and February. Catch success was estimated at 0.28 fish per angler day.

Investigations have failed to reveal whether or not striped bass spawn in the river. However, plankton collections revealed tremendous numbers of eggs of other species, chiefly cottids and gobies.

The lower part of the river is used heavily by naval vessels, and freight barges which ply the river between its mouth and the city of Napa. A number of sources of pollution exist from Napa downstream. Domestic sewage has been the most aggravating. Above Napa, winery and dairy wastes are the principal pollution threats. Fish kills in the Napa River have not been uncommon in the past.

Napa Slough: The typical brackish water fauna occurs in this slough. Quantitative data on angler use are not available, but it may be assumed moderate. In addition, the slough runs through excellent waterfowl habitat and is used by many hunters each year. The State leases 5,000 acres adjoining it from the Leslie Salt Company for use as a waterfowl management area.

San Francisco County

Trout Lakes.

Lake Merced: This is a good trout lake managed by the Department of Fish and Game. Each year from 50,000 to 65,000 catchable-size trout are stocked in it. In 1957, the scheduled allotment included 50,000 catchables in the Lake Merced Impoundment, 260,000 fingerling rainbows and 50,000 eastern brook trout fingerlings in North Lake Merced, and 540,000 fingerlings in South Lake Merced.

The lake receives very heavy fishing pressure. Johnson (1957a) has analyzed the records from the boat fishery. His data are given in Table 41 for the years 1954, 1955 and 1956.

TABLE 41

STATISTICS OF THE LAKE MERCED BOAT FISHERY

Year	Angler Days	Total Catch	Mean Catch per Angler Day
1954	27,031	37,960	1.58
1955	26,740	65,526	2.40
1956	25,412	33,585	1.32

In a later report (1957b), Johnson used postal questionnaires to get an estimate of the amount of shore angling as compared to boat angling. It was determined that shore angling accounts for two to three times as much effort as the boat fishery. A total of 132,305 angler days were reported for both types of angling in 1956.

The lake is a standby water supply consisting of three artificial impoundments totaling 279 surface acres.

Trout Streams.

There are no trout streams as defined in San Francisco County.

Warmwater Lakes.

Stowe Lake: This and other small lakes in Golden Gate Park contain a variety of warmwater fishes and roughfish. Up to now a satisfactory combination of fish species to sustain a sport fishery has not been found. As a result, they are not presently of much value as recreational areas.

Warmwater Streams.

There are no warmwater streams in the county.

Miscellaneous Waters.

The only remaining waters in the county which might be included in this category are the sloughs along the shoreline.

San Mateo County

Trout Lakes.

Pilarcitos Lake: This lake is part of the San Francisco public water supply system and is closed to the public. It has 109 surface acres, and when surveyed in 1931, contained a good population of trout. Tributary streams are available for trout reproduction.

Higgins Creek Reservoir: The fishery at this private reservoir is managed by the State. In 1957, it received 6,000 catchable rainbow trout. Although too small to contribute appreciably to angling in the Bay Area, it is important to the local citizenry.

Upper Bean Hollow Lake: This is an irrigation water supply reservoir of about 50 surface acres. In 1957, it was stocked with 28,000 catchable rainbow trout. Angling pressure is moderate. Although angling is free, a fee is charged for parking.

Trout Streams.

Purissima, San Pedro, Tunitas creeks: These are small coastal streams utilized principally by natural steelhead populations. Angling is light.

Denniston Creek: Formerly managed for catchable-size trout, this creek was dropped from the program when a dam was constructed about a mile upstream from the mouth. Angler use is limited by the fact that the creek is bordered by private lands. It is of minor value for steelhead spawning since the dam is situated below the usable gravels. Angling pressure is negligible except at the beginning of the steelhead season.

Gazos Creek: This minor steelhead stream is also being managed under State's catchable trout program. Gazos Creek was stocked with 9,000 rainbow trout in 1957. During the 1930's, this creek was reported to have received heavy local use by anglers over a long season. It is now of minor value to anglers except for a short period during the winter when steelhead appear. Logging pollution has been a problem on Gazos Creek.

San Gregorio Creek: This is a moderately good steelhead stream for this area. The run is maintained through natural propagation. Resident trout are also present in the stream and support some angling. Angling pressure is heaviest during the winter steelhead season. During a January 1955 census, 188 angler days produced 51 steelhead.

Butano Creek: This is another small coastal stream with self-sustaining populations of steelhead, silver salmon and rainbow trout. Angler use is now limited by private lands which border the creek, but it was

formerly reported to receive heavy trout fishing pressure. Falls about five to six miles upstream presently limit its value for steelhead spawning.

Pescadero Creek: This is one of the best steelhead streams in the Bay Area. The headwaters in Portola State Park are stocked heavily with catchable trout, some 39,000 in 1957. Silver salmon also spawn in the creek. It receives heavy steelhead use and intense angling for catchable trout. The 1954-55 census indicated 2,281 angler days were spent to catch 249 steelhead.

San Francisquito Creek: Formerly a good steelhead stream, this creek has been greatly modified through man's activities. There still is a small run each year which must contend with adverse runoff conditions, pollution, and obstructions. Angling pressure depends to some extent on water conditions but must be considered light. Except during extreme high water, fish are unable to negotiate a dam which they must do to reach the spawning areas.

Warmwater Lakes.

San Andreas Lake, Crystal Springs Reservoir: Both of these are water supply reservoirs for the City of San Francisco and are presently closed to the public. Both contain good warmwater fish populations. Crystal Springs Reservoir has been a designated fish and game refuge for many years.

Searsville Lake: This small water supply reservoir contains a mixed population or largemouth black bass, panfish, and catfish. A boat rental concession has been established on the lake and angling pressure is heavy.

Lake Lucerne: Not much is known about this irrigation storage reservoir except that it contains the usual assemblage of warmwater species. Being a private lake, trespass problems are involved. It is another potential fishery, however.

Lower Bean Hollow Lake: After chemical treatment by the State, this irrigation storage reservoir was stocked with largemouth bass and panfish. Since it has only recently come under any form of management, its angling potential is not known. It appears to be marginal for warmwater species. Though privately owned, it is open to the public.

Warmwater Streams.

There are no well defined warmwater streams in San Mateo County. San Francisquito Creek, however, contains a limited population of forage, gamefish and roughfish species.

Miscellaneous Waters.

Alpine, El Corte Madera, Deer, Frenchman's, La Honda, Lobitas, Mindego, Pomponio Creeks: Each of these creeks contain resident trout populations and some are used by steelhead. However, they have not been specifically surveyed as to their present or potential fisheries value.

Santa Clara County

Trout Lakes.

Stevens Creek Reservoir: This is a water supply reservoir managed as a catchable trout fishery. It was chemically treated first to remove the roughfish before being stocked with trout of which about 27,000 were planted in 1957. The lake is very heavily fished.

Austrian Reservoir: Formerly managed as a catchable trout lake, this water supply reservoir is now closed to public use. Since its closure, the fish population has not been investigated.

Lexington Reservoir: This reservoir was stocked with 30,000 catchable size trout and 100,000 sub-catchables in 1957. Because the reservoir is drawn down severely each year, fishing is limited to the early part of the season, when it is possible at all. Angling pressure is heavy when the reservoir can be fished.

Guadalupe, Almaden Reservoirs: These are small reservoirs subject to severe annual drawdown. They are stocked with catchable-sized trout when water is available. Some warmwater fishes are present.

Trout Streams.

Arroyo Hondo Creek: Until the late 1940's, excellent rainbow and brown trout populations existed in this creek. The present status of the resource and the fishery is not known. Since it is almost completely bordered by private lands, public access is difficult.

San Francisquito Creek: (See San Mateo County).

Warmwater Lakes.

Felt Lake: This is a standby water supply and private reservoir under the management of Stanford University. It contains largemouth black bass, bluegills, and forage species and is used as an experimental pond by University fisheries personnel. It is closed to the public.

Calaveras Reservoir: (See Alameda County).

Calero Reservoir: This water supply reservoir undergoes too great a drawdown each year to support a stable year-around warmwater fishery but it sometimes furnishes angling early in the season.

Le Roy Anderson Reservoir: This reservoir supports one of the best warmwater fisheries in the Bay Area. It has a good population of largemouth bass, bluegills, black crappie and catfish. It is a water supply and as the lake lowers, angling pressure drops from intense early in the spring to light in the fall.

Coyote Reservoir: This is a major reservoir with a good warmwater fish population most years. It is subject to severe draw-down in dry years.

Warmwater Streams.

While there are no typical warmwater streams in Santa Clara County, the tributaries of the Bay in Santa Clara County provide angling for warmwater species.

Among these may be cited the Guadalupe River and Coyote and Los Gatos creeks.

Miscellaneous Waters.

Guadalupe River: The lower part of this river formerly was favored by striped bass, but they are rarely seen there now. Steelhead ascend the river and its tributaries to spawn during the runoff period, but there has also been a progressive decline in the size of the runs. Above Guadalupe Reservoir, the river and its tributaries support small, but locally important, trout populations. Steelhead reproduction occurs in the small tributaries below Guadalupe Dam and good populations of black bass, bluegill and catfish exist in ponds between tidewater and Guadalupe Dam.

Generally speaking, angling quality has been impaired by the degradation of the river. A serious pollution problem has existed in the lower section for many years and although much has been done to alleviate the situation, recent investigations indicate it is still unsatisfactory to fishlife. Pollution is most acute in the late summer during the peak of the canning season.

Coyote Creek: The description of the Guadalupe River is appropriate to Coyote Creek. Except for a considerably larger estuary, the two streams are similar. The same fish species inhabit the estuary and upstream areas. Pollution is also serious in the estuary of this creek.

Stevens Creek: Stevens Creek is similar to the above two except that the estuary is much smaller. The fishery is also less intense. The headwaters of the creek support a local trout fishery.

San Felipe, Penitencia, Packwood, Los Gatos creeks: These are small, mostly intermittent streams supporting local trout fisheries. They do not have a specific management program and have not been surveyed in detail.

Williams Reservoir: This is a small reservoir which usually dries up each year. It provides sporadic fishing.

Solano County

Trout Lakes.

There are no trout lakes in the portion of Solano County discussed in this report.

Trout Streams.

Suisun Creek: A small annual run of steelhead occurs in this creek as well as a limited number of resident trout.

Warmwater Lakes.

Lakes Madigan and *Frey:* These lakes are part of the City of Vallejo's water system. They were stocked with catchable trout from 1940 (except during World War II) until 1960. Angler use (and stocking) varied depending on the water level of the reservoirs and the period of time the City of Vallejo allowed fishing. The lakes were recently surveyed, (Kelley 1959) and were found to be unsuitable for trout management. Kelley recommended development of a warmwater fishery in both.

Pine Lake: This is a 15-acre lake on the property of the Benicia Arsenal. When last checked by the Department of Fish and Game, there were largemouth black bass, bluegill and small forage fishes present. Angling is restricted to military personnel.

Lake Herman: Lake Herman is a water supply reservoir for the City of Benicia. It contains the usual assemblage of warmwater species. The lake is now closed to public fishing, but was open in the past.

Lake Chabot: This is another water supply for the City of Vallejo. It supplies some angling for warmwater fishes but frequently goes dry and requires restocking.

Warmwater Streams.

Suisun, Green Valley, Ledgewood creeks: There are no typical warmwater streams in the portion of Solano County encompassed by this report, although warmwater game species are found in those listed above.

Miscellaneous Waters.

Ledgewood, Green Valley, Sulphur Springs creeks: These creeks are not under a specific management program and have not been surveyed. However, it is assumed they contain both warmwater and salmonid fishes. Angler use has not been investigated but all indications are that it is light.

Sonoma County

Trout Lakes.

There are no trout lakes of public significance in the portion of Sonoma County encompassed by this report.

Trout Streams.

There are no surveyed streams in this category, although unsurveyed tributaries of the larger creeks may possibly fit into this class.

Warmwater Lakes.

Petaluma Reservoir: This reservoir has the potential for development of a warmwater fishery, but it is not presently open to the public. It is a public water supply.

Warmwater Streams.

There are no specific warmwater streams within the portion of Sonoma County encompassed by this report. However, sections of the larger creeks and sloughs above tidal influence contain good populations of catfish, carp, largemouth bass and panfish. Such waters include: Petaluma, Sonoma, and Tolay creeks, Napa Slough, Second and Third Napa Sloughs.

Miscellaneous Waters.

Petaluma Creek: Near the mouth, this creek supports the typical brackish water fauna with striped bass be-

ing the principal game species. Catfish and other warm-water species are present above tidal influence. Some steelhead ascend the creek to upstream tributaries to spawn. Angling and recreational use has not been measured but it is probably minor. Waterfowl and waterfowl hunters also use the creek to some extent. Petaluma Creek is navigable water and receives wastes from both river traffic and shore installations.

Sonoma Creek: The fish fauna of Sonoma Creek near the Bay and into freshwater is similar to Petaluma Creek and seasonally provides excellent striped bass fishing. Above the City of Sonoma, there are steelhead and catchable trout fisheries. Some 5,000 trout are stocked annually. The creek receives moderate local use in the upper section where it is bordered by private lands. The fishery in this area is generally during the summer, although there is a minor winter steelhead fishery also. The Valley of the Moon Recreation District, located on Sonoma Creek, operates a small recreational angling impoundment. The riffles in the upper part of the creek are utilized by steelhead during the spawning period. As at Petaluma Creek, waterfowl utilize the lower part during the winter and some hunting takes place. Dairy and winery wastes are potential pollution threats

Tolay Creek: This creek may be assumed to be similar to the preceding two in the lower section, but on a smaller scale and without the steelhead or trout fisheries

Napa Slough: (See Napa County).

Calabazas Creek: Not much is known about the general fish population of this creek. However, it does have a small annual run of steelhead and is used by them for spawning. Recreational use is limited to summer fishing for juvenile steelhead.

Carriger Creek: This creek supports a minor but locally important steelhead fishery. A fish ladder is present and the stream is included in the State's fish rescue program.

Adobe Creek: The fish population and angling use made of this creek are not well known, although it accommodates a small run of steelhead each year.

FRESHWATER FISHERIES REFERENCES

Allen, K. Radway
1949. The Objects of Freshwater Fisheries Research. Proceedings, Seventh Pacific Science Congress, Vol. 4, pp. 556-562.

Calhoun, A. J.
1950. California Angling Catch Records from Postal Card Surveys: 1936-1948: With an Evaluation of Postal Card Nonresponse. California Fish and Game, Vol. 36, No. 3, pp. 177-234.
1951. California State-Wide Angling Estimates for 1949. California Fish and Game, Vol. 37, No. 1, pp. 69-75.
1953. State-Wide California Angling Estimates for 1951. California Fish and Game, Vol. 39, No. 1, pp. 103-113.

Cope, Oliver B. and Leo F. Erkkila
1952. Weekday Angling Pressure in the Sacramento-San Joaquin Delta, 1948 and 1949. California Fish and Game, Vol. 38, No. 1, pp. 73-84.

Curtis, Brian
1939. Anglers' Catch Records in California. Trans. Am. Fish Soc., Vol. 69, pp. 125-131.
1941. Creel Counts in California. California Fish and Game, Vol. 27, No. 3, pp. 185-189.
1942. The General Situation and the Biological Effects of the Introduction of Alien Fishes into California Waters. California Fish and Game, Vol. 28, No. 1, pp. 2-8.
1949. The Warm Water Game Fishes of California. California Fish and Game; Vol. 35, No. 4, pp. 255-273. (Revised 1954)

Davis, H. S.
1956. Culture and Diseases of Game Fishes. University of California Press, Berkeley and Los Angeles. 332 p. illustrated.

Fisher, C. K.
1957. The 1954-55 Steelhead Fisheries in Region 3 Streams, Based on Angler Census Conducted by Wildlife Protection Officers. Administrative Report in preparation, California Department of Fish and Game.

Hatton, S. Ross
1940. Progress Report on the Central Valley Fisheries Investigations, 1939. California Fish and Game, Vol. 26, No. 4, pp. 334-373.

Hatton, S. Ross and G. H. Clark
1942. A Second Progress Report on the Central Valley Fisheries Investigations. California Fish and Game, Vol. 28, No. 2, pp. 116-123.

Hubbs, Carl L. and Karl F. Lagler
1949. Fishes of the Great Lakes Region. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 186 pp. illustrated.

Job, S. V.
1955. The Oxygen Consumption of Salvelinus Fontinalis University of Toronto Biological Series #61. University of Toronto Press.

Johnson, William C.
1957a. Sampling Fishing Success by Postal Card Questionnaires at Lake Merced, San Francisco County—1956. California Department of Fish and Game, Inland Fisheries Branch Administrative Report No. 57-12, 6 pp. mimeo.
1957b. Lake Merced Boat Catch Records in 1956 and Their Reflection on the Lake's Fisheries Management Program. California Department of Fish and Game, Inland Fisheries Branch Administrative Report No. 57-17, 9 pp. mimeo.

Kelly, D. W.
1959. Investigation at Frey and Modigan Reservoirs, Solano County with Recommendations for Improvement of the Fishery. California Department of Fish and Game, Administrative Report No. 60-4.

Kimsey, J. B.
1958. Possible Effects of Introducing Threadfin Shad (*Dorosoma petenensis*) into the Sacramento-San Joaquin Delta. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report 58-16.

Kimsey, J. B. and Leonard O. Fish
1960. Keys to the Freshwater and Anadromous Fishes of California. California Fish and Game, Vol. 46, No. 4, pp. 453-479.

Lagler, Karl F.
1952. Freshwater Fishery Biology. Wm. C. Brown Company, Dubuque, Iowa, 360 pp. illustrated.

Morgan, Ann Haven, Ph.D.
1930. Field Book of Ponds and Streams. G. P. Putnam's Sons, New York, London; 448 pp. illustrated.

Murphy, Garth I.
1941. A Key to the Fishes of the Sacramento-San Joaquin Basin. California Fish and Game, Vol. 27, No. 3, pp. 165-171.

Neale, George
1915. The Catfish in California. California Fish and Game, Vol. 1, No. 2, p. 62.

Needham, Paul R., Ph.D.
1938. Trout Streams. Comstock Publishing Co., Ithaca, New York. 233 pp. illustrated.

Rounsefell, George A. and W. Harry Everhart
1953. Fishery Science. Its Methods and Applications. John Wiley & Sons, Inc., New York. 444 pp. illustrated.

Ryan, James H.
1959. California Inland Angling Estimates for 1954, 1956 and 1957. California Fish and Game, Vol. 45, No. 2, pp. 93-109.

Shapovalov, Leo and William A. Dill
1950. A Checklist of the Freshwater and Anadromous Fishes of California. California Fish and Game, Vol. 36, No. 4, pp. 382-391.

Shapovalov, Leo, William A. Dill and Almo J. Cordone
1959. A Revised Check List of the Freshwater and Anadromous Fishes of California. California Fish and Game Vol. 45 No. 3 pp. 159-180.

Shebley, W. H.
1917. History of Introduction of Food and Game Fishes Into the Waters of California. California Fish and Game, Vol. 3, No. 1, pp. 1-12.
1922. A History of Fish Cultural Operations in California. California Fish and Game, Vol. 8, No. 2, pp. 61-99.
1927. History of Fish Planting in California. California Fish and Game, Vol. 13, No. 3, pp. 163-174.

Skinner, John E.
1955. California State-Wide Angling Estimates for 1953. California Fish and Game, Vol. 41, No. 1, pp. 19-32.

Snyder, John Otterbein
1905. Notes on the Fishes of the Streams Flowing into San Francisco Bay, California. U. S. Department of Commerce and Labor, Bureau of Fisheries, Appendix to Report of the Commissioner of Fisheries for 1904.
1916. The Fishes of the Streams Tributary to Tomales Bay, California. Bulletin of the U. S. Bureau of Fisheries. Vol. XXXIV, 1914, Document No. 825.
1933. California Trout. California Fish and Game, Vol. 19, No. 2 pp. 81-112.
1940. The Trouts of California. California Fish and Game Vol. 26, No. 2, pp. 95-114.

Wales, J. H.
1957. Trout of California. California Department of Fish and Game, State Printing Office, Sacramento. 56 pp. illustrated.

Welch Paul S.
1935. Limnolgy. McGraw-Hill Book Company, Inc. New York. 471 pp. illustrated.
1948. Limnological Methods. The Blakiston Company, Philadelphia—Toronto. 381 pp. illustrated.

Wohlschlag, Donald E.
1952. Estimation of Fish Population in a Fluctuating Reservoir. California Fish and Game, Vol. 38, No. 1, pp. 63-72.

C—043318

C-043319

GAME BIRDS

WATERFOWL

Historical Account

The accounts of early Spanish, British and American explorers is replete with references to the hordes of waterfowl which once dominated the marsh and wetlands of California. This State has been the historical wintering ground for the major share of the migratory waterfowl of the Pacific Flyway. Great fall flights on their way from Alaska, Canada and Siberia routinely stop at the Klamath Lakes on the California-Oregon border and other suitable areas of the high plateau country of Modoc and Lassen counties. These serve as resting areas until weather conditions force them further south. Principal wintering areas were Buena Vista and Tulare lakes, the overflow lands south of the Tehachapi's, Owens Valley, and the Colorado River. The most expansive area, however, was the hundreds of thousands of acres of marshes, overflow lands and waterways of the Sacramento-San Joaquin Valley, the Delta and the San Francisco Bay Area.

With the advent of the American occupation, large-bore guns, and animal blinds, waterfowl and marsh birds were literally shot by the millions for sport, table and market. In the early literature there is frequent reference to the abundance of ducks and geese in the Sacramento and San Joaquin Valleys and the Delta Area, and the ease with which they were killed. As a matter of fact, waterfowl for the market proved to be such a profitable venture and reached such magnitude, that game birds became the major trade constituent of the so-called game transfer companies of San Francisco.

Offshore, the Farallon Islands provided an ideal situation for gulls, terns, and other far ranging birds common to the Pacific Coast. An item in Hutching's California Magazine (1856, No. 2, Page 53) reported that between 1850 and August 1856, the Farallon Egg Company had taken between three and four million murre or foolish guillemot eggs from the Farallons to the San Francisco markets.

The variety of habitats in the Bay and Delta was conducive to an assortment of species. Open areas of the Bay accommodated the diving ducks while the marshes and sloughs attracted puddler ducks. Shore birds were abundant on the tidal flats and in the marshes.

The marshes of the Bay and Delta were formerly used extensively as breeding areas for resident puddler ducks. The tidal flats and overflow lands provided an abundant supply of food for them.

Appendix G-1 lists the most common waterfowl, shore and upland game birds of the Bay Area.

The following quote from an early biennial report is indicative of the Fish and Game Commission's views concerning the waterfowl in the Delta: "That portion of the Sacramento and San Joaquin Delta before the era of reclamation was a veritable paradise for wild fowl, and to a great extent still furnishes a food supply for a large number of ducks, geese, swan, sandhill cranes, and other waterfowl. All the reeds, seeds, bulbs, and succulent water grasses, except rice, known to the eastern and middle states and classified by the Department of Agriculture grow in the greatest luxuriance. Many varieties of roots and grasses which I am unable to identify are also much in evidence. The most important of these duck foods are the two varieties of what is known locally as tule potatoes, or bulbs and classified as *Sagittaria latifolia* and *Sagittaria arifolia.* These tubers grow in such quantities in the Sacramento Delta that many tons are annually dug by Chinese and shipped to San Francisco for the Japanese and Chinese, by whom they are highly prized for food. There is the wild millet, the sago weed, known locally as gray duck food, perch grass weed, known as the yellow lily pad (*Nymphae flava*) seed, which is very abundant in some localities and furnishes a great amount of food, especially favored by wood ducks, and many other seed bearing grasses, too numerous to mention.

"The variety of food on which wild ducks feed depends entirely on the depth of water. All the deep water or sea ducks [divers] are able to procure their food at from one to ten feet of water, while the waders [puddlers], mallard, sprig, teal, etc., feed on what can be obtained in shallow water, at from a few inches to two feet, or on what remains on the surface after being pulled loose by the diving ducks. *Wild celery* has been introduced in several parts of California, but so far with little success, owing, no doubt, to a lack of knowledge of the conditions necessary to insure its successful growth."

That the Bay and Delta area was a veritable paradise for all forms of waterfowl can scarcely be doubted. Each fall multitudes of ducks and geese would appear from the north to winter on the many thousands of acres of prime waterfowl habitat within and adjacent to the Bay Area. Those areas most heavily used were the vast marshlands on the east and south shores of San Francisco Bay and on the north shores of San Pablo and Suisun Bays. From early accounts, the vicinity of Alvarado appears to have been the most fabulous, followed closely by the Suisun and Napa marshes.

To the misfortune of waterfowl, their habitat is often too easily converted into agriculture land. The

C—043319

C-043320

FIGURE 42. Ducks, geese and whistling swans on wintering grounds. Habitat such as that shown in the photo must be preserved and developed to assure waterfowl for the future. Photo courtesy U.S. Fish and Wildlife Service.

amount of immediately arable land in California was extremely limited and reclamation was inevitable. In rapid succession the Klamath Lake region, Buena Vista and Tulare lakes were drained and reclaimed. Owens Valley was dried up and the overflow lands along the Colorado River eventually eliminated. The marshes along the waterways of the Sacramento-San Joaquin Delta have long since been diked, drained, and the fertile soil put under intensive agriculture. The extensive marshlands bordering South San Francisco Bay were diked and turned into salt evaporation ponds as early as 1879. During a period of about fifty years, all major waterfowl areas were vastly reduced and, in some cases, completely lost.

In contrast to the reclamation picture elsewhere was the formation of the Salton Sea in Imperial County, in 1905 and 1906, when the Colorado River overflowed, creating a large waterfowl wintering area in the desert.

Reclamation was not as complete in the Bay Area as in other localities, but the most important area was lost when the Alvarado marshes were reclaimed for salt production. In the Santa Clara Valley, the loss of waterfowl habitat was offset to a considerable extent when the land was put into grain thereby providing an ideal food supply for wintering waterfowl populations.

Records of the abundance of waterfowl during this period are sparse but scattered reports from game transfer companies and the Fish and Game Commission indicate a large reduction occurred.

Grinnel et al, (1918), in "Game Birds of California" state:

"The array of evidence above given shows beyond question that waterfowl and upland game birds have both on the average decreased by fully one-half within the past forty years. The causes of this decrease are many and diverse, but all are due in last analysis to the settlement of the State by the white man. Some of these factors, such as excessive hunting and sale of game, are subject to control; but those, such as reclamation of land and overhead wires, are inevitable."

They also pointed out the serious threat of oil pollution to waterfowl in portions of the San Joaquin Valley and noted particularly the hazardous practice of dumping oil wastes into bays and estuaries. Cases of waterfowl being washed up along the San Mateo and Marin shores due to the flushing of the tanks of oil ships were common at that time.

About 1900, according to game transfer company records, the San Francisco markets handled a minimum of 250,000 ducks annually. In the 1895-96 season, the average price per duck was about 25 cents. During the 1911-12 season, over 300,000 ducks were sold in the San Francisco markets according to the Fish and Game Commission in its 24th biennial report. The average price at this time had increased to 50 cents, but often went as high as 80 cents. Grinnel et al (*op cit*) cite figures showing 47,565 mallard ducks alone were sold in the San Francisco markets in the winter of 1895-96. One reference indicated that about 1,000 ducks a week being taken from the Alvarado marshes as late as 1913-14.

The Fish and Game Commissioners in their report for the years 1910-12 were obviously concerned over the decrease in the waterfowl population. In the 1912-14 report, the Commissioners, in attempting to bring about legislation to prohibit market hunting stated: "During the season three years ago there were fully 250,000 wild ducks brought into the San Francisco market for sale."

The best figures to be obtained from this period are from the 14th biennial report of the State Board of Fish Commissioners. The numbers of waterfowl and upland game passing through the San Francisco and Los Angeles markets for the 1895-96 season are shown in Appendix G-2. A total of 501,171 waterfowl, upland game, and shore birds worth $62,362 passed through these markets. The species were tabulated by counties; and it is, therefore, possible to obtain the proportion of each contributed by the Bay counties to the total. These amounted to about 13 percent of the ducks, 9 percent of the geese, quail, doves and pigeons, and 14 percent of the shore birds.

The Commission pointed out, "The money values [$62,362] here presented are the amounts received by the hunters, to which should be added the profits of the jobber and retailer.

"To these figures must also be added the large amount of game which goes directly to the tables of our people, furnished by the army of sportsmen.

"This amount of game is considerable as a food supply, comprising 332,630 pounds of ducks, 37,880 pounds of quail, doves, pigeons, lark, rail, and snipe, and 175,444 pounds of geese, etc. For several reasons, these figures do not represent the true commercial value of our game, chiefly because the season was such an unsettled once, and because it has been impossible to reach all the market centers."

In all probability, the kill for local markets and by private citizens for their own sport and table use was far in excess of the numbers reaching these two market centers.

From about 1905 on, there was increasing public sentiment about the plight of the State's waterfowl, particularly in the San Francisco Bay Area. Controversy revolved around market hunting activities, and the game transfer companies which depended so heavily on waterfowl. This controversy finally culminated in legislative action in 1915 prohibiting the sale of waterfowl.

1915 to Present

The continuing downward trend of all of California's game species, resulted in a change of philosophy shortly after 1900. Wildlife protection received added impetus, restrictive legislation was enacted and a number of refuges were established. About 1913,

emphasis was placed on scientific investigation and public education.

Most shorebirds were put on the protected list, market hunting for deer was prohibited and the sale of waterfowl was banned. Wildlife and domestic stock were given added protection with the enactment of a law providing the payment of bounties for predatory species.

Refuges: The greatest benefit to waterfowl came through the establishment of definite areas in strategic locations throughout the State as wintering or resting areas. Reclamation eliminated thousands of acres of valuable waterfowl habitat and continues to do so; but, fortunately, State and Federal agencies have developed and enlarged specific waterfowl habitat areas. Presently, crops are grown on these areas to provide food and prevent serious depredation on private agricultural lands.

Few natural major waterfowl areas remain other than those now specifically designated as refuges and waterfowl management areas. These refuges and management areas are shown in Figure 44. The largest and most important natural area at the present time, not so designated, is San Francisco Bay and the Delta. Hunting is not normally permitted on refuges, while it is on management areas.

As of 1957, there were 19 designated waterfowl areas within the State totaling 202,017 acres and two others located along the Colorado River. Ten of these areas, comprising 54,471 acres, are State-owned or leased.

Three of the State waterfowl areas are located within the Bay Area; the Napa Marshes, 5,000 acres, Suisun Refuge located on Joice Island, 1,887 acres, and Grizzly Island Waterfowl Management area, 8,600 acres. In addition, there is the San Leandro Waterfowl Refuge located on San Leandro Bay, Alameda County, and the Mt. Tamalpais Game Refuge which includes most of Richardson's Bay, Marin County. Lake Merritt in Oakland, Alameda County, is a locally managed waterfowl refuge and Crystal Springs Reservoir, San Mateo County is designated as the San Francisco Fish and Game Refuge.

Reclamation and Land Use

South Bay. Reclamation in the South Bay area has gradually eliminated most of the best waterfowl habitat. Studies by the State Department of Water Resources indicate the extent of reclamation in the Bay Area thus far. In an unpublished report of the State Division of Water Resources, 1951, Wing makes the following statements: "In the South Bay area practically all the former marsh lands have either been occupied and reclaimed or are being held for future reclamation as salt evaporating ponds. In the North Bay, the only remaining marsh areas [,] located at the outlets of small creeks in Marin County [,] are now [being] reclaimed for residential purposes. Extensive areas of unreclaimed marsh land lie along the north shore of San Pablo Bay and are utilized for agricultural purposes. In the San Francisco and East Bay areas reclamation has already extended across the tidelands and into the areas of submerged land."

Wing lists the acreages shown in Table 42 as reclaimable lands in the South Bay area. Table 43 provides data on the amount of land controlled by salt interests.

TABLE 42

LAND RECLAMATION IN THE BAY AREA

Tidelands	30,800 acres
Lands submerged less than 6 feet	31,520 acres
Total	62,320 acres
Marshland (already reclaimed)	74,000 acres
Grand Total	136,320 acres

TABLE 43

ACREAGE IN THE BAY AREA CONTROLLED BY SALT INTERESTS [1]

County	Acreage in Production	Other Lands	Totals
Alameda	17,460	8,600	26,060
Santa Clara	7,600	—	7,600
San Mateo	6,725	3,258	9,983
Sonoma	40	—	40
Napa	5,700	5,000 [2]	10,700
Totals	37,525	16,858	54,383

[1] Information obtained through courtesy of county assessors.
[2] Area leased by Department of Fish and Game from Leslie Salt Company for waterfowl management area.

North Bay. A later report by the Department of Water Resources, Appendix E to the Salt Water Barrier study, provides information on the extent and present development of marsh lands in the North Bay area:

"The survey, fall 1953, determined the gross area of the marsh lands between the Point San Pablo Barrier site and the confluence of the Sacramento and San Joaquin Rivers at Collinsville to be 131,400 acres, the great majority of which lies on the north side of the bays. About 53 percent of the total marsh land area is located in the vicinity of Suisun Bay and 47 percent borders San Pablo Bay."

"Almost 86 percent of the marsh lands are classified as leveed lands." As Table 48 shows, 112,600 acres are leveed and 18,800 are not.

The type of vegetation and present use of these lands are shown in Tables 49 and 50 which were taken from Appendix E of the Department of Water Resources Report on Feasibility of Bay Barriers.

The use of lands for salt evaporating ponds is not as extensive here as in the South Bay, although 9,200 [1]

[1] There is an unresolved discrepancy of about 1,500 acres between this estimate by the Department of Water Resources and the acreage reported in Table 43.

PACIFIC FLYWAY
Showing Fall Migration Routes

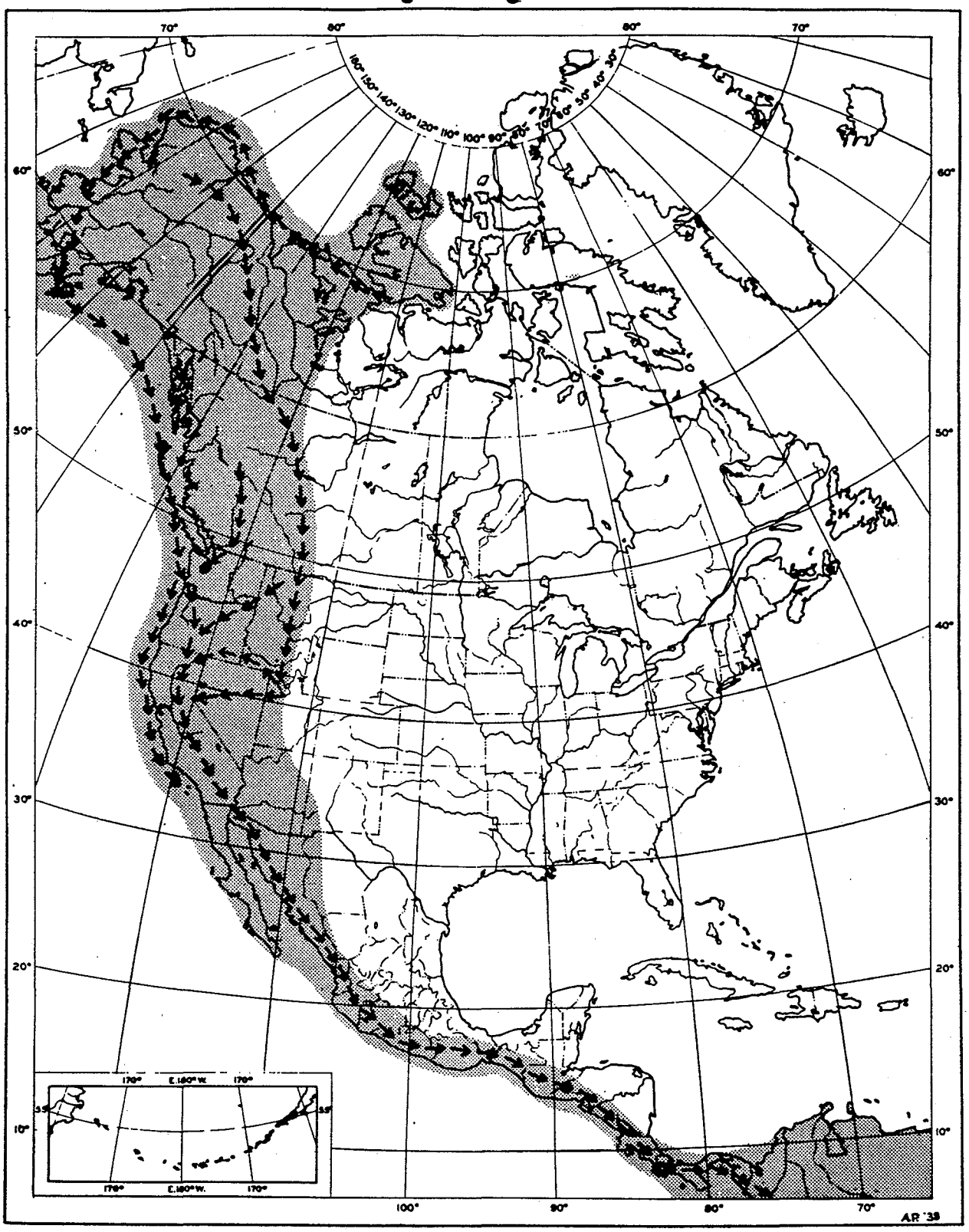


FIGURE 43. Pacific flyway waterfowl migration routes.

acres have been allocated for this purpose and this use may be expected to expand.

Waterfowl Habitat

The U. S. Fish and Wildlife Service (1951) inventoried the important waterfowl areas of the State in two separate reports. One concerns the wetlands, and the other permanent waters of importance to waterfowl.

The Service estimated there are 559,302 acres of wetlands and 613,495 acres of permanent waters of importance to waterfowl in California. Of these totals, the Bay Area accounts for 26.4 percent of the wetlands and 45.2 percent or almost half of the permanent waters. The distribution of this land and water is presented by counties in Table 44.

TABLE 44

WETLANDS AND PERMANENT WATERS OF IMPORTANCE TO WATERFOWL

County	Wetlands (In Acres)	Permanent Waters (In Acres)
Alameda	28,747	47,385
Contra Costa	16,789	39,248
Marin	12,077	68,450
Napa	4,982	470
San Francisco	—	29,250
San Mateo	13,518	3,205
Santa Clara	11,400	49,592
Solano	50,868	31,265
Sonoma	9,103	8,200
Totals for Bay Area	147,484	277,065
Totals for State	559,302	613,495
Bay Area as percentage of State Total	26.4	45.2

Wintering Areas

Annual surveys by Department of Fish and Game and U. S. Fish and Wildlife Service waterfowl biologists have established the relative importance of different sections of the Bay Area according to their use by waterfowl. The wintering areas in order of importance to ducks at the present time are:

1. *The Suisun Marshes (Benicia to Collinsville)*
2. *The Delta Area*
3. *The North Bay Area: Within this latter area specific locations in descending order of importance are: San Pablo Bay and marshes, Napa marshes, Petaluma marshes, Richardson Bay and the North Bay itself.*
4. *South Bay Area: Within this general area specific locations in descending order of importance are: Alviso Slough, Alvarado, Alameda Creek, Stevens Creek, Palo Alto area, the west portion of the Bay between Dumbarton and San Mateo bridges and the East Bay Area.*

Geese are much less common than ducks although up to 40 percent of the wintering population has been enumerated in the Bay Area. The most important wintering area for these large birds is the Suisun marshes, but a few generally winter in the North Bay marshes also.

The Pacific black brant (*Branta nigricans*) is a unique migratory bird. It breeds along the Bering Sea and Arctic coasts of North America and in northeastern Asia. It is strictly a coastal species and is extremely selective, utilizing the large beds of eelgrass (*Zostera marina*) characteristic of shallow coastal bays. The Pacific black brant winters all along the Pacific Coast from southern Alaska to and including Mexico. The entire wintering population averages about 200,000 birds annually, of which approximately 25 percent winter in California. Of those wintering in California about one-quarter prefer Bay Area waters, principally Tomales, Bolinas and Bodega bays and Drakes Estero.

The annual waterfowl inventories have been conducted on a standard basis since 1953 and present a rather accurate picture of birds wintering throughout the State. The state-wide estimate is a composite of the counts made on known wintering grounds in each county. They are made by ground and aerial observers and aerial photographs. The observers maintain separate records for each of the more important species. Counts of the major groups of waterfowl for the years 1953 through 1961 are given in Appendix G-3.

Since these inventories were initiated, the Bay Area has wintered an average of 15 percent of the ducks, 10 percent of the geese, 26 percent of the brants and swans combined and 18 percent of the coots. The actual percentage varies considerably from year to year due to climatic conditions. In 1957, for example, the Bay Area accounted for 42 percent of the ducks and geese, 29 percent of the brant and swans and 35 percent of the coots.

Of the nine Bay counties, Solano County with the Suisun marshes consistently harbors the most birds, followed by Contra Costa and Alameda counties.

The principal species of ducks wintering in the Bay Area are ranked according to their order of abundance in Table 45.

TABLE 45

PRINCIPAL SPECIES OF DUCKS WINTERING IN THE SAN FRANCISCO BAY AREA IN RANKING ORDER OF ABUNDANCE

Pintail (sprig)	Canvasback
Baldpate	Scaup
Mallard	Gadwall
Shovelers	Buffleheads
Greenwing teal	Scoters
Ruddy duck	

Breeding Areas

The Bay Area formerly was an important breeding area for resident ducks as well as a wintering area for migratory birds, particularly the South Bay marshes

from Hayward all along the south shoreline to San Mateo County. This area is now largely in salt ponds. The best breeding area left is the Suisun marshes, although the marshes north of San Pablo Bay are used to some extent.

An annual census is made of the breeding population in the Suisun Marshes. Surveys of the other areas are not considered practical because of the scarcity of breeding birds. Between 1953 and 1957 the Suisun Marshes were used by an estimated 2,000 pairs of breeding ducks. The average brood consists of about five ducklings. Various mortality factors take a heavy toll of the small ducklings.

Anderson (1960) conducted a duck nesting study of the Suisun marshes in 1959 and found the nesting population to be low, encountering but 63 nests on nine sample areas totaling 2,420 acres. Mallard and cinnamon teal were the principal species using the area. "Fluctuating water levels, extensive stands of tules and cattails and cracks in peat soils . . . along with predation . . ." are listed as factors adversely affecting nesting.

The species utilizing the area for breeding in general order of importance are: mallard, gadwall, cinnamon teal, ruddy ducks, and shovelers.

The Bay Area is unimportant as a breeding area for geese, swans, and brant.

Hunter Use and Economics

Ultimately, the preservation of our waterfowl resource will depend on man's desire to retain it for aesthetic and recreational purposes and to a lesser extent as food. Other things being equal, waterfowl abundance is directly related to habitat conditions. Therefore, man's willingness to preserve and enhance the habitat will govern the fate of the resource. Certainly the present sporting interest and economics generated by the waterfowl portend the public desire to preserve and enhance these resources.

Hunter Use. An idea of the importance of waterfowl as a form of sporting recreation to Bay Area residents can be obtained from records maintained at the 8,600 acre Grizzly Island Waterfowl Management Area. Hunters are checked at this station as they go in and out and the numbers using the area are regulated. The area was acquired by the State in 1949 through Wildlife Conservation Board funds.

During the 1950-51 season when a total of 3,897 acres were open to hunting, 4,564 hunters bagged 4,897 ducks and geese. By the 1958-59 season, 5,000 acres were open and the number of hunters had increased to 15,859. Their total kill was 42,135 ducks and geese. This represents more than a tripling in hunter numbers and an almost tenfold increase in the bag. There were 45 shooting days (Saturday, Sunday, Wednesday, and holidays only) during the 1958-59 season, each averaging 352 hunters and 936 birds.

This waterfowl management area consistently yields the greatest number of birds of any such area in the State. During the 1956-57 season, for instance, the total kill on this area was 50,391 birds as compared to 21,460 taken at Mendota, the next best area. Much of the difference, of course, can be attributed to the greater number of hunters using the Grizzly Island area, 14,829 as compared to 7,764 at the Mendota area. Statistics for other years are provided in Table 46.

TABLE 46

HUNTER USE AND WATERFOWL KILL ON GRIZZLY ISLAND WATERFOWL MANAGEMENT AREA 1950-60

Year	Number Shooting Days	Number Hunter Days	Number Waterfowl Shot	Average Number Birds per Hunter per Day
1950-51	25	4,564	4,897	1.1
1951-52	30	9,646	17,723	1.8
1952-53	35	16,047	44,126	2.8
1953-54	32	11,936	41,218	3.5
1954-55	33	8,223	24,853	3.8
1955-56[1]	23	9,824	33,448	3.4
1956-57	38	12,959	43,463	3.4
1957-58	42	14,829	50,391	3.4
1958-59	45	15,857	42,135	2.7
1959-60	43	11,571	20,382	1.8

[1] The winter floods of 1955-56 were responsible for the reduction in the number of hunting days, use, and total kill.

Grizzly Island is the most heavily used state management area, accommodating two to three times the number of hunters using other such areas in the State. The area is used principally by local hunters, as Table 47 indicates. In the 1953-54 season, for example, 92 percent of the hunters were from the nine Bay Area counties.

TABLE 47

RESIDENCY OF HUNTERS USING GRIZZLY ISLAND WATERFOWL MANAGEMENT AREA (1953-54 SEASON)

	Number Hunters	Percentage
Nine Bay counties	11,054	92.6
Rest of State	800	6.7
Unidentified	82	.7
Total	11,936	100.0

An estimate of the total waterfowl bag for the State has been obtained each year since 1948 by means of postal questionnaires. These questionnaires are sent to a random sample of the State's licensed hunters, asking the number of days hunted, the kind and number of waterfowl bagged and area hunted. The figures reported on these questionnaires are somewhat exaggerated but they provide an overall picture of the annual trends in waterfowl hunting and a good idea of the state-wide distribution of the kill.

The records indicate the Bay Area consistently produces about 25 percent of the state-wide duck total, and 5 to 10 percent of the geese. The number of ducks

FIG. 44

CALIFORNIA WATERFOWL MANAGEMENT AND REFUGE AREAS

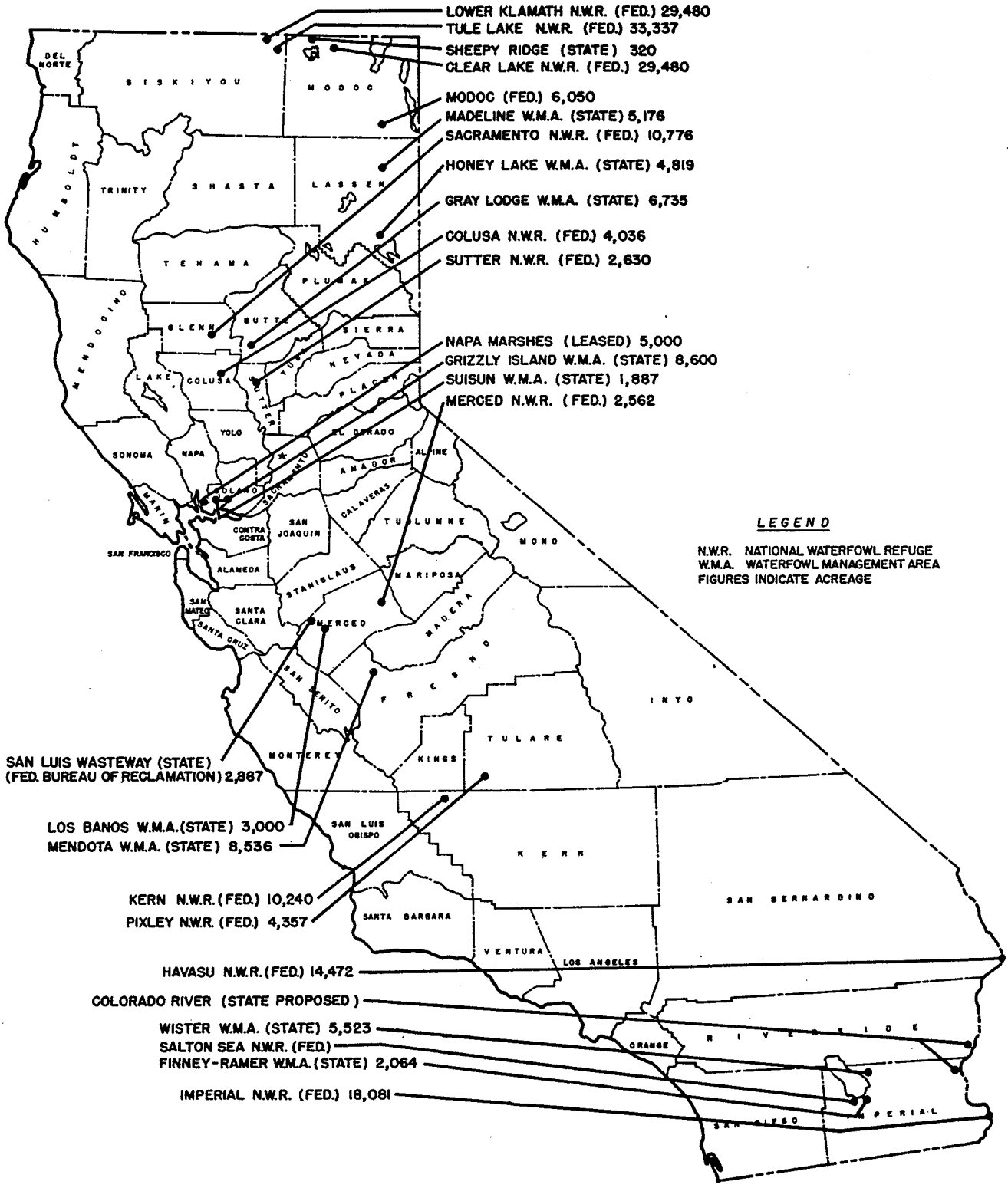


FIGURE 44. California waterfowl refuge and management areas.

reported from the Bay counties generally runs on the magnitude of 700,000 to something over 1,000,000 as compared to the state-wide kill of 3 to 4 million. The reported kill for the years 1948 through 1960 is shown in Appendix G-4 and Figure 47.

Hunter success in the Bay Area in terms of birds per hunter per season is consistently above the state-wide average. (See Appendix G-4.) Only the great rice-growing areas in the Sacramento Valley offer better hunter success.

Economic Evaluation. Waterfowl hunting is probably the most expensive form of hunting in the State. It requires specialized equipment, special tax or license fees, often entails duck club fees or land leases, and involves more travel than other types of hunting and fishing.

The amount spent by individual waterfowl hunters has not yet been determined for California. However, it certainly is at least as much as the average hunter expenditure, which in 1955 was determined to be just under $19 per day. That year there were 180,175 migratory waterfowl stamps purchased in California. Assuming an average of 8 days per hunter, the total expenditure in California on waterfowl hunting would have exceeded 25 million dollars.

One approach to determining the economic value of waterfowl in the Bay Area involves the use of data obtained by the U. S. Fish and Wildlife Service in a national survey of waterfowl hunter expenditures. The Service found that it cost the average hunter $8.16 per duck and $16.32 per goose. Applying these values to the annual average bag for California (Appendix G-4), the gross expenditure on waterfowl was on the order of 33.5 million dollars. The proportion attributable to the Bay Area, on the same basis, is just under 7 million dollars, $6,500,000 for ducks and $420,000 for geese.

Duck Clubs. There were at least 242 known private duck clubs located in the Bay Area in 1957 with an aggregate of 68,320 acres. These clubs are located on the tidal marshes of Suisun, San Pablo and San Francisco bays. For the entire State there are probably more than 1,000 clubs involving over 352,000 acres of land. The actual number of clubs cannot be specified since many are temporary and others change hands frequently or consist only of a few members, making it difficult to obtain accurate statistics.

The acreage in private duck clubs in the Bay Area constitutes about 10 percent of the state-wide total. Most are located on permanent waterfowl habitat, whereas many of those in other sections of the State are temporary.

It has not been possible to obtain an accurate estimate of the amount of money invested in these clubs but the lands alone are worth $150 to $300 per acre for a total value of 10 to 20 million dollars in the Bay Area alone. Some clubs are extensively developed and worth considerably more than others.

Sources of Mortality

In addition to reclamation and other water manipulation projects, waterfowl have suffered as a result of pollution since 1900. As oil refineries were established in the Bay Area between 1900 and 1925 oil pollution became a particular problem. The recovery of oil from the waste products of the plants was poor, and heavy ship traffic and the attendant bilge pumping and flushing of oil tanks in the Bay aggravated the problem. Nor were these the only sources of oil pollution. It was common practice during this period for garages to dump their waste oils directly into sewage systems which flowed into the Bay. In 1925, a Mr. C. M. McCay estimated from data furnished by the garages in Berkeley and Oakland that 3,000 gallons reached the Bay each day from this source.

As early as 1890 naturalists studying the fauna of the Bay Area noted the threatening aspects of domestic sewage pollution, particularly along the East Bay shore. It is difficult to prove any appreciable waterfowl reductions as a direct result of pollution, but there were undoubtedly indirect losses through reduction of habitat. The normal healthy aquatic vegetation and animal organisms upon which waterfowl feed become suppressed under polluted conditions and eventually are succeeded by forms not usable. In some instances, pollution has become so severe as to render areas sterile to all but a few extremely resistant forms of plant and animal life.

Other Sources of Mortality

The Bay area appears to be a focal point for such waterfowl diseases as fowl cholera and botulism. Large scale kills have occurred in the past and it is not uncommon to find individual dead birds. Botulism outbreaks among waterfowl are abetted by organic waste discharges. The decaying matter and the subsequent lowering of dissolved oxygen favors the growth of the anaerobic bacteria which cause the disease. Waterfowl feeding in the vicinity of these wastes are killed by the toxins produced by the bacteria. A particularly bad area is in the vicinity of the Sunnyvale sewage outfall.

Fowl cholera generally attacks the birds during the winter and usually only when they become weakened due to poor forage or environmental conditions. The infectious bacteria are picked up by weakened birds and quickly spread through their system, eventually causing death of the bird.

Waterfowl disease experts of the Department have also observed birds in the Bay killed by coliform organisms. Apparently, these bacteria become so abundant at times that waterfowl pick up a sufficient number of them to cause death.

Waterfowl for the Future

Future waterfowl abundance in the Bay Area will depend to a large extent on the quantity and quality of

FIGURE 45a. Pintail or sprig. Most abundant duck wintering in the Bay area. Photo courtesy U.S. Fish and Wildlife Service.

FIGURE 45b. Mallard—Common resident duck of the Bay area. Highly favored both for sport and table. Photo courtesy U.S. Fish and Wildlife Service.

C—043328

C-043329

FIGURE 46. A sanctuary at work. Wintering snow, Canada and white-fronted geese. Photo courtesy U.S. Fish and Wildlife Service.

suitable habitat available for wintering purposes. Any reduction in habitat will result in shifting these birds to other more inviting areas or their eventual loss. Reclamation for agriculture has already eliminated a large proportion of the original habitat and its accompanying quota of birds. Industrialization and urbanization has similarly encroached upon waterfowl habitat around the Bay and continues to do so.

The need for permanent habitat is illustrated by the annual waterfowl inventories. In 1957, for instance, the lack of rainfall throughout the State prior to the January inventory, concentrated over 40 percent of the State's entire wintering population of ducks and geese in the Bay Area as compared to the annual average of 18 percent for ducks and 9 percent for geese.

Many of the wintering areas normally created by fall and winter rains were dry and completely devoid of waterfowl. Thus, while the Bay Area wintered two to three times its normal concentration, the State as a whole was down 25 percent. Many of the birds stayed in Oregon or Washington or continued south into Mexico.

In the South Bay all but a few minor areas of native marsh have already been reclaimed and presumably most of the North Bay will likewise be reclaimed in the future. It is difficult to foresee the extent, but certainly, here also most of the natural marshland will probably be eliminated. Due to the physical characteristics of the marshes and the numerous islands in this area, reclamation may not be quite as complete as in the South Bay. The engineering firm of Parsons, Brinckerhoff, Hall and MacDonald for instance, in their study of the proposed rapid transit system for the Bay Area, reserved the marshland north of Suisun Bay and a small area on the South Bay as permanent open land. It was their contention that these areas are unsuitable for urban, agricultural or industrial development.

Eventually each acre of habitat will become increasingly important. Areas not now used because of pollution should be rehabilitated, and the few remaining areas of unreclaimed native habitat should be preserved. Areas such as San Leandro Bay, Richardson's Bay, and the area west of Mare Island behind the Rock

TRENDS IN THE ANNUAL WATERFOWL KILL FOR THE STATE AND SAN FRANCISCO BAY AREA

FIG. 47

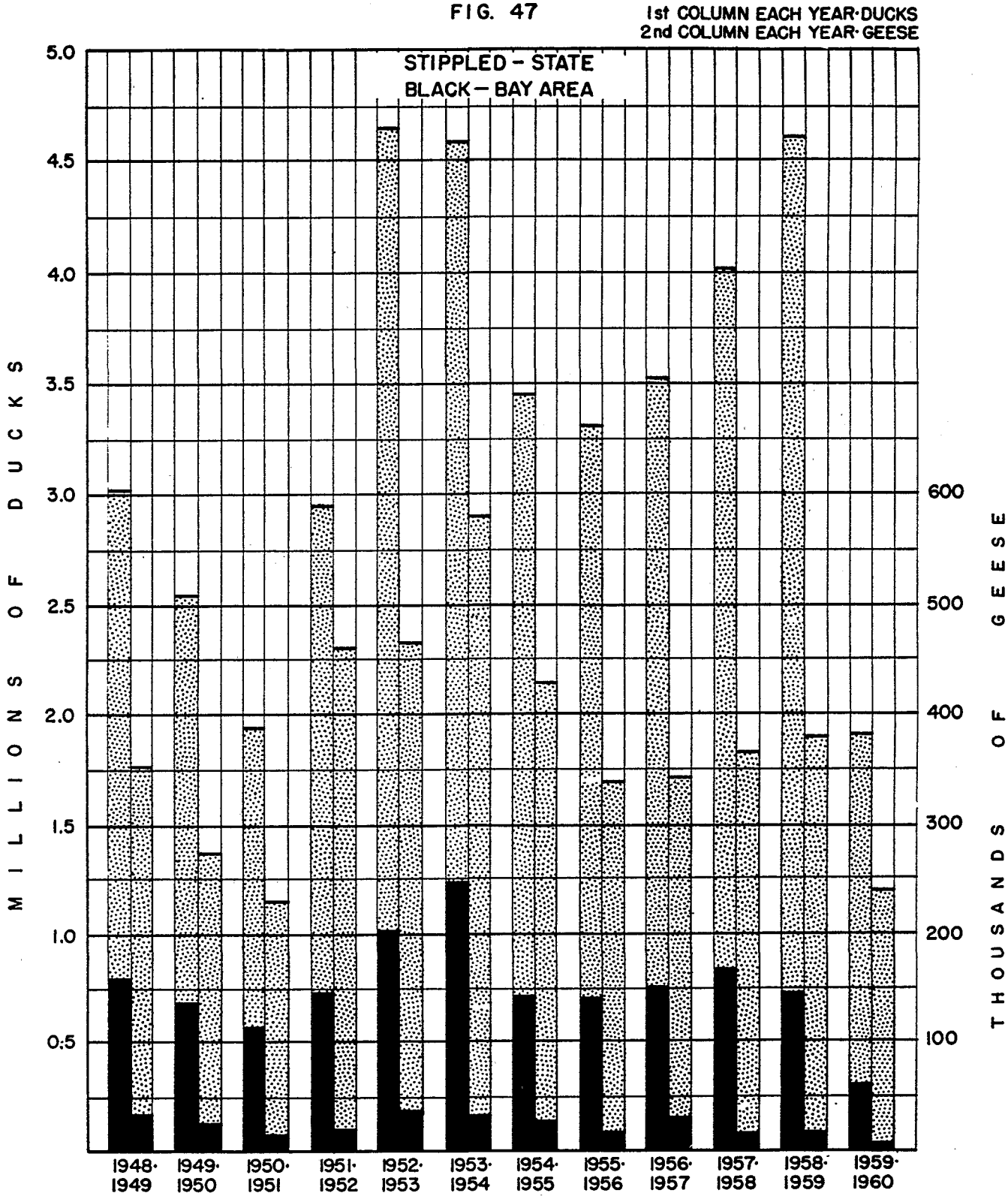


FIGURE 48. Ducks killed by oil pollution. The oil saturates the feathers and prevents the ducks from properly shedding water thus preventing flight. Photo courtesy Jack Van Coevering.

Wall, are preferred by waterfowl for the protection they offer and could be extremely valuable for wintering waterfowl.

Present waterfowl areas, less those lands which will be reclaimed or otherwise rendered unsuitable represent the future waterfowl habitat of the Bay Area.

However, areas such as San Leandro Bay, which are currently of minor importance because of pollution, could be made attractive to migratory waterfowl.

The areas most likely to be maintained for waterfowl will be those already designated as refuges or management areas, state or municipally owned marsh and tidelands not specifically so designated, private duck club lands, and the numerous sloughs, creeks and other waterways.

The open bays, of course, will always provide resting area for diving ducks. These species feed on bottom living, animal organisms, which may form up to 60% or more of their diet. Their presence on these open waters would, therefore, depend on a healthy bottom in the littoral zone and the complete absence of oil pollution.

A check of the State Lands Division records revealed that the only State-owned lands bordering the bays are the Suisun Refuge and Grizzly Island Waterfowl Management Area. Most of the tidelands, except those along the north shore of San Pablo Bay, have been disposed of. Therefore, State-owned lands cannot be considered in any long range program to preserve waterfowl habitat, unless, of course, the State purchases or otherwise gains title to these valuable tidelands and marshlands.

Studies by the Department of Water Resources reveal the amount of marsh land along San Pablo and Suisun bays and the acreage in various types of vegetation. The following three tables from Appendix E of the Bay Barrier report are helpful in outlining the potential for waterfowl. Table 48 shows the amount of

leveed and unleveed land around San Pablo and Suisun bays, while Table 49 indicates the principal types of vegetative growth upon these marshlands.

TABLE 48

LEVEED AND UNLEVEED MARSHLANDS ADJACENT TO SAN PABLO AND SUISUN BAYS

Location	Leveed Lands	Unleveed Lands	Total
San Pablo Bay	49,500	12,200	61,700
Suisun Bay	63,100	6,600	69,700
Totals	112,600	18,800	131,400

TABLE 49

PRESENT VEGETATION ON MARSHLANDS ADJACENT TO SAN PABLO AND SUISUN BAYS

	Area in Acres			Area in Percent of Total Area
Classification	San Pablo Bay	Suisun Bay	Total	
Cultivated Crops [1]	24,300	5,900	30,200	23.0
Native Pasture	11,400	11,600	23,000	17.5
Marsh Grasses [2]	10,200	38,000	48,000	36.7
Aquatic Growth	6,100	12,400	18,500	14.1
Water Surface [3]	9,200	800	10,000	7.6
Miscellaneous	500	1,000	1,500	1.1
Totals	61,700	69,700	131,400	100.0

[1] Chiefly grain and grain hay.
[2] Salt grass, pickleweed, etc.
[3] Includes salt ponds in process of development in 1954.

Fully 50 percent of these lands are still in marsh grasses and aquatic growth, thereby providing waterfowl habitat. The other 50 percent is developed to some extent for agricultural purposes. Table 50 provides data on the present use of these lands.

TABLE 50

PRESENT USE OF MARSHLAND ADJACENT TO SAN PABLO AND SUISUN BAYS

	Areas in Acres			Area in Percent of Total Area
Classification	San Pablo Bay	Suisun Bay	Total	
Agricultural				
Cultivated	24,300	5,900	30,200	23.0
Noncultivated (pasture)	14,000	22,300	36,300	27.6
Subtotals	38,300	28,200	66,500	50.6
Recreational Lands				
Duck Clubs	5,100	27,700	32,800	25.0
Refuges	——	6,200	6,200	4.7
Subtotals	5,100	33,900	39,000	29.7
Other Developed Lands				
Salt Ponds	9,200	.....	9,200	7.0
Miscellaneous	600	1,000	1,600	1.2
Subtotals	9,800	1,000	10,800	8.2
Unused Lands	8,500	6,600	15,100	11.5
Totals	61,700	69,700	131,400	100.0

According to these data, there are 39,000 acres in duck clubs and refuges, and 15,000 acres of unused land for a total of 54,100 acres of waterfowl habitat. This amount of marshland provides some optimism for the future of waterfowl in the Bay. However, the largest share of these lands is in duck clubs, and, as was the case in the South Bay, these clubs cannot be depended upon to maintain their holdings in view of the lucrative offers made for them by industry. On the other hand, land for duck clubs is also becoming increasingly valuable and this may result in a change in this outlook.

UPLAND GAME AND SHORE BIRDS

The Bay Area possesses a large variety of shore, water, and upland game birds as well as waterfowl. They also were very abundant prior to the turn of the century. Many are considered table delicacies and before they were protected, were hunted heavily for the market. Several species are considered excellent game birds.

Quail

The California valley quail was by far the most popular and abundant native game bird in the early days. They abounded throughout the unforested portions of the coastal mountains and in the drier parts of the valleys.

There are several subspecies of which two are common to the Bay Area, namely *Lophortyx californica brannescens* and *Lophortyx californica californica*. The mountain quail (*Oreortyx picta palmeri*) inhabits portions of Napa, Solano and most of Sonoma County.

The first named species is found throughout the coastal mountains from Monterey northward. Good range and some heavily populated areas are present from San Francisco County southward. The second is found on the valley side of the Bay Area and is the most widely distributed and abundant quail in the State.

Quantitative data on the take of these birds for the early years is lacking except for a few records of the numbers bought and sold through game transfer companies. In the 1895-96 season, for example (Appendix G-2), these companies handled 177,366 birds worth $15,116 of which Bay Area counties contributed 15,326 birds (8.6 percent). As was brought out in the waterfowl discussion, the numbers of birds reaching the market centers were but a small fraction of the total number shot.

An account by E. B. Ralston (1916) gives an idea of their original abundance in San Mateo County. In 1861, his father, John Ralston, captured 60 dozen quail on their ranch on El Corte de Madera Creek. The price in San Francisco markets was then 25¢ per dozen. The author reported shooting 26 quail with one shot and a high of 192 with seven shots from a 14 gauge Parker shotgun. He contended that quail began

to decline around 1869 when the Chinese began clearing and grubbing the hills and flats and that they were driven away from feeding and watering places and left without cover by grazing horses and cattle.

In 1956, there were 1,154,400 quail reported taken in the State by hunters on the annual hunter questionnaire. The Bay Counties contributed 93,600 or about 8 percent of the total. This is consistent with the figures reported since 1949, which are shown in Table 51.

TABLE 51

ANNUAL QUAIL KILL

Year	State-wide Kill	Bay Area Kill	Bay Area Kill As Percentage of State Total
1948	1,714,391	----------	-----
1949	1,132,800	104,500	9.2
1950	1,129,100	119,300	10.6
1951	1,432,100	124,600	8.7
1952	1,644,700	171,300	10.4
1953	2,041,400	202,500	9.9
1954	1,483,800	109,900	7.4
1955	1,295,900	115,500	8.9
1956	1,154,400	93,600	8.1
1957	1,648,800	109,500	6.6
1958	1,939,800	115,400	5.9

Ring-Necked Pheasant

The ring-necked pheasant (*Phasianus colchicus*) is the largest upland game bird in the Bay Area and is extremely popular with hunters. It is an Asian import which thrives on agricultural lands. The ring-neck did well in the Santa Clara Valley when grain and row crops predominated, but faded out, as agriculture there shifted to orchards and row crops. They are now most abundant in Solano and Contra Costa counties. The Bay Area contributes somewhat less than 10 percent of the state-wide total. Most Bay Area hunters depend on the rice growing areas of the Central Valley for this sport.

Other Upland Game Birds

The Western Mourning Dove (*Zenaidura macroura marginella*) is now the most abundant and widely distributed single upland game bird in California. About two and a half million or more are shot by hunters each year. The Bay Area total generally ranges between 150,000 and 200,000 or a little less than 10 percent of the state-wide total. The leading counties are Solano, Santa Clara, and Napa.

The Pacific band-tailed pigeon (*Columba fasciata monilis*) is another of the Bay Area's upland game species. The kill is not large but the total annual take for the region is about 10 percent of the state-wide total which in 1955 was reported at 135,500 birds.

Other Shore and Water Birds

Except for ducks and geese, most shore and water birds are now protected. Seasons and bag limits for migratory birds are set by the U. S. Fish and Wildlife Service. Jacksnipe or Wilson's snipe (*Capella gallinago delicata*) is one of the few shore birds which has been available to hunters in recent years. The numbers of snipe, dowitchers, plovers, curlews, willets and godwits are greatly reduced from former levels. Overhunting took a heavy toll originally, but reclamation is responsible for their present permanent low level of abundance.

The numbers of these birds passing through the markets in the 1895-96 season are shown in Appendix G-2. Recent data are available on jacksnipe only, for which there has been an open season the last few years. The annual kill in the State, of which the Bay Area provides approximately 20 percent, is given in Table 52.

TABLE 52

STATE AND REGIONAL JACKSNIPE BAG 1953-58

Year	State	Bay Area	Percentage from Bay Area
1953	44,200	----	----
1954	14,500	2,500	17.2
1955	19,500	4,300	22.1
1956	44,300	9,200	20.8
1957	43,600	6,400	14.7
1958	67,900	7,400	10.9

Mr. Donald D. McLean, formerly of the Department of Fish and Game, has permitted the use of data on the shore birds of South San Francisco Bay gathered by him over a 14-year period. At comparable dates each year, he spent one day in the spring and another in the fall enumerating the birds. His data, which include 14 species, are given in Appendix G-5. Most of these birds will never again be put on the list of legal game, but are being protected for aesthetic and scientific purposes.

Other species, such as gulls, are beneficial. They are scavengers which remove dead and dying fish and other trash from the water. The herons, egrets, pelicans and similar birds lend incalculable aesthetic values to the area.

The California clapper rail, (*Rallus longirostris obsoletus*), is a scientific rarity. This species at one time was exceedingly abundant. It was a highly prized game bird of about three-fourths pound and was one of the more common species in the San Francisco markets. It, too, has been drastically reduced by land reclamation. They are found only in association with pickleweed (*Salicornia rubra*). Their food consists of worms, insects and crustaceans which they dig from the tidal flats.

Pollution is a definite threat to the clapper rail in that oil or other pollutants which destroy the bottom

organisms associated with the tidal flats eliminate their food supply.

Quail, and doves inhabit the foothills, coastal mountains or drier parts of the valleys. Their diet consists mainly of grain, weed seed, wild berries and insects. As far as water is concerned, they require only a sufficient and wholesome supply for drinking purposes.

The shore birds, on the other hand, depend on shallow water and the shorelines for an adequate supply of food. Contamination of these waters and the bottom therefore endangers their existence. Furthermore, certain pollutants, particularly petroleum products, are injurious to the birds themselves.

Other water birds such as gulls, cormorants and loons, depend upon fish, crustaceans, shellfish and aquatic organisms for food. Any form of pollution which threatens these organisms also threatens the birds. Since these birds spend most of their time on the water, they are especially susceptible to oil pollution.

WATERFOWL, SHORE AND UPLAND GAME BIRD REFERENCES

Anderson, William
1960 A Study of Waterfowl Nesting in the Suisun Marshes. California Fish and Game, Vol. 46, No. 2, pp. 217-226.

California Department of Fish and Game
1957 Poll Showing Hunting, Angling Spending in State, Outdoor California, Vol. 18, No. 4, April 1957.

California Department of Water Resources
1955 Fish and Wildlife (Appendix C) of Report to the Water Project Authority of the State of California.

California State Water Pollution Control Board
1952 Water Quality Criteria, Publication No. 3; Also Addendum No. 1, 1954.

California State Water Pollution Control Board
1956 Report on Oily Substances and their Effects on the Beneficial Uses of Water, Publication No. 16.

California State Water Resources Board
1951 Water Resources of California. Bulletin No. 1.

Grinnel, Joseph, H. C. Bryant and Tracy L. Storer
1918 Game Birds of California. University of California Press, Berkeley.

Kortright, F. H.
1943 The Ducks, Geese and Swans of North America American Wildlife Institute, Washington, D. C.—476 pp. Illustrated.

Kozlik, Frank M.
1955 Waterfowl Hunting Areas Operated by the California Department of Fish and Game. California Fish and Game, Vol. 14, No. 1.

La Fave, Lynn D.
1957 More Sea Birds Affected by Oil. The Murrelet, Vol. 38, No. 1 (Jan-Apr) 1957.

Leopold, A. Starker
1951 Game Birds and Mammals of California, California Book Company, Ltd., Berkeley, California.

Leopold, A. Starker and Robert H. Smith
1953 Numbers and Winter Distribution of Pacific Black Brant in North America. California Fish and Game, Vol. 39, No. 1, January, 1953.

Petersen, Roger Tory
1941 Field Guide to Western Birds. Houghton, Mifflin Company, Boston.

U.S. Department of Commerce, Bureau of Fisheries
1925 Effect of Oil Pollution on Marine and Wildlife Report to the Commissioner of Fisheries, Doc. 995, pp. 171-181.

U.S. Fish and Wildlife Service
1949 A Report on Waterfowl Resources in Relation to the Grasslands Central Valley Project, California (unpublished). U.S. Department of the Interior, Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service
1950 Waterfowl Conservation in the Lower San Joaquin Valley. Its Relation to the Grasslands and the Central Valley Project. U.S. Department of the Interior, Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service
1954 Inventory of Wetlands for the State of California. U.S. Department of the Interior, Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service
1955 Inventory of Permanent Water of Importance to Waterfowl-California. U.S. Department of the Interior, Fish and Wildlife Service, Portland, Oregon.

Wildlife Management Institute
1946 Sportsman's Guide to Wild Ducks Wildlife Management Institute, Washington, D.C.

Wildlife Management Institute
1948 Waterfowl Management on Small Areas Wildlife Management Institute, Washington, D.C.

THE MAMMALIAN RESOURCES

HISTORICAL ACCOUNT

Under primeval conditions, California was endowed with a varied and bountiful supply of wild game, among them the most precious furbearers in the world. It was the early fur trade more than any other single factor that opened up the West, and the Bay Area in particular, to world trade. The Spanish, French, English, Russians and Americans engaged in the California fur trade before 1825. American ships sailed round the Horn and across the Pacific to China to engage in this trade. Prodigious quantities of the most valuable kinds of furbearers were taken—beaver, river otter, marten, fisher, mink, fox, weasel, harbor and fur seals and sea otter. The Bay Area contributed most of these species to the industry as well as many of the lesser varieties such as raccoon, badger, skunk, and others. Common mammals of the region are listed in Appendix H-1.

A great deal has been written of the early California fur industry and a considerable amount of research spent on its history. The Bancroft Library, San Francisco, and Scammon's *Marine Mammals of California* are particularly excellent sources on the early history of the fur and whaling industries in California.

The Marine Mammals

The Sea Otter. The first trade began as early as 1784 when a Spanish expedition headed by Senor Vicente Vasadre y Vega traded abalone shells, beads, and various metal articles to the Indians for pelts of the sea otter (*Enhydra lutris nereis*). In 1785 Senor Vega organized and expanded the sea otter trade. The furs obtained were sent to Mexico for tanning and thence to China in exchange for quicksilver which was badly needed in the Mexican mines. Between 1786 and 1790, 9,729 sea otter pelts and an unknown number of seal skins were shipped to Manila, which according to Senor Vega brought $3,120,000 ($321 each).

In 1786 France sent Conte de La Perouse to investigate the fur trade possibilities. Between Alaska and California he obtained about a thousand sea otter pelts which he sold in China for $10,000. In view of the contrast in values cited above it is amusing to note the following comment by La Perouse. "Antecedent to this year an otter's skin bore no higher value than two hare's skins; the Spanish never suspected that they would be much sought after; they had never sent them to Europe and Mexico was too hot a climate to suppose there would be any sale for them there." (*The Pacific Science Congress of 1940 proclaimed: "The sea otter is the rarest as well as the most valuable of all the furbearing mammals ever known."*)

Between 1727 and 1742 single sea otter pelts (from the Asiatic Pacific) sold for $80 to $100 in China where it was the royal fur. Between 1775 and 1777 England sold 29,932 pelts to Russia for $90 to $100 each. After that the price declined until the middle 1800's when the scarcity of the animal again encouraged good prices.

In 1812, Kuskof, a Russian engaged in the sea otter trade founded the "Russian American Company" at Fort Ross, Sonoma County. His party also set up a station on the Farallon Islands.

The following paragraphs from Scofield (1954) reflect the situation during this period:

"The Spanish explorations along the west coast claimed the land for the Crown of Spain but little was done toward occupying the country. Trappers invaded the Central Valley of California, selling their beaver pelts to the English traders at Fort Astoria near the mouth of the Columbia River (1811) and Russians established settlements in California, primarily to gather the furs of 'sea beavers' and secondarily to grow grain to feed their nationals in Alaska. Spain, fearing that Alta California might be lost to the Crown, decided to hold the new land by occupying it. Military forts (presidios), civilian towns (pueblos) and church settlements (missions) were established. Trade with foreign ships was prohibited and a little later, under Mexican rule, the killing of sea otter was outlawed. But smuggling flourished, and the hunting of otter and sea lions was carried on by ships of several nations. The most persistent hunting was conducted by the Russians and as early as 1804 they brought about 100 Aleutian Indians to the California coast to hunt otter from skin canoes.

"Sea otter were abundant all along the coast but were especially plentiful around the Channel Islands and the Farallons. The mild climate and abundance of food from the ocean led to a dense population of native Indians along the shore, especially in the Santa Barbara region and on several of the Channel Islands, particularly Santa Catalina and San Nicolas. The peaceful natives of the islands were friendly but the Aleuts played too rough. When not hunting otter they killed as many men as they could find and carried off the native women. They were so efficient that in eight years (1812) the otter of the Channel Islands were becoming scarce and the population of native Indians on the islands had been greatly reduced. Scourges of measles contributed to the wiping out of the natives

C—043335

C-043336

but a few survived and those remaining at San Nicolas Island were transported in 1835 to the mainland where they promptly died of measles.

"In this chronicle of killing, the sea otter were the stake. The furs were very valuable and fantastically high prices were paid for them by Chinese Mandarins. These prices attracted the greedy. The otter helped to settle California but they were reduced almost to the point of extinction till a belated state law of 1913 protected the remnant that was left along the San Simeon coast south of Monterey Bay."

Although the Russians are credited with taking immense quantities of these animals, the Americans had already siphoned off the cream in the fur bonanza. Several ships out of Boston were engaged in the fur seal and sea otter trade, making regular trips around the Horn to San Francisco and other ports. Bancroft (1884) states that 16 ships were engaged in the fur trade as early as 1801, 15 American and one English. Upwards of 18,000 otter skins were collected for the Chinese market by the American vessels alone. In 1802 "more than 15,000 sea otter skins were collected and carried to China".

Sea otter were particularly abundant about the Farallons and in San Francisco Bay. It is reported that the Russians took 1,200 skins from San Francisco Bay alone in 1811. There is some disagreement on the numbers taken thereafter, but one source states the Russians took 700 to 800 pelts in a single week in 1812. They are reported to have taken 50,000 skins within five years after first settling here and about 5,000 annually thereafter until 1831. Grinnel et al (1937) accorded at least 13,600 skins to them although they point out that valuable furs of other kinds were also taken in considerable quantities. A perhaps exaggerated statement from a manuscript of General Vallejo referring to the abundance of sea otter in the Bay states: "They were so abundant in 1812 that they were killed by boatmen with their oars in passing through the kelp."

Over-hunting imposed a decline on this valuable species which was felt initially about 1820, but even after this they were found in fairly good numbers. In 1830, 30 of a herd of about 100 near Point San Quentin were lassoed by a Senor Amador and three or four Indians. At the entrance to Sonoma Creek a herd existed under the protection of General Vallejo. In 1847, 42 of them were shot by hunters who received $60 each for the pelts in San Francisco. After 1850 sea otters were extremely rare in the Bay Area.

Fisher (1941) has done considerable research on the sea otter trade and is the source of most of the data for Appendix H-2 on prices of sea otter pelts.

The Fur Seals. Although the sea otter was by far the most valuable of the Bay's furbearing animals, it was but a single item in the overall fur industry. The Pribilof and Guadalupe fur seals were also hunted keenly and their importance heightened as sea otters declined.

Bryant (1915) reported that a Captain Wm. Smith, about 1808, took 130,000 seal skins to China in two years for which he received about $2.50 each. The same source states the Russians took as many as 80,000 a year at the Farallons. The records are not clear as to whether these were Guadalupe or Pribilof seals but both were probably taken up to 1833.

The Pribilof fur seal (*Callorhinus ursinus cynocephalus*) is a migratory animal which circumnavigates the North Pacific Ocean. It annually appears off the California coast between December and April but rarely comes ashore. They are usually observed off the Farallon Islands as they move northward.

The Guadalupe fur seal (*Arctocephalus townsendi*) is primarily a southern species which formerly inhabited and bred on the Farallon Islands. Records indicate that 73,402 were killed between 1810 and 1812 by the Russians. From 1812 to 1824, 1,200 to 1,500 were taken annually. After that only 200 to 300 per year were caught although, over 1,000 were reported taken in 1824. The catch continued to diminish until only 54 were secured in 1833. According to Starks (1922) Guadalupe fur seals bred on the Farallons until 1833.

The small harbor seal was also hunted until about 1890. This species was common about the bays, with "extensive" rookeries at the southern end of San Francisco Bay near Alviso, according to Bonnot (1928) They also were eventually depleted by fur hunters.

The Sea Lions. There are two species of sea lions common to the California Coast and which are represented in the Bay Area fauna. These are the Stellar's sea lion (*Eumetopias jubata*) and the California sea lion (*Zalophus californicus*).

Bonnot (*op. cit.*) states: "Before 1860 sea lions were extremely numerous along the California Coast. During the sixties they were commercially valuable and their numbers therefore steadily decreased until the late seventies, when the products gained from them (oil and hides) were bringing such a low price that it was unprofitable to hunt them." Quoting Scammon (1874), Bonnot continues, "A few years ago great numbers of sea lions were taken along the coast of upper and lower California, and thousands of barrels of oil were obtained. The number of seals slain exclusively for their oil would appear fabulous when we realize that it requires, on the average, throughout the season, the blubber of three or four sea lions to produce a barrel of oil. Their thick, coarse-grained skins were not considered worth preparing for market in a country where manual labor was so highly valued. At the present time, however, they are valuable for glue stock, and the seal hunter now realizes more comparative profit from the hides than from the oil."

The Chinese killed them frequently for the "trimmings" (testes and penis).

In the past sea lions evinced considerable comment from commercial fishermen who claim they consume large numbers of salmon. Although this contro-

versy is still going on, it is doubtful that they cause near the destruction with which they are charged.

Currently, their principle value probably is their attraction to tourists. The animals congregate in large numbers around the Seal Rocks off the Golden Gate where they are observed by thousands of spectators annually.

The Cetaceans. The whales, porpoises and dolphins might be mentioned since they have been important mammals in the past. Historically, most of the Pacific species were found along the California Coast, and several species were very common, seasonally, off the Bay counties. As a matter of fact, the Bay porpoise was common in San Francisco Bay. There is a reported instance of a killer whale being taken as far inland as Benicia. All are scarce at the present time, but may be observed occasionally in the ocean just off the coast of the Bay counties. Whales were the basis of an important industry which existed for many years in California (see Commercial Fisheries).

The Inland Fur Bearers

About the time the coastal and oceanic fur industry began to decline, the Hudson Bay Company began to exploit California's inland fur resources. Between 1826 and 1845 the British sent parties out annually from Fort Astoria and Fort Vancouver into the Sacramento and the San Joaquin valleys as far south as French Camp on the San Joaquin River.

These trapping expeditions must have been extremely profitable to justify the long overland trip each year. It appears that the golden beaver was one of the most valued of the animals taken, and apparently was found in great abundance. McKay of Hudson Bay is reported to have taken 4,000 beaver skins on the shores of San Francisco Bay. At the time, these pelts sold for $2.50 a pound or about $4 each.

Thomas Farnham in 1840 stated beaver were very numerous near the mouths of the Sacramento and San Joaquin rivers and on the hundreds of small "rush-covered" islands. Of them he said: "There is probably no spot of equal extent in the whole continent of America which contains so many of these much-sought animals." This area incidentally, is probably where McKay was so successful, rather than the Bay itself.

Little can be said of other varieties of furbearers and game animals during the early years because they have not been individually or specifically treated in the early literature to any extent. Many of them, however, are given frequent mention in the many treatises on the California fur trade. After 1850 they undoubtedly comprised the bulk of the trade.

Economic Value. It is difficult to provide an accurate estimate of the economic value of the fur trade prior to 1922, but between 1800 and 1850 it apparently amounted to two or three million dollars annually. From 1800 to 1825 the sea otter and fur seals supported the trade and the available evidence indicates that an estimate of 20 to 30 thousand sea otter annually is probably not too high. The price per pelt during this period averaged from $30 to $50, making the total value at the primary level $750,000 to $1,250,000 per year for sea otter alone.

After 1825 the number of sea otter were fewer but the trapping of inland furbearers took up the slack and in all probability the total value exceeded that of the 1800 to 1825 era. Fur trapping continued as a major occupation in California until after 1900, and as a matter of fact, as late as 1928 amounted to almost $470,000 at the primary level (raw furs).

Although much more information exists in the literature on the early fur industry of California and the Northwest generally, the preceding account indicates the general magnitude and importance of the fur resources during those early years. California, and San Francisco specifically, was the center of this industry. Originally, the Bay Area was a major source of the animals themselves.

Even as the seal and sea otter resources diminished locally, San Francisco continued as a center of trade and principal port for fur expeditions to the Aleutian and Kurile Islands of the north and west Pacific. Eventually, even those areas became seriously depleted and about 1903 international agreements between the United States, Canada, Russia, and Japan were drawn up to protect these valuable fur resources.

Big Game Animals

Other important mammals prominent in the early history of the Bay Area include the Roosevelt elk, tule elk, black-tailed deer, pronghorn antelope, and the grizzly and black bears. These are considered big game animals. The puma or mountain lion is also in this class but generally has been relegated to the category of predator.

Roosevelt and Tule Elk. Elk are large members of the deer family, the males of which possess ponderous antlers. Historically, Roosevelt elk (*Cervus canadensis roosevelti*) extended along the Coast Range from the Marin Peninsula northward. These magnificent animals were once plentiful in Marin and Sonoma counties. An article describing an elk hunt in Marin County in 1846, by Joseph Warren Revere, "*A Tour of Duty in California*", was published in New York in 1849. The hunt took place on Point Reyes where a herd of not less than 400 animals were reported observed. The encroachment of civilization and hunting drove them from the Bay Area about 1870.

Tule elk (*Cervus canadensis nannodes*) primarily inhabitants of the Central Valley, were only found in those Bay Area Counties bordering the Valley and Delta. Elk provided a source of excellent food as well as fine hides. They were hunted heavily and greatly reduced by 1850 in the Bay Area.

Grizzly Bears. The grizzly bears, of which two species (*Ursus caifornicus* and *Ursus mendocinensis*) were represented in the Bay Area, were distributed throughout California, except along the crest and eastern slope of the Sierra Nevada. After the American occupation about 1850, the livestock industry which had been given a good start by the Spanish and Mexicans, became very prominent and ranchers slaughtered the grizzly at every opportunity. They were extremely scarce by 1900. The last one reported in the State was shot August, 1922 at Horse Corral Meadows, Tulare County. Grizzly Peak, east of Berkeley, is a reminder of this animal's presence there.

Black or cinnamon bears (*Euarctus americanus*) are still found within the confines of the area covered by this report but they are very scarce.

Black-Tailed Deer. Black-tailed deer (*Odocoileus hemionus columbianus*) were an important source of food and clothing to the Indians and early settlers. The hides were also used for a number of domestic purposes. Concerning their early presence (1768-1800) Longhurst, et al, (1952) state: "Deer are mentioned by Juan Batiste de Anza as being common in the San Francisco Bay Area . . . ."

Pronghorn Antelope. The American or pronghorn antelope (*Antilocapra americana*) was a member of the native fauna of the Bay Area, inhabiting the valleys and eastern portions of the coastal range. Grinnell (1933) indicates their original range included the open hills of Contra Costa County. Presumably, similar habitat in Alameda, Santa Clara, Napa, Sonoma and Solano counties also were antelope range. Information on the early status of this animal is lacking, although it is known that there was a flourishing trade in Stockton and San Francisco for their meat and hides.

Mountain Lion. Mountain lions (*Felis concolor californica*) were apparently quite common throughout the State, particularly in the brushy and lightly forested areas inhabited by their principal prey, the deer. In the Bay counties they were most common in Santa Clara, Alameda, and Sonoma counties, just as they are today. This animal has always been severely hunted because of its depredations on deer and livestock. In recent years game managers and biologists have concluded that the widespread killing of these animals may not be commensurate with sound game management principles.

A legislative act of 1906 provided for the payment of a bounty on them and the practice has continued to the present even though actual depredations on livestock are rare.

The livestock industry has had a profound affect on the entire native fauna. The wild animals were hunted to eliminate depredation, trapped for their fur, used as food, or lost grazing range to the large herds of domestic stock. The latter is illustrated by a quotation from Longhurst, et al, (op. cit.). "The Spanish settlers although few in number and restricted in the area they occupied, nevertheless brought about many changes in the land, particularly as a result of their introduction of domestic cattle, sheep, horses and goats. The domestic herds were large, and much spread out. In 1825 it is estimated that there were 1,003,970 head of sheep at the Spanish missions, and about as many more kept by ranchers outside the missions (Miller, 1942)".

1870 TO 1915

By 1870 the local fur seal and sea otter resources were insignificant, and although the Bay remained the center of the fur trade, the animals were hunted elsewhere. The grizzly bear, Roosevelt elk, and tule elk were extremely rare by this time due to excessive hunting and the ever increasing encroachment of civilization. The smaller furbearers were trapped heavily and the local game resources were exploited for both home and market.

Lumbering, agriculture and livestock practices were responsible for game habitat destruction and the eventual diminution of some species, while over-hunting and the gradual settling of the Bay Area were primary causes of reductions in other species.

Between 1870 and 1915, the public and the newly created Fish and Game Commission, aware of the loss of these resources, initiated a number of legislative movements to protect the wildlife resources of the State. More of these were directed at the fauna of the Bay Area than any other area of the State. Restrictive and protective legislation was enacted to benefit sea otter, fur seals, waterfowl, shore birds, deer, elk and other species.

For the most part, however, legislation was too late, or there was a direct conflict between man and the animal resources which eventually resulted in the loss of the latter. Man's activities often are not compatible with the wild creatures he wishes to preserve. Such was the case of the grizzly bear, antelope and elk. The sea otter was simply over-hunted, almost to the point of extinction, and their recovery was inhibited by poaching, a relatively poor reproductive rate, high mortality of the young, and perhaps also the loss of habitat areas like San Francisco Bay, which appears to have been particularly favorable.

1915 TO PRESENT

Systematic quantitative game records commenced when the Fish and Game Commission licensed trappers and polled them as to the kind and quantity of furbearers taken each season. The first year for which this information was available was 1922. It has been continued each year since. In 1927 accurate deer kill figures became available when the "deer tag" system was inaugurated. Deer hunters have since been required to purchase tags which successful hunters

C—043338

C-043339

must attach to the deer in the field and return to the Department of Fish and Game.

Since 1948 the department has conducted annual postal surveys to obtain hunting statistics.

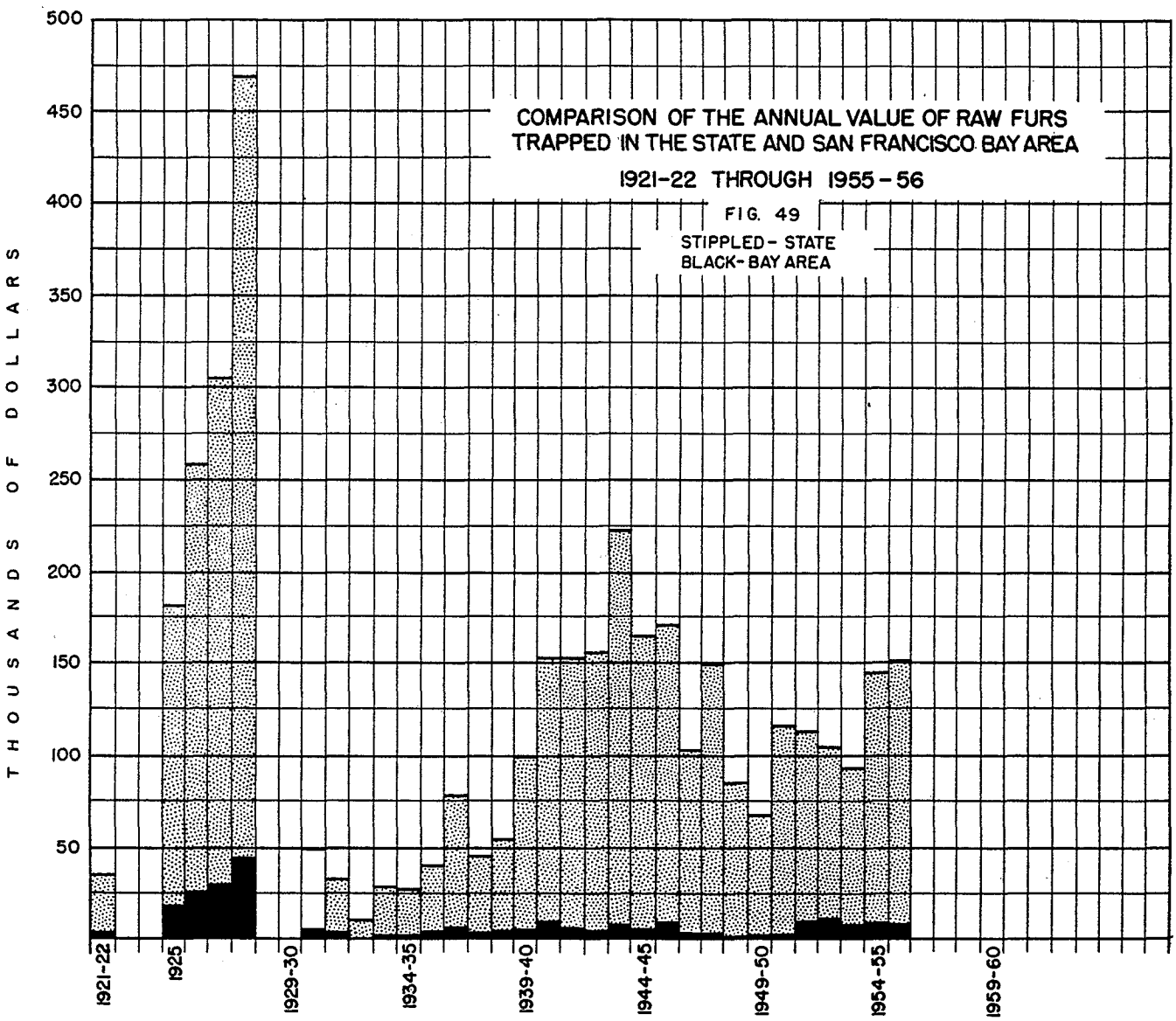
The Trapping Industry

Trapping is now of minor economic importance, although approximately $100,000 worth of furs are taken annually (31 year average of $122,971) of which the Bay Area contributes about seven percent (see Appendix H-4). The number of licensed trappers has declined from over 6,000 in the 1928-29 season to about 600 annually at the present time. The number operating in the Bay Area is somewhat less than ten percent of the state-wide total. The number of trapping licenses issued in California each year since 1917 is listed in Appendix I-3.

The fur market is now influenced strongly by fashion, and economic conditions. Furs which formerly were used to provide warm clothing are no longer required. As a result, only the dark, short haired pelts are currently in sufficient demand to interest trappers.

According to George Seymour, a Department of Fish and Game specialist in this field, the present abundance of a number of the more desirable furbearing species probably compares favorably with that of 50 to 100 years ago. However, because of the lack of demand and price for these furs the animals are not trapped.

Of the twenty or more species of furbearers trapped in California in recent years, the Bay Area consistently contributes about fourteen. Some of these, like the coyote, are not trapped for their fur, but rather as predators.



The number of furbearers taken annually in California since the 1921-22 season is shown in Appendix H-3. The Bay Area catch is also shown; however, the figures shown prior to the 1937-38 season are estimates based on the percentage of each species contributed by the Bay Area to the state-wide total between 1938 and 1956. It has only been possible to obtain separate data on the Bay Area catch since 1938. About 4,000 or 5.6 percent of the total annual number of pelts came from the Bay Area between 1938 and 1956.

Four of the 14 species under discussion are strictly aquatic animals and the raccoon is generally associated with aquatic environments. The Bay Area, as might be expected, accounts for a proportionally greater percentage of the State total of these aquatic species. This group includes the river otter, mink, beaver, muskrat, and raccoon. Otter, mink and muskrat are among the most valuable of the wild furbearers.

The 14 species and the mean percentage contribution of the Bay Area to the total State catch of each is listed in Table 53. The annual value of the fur catch for 1922-1956 is given in Appendix H-4 and illustrated in Figure 49.

TABLE 53

THE MEAN ANNUAL PERCENTAGE CONTRIBUTION OF THE BAY AREA TO THE TOTAL STATE CATCH OF THE PRINCIPAL FURBEARERS [1]

Species	Percentage	Species	Percentage
Mink	21.9	Civet (spotted skunk)	14.0
River Otter	27.8	Ringtail	0.5
Muskrat	3.8	Fox	7.5
Beaver	4.9	Coyote	2.3
Raccoon	14.9	Bobcat	6.4
Weasel	2.6	Opossum	9.5
Skunk (striped)	11.6	Badger	8.7

[1] Based on data for the years 1938-1956.

The Marine Mammals

Sea Otter. Sea otters, which were on the verge of extinction about the turn of the century, are now completely protected, and are making a slow but definite recovery. It is interesting to note the following comment by Grinnel et al. (1937) concerning their future. "All these facts together with the records showing that within the last century and a half there have been at least two periods of profitable hunting of this animal, give basis for the belief that the sea otter might again become a rather important part of the coastal fauna of California. The conditions for subsistence of the species probably remain about as favorable as ever except for the presence of the human hunter, and his activities could be regulated."

An estimate by D. D. McLean, of the Game Management Branch of the Department of Fish and Game, places the current number along the California coast at about 1,000 individuals. They are located off Monterey and San Luis Obispo counties. Stragglers may appear off the Bay counties but this is unusual. Their future appearance in the Bay Area can only be speculated upon, but it is logical to assume that any large increase in the population would move them northward to the Bay Area, provided of course, suitable habitat and conditions prevail.

Sea otters are apparently limited to the offshore kelp beds and rocky shorelines. The reproductive rate is low, one pup per female every other year. The young are born in the kelp beds. The food of sea otters consists of long-spined urchins, sea mussels, abalones, kelp crabs and occasional fish.

As an indication of the value of their pelts under present market conditions, 100 pelts from Alaska were sold in April of 1957 by the federal government for an average of about $100 each. These were a miscellaneous collection of pelts from wounded or dead animals, as well as some that were confiscated from poachers and of which few were considered as prime pelts.

Fur Seals. Pribilof fur seals are strictly migratory animals which each season move northward some distance off the California Coast. They may be observed off the Farallon Islands, but rarely come ashore either there or on the mainland. Under the protection of international agreements the number of these animals has increased to the point that more than 50,000 pelts were permitted to be taken off the Pribilof Islands in 1956. The U.S. Government at its semi-annual sales sold 27,819 skins in April 1957 for $2,547,182, for an average of $91.56 per skin. Sales in October 1956 brought $2,714,852 for 26,890 skins or $100.96 per skin. Since the international convention of 1911 which set up the machinery to protect them, more than a million seals have been harvested. The population, meanwhile, has increased steadily. In 1941 it was estimated at 1,600,000 animals, just 400,000 below the estimated population of 1860.

Guadalupe fur seals are no longer found in the Bay Area, but they are increasing slowly, under complete protection, off Southern California and Mexico.

Neither of the above species are likely to become an important part of the Bay Area fauna.

Sea Lions. Both the California and Stellar's sea lions are quite numerous along the shores outside the Golden Gate, and are commonly observed within the Bay itself. Their continued presence seems assured. They are given adequate protection by law, and there is no reason to believe that other factors, including pollution, will affect their abundance to any great extent.

Harbor Seals. Harbor seals, unlike the preceding three species, are common residents of the Bay and have been observed by the writer as far inland as Grizzly Bay. A rookery still exists in the south end of San Francisco Bay. These curious little animals are a prominent part of the local fauna and should be preserved. Legal protection from hunters, however, is

not alone sufficient to preserve them. Pollution could be a serious threat to their existence by destroying the shellfish and bottom fauna upon which they feed, or in the case of oil pollution causing direct physical injury.

Their future in the Bay is therefore dependent to some extent upon the quality of the Bay water. Without the threat of pollution there is every reason to believe they will become even more abundant.

Rookeries and Hauling Grounds in the Bay Area. The locally important areas for seals and sea lions are listed below. Bonnot (1928) is the source of most of the information.

Point Reyes: Formerly, an extensive rookery was located here, but after the herd was exterminated in 1899-1900 the area has been used primarily as a fishing ground for Stellar sea lions.

Tomales Bay: This bay is the hauling grounds for a small resident herd of harbor seals which in 1927 and 1928 numbered forty.

Farallon Islands: At one time these islands supported the largest rookery along the coast. The valuable Guadalupe fur seal occurred here in vast numbers. Both Stellar and California sea lions currently have rookeries here.

Seal Rocks: These are the rocks just off Golden Gate Park, San Francisco. They are primarily hauling grounds for Stellar sea lions.

The Sisters: This is a group of rocks located in San Francisco Bay near Point San Pedro. They are used as hauling grounds by harbor seals.

Calaveras Point: Harbor seals use the area only as a hauling ground according to Bonnot. This area formerly (1890) was an extensive rookery and according to Mr. McLean of the Department of Fish and Game, a number of pups are still born in that vicinity each year. It is located in the south end of San Francisco Bay near Mowry Slough.

Purissima: This area just south of Half Moon Bay, San Mateo County, has supported a moderate number of Stellar sea lions (150 in 1927). According to the U. S. Commissioner of Fisheries report of 1902, 3,583 were killed in the last six months of 1901 at this location. It is a hauling ground.

Ano Nuevo: This island just south of Pigeon Point was the largest sea lion rookery on the California Coast in 1929. It is used chiefly by Stellar sea lions.

The Inland Furbearers

River otter and mink populations have probably remained at a near constant level since the early 1900's. Raccoon and the non-native muskrat on the other hand have unquestionably undergone significant increases. The golden beaver, despite intermittent closed seasons and other protective measures, seems to have suffered a steady decline.

Mink and River Otter. According to Grinnell et al. (1937), the center of abundance of the California river otter (*Lutra canadensis brevipilosus*) appears always to have been along the lower Sacramento River, particularly in the extensive tule marshes and in the region about Suisun Bay. Similarly, mink (*Mustela vison*) are most abundant on the marshy lands along the lower courses of the Sacramento and San Joaquin rivers and the upper parts of San Francisco Bay.

These are the two most valuable individual fur bearers currently taken in California. The market for their fur is quite steady, especially for mink, which generally ranks second behind muskrat in terms of the total value of furs taken. Individual mink pelts, at present market prices, vary from $10 to $25, with those in the Bay Area closer to the former figure. Otter pelts may bring as much as $20 or more but generally $15.

Neither can be considered as being particularly abundant in the Bay Area, but populations are holding their own, while providing upwards of 20 percent of the state's supply of pelts.

Reclamation is perhaps the most serious threat to these two species. Their future abundance will probably be influenced less by pollution than reclamation. Although they are primarily aquatic mammals it probably would require severe pollution conditions to affect the population adversely. Destruction of their food supply by pollution, however, could reduce them.

Grinnell et al. (*op. cit.*) states: "The river otter in California can never be expected to figure importantly as a fur animal. Fresh water habitat of a sort to provide proper food and shelter for otters is becoming more and more restricted".

Muskrat. The muskrat (*Ondatra zibethica*), in the last twenty years has risen to the status of the most important fur bearer in the state, in terms of number of animals and total value of the raw furs. The animal which now comprises the bulk of the market furs is an exotic species. Originally introduced into the northeastern counties, they have moved down the Sacramento and into the San Joaquin system since 1943. It has only been since 1950 that they have been trapped in profitable numbers in the Bay Area counties. The catch has increased from less than 100 in 1950 to between 6,000 and 9,000 annually at the present time. This species can be expected to increase significantly in the Bay Area in the future and in all probability will become the most important fur bearer in the region. Many freshwater streams and sloughs in which it is not now found are likely to provide habitat for them. As in the case of the previous two species, reclamation is the most serious threat to their existence. Unlike the two previous species, muskrats are principally vegetarians and their food supply would not be similarly affected by pollution.

Beaver. The golden beaver *(Castor canadensis subauratus)*, it was pointed out earlier, was apparently very abundant in the freshwater areas of the Sacramento and San Joaquin Delta. Evidence exists to show that they were also found along the Napa River, and in Coyote and Sonoma creeks in small numbers at least. The beaver is adapted to freshwater and its presence about the bays is inhibited by saline conditions. Some of the greatest local concentrations of beaver in the state are found within the Bay counties. The delta area of Contra Costa County and the Cache Slough area of Solano County are particularly favorable locations. These areas however, are outside the geographic area encompassed by this report and the absence of suitable habitat and other conditions precludes any serious consideration regarding the future of beaver in the Bay Area.

Due to its habit of burrowing in banks and levees, beaver were classified as an undesirable rodent within prescribed areas of the Sacramento and San Joaquin valleys in 1950. There is no closed season on them within that area, which aids in limiting the abundance and extension of the species. Alameda, Contra Costa and Solano counties are included in this area.

Raccoon. One of the most consistently important furbearers of the Bay Area has been the raccoon *(Procyon lotor)*. This native has always been prominent in the fur trade. Individual pelts are not especially valuable, but they are taken in sufficient quantity each year to remain among the top five furbearers in total value. The price per pelt was about five dollars in the 1920's. During the 1927-28 season raccoon pelts brought $105,000. This was more than any other kind, and comprised about one-fourth of the total value of all furs.

Raccoons are abundant in the area surrounding the Bay and Delta, and when the demand for this fur exists they are trapped heavily in Napa, San Mateo, Santa Clara, Alameda, Contra Costa, Sonoma, and Solano counties.

According to Grinnell et al. (*op. cit.*), "It is safe to consider as the chief requirement for the presence of coons in a locality, ready access to water, whether in running streams, ponds, or marshes. Even though the animal can and does go far from water it seems to be so adjusted that it must make regular and frequent visits to the stream side or marsh."

Populations are not likely to be affected by water quality except as it might affect their food supply. Their diet usually consists of a high percentage of aquatic organisms; frogs, crayfish, aquatic invertebrates and quite often fish. They will, however, turn to rodents, insects, plants, and berries.

The raccoon is considered by some people to be a choice article of food, and is captured specifically for this purpose.

Prospects for this species are encouraging. There are extensive areas of favorable raccoon habitat in the Bay Area and as long as a water supply is available they can be expected to remain plentiful.

The Lesser Furbearers. Some of the lesser varieties of furbearers collectively constitute an important segment of the Bay Area fur resources. Generally speaking, their individual pelts are not as valuable as the preceding species and there is not a steady demand for them. Skunk are something of an exception in that pelts are consistently worth $0.50 to $1.00, and are obtained in good quantity. There are two species of skunk. The striped skunk *(Mephitis mephitis)*, is the most important, although the spotted skunk or civet *(Spilogale gracilis)*, is also taken in fair numbers. In terms of value, skunks have been the most important furbearers of a group which includes foxes, badgers, ringtail cats, opossums, weasels, coyotes and wildcats. Several of these species provide food and/or recreation in the form of hunting or trapping.

These furbearers are not primarily aquatic, nor do they depend upon water other than an adequate supply for drinking purposes. Their contribution to the Bay Area fur production can be obtained from Appendix H-3.

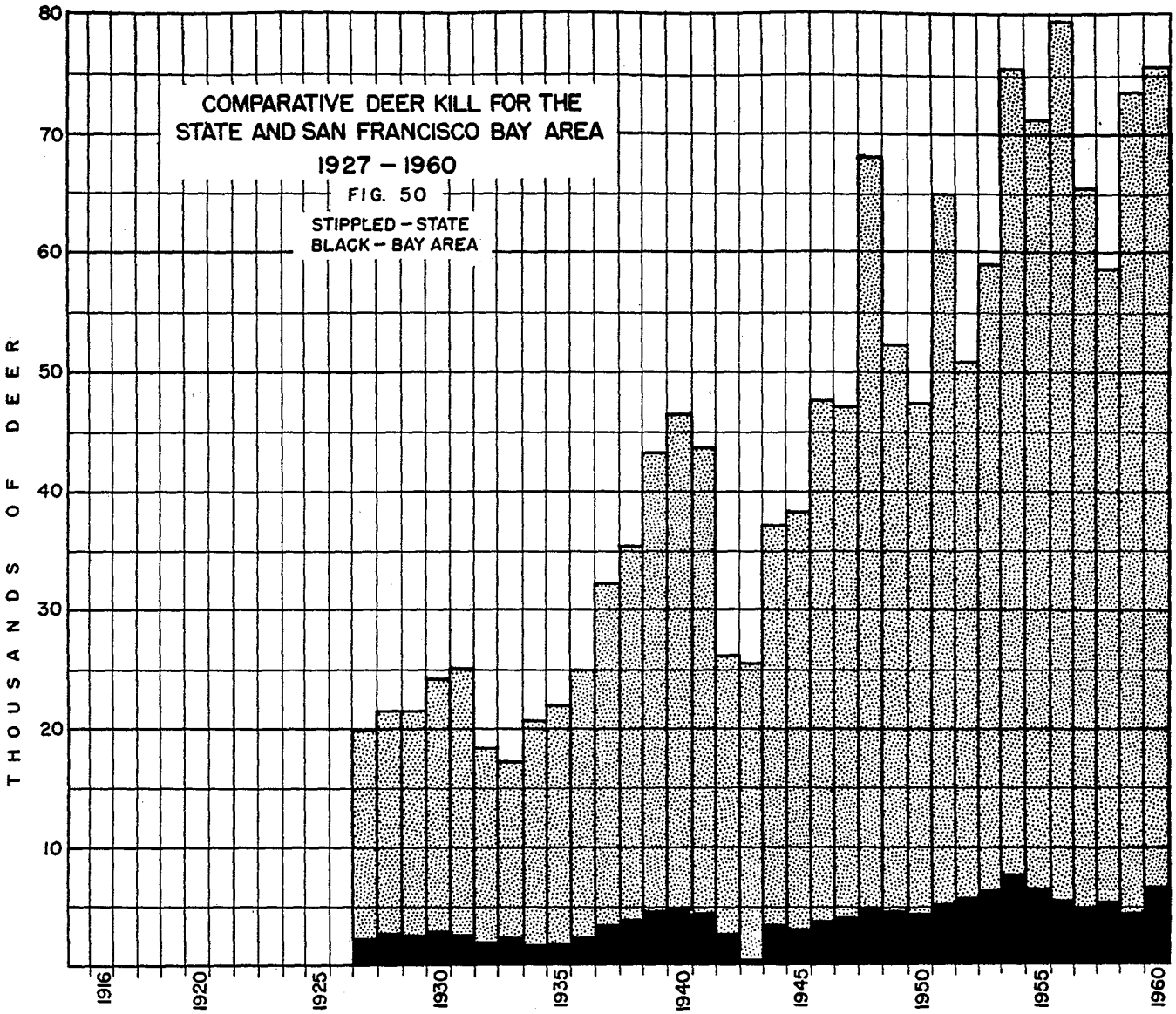
A few species are increasing in numbers as a result of present land use practices. Generally speaking, however, this group has probably reached a rather stationary level under prevailing conditions. Some, like the coyote, fox, and skunk are considered predators and excess animals are cropped by ranchers and trappers. Their numbers are unlikely to change unless particular factors such as demand for their fur, radically changed land use practices, or disease affects them.

Small Game Animals

The Bay counties provide a varied assortment of small game animals which furnish a considerable amount of hunting for local residents. This category includes several species of squirrels, rabbits, and varmints. Some of the minor furbearers are also in this category.

Jack rabbits *(Lepus californica)* provide the greatest amount of hunting in this group. In 1956 the bag for the Bay counties totaled 75,800 jackrabbits or about 8.3 percent of the state-wide total. Solano County was the largest single producer. About 3.1 percent or 11,000 brush rabbits *(Sylvilagus bachmani)* and cottontail rabbits *(Sylvilagus auduboni)* combined were taken in the Bay Area against a total of 356,000 for the State. As a group, rabbits are the fourth most important game animal in California.

Only 3,200 tree squirrels were taken for 7.7 percent of the state-wide total of 41,700. Those represented in the Bay fauna are the western gray squirrel *(Sciurus griseus)*, eastern gray squirrel *(Sciurus carolinensis)* and the fox squirrel *(Sciurus niger)*.



Precluding disease or some other catastrophic event they should continue in good abundance. The western gray squirrel is just recovering from an outbreak of scabies which occurred in the early part of this century.

Big Game Animals

The black-tailed deer, the black or cinnamon bear and the mountain lion are the only big game animals remaining in the Bay Counties. Bears are extremely scarce and are known to be present only in Sonoma and Napa counties although evidence indicates they may also be present in Marin and Solano Counties. Department game kill records were not designed to obtain the county of kill for bears until 1957; since that time only two have been reported and these were taken in Sonoma County.

Black-tailed deer are found in moderate abundance at the present time in most Bay counties. The number taken by hunters from 1927 to 1952 has averaged about 8.6 percent of the annual state-wide total. The kill by county for 1953-56 is given in Table 54. Deer kill records for the state and the Bay counties for the 34-year period 1927-1960 are compared in Appendix H-5. The recent status of deer and deer habitat in the Bay Area is summarized in Tables 55 and 56.

It is an established fact that deer thrive through partial removal of forests when replaced by favorable forms of agriculture, and it is entirely possible that deer are more numerous now than under primeval conditions as the following paragraphs from Longhurst, et al. (op. cit.) indicate. "Ralph S. Roy, who spent all of his 68 years on a 2,000 acre dairy ranch near Lagunitas, Marin County, was 14 years old (1894) when he saw his first deer and it was several years before he

saw another. As he grew to maturity, however, deer became increasingly common and by 1920 several legal bucks were killed each year on the ranch. In 1947 members of the family and their friends killed 30 bucks on the same area, and Mr. Roy was in our office to report acute deer damage to his crops and orchards."

The mountain lion or puma is rarely encountered except by experienced hunters and trappers. The statewide kill ranges from 150 to 250 animals per year. In the Bay counties they are mostly found in the Mount Hamilton Range of Santa Clara County, from which over 65 percent of this area's total has been taken.

The Department of Fish and Game has maintained records on mountain lion bounties since 1906. Since that time 284 lions have been taken from the nine Bay counties, for which bounties were paid. Santa Clara County alone produced 186.

Alameda and Sonoma are the only other Bay Area counties which consistently produce lions but these have contributed only 49 and 36, respectively, for an annual average of about one each. These figures are

TABLE 54

COMPARISON OF STATE AND BAY AREA DEER KILL 1927-1956

County	Average 1927-1952	1953	1954	1955	1956
Sonoma	932	1,679	1,979	1,586	1,303
Napa	706	1,161	1,386	1,329	1,144
Santa Clara	629	1,172	1,695	1,434	1,239
Marin	499	885	1,048	901	707
Alameda	360	763	911	639	538
San Mateo	113	139	140	157	134
Solano	71	113	139	143	147
Contra Costa	65	232	311	175	187
Totals	3,045	6,144	7,609	6,364	5,399
State Total	35,330	58,992	75,602	71,126	79,371
Bay Area bag as percentage of the state total	8.6	10.4	10.1	8.9	7.7

TABLE 55

SUMMARY OF RANGE CONDITION AND DEGREE OF STOCKING IN THE VARIOUS SUB-UNITS OF DEER RANGE (1948-1949) [1]

LEGEND

E—Excellent
G—Good
F—Fair
P—Poor

VP—Very Poor
I—Improving
S—Static

D—Declining
U—Understocked
C—Stocked to Capacity

O—Overstocked
Inc.—Increasing
Dec.—Decreasing

Unit and Sub-Unit	Range Condition for Deer	Range Trend	Deer in Relation to Range Capacity	Livestock in Relation to Range Capacity	Deer Population Trend
North Bay					
Monticello	F	S	O	O	S
Santa Rosa	F	S	C	C	S
Petaluma	F	S	C	O	S
South Bay					
Santa Cruz	F	S	C-O	C	S
Mt. Diablo	P	D	O	O	Dec.
Mt. Hamilton	P	D	O	O	Dec.

[1] After Longhurst et al (1952).

TABLE 56

RANGE AREAS, REPORTED KILL, AND ESTIMATED DEER HUNTERS IN VARIOUS SUB-UNITS OF THE BAY AREA [1]

	North Bay			South Bay			
	Monticello	Santa Rosa	Petaluma	Santa Cruz	Mt. Diablo	Mt. Hamilton	Totals
1. Summer Deer Range Area (square miles)	1,100	1,390	740	880	540	1,340	5,990
2. Winter Deer Range Area (square miles)	1,100	1,390	740	880	540	1,340	5,990
3. Area closed to hunting by public agencies (square miles)	—	—	45	110	100	10	265
4. Area: Kill ratio for 1947 (bucks killed per square mile of hunted range)	1.20	0.81	0.79	0.42	0.50	0.71	
5. Estimated Summer deer density (deer per square mile) (1947-1949)	24	19	24	10	15	18	
6. Estimated Winter deer density (deer per square mile) (1947-1949)	24	19	24	10	15	18	
7. Estimated total deer numbers (1947-1949)	26,000	26,000	18,000	9,000	8,000	24,000	111,000

[1] After Longhurst et al (1952).

presented in more detail in Table 57. The population of these animals has remained rather static in the State since 1931 or so judging from the bounty records. McLean (1954) has placed the total population of the State at close to 600.

Bears and mountain lions are extremely rare and each will probably continue in their present low abundance. Deer on the other hand, have unquestionably increased in numbers since the 1800's. The population is now maintained at a relatively constant level by hunters. When they become so numerous as to cause damage to agricultural crops special hunts may be held.

TABLE 57

NUMBER OF MOUNTAIN LIONS BOUNTIED 1906-1955

County	1953	1954	1955	1907-1955
Alameda	2	5	5	49
Contra Costa	1	1	—	3
Marin	—	1	—	4
Napa	—	—	—	4
San Mateo	—	—	1	2
Santa Clara	7	3	7	186
Solano	—	—	—	—
Sonoma	—	—	—	36
Totals	10	10	13	284
State-wide Totals	181	160	184	11,390
Percentage from Bay Area	5.5	6.3	7.1	2.5

MAMMALIAN RESOURCES REFERENCES

Anonymous
1939. Sea Otter Past and Present. Nature Magazine. Vol. 32, pp. 425-428.

Anonymous
1958. The Playful Sea Otter.
Outdoor California: Vol. 19, No. 8, pp. 12.

Bancroft, H. H.
1884. History of the Northwest Coast. A. L. Bancroft & Sons, San Francisco.

Bonnot, Paul
1928. Report on the Seals and Sea Lions of California
California Department of Fish and Game, Fish Bulletin No. 14.
1928. The Sea Lions of California. California Fish and Game. Vol. 14, No. 1, pp. 1-15.
1937. California Sea Lion Census for 1936. California Fish and Game, Vol. 23, No. 2, pp. 108-112.
1938. California Sea Lion Census for 1938. California Fish and Game, Vol. 24, No. 4, pp. 415-419.

Bryant, Harold C.
1915. California's Fur Bearing Mammals. California Fish and Game, Vol. 1, No. 3, pp. 96.

California Department of Fish and Game
1957. Game Management Handbook (mimeographed annually)

California Department of Fish and Game
Annual Licensed Fur Trapper Reports. California Department of Fish and Game Mimeographed Reports 1921 to 1957.

California Department of Natural Resources
1951. Geologic Guidebook of the San Francisco Bay Counties; Bulletin 154, Division of Mines, Ferry Building, San Francisco.

Dasmann, William P.
1958. Big Game of California.
California Department of Fish and Game, Sacramento, 56 pp. illust.

Fisher, Edna M.
1949. Prices of Sea Otter Pelts. California Fish and Game, Vol. 27, No. 4, pp. 261-265.

Fry, Donald H. Jr.
1939. A Winter Influx of Sea Lions From Lower California. California Fish and Game, Vol. 25, No. 3.

Graf, William
1955. The Roosevelt Elk.
Port Angeles Evening News, Port Angeles, Washington, 105 pp. illust.

Grinnell, Joseph
1933. Review of the Recent Mammal Fauna of California. University of California Publications in Zoology, Vol. 40, No. 2, pp. 71-234.

Grinnell, Joseph, Joseph S. Dixon and Joan M. Linscale
1937. Fur Bearing Mammals of California
University of California Press, Berkeley, 2 vols. 777 pp.

Johnson, Floyd A.
1948. Upland Game Management
Wildlife Management Institute, Washington 5, D.C.

Jordan, David Starr
1898. The Fur Seals and Fur Seal Islands of the North Pacific Ocean
Report of the Fur Seal Investigations 1896-1897, Parts 3 and 4
U. S. Government Printing Office, Washington, D. C.

Littlejohn, Chase
1916. Habits and Hunting of the Sea Otter.
California Fish and Game, Vol. 2, No. 2, pp. 79-82.

Longhurst, William A., A. Starker Leopold, and Raymond F. Desmann
1952. A Survey of California's Deer Herds, Their Ranges and Management Problems, California Department of Fish and Game, Game Bulletin No. 6.

Leopold, A. Starker
1951. Game Birds and Mammals of California
California Book Company Ltd., Berkeley, California

McCracken, Harold
1955. The Beast That Walks Like a Man—The Story of the Grizzly Bear
Hanover House, Garden City, N. Y., 319 pp.

McLean, Donald D.
1944. The Pronghorn Antelope in California.
California Fish and Game, Vol. 3, No. 4, pp. 221-241.
1954. Mountain Lions in California.
California Fish and Game, Vol. 40, No. 2, pp. 147-166.
1955. Upland Game of California.
California Department of Fish and Game, Sacramento, 39 pp. illust.

Ogten, Adele
1941. The California Sea Otter Trade 1784-1848
University of California Press, Berkeley, 251 pp. illust.

Pacific Science Congress, Sixth Proceedings of;
1940. Sea Otter Past and Present. Vol. 3, pp. 223-236
University of California Press, Berkeley.

7—41686-E

Sanderson, Ivan T.
1951. How to Know the American Mammals. New American Library of World Literature Inc., N. Y., 164 pp., illust.

Seymour, George D.
1954. Recent Extension of the Range of Muskrats in California.
California Fish and Game, Vol. 40, No. 4, pp. 375-384.

Starks, Edwin C.
1922. Records of the Capture of Fur Seals on Land in California.
California Fish and Game, Vol. 8, No. 3, pp. 155-160.

Van Atta, C. E.
1946. Notes on the Former Presence of Grizzly and Black Bears in Marin County, California.
California Fish and Game, Vol. 32, No. 1, pp. 27-29.

COMMENTS REGARDING CHANGES IN THE FISH AND WILDLIFE RESOURCES OF THE BAY AREA

The purpose of this section is to reiterate some of the changes which have occurred in the fish wildlife resources of the Bay Area and to discuss the reasons for them insofar as possible. Where appropriate, it will also be indicated where information on the magnitude, value and recreational importance of the resource is lacking, and if possible, to indicate what must be done to obtain the necessary information.

COMMERCIAL FISHERIES

Records of commercial fish landings are available subsequent to 1915. In general, catch statistics over long-term periods can be indicative of the condition of the resource. However, they are not always a true index of abundance since consumer demand, vagaries of weather, wage disputes, technical advances and other factors may influence the catch greatly. Sudden changes in the rate of exploitation, caused by the discovery of new uses or obsolescence of fishery products, further complicate the interpretation of catch records. As an example, the landings of a particular fishery may gradually increase over a period of time, giving the impression of a healthy resource; however, the increased landings may be due to an increase in effort or efficiency of the forces exploiting the resource rather than an increase in the size of the stock. Thus, a fish population may actually be declining while landings are on the increase. If such a condition should continue, a sudden decline may be expected.

The Schooling, Pelagic Bait and Forage Fishes

Several noteworthy changes have taken place in this group of fishes. The most outstanding is the rise and decline of the sardine fishery. The fishery reached tremendous proportions as the industry developed an expanding market for sardine products. The Bay Area fleet entered the sardine picture in earnest about 1925. Landings gradually increased until 1939; then, after a few more years of good fishing, the fishery completely collapsed. Bay Area landings plummetted from over 284 million pounds in 1944 to less than 300,000 pounds in 1948. Overfishing is presumed to be the principal cause, although oceanographic factors may also be involved.

Anchovies, like sardines, are principally caught in the ocean. There is no indication that the population off the Bay Area has undergone any appreciable change. Since they are not taken in the Bay, there is no way of knowing how the stocks which enter San Francisco Bay compare in magnitude with those of former years. Considering present conditions in San Francisco Bay it is improbable that the Bay supports an equal or greater population of anchovies.

Herring, smelt, and whitebait catches in the Bay Area have not changed appreciably since 1915. It is probable that these three species could support heavier exploitation than they are now subjected to.

There has been an appreciable decrease in the populations of the schooling, pelagic bait, and forage fishes within the Bay during the past seventy years, judging from the conditions described in the early literature. For example, the paucity of these fishes in the South Bay at the present time is in strong contrast to the descriptions of their abundance some eighty or ninety years ago. Perhaps other factors could be cited as having an adverse effect on this group of fishes, but certainly none is more obvious than pollution. Large areas of the South Bay are, and have been, polluted since before the turn of the century. The littoral zone and tidal flats have been particularly affected. Generally, these areas are the most frequented by fish since they are more productive of food organisms.

There is a tremendous void in our knowledge with respect to the seasonal abundance and use of the Bay by this group for spawning. There is a definite need for study along these lines to aid in evaluating the importance of the Bay to fish and wildlife. Herring, for instance, which are forage for many other fish species, spawn in the Bay; thus, if the Bay is an essential feature of their life history, its degradation by pollution would be reflected in the piscivorous species which feed upon herring.

Flatfishes

At present, the entire flatfish catch of the San Francisco Bay Area is taken in the ocean. The average annual catch during recent years has been about four million pounds or about one-half of what it was between 1915 and 1937. The rapid decline in the fishery between 1938 and 1942 was caused by the sudden shift to shark fishing. A large proportion of the fishermen of the San Francisco fishing fleet are of Italian birth, and when World War II broke out, they were restricted from fishing as a security measure. As a result, the landings dropped severely. Landings have now recovered to about one-half their former level, but further increases can only be expected to occur slowly.

Flatfishes are no longer taken commercially in the Bay itself. The industry has shifted to the north where

C—043347

C-043348

the most suitable species for the fillet and frozen fish trade are more abundant. The species taken in the ocean off San Francisco have been used primarily in the restaurant and fresh fish trade. However, dealers are able to supply the latter trades from their operations in the north, and therefore need not operate out of San Francisco. These are the primary reasons the landings in this fishery are now below those of former years.

Pollution, therefore, probably has not affected the flatfish fishery insofar as the quantity of the landings is concerned. However, it should be reiterated here that there is a remote possibility of the Bay being a nursery area for several species of flatfish taken in the ocean. The actual relationship between the immature fish in the Bay and the adults taken in the outside fishery is not known and deserves investigation.

On the Atlantic Coast, the dependence of flounders on estuaries has been well documented.

Bottom Fishes

Bottom fish, such as lingcod and cabezon, entering the commercial fishery, are taken entirely in the ocean. Landings in the San Francisco Area underwent a severe reduction between 1936 and 1950 but are now recovering. The cause for the reduced landings was economic (lack of demand) rather than a scarcity of fish.

These fish have not been taken commercially in the Bay for at least thirty years, and, therefore, there is no way to compare their present abundance with that of earlier years. It would require a special study to determine the abundance of bottom fish in the Bay.

Sharks, Skates, and Rays

A major change in this fishery occurred between 1938 and 1942 when the annual landings soared to more than 5,000,000 pounds as compared to a normal 200,000 to 400,000 pounds. This abrupt increase in landings was triggered by a demand for the oil of soupfin shark livers, a rich source of Vitamin A. When a synthetic Vitamin A product was developed, the fishery subsided to its normal level. There is no evidence indicating any change in the fish population itself.

Mollusks

The molluscan fisheries of the Bay Area have undergone a tremendous change from the heyday of the early 1890's. The landings dropped continuously until 1930 when the introduction of the Pacific oyster resulted in a temporary increase. However, efforts at culturing this species in the Bay Area have subsided until at the present time the total amount produced in the San Francisco Area is less than 400,000 pounds.

Pollution appears to be the major factor contributing to the downfall of the oyster industry in this area. There are still extensive areas available for oyster culture but water quality is inadequate to produce a satisfactory product. Health agencies have quarantined many sections of the Bay as possible sources of contamination.

It would be most desirable to restore water quality conditions in the Bay to a level compatible with oyster culture. The potential in this industry, as discussed in a previous section, is tremendous.

A few pollution-tolerant species of clams are still quite abundant around the Bay, but in the main the public health hazard renders them unusable for human consumption.

Crustaceans

Crustacean landings in the Bay Area since 1910 have consisted primarily of the market crab. Annual production of this species has consistently exceeded four million pounds for the last thirty years. Although wide fluctuations appear, there has not been a major change in the fishery and it may be assumed to be in good condition.

The Bay shrimp fishery is now lagging far behind production of former years. This is due in part to economic conditions, in part to restrictive legislation and, perhaps, to some extent, to pollution. Here, again, is a case in which the catch data fail in properly appraising the condition of the fishery. Economic factors have depressed the landings and it is impossible to know exactly how abundant the species is. Nevertheless, it appears that the resource has dwindled appreciably from former levels.

Shrimp is a major component of the diet of a great number of fish species in the Bay, and factors favoring the fishery would serve to benefit those species as well as bolster the shrimp market.

This is another species about which accurate information on present distribution and abundance is lacking. An intensive study of Bay shrimps would be most desirable from the standpoint of the condition of the resource and its relation to pollution in the Bay and to review the potential of the resource with respect to further commercial exploitation.

Freshwater Commercial Fishes

The fishery for these species was relatively stable. In 1953, the legislature abolished the commercial catfish fishery, after investigation indicated a decline in the resource and a growing sport fishery with competing demands for the available fish. Then, in 1957, when the salmon and shad gill net fishery was banned, commercial fishing virtually ceased in the Delta, and the roughfish also dropped out of the commercial landings.

ANADROMOUS FISHERIES

Any detailed analysis of the factors affecting the abundance and landings in this group of fishes would be exceedingly difficult. Environmental conditions have been so greatly modified by man's activities that it is virtually impossible to ascertain the relative effect of any one factor on these resources.

King Salmon

The commercial fishery formerly consisted of the gill net fleet, which always operated inside the Golden Gate, and the ocean troll fleet. The former was abolished by the legislature in 1957.

The gill net fishery landings exhibited tremendous fluctuations from year to year throughout the recorded history of the fishery. However, the trend over the ninety-year period for which catch figures are available was downward. The 1957 catch was the smallest ever recorded.

There are several explanations which could account for the decrease. One cause can be ascribed to water development projects in California. Virtually every permanent stream the full length of the Central Valley has one or more dams constructed across it. These have eliminated spawning areas and adversely affected temperature and flow regimes. Unscreened water diversions also take a heavy toll of small fish.

Since both the gill net fishery and the ocean troll fishery operated on the same salmon stocks the latter certainly contributed substantially to the reduction in the gill net landings. There has been a large increase in the size of the ocean troll fleet and its catch over former years as well as a spectacular increase in the ocean sport fishery in the last 15 years.

Although the salmon resources certainly have been overfished at various periods throughout the last 50 or 60 years, it is quite unlikely that overfishing alone has been responsible for the long-term decline.

Pollution has also been involved in the salmon decline. However, it is impossible to demonstrate the relative effects of pollution on the resource. Mining and logging pollution and silt have been prevalent in some streams, domestic sewage and dairy pollution in others, and cannery and winery wastes in still others. Along the Bay proper, the numerous industrial waste outfalls threaten the small downstream migrants which are inadvertently swept into the vicinity of them. Untreated or inadequately treated domestic sewage discharges both in the Bay and in upstream tributaries create similar problems.

Striped Bass

Generally speaking, this fishery has remained relatively stable. The species was completely removed from the commercial category in 1935 and since then has been subjected to hook-and-line fishing only, except for fish which were taken incidentally with shad and salmon by the gill net fishery. The sport fishery is so intense it is believed that up to 25 percent of all legal-sized fish are removed from the fishery each year.

A review of the catch records and other pertinent data revealed a decline in the fishery from 1944 through 1955. As a consequence, further restrictions in size and bag limits were put into effect to bring the fishery into balance. This appears to have been accomplished.

Under present conditions, it appears that the sport fishery is now exerting sufficient pressure to have a definite influence on striped bass stocks. The governing factor, however, lies in the change in environmental conditions. These have been modified so greatly over the past fifty years that there has been an appreciable loss in the total habitat available to striped bass.

At least three adverse factors, excluding angling, are affecting the striped bass population: reclamation, water development projects, and pollution. It would be next to impossible to evaluate the relative importance of each. Reclamation, many years ago, resulted in extensive habitat changes which removed rich nursery grounds. Water development projects have modified temperature, flow, and salinity patterns in the Delta and in spawning areas, and numerous diversions take a heavy toll of fish. Pollution has resulted in an extensive loss of habitat, destruction of forage organisms, and, frequently, in the outright killing of the fish themselves.

The absence of striped bass in many areas of the Bay may be taken as rather clear evidence of pollution. South San Francisco Bay in particular can be cited, and there are other once-favorable localities which are now similarly devoid of striped bass.

Shad

Shad landings, in the past, have been influenced strongly by economic conditions. Generally the catch was considerably less than the fishery could have supplied. Nevertheless, there appears to have been a definite decline in the fishery, unrelated to economic conditions, and presumably caused by the same factors which have influenced salmon and striped bass populations. The most significant recent development with respect to the shad resource is the evolution of the sport fishery in the past few years.

WATERFOWL

There has been a decided reduction in the waterfowl of the Bay Area, both in resident and wintering populations. Reclamation of the marshlands and tidal flats has unquestionably been the major causative factor in the decrease. Most of the breeding areas around

the Bay have been eliminated, reducing the number of resident waterfowl to insignificance. There are still extensive areas used by birds for wintering purposes, but the prime habitat is gone. In the early days, overhunting was undoubtedly a serious factor in diminishing waterfowl numbers.

Pollution has affected waterfowl and shorebirds in the Bay Area through both habitat destruction and direct mortality through disease organisms and toxic substances. In numerous instances, birds have been lost when wings and feathers have become coated with oil or other petroleum products floating in the water.

Although marginal areas undoubtedly would harbor greater numbers of birds in the absence of pollution, relatively few areas are so contaminated that birds cannot tolerate them. Nonetheless, the destruction of aquatic plants and the bottom fauna by polluting substances contributes to the scaricty of waterfowl and shorebirds. Birds can make only limited use of areas which do not provide food or shelter.

ECONOMICS OF THE FISH AND WILDLIFE RESOURCES OF THE SAN FRANCISCO BAY AREA

In this section of the report an attempt is made to summarize the available information on the economics of the fish and wildlife resources of the Bay Area. Collectively, the resources, by whatever means of analysis, generate an economy of tremendous magnitude.

Unfortunately, a standard method has not yet been developed for expressing the value of sport fish and wildlife resources. Various agencies may use different methods to estimate the value of the same resource.

Unlike most things subjected to economic analysis, fish and wildlife, or water in a flowing stream or in a lake, have an aesthetic value over and above the actual wealth which they generate. A uniformly acceptable means of integrating this intangible element into an economic formula has not yet been devised.

There are several common methods of analysis. Those most often employed are based either on gross expenditures or on the primary or net value of the resource.

The gross expenditure by an angler or a hunter for example, usually far exceeds the actual market value of the game which he seeks. For example, economic surveys have shown that it costs the average angler more than $16 to catch a single salmon or steelhead. Obviously, this cost exceeds the food or commercial value of the fish by a considerable margin.

Proponents of the gross expenditure method maintain that the expenditure incurred by the participant, over and above the commercial value of the game, reflects the aesthetic and recreational value of the resource to the participant.

The other extreme, of course, is to consider only that value which the resource would command on the market at the primary level. This is usually complicated by the fact that few game species are sold commercially. This method obviously neglects the recreational and aesthetic qualities entirely.

Where strictly commercial fisheries are involved, the problem usually does not exist. The value received by the fisherman (primary value) less the overhead is usually used.

But in the case of salmon, which is both a commercial and sport fish, the proportion of the resource subject to exploitation by each is usually considered separately.

In the following discussion the gross expenditure method is employed in assessing the economy of the non-commercial wildlife resources. Commercial fisheries are generally evaluated at the primary or ex-vessel value. Estimates are also given of the capital investments in the resources insofar as they could be determined.

The numbers of angling, hunting and trapping licenses and sales of commercial fishing licenses since the inception of each are given in Appendices I-1, I-2, I-3 and I-4, respectively. It is interesting to note that the number of anglers and hunters is increasing at a more rapid rate than the general population.

FISHERIES

Commercial Fisheries

The fisheries products marketed at San Francisco since 1941 have yielded from less than three to more than five million dollars annually to the fishermen. During the five-year period 1951-1955, the ex-vessel value has average $3,457,206. The retail value of most fresh fish products is about three times the ex-vessel value, and for canned or specially prepared products five to ten times the price paid to the fishermen. The total value of these products therefore, at the consumer level, could conceivably range from a minimum of $13,500,000 to more than $18,300,000 annually, as shown in Table 58.

In the anadromous fisheries section of this report, it was reported that 70 percent of the California salmon landings are from stocks which depend on passing safely through the Bay Area. On the basis of the 1952-56 catches, $2,000,000 annually was attributed to these commercial salmon. Only one-half this amount is reflected in the $3,457,206 shown above since the other half of the salmon is landed, and the value accredited to the fisheries north of San Francisco. Inclusion of this additional $1,000,000 puts the total annual primary value of the commercial fisheries of the Bay Area on the order of $4,500,000.

A further breakdown would show the crustacean fisheries valued at approximately $650,000 per year and the mollusks at about $50,000 annually, at the primary level.

Pelgen (1955 b) in evaluating the effects of a salt-water barrier on fish and wildlife, assigned a value of $6,175,000 to commercial fisheries and $26,500,000 to sport fisheries. These values are not directly comparable with those presented above since the later include only that portion of the ocean catch which would supposedly be influenced by a barrier in San Francisco Bay.

It has not been possible to secure reliable information on the total amount of capital invested in the

C—043351

C-043352

commercial fishing industry. There apparently is no agency which maintains such records. However, consultation with officials of various organizations affiliated with the commercial fishing industry has made it possible to provide an approximate magnitude of such investments. Considering also the number and size of processing plants, fishing vessels, gear and other shore property such investments would appear to exceed $25,000,000. The value of equipment used in that segment of the fishery east of Carquinez Bridge was assessed at $600,000 by the industry. This is the amount of claims presented to the State Board of Control for damages suffered when the legislature prohibited commercial fishing in this area in 1957.

Sport Fisheries

Salmon. An earlier study by Pelgen (1955 a) indicated anglers spend about $10,000,000 annually on salmon fishing. Since as much as 70 percent of California's commercial salmon catch originates in the Central Valley, it appears reasonable to make the same assumption for sport-caught salmon. It is the writer's belief, however, upon considering the characteristics of the sport fishery, that the coastal salmon streams probably account for closer to 50 percent of the annual sport salmon expenditures. Thus, the gross expenditures on the proportion of the salmon sport fishery dependent on safe passage through the Bay is at least $5,000,000 and perhaps as much as $7,000,000 yearly. These estimates are based on the average cost and total number of days spent salmon angling. No distinction is made between king and silver salmon.

Steelhead. It was shown in the steelhead discussion that an estimated 58,000 days were spent steelhead angling in the Sacramento-San Joaquin river systems in 1953. It is reasonable to assume at least a third as many are also spent in the numerous steelhead streams of the San Francisco region. This would bring the total to about 80,000 angler days per year dependent on a fishery either originating in or dependent upon safe passage through the Bay. At the average cost of $18 per angler day for this type of fishing, angler expenditures are on the order of $1,440,000 annually.

Striped Bass. The average daily expenditure per striped bass angler, as determined by Pelgen, was about $9, which when multiplied by the number of days spent fishing (2,000,000 annually) gives an expenditure of $18,000,000 per year. Approximately $100,000 of this is spent for party boat fares each year.

Freshwater Sport Fisheries. Estimates of the economic values of freshwater fisheries of the Region are lacking. However, Kimsey (1957) by personal interview obtained data on the daily expenditures directly related to angling for warmwater species at representative lakes throughout the State. Mahoney (1960) conducted an extensive postal survey to obtain similar data in a comparison of saltwater and freshwater angling. The latter study showed a mean daily expenditure figure slightly higher ($14.27) than the former ($12.60), for freshwater fishing. Presumably this is reflection of the higher cost of trout angling, which was not represented in Kimsey's study. Mahoney's results indicate a total state-wide expenditure of almost $227,000,000 in California on all forms of freshwater (inland) fishing and $92,000,000 on saltwater fishing.

According to Department of Fish and Game postal surveys, roughly 20 percent of the state-wide catch of warmwater fish and somewhat less than 10 percent of the trout catch is made in the Bay counties. Assuming effort (angling days) is approximately proportional to the catch, it may reasonably be inferred that 15 to 20 percent of Mahoney's freshwater expenditure figure or between 34 and 45 million dollars is attributable to freshwater angling in the Bay Area. These figures, of course, include a portion of the silver salmon and steelhead angling expenditures previously discussed.

Saltwater Sport Fisheries. Mahoney's survey indicated the average daily expenditure for saltwater angling was $12.51. Clark (1953) established that a little more than 2,500,000 angling days were expended on saltwater fishing north of Santa Barbara, excluding San Francisco Bay. Assuming that one-third or 825,000 of this number is attributable to sportfishing in the ocean off the Bay Counties each year, the annual expenditure of the saltwater sport fishery of Bay Area is on the order of $10,300,000.

The distribution of angler expenditures for these forms of fishing is given in detail in Appendix I-5.

As indicated in the anadromous fisheries section there is a tremendous business built around the sport

TABLE 58

ECONOMICS OF THE BAY AREA FISHERIES RESOURCES

Resources	Level of Evaluation: Primary		Ultimate[1]
Commercial Fishery Products			
Salmon	$2,000,000		$6,000,000
Mollusks	50,000	$150,000	500,000
Crustaceans	650,000	1,950,000	6,500,000
Fresh Fish (other than salmon)	1,760,00		5,280,000
Estimated Average Annual Commercial Value	$4,460,000	$13,380,000	—$18,280,000
Sport Fishing Expenditures			
Anadromous fisheries			
Salmon		$5,000,000	
Steelhead		1,440,000	
Striped Bass		18,000,00	
All Freshwater Fishing in Bay Area[2]			$40,000,000
All Saltwater Fishing in Bay Area[2]			10,300,000
Total Estimated Annual Sport Fishing Expenditure			$50,300,000

[1] The ultimate level as used here refers to the value of the products to the consumer (See text for explanation).

[2] Anadromous sport fishing expenditures are included in these figures (See text).

sheries of the Bay Area. Estimates of the total investment in boat liveries, berthing facilities, bait stores and so on simply are not available, but such investments must run into several million dollars. The Bay accommodates a large fleet of party and charter boats and the value of these undoubtedly exceeds a million dollars. It would seem therefore, that capital investment related to the sport fisheries of the Bay would be on the order of at least five million dollars.

Table 58 is a summary of the angler expenditures and values of commercial fishery products originating in, or dependent upon water conditions in the Bay Area. The combined figures of $40,000,000 for freshwater fishing and $10,000,000 for saltwater fishing are the total for all sport fishery expenditures. Salmon, steelhead and striped bass, which have been discussed separately, are included under these two categories.

HUNTING

Waterfowl

Hunting Values. It was shown in the section on waterfowl that hunters spend on the average, $16.32 per goose and $8.16 per duck. Using these values and the nine year (1948-1949 to 1956-1957) average annual waterfowl kill in the Bay Area results in an annual expenditure on the order of $6,500,000 for ducks and $420,000 for geese for a total of $6,920,000. Pelgen (op. cit.) on the basis of the 1953 kill evaluated the Bay and Delta waterfowl at $10,500,000 annually.

Duck Club Investments. Private investments related to wildlife are mostly limited to refuges and hunting clubs. About the only known value which can be assigned to this category is the value of waterfowl club lands. As indicated in the waterfowl section, there were 242 duck clubs with an aggregate of 68,320 acres of land in the Bay Area. At an assessed value of $150 to $300 per acre the total investment in such lands ranges between 10 and 20 million dollars. For working purposes the intermediate value of 15 million dollars was used in Table 60.

Other Game Species

Separate studies for other game species are not available, but an economic study by the Department of Fish and Game of 1955 hunter expenditures indicates that $168,000,000 was spent by sportsmen on all forms of hunting. The mean cost of a day's hunting was found to be $18.97.

Game bag estimates indicate 10 percent of the deer, 8 percent of the rabbits and squirrels, 8 to 10 percent of the quail and a little less than 10 percent of the pheasants, doves and pigeons are consistently taken in the nine Bay counties. Because of the close agreement an arbitrary average of 10 percent of the state-wide totals is assumed for purposes of computation. It is further assumed effort (hunting days) and hence expenditures are roughly proportional to the game kill statistics. Therefore, 10 percent of the total state-wide expenditure or $16,800,000 can be attributed to hunting pursuits in the Bay Area.

The above estimate includes waterfowl hunting expenditures. Because the Bay Area contributes a considerably larger proportion of waterfowl to the state-wide bag (25 percent) as compared to other species (10 percent), and because of the greater expense involved in waterfowl hunting, the estimate should be revised to reflect the difference of such expenditures in the Bay Area.

This can be done by deducting the known state-wide waterfowl expenditures from the total state-wide hunting expenditures and allotting the correct proportion of each to the Bay Area. The revised total expenditure in the Bay Area, arrived at by this process, amounts to almost $20.5 million annually rather than $16.8 million. The figures are shown in Table 59a.

The furbearers of this area contribute an additional small amount to the fish and wildlife economy each year. Since 1921 the average annual value of the raw furs has been about $8,000 as compared to $123,000 for the State.

The economics of the game resources are summarized in Table 59-b.

TABLE 59a

GAME RESOURCE ECONOMICS [1]

	Bay Area	State Total less Bay Area	Statewide Total
Unweighted total all Hunting Expenditures	16.8 (10%)	151.2	168.0
Total Waterfowl Expenditures	7.0 (21%)	26.5	33.5
All Expenditures Except Waterfowl	13.5 (10%)	121.0	134.5
Weighted Total All Expenditures	20.5 (12%)	147.5	168.0

[1] Expenditures in millions of dollars.

TABLE 59b

SUMMARY OF ECONOMICS OF BAY AREA GAME RESOURCES

Estimated annual waterfowl hunting expenditures	$7,000,000
Estimated annual expenditures for all other types of hunting	13,500,000
Average annual value of fur resources	8,000
	$20,508,000

MANAGEMENT ECONOMICS

Further economic treatment involves the cost of maintaining, protecting, investigating, and enhancing the fish and wildlife resources of the Bay Area. A basic evaluation of the costs involved has been obtained through the cooperation of the U. S. Bureau of Reclamation, U. S. Fish and Wildlife Service, State Department of Water Resources, and the appropriate regional offices of the Department of Fish and Game. Expenditures fall into two broad categories, capital outlay and management costs. A major share of the former includes large expenditures on anadromous fish facilities, patrol boats, and land purchases. Manage-

ment expenses are largely taken up by wildlife protection, administration, salaries and the operational and maintenance costs of the larger installations.

A review of the capital outlay expenditures indicates a minimum of $16,300,000 either spent, allocated, or proposed for fish and wildlife projects. Of this amount, completed projects account for over $11,000,000, more than $5,000,000 worth of projects are contemplated, and just over $100,000 in projects are being constructed. The anticipated expenditures for fish salvage facilities in relation to the Feather River Project and a Delta Salinity Control Project are included in contemplated projects.

The amounts specified are comprised of expenditures within the confines of the nine Bay Area counties, for all forms of fish and wildlife; plus expenditures in the Central Valley for the maintenance, protection, and management of anadromous fishes which pass through San Francisco Bay. A third category includes capital outlay for the purchase of land for access sites and construction of a number of boat launching ramps. Most of these are for the purpose of providing fishing access to the Sacramento River system. Finally estimates are given for capital investments or holdings of businesses dependent upon the fish and wildlife resources of the Bay Area. These are summarized in Table 60.

The figures reported herein for fish screens and ladders may be considered conservative since they are based on the initial costs of the structures and numerous small screens and ladders have either been omitted or not assigned a value. Furthermore, many fish ladders and screens were built by private interests in compliance with state laws, and for which the Department of Fish and Game does not have cost figures.

A tabular summary of the economics involved in the administration of the fish and wildlife resources of the Bay Area or dependent upon its waters is given in Table 60. The individual projects are listed in Appendix I-7.

TABLE 60

SUMMARY OF ECONOMICS OF FISH AND WILDLIFE RESOURCES OF THE SAN FRANCISCO BAY AREA

Resource	Annual Value
Commercial Fishery Products[1]	$13,300,000
Sport Fishing Expenditures	50,300,000
Game Expenditures	20,508,000
Total Annual Value	$84,108,000
Capital Outlay and Investments	
Private Commercial Fishing Interests	$25,000,000
Private Sportfishing Interests	5,000,000
Private Waterfowl Club Lands	15,000,000
	$45,000,000
Governmental Agencies	$16,304,815
Total Investment	$61,300,000
Annual Operation and Maintenance Costs	$1,124,000

[1] Value at intermediate consumer level to compare with gross expenditures.

ECONOMICS REFERENCES

Calhoun, A. J.
1950. California Angling Catch Records from Postal Card Surveys: 1936-1948; With an Evaluation of Postal Card Nonresponse. California Fish and Game, Vol. 36, No. 3, pp. 177-234.
1951. California Statewide Angling Estimates for 1949 California Fish and Game, Vol. 37, No. 1, pp. 69-75.
1953. State-Wide California Angling Estimates for 1951. California Fish and Game, Vol. 39, No. 1, pp. 103-113.

California State Department of Natural Resources
1951. Geologic Guidebook of the San Francisco Bay Counties. Division of Mines, Bulletin No. 154, 392 pp. illust.

Clark, Frances N.
1953. California Marine and Freshwater Sport Fishing Intensity in 1951. California Fish and Game, Vol. 39, No. 1, pp. 115-125.

Cope, Oliver B. and Leo F. Erkkila
1952. Weekday Angling Pressure in the Sacramento-San Joaquin Delta, 1948 and 1949. California Fish and Game, Vol. 38, No. 1, pp. 73-84.

Kahn, Richard A. and George A. Rounsefell
1947. Evaluation of Fisheries in Determining Benefits and Losses from Engineering Projects. U. S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report No. 40, 10 pp.

Kimsey, J. B. and Chris J. Axelgard
1957. Economic Value of Warmwater Sport Fishing in California Lakes and Reservoirs. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report Number 57-26.

Mahoney, John
1960. An Economic Evaluation of California's Sport Fisheries. California Fish and Game, Vol. 46, No. 2, pp. 199-209.

Matthai, H. F., Wiliam Back, R. P. Orth and Robert Brennan
1957. Water Resources of the San Francisco Bay Area. U. S. Geological Survey Circular 378, 55 pp.

Pelgen, David E.
1955a. Economic Values of Striped Bass, Salmon, and Steelhead Sport Fishing in California. California Fish and Game, Vol. 41, No. 1, pp. 5-17.
1955b. The Effect of a San Francisco Bay Salinity Control Barrier On Fisheries and Wildlife. Appendix C of Report to the Water Project Authority of the State of California on the Feasibility of Construction of Barriers in the San Francisco Bay System.

Ryan, James H.
1959. California Inland Angling Estimates for 1954, 1956 and 1957. California Fish and Game, Vol. 45, No. 2, pp. 93, 109.

Skinner, John E.
1955. California State-Wide Angling Estimates for 1953. California Fish and Game, Vol. 41, No. 1, pp. 19-32.

U. S. Department of the Interior, Fish and Wildlife Service
1956. National Survey of Fishing and Hunting, 50 pp. illustrated U. S. Government Printing Office, Washington, D. C.

APPENDIX A

FISHING PORTS OF THE SAN FRANCISCO BAY AREA[1]

SONOMA COUNTY
- Stewarts Point
- Fort Ross
- Jenner
- Bodega Bay
- Healdsburg
- Sebastopol
- Petaluma
- Valley Ford

MARIN COUNTY
- Dillon Beach
- Tomales Bay
- Tomales
- Hamley (Telmat)
- Nicks Cove
- Blakes Landing
- Blue Baie Tavern
- Marshall
- Marconi
- Millerton
- Tomales Bay Oyster Co.
- Bivalve
- Point Reyes-Drakes Bay
- Bolinas Bay
- Stinson Beach
- Sausalito
- Mill Valley
- Tiburon
- California City
- San Quentin
- San Rafael
- Point San Pedro-McNears Pt.
- China Camp

[1] After Scofield 1954.

SAN FRANCISCO COUNTY
- San Francisco
- Hunters Point
- Farallon Islands

ALAMEDA COUNTY
- Hayward
- Alameda
- Oakland
- Berkeley

CONTRA COSTA COUNTY
- Richmond
- Point San Pedro
- El Sobrante
- Carquinez Strait
- Crockett
- Port Costa
- Point Carquinez
- Ozol

- Martinez
- Port Chicago
- McAvoy
- Pittsburg
- Antioch
- Oakley
- Brentwood
- Orwood
- Bethel Island
- Old River

SOLANO COUNTY
- Vallejo
- Benicia
- Suisun
- Collinsville
- Rio Vista

SAN MATEO COUNTY
- Daly City
- San Mateo
- San Carlos
- Redwood City
- Menlo Park
- Rockaway Beach
- San Pedro Valley
- San Pedro Point
- Point Montara
- Moss Beach
- Miramar
- Princeton by the Sea
- Half Moon Bay
- Martins Beach
- Pigeon Point
- Point Ano Nuevo

SANTA CLARA COUNTY
- Sunnyvale
- Alviso
- San Jose
- Campbell

C—043355

C-043356

APPENDIX B

COMMERCIAL FISH AND FISHERIES

APPENDIX B-1

COMMON MARINE SPORT AND COMMERCIAL FISHES OF THE SAN FRANCISCO BAY AREA

Common Name	Scientific Name	Code[1]
Sharks, Skates and Rays		
Sixgill cowshark	*Hexanchus griseum*	
Sevengill cowshark	*Notorynchus maculatum*	
Brown smoothhound	*Rhinotriacis henlei*	
Leopard shark	*Triakis semifasciata*	
Soupfin shark	*Galeorhinus zyopterus*	
Dogfish	*Squalus acanthias*	
California skate	*Raja inornata*	C
Big skate	*Raja binoculata*	C
Bat ray	*Holorhinus californicus*	
Schooling Pelagic, Bait and Forage Fishes		
Pacific sardine	*Sardinops caerulea*	C***
Pacific herring	*Clupea pallasi*	C*
Ocean northern anchovy	*Engraulis mordax mordax*	C***
Bay northern anchovy	*Engraulis mordax nanus*	
Surf smelt	*Hypomesus pretiosus*	C* S**
Whitebait smelt	*Allosmerus elongatus*	
Night smelt	*Spirinchus starksi*	C
Jacksmelt	*Atherinopsis californiensis*	C*
Topsmelt	*Atherinops affinis*	C*
Flatfishes		
English sole	*Parophrys vetulus*	C***
Petrale sole	*Eopsetta jordani*	C***
Dover sole	*Microstomus pacificus*	C***
Rex sole	*Glyptocephalus zachirus*	C**
Pacific sanddab	*Citharichthys sordidus*	C*
Starry flounder	*Platichthys stellatus*	C* S*
Diamond turbot	*Hypsopsetta guttulata*	C
Curlfin turbot	*Pleuronichthys decurrens*	C
Pacific halibut	*Hippoglossus stenolepis*	C
Arrowtooth halibut	*Atheresthes stomias*	C
California halibut	*Paralichthys californicus*	
Bottom Fishes		
Sablefish	*Anoplopoma fimbria*	C***
Pacific hake	*Merluccius productus*	C**
Lingcod	*Ophiodon elongatus*	C** S***
Cabezon	*Scorpaenichthys marmoratus*	C* S*
Pacific tomcod	*Microgadus proximus*	
Rockfish		
Bocaccio	*Sebastodes paucispinis*	C*** S***
Chilipepper	*Sebastodes goodei*	C** S*
Splitnose rockfish	*Sebastodes diploproa*	
Yellowtail rockfish	*Sebastodes flavidus*	C
Black rockfish	*Sebastodes melanops*	C
Orange rockfish	*Sebastodes pinniger*	C
Widow rockfish	*Sebastodes entomelas*	
Blue rockfish	*Sebastodes mystinus*	S**
Black and yellow rockfish	*Sebastodes chrysomelas*	S
Greenstriped rockfish	*Sebastodes elongatus*	
Vermilion rockfish	*Sebastodes miniatus*	C
Saltwater Perch		
Walleye surfperch	*Hyperprosopon argenteum*	C* S*
White seaperch	*Phanerodon furcatus*	C*
Rubberlip perch	*Rhacochilus toxotes*	C* S*
Black perch	*Embiotoca jacksoni*	S*
Striped seaperch	*Embiotoca lateralis*	S*
Calico surfperch	*Amphistichus koelzi*	C* S**
Barred surfperch	*Amphistichus argenteus*	S*
Redtail surfperch	*Amphistichus rhodoterus*	C* S*
Silver surfperch	*Hyperprosopon ellipticum*	C* S*
Rainbow seaperch	*Hypsurus caryi*	C* S*
Pileperch	*Rhacochilus vacca*	C* S*
Shiner perch	*Cymatogaster aggregata*	C* S*
Miscellaneous		
White seabass	*Cynoscion nobilis*	C S
White croaker	*Genyonemus lineatus*	C S
Albacore	*Thunnus germo*	C***

[1] C denotes commercial importance, S sport importance, and the number of asterisks the relative degree of importance at the present time.

C—043356

C-043357

APPENDIX B-2

COMPARATIVE COMMERCIAL FISH LANDINGS FOR THE STATE AND SAN FRANCISCO BAY AREA 1916-1958

LANDINGS OF SCHOOLING, PELAGIC, BAIT AND FORAGE FISHES IN POUNDS

Year		Anchovy	Herring	Sardine	Smelt	Whitebait	Totals
1916	State	531,209	2,928,591	15,648,839	991,509	161,797	20,261,945
	Bay Area	239,724	2,358,392	13,967	289,326	161,797	3,063,206
	Percentage [1]						15.1 [1]
1917	State	528,753	7,435,997	104,103,331	984,270	123,079	113,175,430
	Bay Area	100,258	7,377,320	142,398	210,997	123,014	7,953,987
							7.0
1918	State	868,161	7,938,280	157,652,811	796,984	135,857	167,392,093
	Bay Area	268,470	7,925,069	892,717	228,228	117,450	9,431,934
							5.6
1919	State	1,609,548	4,289,899	153,877,179	756,980	5,915	160,539,521
	Bay Area	305,896	4,281,903	1,504,218	212,462	5,915	6,310,394
							3.9
1920	State	569,774	274,364	118,520,914	744,187	678	120,109,917
	Bay Area	221,233	266,789	1,105,089	141,124	678	1,734,913
							1.4
1921	State	1,946,881	542,124	59,332,305	765,073	5,229	62,591,612
	Bay Area	175,255	533,359	153,978	140,946	5,229	1,008,767
							1.6
1922	State	652,516	341,621	93,399,900	830,140	84,007	95,308,184
	Bay Area	150,786	333,882	170,515	117,064	63,133	835,380
							0.9
1923	State	307,074	383,950	158,159,356	806,380	67,818	159,724,578
	Bay Area	184,085	363,907	339,804	154,885	41,658	1,084,339
							0.7
1924	State	346,951	435,620	242,685,958	721,912	122,483	244,312,924
	Bay Area	10,718	420,226	1,090,852	164,331	65,983	1,752,110
							0.7
1925	State	93,071	865,774	315,294,986	751,669	70,968	317,076,468
	Bay Area	26,012	847,071	464,182	118,936	32,951	1,489,152
							0.5
1926	State	60,157	453,607	286,741,250	883,123	85,557	288,223,694
	Bay Area	3,400	432,817	7,056,765	113,546	12,027	7,618,555
							2.6
1927	State	368,201	1,168,321	342,275,289	965,921	134,149	344,911,881
	Bay Area	278,125	1,098,560	18,741,812	123,730	30,975	20,273,202
							5.9
1928	State	357,470	1,139,682	420,269,665	926,116	135,186	422,828,119
	Bay Area	125,515	1,054,578	26,965,736	114,032	31,101	28,290,962
							6.7
1929	State	382,445	957,563	651,771,904	933,095	243,119	654,288,126
	Bay Area	239,575	921,682	41,091,857	124,211	95,582	42,472,907
							6.5
1930	State	319,561	717,634	494,450,747	1,054,665	174,917	496,717,524
	Bay Area	261,850	602,157	48,468,957	203,031	71,153	49,607,148
							10.8
1931	State	307,494	685,759	301,307,801	1,074,810	141,495	303,517,359
	Bay Area	164,657	634,012	50,661,534	243,609	10,410	51,714,222
							17.0
1932	State	299,217	765,724	312,171,716	899,216	133,540	314,269,413
	Bay Area	147,627	726,925	29,357,768	299,423	28,875	30,560,618
							9.7
1933	State	317,292	601,445	509,797,481	729,702	95,751	511,541,671
	Bay Area	185,095	544,995	62,214,480	318,844	44,682	63,308,096
							12.4

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.

APPENDIX B-2—Continued

LANDINGS OF SCHOOLING, PELAGIC, BAIT AND FORAGE FISHES IN POUNDS—Continued

Year		Anchovy	Herring	Sardine	Smelt	Whitebait	Totals
1934	State	257,505	801,601	902,585,099	732,191	105,982	904,482,378
	Bay Area	66,965	755,714	134,427,065	264,388	12,939	135,527,071
							15.0
1935	State	178,970	928,880	829,512,548	875,480	164,345	831,660,223
	Bay Area	74,550	792,090	147,257,938	323,036	30,742	148,478,356
							17.9
1936	State	195,122	840,530	955,525,700	841,231	197,738	957,600,321
	Bay Area	133,050	831,608	283,789,775	380,517	13,184	285,148,134
							29.8
1937	State	226,229	631,330	891,430,525	682,070	86,177	893,056,331
	Bay Area	102,100	613,361	255,367,373	322,753	8,748	256,414,335
							28.7
1938	State	735,144	504,884	935,611,489	567,861	106,724	937,526,102
	Bay Area	251,750	495,621	358,853,647	235,915	8,090	359,845,023
							38.4
1939	State	2,147,901	302,242	1,160,793,581	474,936	166,883	1,163,885,543
	Bay Area	214,907	278,399	491,842,739	172,313	22,444	492,530,802
							42.3
1940	State	6,317,797	453,193	905,973,403	449,360	127,449	913,321,202
	Bay Area	13,775	413,486	231,359,394	116,461	17,478	231,920,594
							25.4
1941	State	4,105,382	789,753	1,262,480,393	452,739	131,102	1,267,959,369
	Bay Area	600	686,220	395,325,120	112,650	40,882	396,165,472
							31.2
1942	State	1,694,290	190,815	969,747,099	443,939	159,258	972,235,401
	Bay Area	5,400	109,022	210,687,961	166,927	8,227	210,977,537
							21.7
1943	State	1,570,803	630,358	972,269,915	1,566,273	141,367	976,178,716
	Bay Area	78,793	495,132	244,695,817	969,619	3,487	246,242,848
							25.2
1944	State	3,891,029	422,290	1,147,207,882	1,541,044	269,425	1,153,331,670
	Bay Area	110,010	270,524	284,493,570	1,207,263	20,423	286,101,790
							24.8
1945	State	1,616,880	460,465	845,062,774	2,369,580	291,152	849,800,851
	Bay Area	292,030	309,305	185,199,860	1,715,864	46,950	187,564,009
							22.1
1946	State	1,921,627	481,776	510,759,173	793,463	344,462	514,300,501
	Bay Area	263,776	458,447	6,401,124	462,316	65,751	7,651,414
							1.49
1947	State	18,940,521	1,654,850	255,513,948	713,264	326,603	277,149,186
	Bay Area	390,173	662,257	626,228	433,202	73,664	2,185,524
							0.8
1948	State	10,835,930	8,000,377	362,037,087	782,096	222,499	381,877,989
	Bay Area	380,251	6,772,274	229,809	427,287	56,234	7,865,855
							2.1
1949	State	3,322,273	379,311	633,374,991	715,528	241,764	638,033,867
	Bay Area	216,474	274,559	33,879,165	440,195	29,860	34,840,253
							5.5
1950	State	4,878,687	1,425,351	714,521,761	590,968	207,607	721,624,374
	Bay Area	338,559	1,194,201	26,442,685	306,687	79,040	28,361,172
							3.9
1951	State	6,954,852	4,917,643	328,892,130	1,095,504	162,054	342,022,183
	Bay Area	284,100	3,672,383	165,144	422,213	38,134	4,581,974
							1.3
1952	State	55,782,870	9,209,386	14,189,420	646,116	152,115	79,979,907
	Bay Area	5,831,115	3,223,314	—	281,560	64,712	9,400,701
							11.8
1953	State	85,835,478	7,801,928	9,429,816	670,116	179,292	103,916,630
	Bay Area	3,072,524	4,791,961	—	248,833	65,420	8,178,738
							7.9

APPENDIX B-2—Continued

LANDINGS OF SCHOOLING, PELAGIC, BAIT AND FORAGE FISHES IN POUNDS—Continued

Year		Anchovy	Herring	Sardine	Smelt	Whitebait	Totals
1954	State	42,410,214	911,906	134,091,068	608,609	267,281	178,289,078
	Bay Area	261,759	475,161	.....	295,441	56,593	1,088,954
							0.6
1955	State	44,691,582	1,946,521	145,607,749	780,172	214,558	193,240,582
	Bay Area	206,650	1,147,567	.....	447,706	29,159	1,831,082
							0.9
1956	State	56,920,585	1,735,776	69,554,345	466,333	148,820	128,825,859
	Bay Area	387,981	925,121	.....	147,492	53,340	1,513,934
							1.2
1957	State	40,547,526	1,188,080	45,861,931	371,472	243,600	88,212,609
	Bay Area	10,135	547,708	.....	139,615	71,817	769,275
							0.9
1958	State	11,602,724	2,399,730	207,445,837	549,854	306,805	222,304,950
	Bay Area	2,888	1,621,471	.....	73,071	70,073	1,767,503
							0.8

LANDINGS OF FLATFISHES IN POUNDS

Year		Flounder	Halibut	Sand Dab	Sole	Turbot	Totals
1916	State	453,916	4,122,517	2,228,734	6,407,186	2,608	13,214,961
	Bay Area	433,889	25,842	1,466,280	4,565,499	2,322	6,493,832
	Percentage [1]						49.1
1917	State	1,151,876	4,510,897	2,631,862	8,728,429	1,327	17,024,391
	Bay Area	1,044,149	116,964	1,812,036	6,857,802	1,301	9,832,252
							57.8
1918	State	818,835	4,753,691	1,751,609	7,027,767	3,664	14,355,566
	Bay Area	721,411	103,226	1,380,057	4,696,984	3,087	6,904,765
							48.1
1919	State	435,731	4,859,498	709,738	5,528,685	2,115	11,535,767
	Bay Area	373,824	145,309	628,206	4,914,548	2,115	6,064,002
							52.6
1920	State	481,587	4,444,890	721,810	3,821,748	855	9,470,890
	Bay Area	434,074	140,001	571,377	3,107,815	855	4,254,122
							44.9
1921	State	293,656	3,795,757	784,011	4,870,870	219	9,744,513
	Bay Area	229,792	117,872	683,828	4,179,478	219	5,211,189
							53.5
1922	State	539,220	3,403,484	1,170,979	7,043,336	1,534	12,158,553
	Bay Area	472,340	107,939	1,020,778	6,335,442	1,534	7,938,033
							65.3
1923	State	508,961	2,426,837	1,363,911	7,086,035	1,011	11,386,755
	Bay Area	434,345	28,210	1,220,604	6,174,566	991	7,858,716
							69.0
1924	State	379,770	2,708,898	1,699,832	8,835,351	1,868	13,625,719
	Bay Area	328,992	19,617	1,650,232	8,413,153	1,868	10,413,862
							76.4
1925	State	594,420	2,613,861	1,952,847	8,762,535	3,926	13,927,589
	Bay Area	474,310	55,795	1,668,903	7,101,215	3,926	9,304,149
							66.8
1926	State	667,711	1,687,720	1,143,935	8,649,870	1,365	12,150,601
	Bay Area	475,432	115,376	937,994	6,272,223	1,365	7,802,390
							64.2
1927	State	590,064	1,872,231	892,718	10,479,765	3,950	13,838,728
	Bay Area	481,172	60,838	767,288	9,370,016	3,950	10,683,264
							78.3
1928	State	399,880	1,563,491	1,108,764	10,281,719	9,234	13,363,088
	Bay Area	345,043	55,650	878,486	8,178,096	9,234	9,466,509
							70.8
1929	State	580,752	1,853,197	1,051,868	11,706,761	1,323	15,193,901
	Bay Area	513,756	96,968	974,258	10,835,233	1,323	12,421,538
							81.8

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.

APPENDIX B-2—Continued

LANDINGS OF FLATFISHES IN POUNDS—Continued

Year		Flounder	Halibut	Sand Dab	Sole	Turbot	Totals
1930	State	391,096	1,511,718	616,349	10,924,085	7,345	13,450,593
	Bay Area	356,828	52,027	498,437	8,123,911	7,345	9,038,548
							67.2
1931	State	169,806	1,760,157	472,805	9,412,882	18,284	11,833,934
	Bay Area	159,540	62,613	454,714	8,959,810	18,284	9,654,961
							81.6
1932	State	543,806	1,595,530	665,345	8,890,840	23,422	11,718,943
	Bay Area	514,403	143,477	640,885	8,522,609	23,380	9,844,754
							84.0
1933	State	457,998	1,311,313	562,994	8,311,095	49,615	10,693,015
	Bay Area	440,746	158,457	532,829	7,587,811	49,611	8,769,454
							82.0
1934	State	537,164	2,059,973	767,025	8,967,603	72,548	12,404,313
	Bay Area	516,970	244,308	733,307	8,351,633	65,802	9,912,020
							79.9
1935	State	656,113	2,448,834	675,597	9,164,263	72,287	13,017,094
	Bay Area	636,142	122,894	624,919	8,515,218	62,313	9,961,486
							76.5
1936	State	621,186	2,113,364	621,675	8,325,008	116,275	11,797,508
	Bay Area	604,961	58,313	591,127	7,812,392	105,949	9,172,742
							77.8
1937	State	974,770	1,523,876	516,195	8,302,222	75,990	11,393,053
	Bay Area	960,337	92,287	495,168	7,868,726	68,317	9,484,835
							83.3
1938	State	542,812	1,500,139	639,328	7,737,647	85,896	10,505,822
	Bay Area	251,683	14,823	358,466	3,192,731	76,075	3,893,778
							37.1
1939	State	739,311	1,393,871	821,204	9,744,792	104,585	12,803,763
	Bay Area	478,462	25,282	512,689	4,207,821	99,463	5,323,717
							41.6
1940	State	804,089	1,257,948	779,078	7,388,005	62,124	10,291,244
	Bay Area	582,131	62,504	420,038	3,423,981	54,817	4,543,471
							44.1
1941	State	601,577	941,412	442,484	4,625,855	26,940	6,638,268
	Bay Area	302,632	25,059	228,200	1,720,604	22,793	2,299,288
							34.6
1942	State	370,125	989,527	353,540	3,155,757	6,571	4,875,520
	Bay Area	89,101	6,140	112,555	589,773	3,001	800,570
							16.4
1943	State	505,399	1,393,119	505,338	4,782,379	38,047	7,224,282
	Bay Area	160,003	11,939	143,862	996,257	13,196	1,325,257
							18.3
1944	State	366,520	1,736,409	551,269	4,700,374	72,825	7,427,397
	Bay Area	131,197	10,910	275,552	1,252,593	17,399	1,687,651
							22.7
1945	State	339,313	2,038,794	588,356	7,754,945	159,870	10,881,278
	Bay Area	189,784	62,627	325,038	2,133,492	38,417	2,749,358
							25.3
1946	State	509,448	2,859,025	679,072	10,567,058	49,847	14,664,450
	Bay Area	210,887	52,792	252,660	2,355,188	33,804	2,905,331
							19.8
1947	State	527,072	2,070,001	701,403	12,333,594	101,767	15,733,837
	Bay Area	205,150	58,120	261,357	3,598,738	75,385	4,198,750
							26.7
1948	State	405,249	1,437,057	804,695	21,654,927	114,701	24,416,629
	Bay Area	225,703	83,462	447,701	4,546,201	80,580	5,383,647
							22.0
1949	State	356,374	1,429,861	722,151	19,729,254	95,602	22,333,242
	Bay Area	138,940	90,215	451,886	4,504,053	80,629	5,265,723
							23.6
1950	State	913,110	1,350,836	682,861	23,893,198	127,549	26,967,554
	Bay Area	324,437	117,713	364,530	6,590,887	100,196	7,497,763
							27.8

C—043359—001

C-043361

APPENDIX B-2—Continued

LANDINGS OF FLATFISHES IN POUNDS—Continued

Year		Flounder	Halibut	Sand Dab	Sole	Turbot	Totals
1951	State	1,118,279	730,028	542,921	17,403,137	107,314	19,901,679
	Bay Area	590,164	65,145	279,651	4,684,163	97,935	5,717,058
							28.7
1952	State	595,470	715,743	658,742	19,581,827	81,884	21,633,666
	Bay Area	322,675	196,597	332,637	3,967,804	64,304	4,884,017
							22.6
1953	State	497,608	485,958	686,591	15,914,902	69,158	17,654,217
	Bay Area	239,437	58,388	263,908	3,167,918	35,058	3,764,709
							21.3
1954	State	478,704	535,225	749,771	17,160,443	161,353	19,085,496
	Bay Area	190,857	27,818	389,459	4,793,993	70,207	5,472,334
							28.7
1955	State	646,948	1,099,899	778,839	15,838,621	99,981	18,464,288
	Bay Area	360,987	73,060	435,302	5,070,662	83,639	6,023,650
							32.6
1956	State	374,114	1,432,424	787,972	14,784,951	83,294	17,462,755
	Bay Area	223,041	43,578	455,097	4,329,806	63,985	5,115,507
							29.3
1957	State	503,552	1,277,563	691,183	16,307,353	96,055	18,875,706
	Bay Area	322,351	34,975	324,126	3,262,486	71,402	4,015,340
							21.3
1958	State	464,159	840,086	404,872	15,913,365	72,389	17,694,871
	Bay Area	269,924	48,549	238,657	3,692,627	39,929	4,289,686
							24.2

LANDINGS OF BOTTOM FISHES IN POUNDS

Year		Cabezon	Tomcod	Lingcod	Hake	Sablefish	Rockfish	Totals
1916	State	569	65,218	617,236	189,219	83,623	4,918,952	5,874,817
	Bay Area	—	65,218	312,235	169,423	49,554	997,951	1,594,381
	Percentage [1]							27.1
1917	State	434	25,060	930,519	254,331	909,846	7,774,026	9,894,216
	Bay Area	—	25,060	539,107	172,176	858,275	1,591,135	3,185,753
								31.9
1918	State	167	8,811	915,836	193,018	498,937	8,242,754	9,859,523
	Bay Area	—	8,756	487,633	143,686	478,863	1,631,029	2,749,967
								27.9
1919	State	—	31,310	1,063,136	133,181	334,950	5,398,109	6,960,686
	Bay Area	—	31,310	833,657	122,913	319,666	1,397,623	2,705,169
								40.4
1920	State	—	37,237	687,954	141,981	781,032	5,633,077	7,281,281
	Bay Area	—	36,646	450,996	140,801	736,982	1,031,328	2,396,753
								32.9
1921	State	—	41,779	425,543	90,218	1,022,642	4,761,658	6,341,840
	Bay Area	—	39,454	265,118	81,143	388,141	792,726	1,566,582
								24.7
1922	State	—	32,114	568,481	74,516	268,554	4,312,014	5,255,679
	Bay Area	—	30,799	421,736	57,666	209,807	714,593	1,434,601
								27.3
1923	State	—	41,767	467,347	78,969	538,292	5,096,622	6,222,997
	Bay Area	—	38,292	328,436	70,232	198,590	570,965	1,206,515
								19.4
1924	State	—	42,524	400,432	60,780	933,310	4,742,885	6,179,931
	Bay Area	—	34,037	244,688	58,405	353,446	558,199	1,248,775
								20.2
1925	State	3,352	14,508	683,130	22,017	722,472	5,488,621	6,934,100
	Bay Area	—	12,633	457,414	16,892	418,442	775,847	1,681,228
								24.2
1926	State	—	4,325	649,902	58,335	175,642	7,540,969	8,429,173
	Bay Area	—	3,950	469,801	42,498	90,105	905,164	1,511,518
								17.9

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.

APPENDIX B-2—Continued

LANDINGS OF BOTTOM FISHES IN POUNDS—Continued

Year		Cabezon	Tomcod	Lingcod	Hake	Sablefish	Rockfish	Totals
1927	State	752	690	556,308	84,553	992,654	6,390,604	8,025,561
	Bay Area	.....	690	373,647	75,951	420,308	952,273	1,822,869
								22.7
1928	State	2,628	11,923	853,537	108,648	916,955	6,419,909	8,313,600
	Bay Area	.....	11,798	593,064	76,047	342,389	1,022,602	2,045,900
								24.6
1929	State	1,196	15,884	1,167,120	145,669	1,439,408	6,036,409	8,805,686
	Bay Area	.....	15,822	813,365	131,453	505,479	1,191,813	2,657,932
								30.2
1930	State	1,046	23,172	1,288,172	56,088	1,359,147	7,225,424	9,953,049
	Bay Area	229	22,460	745,361	50,983	534,548	1,104,494	2,458,075
								24.7
1931	State	1,115	3,799	1,229,088	12,501	1,021,215	7,277,688	9,545,406
	Bay Area	624	3,799	850,183	12,216	159,750	1,043,284	2,069,856
								21.7
1932	State	4,678	4,271	899,912	29,001	975,373	5,636,319	7,549,554
	Bay Area	3,561	4,243	647,159	28,327	98,527	994,498	1,776,315
								23.5
1933	State	4,265	729	1,088,955	37,539	1,332,573	4,787,774	7,251,835
	Bay Area	1,961	729	749,668	31,581	237,467	1,137,235	2,158,641
								29.8
1934	State	5,265	923	857,600	56,901	2,117,048	4,604,031	7,641,768
	Bay Area	765	923	600,647	55,810	321,069	911,601	1,890,815
								24.7
1935	State	10,537	685	1,017,503	73,843	2,848,672	4,831,174	8,782,414
	Bay Area	500	685	627,381	68,462	714,075	886,374	2,297,477
								26.2
1936	State	18,468	4,153	758,547	50,791	1,035,530	4,603,904	6,471,393
	Bay Area	6,277	4,153	395,952	46,741	95,948	861,710	1,410,781
								21.8
1937	State	8,189	1,056	968,258	63,454	733,499	4,291,214	6,065,670
	Bay Area	3,465	1,056	577,651	61,067	73,467	1,036,832	1,753,538
								28.9
1938	State	5,425	3,040	646,004	36,428	415,836	3,637,137	4,743,870
	Bay Area	1,569	875	173,898	18,015	8,507	558,839	761,703
								16.1
1939	State	4,023	4,675	576,972	13,661	767,044	3,333,126	4,699,501
	Bay Area	208	870	192,811	9,641	14,757	388,566	606,853
								12.9
1940	State	3,392	4,567	692,243	18,049	573,785	3,570,636	4,862,672
	Bay Area	1,488	2,371	271,088	13,058	77,681	454,606	820,292
								16.9
1941	State	13,356	959	529,772	15,044	536,540	3,405,622	4,501,293
	Bay Area	6,470	264	290,314	9,042	66,209	452,597	824,896
								18.3
1942	State	2,312	145	314,334	41,981	1,972,522	1,423,440	3,754,734
	Bay Area	504	.....	42,261	2,991	29,512	70,019	145,287
								3.9
1943	State	7,532	13	719,318	10,505	3,205,374	2,762,192	6,704,934
	Bay Area	140	.....	151,410	3,057	36,901	202,781	394,289
								5.9
1944	State	3,906	135	746,039	4,751	4,116,451	6,422,230	11,293,512
	Bay Area	2,933	.....	121,501	956	47,332	68,965	241,687
								2.1
1945	State	4,417	.....	758,704	2,415	6,259,087	13,285,974	20,310,597
	Bay Area	3,492	.....	147,932	313	165,361	185,536	502,634
								2.5
1946	State	7,860	.....	1,156,398	550	2,656,873	11,168,277	14,989,958
	Bay Area	2,805	.....	199,967	.....	99,637	221,123	523,532
								3.5
1947	State	4,526	.....	1,940,747	606	902,110	8,498,584	11,346,573
	Bay Area	473	.....	243,380	.....	21,610	211,505	476,968
								4.2

APPENDIX B-2—Continued

LANDINGS OF BOTTOM FISHES IN POUNDS—Continued

Year		Cabezon	Tomcod	Lingcod	Hake	Sablefish	Rockfish	Totals
1948	State	8,202	.....	2,058,675	4,600	2,068,433	6,540,976	10,680,886
	Bay Area	378	.....	284,346	3,800	23,827	271,135	583,486
								5.5
1949	State	16,046	.....	1,655,961	1,535	1,771,223	6,067,877	9,512,642
	Bay Area	4,570	.....	382,617	1,135	50,841	521,071	960,234
								10.1
1950	State	21,679	317	1,914,725	500	1,919,971	8,115,909	11,973,101
	Bay Area	2,492	.....	777,112	.....	65,854	989,603	1,135,061
								9.5
1951	State	23,857	2,018	1,657,546	24,972	2,535,813	10,928,309	15,172,515
	Bay Area	1,263	1,418	583,612	24,972	265,858	2,204,245	3,081,368
								20.3
1952	State	34,494	976	1,350,931	6,145	1,322,451	10,420,723	13,135,720
	Bay Area	6,132	170	593,863	1,305	246,257	3,580,550	4,428,277
								33.7
1953	State	13,306	517	912,697	100,491	1,609,056	12,045,983	14,682,050
	Bay Area	2,901	517	207,992	10,370	222,109	4,170,739	4,614,628
								31.4
1954	State	6,212	.....	895,095	527,895	2,268,945	12,102,186	15,800,333
	Bay Area	758	.....	235,744	17,105	398,188	2,984,427	3,636,222
								23.0
1955	State	6,944	2,869	934,200	883,007	2,010,112	12,345,411	16,182,543
	Bay Area	759	2,869	335,568	41,245	346,047	1,562,607	2,289,095
								14.1
1956	State	12,397	1,153	909,006	1,317,103	2,809,315	14,656,584	19,705,558
	Bay Area	190	1,153	317,665	7,290	830,216	2,942,536	4,099,050
								20.8
1957	State	13,206	.....	1,613,613	1,130,978	2,132,185	15,912,382	20,802,364
	Bay Area	286	.....	310,251	10,370	425,486	2,817,836	3,564,229
								17.1
1958	State	19,520	.....	1,526,061	1,027,639	1,692,293	17,559,885	21,825,398
	Bay Area	5,550	.....	491,636	33,315	464,040	4,195,068	5,189,609
								23.8

LANDINGS OF SHARKS, SKATES AND RAYS IN POUNDS

Year		Shark	Skate	Totals	LANDINGS OF SALTWATER PERCH IN POUNDS
1916	State	36,247	307,716	343,963	221,186
	Bay Area	27,805	303,706	331,511	93,539
	Percentage[1]			96.4	42.3
1917	State	287,872	314,837	602.709	252,503
	Bay Area	240,965	307,874	548,839	145,966
				91.1	57.8
1918	State	403,093	398,031	801,124	203,420
	Bay Area	352,177	384,301	736,478	119,356
				91.9	58.7
1919	State	612,683	295,800	908,483	192,481
	Bay Area	144,815	284,011	428,826	78,669
				47.2	40.9
1920	State	811,349	479,812	1,291,161	186,381
	Bay Area	128,384	209,824	338,208	96,923
				26.2	52.0
1921	State	539,333	69,932	609,265	253,199
	Bay Area	85,550	53,752	139,302	90,571
				22.9	35.8
1922	State	282,018	121,210	403.228	243,776
	Bay Area	93,436	107,472	200,908	78,357
				49.8	32.1

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.

APPENDIX B-2—Continued

LANDINGS OF SHARKS, SKATES AND RAYS IN POUNDS—Continued

Year		Shark	Skate	Totals	LANDINGS OF SALTWATER PERCH IN POUNDS
1923	State	360,363	134,353	494,716	359,682
	Bay Area	152,208	127,224	279,432	86,640
				56.5	24.1
1924	State	392,634	131,137	523,771	305,726
	Bay Area	93,606	121,627	215,233	118,075
				41.1	38.6
1925	State	372,332	183,484	555,816	272,351
	Bay Area	196,131	156,978	353,109	91,718
				63.5	33.7
1926	State	506,723	232,993	739,716	208,910
	Bay Area	224,966	158,288	383,254	99,962
				51.8	47.8
1927	State	325,653	263,715	589,368	262,893
	Bay Area	188,194	223,293	411,487	96,722
				69.8	36.8
1928	State	623,816	462,222	1,086,038	267,078
	Bay Area	400,738	317,857	718,595	90,147
				66.2	33.8
1929	State	883,985	427,986	1,311,971	327,502
	Bay Area	365,531	318,310	683,841	109,559
				54.2	33.5
1930	State	647,297	286,390	933,687	304,737
	Bay Area	221,672	221,324	442,996	112,182
				47.4	36.8
1931	State	596,134	174,785	770,919	265,957
	Bay Area	121,802	132,349	254,151	92,826
				33.0	34.9
1932	State	850,888	292,412	1,143,300	244,048
	Bay Area	223,694	249,045	472,739	76,664
				41.3	31.4
1933	State	471,030	193,711	664,741	228,166
	Bay Area	93,971	151,415	245,386	110,529
				36.9	48.4
1934	State	526,280	232,305	758,585	225,220
	Bay Area	106,366	198,666	305,032	113,495
				40.2	50.4
1935	State	555,256	307,122	862,378	281,607
	Bay Area	159,770	255,414	415,184	132,324
				48.0	47.0
1936	State	471,861	381,944	853,805	251,742
	Bay Area	170,451	318,783	489,234	96,104
				57.3	38.2
1937	State	914,205	447,392	1,361,597	249,589
	Bay Area	407,637	377,353	784,990	98,666
				57.7	39.5
1938	State	7,531,667	528,273	8,059,940	183,421
	Bay Area	4,318,794	329,385	4,648,179	69,276
				57.7	37.8
1939	State	9,228,500	336,854	9,565,354	140,187
	Bay Area	4,631,579	204,598	4,836,177	57,995
				50.6	41.4
1940	State	7,860,030	238,287	8,098,317	58,643
	Bay Area	4,934,940	160,628	5,095,568	22,447
				63.0	38.3
1941	State	7,617,334	224,698	7,842,032	26,052
	Bay Area	2,890,498	121,716	3,012,214	2,898
				38.4	11.1
1942	State	3,550,337	105,791	3,656,128	58,084
	Bay Area	1,155,759	54,410	1,210,169	14,498
				33.1	25.0
1943	State	3,729,334	81,109	3,810,443	113,035
	Bay Area	1,064,882	34,116	1,098,998	28,694
				28.8	25.4

APPENDIX B-2—Continued

LANDINGS OF SHARKS, SKATES AND RAYS IN POUNDS—Continued

Year		Shark	Skate	Totals	LANDINGS OF SALTWATER PERCH IN POUNDS
1944	State	2,613,431	50,419	2,663,850	148,858
	Bay Area	559,229	28,909	588,138	44,401
				22.1	29.8
1945	State	2,438,096	74,089	2,512,185	218,870
	Bay Area	395,068	30,376	425,444	81,034
				16.9	37.0
1946	State	1,608,876	78,038	1,686,914	192,626
	Bay Area	246,793	31,128	277,921	72,426
				16.5	37.7
1947	State	2,637,926	103,696	2,741,622	290,610
	Bay Area	263,372	70,942	334,314	69,328
				12.2	23.9
1948	State	2,480,555	119,101	2,599,656	305,164
	Bay Area	201,950	87,980	289,930	87,358
				11.2	28.6
1949	State	1,551,583	123,464	1,675,047	326,589
	Bay Area	166,725	77,224	243,949	100,933
				14.6	30.9
1950	State	717,247	153,758	871,005	245,440
	Bay Area	58,993	105,015	164,008	80,752
				18.8	32.9
1951	State	796,823	84,634	881,457	233,748
	Bay Area	80,507	62,095	142,602	78,833
				16.2	33.7
1952	State	611,831	138,624	750,455	297,227
	Bay Area	132,802	114,878	247,680	84,714
				33.0	28.5
1953	State	433,067	415,669	848,736	295,915
	Bay Area	77,802	74,090	151,892	65,443
				17.9	22.1
1954	State	733,397	136,221	869,618	118,499
	Bay Area	50,270	89,651	139,921	35,170
				16.1	29.7
1955	State	546,968	152,622	699,590	136,554
	Bay Area	60,173	122,293	182,466	37,646
				26.0	27.6
1956	State	1,045,634	175,546	1,221,180	187,681
	Bay Area	43,282	96,940	140,222	44,497
				11.4	23.7
1957	State	709,473	171,678	881.151	245,028
	Bay Area	54,400	118,080	172,480	40,035
				19.4	16.3
1958	State	474,754	176,896	651,650	189,679
	Bay Area	69,388	116,531	185,919	43,235
				28.5	22.8

LANDINGS OF WHITE SEA BASS AND CROAKERS IN POUNDS

Year		White Sea Bass	White Croaker	Totals	LANDINGS OF MISCELLANEOUS MARINE LANDINGS IN POUNDS [2]
1916	State	798,115	779,287	1,577,402	666,204
	Bay Area	77,904	60,945	138,849	396,445
	Percentage [1]			8.8	59.5
1917	State	899,997	835,259	1,735,256	369,598
	Bay Area	7,184	55,364	62,548	213,812
				3.6	57.8
1918	State	1,613,520	1,014,820	2,628,340	332,270
	Bay Area	51,334	62,736	114,070	97,538
				4.3	29.3

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.
[2] Miscellaneous landings include odd and unidentified species or landings.

APPENDIX B-2—Continued

LANDINGS OF WHITE SEA BASS AND CROAKERS IN POUNDS—Continued

Year		White Sea Bass	White Croaker	Totals	LANDINGS OF MISCELLANEOUS MARINE LANDINGS IN POUNDS [2]
1919	State	2,455,367	609,175	3,064,542	554,879
	Bay Area	50,949	41,525	92,474	46,060
				3.0	8.3
1920	State	2,628,108	461,459	3,089,567	258,408
	Bay Area	41,596	8,690	50,286	40,276
				1.6	15.6
1921	State	2,569,489	391,085	2,960,574	1,238,326
	Bay Area	39,888	10,813	50,701	65,744
				1.7	5.3
1922	State	2,932,051	581,863	3,513,914	251,206
	Bay Area	48,423	3,459	51,882	96,083
				1.5	38.2
1923	State	2,373,847	411,564	2,785,411	170,045
	Bay Area	22,575	735	23,310	51,022
				0.8	30.0
1924	State	1,489,589	384,317	1,873,906	339,033
	Bay Area	35,624	2,513	38,137	98,369
				2.0	29.0
1925	State	1,885,109	536,654	2,421,763	215,603
	Bay Area	56,085	3,888	59,973	25,307
				2.5	11.7
1926	State	2,216,402	484,921	2,701,323	230,124
	Bay Area	108,919	41,597	150,516	32,568
				5.6	14.2
1927	State	2,273,407	529,267	2,802,674	207,453
	Bay Area	23,956	47,521	71,477	25,961
				2.6	12.5
1928	State	1,300,214	441,758	1,741,972	181,735
	Bay Area	35,915	26,785	62,700	33,177
				3.6	18.3
1929	State	1,562,232	476,497	2,038,729	352,603
	Bay Area	67,328	44,932	112,260	32,180
				5.5	9.1
1930	State	1,626,422	457,167	2,083,589	134,299
	Bay Area	48,411	40,346	88,757	12,460
				4.3	9.3
1931	State	1,399,413	414,034	1,813,447	67,187
	Bay Area	28,234	4,646	32,880	41,659
				1.8	62.0
1932	State	804,796	447,531	1,252,327	151,167
	Bay Area	11,389	10,529	21,918	98,886
				1.8	65.4
1933	State	1,163,083	564,274	1,727,357	148,189
	Bay Area	1,306	15,755	17,061	114,633
				1.0	77.4
1934	State	851,197	634,345	1,485,542	234,823
	Bay Area	354	19,247	19,601	219,147
				1.3	93.3
1935	State	1,066,419	768,676	1,835,095	229,546
	Bay Area	407	13,458	13,865	207,057
				0.8	90.2
1936	State	808,093	652,134	1,460,227	178,417
	Bay Area	4,442	13,460	17,902	163,005
				1.2	91.4
1937	State	599,419	645,759	1,245,178	163,252
	Bay Area	11,634	6,165	17,799	138,605
				1.4	84.9
1938	State	626,647	493,209	1,119,856	284,279
	Bay Area	11,071	6,213	17,284	77,040
				1.5	27.1

[2] Miscellaneous landings include odd and unidentified species or landings.

APPENDIX B-2—Continued

LANDINGS OF WHITE SEA BASS AND CROAKERS IN POUNDS—Continued

Year		White Sea Bass	White Croaker	Totals	LANDINGS OF MISCELLANEOUS MARINE LANDINGS IN POUNDS [2]
1939	State	994,396	542,901	1,537,297	269,902
	Bay Area	16,817	5,386	22,203	72,364
				1.4	26.8
1940	State	915,716	412,228	1,327,944	237,759
	Bay Area	27,569	16,510	44,079	75,004
				3.3	31.5
1941	State	908,296	325,155	1,233,451	258,315
	Bay Area	42,274	2,676	44,950	48,395
				3.6	18.7
1942	State	553,855	284,225	838,080	111,471
	Bay Area	14,440	1.617	16,057	16,941
				1.9	15.2
1943	State	500,183	396,633	896,816	158,698
	Bay Area	13,948	4,829	18,777	26,174
				2.1	16.5
1944	State	393,988	367,701	761,689	99,569
	Bay Area	8,912	1,980	10,892	12,668
				1.4	12.7
1945	State	527,355	459,515	986,870	372,668
	Bay Area	34,435	8,255	42,690	39,193
				4.3	8.9
1946	State	616,511	437,023	1,053,534	171,753
	Bay Area	20,157	8,113	28,270	19,170
				2.7	11.2
1947	State	1,083,023	458,686	1,541,709	310,123
	Bay Area	12,093	4,588	16,681	11,902
				1.1	3.8
1948	State	1,114,290	643,027	1,757,317	202,009
	Bay Area	5,692	5,176	10,868	66,896
				0.6	33.1
1949	State	1,412,238	764,429	2,176,667	254,404
	Bay Area	8,718	2,348	11,066	41,046
				0.5	16.1
1950	State	1,532,730	747,387	2,280,117	120,350
	Bay Area	3,635	5,227	8,862	32,463
				0.4	27.0
1951	State	955,145	681,950	1,637,095	156,972
	Bay Area	2,407	7,893	10,300	56,691
				0.6	36.1
1952	State	692,232	3,273,384	3,965,616	137,231
	Bay Area	5,620	12,455	18,075	41,962
				0.5	30.6
1953	State	471,206	1,201,060	1,672,266	266,682
	Bay Area	219	3,179	3,398	48,757
				0.2	18.3
1954	State	434,354	913,674	1,348,028	4,131
	Bay Area	11,423	6,070	17,493	271
				1.3	6.5
1955	State	544,953	818,997	1,363,950	4,486
	Bay Area	1,329	8,114	9,443	56
				0.7	1.2
1956	State	413,956	889,850	1,303,806	2,000
	Bay Area	197	9,637	9,834	22
				0.8	1.1
1957	State	1,261,955	535,317	1,797,272	1,717
	Bay Area	3,237	3,373	6,610	127
				0.4	7.4
1958	State	2,750,652	770,534	3,521,186	1,752
	Bay Area	13,246	6,165	19,411	59
				0.6	3.4

[2] Miscellaneous landings include odd and unidentified species or landings.

APPENDIX B-2—Continued

LANDINGS OF MOLLUSCAN FISHERIES IN POUNDS

Year		Abalone	Misc.[2] Clams	Softshell Clams	Oysters	Octopus	Totals
1916	State	762,001	679,035	73,674	2,005,364	26,383	3,546,457
	Bay Area	6,091	585,709	75,674	2,005,364	10,989	2,683,827
	Percentage[1]						75.6
1917	State	637,780	438,544	187,864	857,452	37,935	2,159,575
	Bay Area	10,316	295,641	187,864	857,452	11,896	1,363,169
							63.1
1918	State	602,919	223,171	312,143	1,423,879	32,739	2,594,851
	Bay Area	405	119,789	311,058	1,423,879	14,693	1,869,824
							72.1
1919	State	759,203	126,656	302,576	1,607,375	21,492	2,817,302
	Bay Area	225	58,752	302,366	1,607,375	6,330	1,975,048
							70.1
1920	State	806,716	131,041	233,124	1,180,901	70,740	2,422,522
	Bay Area	520	49,670	232,684	1,180,901	25,100	1,488,875
							61.5
1921	State	1,481,170	83,532	216,600	773,884	56,266	2,611,452
	Bay Area	405	52,939	215,944	773,884	7,424	1,050,596
							40.2
1922	State	1,523,394	110,727	343,262	743,252	98,588	2,819,223
	Bay Area	—	55,554	342,746	743,252	10,889	1,152,441
							40.9
1923	State	1,555,134	121,988	283,095	688,103	110,222	2,758,542
	Bay Area	55	43,778	283,095	688,103	10,096	1,025,127
							37.2
1924	State	2,241,812	104,943	243,324	526,775	166,291	3,283,145
				243,324	526,775	7,800	826,797
	Bay Area	—	48,898				25.2
1925	State	2,352,861	90,772	264,056	569,168	133,449	3,410,306
	Bay Area	—	66,903	264,056	569,168	15,716	915,843
							26.9
1926	State	2,060,770	67,792	245,962	610,782	63,304	3,048,610
	Bay Area	—	47,309	245,962	610,422	8,552	912,245
							29.9
1927	State	2,816,530	100,208	151,383	554,921	36,693	3,659,735
	Bay Area	—	57,286	151,383	554,921	3,908	767,498
							21.0
1928	State	2,066,243	68,923	148,542	753,148	9,732	3,046,588
	Bay Area	—	56,958	148,422	753,148	2,553	961,081
							31.5
1929	State	3,438,858	79,992	101,460	499,207	87,123	4,206,640
	Bay Area	8,751	51,858	101,450	495,009	18,120	675,188
							16.1
1930	State	3,176,513	142,804	116,571	623,610	76,980	4,136,478
	Bay Area	—	90,658	116,571	623,610	13,719	844,558
							20.4
1931	State	3,262,166	135,285	101,738	629,932	64,601	4,193,722
	Bay Area	—	58,381	101,543	629,932	5,864	795,720
							19.0
1932	State	2,817,345	184,754	165,041	390,791	21,187	3,579,118
	Bay Area	123	127,593	164,351	381,649	2,980	676,696
							18.9
1933	State	2,756,188	119,320	173,039	428,240	31,521	3,508,308
	Bay Area	—	71,669	173,039	350,152	8,855	603,715
							17.2
1934	State	3,223,492	119,345	222,011	610,178	30,385	4,205,411
	Bay Area	—	60,885	221,801	559,938	10,567	853,191
							20.3
1935	State	3,870,921	127,599	153,405	669,057	81,204	4,902,186
	Bay Area	17,775	58,804	153,405	599,177	23,998	853,159
							17.4

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.
[2] Includes mussels.

APPENDIX B-2—Continued

LANDINGS OF MOLLUSCAN FISHERIES IN POUNDS—Continued

Year		Abalone	Misc. Clams	Softshell Clams	Oysters	Octopus	Totals
1936	State	3,302,195	63,320	90,971	665,264	62,452	4,184,202
	Bay Area	33,667	6,839	90,971	655,998	12,305	799,780
							19.1
1937	State	2,863,175	55,067	92,915	1,088,947	23,884	4,123,988
	Bay Area	—	6,758	92,836	1,062,062	3,695	1,165,351
							28.2
1938	State	2,121,468	51,612	87,219	1,520,324	32,632	3,813,255
	Bay Area	—	6,778	86,685	1,459,129	6,181	1,558,773
							40.9
1939	State	1,804,440	47,991	75,721	1,803,790	29,539	3,761,481
	Bay Area	—	7,799	75,187	1,715,126	3,007	1,801,119
							47.9
1940	State	1,724,084	40,597	63,235	1,430,389	26,580	3,284,885
	Bay Area	—	5,215	62,921	1,303,248	5,684	1,377,068
							41.9
1941	State	1,002,330	22,694	65,988	1,829,159	40,075	2,960,246
	Bay Area	—	2,609	65,988	1,640,535	6,499	1,715,631
							58.0
1942	State	164,462	10,865	73,144	707,341	7,396	963,208
	Bay Area	—	1,017	73,144	411,254	1,015	486,430
							50.5
1943	State	680,274	898	46,557	851,431	18,020	1,597,180
	Bay Area	5,891	120	46,557	411,780	4,961	469,309
							29.4
1944	State	1,630,402	1,830	31,316	743,582	7,536	2,414,666
	Bay Area	289,301	—	31,316	284,077	4,385	609,079
							21.2
1945	State	2,429,312	7,634	13,425	375,319	12,586	2,838,276
	Bay Area	390,310	—	13,067	146,109	7,144	556,630
							19.6
1946	State	2,095,762	21,155	22,239	172,609	37,997	2,349,762
	Bay Area	15,161	—	22,239	86,328	11,499	135,227
							5.8
1947	State	2,669,285	11,477	22,584	179,814	53,019	2,936,179
	Bay Area	—	—	22,584	133,779	19,967	176,330
							6.0
1948	State	3,228,727	67,980	1,373	497,762	120,697	3,916,539
	Bay Area	41,616	—	1,063	342,809	50,543	436,031
							11.1
1949	State	3,599,998	60,298	—	281,669	75,051	4,017,016
	Bay Area	53,644	—	—[4]	158,387	24,154	236,185
							5.9
1950	State	3,954,791	38,121	—	296,857	59,629	4,349,398
	Bay Area	18,369	—	—	277,747	26,660	322,776
							7.4
1951	State	4,084,115	47,056	—	330,019	29,200	4,490,390
	Bay Area	8,005	—	—	328,771	12,662	349,438
							7.8
1952	State	4,784,033	11,010	—	349,412	18,592	5,163,047
	Bay Area	4,923	—	—	298,225	6,865	310,013
							6.0
1953	State	4,720,350	13,122	—	291,253	17,124	5,041,849
	Bay Area	27,325	248	—	264,182	4,205	295,960
							5.9
1954	State	4,099,525	11,843	—	591,595	30,758	4,733,721
	Bay Area	13,553	112	—	280,076	9,113	302,854
							6.4
1955	State	4,185,875	9,493	—	1,794,545	26,346	6,016,259
	Bay Area	23,664	113	—	338,940	11,694	374,411
							6.2

[4] No commercial softshell clams landed in Bay Area after 1948.

APPENDIX B-2—Continued

LANDINGS OF MOLLUSCAN FISHERIES IN POUNDS—Continued

Year		Abalone	Misc. Clams	Softshell Clams	Oysters	Octopus	Totals
1956	State	4,284,063	11,317	—	6,273,600	16,217	10,585,197
	Bay Area	17,965	—	—	473,560	5,249	496,774
							4.7
1957	State	5,421,914	3,899	—	11,291,689	30,920	16,748,422
	Bay Area	17,225	—	—	516,792	6,167	540,184
							3.2
1958	State	4,224,018	4,641	—	9,646,911	15,110	13,890,680
	Bay Area	13,075	—	—	629,331	3,378	645,784
							4.6

LANDINGS OF CRUSTACEAN FISHERIES IN POUNDS

Year		Crab	Shrimp	Totals
1916	State	1,296,912	411,847	1,708,759
	Bay Area	821,568	411,847	1,233,415
	Percentage[1]			72.2
1917	State	2,580,840	605,004	3,185,844
	Bay Area	2,054,472	605,004	2,659,476
				835
1918	State	1,619,280	722,178	2,341,458
	Bay Area	1,490,496	722,178	2,212,674
				94.5
1919	State	1,304,904	747,023	2,051,927
	Bay Area	1,246,440	747,023	1,993,463
				97.2
1920	State	1,220,568	817,091	2,037,659
	Bay Area	1,143,840	817,091	1,960,931
				96.2
1921	State	800,952	908,473	1,709,425
	Bay Area	719,328	907,467	1,626,795
				95.2
1922	State	860,328	990,349	1,850,677
	Bay Area	714,840	990,349	1,705,189
				92.1
1923	State	1,075,800	1,113,358	2,189,158
	Bay Area	813,744	1,113,358	1,927,102
				88.0
1924	State	1,506,816	1,551,086	3,057,902
	Bay Area	1,289,400	1,551,086	2,840,486
				92.9
1925	State	3,234,312	1,460,234	4,694,546
	Bay Area	2,976,000	1,460,234	4,436,234
				94.5
1926	State	3,296,280	1,431,511	4,727,791
	Bay Area	3,051,696	1,431,511	4,483,207
				94.8
1927	State	2,960,712	1,697,365	4,658,077
	Bay Area	2,539,872	1,697,365	4,237,237
				91.0
1928	State	3,574,734	2,280,871	5,855,605
	Bay Area	3,015,888	2,280,871	5,296,759
				90.5
1929	State	1,792,776	3,054,748	4,847,524
	Bay Area	1,691,784	3,054,748	4,746,532
				96.9
1930	State	1,992,396	2,696,567	4,688,963
	Bay Area	1,898,832	2,687,831	4,586,663
				97.8

LANDINGS OF COMMERCIAL FRESHWATER FISHERIES IN POUNDS

Year		Catfish	Roughfish	Totals
1916	State	372,420	267,252	639,672
	Bay Area	338,076	241,879	579,955
				90.7
1917	State	443,316	250,467	693,783
	Bay Area	434,824	189,185	624,009
				89.9
1918	State	409,752	369,247	778,999
	Bay Area	400,776	274,130	674,906
				86.6
1919	State	329,716	348,608	678,324
	Bay Area	329,716	345,969	675,685
				99.6
1920	State	224,730	172,677	397,407
	Bay Area	224,536	167,447	391,983
				98.6
1921	State	296,232	204,383	500,615
	Bay Area	296,232	204,324	500,556
				99.9
1922	State	251,358	104,323	355,681
	Bay Area	251,358	104,170	355,528
				99.9
1923	State	258,572	177,092	435,664
	Bay Area	258,572	177,092	435,664
				100.0
1924	State	703,920	105,697	809,617
	Bay Area	703,920	105,697	809,617
				100.0
1925	State	732,558	136,993	869,551
	Bay Area	732,558	136,738	869,296
				99.9
1926	State	514,754	126,103	640,857
	Bay Area	514,754	113,246	628,000
				98.0
1927	State	742,606	115,398	858,004
	Bay Area	742,606	112,797	855,403
				99.7
1928	State	918,202	234,531	1,152,733
	Bay Area	918,202	234,531	1,152,733
				100.0
1929	State	1,012,318	153,191	1,165,509
	Bay Area	1,012,318	153,191	1,165,509
				100.0
1930	State	866,382	133,996	1,000,378
	Bay Area	866,382	131,621	998,003
				99.8

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.

APPENDIX B-2—Continued

LANDINGS OF CRUSTACEAN FISHERIES IN POUNDS—Continued

LANDINGS OF COMMERCIAL FRESHWATER FISHERIES IN POUNDS—Continued

Year		Crab	Shrimp	Totals	Catfish	Roughfish	Totals
1931	State	2,231,440	1,688,877	3,920,317	741,360	135,805	877,165
	Bay Area	2,116,601	1,684,763	3,801,364	741,360	95,283	836,643
				97.0			95.4
1932	State	2,434,132	2,682,789	5,116,921	508,112	533,861	1,041,973
	Bay Area	2,290,131	2,681,807	4,971,938	508,112	523,311	1,031,423
				96.7			99.0
1933	State	3,223,312	2,088,750	5,312,062	344,926	246,966	591,892
	Bay Area	2,893,726	2,087,952	4,981,678	344,926	246,966	591,892
				93.8			100.0
1934	State	3,792,651	1,784,573	5,577,224	369,710	446,700	816,410
	Bay Area	3,422,158	1,783,651	5,205,809	369,710	424,952	794,662
				93.3			97.3
1935	State	3,693,005	3,447,442	7,140,447	586,648	313,836	900,484
	Bay Area	3,496,990	3,444,840	6,941,830	579,248	265,770	845,018
				97.2			93.8
1936	State	2,328,004	2,242,710	4,570,714	610,054	293,450	903,504
	Bay Area	2,075,646	2,240,849	4,316,495	604,232	293,308	897,540
				94.4			99.3
1937	State	1,629,463	1,111,802	2,741,265	637,942	112,000	749,942
	Bay Area	1,423,521	1,108,747	2,532,268	637,942	112,000	749,942
				92.4			100.0
1938	State	3,877,447	1,851,211	5,728,658	624,618	64,416	689,034
	Bay Area	3,169,658	1,847,926	5,017,584	624,490	62,505	686,995
				87.6			99.7
1939	State	5,957,345	1,180,250	7,137,595	434,072	42,831	476,903
	Bay Area	3,561,416	1,175,979	4,737,395	434,028	42,831	476,859
				66.4			99.9
1940	State	5,154,474	1,082,551	6,237,025	303,260	27,956	331,216
	Bay Area	3,856,126	1,080,190	4,936,316	303,260	27,391	330,651
				79.1			99.8
1941	State	4,262,985	957,509	5,220,494	353,846	208,149	561,995
	Bay Area	3,750,652	952,152	4,702,804	353,846	29,033	382,879
				90.1			68.1
1942	State	2,414,190	800,958	3,215,148	341,160	181,099	522,259
	Bay Area	1,638,944	800,958	2,439,902	341,160	148,449	489,609
				75.9			93.7
1943	State	2,315,338	253,258	2,568,596	419,050	31,235	450,285
	Bay Area	2,021,556	253,215	2,274,771	418,970	31,235	450,205
				88.6			99.9
1944	State	2,925,316	291,974	3,217,290	680,936	28,777	709,713
	Bay Area	2,429,439	291,974	2,721,413	680,936	24,794	705,730
				84.6			99.4
1945	State	4,346,083	383,599	4,729,682	850,668	135,984	986,652
	Bay Area	2,914,474	382,147	3,296,621	850,668	104,989	955,657
				69.7			96.8
1946	State	9,645,230	437,320	10,082,550	820,666	272,314	1,092,980
	Bay Area	3,748,144	432,145	4,180,289	820,666	211,884	1,032,550
				41.5			94.5
1947	State	10,748,623	842,773	11,591,396	599,744	293,648	893,392
	Bay Area	5,077,135	841,086	5,918,221	599,744	293,648	893,392
				51.1			100.0
1948	State	11,912,191	930,817	12,843,008	274,730	1,064,383	1,339,113
	Bay Area	5,977,942	926,707	6,904,649	274,730	971,797	1,246,527
				53.8			93.1
1949	State	11,133,046	804,393	11,937,439	201,730	662,601	864,331
	Bay Area	3,807,323	800,441	4,607,764	201,730	497,207	698,937
				38.6			80.9
1950	State	11,721,352	918,971	12,640,323	299,494	1,067,612	1,367,106
	Bay Area	5,052,470	913,181	5,965,651	299,494	835,759	1,135,253
				47.2			83.0

APPENDIX B-2—Continued

LANDINGS OF CRUSTACEAN FISHERIES IN POUNDS—Continued

Year		Crab	Shrimp	Totals
1951	State	11,566,901	934,017	12,500,918
	Bay Area	3,551,917	931,323	4,483,240
				359
1952	State	12,958,654	1,121,059	14,079,713
	Bay Area	3,894,965	916,223	4,811,188
				34.2
1953	State	8,274,865	1,006,780	9,281,645
	Bay Area	4,125,890	777,651	4,903,541
				52.8
1954	State	7,828,208	1,037,605	8,865,813
	Bay Area	4,020,525	857,519	4,787,044
				55.0
1955	State	6,113,884	1,522,451	7,636,335
	Bay Area	4,466,563	1,013,412	5,479,975
				71.8
1956	State	14,320,169	1,888,380	16,208,549
	Bay Area	5,974,661	991,551	6,966,212
				43.0
1957	State	19,269,615	1,567,410	20,837,025
	Bay Area	8,559,912	643,308	9,203,220
				44.2
1958	State	17,449,728	1,775,546	19,225,274
	Bay Area	7,405,578	218,759	7,624,337
				39.7

LANDINGS OF COMMERCIAL FRESHWATER FISHERIES IN POUNDS—Continued

Year		Catfish	Roughfish	Totals
1951	State	238,126	933,864	1,171,990
	Bay Area	238,126	829,473	1,067,599
				91.1
1952	State	178,630	833,409	1,012,039
	Bay Area	178,630	598,305	776,935
				76.8
1953	State	29,754	437,966	467,720
	Bay Area	29,754	333,334	363,088
				78.1
1954	State	Prohibited[5]	601,079	601,079
	Bay Area	—	599,788	599,788
				99.8
1955	State	—	800,658	800,658
	Bay Area	—	800,210	800,210
				99.9
1956	State	—	932,453	932,453
	Bay Area	—	932,453	932,453
				100.0
1957	State	—	578,098	578,098
	Bay Area	—	578,098	578,098
				100.0
1958	State	—	756,434	756,434
	Bay Area	—	756,434	756,434
				100.0

LANDINGS OF ANADROMOUS FISHERIES IN POUNDS

Year		Salmon	Shad	Striped Bass	Totals
1916	State	10,939,594	4,692,695	941,849	16,574,138
	Bay Area	3,654,716	4,684,804	937,224	9,276,744
	Percentage[1]				56.0
1917	State	11,060,581	5,675,509	1,095,856	17,831,946
	Bay Area	5,575,616	5,655,264	1,085,615	12,316,495
					69.1
1918	State	13,093,188	2,383,635	1,407,841	16,884,664
	Bay Area	8,855,691	2,381,566	1,402,634	12,639,891
					74.9
1919	State	13,145,727	1,574,413	768,934	15,489,074
	Bay Area	8,651,224	1,574,388	767,903	10,993,515
					71.0
1920	State	11,133,819	1,409,768	671,747	13,215,334
	Bay Area	8,196,108	1,409,522	671,690	10,277,320
					77.8
1921	State	7,990,932	862,897	601,614	9,455,443
	Bay Area	5,359,361	862,887	601,432	6,823,680
					72.2
1922	State	7,235,124	1,109,445	684,198	9,028,767
	Bay Area	4,283,350	1,109,445	683,928	6,076,723
					67.3
1923	State	7,090,260	1,285,383	909,573	9,285,216
	Bay Area	4,302,725	1,285,334	909,343	6,497,402
					70.0
1924	State	10,015,269	1,539,217	661,777	12,216,263
	Bay Area	6,944,395	1,538,735	660,434	9,143,564
					74.8
1925	State	9,525,753	2,439,726	837,773	12,803,252
	Bay Area	4,631,976	2,439,441	837,716	7,909,133
					61.8

[1] Percentage of annual statewide catch of each group landed in the San Francisco Bay area each year.
[5] Catfish closed to commercial fishing in 1954.

APPENDIX B-2—Continued

LANDINGS OF ANADROMOUS FISHERIES IN POUNDS—Continued

Year	Catch	Salmon	Shad	Striped Bass	Totals
1926	State	6,084,079	902,202	750,801	7,737,082
	Bay Area	3,206,484	902,202	750,731	4,859,417
					62.8
1927	State	6,511,929	4,103,423	647,594	11,262,946
	Bay Area	3,938,430	4,103,423	647,594	8,689,447
					77.2
1928	State	4,478,566	2,088,878	484,113	7,051,557
	Bay Area	2,932,307	2,088,878	484,113	5,505,298
					78.1
1929	State	5,044,871	1,602,970	528,981	7,176,822
	Bay Area	2,470,151	1,602,970	528,981	4,602,102
					64.1
1930	State	6,002,894	1,199,462	866,808	8,069,164
	Bay Area	3,335,972	1,199,459	866,808	5,402,239
					66.9
1931	State	5,294,511	851,974	975,807	7,122,292
	Bay Area	1,388,282	851,954	975,807	3,216,043
					45.2
1932	State	4,618,171	1,173,471	537,427	6,329,069
	Bay Area	1,492,393	1,173,355	537,427	3,203,175
					50.6
1933	State	4,558,434	1,157,526	485,926	6,201,886
	Bay Area	647,849	1,157,521	485,926	2,291,296
					36.9
1934	State	4,319,102	872,603	801,341	5,993,046
	Bay Area	1,264,088	827,557	801,301	2,892,946
					48.3
1935	State	5,661,980	1,602,251	502,080	7,766,311
	Bay Area	1,942,655	1,602,194	502,073	4,046,922
					52.1
1936	State	5,042,654	2,272,989	Prohibited[6]	7,315,643
	Bay Area	1,396,727	2,272,978	—	3,669,705
					50.2
1937	State	6,909,867	652,657	—	7,562,524
	Bay Area	2,183,285	652,620	—	2,835,905
					37.5
1938	State	3,839,297	1,338,727	—	5,178,024
	Bay Area	1,785,925	1,338,722	—	3,124,647
					60.3
1939	State	2,735,688	1,316,768	—	4,052,456
	Bay Area	931,559	1,316,765	—	2,248,324
					55.5
1940	State	6,675,991	1,764,027	—	8,440,018
	Bay Area	2,692,674	1,764,027	—	4,456,701
					52.8
1941	State	3,790,957	113,101	—	3,904,058
	Bay Area	1,220,729	112,912	—	1,333,641
					34.2
1942	State	6,616,250	2,571,633	—	9,187,883
	Bay Area	4,194,961	2,571,595	—	6,766,556
					73.6
1943	State	6,580,951	2,348,143	—	8,929,094
	Bay Area	3,316,632	2,347,902	—	5,664,534
					63.4
1944	State	10,286,991	2,688,664	—	12,975,655
	Bay Area	5,911,857	2,688,664	—	8,600,521
					66.3
1945	State	13,380,714	1,483,674	—	14,864,388
	Bay Area	7,899,914	1,482,894	—	9,382,808
					63.1

[6]Striped bass removed from commercial category by legislation in 1935.

APPENDIX B-2—Continued

LANDINGS OF ANADROMOUS FISHERIES IN POUNDS—Continued

Year		Salmon	Shad	Striped Bass	Totals
1946	State	13,659,463	771,303	—	14,430,766
	Bay Area	8,542,694	771,231	—	9,313,925
					64.5
1947	State	11,484,588	305,566	—	11,790,154
	Bay Area	4,866,141	305,147	—	5,171,288
					43.9
1948	State	7,769,178	426,386	—	8,195,564
	Bay Area	3,484,280	426,386	—	3,910,666
					47.7
1949	State	6,847,774	735,826	—	7,583,600
	Bay Area	3,354,633	735,826	—	4,090,459
					53.9
1950	State	7,758,591	1,263,365	—	9,021,956
	Bay Area	4,072,973	1,263,365	—	5,336,338
					59.1
1951	State	7,085,603	606,191	—	7,691,794
	Bay Area	4,508,571	606,076	—	5,114,647
					66.5
1952	State	7,259,499	640,277	—	7,899,776
	Bay Area	3,675,704	640,040	—	4,315,744
					54.6
1953	State	7,965,672	608,223	—	8,573,895
	Bay Area	4,184,243	608,223	—	4,792,466
					55.9
1954	State	9,497,173	737,481	—	10,234,654
	Bay Area	4,281,143	737,481	—	5,018,624
					49.0
1955	State	11,939,364	478,454	—	12,417,818
	Bay Area	6,256,774	478,454	—	6,735,228
					54.2
1956	State	11,401,372	431,125	—	11,832,497
	Bay Area	4,078,171	431,125	—	4,509,296
					38.1
1957	State	5,498,733	448,048	—	5,946,781
	Bay Area	1,630,688	448,048	—	2,078,736
					34.9
1958	State	3,646,100	—	—	3,646,100
	Bay Area	1,675,040	—[7]	—	1,675,040
					45.9

[7] Sacramento-San Joaquin gill net fishery eliminated by legislation, 1937.

APPENDIX B-3

COMPARATIVE COMMERCIAL FISHERY STATISTICS FOR CALIFORNIA AND THE SAN FRANCISCO BAY AREA (1879-1958)[1]

Year		Number of Fishermen	Number of Vessels and Boats	Value of[2] Products	Total[3] Investment
1879-80	State	—	—	—	—
	Bay Area	391	90	$338,150	$26,000
	Percentage[4]	—	—	—	—
1880[5]	State	3,094	902	1,193,555	1,403,487
	Bay Area	—	—	—	—
	Percentage	—	—	—	—

[1] Values are ex-vessel and include imports from 1916-1951.
[2] Values of products for the years 1926-1935 were estimated from a graph (Fish Bulletin No. 49, pp. 137-8).
[3] Total investment includes capital outlay for vessels, gear, shore property and cash capital.
[4] Percentage of the statewide totals attributable to the San Francisco Bay Area.
[5] Data from Jordan (1887) and Collins (1892).

APPENDIX B-3—Continued

COMPARATIVE COMMERCIAL FISHERY STATISTICS FOR CALIFORNIA AND THE SAN FRANCISCO BAY AREA (1879-1958) [1]

Year		Number of Fishermen	Number of Vessels	Value of Products	Total Investment
1887 [6]	State	—	—	—	—
	Bay Area	394	90	—	$26,000
	Percentage	—	—	—	—
1888 [7]	State	5,338	1,448	$4,463,369	2,684,210
	Bay Area	4,259	1,023	4,195,864	2,541,730
	Percentage	79.9	70.6	93.5	94.7
1889	State	4,684	—	2,465,317	2,081,950
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1890	State	—	—	2,592,826	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1891	State	—	—	3,031,430	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1892	State	5,509	1,391	2,987,439	2,537,051
	Bay Area	4,430	900	2,793,535	2,334,853
	Percentage	80.4	64.7	93.5	92.0
1895	State	4,770	1,508	1,786,479	2,612,298
	Bay Area	811	—	—	—
	Percentage	17.0	—	—	—
1899	State	3,974	—	2,551,000	2,774,493
	Bay Area	1,475	—	—	—
	Percentage	37.1	—	—	—
1904	State	4,406	—	2,523,000	1,489,000
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1908	State	4,100	—	1,970,000	1,568,000
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1916	State	2,663	2,137	—	5,180,443
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1917	State	2,152	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1918	State	4,522	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1919	State	5,087	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1920	State	5,269	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1921	State	4,462	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1922	State	4,472	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—

[1] Values are ex-vessel and include imports from 1916-1951.
[6] After Jordan (1887).
[7] Biennial Report State Board Fish Commissioners for 1893-1894 and Collins (1892).

APPENDIX B-3—Continued

COMPARATIVE COMMERCIAL FISHERY STATISTICS FOR CALIFORNIA AND THE SAN FRANCISCO BAY AREA (1879-1958) [1]

Year		Number Fishermen	Number of Vessels and Boats	Value of Products	Total Investment
1923	State	4,123	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1924	State	4,671	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1925	State	5,072	—	—	—
	Bay Area	—	—	—	—
	Percentage	—	—	—	—
1926	State	5,078	—	$6,650,000	—
	Bay Area	—	—	1,600,000	—
	Percentage	—	—	24.1	—
1927	State	5,206	—	6,900,000	—
	Bay Area	—	—	2,000,000	—
	Percentage	—	—	29.0	—
1928	State	5,340	—	7,600,000	—
	Bay Area	—	—	1,800,000	—
	Percentage	—	—	23.7	—
1929	State	6,014	1,898	9,450,000	—
	Bay Area	—	621	1,900,000	—
	Percentage	—	32.7	20.1	—
1930	State	6,179	—	7,250,000	—
	Bay Area	—	—	1,850,000	—
	Percentage	—	—	25.5	—
1931	State	5,651	—	4,500,000	—
	Bay Area	—	—	900,000	—
	Percentage	—	—	20.0	—
1932	State	4,955	—	3,000,000	—
	Bay Area	—	—	750,000	—
	Percentage	—	—	25.0	—
1933	State	4,991	—	4,000,000	—
	Bay Area	—	—	1,050,000	—
	Percentage	—	—	26.3	—
1934	State	5,323	2,123	7,250,000	—
	Bay Area	—	665	1,650,000	—
	Percentage	—	31.3	22.8	—
1935	State	6,007	2,453	8,300,000	—
	Bay Area	1,100	723	2,150,000	—
	Percentage	18.3	29.5	25.9	—
1936	State	6,981	2,660	—	—
	Bay Area	—	714	—	—
	Percentage	—	26.8	—	—
1937	State	7,665	2,843	—	—
	Bay Area	—	755	—	—
	Percentage	—	26.6	—	—
1938	State	7,793	3,057	—	—
	Bay Area	—	822	—	—
	Percentage	—	28.9	—	—
1939	State	8,724	3,110	18,963,100	—
	Bay Area	1,835	821	3,534,900	—
	Percentage	21.0	26.4	18.6	—
1940	State	9,047	3,454	$20,399,500	$47,000,000 [2]
	Bay Area	1,870	850	2,214,400	—
	Percentage	20.7	24.6	10.9	—

[1] Values are ex-vessel and include imports from 1916-1951.
[2] Cash Capital not included in this figure.

APPENDIX B-3—Continued

COMPARATIVE COMMERICAL FISHERY STATISTICS FOR CALIFORNIA AND THE SAN FRANCISCO BAY AREA (1879-1958) [1]

Year		Number Fishermen	Number of Vessels and Boats	Value of Products	Total Investment
1941	State	9,344	3,202	$22,499,100	—
	Bay Area	1,717	778	4,679,800	—
	Percentage	18.4	24.3	20.8	—
1942	State	9,043	2,965	26,210,100	—
	Bay Area	1,294	641	3,622,600	—
	Percentage	14.3	21.6	13.8	—
1943	State	11,804	3,726	31,861,600	—
	Bay Area	1,789	795	4,794,600	—
	Percentage	15.2	21.3	15.0	—
1944	State	10,871	3,782	36,129,400	—
	Bay Area	1,970	938	5,143,700	—
	Percentage	18.1	24.8	14.2	—
1945	State	11,747	4,145	38,658,300	—
	Bay Area	2,043	1,034	4,626,000	—
	Percentage	17.4	24.9	12.0	—
1946	State	12,312	4,857	45,346,300	—
	Bay Area	2,055	1,125	3,378,200	—
	Percentage	16.7	23.2	7.4	—
1947	State	12,894	5,042	60,462,500	—
	Bay Area	1,984	1,064	2,979,100	—
	Percentage	15.4	21.1	4.9	—
1948	State	14,261	5,722	80,556,971	—
	Bay Area	1,957	1,144	3,086,799	—
	Percentage	13.7	20.0	3.8	—
1949	State	14,962	6,160	73,226,801	—
	Bay Area	1,944	1,169	3,289,102	—
	Percentage	13.0	19.0	4.5	—
1950	State	14,600	6,103	85,223,449	—
	Bay Area	2,025	1,217	4,691,286	—
	Percentage	13.9	19.9	5.5	—
1951	State	13,193	5,837	66,796,883 [2]	—
	Bay Area	1,898	1,147	3,147,723	—
	Percentage	14.4	19.7	4.7	—
1952	State	11,566	5,454	65,840,044	—
	Bay Area	1,694	1,066	3,343,359	—
	Percentage	14.6	19.5	5.1	—
1953	State	11,372	5,430	59,423,096	—
	Bay Area	1,623	1,020	3,272,670	—
	Percentage	14.3	18.8	5.5	—
1954	State	11,647	4,902	67,402,524	—
	Bay Area	1,752	987	2,830,993	—
	Percentage	15.0	20.1	4.2	—
1955	State	10,277	4,450	53,184,536	—
	Bay Area	1,781	947	3,838,539	—
	Percentage	17.3	21.3	7.2	—
1956	State	9,811	4,352	57,359,570	—
	Bay Area	1,796	959	3,275,559	—
	Percentage	18.3	22.0	5.7	—
1957	State	9,595	4,255	50,307,104	—
	Bay Area	1,612	—	2,389,654	—
	Percentage	16.8	—	4.8	—
1958	State	8,570	3,839	55,929,675	—
	Bay Area	1,184	—	2,963,420	—
	Percentage	13.8	—	5.3	—

[1] Values are ex-vessel and include imports from 1916-1951.
[2] Value of catch does not include shipments after 1951.

8—41686-E

APPENDIX B-4 (Pounds)

LANDINGS OF SELECTED COMMERCIAL SPECIES PRIOR TO 1918

	Salmon	Striped Bass	Shad	Sturgeon	Oysters	Clams and Mussels	Bay Shrimp	Crab	Abalones
1864	96,000+	—	—	—	—	—	—	—	—
1865	96,000+	—	—	—	—	—	—	—	—
1869	—	—	—	—	Eastern oyster introduced 1869	Soft-shell Clam intro. 1869?	—	—	—
1870	—	—	—	—	—	—	—	—	—
1871	—	—	Introduced 1871	—	—	—	—	—	—
1872	—	—	—	—	—	—	—	—	—
1873	—	—	—	—	—	—	—	—	—
1874[1]	4,079,025	—	16±	—	—	—	—	—	—
1875[1]	5,095,781	—	—	118,350	—	—	—	—	—
1876[1]	5,331,423	—	—	274,375	—	—	—	—	—
1877[1]	6,493,563	—	—	295,650	—	—	—	—	—
1878[1]	6,520,768	—	—	334,500	—	—	—	—	—
1879[1]	4,432,250	Introduced 1879	3,000±	607,800	—	—	250,000	—	787,600
1880[1]	10,837,400		600+	—	750,000	—	—2,500,000—		—
1881	9,605,000	—	—	291,050	—	—	—	—	—
1882	9,605,280	—	—	251,700	—	2,880,000	5,313,345	2,862,320	—
1883[2]	9,585,672	—	3,620+	125,850	—	—	—	—	—
1884	3,909,600	—	—	—	—	—	—	—	—
1885	4,320,000	—	—	—	—	—	—	—	—
1886	1,886,400	—	5,152+	—	—	185,104 gal.	—	—	—
1887	3,640,000	—	75,000	1,658,000	—	—	4,000,000±	300,000	190,000±
1888	6,622,978	—	90,871	460,000	8,190,000[4]	2,294,415	4,902,360	1,867,200[6]	2,600,000
1889[3]	6,471,095	1,000+	—	495,000	12,369,000[4]	1,295,000[5]	5,000,000±	1,862,000[6]	—
1890	2,970,111	5,000	300,000	587,625	12,829,500	1,750,000[5]	5,000,000±	1,920,000[6]	70,000[7]
1891	1,957,354	25,000	600,000	715,795	13,387,800	2,100,000[5]	5,000,000±	2,160,000[6]	60,000[7]
1892	3,435,710	56,209	526,494	765,297	15,098,700	2,654,800	5,315,075±	2,640,000[6]	75,000[7]
1893	3,950,373	79,738	405,391	—	—	—	—	—	—
1894	4,494,618	144,754	269,379	—	—	—	—	—	—
1895[2]	4,350,375	252,452	146,399	299,729	14,975,682	2,070,954	5,425,000	2,565,000	302,292
1896[8]	3,276,587	60,628+	68,742+	175,675	—	—	—	—	—
1897[8]	3,979,397	358,194+	111,137+	190,445	—	—	—	—	—
1898[8]	4,079,397	43,857+	107,744+	—	—	—	—	—	—
1899	6,458,959	1,234,320	1,137,801	205,659	2,940,000	2,535,010	4,047,186	3,676,680	369,411
1900	1,886,592	1,251,202	620,891	—	—	—	—	—	—
1901	2,414,592	—	—	Prohibited 1901	—	—	—	—	—
1902	2,312,256	—	—		—	—	—	—	—
1903	3,092,640	2,000,000	—	—	—	—	—	—	—
1904	8,233,148	1,570,404	—	—	1,320,000	—	—	—	—
1905	2,472,480	—	—	—	—	—	—	—	—
1906	2,585,952	—	—	—	—	—	—	—	—
1907	9,111,200	—	—	—	—	—	—	—	—
1908[2]	8,001,750	1,776,000	1,169,000	—	729,000	—	979,000	—	—
1909[2]	11,211,400	—	—	—	—	—	—	—	—
1910	10,256,000	—	—	—	—	—	—	—	—
1911	—	—	—	—	—	—	—	—	—
1912	—	—	—	—	—	—	—	—	—
1913	45,600	—	—	—	—	—	—	—	—
1914	831,120	—	—	—	—	—	—	—	—
1915	3,471,624	1,784,448	3,111,448	—	—	—	—	—	—
1916	3,450,786	—	—	15,178	—	—	—	—	—
1917	3,975,486	—	—	9,822	—	—	—	—	—

See Appendix B-2

[1] Season: August 1 to August 1.
[2] Salmon figures for 1883, 1895, 1908 and 1909 are from U. S. Bureau Commercial Fisheries and State Fish Commission records and differ from those reported by Clark (1929) and Appendix C-2.
[3] Not a full year report in 1889.
[4] Poundage estimated from bushels reported on basis of 70 lbs./bu. (910,000 pounds native oysters shown in Table 33, excluded.)
[5] Poundage estimated from boxes reported on basis of 70 lbs./box.
[6] Poundage estimated from dozens reported on basis of 24 lbs./dozen.
[7] Poundage estimated from dozens reported on basis of 50 lbs./dozen.
[8] Statistics for striped bass and shad based on market sales in San Francisco only.

APPENDIX B-4—Continued

LANDINGS OF SELECTED COMMERCIAL SPECIES PRIOR TO 1918

	Steelhead	Catfish	Sacramento Perch	Sacramento Pike	Carp	Suckers	Hardhead	Splittail
1872	—	—	—	—	Introduced	—	—	—
1873	—	—	—	—	1872	—	—	—
1874	—	Introduced	—	—	—	—	—	—
1875	—	1874	—	—	—	—	—	—
1876	—	—	—	—	—	—	—	—
1877	—	—	—	—	—	—	—	—
1878	—	—	—	—	—	—	—	—
1879	—	—	—	—	—	—	—	—
1880	—	—	—	—	—	—	—	—
1881	—	—	—	—	—	—	—	—
1882	—	—	—	—	—	—	—	—
1883	—	—	—	—	—	—	—	—
1884	—	—	—	—	—	—	—	—
1885	—	—	—	—	—	—	—	—
1886	—	—	—	—	—	—	—	—
1887	—	6,000±	—	—	—	—	—	—
1888	—	10,000±	432,000	20,000	100,000	175,000	—	—
1889	—	12,000±	425,000	18,000	69,000	150,000	—	—
1890	—	10,000±	150,000	25,000	75,000	175,000	—	—
1891	—	20,000±	100,000	22,000	90,000	160,000	—	—
1892	—	196,395	40,000	20,000	75,000	140,000	—	—
1893	—	36,544	—	—	33,084	—	—	—
1894	—	32,465	—	—	42,580	—	—	—
1895	461,225	276,605	—	—	45,691	—	—	—
1896	—	18,135+	—	—	—	—	—	—
1897	—	18,020+	—	—	—	—	—	—
1898	—	13,099+	—	—	—	—	—	—
1899	113,600	465,911	429,485	—	283,514	—	185,882	131,926
1900	—	24,378+	—	—	133,469	—	—	—
1901	—	—	—	—	—	—	—	—
1902	—	—	—	—	—	—	—	—
1903	—	—	—	—	—	—	—	—
1904	—	—	—	—	—	—	—	—
1905	—	1,096,100	—	—	—	—	—	—
1906	—	—	—	—	—	—	—	—
1907	—	—	—	—	—	—	—	—
1908	—	1,069,000	—	—	—	—	—	—
1909	—	—	—	—	—	—	—	—
1910	—	—	—	—	—	—	—	—

APPENDIX C

ANADROMOUS FISH AND FISHERIES

APPENDIX C-1

SELECTED ANADROMOUS FISHES OF THE SAN FRANCISCO BAY AREA

Common Name	Scientific Name	Common Name	Scientific Name
Pacific lamprey	*Entosphenus tridentatus*	Pink salmon (rare)	*Oncorhynchus gorbuscha*
White sturgeon	*Acipenser transmontanus*	Chum salmon (rare)	*Oncorhynchus keta*
Green sturgeon	*Acipenser medirostris* [1]	Red salmon (rare)	*Oncorhynchus nerka*
American shad	*Alosa sapidissima*	Steelhead rainbow trout	*Salmo gairdnerii gairdnerii*
King (Chinook) Salmon	*Oncorhynchus tshawytscha*	Striped bass	*Roccus saxatilis*
Silver (Coho) salmon	*Oncorhynchus kisutch*		

[1] Green Sturgeon apparently are not a truly anadromous species in that their migrations are between ocean and estuarine habitat rather than ascending and spawning in freshwater streams.

APPENDIX-C-2

SACRAMENTO-SAN JOAQUIN RIVER COMMERCIAL SALMON CATCH 1864-1957 [1]

Year	Catch in Pounds	Year	Catch in Pounds	Year	Catch in Pounds	Value
1864	96,000	1901 [3]	2,414,592	1930	1,213,698	—
1865	96,000	1902 [3]	2,312,256	1931	941,605	—
1874	4,079,025	1903 [3]	3,092,640	1932	1,264,987	—
1875	5,095,781	1904	8,233,148	1933	454,253	—
1876	5,311,423	1905 [3]	2,472,480	1934	397,572	—
1877	6,493,563	1906 [3]	2,585,952	1935	888,868	—
1878	6,520,768	1907	9,111,200	1936	949,179	—
1879	4,432,250	1908	7,292,000	1937	974,871	—
1880	10,837,400	1909	8,796,828	1938	1,668,376	—
1881	9,605,000	1910	10,256,000	1939	496,933	$57,024
1882	9,605,280	1911	—	1940	1,515,588	120,094
1883	9,000,000	1912	—	1941	844,963	64,514
1884 [3]	3,909,600	1913 [3]	45,600	1942	2,552,944	300,138
1885 [3]	4,320,000	1914 [3]	831,120	1943	1,295,424	202,140
1886 [3]	1,886,400	1915	3,471,624	1944	3,265,143	415,974
1887	3,640,000	1916	3,450,786	1945	5,467,960	782,578
1888	6,622,978	1917	3,975,486	1946	6,463,245	921,304
1889	6,471,095	1918	5,938,029	1947	3,380,484	586,054
1890	2,970,111	1919	4,529,222	1948	1,939,801	467,686
1891	1,957,354	1920	3,860,312	1949	899,090	220,098
1892	3,435,710	1921	2,511,127	1950	1,211,513	292,703
1893	3,950,373	1922	1,765,066	1951	1,343,171	301,677
1894	4,494,618	1923	2,243,945	1952	738,171	164,907
1895	3,581,244	1924	2,640,110	1953	869,696	177,938
1896	3,276,587	1925	2,778,846	1954	900,961	262,270
1897	3,979,397	1926	1,261,776	1955	2,320,746	600,841
1898	4,079,397	1927	917,525	1956	1,139,585	361,933
1899	6,458,959	1928	553,777	1957	321,824	99,121
1900 [3]	1,886,592	1929	581,497	1958 [2]	—	—

[1] Partly after Clark (1929).
[2] Gill net fishery discontinued by legislative action in 1957.
[3] Poundage based on recorded pack of canned salmon only.

C—043379

C-043381

APPENDIX C-3

PACK OF CANNED SALMON FROM 1864 TO 1919 ON THE SACRAMENTO RIVER [1]

Year	Cases Packed [2]	Canneries Operating	Year	Cases Packed [2]	Canneries Operating	Year	Cases Packed [2]	Canneries Operating
1864	2,000	1	1886	39,300	9	1900	39,304	..
1865	2,000	1	1887	36,500	..	1901	50,304	..
1874	2,500	..	1888	68,075	6	1902	48,172	..
1875	3,000	..	1889	57,300	3	1903	64,430	..
1876	10,000	2	1890	25,065	..	1904	54,710	2
1877	21,500	..	1891	10,353	..	1905	51,510	1
1878	34,017	6	1892	2,281	..	1906	53,874	..
1879	13,855	4	1893	23,336	3	1913	950	1
1880	62,000	9	1894	28,463	2	1914	17,315	2
1881	181,200	20	1895	25,185	3	1915	5,229	3
1882	200,000	19	1896	13,387	..	1916	6,636	1
1883	123,000	21	1897	38,543	..	1917	9,443	3
1884	81,450	..	1898	29,731	..	1918	7,607	3
1885	90,000	6	1899	52,580	..	1919	3,125	2

[1] Cobb, John N. Pacific Salmon Fisheries. Appendix I to Report of U.S. Commissioner of Fisheries for 1921, U.S. Bureau of Fisheries Document No. 902, also Biennial Reports of California Fish and Game Commission. Includes San Joaquin River, Sacramento River and Suisun Bay.
[2] Reduced to a common basis of 48 one-pound cans to the case.

APPENDIX C-4

THE STRIPED BASS PARTY BOAT FISHERY BY BLOCK AND YEAR (1938-1958) [1]

Full Day Boats

	Block 308	Block 301	Block 303	Block 488	Block 302	Block 489	Totals
1938							
Boat Days	591	495	58	343	176	321	1,984
Angler Days	3,248	2,670	247	1,514	876	1,882	10,377
Striped Bass	7,262	3,605	401	2,357	2,003	3,257	18,885
1939							
Boat Days	1,083	861	98	236	509	47	2,834
Angler Days	6,040	4,789	341	1,010	2,740	188	15,108
Striped Bass	17,952	9,637	193	1,145	10,744	112	39,783
1940							
Boat Days	1,251	1,514	155	305	401	299	3,925
Angler Days	6,369	8,082	549	1,321	2,250	1,353	19,924
Striped Bass	18,394	17,796	773	2,792	6,500	924	47,179
1941							
Boat Days	900	1,354	118	689	282	626	3,969
Angler Days	4,575	7,785	441	3,456	1,414	3,825	21,496
Striped Bass	11,378	14,061	533	7,653	3,701	6,460	43,786
1942							
Boat Days	533	633	62	277	80	44	1,629
Angler Days	3,099	3,642	199	1,247	354	198	8,739
Striped Bass	8,389	7,157	261	2,324	707	94	18,932
1943							
Boat Days	439	539	44	236	93	10	1,361
Angler Days	3,180	3,789	131	1,246	487	51	8,884
Striped Bass	9,120	6,846	297	2,725	1,497	28	20,513
1944							
Boat Days	333	147	87	194	98	1	860
Angler Days	2,674	912	303	877	456	6	5,228
Striped Bass	5,880	1,649	698	933	1,484	0	10,644
1945							
Boat Days	796	394	398	202	73	6	1,869
Angler Days	5,165	2,923	1,914	974	343	35	11,354
Striped Bass	14,142	5,027	2,961	1,084	658	0	23,872

[1] For a description of block areas see text.

APPENDIX C-4—Continued

THE STRIPED BASS PARTY BOAT FISHERY BY BLOCK AND YEAR (1938-1958)

Full Day Boats

	Block 308	Block 301	Block 303	Block 488	Block 302	Block 489	Totals
1946							
Boat Days	1,189	424	844	188	77	14	2,736
Angler Days	7,079	2,500	3,586	892	345	79	14,481
Striped Bass	13,963	3,348	4,540	933	459	18	23,261
1947							
Boat Days	1,698	313	1,185	96	154	41	3,487
Anglers Days	11,124	1,842	4,872	442	729	217	19,226
Striped Bass	26,716	3,223	5,950	381	1,425	70	37,765
1948							
Boat Days	1,082	518	1,074	33	54	292	3,053
Angler Days	6,375	2,900	4,158	166	239	1,500	15,338
Striped Bass	13,087	6,373	6,453	207	349	984	27,453
1949							
Boat Days	788	740	1,427	20	22	232	3,229
Angler Days	5,216	3,859	6,479	83	114	1,046	16,797
Striped Bass	8,497	8,498	8,802	3	174	573	26,547
1950							
Boat Days	889	270	1,098	5	13	50	2,365
Angler Days	5,614	1,522	4,683	14	62	425	12,320
Striped Bass	11,289	2,862	5,181	0	105	88	19,525
1951							
Boat Days	1,082	220	1,204	64	12	65	2,647
Angler Days	6,456	1,173	4,921	348	37	289	13,224
Striped Bass	13,052	3,465	7,520	468	134	53	24,692
1952							
Boat Days	815	258	1,539	180	5	2	2,799
Angler Days	4,709	1,708	6,809	1,029	24	7	14,286
Striped Bass	7,060	2,136	9,790	892	33	3	19,914
1953							
Boat Days	924	184	1,432	405	50	17	3,012
Angler Days	5,983	1,273	6,515	2,563	294	104	16,732
Striped Bass	12,012	4,113	6,089	1,609	520	47	24,390
1954							
Boat Days	898	237	986	222	40	32	2,415
Angler Days	6,473	1,861	4,378	1,382	244	175	14,513
Striped Bass	13,025	4,181	3,073	1,593	654	80	22,606
1955							
Boat Days	807	225	855	90	36	16	2,029
Angler Days	6,082	1,894	3,677	599	201	60	12,513
Striped Bass	11,199	2,719	3,768	244	318	12	18,260
1956							
Boat Days	550	323	684	205	8	22	1,792
Angler Days	3,875	2,687	2,467	1,255	32	113	10,429
Striped Bass	4,299	3,238	2,024	1,873	9	50	11,493
1957							
Boat Days	640	392	785	1,204	13	47	3,081
Angler Days	5,092	3,636	3,679	7,352	63	245	20,067
Striped Bass	7,991	6,100	2,222	13,743	94	147	30,297
1958							
Boat Days	414	942	578	806	5	20	2,765
Angler Days	2,730	8,766	2,469	4,760	18	110	18,853
Striped Bass	4,170	20,445	2,133	10,022	16	153	36,939

APPENDIX C-5

Half Day Boats

	Block 308	Block 301	Block 303	Block 488	Block 302	Block 489	Totals
1953							
Boat Days	1,265	201	21	42	73	1	1,603
Angler Days	8,360	1,962	60	218	326	3	10,929
Striped Bass	10,610	2,572	69	265	719	0	14,235
1954							
Boat Days	1,223	208	23	38	65	6	1,563
Angler Days	10,210	2,524	67	201	253	17	13,272
Striped Bass	8,148	2,192	35	127	242	5	10,749
1955							
Boat Days	1,279	179	15	21	2	1	1,497
Angler Days	9,626	1,859	46	114	21	10	11,676
Striped Bass	1,707	1,509	20	173	24	0	9,433

APPENDIX D

MOLLUSCAN FISHERIES

SELECTED MOLLUSKS OF THE SAN FRANCISCO BAY AREA

Common Name	Scientific Name
Oysters	
Native oyster	*Ostrea lurida*
Giant Pacific oyster	*Crassostrea gigas*
Eastern oyster	*Crassostrea virginica*
Scallops	
Rock scallop	*Hinnites multirugosus*
Mussels	
Ribbed horsemussel	*Arcuatuta demissa*
California sea mussel	*Mytilus californianus*
Bay mussel	*Mytilus edulis*
Straight horsemussel	*Volsella recta*
Clams	
Common Washington clam	*Saxidomus nuttalil*
Basket cockle	*Clinocardium nuttali*
Pismo clam	*Tivela stultorum*
Common littleneck	*Protothaca staminea*
Clams—Continued	
Japanese littleneck	*Tapes semidecussata*
Gaper	*Schizothaerus nuttallii*
Soft-shell clam	*Mya arenaria*
Bent-nose clam	*Macoma nasuta*
Abalones	
Red abalone	*Haliotis rufescens*
Northern green abalone	*Haliotis wallalensis*
Japanese abalone	*Haliotis kamschatkana*
Black abalone	*Haliotis cracherodii*
Piddocks and Borers	
Marine borer	*Teredo navalis*
Marine borer	*Teredo diegensis*
Marine borer	*Bankia setacea*
Mud piddock	*Barnea pacifica*
Rough piddock	*Zirfea pilsbryi*

C—043383

C-043385

APPENDIX E

CRUSTACEAN FISHERIES

SELECTED CRUSTACEANS OF THE SAN FRANCISCO BAY AREA

Fairy Shrimps (*Anostraca*)
- Brine Shrimp — *Artemia salina*

Barnacles (*Cirrapedia*)
- *Balanus improvisus*
- *Balanus glandula*
- *Balanus crenatus*

Sand fleas, skeleton shrimp (Amphipoda)
- *Corophium spinicorne*
- *Ampelisca milleri*
- *Anisogammarus confervicolus*
- *Pantharpina sp.*

Mysids (Mysidacea)
- *Neomysis mercedis*

Pill bugs (Isopoda)
- *Syndotea laticauda*
- *Gnorinosphaeroma oregonensis*

Shrimps, lobsters and crabs (Decapoda)

True shrimps and prawns (Natantia)
- Commercial ocean shrimp
  - *Pandalus jordani*
  - *Pandalus danae*
- Commercial bay shrimp
  - *Crago migricauda*
  - *Crago macronigricauda*
  - *Crago franciscorum*
- Other Shrimps
  - *Crago communis*
  - *Crago alba*
  - *Crago resima*
  - *Crago spinosissima*
  - *Crago munitella*
  - *Crago stylirostris*
  - *Crago alaskensis elongata*
  - *Spirontocaris gracilis*
  - *Spirontocaris paludicola*
  - *Spirontocaris brevirostris*
  - *Spirontocaris taylori*
  - *Spirontocaris cristata*
  - *Spirontocaris franciscana*

Freshwater Crayfish
- *Pacifastacus nigrescens*
- *Pacifastacus klamathensis*
- *Pacifiastacus leniusculus*
- *Procambarus clarkii*

Hermit crabs, sand crabs, ghost shrimp (Anomura)
- *Calianassa gigas*
- *Eupagurus turgidus*
- *Holopagurus pilosus*
- *Pagurus samuelis*
- *Pylopagurus minimus*
- *Emerita analoga*
- *Petrolisthes cintipes*
- *Upogebia pugettensis*
- *Paguristes bakeri*
- *Pagurus ochotensis*
- *Pagurus hirsutiusculus*
- *Acantholithodes hispidus*
- *Oedignathus inermis*

True crabs, spider crabs edible crabs (Brachyura)
- *Randallia ornata*
- *Epialtus productus*
- *Cancer magister*
- *Cancer antennarius*
- *Pinnixa littoralis*
- *Pinnixa schmitti*
- *Pachygrapsus crassipes*
- *Hemigrapsus nudus*
- *Pugettia productus*
- *Oregonia gracilis*
- *Cancer productus*
- *Cancer gracilis*
- *Pinnixa occidentalis*
- *Pinnixa franciscana*
- *Scleroplax granulata*
- *Hemigrapsus oregonensis*
- *Rithropanopeus harrissi*

C—043384

C-043386

APPENDIX F

FRESHWATER FISH AND FISHERIES

APPENDIX F-1

LIST OF SELECTED FRESHWATER FISHES OF THE SAN FRANCISCO BAY AREA

Trouts
- Brown trout — *Salmo trutta*
- Rainbow trout — *Salmo gairdnerii*
- Brook trout — *Salvelinus fontinalis*

Centrarchids (black basses and sunfishes)
- Largemouth bass — *Micropterus salmoides*
- Smallmouth bass — *Micropterus dolomieui*
- Green sunfish — *Lepomis cyanellus*
- Pumpkinseed — *Lepomis gibbosus*
- Bluegill — *Lepomis machrochirus*
- Redear sunfish — *Lepomis microlophus*
- White Crappie — *Pomoxis annularis*
- Black Crappie — *Pomoxis nigromaculatus*
- Sacramento perch — *Archoplites interruptus*

Catfishes
- Channel catfish — *Ictalurus punctatus*
- White catfish — *Ictalurus catus*
- Brown bullhead — *Ictalurus nebulosus*
- Black bullhead — *Ictalurus melas*

Suckers
- Sacramento western sucker — *Catastomus occidentalis occidentalis*

Carp and Minnows
- Carp — *Cyprinus carpio*
- Goldfish — *Carassius auratus*
- Tench — *Tinca tinca*
- Golden shiner — *Notemigonus crysoleucas*
- Sacramento blackfish — *Orthodon microlepidotus*
- Fathead minnow — *Pimephales promelas*
- Hardhead — *Mylopharodon conocephalus*
- Sacramento hitch — *Lavinia exilicauda exilicauda*
- Sacramento squawfish — *Pytchocheilus grandis*
- Splittail — *Pogonichthys macrolepidotus*
- Venus roach — *Hesperoleucus venustus*
- Sacramento tui chub — *Siphatales bicolor formosus*
- Pacific speckled dace — *Rhinichtys osculus carringtonii*

Miscellaneous Fishes
- Mosquitofish — *Gambusia affinis*
- Yellow perch — *Perca flavescens*
- Tule perch — *Hysterocarpus traskii*
- Shiner perch — *Cymatogaster aggregata*
- Prickly sculpin — *Cottus asper*
- Staghorn sculpin — *Leptocottus armatus*
- Arrow goby — *Clevelandia ios*
- River lamprey — *Lampetra ayresii*

C—043385

C-043387

APPENDIX F-2

SOME INITIAL INTRODUCTIONS OF FRESHWATER FOOD AND GAME FISHES NOW OCCURRING IN THE SAN FRANCISCO BAY AREA

Species	Year	Number Eggs or Fish	Source of Stock	Location Stocked
Eastern brook trout (*Salvelinus fontinalis*) [1]	1872	6,000	.....	North Fork, American River Alameda Creek, Alameda County San Andreas Reservoir, San Mateo County
	1875	60,000	New Hampshire	Sonoma, Napa, Alameda, Santa Clara, Mendocino, Yolo, Nevada and Placer Counties
Subsequent introductions 1877, 1878, 1879.				
Brown trout				
(Lock Leven) trout (*Salmo trutta*)	1894	20,000	Northville, Mich.	Webber Lake, Nevada County
(German, or Von Behr) trout (*Salmo fario* = trutta) [2]	1893	.....	.....	Humboldt County by U. S. Fish Commission
	1895	135,000	.....	Widespread throughout the north half of State.
Smallmouth black bass (*Micropterus dolomieu*)	1874	75 adults 24 juveniles	Lake Champlain, Vt. St. Johns River, Mich.	Napa Creek, Napa County Alameda Creek, Alameda County
Largemouth black bass (*Micropterus salmoides*) [3]	1874	.....	Lake Champlain, Vt. St. Johns River, Mich.	
	1879	22		Crystal Springs Reservoir San Mateo County, Lake Temascal, Alameda County
Subsequent introductions 1891, 1895.				
White catfish (*Ictalurus catus*)	1874	54–56	Raritan River, N. J.	San Joaquin River near Stockton
Brown bullhead (*Ictalurus nebulosus*)	1874	70	Lake Champlain, Vt.	Ponds near Sacramento
	1874	144	Schuylkill River, Penn.	San Joaquin River near Lathrop
Channel catfish (*Ictalurus punctatus*)	1891	yearlings	.....	Feather River and Lake Cuyamaca, Santa Barbara County
	1895	10 adults	.....	Chico Creek
Carp (*Cyprinus carpio*)	1872 1877	5 adults 88	Holstein, Germany Japan	Private pond, Sonoma County
Subsequent introductions 1879, 1882, 1883.				
Tench (*Tinca tinca*)	1922	12–24 4 to 6 in. fish	Italy	Reservoir on Balonesi Ranch, Lobitas Creek, San Mateo County
Bluegill (*Lepomis macrochirus*)	1890–1	.....	.....	Lake Cuyamaca, Santa Barbara County
Green sunfish (*Lepomis cyanellus*)	1890–1	.....	.....	Lake Cuyamaca, Santa Barbara County
Pumpkinseed (*Lepomis gibbosus*)	1915 [4]	.....	.....	Mecca, Riverside County Susan River, Lassen County
	1942	.....	.....	Antelope Creek, Modoc County
	1951	.....	.....	Klamath River, Siskiyou County
Redear sunfish (*Lepomis microlophus*)	1954	3,960 fingerlings	.....	Southern California
	1956	166 adults	.....	Central Valley Hatchery and other ponds, Sacramento County
White crappie (*Pomoxis annularis*)	1891	285	.....	Lake Cuyamaca, Santa Barbara County
Black crappie (*Pomoxis nigromaculatus*)	1891	.....	.....	Lake Cuyamaca, Santa Barbara County

[1] The California Acclimatization Society is reported to have raised eastern brook trout from eggs imported from the East as early as 1869 or 1870.
[2] At the present time in California only one species of brown trout is recognized, namely *Salmo trutta*.
[3] Apparently largemouth black bass were introduced at the same time as the smallmouth, but details are lacking.
[4] No record of introduction, but apparently first brought to California by U.S. Bureau of Fisheries.

APPENDIX G

WATERFOWL, UPLAND GAME AND SHORE BIRDS

APPENDIX G-1

A LIST OF THE MORE COMMON WATERFOWL, UPLAND GAME AND SHORE BIRDS OF THE SAN FRANCISCO BAY AREA

The common and scientific names are listed followed by code lettering, which indicates the abundance, duration, and season of residence in the Bay Area.

Abundance Code	Season Code	Residence Code
A—Abundant	F—Fall	R—Resident
C—Common	W—Winter	V—Visitant
R—Rare	Sp—Spring	M—Migrant
	S—Summer	

Thus: RR would indicate a rare resident
ASpSFV would indicate abundant spring, summer, and fall visitant
CSpFM would indicate common spring and fall migrant
CR&AWV would indicate common resident and abundant winter visitant

Group I Ducks

A. Puddlers or Dabblers

These species feed primarily at or near the water surface, although many of them also leave the water to graze.

Common Name	Scientific Name	Code
Mallard	*Anas platyrhynchos platyrhynchos*	CR & AWV
Gadwall	*Anas strepera*	CR & AWV
Baldpate or widgeon	*Mareca americana*	RR & AWV
European widgeon	*Mareca penelope*	RWV
Pintail or sprig	*Anas acuta*	CR & AWV
Green winged teal	*Anas carolinensis*	RR & CWV
Cinnamon teal	*Anas cyanoptera*	CR & RWV
Shoveler	*Spatula clypeata*	RR & AWV
Wood duck	*Aix sponsa*	CR & WV

B. Diving Ducks

These species feed in water depths up to ten feet or more and frequently a large proportion of their diet consists of animal organisms as well as vegetation.

Redhead	*Aythya americana*	CR & CWV
Ring-necked duck	*Aythya collaris*	RWV
Canvasback	*Aythya valisineria*	CWV
Lesser scaup or bluebill	*Aythya affinis*	AWV
Greater Scaup	*Aythya marila*	CWV
American golden-eye	*Bucephala clangula americana*	CWV
Barrow's golden-eye	*Bucephala islandica*	RWV
Buffle-head	*Bucephala albsola*	CWV
Ruddy duck	*Oxyura jamaicensis*	CR & AWV
Old squaw	*Clangula hyemalis*	RWV
Western harlequin duck	*Histrionicus histrionicus pacificus*	RWV
American scoter	*Cidemia americana*	RWV
White-winged scoter	*Melanitta deglandi*	CR & AWV
Surf scoter	*Melanitta perspicillata*	RR & AWV

Common Name	Scientific Name	Code
C. Tree Ducks		
Fulvous tree duck	*Dendrocygna bicolor helva*	RSV
D. Mergansers or Fish Ducks		
Hooded merganser	*Lophodytes cucullatus*	RWV
American merganser	*Mergus merganser americanus*	CWV
Red breasted merganser	*Mergus serrator*	CWV
Group II Geese and Brant		
Great Basin Canada goose	*Branta canadensis moffitti*	CWV
Lesser Canada goose	*Branta canadensis leucoparia*	CWV
Cackling goose	*Branta canadensis minima*	CWV
Pacific black brant	*Branta nigricans*	CWV
Emperor goose	*Philacte canagica*	RWV
White fronted goose	*Anser albifrons albifrons*	AWV
Tule goose	*Anser albifrons gambeli*	RWV
Lesser snow goose	*Chen hyperborea*	AWV
Ross' goose	*Chen rossi*	CWV
Group III Swans		
Whistling swan	*Cygnus columbianus*	CWV
Group IV Coots		
Coot or mudhen	*Fulica americana*	CR & AWV
Group V Upland Game Birds		
California or valley quail	*Lophortyx californicus californicus*	CR
	Lophortyx californicus brunnescens	CR
Mountain quail	*Oreortyx picta palmeri*	RR
Ring-necked pheasant	*Phasianus colchicus*	CR
Mourning dove	*Zenaidura macroura marginella*	AR & WV
Pacific band-tailed pigeon	*Columba fasciata monilis*	CR & WV

C—043387

C-043389

APPENDIX G-1—Continued

A LIST OF THE MORE COMMON WATERFOWL, UPLAND GAME AND SHORE BIRDS OF THE SAN FRANCISCO BAY AREA

Common Name	Scientific Name	Code
Group VI Shore and Wading Birds		
California clapper rail	*Rallus longirostris obsoletus*	CR
Virginia rail	*Rallus limicola*	CR
Sora rail	*Porzana carolina*	CR
Black rail	*Laterallis jamaicensis coterniculus*	RR & WV
Black gallinule	*Gallinula chloropus*	RR
Wilson's snipe (jacksnipe)	*Capella gallinago delicata*	CFWSpV
Avocet	*Recurvirostra americana*	RR & WV
Black necked stilt	*Himantopus mexicanus*	SpFM
Least sandpiper	*Erolia minutilla*	AWV
Western sandpiper	*Ereunetes mauri*	AWV
Red-backed sandpiper	*Erolia alpina pacifica*	AWV
Pectoral sandpiper	*Erolia melanotos*	RSpFM
Black-bellied plover	*Squatarola squatarola*	CWV
Semipalmated plover	*Charadrius semipalmatus*	AWV
Long-billed curlew	*Numenius americanus*	CWV
Hudsonian curlew	*Numenius phaeopus hudsonicus*	CSpFM
Greater yellow legs	*Totanus melanoleucus*	CSpFM
Lesser yellow legs	*Totanus flavipes*	RSpFM
Marbled godwit	*Limosa fedoa*	CSpFM & RWV
Willet	*Cataptrophorus semipalmatus*	CWV
Dowitcher	*Limnodromus griseus*	CWV
Northern phalarope	*Lobipes lobatus*	CSpFM
Great blue heron	*Ardea herodias*	CR
Little green heron	*Butorides virescens anthonyi*	SV
American bittern	*Botaurus lentiginosus*	CR
American egret	*Cosmerodius albus egretta*	CR
Snowy egret	*Leucophoyx thula brewsteri*	CV

Common Name	Scientific Name	Code
Group VII Miscellaneous Marsh and Water Birds		
White pelican	*Pelicanus erythrorhynchos*	CR & WV
Brown pelican	*Pelicanus occidentalis californicus*	CFWV
Double crested cormorant	*Phalacrocorax auritus*	CR
White tailed kite	*Elanus leucurus majusculus*	RR
Marsh hawk	*Circus cyaneus hudsonius*	RR & CWV
Common loon	*Gavia immer*	CWV
Pacific loon	*Gavia arctica pacifica*	CWV
Red throated loon	*Gavia stellata*	CWV
Eared grebe	*Podiceps caspicus californicus*	CWV
Western grebe	*Aechmophorus occidentalis*	CWV
Pied-billed grebe	*Podilymbus podiceps podiceps*	CR
Fork-tailed petrel	*Oceanodroma furcata*	RV
Ashy petrel	*Oceanodroma homochroa*	CSpSV
Western gull	*Larus occidentalis*	AR
Herring gull	*Larus argentatus*	AWV
California gull	*Larus californicus*	AWV
Ring-billed gull	*Larus delawarensis*	AWV
Bonaparte's gull	*Larus philadelphia*	CWV
Glaucous-winged gull	*Larus glaucescens*	AWV
Forster tern	*Sterna forsteri*	RSV & CWV
Caspian tern	*Hydroprogne caspia imperator*	CR

APPENDIX G-2

GAME BIRDS IN THE SAN FRANCISCO AND LOS ANGELES MARKETS IN THE 1895-96 SEASON

Species	Number	Value	Number from Bay Counties	Percentage of Birds from Bay Counties
Canvasback	6,259	$2,626.00	2,379	
Mallard	47,565	11,891.50	6,399	
Sprig	35,022	5,305.50	4,206	
Teal	82,525	8,662.45	7,436	
Widgeon	52,522	6,659.58	4,416	
Small ducks	25,882	2,227.20	2,874	
Gray ducks	671	98.00	373	
Blackjack	2,001	116.75	1,277	
Redhead	519	79.58	49	
Butterballs	328	26.75	77	
Wood ducks	440	36.67	51	
Wiretails	89	6.83	3	
Sheldrake	217	18.00	12	
Sub-Totals	254,040	37,754.81	29,552	12.9
Gray geese	19,419	4,042.30	1,559	
White geese	10,251	856.50	926	
Honker	2,411	703.50	727	
Brant	16,319	2,040.00	956	
Swans	518	174.25	65	
Sub-Totals	48,918	7,816.55	4,233	8.7
Quail	177,366	15,116.08	15,326	
Doves	5,160	252.73	158	
Wild Pigeons	512	42.67	76	
Sub-Totals	183,038	15,411.48	15,560	8.5
Rail	27	3.33	2	
Larks	2,354	98.00	386	
Common Snipe	3,145	212.55	141	
English Snipe	6,446	753.88	1,442	
Curlew	1,173	45.33	19	
Plover	1,620	63.58	96	
Sub-Totals	14,765	1,176.67	2,086	14.1
Crane	385	192.50	76	
Bittern	25	10.00	3	
Sub-Totals	410	202.50	79	19.3
Totals	501,171	$62,362.01	51,510	10.3

C-043392

C—043390

APPENDIX G-3

ANNUAL WATERFOWL INVENTORIES 1953-1961 [1]

YEAR	DUCKS			GEESE			BRANT AND SWANS			COOTS			COMBINED TOTALS		
	State Total	Bay Area	Percentage [2]	State Total	Bay Area	Percentage	State Total	Bay Area	Percentage	State Total	Bay Area	Percentage	State	Bay Area	Percentage
1953	4,206,404	501,589	11.9	845,282	12,693	1.6	57,783	7,157	12.4	615,239	68,655	11.2	5,724,708	590,094	10.3
1954	4,189,029	456,758	10.9	696,462	20,581	3.0	42,523	5,575	13.1	925,621	110,850	12.0	5,853,635	593,764	10.1
1955	4,035,426	893,751	22.2	743,104	21,623	2.9	59,467	8,975	15.1	534,432	57,209	10.7	5,372,429	981,558	18.3
1956	5,027,722	427,142	8.5	813,428	19,600	2.4	67,189	12,025	17.9	665,807	51,910	7.8	6,574,146	510,677	7.8
1957	3,793,731	1,582,022	41.7	583,819	245,907	42.1	59,111	16,941	28.7	741,323	256,347	34.6	5,177,984	2,101,217	40.6
1958	5,366,932	372,742	6.9	646,867	49,583	7.7	54,882	9,508	17.3	612,701	83,610	13.6	6,681,382	515,443	7.7
1959	4,784,399	811,946	17.0	699,907	80,478	11.5	31,340	10,415	33.2	810,963	233,935	28.8	6,326,609	1,136,774	18.0
1960	3,718,285	422,676	11.4	701,227	128,954	18.4	33,198	18,253	55.0	619,957	138,820	22.4	5,072,667	708,703	14.0
1961	3,526,614	396,565	11.2	819,159	56,627	6.9	39,085	24,960	63.9	1,006,983	164,936	16.4	5,391,841	643,088	11.9
9 Year Means	4,294,282	651,688	15.2	727,695	70,672	9.7	49,398	12,645	25.6	725,892	129,586	17.8	5,797,267	864,591	14.9

[1] These inventories are conducted during a one-week period early in January of each year.
[2] The percentages given represent the proportion of the State total counted in the Bay area.

APPENDIX G-4

TREND IN STATE AND BAY AREA WATERFOWL HUNTING SUCCESS

Season	Duck Kill[4]			Goose Kill[4]			Average Hunter Success (Birds per hunter per season)	
	State	S.F. Bay Area	Percentage of State Total	State	S.F. Bay Region	Percentage of State Total	State[1]	S.F. Bay Region
1948-49	3,024,200	799,400	26.4	356,100	33,800	9.5	12.7	18.4
1949-50	2,550,600	687,000	26.9	275,240	25,485	9.3	11.3	14.8
1950-51	1,945,300	575,300	29.6	230,900	14,000	6.1	9.1	14.6
1951-52	2,966,000	734,400	24.8	460,000	20,000	4.3	12.6	16.1
1952-53	4,659,000	1,003,200	21.5	465,850	36,250	7.8	15.1	19.7
1953-54	4,590,000	1,232,400	26.8	580,500	30,650	5.3	12.9	21.3
1954-55	3,461,600	701,100	20.3	428,200	26,150	6.1	13.0	19.7
1955-56	3,312,700	693,900	21.0	339,650	15,700	1.6	15.4	18.3
1956-57	3,526,500	737,700	20.9	343,250	29.450	8.6	14.5	20.0
1957-58[2]	4,025,000	827,000	20.5	366,900	14,100	3.8		
1958-59	4,610,300	721,284	15.6	379,200	14,162	3.7		
1959-60	1,912,300	293,844	15.3	257,400	6,551	2.5		
9 Year (1948-57) Averages	3,337,000	796,000	23.9	386,600	25,700	6.7		
Values[3]	$27,233,000	$6,496,000		$6,310,000	$420,000			

[1] Figures in this column are the weighted means of 14 geographical areas in the State exclusive of the Bay Area.
[2] Data subsequent to 1956-57 obtained after computation of averages and values. Change in inventory technique precluded determination of hunter success subsequent to 1956-57.
[3] Values based on nine-year average State and Bay Area kill figures and the hunter expenditures obtained by the U. S. Fish and Wildlife Service in a national survey (see text).
[4] Data from hunter postal surveys.

C-043394

C—043392

APPENDIX G-5

FOURTEEN YEAR SPRING AND FALL CENSUS OF SHORE BIRDS OVER THE SAME ROUTE BETWEEN ALVISO AND THE DUMBARTON RAILROAD BRIDGE OVER THE SOUTH ARM OF SAN FRANCISCO BAY [1]

	Black-Bellied Plover	Semi-palmated Plover	Greater Yellow-Legs	Lesser Yellow-Legs	Western Willet	Marbled Godwit	Long-Billed Curlew	Hudsonian Curlew	Least Sand-Piper	Western Sand-Piper	Red-Backed Sand-Piper	Pectoral Sand-Piper	Dowitchers	Northern Phalarope	Sea-sonal Totals
1928 Spring	8,700	604	1,100	..	1,200	400	290	900	22,000	17,000	14,000	6	5,200	8,700	80,100
1928 Fall	16,000	1,300	1,500	46	3,200	700	350	2,900	60,000	70,000	23,000	72	14,000	17,000	210,068
1929 Spring	9,100	500	1,000	1	1,250	300	260	1,000	20,000	17,000	14,000	..	4,000	9,000	77,411
1929 Fall	15,000	1,200	1,200	92	2,700	950	475	3,400	55,000	65,000	25,000	83	11,000	16,000	197,100
1930 Spring	10,000	700	650	2	1,320	340	310	1,100	16,000	19,000	14,000	..	3,000	5,000	71,422
1930 Fall	16,000	1,100	1,300	27	2,600	760	840	2,700	60,000	58,000	24,000	17	9,000	14,000	190,344
1931 Spring	10,200	400	700	..	1,300	410	570	600	24,000	22,000	16,000	..	2,000	6,000	84,180
1931 Fall	17,000	1,000	1,600	53	2,400	1,100	800	2,100	53,000	50,000	30,000	51	11,000	13,000	183,104
1932 Spring	10,400	600	1,200	3	1,400	507	605	700	23,000	15,000	13,000	2	2,000	700	69,117
1932 Fall	15,000	1,200	1,700	66	3,300	1,100	1,100	1,600	54,000	55,000	17,000	64	12,000	4,000	167,130
1933 Spring	9,300	800	1,200	.	1,700	560	410	875	25,000	16,000	12,000	..	2,600	900	71,345
1933 Fall	17,000	1,200	1,700	51	3,200	1,200	1,100	2,200	51,000	71,000	22,000	76	6,000	3,500	181,227
1934 Spring	11,000	800	1,400	..	1,800	1,200	317	1,200	20,000	19,000	17,000	4	1,900	1,200	76,821
1934 Fall	21,000	1,400	1,900	49	3,700	790	780	4,500	50,000	63,000	35,000	71	9,000	6,000	197,190
1935 Spring	12,000	900	900	4	1,200	500	507	1,600	7,000	24,000	6,000	..	2,200	5,000	91,811
1935 Fall	21,000	1,500	2,000	67	3,400	690	800	1,900	41,000	70,000	21,000	81	12,000	11,000	186,438
1936 Spring	13,000	600	1,100	..	1,600	360	400	1,100	19,000	20,000	9,000	4	3,100	7,000	76,264
1936 Fall	20,000	1,600	2,000	57	3,800	700	850	2,100	57,000	70,000	19,000	73	13,000	10,000	200,180
1937 Spring	12,000	700	1,300	2	1,900	900	560	950	22,000	14,000	10,000	2	4,300	4,000	72,614
1937 Fall	19,000	1,100	2,200	46	4,900	1,200	475	1,900	60,000	55,000	17,000	4	9,000	7,500	179,325
1938 Spring	15,000	370	1,200	1	2,200	1,200	600	900	25,000	16,000	10,000	..	5,500	3,500	81,471
1938 Fall	20,000	900	2,200	34	4,600	1,600	750	2,000	60,000	55,000	20,000	16	11,000	6,500	184,600
1939 Spring	12,000	400	700	5	1,700	1,000	500	1,000	22,000	17,000	9,000	7	5,000	2,700	73,012
1939 Fall	18,000	900	1,500	60	4,500	2,000	775	1,900	58,000	58,000	16,000	29	9,000	4,000	174,664
1940 Spring	10,000	600	700	..	1,800	750	400	900	24,000	19,000	9,000	5	6,000	2,000	75,155
1940 Fall	16,000	1,100	1,600	90	3,500	1,700	700	2,200	65,000	65,000	16,000	36	9,500	3,500	185,926
1941 Spring	8,000	600	550	26	1,400	700	300	850	27,000	20,000	10,000	16	4,000	1,200	74,642
1941 Fall	14,000	1,200	1,100	105	2,700	1,700	550	2,000	70,000	70,000	18,000	41	11,000	2,400	194,796
Spring Average	10,764	612	979	3	1,555	652	431	977	22,571	18,214	12,357	3	3,629	4,064	76,812
Fall Average	17,500	1,193	1,679	60	3,474	1,156	739	2,386	56,714	62,500	21,643	51	10,464	8,457	188,006

[1] Census based on one day observation each spring and fall at comparable dates. Unpublished data supplied by Mr. D. D. McLean, formerly of the Game Management Branch of the Department of Fish and Game.

APPENDIX H

MAMMALIAN RESOURCES

APPENDIX H-1

LIST OF SELECTED MAMMALS OF THE SAN FRANCISCO BAY AREA

Common Name	Scientific Name
A. Aquatic Mammals	
Southern sea otter	*Enhydra latris nereis*
Pribilof fur seal	*Callorhinus ursinus cynocephalus*
Guadalupe fur seal[1]	*Arctocephalus townsendi*
Harbor seal	*Phoca vitulina richardii*
Steller's sea lion	*Eumetopias jubata*
California sea lion	*Zalophus californianus*
California river otter	*Lutra canadensis brevipilosus*
California mink	*Mustela vison aestuarina*
Muskrat	*Ondatra zibethica ssp.*
Golden beaver	*Castor canadensis subauratus*
B. Inland Fur Bearers	
Striped skunk	*Mephitis mephitis*
Spotted skunk (civet)	*Spilogale gracilis*
Racoon	*Procyon lotor*
Ringtail cat	*Bassariscus astutus*
Opossum	*Didelphis virginiana*
Coyote	*Canis latrans*
Badger	*Taxidea taxus*
Weasel	*Mustela xanthogenys*
Bobcat	*Lynx rufus*
C. Big Game	
Roosevelt elk[1]	*Cervus candensis roosevelti*
Tule elk[1]	*Cervus canadensis nannodes*
Black-tailed deer	*Odocoileus hemionus columbianus*
C. Big Game—Continued	
California Coast grizzly bear[1]	*Ursus californicus*
Mendocino grizzly bear[1]	*Ursus mendocinensis*
Black or cinnamon bear	*Euarctus americanus*
Mountain lion or puma	*Felis concolor californica*
American or pronghorn antelope[1]	*Antilocapra americana*
D. Small Game	
Blacktailed jackrabbit	*Lepus california*
Cottontail	*Sylvilagus auduboni*
Brush rabbit	*Sylvilagus bachmani*
Western gray squirrel	*Sciurus griseus*
Fox squirrel	*Sciurus niger ssp.*
Eastern gray squirrel	*Sciurus carolinensis*
E. Cetaceans	
Pacific harbor porpoise	*Phocaena vomerina*
Striped porpoise	*Lagenorhynchus obliquidens*
Baird dolphin	*Delphinus bairdii*
Killer whale	*Grampus rectipinna*
California gray whale	*Eschrichtius glaucus*
Common finback whale	*Balaenoptera physalus*
Blue whale	*Balaenoptera musculus*
Humpback whale	*Megaptera nodosa*
Sperm whale	*Physeter catodon*

[1] These animals now totally absent from San Francisco Bay Area Fauna.

C—043393

C-043395

APPENDIX H-2

DATA ON PRICES AND NUMBERS OF SEA OTTER PELTS

Year	Price per pelt	Remarks
1727-1742	20- 50 rubles	Locally
	80-100 rubles	Chinese Frontier
1775-1777	90-100 rubles	29,932 pelts sold by English to Russia
1786-1787	$40-$90	
1790	$80-$120	Chinese market
1799	$25	Chinese market
1808	$30-$40	
1847	$60	42 sold in San Francisco markets
1869	$40-$60	San Francisco market
1873	$75	about 3,000 sold
1880	$110	
1887	$150-350	
1888	$82	2,671 pelts sold for $218,625
	$105	London
	$87	1,901 pelts sold for $164,775

Year	Price per pelt	Remarks
1889	$165	London
1891	$285	
1903	$440-$1,000	Best skins $1,125
1910	$1,700	Single pelt
1920	$2,000-$2,500	
1957	$100	About 100 pelts sold by Federal Government

Year	No. Ships	No. Sea Otters	Sale Price Canton Market
1799	7	11,000	$25 per pelt
1800	6	9,800	$22 per pelt
1801	10	13,000	$21 per pelt
1802	8	14,000	$20 per pelt

APPENDIX H-3

Appendix H-3 on the following page is a tabulation of state-wide catch of furbearers from 1921-22 through 1955-56. The state-wide records are actual reports of animals taken by licensed trappers.

Data for the Bay Area are actual records of catch by county from 1938 through 1956. Prior to 1938 county of catch was not reported. Therefore, the figures given for the Bay Area for 1921 through 1937 are computed figures for each species based on the proportion of each taken in Bay Area in the 1938-56 period.

C-043397

C—043395

APPENDIX H-3—Continued

ANNUAL CATCH OF FURBEARING MAMMALS IN THE SAN FRANCISCO BAY AREA (1921-1956)

Season	Mink	River Otter	Muskrat	Beaver	Raccoon	Weasel	Skunk	Civet	Ringtail	Fox	Coyote	Bobcat	Opossum	Badger	Total	Percentage taken in SF Bay Area
1921-22 Bay Area	253	10	--	--	321	2	981	--	3	113	27	64	7	3	1,784	10.9
State	1,156	36	127	4	2,156	86	8,454	--	545	1,505	1,190	997	73	35	16,364	
1924-25 Bay Area	671	39	--	--	1,640	9	3,375	471	12	721	185	348	34	40	7,545	9.9
State	3,066	142	3,120	--	11,006	338	29,092	3,364	2,304	9,607	8,043	5,443	356	457	76,338	
1925-26 Bay Area	743	39	--	197	1,990	6	3,260	601	13	688	196	390	58	43	8,224	9.4
State	3,394	141	6,207	4,019	13,358	227	28,107	4,292	2,698	9,168	8,509	6,087	613	496	87,316	
1926-27 Bay Area	1,066	44	--	34	2,314	9	4,533	677	17	800	222	449	101	65	10,331	9.3
State	4,867	158	13,261	692	15,527	347	39,074	4,839	3,477	10,666	9,631	7,015	1,064	742	111,360	
1927-28 Bay Area	1,282	45	--	34	2,858	17	6,547	1,320	22	991	321	784	210	106	14,537	8.8
State	5,854	163	24,736	700	19,182	661	56,438	9,425	4,368	13,209	13,941	12,250	2,208	1,216	164,351	
1930-31 Bay Area	280	18	--	3	503	2	1,470	194	5	187	60	108	26	12	2,868	10.5
State	1,279	66	322	60	3,373	89	12,673	1,383	990	2,494	2,596	1,684	276	140	27,425	
1931-32 Bay Area	247	9	--	3	534	1	1,512	146	5	184	50	80	52	10	2,833	10.7
State	1,129	33	150	58	3,582	39	13,038	1,042	970	2,448	2,179	1,250	552	120	26,590	
1932-33[1] State	614	16	555	--	1,883	--	3,983	478	579	1,147	1,324	725	274	52	11,630	
1933-34 Bay Area	216	5	--	--	386	1	807	111	3	174	51	83	59	16	1,912	7.1
State	986	18	8,197	--	2,589	54	6,958	790	682	2,321	2,200	1,290	625	187	26,897	
1934-35 Bay Area	244	4	--	--	397	2	745	88	4	226	60	92	53	15	1,930	6.9
State	1,115	14	8,550	--	2,662	60	6,423	628	877	3,009	2,606	1,436	562	172	20,116	
1935-36 Bay Area	347	9	--	--	568	2	859	79	4	271	54	128	50	12	2,383	7.1
State	1,583	31	10,454	--	3,809	56	7,402	565	880	3,609	2,336	1,994	526	141	33,396	
1936-37 Bay Area	544	7	--	--	875	--	1,520	118	4	278	75	170	81	23	3,695	7.3
State	2,483	24	16,959	--	5,873	--	13,103	840	772	3,706	3,246	2,650	851	259	50,766	
1937-38 Bay Area	293	11	--	--	752	3	763	87	5	280	77	147	63	11	2,492	5.6
State	1,340	40	19,857	--	5,049	125	6,578	622	999	3,731	3,341	2,292	662	125	44,761	
1938-39 Bay Area	597	8	--	--	803	1	1,125	138	--	218	24	159	31	18	3,122	5.3
State	1,865	42	36,216	--	4,067	95	7,326	784	--	3,050	2,536	2,227	459	128	58,795	
1939-40 Bay Area	563	6	38	--	1,039	2	1,879	131	3	321	68	190	80	8	4,328	5.2
State	1,908	52	51,528	--	4,922	185	11,487	933	983	3,601	3,710	2,474	829	164	82,776	
1940-41 Bay Area	480	4	165	--	1,584	5	2,043	204	10	467	56	229	139	7	5,393	5.9
State	1,710	26	51,426	--	7,265	171	14,535	1,368	1,491	5,276	3,285	2,776	1,485	156	90,970	
1941-42 Bay Area	389	6	136	--	1,273	2	1,355	148	3	350	196	226	156	8	4,248	4.6
State	1,617	41	48,966	--	8,880	245	14,096	1,195	1,458	6,051	4,359	3,239	1,504	224	91,875	
1942-43 Bay Area	310	7	82	--	640	6	622	76	1	221	76	163	175	17	2,396	3.1
State	778	33	55,597	--	4,473	74	6,365	459	683	2,523	2,766	1,923	598	106	76,378	
1943-44 Bay Area	597	17	20	--	799	7	555	72	1	216	91	85	65	3	2,528	3.3
State	2,098	56	46,486	--	6,554	48	9,898	615	663	3,519	3,980	2,780	794	125	77,616	
1944-45 Bay Area	625	8	3	--	612	7	638	73	4	298	136	207	65	23	2,699	3.8
State	2,325	55	44,888	--	6,567	65	7,176	524	719	3,182	3,590	2,063	433	84	71,671	

C-043398

C—043396

APPENDIX H-3—Continued

ANNUAL CATCH OF FURBEARING MAMMALS IN THE SAN FRANCISCO BAY AREA (1921-1956)

Season	Mink	River Otter	Muskrat	Beaver	Raccoon	Weasel	Skunk	Civet	Ringtail	Fox	Coyote	Bobcat	Opossum	Badger	Total	Percentage taken in SF Bay Area
1945-46..Bay Area	922	26	2	--	937	3	820	91	--	266	62	118	73	13	3,333	5.8
State	3,151	79	33,647	--	6,756	167	4,518	627	1,213	2,798	2,310	1,730	498	57	57,551	
1946-47..Bay Area	484	18	27	--	605	7	382	60	3	126	4	53	16	16	1,801	3.6
State	2,996	122	32,771	--	5,042	236	2,650	635	710	1,585	2,341	1,072	361	74	50,595	
1947-48..Bay Area	402	39	23	123	504	2	174	42	1	75	1	17	10	3	1,416	2.5
State	2,283	116	41,746	843	2,429	162	783	241	399	773	1,248	689	274	32	52,018	
1948-49..Bay Area	198	39	20	--	340	1	65	27	10	38	--	30	9	3	780	1.5
State	1,374	85	43,064	--	2,489	71	762	183	231	665	647	510	454	10	50,545	
1949-50..Bay Area	235	28	97	72	179	1	77	--	5	17	5	3	4	--	723	1.6
State	1,569	78	38,581	1,511	1,652	174	812	--	164	629	421	375	508	16	46,490	
1950-51..Bay Area	252	7	635	78	261	--	53	--	6	26	--	3	14	--	1,335	2.3
State	1,454	49	50,661	690	2,160	115	970	--	212	681	368	293	508	37	58,198	
1951-52..Bay Area	346	24	6,111	50	184	2	14	--	--	2	2	--	29	--	6,764	8.6
State	1,668	75	71,553	1,642	1,595	61	794	--	144	408	307	239	350	8	78,844	
1952-53..Bay Area	223	17	9,589	42	119	3	25	--	--	12	--	--	16	--	10,046	11.1
State	1,193	42	83,053	692	1,665	21	1,487	--	163	572	353	336	770	25	90,370	
1953-54..Bay Area	277	26	7,966	46	277	3	14	--	1	12	--	--	22	--	8,644	8.5
State	1,690	75	95,311	947	1,688	46	617	--	157	561	217	144	145	56	101,654	
1954-55..Bay Area	282	26	5,723	16	284	--	35	--	--	16	--	3	64	--	6,449	6.0
State	2,240	107	100,844	1,006	1,448	31	867	--	230	303	276	223	207	31	107,813	
1955-56..Bay Area	192	31	6,878	3	85	--	63	--	--	40	44	7	12	--	7,355	8.8
State	1,796	81	77,128	1,467	1,193	13	651	--	120	274	205	228	169	24	83,349	
TOTALS																
1938-56..Bay Area	7,374	337	37,515	430	10,525	52	9,939	1,062	48	2,721	765	1,493	980	119	73,360	5.6
(18 years) State	33,715	1,214	1,003,466	8,796	70,845	1,980	85,794	7,564	9,740	36,451	32,919	23,321	10,346	1,357	1,327,508	
Percentage[2]	21.9	27.8	3.7	4.9	14.9	2.6	11.6	14.0	0.5	7.5	2.3	6.4	9.5	8.7	5.5	
ANNUAL[3] Bay Area	410	19	2,084	24	585	3	552	59	3	151	43	83	54	7	4,076	
AVERAGE State	1,873	67	55,748	489	3,935	110	4,766	420	541	2,025	1,829	1,296	575	75	73,750	

[1] Bay Area excluded because data were available for only northern and eastern counties.
[2] Mean annual percentage of each species attributable to the Bay Area for the 18-year period 1938-56.
[3] Mean annual number of each species trapped for the State as a whole and within the Bay Area counties for the period 1938-56.

APPENDIX H-4

VALUE OF THE ANNUAL FUR CATCH

Season	Total State-wide Value [1]	Estimated Bay Area Value [2]	Season	Total State-wide Value [1]	Estimated Bay Area Value [2]
1921-22	$35,011	$3,816	1942-43	$156,218	$4,843
1924-25	181,115	18,112	1943-44	222,002	7,326
1925-26	257,745	25,001	1944-45	165,591	6,292
1926-27	304,285	29,516	1945-46	171,800	9,964
1927-28	468,960	44,082	1946-47	102,000	3,672
1930-31	49,128	5,158	1947-48	149,700	3,743
1931-32	32,710	3,500	1948-49	84,927	1,274
1932-33 [3]	10,572	——	1949-50	67,332	1,077
1933-34	28,551	2,370	1950-51	116,341	2,676
1934-35	27,034	2,163	1951-52	113,901	9,795
1935-36	40,923	3,397	1952-53	104,500	11,600
1936-37	78,776	6,696	1953-54	92,750	7,884
1937-38	44,433	3,244	1954-55	144,600	8,676
1938-39	54,779	3,670	1955-56	100,168	8,815
1939-40	99,818	5,091			
1940-41	153,100	9,033	TOTALS	$3,812,102	$259,386
1941-42	153,332	6,900	AVERAGES	$122,971	$8,646

[1] Values obtained from Department of Fish and Game Licensed Fur Trapper Reports.
[2] Unweighted values based on percentage of state-wide catch taken in the San Francisco Bay Area.
[3] Reports for 1932-33 season are for the northern and eastern counties only.

APPENDIX H-5

COMPARISON OF BAY AREA AND STATE-WIDE DEER KILL (1927-1960)

Year	Alameda	Contra Costa	Marin	Napa	San Mateo	Santa Clara	Solano	Sonoma	Bay Area Totals	State-wide Totals	Percentage [2]
1927	220	5	367	442	77	397	45	751	2,304	19,507	11.8
1928	263	6	444	569	89	536	52	753	2,712	21,515	12.6
1929	275	14	394	523	102	577	54	732	2,671	21,222	12.6
1930	252	6	403	536	100	650	58	865	2,870	24,132	11.9
1931	248	11	449	488	103	697	45	903	2,944	25,805	11.4
1932	164	8	376	304	85	415	31	709	2,092	18,380	11.4
1933	148	9	301	285	105	393	19	748	2,208	17,686	12.5
1934	204	19	341	288	133	421	20	554	1,980	20,805	9.5
1935	268	27	328	278	99	463	23	445	1,931	21,955	8.8
1936	266	32	411	415	106	595	32	536	2,393	25,008	9.6
1937	398	30	482	544	153	754	39	744	3,144	32,241	9.8
1938	491	40	534	795	135	744	63	948	3,750	35,045	10.7
1939	623	61	649	927	148	1,017	87	1,094	4,606	43,250	10.6
1940	658	66	581	907	149	993	95	1,242	4,691	46,317	10.1
1941	502	74	615	962	180	807	100	1,005	4,245	43,493	9.8
1942	233	51	403	557	72	456	76	489	2,337	25,902	9.0
1943 [1]	----	---	----	----	21	49	----	----	70	25,216	0.03
1944	368	88	579	932	101	463	159	685	3,375	36,940	9.1
1945	295	67	438	809	87	404	120	787	3,007	38,129	7.9
1946	370	115	520	887	66	437	91	1,102	3,588	47,419	7.6
1947	354	128	488	899	114	528	83	1,151	3,745	47,178	7.9
1948	441	141	634	1,027	119	559	95	1,505	4,521	67,789	9.5
1949	356	117	597	1,020	151	764	88	1,269	4,362	52,082	8.4
1950	386	130	554	952	144	763	102	1,138	4,166	47,128	8.8
1951	580	178	767	983	135	939	78	1,447	5,107	64,619	7.9
1952	627	200	832	1,220	167	1,051	126	1,553	5,776	50,667	11.4
1953	763	232	885	1,161	139	1,172	113	1,679	6,144	58,992	10.4
1954	911	311	1,048	1,386	140	1,695	139	1,979	7,609	75,602	10.1
1955	639	175	901	1,329	157	1,434	143	1,586	6,364	71,126	8.9
1956	538	187	707	1,144	134	1,239	147	1,303	5,399	79,371	6.8
1957	451	176	548	1,045	180	1,027	130	1,267	4,824	65,214	7.4
1958	655	211	613	994	198	1,177	155	1,172	5,175	58,669	8.8
1959	489	143	407	997	223	993	139	1,016	4,407	73,483	6.0
1960	849	266	659	1,306	286	1,481	163	1,483	6,493	75,584	8.6
33 Year Means	433	101	553	815	132	789	88	1,505	3,967	43,402	9.1

[1] Military Closures Prohibited Hunting Over Much of the Bay Area in 1943 (also excluded in computing mean kill).
[2] Bay Area kill as percentage of total State kill.

APPENDIX I

ECONOMICS

APPENDIX I-1

COMBINED CALIFORNIA ANGLING LICENSE SALES, 1914-1959

Year	Number Licenses	Revenue	Year	Number Licenses	Revenue
1914	81,965	$84,417.	1937	326,745	$663,144.
1915	87,262	89,620.	1938	348,227	705,611.
1916	111,994	115,518.	1939	336,452	746,061.
1917	No Record	125,572.	1940	390,342	791,472.
1918	No Record	123,080.	1941	460,715	933,586.
1919	No Record	146,724.	1942	433,431	876,003.
1920	No Record	163,183.	1943	447,352	899,782.
1921	176,873	183,319.	1944	436,940	883,841.
1922	183,116	189,738.	1945	557,536	1,120,661.50
1923	225,171	232,995.	1946	768,816	1,553,706.50
1924	202,690	210,988.	1947	884,747	1,793,313.50
1925	222,983	232,501.	1948 [2]	960,146	2,932,024.
1926	246,167	256,629.	1949	992,519	3,024,816.50
1927	262,886	273,202.	1950	983,019	2,993,698.
1928 [1]	217,788	445,764.	1951	1,015,469	3,083,976.
1929	225,774	471,826.	1952	1,098,597	3,298,308.
1930	248,319	508,875.	1953	1,187,328	3,563,452.
1931	242,857	497,317.	1954	1,240,060	3,716,006.
1932	212,662	436,373.	1955	1,303,096	3,859,712.
1933	175,936	358,568.	1956	1,380,864	4,072,383.
1934	211,190	430,128.50	1957 [3]	1,433,859	4,207,018.
1935	224,661	457,373.50	1958 [4]	1,383,489	4,022,912.
1936	300,611	608,515.50	1959 [4]	1,465,066	4,206,900.

[1] Angling licenses increased from one to two dollars.
[2] Angling licenses increased from two to three dollars.
[3] Angling licenses increased from three to four dollars for inland fishing and five dollars to fish for trout. Ocean fishing only required three-dollar license.
[4] License sales and revenue for 1958 and 1959 incomplete.

APPENDIX I-2

COMBINED CALIFORNIA HUNTING LICENSE SALES, 1907-1960

Year	Number Licenses	Revenue	Year	Number Licenses	Revenue
1907-08	113,975	$118,427.	1926-27	253,532	$279,701.
1908-09	111,911	114,950.	1927-28 [1]	257,738	285,362.
1909-10	124,421	128,450.	1928 [2]	228,696	464,145.
1910-11	138,669	143,265.	1929	241,709	488,638.
1911-12	141,777	146,181.	1930	231,970	464,157.
1912-13	159,762	165,984.	1931	214,577	424,188.
1913-14	159,164	164,111.	1932	154,031	453,159.15
1914-15	161,402	166,307.	1933-34	171,139	334,746.50
1915-16	155,522	159,991.	1934-35	174,667	338,538.50
1916-17	166,372	170,806.	1935-36	190,257	367,880.
1917-18	No Record	177,065.	1936-37	225,448	434,255.
1918-19	No Record	178,937.	1937-38	248,365	498,582.50
1919-20	No Record	221,433.	1938-39	252,117	487,763.50
1920-21	225,454	240,353.	1939-40	270,095	528,952.
1921-22	222,791	236,891.	1940-41	291,507	565,395.
1922-23	226,381	239,149.	1941-42	331,878	643,700.
1923-24	246,299	260,846.	1942-43	268,128	522,985.
1924-25	226,421	245,591.	1943-44 [3]	284,370	557,254.
1925-26	231,305	252,017.	1944-45	318,910	626,635.

[1] Purchase of tags first required for deer hunting.
[2] Fee increased from $1.00 to $2.00.
[3] Purchase of tags for pheasant hunting required 1943 and 1944.

C—043398

C-043400

APPENDIX I-2—Continued

COMBINED CALIFORNIA HUNTING LICENSE SALES, 1907-1960

Year	Number Licenses	Revenue	Year	Number Licenses	Revenue
1945-46	393,282	$780.106.50	1953-54	613,928	$1,764,986.
1946-47	487,307	965,916.	1954-55	620,587	1,810,630.
1947-48	507,552	1,017,681.	1955-56	634,131	1,849,325.
1948-49 [4]	504,173	1,482,809.	1956-57 [5]	668,165	1,943,855.
1949-50	496,735	1,446,087.	1957-58	647,252	
1950-51	491,424	1,430,800.	1958-59 [6]	608,000	
1951-52	534,684	1,553,095.	1959-60 [6]	613,280	
1952-53	588,764	1,704,432.			

[4] Fee increased from $2.00 to $3.00 and purchase of tags for pheasant hunting required.
[5] Legislative act increased hunting license from $3.00 to $4.00 effective 1957-58 season.
[6] Not final figures.

APPENDIX I-3

NUMBER OF TRAPPING LICENSES SOLD IN CALIFORNIA, 1917-1960

Season	Number Licenses	Revenue	Season	Number Licenses	Revenue
1917-18	2,300	$2,321.	1939-40	2,038	$2,054.
1918-19	2,590	2,614.	1940-41	1,929	1,956.
1919-20	4,940	4,971.	1941-42	2,149	2,168.
1920-21	3,359	3,392.	1942-43	1,163	1,179.
1921-22	3,036	3,094.	1943-44	1,539	1,555.
1922-23	3,072	3,136.	1944-45	1,612	1,631.
1923-24	2,563	2,597.	1945-46	1,774	1,796.
1924-25	2,927	2,984.	1946-47	1,978	1,992.
1925-26	3,430	3,598.	1947-48	1,582	1,594.
1926-27	3,790	3,872.	1948-49	1,264	1,272.
1927-28	5,243	5,347.	1949-50	1,169	1,176.
1928-29	6,481	6,581.	1950-51	1,053	1,056.
1929-30	4,378	4,438.	1951-52	1,036	1,042.
1930-31	2,714	2,860.	1952-53	897	901.
1931-32	2,814	2,858.	1953-54	950	957.
1932-33	1,644	1,660.	1954-55	880	882.
1933-34	1,404	1,413.	1955-56	912	916.
1934-35	1,670	1,681.	1956-57	858	860.
1935-36	1,523	1,532.	1957-58	825	827.
1936-37	2,079	2,093.	1958-59	657	659.
1937-38	2,473	2,502.	1959-60	583	585.
1938-39	2,045	2,059.			

APPENDIX I-4

CALIFORNIA COMMERCIAL FISHING LICENSE SALES

Year	Revenue	Year	Revenue
1909-10	$	1935-36	$60,070.
1910-11	23,595.	1936-37	69,860.
1911-12	23,545.	1937-38	78,210.
1912-13	23,860.	1938-39	78,110.
1913-14	26,980.	1939-40	87,170.
1914-15	39,210.	1940-41	90,920.
1915-16	38,320.	1941-42	93,500.
1916-17	36,450.	1942-43	91,720.
1917-18	42,110.	1943-44	118,110.
1918-19	45,220.	1944-45	108,490.
1919-20	50,870.	1945-46	117,970.
1920-21	52,690.	1946-47	124,060.
1921-22	44,620.	1947-48	128,990.
1922-23	44,720.	1948-49	142,520.
1923-24	41,230.	1949-50	149,670.
1924-25	46,710.	1950-51	146,200.
1925-26	50,720.	1951-52	131,950.
1926-27	50,780.	1952-53	115,700.
1927-28	52,060.	1953-54	113,640.
1928-29	53,400.	1954-55	116,460.
1929-30	60,140.	1955-56	102,820.
1930-31	61,790.	1956-57	98,120.
1931-32	56,510.	1957-58	95,160.
1932-33	49,550.	1958-59	128,520.
1933-34	49,910.	1959-60	118,995.
1934-35	53,230.		

APPENDIX I-5

REPORTED FISHING EXPENDITURES FROM 1955 ECONOMIC SURVEY [1]

	FRESHWATER ANGLING			SALTWATER ANGLING		
Categories on Questionnaire	Average per Fisherman	Percentage	Total Spent	Average per Fisherman	Percentage	Total Spent
Transportation, Auto & Misc.— 7½ cents per mile; bus, train, bridge tolls	$63.19	29.0	$65,796,631	$37.23	26.3	$23,837,636
Meals—restaurant meals, candy, ice cream, snacks	51.64	23.7	53,771,729	28.73	20.3	18,399,392
General Purpose Equipment—tents, sleeping bags, etc.	35.30	16.2	36,755,359	15.85	11.2	10,151,389
Fishing Equipment—rods, reels, tackle	23.10	10.6	24,049,803	16.28	11.5	10,423,301
Lodgings—motels, cabins, hotels	10.89	5.0	11,344,246	5.38	3.8	3,444,221
Rentals—boats, motors, camping and fishing gear	10.24	4.7	10,663,591	5.94	4.2	3,806,770
Bait	9.15	4.2	9,529,167	6.23	4.4	3,988,045
Gas and oil for boats and motors	4.36	2.0	4,537,698	4.53	3.2	2,900,396
License	2.40	1.1	2,495,734	1.56	1.1	997,011
Repair and Maintenance— cost of repair fishing equipment	1.96	0.9	2,041,964	1.98	1.4	1,268,923
Extra Vehicle—cost allotted on the basis of use	1.96	0.9	2,041,964	.57	0.4	362,549
Party and charter boat fees	1.53	0.7	1,588,194	15.99	11.3	10,242,026
Publications—books and magazines	1.30	0.6	1,361,309	.85	0.6	543,824
Club Dues—initiation fees, donations	.87	0.4	907,539	.42	0.3	271,912
Sub-total						$90,637,403
3-Day Special Licenses						1,589,630
Totals	$217.89		$226,884,935	$141.54		$92,227,033

	FRESHWATER ANGLING	SALTWATER ANGLING
Average number of days fished	15	11
Average daily expenditures	$14.27	$12.51

[1] After Mahoney (1960).

APPENDIX I-6

REPORTED HUNTING EXPENDITURES FROM 1955 ECONOMIC SURVEY

	Average Per Hunter	Percentage	Total Spent
Hunting Equipment—guns, ammunition, bows, arrows, etc.	$70.01	26.4	$44,309,000
Automobile Expenses—7½ cents per mile driven	52.64	19.8	33,312,500
Food and Beverages—meals, drinks, candy, etc.	47.07	17.7	29,790,400
Camping Equipment—tents, sleeping bags, stoves, etc.	18.24	6.9	11,544,000
Dog Expenses—purchase, food, Vet. and training fees	14.74	5.6	9,328,900
Clothing—hiking boots, hunting jackets, etc.	8.97	3.4	5,677,100
Waterfowl Hunting Gear—decoys, boats, motors, etc.	8.84	3.3	5,594,800
Lodging—hotels, motels, cabin rentals	7.65	2.9	4,841,700
Private Hunting Clubs—dues, shares, assessments	6.82	2.6	4,316,400
Transportation (Not auto expense)—train, bus, plane, bridge tolls	6.16	2.3	3,898,600
Optical Equipment—binoculars, spotting scopes	6.12	2.3	3,810,000
Licenses—hunting, deer tags, pheasant tags, duck stamps	4.59	1.7	2,906,032[1]
Game Storage—butcher service, freeze locker fees	$3.53	1.3	$2,234,100
Publications—books and magazines on hunting subjects	2.72	1.0	1,721,500
Packing and Guide Fees—pack-trips, horse rental and feed	2.66	1.0	1,683,500
Club Dues—initiation fees, dues, donations	1.64	0.6	1,037,900
Commercial Hunting Club Fees—hunting fees	1.35	0.5	854,400
Miscellaneous—not under other categories	1.10	0.4	696,200
Hunting fees, community/organizational hunting area fees	.42	0.2	265,800
Private land trespass fees	.38	0.1	240,500
Total	$265.55	100.0	$168,063,332

Average number of miles driven per hunter per annum	702
Average number of hunting days	14
Average daily expenditure	$18.97
Total number hunters	632,895

[1] Actual figures as supplied by the License Section of the California Department of Fish and Game; duck stamp figure as reported by the U. S. Fish and Wildlife Service.

APPENDIX I-7

CAPITAL OUTLAY AND MANAGEMENT COSTS RELATED TO THE FISH AND WILDLIFE RESOURCES OF THE BAY AREA

CAPITAL OUTLAY PROJECTS

Fish Ladders

Name	Location	Stage of Construction	Estimated or Actual Original Cost
Clear Creek	Clear Creek, Shasta County	Completed	$93,000
Wards' Dam	Mill Creek, Tehama County	Completed	1,000
Clough Dam	Mill Creek, Tehama County	Completed	8,000
Upper Mill Creek	Mill Creek, Tehama County	Completed	1,000
North Stanford Vina Diversion	Deer Creek, Tehama County	Completed	2,000
South Stanford Vina Diversion	Deer Creek, Tehama County	Completed	13,000
Lower Deer Creek Falls	Deer Creek, Tehama County	Completed	10,000
Upper Deer Creek Falls	Deer Creek, Tehama County	Completed	60,000
Wildoat Diversion	Battle Creek (N.F.) Shasta County	Completed	—
Eagle Creek	Battle Creek (N.F.) Shasta County	Completed	—
Inskip Canal	Battle Creek (S.F.) Shasta County	Completed	—
Coleman Canal, Inskip Powerhouse	Battle Creek (S.F.) Shasta County	Completed	—
South Powerhouse Inskip Canal	Battle Creek (S.F.) Shasta County	Completed	—
Woodbridge Dam	Mokelumne River, San Joaquin County	Completed	100,000
Granlee Dam	Cosumnes River, Sacramento County	Completed	6,000
Daguerre Point Dam	Yuba River, Yolo County	Completed	56,000
Sutter Butte Dam	Feather River, Butte County	Completed	55,000
Intake Dam	Feather River (N.F.) Butte County	Completed	5,000
Enterprise Dam	Feather River (N.F.) Butte County	Completed	5,000
Howard Slough Dam	Butte Creek, Butte County	Completed	20,000
McGowan Dam	Butte Creek, Butte County	Completed	15,000
Adam's Dam	Butte Creek, Butte County	Completed	15,000
Western Canal Dam	Butte Creek, Butte County	Completed	20,000
Gorrill Dam	Butte Creek, Butte County	Completed	5,000
Lower Durham Mutual Dam	Butte Creek, Butte County	Completed	3,000
Durham Mutual	Butte Creek, Butte County	Completed	8,000

APPENDIX I-7—Continued

CAPITAL OUTLAY AND MANAGEMENT COSTS RELATED TO THE FISH AND WILDLIFE RESOURCES OF THE BAY AREA — Continued

CAPITAL OUTLAY PROJECTS—Continued

Fish Ladders (Cont.)

Name	Location	Stage of Construction	Estimated or Actual Original Cost
Parrott-Phelan Dam	Butte Creek, Butte County	Completed	10,000
Iron Canyon Barrier	Big Chico Creek, Butte County	Completed	19,750
Antelope Creek Dam	Antelope Creek, Tehama County	Proposed	—
Keswick Dam Fish Trap	Sacramento River, near Redding, Shasta County	Completed	908,449
Mendota Dam	Firebaugh, Fresno County	Comlpeted	1,000
Salt Slough	Salt Slough, Merced County	Completed	3,000
Temple Slough Dam	Temple Slough, Madera County	Completed	1,000
Dennet Dam	Tuolumne River, Stanislaus County	Completed	1,000
Crocker-Huffman Dam	Merced River, Merced County	Completed	500
Merced Falls Dam	Merced River, Merced County	Completed	1,000
Shaffer Dam	Merced River, Merced County	Completed	100
Vertical Baffle Fishway [1]	Ryde Barrier, Sacramento, Solano County	Proposed	70,000
Vertical Baffle Fishway [1]	Cross Delta Canal, Sacramento County	Proposed	100,000
Sub-total for Completed Ladders (at least 36)			$1,446,799
Sub-total for Proposed Ladders (3)			170,000
Total for Ladders			$1,616,799

Fish Screens

North Stanford Vina	Deer Creek, Tehama County	Completed	$6,700
South Stanford Vina	Deer Creek, Tehama County	Completed	3,500
Ward Dam	Mill Creek, Tehama County	Completed	6,050
Clough Dam Diversion	Mill Creek, Tehama County	Completed	2,750
Upper Mill Creek Dam	Mill Creek, Tehama County	Completed	6,250
Gover Diversion	Battle Creek, Shasta County	Completed	20,300
Coleman Canal, Inskip, P.G.&E. Powerhouse	Battle Creek (S.F.) Shasta County	Completed	—
South Battle Creek Canal, P.G.&E. Powerhouse	Battle Creek (S.F.) Shasta County	Completed	—
Battle Creek	Battle Creek (S.F.) Shasta County	Completed	9,408
Glenn-Colusa Bar Screen	Sacramento River, Glenn County	Completed	25,000
Parrott-Phelan	Butte Creek, Butte County	Completed	10,000
Granlee Dam	Cosumnes River, Sacramento County	Completed	2,500
North San Joaquin Diversion	Mokelumne River	Completed	3,000
Merced Diversion	Merced River, Merced County	Completed	2,496
North Bay Aqueduct [1]	Lindsay Slough	Proposed	500,000
Cross Delta Canal [1]	Cross Delta Canal, Sacramento County	Proposed	900,000
Contra Costa Canal	Contra Costa Canal, Contra Costa County	Completed	25,000
Small Diversion Allocations	Mostly Sacramento River	Completed	15,000
Sub-total for Completed Screens (16)			$137,954
Sub-total for Proposed Screens (2)			1,400,000
Total for Screens			$1,537,954

Installations

Name and Kind			
Coleman Fish Cultural Station	Anderson, Shasta County	Completed	$2,300,000
Mill Creek Experimental Station	Los Molinos, Tehama County	Completed	20,000
Nimbus Hatchery	American River, Sacramento County	Completed	1,217,000
Tracy Fish Salvage Facility	Old River, Contra Costa County	Completed	3,220,000
Delta Fisheries Base and Equipment	Antioch, Contra Costa County	Completed	100,000
Feather River Fish Hatchery	Oroville, Butte County	Proposed	525,000
Elk Grove Screen Shop	Elk Grove, Sacramento County	Completed	25,000
Research Boat (Striper)	Antioch, Contra Costa County	—	7,000
Feather River, Project, Fish Salvage Facility	Contra Costa County	Proposed	3,000,000
Sub-total for Completed Installations (6)			$6,889,000
Sub-total for Proposed Installations (2)			3,525,000
Total for Installations			$10,414,000

[1] Proposed fish facilities associated with the salinity control barrier investigation.

APPENDIX I-7—Continued

OTHER CAPITAL OUTLAY EXPENSES RELATED TO FISH AND WILDLIFE IN THE SAN FRANCISCO BAY AREA

Name and Kind of Facility	Location	Cost
Patrol Boats, Skiffs, Motors, etc.	San Francisco Headquarters	$500,000
Property and Equipment	Bay Counties	250,000
Grizzly Island Waterfowl Management Area	Grizzly Island, Solano County	1,112,940
Montezuma Slough Bridge	Grizzly Island, Solano County	139,500
Quail Habitat Improvement	Bay Counties	4,698
	Total	$2,007,138

CAPITAL OUTLAY PROJECTS FOR ANGLING ACCESS

Name and Kind of Facility	Location	Stage of Development	Cost of Development
Nicks Cove, coastal access	Marin County	Completed	$5,500
Petaluma River, angling access	Marin County	Proposed	15,200
Miller Park, coastal access	Tomales Bay, Marin County	Completed	46,737
Alameda City, Bay access	Alameda City, Alameda County	Completed	24,832
Berkeley Fishing Pier	Berkeley, Alameda County	Completed	168,500
Grizzly Island, angling access	Grizzly Island, Solano County	Completed	13,481
Suisun City, angling access	Suisun City, Solano County	Completed	18,254
Vallejo, angling access	Vallejo, Solano County	Completed	63,514
Anderson, angling access	Anderson, Shasta County	Completed	18,411
Redding, angling access	Redding, Shasta County	Completed	423
Ball's Ferry, angling access	Ball's Ferry, Shasta County	Completed	19,281
Bend Bridge, angling access	Bend Bridge, Tehama County	Completed	21,462
Red Bluff, angling access	Red Bluff, Tehama County	Completed	23,234
Tehama City, angling access	Tehama City, Tehama County	Proposed	21,500
Tehama County Park, angling access	Tehama County	Completed	6,825
Woodson Bridge, angling access	Tehama County	Completed	12,200
Boyds Pump, angling access	Sacramento River, Sutter County	Completed	22,500
Tisdale Weir, angling access	Sacramento River, Sutter County	Proposed	2,550
Yuba City, angling access	Feather River, Sutter County	Completed	20,798
Jorgeson, angling access	Sacramento River, Glenn County	Proposed	13,000
Princeton, angling access	Sacramento River, Glenn County	Proposed	1,250
Clarksburg, angling access	Sacramento River, Yolo County	Under Construction	25,000
Knights Landing, angling access	Sacramento River, Yolo County	Completed	20,360
Chico Creek, angling access	Sacramento River, Butte County	Proposed	14,500
Star Bend, angling access	Yuba County	Proposed	25,620
Louis Park, angling access	San Joaquin River, San Joaquin County	Under Construction	24,700
San Joaquin River, angling access	Near Friant, Fresno County	Under Construction	79,292
	Sub-total for 17 access projects completed		$528,812
	Sub-total for 3 access projects under construction		106,492
	Sub-total for 7 access projects proposed		93,620
	Total angling access projects		$728,924

OPERATIONAL AND MAINTENANCE EXPENSES

Expenses Directly Related to Anadromous Fisheries

Item	Type of Expense	Cost Per Annum
Coleman Fish Cultural Station	Operational and Maintenance	$150,000
Mill Creek Experimental Station	Operational and Maintenance	10,000
Keswick Fish Trap	Maintenance	10,000
Annual Salmon Inventories	Management	22,000
Nimbus Hatchery	Operational and Maintenance	120,000
Elk Grove Screen Shop	Operational and Maintenance	31,000
Salmon and Steelhead Problems	Management	10,000
Tracy Fish Collection Facility	Operational and Maintenance	110,000
Delta Field Base and Vessel Striper	Operational and Maintenance	10,000
Inspection of Fishways and Screens	Management	2,000
Striped Bass and Sturgeon Investigation	Research	20,000
Sacramento River Salmon and Steelhead Investigation	Research	45,000
	Total Operational and Maintenance expenses directly related to anadromous fisheries	$540,000 per annum

APPENDIX I-7—Continued

MANAGEMENT EXPENSES PARTLY DEVOTED TO THE ANADROMOUS FISHERIES BUT COMPLETELY WITHIN THE BAY AREA

Item	Type of Expense	Cost Per Annum
Wildlife Protection (Patrol)	Enforcement (Salaries and Expenses)	$350,000
Patrol Boats	Maintenance	10,000
Administration	Salaries (except patrol) Expenses and Services	139,000
Miscellaneous Fisheries Investigation	Research	10,000
Trout Stocking	Management	75,000
Total Operational and Maintenance completely within Bay Area		$584,000 per annum
Grand total operational and maintenance per annum		$1,124,000

APPENDIX J

A LIST OF THE FEDERAL, STATE AND MUNICIPAL FISH AND WILDLIFE REFUGES OF THE SAN FRANCISCO BAY AREA

Refuge	County	Administrative Agency	Type of Refuge
Mount Tamalpais Refuge	Marin	State Dept. Fish & Game	All wildlife
Fish and Game District 3F (Mt. Diablo)	Contra Costa	State Dept. Fish & Game	All wildlife
San Francisco Fish and Game Refuge	San Mateo	State Dept. Fish & Game	All wildlife
San Leandro Waterfowl Refuge	Alameda	State Dept. Fish & Game	Waterfowl
Fish and Game District 3G (Stanford University)	San Mateo & Santa Clara	State Dept. Fish & Game	All wildlife
Bolinas Quail Refuge	Marin	State Dept. Fish & Game	Quail
Suisun Waterfowl Refuge	Solano	State Dept. Fish & Game	Waterfowl
Grizzly Island Waterfowl Management Area	Solano	State Dept. Fish & Game	Waterfowl
Lake Merritt Waterfowl Refuge	Alameda	City of Oakland	Waterfowl
Golden Gate Park	San Francisco	City & County of S. F.	All wildlife
Farallon Islands	San Francisco	U. S. Coast Guard	All wildlife
Ano Nuevo Island	San Mateo	U. S. Coast Guard	All wildlife
South San Francisco Bay Refuge—Anderson	Santa Clara	Private Conservation	Shorebirds and waterfowl
Greco Island	San Mateo	Private Conservation	Shorebirds and waterfowl
Newark Slough—Dumbarton Point	Alameda	Private Conservation	Shorebirds and waterfowl
Richardson Bay	Marin	Private Conservation	Shorebirds and waterfowl

△41686 6-61 2,500

printed in CALIFORNIA STATE PRINTING OFFICE