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CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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A PRELIMINARY REPORT ON THE FISHERY RESOURCES OF CALIFORNIA IN RELATION TO THE CENTRAL VALLEY PROJECT [1]

By RICHARD VAN CLEVE,
Chief Bureau of Marine Fisheries,
California Division of Fish and Game

Introduction

The difficulties encountered on the Pacific Coast in attempting to maintain supplies of anadromous fishes in connection with extensive programs of dam construction have been brought into sharp focus in recent years.

The first project that presented a major problem of fishery maintenance was Bonneville Dam on the lower Columbia River. Some $7,000,000 of the cost of the dam was charged to fishways and other devices to protect the valuable Columbia River salmon and steelhead runs. The devices built at Bonneville Dam for passage of adult salmon have worked because of the low height of the dam; but there still remains some doubt as to the success with which young, seaward-migrant salmon and steelhead pass this dam on their way to the ocean.

The second major fishery protection problem encountered was Grand Coulee Dam on the upper Columbia River. Over $3,000,000 have been expended for investigations and for construction of hatcheries, tank trucks, traps, and other devices needed to preserve the runs blocked by this dam. The success of the effort is still to be demonstrated.

The third major problem of this kind was caused by the construction of Shasta Dam near Redding, California, on the upper Sacramento River. Close to $2,000,000 have been expended on the fish protection program there to date.

Table Mountain Dam is now being seriously considered for construction on the Sacramento River near Red Bluff, California, some 40 miles below Shasta Dam. If this dam is built, it will block all salmon and steelhead at its site, and completely nullify the entire protection program made necessary by Shasta Dam. It will introduce additional hazards that will make the maintenance of the salmon runs affected difficult and uncertain.

The proposed postwar construction of a series of dams on tributaries of the Sacramento and San Joaquin rivers will affect the valuable fish resources of the Central Valley of California to a marked degree. Some, like Table Mountain Dam, will cause serious harm if they are built. Others, like the Folsom Dam on the American River, might benefit salmon and steelhead runs if an adequate minimum flow can be maintained below them, providing that all other limiting factors are eliminated to permit survival of greater numbers of adults and young.

The salmon that spawn in the Sacramento-San Joaquin system represent the escapement from both the ocean troll fishery and the river gill-

[1] Submitted for publication, December, 1944.

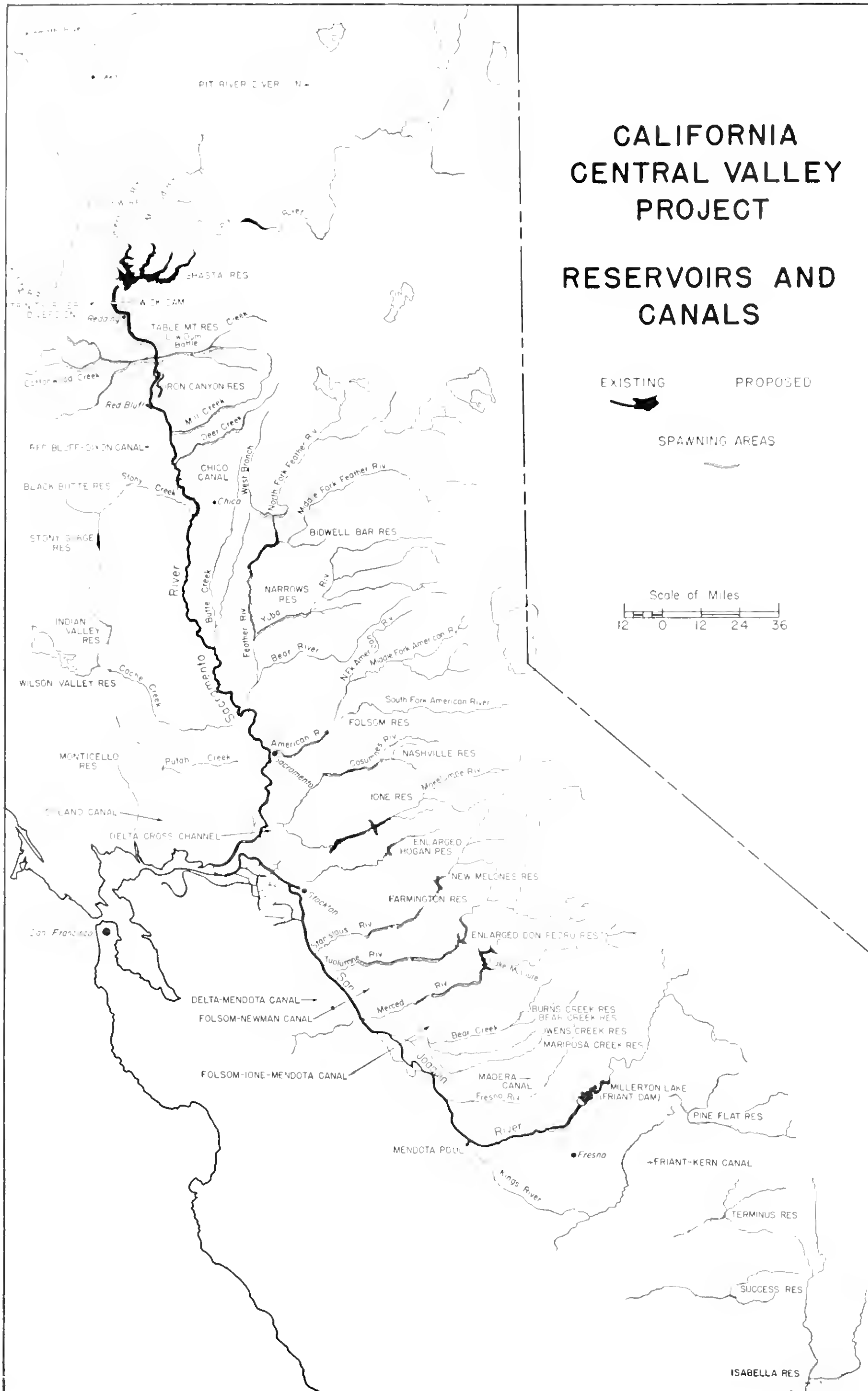

Fig. 13. Map of Central Valleys Project

net fishery, as well as from the marine and fresh-water sport fisheries. The salmon that survive to maturity seek the gravel beds of Central Valley streams for spawning, after which they die. If dam construction proceeds without consideration for such a self-perpetuating, natural resource, the State and Nation as a whole will suffer a heavy and irreplaceable loss. The annual value of the salmon originating in Central Valley streams and caught by commercial and sport fishermen is estimated to be approximately $1,300,000. That proportion of the runs that originates above Table Mountain Dam is estimated to be worth approximately $520,000. It is, therefore, of paramount importance that the effect of the dams on fishery resources be considered on the same basis as irrigation, power, flood control, and salinity control in studying the economy of the basin-wide, multiple-use projects.

In addition to salmon and steelhead, shad and striped bass may be seriously affected by the proposed dams and the salt-water barrier. Catfish, large- and small-mouthed bass, and other fresh-water species will also be affected. The striped bass alone supports a large sport fishery, and was the principal species sought by over 200,000 anglers who fished in the Central Valley area in 1941.

Difficult and complex fisheries problems have been created by Shasta and Friant dams, and others will develop as construction of other dams and diversion canals progresses. It is essential that a comprehensive program of study be undertaken with respect to the fisheries concerned so that a minimum of harm may result, and so that these resources may not be destroyed. In the short time available for the preparation of this report, it has not been possible to cover the subject in adequate detail, either as to the studies required or as to specific problems. However, a summary of data already available is presented along with an outline of studies that should be undertaken. Tables are included to present the information in summarized form. One map is included that shows in broad detail the major dams and water transfer canals proposed, with the spawning areas affected.

The present paper embodies the general recommendations of the California Division of Fish and Game concerning protection of fish in the Central Valleys from the effects of the dams and diversions proposed for this area.

The assistance of the following people is gratefully acknowledged: Dr. Willis H. Rich, Dr. Paul R. Needham, Dr. James W. Moffett, and Mr. Harry A. Hanson of the U. S. Fish and Wildlife Service; and Mr. A. C. Taft of the California Division of Fish and Game, who have contributed their knowledge of salmon in considering the effects of the proposed structures, including Table Mountain Dam, upon the fish inhabiting this area. The staff of the U. S. Fish and Wildlife Service has supplied data concerning the salmon maintenance program below Shasta Dam. Donald H. Fry, Jr. of the Bureau of Marine Fisheries assisted with compilation of the tables, and in working out the evaluation of the fishery.

General Principles of Fishery Protection

Anadromous fishes are delicately balanced organisms which have become adapted to a complete dependence upon fresh water streams for their period of reproduction and upon the sea for their growth to maturity. Completion of their life cycle requires access to both types of environment. Any program for their protection from artificial hazards must recognize the need of providing conditions for these fish that are as near natural as possible.

Judging from past records of the success of hatcheries, it is neither economically feasible nor biologically sound to attempt to substitute artificial propagation for natural propagation where suitable conditions for natural propagation can be maintained. However, studies should be instituted to determine the efficiency of hatchery methods, and to set forth the exact role each should play in the future of salmon protection in the Central Valley.

Table 1 shows the months during which salmon are passing through the various stages of their fresh-water cycle. They require water during all these stages, although the amount may vary. The general principles set forth below involve those requirements that will allow the fish to move upstream, to remain there while their eggs ripen, and to spawn. They will then permit proper development of the eggs, and growth and downstream migration of the young.

Some dams built in the past have not followed all of these requirements. The effect of these dams has been largely responsible for the development of laws that now control such works. The potential threat to the continued existence of salmon runs that results from construction of dams and water diversions has been recognized only recently. The effect of water development upon fish life has been cumulative; and the realization of proposed postwar projects will bring the problem to the acute stage. Development of methods for overcoming the adverse effect of dams and diversions on anadromous fishes has but recently been undertaken, and results to date give no guarantee of success.

Table 1. Salmon Life History In Relation To Their Activities In Different Months of the Year

	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Spring run	Upstream run				xx	xx	xx						
	Holding period in stream							xx	xx	x			
	Spawning									x	xx	x	
Fall run	Upstream run									xx	xx	xx	xx
	Spawning	x									xx	xx	xx
Young	Development of eggs	xx	xx	x						x	xx	xx	xx
	Downstream migration	xx	xx	xx	xx	xx	x						x

In general, on every stream where salmon and steelhead runs exist, the following provisions are recommended:

1. Dams should be located as far upstream as feasible to avoid destruction of spawning grounds. The transfer of runs to other streams is a poor substitute for the maintenance of original spawning areas.

2. Adequate flows must be maintained below dams:
   a) To permit the upstream migration of adults
   b) to provide water for maintenance of spring-run fish in good condition over the summer
   c) to provide water during spawning, hatching, and growing periods
   d) to permit the young salmon to perform their seaward migration

It is essential in this regard that there be no artificial reduction in the flow from any dam from the beginnig of the spawning period to the end of the period of emergence of young fish from the gravel. Variation from high to low flows will cause the loss of large numbers of eggs since spawning is usually concentrated along the stream margins which are dried up with any drop in flow. At times spawning fish may be trapped by a sudden reduction in flow.

3. The adults must have free access to the spawning grounds remaining available below high dams. Streams should not be blocked by canal crossings. These crossings should be accomplished by siphons or bridges wherever they are located below or within the limits of a salmon migratory route.

4. All mixing of waters from different streams through direct discharge from canals above the point where mixing naturally occurs should be kept at a minimum. Canals that dump directly into stream beds, mixing water supplies, are believed to be major hazards to fish life.

5. Adequate protection should be provided during construction periods:
   a) To permit safe migration of both young and adults
   b) to permit safe spawning and incubation of eggs and growth of young
   c) to permit holding of spring-run fish
   d) to prevent any man-made catastrophe which might eliminate for all time a portion of, or a whole, annual cycle of salmon.

6. Planning, design, and construction of temporary fish ladders, traps, lifts, tank trucks, or other facilities should be well in advance of the time they are actually required. This is essential and was learned from hard experience.

7. Studies should be initiated to determine the need for screens and racks at all points where losses of either young or adults may occur in diversions. These investigations must determine the type of screen required for each locality and the size of fish which must be protected. In the case of low dams, suitable fish ladders must be installed wherever fish may be blocked from upstream spawning areas. These ladders must be adapted to the particular conditions of each locality. Construction and design of both screens and ladders should conform with the best standards established for fish protection.

8. As a general principle of fish protection, consideration should be given by the engineers, in planning dams, to the levels at which water will be withdrawn from the reservoirs. These must be as low as possible in order that cool water may be discharged through them. Fish life in general and salmon in particular, require cool water. Water drawn from the warmer upper layers of reservoirs during holding, spawning,

incubation periods will cause heavy losses if the temperatures exceed the tolerance levels of the fish.

(e) The design and operation of all fish protective devices should be under the supervision of fisheries biologists, and no alteration of either design or plan of operation should be permitted without the consent of the biologists.

Value of Central Valley Fish Resources

The annual value of the present Sacramento-San Joaquin salmon fishery is about $1,300,000.

The annual value of the commercial fishery alone is $356,000. This figure was determined from statistics of pounds landed as given in the published records of the California Division of Fish and Game. It was

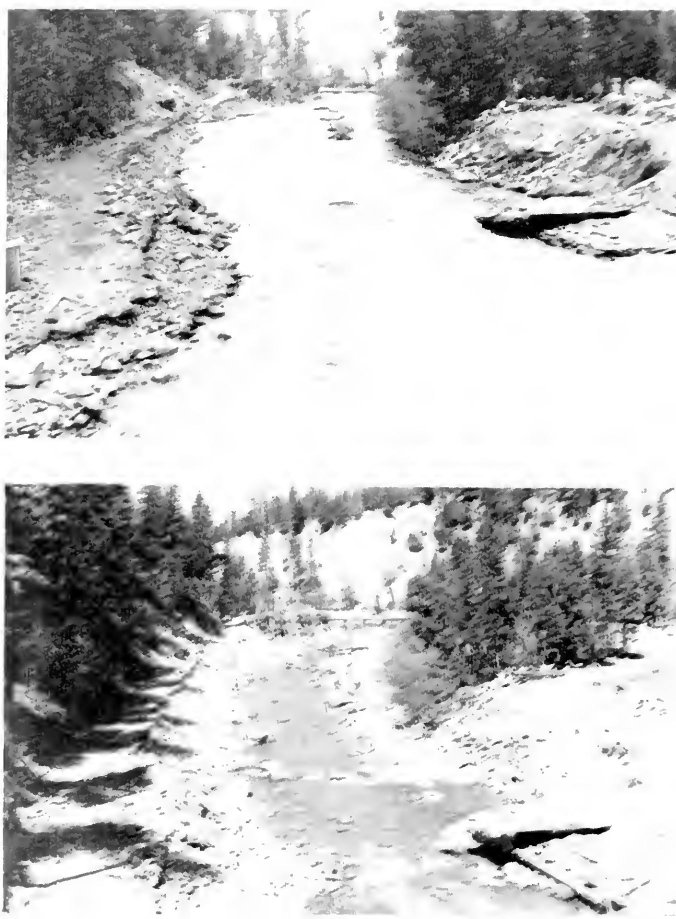

FIG. 14. What can happen. The Pit River just downstream from the diversion dam for "Pit 5" Power House, showing the effects of power diversion. Above, before diversion, flow 2700 cubic feet per second; below, after diversion, with only 50 cubic feet per second released through dam.

assumed that, of the ocean-caught salmon taken south of the Mendocino-Sonoma County line, 90 per cent were chinooks from the Central Valley streams. Silver salmon in this area amount to less than 10 per cent of the catch, and any chinooks from Klamath or other northern streams should be approximately balanced by Sacramento-San Joaquin fish caught in the northern part of the State. To the ocean catch thus calculated were added the San Francisco Bay and Sacramento River catches. The value per pound used was the average wholesale price of 22 cents which is approximately that which held during the years 1936 to 1939. In calculating the total value, it was necessary to deduct 20 per cent from the total weight to allow for cleaning losses.

The value of the salmon sport fishery attributable to the Central Valley area is estimated at $950,000 per year. To determine this, the numbers of fish landed were obtained from unpublished data of the California Division of Fish and Game. An average weight of 10 pounds was assigned to these fish. The U. S. Fish and Wildlife Service obtained an average of 18.1 pounds for over 800 salmon trapped at Redding, but sportsmen take a higher percentage of young fish than the commercial fishery. To the total weight thus obtained (950,000 pounds), a value of $1 per pound was assigned. While this same figure has been used by others in estimating the value of other sport fisheries, higher figures have also been used. The value adopted for the present estimate is considered to be conservative.

The total value of $1,306,000 calculated above for the Central Valley is considerably higher than that arrived at by the Board of Consultants on Fish Problems at Shasta Dam.[2] In their report, however, these consultants did not include the value of the sport fishery. Moreover, the value per pound used by them was only that paid to the commercial fishermen in the years 1929 to 1938. The total weight used was based upon the size of the runs above Shasta Dam. The area included between Table Mountain dam site and Shasta Dam is estimated to support an additional run two-thirds as great as that which formerly spawned above Shasta. The wholesale price which held during the years 1936 to 1939 is considered to be a more accurate measure of the value of the catch to the whole commercial fishing industry.

The full *potential, or maximum,* value of salmon and steelhead runs in the Central Valley streams has been calculated to be slightly over $2,000,000 per year (Table 2). This figure was arrived at as follows:

The size of the potential runs was computed by measuring the area of suitable spawning gravel below the first impassable fish barrier or below the locations of proposed dams that will present such a barrier to the migratory fish. These figures were then divided by the average area utilized by each female salmon for spawning, giving the number of females the stream would accommodate. This number was doubled to allow one male for each female. All observations made on the spawning grounds to date have shown more than two males to each female. If this were taken into consideration, the potential value would be approximately one-third greater. However, in view of the doubtful accuracy of the estimates of the potential capacity of the spawning areas, the more conservative figure is retained.

[2] "Report of the Board of Consultants on the Fish Problems of the Upper Sacramento River," by R. D. Calkins, W. F. Durand, and Willis H. Rich. U. S. Bureau of Reclamation, mimeographed, June 21, 1940.

The potential catch was considered to be equivalent to the potential stream capacities in terms of spawning fish, on the assumption that one fish could be caught for each one allowed to spawn. This ratio is conservative. On the Columbia River, Rich[3] determined that for chinook salmon the ratio of fish caught to fish escaping to spawn varied from 5 to 1 for spring fish, to 2 to 1 for fall fish.

The final potential value was obtained as follows from the calculated number of salmon. Sport-caught fish average smaller than those caught commercially, but are worth more per pound, so that the value of sport-caught fish averages higher. Since we have no way of knowing what

Table 2. Major Salmon Streams Affected By Central Valley Water Project

	Proposed Federal dams which may have serious effect on salmon and steelhead	Size of present annual salmon-run[1]	Potential run that might be developed	Potential annual value of run in dollars[3]	Recommended minimum flows in c. f. s.
San Joaquin River	Friant (built but not on full operating schedule)	E 15,000 IC 6,000	100,000	318,400	350 at Friant
Merced River		E 2,000	15,000	47,800	[5]50 at driest point below Exchequer
Tuolumne River	Jacksonville Dam and raising Don Pedro Dam	C 64,767	65,000	207,000	400 at Modesto [5]100 below LaGrange Dam
Stanislaus River	3 proposed	E over 5,000	25,000	79,600	[5]100 below proposed Oakdale Dam
Mokelumne River		E 16,000	40,000	127,400	[5]100 below Woodbridge Dam
Cosumnes River	Cosumnes Diversion, Nashville	IC 358	12,000	38,200	[5]50 below Cosumnes Diversion
American River	Folsom	T 15,000	70,000	[4]222,900	250 below proposed Folsom Dam
Yuba River	Lower Narrows	Unknown	60,000	191,000	[5]250 below Narrows Dam [5]75 below Daguerre Pt. Dam
Feather River	Bidwell Bar, Oroville	E over 10,000	90,000	286,600	[5]400 at driest point below Sutter-Butte Dam
Deer Creek	Power and irrigation	[2]3,000	12,000	38,200	50 below Stanford-Vina Dam
Mill Creek	Power and irrigation	C 6,500 (Unknown spring-run)	10,000	31,800	50 below Clough Dam
Sacramento (Basin) above Table Mountain (Dam Site)	Table Mountain and Iron Canyon	C and E 100,000	140,000	445,800	3,000 below Table Mountain
Totals		243,625	639,000	2,034,700	

[1] C=Reasonably complete counts (average of 3 years on the Tuolumne).
IC=Incomplete counts—possibly a high percent of run missed.
E=Estimated.
T=Calculated from tag returns.

[2] 3,000 is the native run. An additional 8,000 were transferred in the Shasta Salmon Program in 1944 and over 5,000 in 1943.

[3] There is no way of estimating the proportion of these runs that would be taken by sport fishermen. Therefore, the potential values are calculated on the basis of commercial values only. (See text.) These are much lower than accepted values for the sport catch.

[4] An annual return of $560,000 would be obtained for the potential value on this stream if the calculations were based on a 2:1 ratio of catch to escapement instead of 1:1, and if a price of 20 cents per pound and an average weight of 25 pounds per fish was used. These figures are not greatly different from those obtaining elsewhere so the values given above may be considered as minimal.

[5] Estimated flow.

[3] "The Salmon Runs of the Columbia River in 1938," by Willis H. Rich, Fishery Bull. No. 37, U. S. Fish and Wildlife Service.

proportion of the fish will be sport-caught, the potential value was calculated as though the entire catch would be commercial. To partially counterbalance the greater value of sport-caught fish, the average weight of 18 pounds was used.

The values calculated above do not include intangible factors that can not at present be expressed in terms of dollars and cents. Moreover, it does not recognize that salmon is the foundation of the entire small-boat fishery in northern California. Loss of the salmon fisheries would probably mean the loss of all of the fisheries dependent upon these boats since they could not operate economically on the other species alone.

The potential runs that might be developed on the various streams can not be credited wholly to possible increased flows. The State of California for some time has been engaged in a comprehensive program of improvement of fish protective devices. These, added to adequate regulation of the commercial and sport fisheries, should result in substantial increases in the number of salmon and steelhead. This is especially true of such a stream as the Feather, where sufficient water is available during the period of salmon runs. Even on such streams as the American, where controlled flows *might* improve conditions, an unknown benefit will be derived from proper ladders over dams and proper screening of water diversions. The benefit to be derived from either water regulation or screens and ladders can not now be assessed. The two factors are so closely interdependent that valid separation is impossible, since the runs can not survive without water, and will certainly be reduced by unscreened irrigation or power diversions, and killed outright by an impassable dam located downstream from spawning areas.

A fundamental difference between engineering and fisheries problems is that while the former can be worked out on paper, the answers to the latter are often not known until they become evident through the natural, or induced, course of events. Because of the fundamental differences between engineering and fisheries, there is no foundation for balancing, on paper, fish losses in one stream that result from construction of a dam by hypothetical gains that may result from artificially controlled flows in other streams. Such an exercise assumes without any basis in fact that gains from controlled flows will automatically occur. It also disregards the possible major upset in economy of the fisheries that will result if the harmful dam is built first, and the salmon run dependent upon that stream is killed off before the construction of so-called favorable dams and the hypothetical increase has occurred. Under such circumstances it is necessary to recognize that the increases that are shown as *possible* are deduced only from the size of the spawning area. They will not occur unless all factors affecting survival are improved. They can occur only if some additional source of production is available. There is little cause for optimism in contemplating the future potentialities of the Central Valley salmon runs if the plan of construction of dams is such as to kill important runs before the building up of others has been realized, or even proved to be possible.

Although emphasis has been given to the salmon and the hazards to their survival created by the proposed dams, it should not be overlooked that there is a commercial fishery for shad and catfish as well as a large sports fishery for other species in this area. In 1941, 203,350 licensed anglers fished in the waters of the Central Valley counties of California. The principal fishes involved are striped bass, large- and small-mouthed bass, catfish, crappie, sunfish, and steelhead. These fishes are not only valuable as food, but are the basis of an extensive recreational business, which prior to the war was increasing rapidly. Between 1930 and 1940, while the population of California increased 22 per cent, the number of angling licenses sold increased 56 per cent.

The uncertainty that exists as to the effects of the proposed dams and accessory facilities can be pointed out best by reference to the striped bass, the most important fish in this sport fishery. These fish spend a portion of their life in the ocean, but enter San Francisco Bay and pass into the lower reaches of the Sacramento and San Joaquin rivers to feed and to spawn. During 1941 111,400 anglers took 2,035,000 striped bass. At an average weight of three pounds, this catch amounted to about 6,105,000 pounds. Both the feeding and spawning grounds of these fish may be adversely affected through changes in water flows and salinity. No information exists at present as to the harmful or beneficial results that might follow the proposed construction. It is urgent that studies be undertaken at the earliest possible date, to find means of protecting these important fisheries.

Special Problems

A list of the proposed dams that will impose problems of fishery maintenance is given in Table 3. Certain of the problems are discussed in more detail in the following sections.

Table 3. List of Dams Impassable To Fish, With Recommended Minimum Flows

Name	Height of dam in ft.	Stream	Recommended minimum flows in c. f. s.	Major fish problems
Table Mountain	Initial 170 Ultimate 250	Upper Sacramento River	3,000	Involves difficult salmon salvage program below site of Table Mountain; nullifies present salvage of program for Shasta Dam
Bidwell Bar	696	Middle Fork, Feather River	400 Below Sutter Butte Dam	Eliminates spawning grounds in Middle and South Forks of Feather River. Good minimum flow might actually improve conditions
Narrows	605	Yuba River	250 Below Narrows Dam; 75 Below Daguerre Point Dam	Good minimum flow can improve conditions in this stream
Folsom	265	American River	250	Minimum flow of 250 c. f. s. is the answer to salmon problem in this stream
Monticello	239	Putah Creek	20	Of uncertain value to salmon and steelhead
Wilson Valley	280	Cache Creek	20	Of uncertain value
Black Butte	124	Stoney Creek	Not determined	Might be used for salmon if adequate flows are provided
Nashville Dam	340	Cosumnes River	50 Below Cosumnes Diversion	Minimum flow major problem here
Oakdale Dam	170	Stanislaus River	100 Below proposed Oakdale Dam	Minimum flow major problem here

Table Mountain Dam

It is understood that only a "tight" dam is now planned for this site. Earlier, consideration was given to construction of an open-type round-head, buttress dam that would store water only when flows exceeded 24,000 c.f.s. At flows lower than this, salmon could pass through to spawning grounds upstream. Even the latter type dam would have serious effects on salmon by (1) flooding out spawning grounds, (2) stranding seaward migrants as forebay levels fell in the reservoir, and (3) interrupting the migrations of adults and young fish during storage of flood waters.

Other plans propose an initial low dam to be followed later by the construction of a high dam at Table Mountain. In terms of fishery protection, both the initial and ultimate dams will have equally bad effects on salmon and steelhead runs except that the low dam (pool elevation 400 feet above sea level) will not flood out the new Coleman Salmon Hatchery on lower Battle Creek now being used in the Shasta program. It will flood the Balls Ferry rack and trap. Even though the low dam will not flood out the hatchery, it is questionable whether it will still be usable. The high dam will put all these facilities under 60 or 70 feet of water.

In view of the serious losses to the fisheries that may result from the construction of Table Mountain Dam, a re-examination of the economics of the entire project is recommended. The dam will completely nullify the present maintenance program now in operation below Shasta Dam, on which nearly $2,000,000 has already been expended. Furthermore, from a preliminary examination, the suggested methods for maintaining or transferring the runs appear to offer little hope of success.

The present annual value of salmon, exclusive of steelhead, originating in the upper Sacramento above Table Mountain is estimated to be $520,000. This is derived directly from the observed and estimated sizes of runs spawning in the different streams, as shown in Table 2. This area accounts for approximately 40 per cent of the total Central Valley salmon run. In addition to the loss of this annual income to the State, Table Mountain Dam will prevent full, future potential development of salmon runs to the upper Sacramento River. The annual value of this potential increase is estimated to be in the order of $140,000.

The magnitude of the problem and the difficulties involved in salmon maintenance at the Table Mountain site can be better appreciated in the light of the following facts.

1. A maximum run of 150,000 salmon migrate past Table Mountain dam site into the upper river. Of these, 125,000 compose the fall run, and the remaining 25,000 the spring run. The fall run peaks in late October, and the spring run about June 1.

2. One of the gravest dangers to salmon from construction of Table Mountain Dam is the problem of water temperatures. Water stored in Shasta Reservoir will be warmed considerably there. Released to flow into Table Mountain Reservoir, it would be warmed again, and might very well reach temperatures in excess of those tolerated by either young or adult salmon. These dangers would be more pronounced in the years of low run-off when the discharge from Shasta and Table Mountain reservoirs would be principally from the upper, warmer layers.

3. The temperature problem would also be present in the plan to divert water at or below Table Mountain to rehabilitate tributaries entering the Sacramento below it. The water would have to be carried considerable distances in open ditches and, even though it was drawn off the bottom of the reservoir, its suitability for salmon would be limited by its maximum temperature.

The following proposals have been advanced as offering possible solution of the salmon problem (or part of it) created by Table Mountain Dam. Fishery investigators are in agreement that none of them will prevent serious damage to the resource.

1. The salmon runs blocked at Table Mountain Dam might be maintained through artificial propagation. This idea is erroneous. To handle a run of 150,000 adult salmon would require hatcheries of unprecedented capacities, and to date no salmon run of commercial size has ever been maintained successfully by artificial propagation. All that hatcheries have done so far is to supplement natural spawning. In addition, there are no streams or springs in the vicinity of Table Mountain having the quantity and quality of water needed to supply a hatchery or hatcheries of the required capacity. The run now passing Table Mountain dam site can not be maintained by means of hatcheries alone.

2. The runs might be maintained by a combination of artificial propagation and natural spawning as in the present Shasta maintenance program. This might be accomplished by diverting Battle Creek around the forebay of Table Mountain reservoir and constructing another hatchery with rearing and holding areas near Table Mountain Dam. This would be expensive, and might not be justified in light of economic and biological studies.

3. Water might be diverted from a low dam immediately below Table Mountain Dam to rehabilitate a number of intermittent tributaries. The economic, engineering, and biological feasibility of this plan remains to be determined.

4. All spring-run salmon might be trapped below Table Mountain Dam and transferred to Mill Creek and Deer Creek for natural spawning. Only detailed studies would determine the practicability of this plan.

5. It has been suggested that fishing for resident game fishes in Table Mountain Reservoir would more than counter-balance the loss of salmon and steelhead runs to the upper Sacramento River. Reservoirs with highly fluctuating forebay levels are poor producers of fish. The periodic drying up of the richer, food producing, shallow-water areas by seasonal storage and release of water seriously reduces production of fish. The history of most such reservoirs in terms of angling is one of diminishing returns. In most California reservoirs, the fishing has not compensated for the loss of runs of salmon and steelhead; and it is exceedingly doubtful that it would do so in this case.

Minimum Flows

One of the most important considerations on each stream, as far as fish are concerned, is the minimum flow. The recommended flows for all important Central Valley streams, on which dams are planned, are given in Tables 2 and 3. These minima have been estimated from examination of the various streams under all conditions. The figures are necessarily preliminary. However, they are believed to be the lowest which will provide adequate coverage of the spawning areas, adequate feeding areas for the young salmon previous to their seaward migration, and which will also permit the upstream migration of the fish over natural barriers. There are many other projects proposed for other streams such as the Pine Flat Reservoir on Kings River, the Isabella Reservoir on Kern River, and others that have not as yet been studied but on which minimum flows will be required.

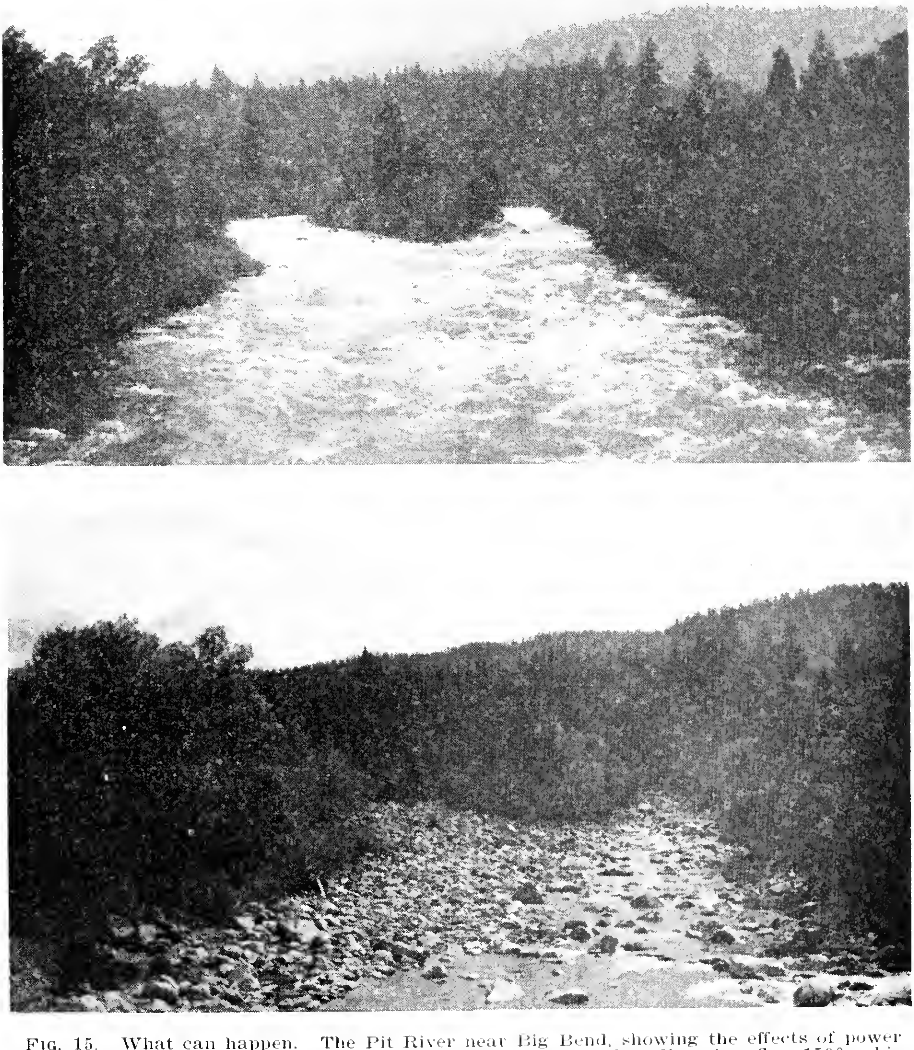

FIG. 15. What can happen. The Pit River near Big Bend, showing the effects of power diversion for the "Pit 5" Power House. Above, before diversion, flow 1500 cubic feet per second; below, after diversion, flow about 140 cubic feet per second (release of 50 cubic feet per second through dam about 5 miles upstream, plus inflow from tributaries below dam).

Delta Cross Channel

This channel, if constructed, will raise many entirely new and complicated problems concerned with the safe passage of fish both down and upstream. An open type of channel would probably result in heavy losses of young salmon no matter what type of screening might be devised. Losses would also result from interference with normal migratory routes, confusion to fish caused by new directions of flow, and by mixing waters from different drainage basins. A closed type of channel is essential to prevent the loss of salmon runs from intercepted streams.

Siphons or bridge crossings should be provided for the Delta Cross Channel over the lower end of the Cosumnes River, the Stockton ship channel, and the San Joaquin River. Water must not be spilled in large quantities directly from the channel to the lower reaches of other rivers.

Studies should be instituted to determine whether or not the pump lifts from the Sacramento River will require screening. Seaward migrant salmon as small as 30 mm. total length have been taken near Hood, and if screens are required they must be built to protect these fish. It may prove necessary to screen against the young of striped bass and shad of even smaller size than the salmon.

Lateral Canals

These canals include the Red Bluff-Dixon Canal taking off from the west side of the Sacramento River near Red Bluff, the Folsom-Newman and Folsom-Ione-Mendota Canals arising from the American River near Folsom, and the pumping connection to the latter canals from the Sacramento River near Hood. The same principles noted above for the Delta Cross Channel should be followed in constructing these canals. Studies should be instituted to determine the type of screens required on take-offs for the Red Bluff-Dixon, Hood pumping, and other canals diverting from the main streams. Siphons or bridges should be provided to take the canals across important salmon streams so as not to intercept the runs. No water should be spilled directly from them into the various river channels except where studies indicate that conditions for fish life will not be adversely affected.

Mendota Pool

The Mendota pool into which the Ione-Mendota or the Delta-Mendota canals, or both, will dump water should be isolated from the main San Joaquin channel and the water of the main San Joaquin River. One way that this might be accomplished would be by digging a new channel for the river to the east of the pool and returning it to the present river bed downstream from it.

Salt Water Barrier

If this structure is built to prevent penetration of salt water into the delta area by tidal action it will create serious problems for the continued survival of anadromous fishes as well as other aquatic life that depends upon brackish water for all or part of its existence. The complexities of the problem will require much study.

Salmon Refuges

Streams such as Deer Creek, near Vina, California, and Mill Creek near Los Molinos, California, might be set aside as salmon refuges in which no other conflicting use of the water would be permitted. The principle of providing such salmon refuges should be recognized and the machinery set up whereby they may be established. Deer Creek is being utilized now as an important element in the Shasta salmon program. Since 1942 over 13,000 adult spring-run salmon blocked by Shasta Dam have been transferred to Deer Creek for natural spawning. The offspring of these fish will return to Deer Creek; and it is important that every effort be made to assure unhindered migration of these fish in and out of this stream in future years.

Proposed Program for the Study of Fish Protection Problems in the Central Valley of California

A summary of proposed studies on each stream is given in Table 4. Additional details relating the various projects noted in the table to the entire program are outlined below. The outline lists the information required for each stream to determine the measures necessary to off-set the effects of dams and diversions on fish life.

A. Determination of size of present runs
- a) By counts at weirs and dams
- b) By calculation from tag returns
- c) By a combination of the above methods

B. Stream Surveys
- a) Estimate the spawning capacity of each stream
- b) Estimate variation in spawning capacity at different flows
- c) Establish minimum flows required
- d) Locate all hazards to fish life
  1. Dams
  2. Diversions
  3. Pollution, mining, industrial, agricultural, and domestic
     1) Determine extent to which pollution will be aggravated by reduced flows
- e) Make temperature studies of streams including the effects of storage, reduced flows, depth of outlet and other conditions

C. Study of methods of protecting fish from man-made hazards
- a) Determine place, size, and type of fish ladders needed
- b) Determine where bar screens are necessary to protect adults
- c) Determine location, type and mesh of screens needed to protect young migrants
  1. Determine time of migration of young, and size of migrants

D. Development of protection programs where necessary
- a) Determine size of present runs that must be handled
- b) Determine which nearby streams, if any, may be used for the transfer of fish for either natural or artificial propagation
- c) Consider methods of transfer, if needed
- d) Survey spawning areas that might be developed by addition of water to dry or nearly dry stream beds
- e) Evaluate the role of artificial propagation in the program

E. Study of needs for protection during construction
- a) Temporary fish ladders

b) Problems of fish passage around coffer dams, side spills, etc., under varying flows
c) Timing construction of protective devices to have them ready *before* dam construction blocks existing passages
d) Pollution by construction agencies
e) Problem of holding fish below dam without losses

F. Determination of the utility of the new reservoirs for other than anadromous fishes

G. Determination of the effects of the proposed salt-water barrier on the fish resources of the Central Valley, including the striped bass

Table 4. Summary of Studies Proposed

Name of stream	Section —Studies—	Count adult salmon	Survey stream and spawning beds	Minimum flows	Develop possible salvage program	Stream bed improvements necessitated by reduced flows	Need for fish screens and ladders	Collect seaward migrants to determine time of run and size of fish	Determine effects of different cross delta canal plans	Water temperatures	Fish protection during construction
San Joaquin River	Friant Dam to mouth	Yes	Done	Yes	Yes	Yes	Yes	Yes	Yes	Yes	------
*Merced River	Exchequer Dam to mouth	Yes	Yes	Yes	------	Yes	Yes	------	------	Yes	------
Tuolumne River	LaGrange Dam to mouth	Yes	Yes	Yes	------	Yes	Yes	------	------	Yes	------
Stanislaus River	Melones Dam to mouth	Yes	Yes	Yes	------	Yes	------	------	------	------	Yes
*Mokelumne River	Pardee Dam to mouth	Yes	Yes	------	------	Yes	------	Yes	Yes	------	------
Cosumnes River	Nashville Dam Site to mouth	Yes	Yes	Yes	------	------	------	------	------	------	Yes
American River	Folsom Dam to mouth	Yes	Done	Done	------	------	------	Yes	------	------	Yes
Yuba River	Lower Narrows Dam site to mouth	Yes	Done	Yes	------	Yes	Yes	------	------	Yes	Yes
Feather River	Bidwell to mouth	Yes	Yes	Yes	------	Yes	Yes	Yes	------	Yes	Yes
*Butte Creek	All Which is available to salmon	Yes	Yes	------	------	Yes	Yes	------	------	------	------
Sacramento River[1]	Keswick Dam to mouth	Yes	Yes	Yes	Yes	Yes	Yes	Yes	------	Yes	Yes
Stoney Creek	Mouth to Black Butte	------	Yes	Yes	------	Yes	Yes	------	------	Yes	------
Deer Creek[2]	Upper Falls to mouth	------	Yes	Yes	------	Yes	Yes	Yes	------	Yes	------
Mill Creek[3]	Black Rock Falls to mouth	------	Yes	Yes	------	Yes	Yes	Yes	------	Yes	------
Battle Creek[4]	Coleman Hatchery to mouth	------	------	------	------	------	------	------	------	Yes	------
Sacramento and San Joaquin	Salt water barrier	------	------	Yes	------	Yes	Yes	Yes	Yes	Yes	Yes

* These streams not directly affected by proposed dams, but information needed to complete the over-all picture and because the streams may be necessary for salvage purposes.
[1] All this with special reference to Table Mountain Dam.
[2] Deer Creek now in full use as part of Shasta Salmon Salvage Project.
[3] May be used to salvage Sacramento salmon.
[4] Now in use as part of Shasta Salmon Salvage Project.

Payment of Costs for Water Development for Fish Life

At present there is no provision in either the Federal or State statutes that makes possible the definite allocation of funds for water development for fish life. It is suggested, therefore, that this problem be studied. For example, it seems unfair to charge either irrigation or power interests with the cost of construction to provide a minimum flow of 250 c.f.s. on the American River below the proposed Folsom Dam. Heretofore the costs of fishery protection have been paid from construction costs, but at none of the dams built in the past few years has any water development been attempted solely for fish life. Funds for protective measures should continue to be provided in the budget for each structure, while costs of water development, *per se*, might be listed as nonreimbursable and thus made comparable with flood control and navigation.

Summary and Recommendations

1. The general principles of fishery protection in relation to the habits and environmental requirements of salmon are presented.

2. The present total value of the commercial and sport fishery for salmon that originate in the Sacramento-San Joaquin system is estimated to be approximately $1,300,000 per annum. The potential value of salmon and steelhead runs that might be developed and maintained, if adequate minimum flows and other protection is afforded, is estimated to be over $2,000,000 per annum. The present annual wholesale value of the commercial salmon fisheries depending on Central Valley streams is about $350,000. In 1941 over 200,000 licensed anglers fished in waters of the Central Valley. The sport fishery for salmon alone is estimated to be worth $950,000 per annum. During 1941 over 100,000 anglers took over six million pounds of striped bass in waters of the Central Valley system. No intangible benefits are included in the evaluations presented in this report; and while all values presented are preliminary, it is believed that they are conservative.

3. On the basis of partial counts and estimates made since 1940, about 250,000 adult salmon spawn in the Sacramento-San Joaquin system each year. Of these, 100,000, or some 40 per cent, use spawning grounds above the site of Table Mountain Dam. Data on the runs in each tributary are given in Table 2.

4. Dangers to fish life are pointed out with reference to canals and to stream crossings by canals. Screens, fish ladders, and other devices are recommended for construction wherever they will be required. The list compiled in this report is not complete.

5. It is recommended that spearing of adult salmon in all streams be made illegal by State law.

6. It is recommended that the capacity of the dams and reservoirs be made great enough to maintain flows of sufficient volume to develop the full potential fishery values that remain in the streams. At present it is impossible to separate benefits in terms of hypothetical

increases in salmon and steelhead runs, that will result from stabilized flows, from those gains that will be made through improved fish screens and ladders. The minimum flows listed in Tables 2 and 3 are tentative except for the 250 c.f.s. recommended for the American River.

7. It is essential that a minimum flow below Friant Dam be set in the immediate future in order to save the 15,000 salmon that spawn there annually, and to permit the realization of the full potentialities of this spawning area.

8. It is recommended that the Mendota Pool be isolated from the main channel of the San Joaquin River for protection of salmon.

9. Table Mountain Dam, will completely nullify the present salmon maintenance program that has been set up to care for the runs affected by Shasta Dam, and it will greatly endanger the future of the salmon resources in the upper Sacramento River. It is highly questionable that means can be found for saving the runs blocked by this dam that will be both economically justified and biologically feasible. Direct losses of salmon resources alone from Table Mountain Dam will be in the order of $520,000 annually. It is recommended that in view of the serious losses to the fisheries that will undoubtedly result from this dam, the economic justification for the entire project be re-examined.

10. It is recommended that at each project, the constructing agency provide all temporary fish protection devices needed during construction, as well as permanent facilities such as hatcheries, weirs, traps, etc., needed for fishery maintenance.

11. Studies should be undertaken to properly allocate costs of water development to protect fish life. Provision should be made for both construction and operation costs of fish protection devices. It is recommended that all these costs be classified as nonreimbursable.

12. A definite plan for operating procedures should be developed between Federal and State agencies. Decisions should be reached with regard to such matters as:
    a) Source of funds for the fishery investigations
    b) Provision of engineers, plans, and designs of projects, to assist fishery technicians
    c) Which agency shall operate the various facilities provided
    d) Methods of reporting progress and experience

13. A comprehensive basin-wide program for the study of fish problems that will be affected by the Central Valley Project is proposed. At least four years' time and a minimum of $218,000 would be required. Fishery surveys at each project should be concurrent with the preliminary engineering surveys so as to permit careful *advance* planning. A minimum period of four years' investigation preceding the beginning of construction is recommended.

THE BOUNTY SYSTEM AND PREDATOR CONTROL [1]

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The control of predators in the Western United States has become generally recognized as an established function of government either through direct field activities, cooperation with agricultural or conservation groups, payment of bounties, or through other types of assistance, all involving some form of financial participation. The reasons for predator control are self-evident to westerners and include preventing losses to livestock, poultry and certain fruit crops; protecting valuable game species against destruction; and aiding to insure against the retention of an enormous potential natural rabies reservoir, which periodically proves to be a source of infection for this most dreaded disease of humans, domestic pets, livestock and other native mammals.

Our discussion of bounties as a means of suppressing predators must largely be a summary of historical data and current facts and comments. It is not to be construed as in opposition to any sound bounty plan, although of necessity it is directed to pointing out the undesirable features associated with bounty payment schemes. At no time in our 30 years of direct and indirect association with predatory animal control work in the Western States have we encountered any bounty payment plan which of itself has successfully brought about the reduction of predators when and where needed. Apparently the ideal bounty system has yet to be devised, which through proper and periodic upward adjustments of payment commensurate with the scarcity of the animals to be controlled will continue to induce hunters or trappers to seek out a reduced predator population or wary specimen, before dishonest and fraudulent practices creep in to nullify any advantages gained.

Exceptional interest attaches to the outcome of the present trial being made with a State bounty law in Utah, effective in March, 1944, particularly in the light of California's experience with a bounty law in the 1890's, both of which are reviewed later.

The most favorable reaction toward bounties of which we are aware appeared in Research Bulletin No. 1, "The Pennsylvania Bounty System," issued by the Pennsylvania Board of Game Commissioners in 1937. In that State experience with some form or other of bounty dates back to 1683, and it required more than two centuries, or until April, 1915, to find legal provisions which gave some semblance of satisfaction with the suppression of only one predator out of a group of several listed, namely, the wildcat, a far less aggressive animal than the coyote with which the Western States must contend. Furthermore, the problem in Pennsylvania is primarily game and wildlife conservation. In 1915 Pennsylvania's wildcat bounty was $6. It was raised to $8 in 1919, and again in

[1] Submitted for publication, December, 1944.

1923 to $15, where it remained until 1937, the date of the publication. The following paragraphs are quoted from the above mentioned bulletin:

> In conclusion, the fact must be admitted that because it is impossible to show how or to what extent the payment of bounties has influenced the game supply, it is also impossible to prove that the Pennsylvania bounty system has during the past 20 years been of value as a game protective agency even though such may possibly be the case.
>
> The cost figures for that period from April 15, 1915, through May 31, 1935, have been minutely studied. The total amount of payments during the 20-year period was found to be $1,880,290, while the administrative cost involved in handling the same approximated $180,000, making the total cost of the operation of the system over $2,060,000. Two-thirds of the payment have been expended for the destruction of weasels and the amount of the average annual payment was $94,016.50.
>
> The effects of the operation of the bounty system have been analyzed in detail and it has been shown that as a predator control measure the payment of bounties has proven grossly inefficient, resulting in the control of only one relatively small species population, namely, the wildcat. Also, it has been impossible to prove that the operation of the bounty system over a relatively long period of years has improved game conditions. Furthermore, it was shown that the annual amount of money expended for bounty payments was controlled not by the abundance of predators, but principally by climatic and general economic conditions.

A more frank comment comes from Frank B. Foster while a member of the Pennsylvania Board of Game Commissioners in 1940, who stated in a letter to a staff member of our California Commission:

> The money that this State is wasting on bounties is absolutely appalling and I have been trying for years to get the Game Commission to abolish this extravagance.
>
> Of course, the weasel bounty is a great big racket and the same thing applies even to a greater extent on the gray foxes.

Pennsylvania has without doubt given bounty payment plans the most complete and intelligent consideration among the several commonwealths of our Nation, including recognition of the need to advance the amount of payment whenever the members of a particular species has been reduced and in order to provide the proper economic incentive.

The basic requirements for any bounty scheme were set forth in the U.S.D.A. Yearbook for 1896 (Pages 55-68) by Dr. T. S. Palmer, then First Assistant in the U. S. Biological Survey, as follows:

> Any scheme intended to bring about the extermination of a species must fulfill certain conditions before it can prove successful in practice: (1) It must be applied over a wide area practically covering the range of the species, otherwise the animals will increase in the unprotected region; (2) it should be uniform (i.e., the rates should be the same) in all localities; (3) it should provide some inducement for carrying out its provisions; (4) it should be economical, for if expensive, the cost will exceed the losses which it seeks to avert; (5) it should provide so far as possible against fraud or the misappropriation of public funds.

Strangely enough these premises would be fundamental today. In support of one of his conditions Dr. Palmer cited a close-to-home instance:

> While the coyote law was in force in California (1891-92) the premium was $5 but in Nevada only fifty cents was allowed. Nevada reported the destruction of comparatively few coyotes, but thousands of scalps were presented for payment in California, and it was notorious that many were imported from neighboring States, and even from Lower California.

In his final summary Dr. Palmer includes the following important statement:

> Objections to the bounty system may be grouped under four main heads: (a) Expense, which is usually out of all proportion to the benefit gained, and may be greater than the county or State can afford; (b) impossibility of maintaining bounties in all parts of an animal's range for any length of time; (c) impossibility of maintaining equal rates in all States; (d) impossibility of preventing payments for animals imported from other States, for counterfeit scalps, or for animals raised especially for the bounty. These objections have never been satisfactorily overcome, and most laws have failed through one or another of these causes.

At the time of the above writings (1896) Dr. Palmer also concluded that the individual landowner could perhaps best cope with the problem of pest animal control. This, however, was many years before the agency with which he was associated had evolved and sponsored a uniform cooperative plan of operation supported by the several levels of government and by livestock associations, and involving the employment of paid hunters and trappers, generally under formal agreements whereby National, State and county governments directed public expenditures to the problem of suppressing predators such as the wolf and coyote whose migratory habits took them clearly outside any effective vulnerability to local effort.

Since the experience of California with a bounty law has been mentioned, we might now review its development and rapid decline. Apparently there was much agitation in the late 80's for a uniform bounty in California under State supervision to replace the varying bounties allowed by county boards of supervisors. In some counties, there was no levy for that purpose at all. There were many complaints that adjoining counties were not bearing their share of expense, also, that unless an increasing scale were paid the bounty would not work.

"An Act fixing a bounty on coyote scalps" was approved March 31, 1891 (Ch. 198, Stats. 1891). By the middle of July, considerable opposition arose to this act. The arguments were that the process was costly because scalps were being shipped in from Mexico, Arizona, Nevada and Oregon. Also, some of the people in the San Joaquin Valley, where jack rabbits were particularly abundant, began to complain that the reduction in coyote numbers allowed an appreciable increase in rodent pests, particularly jack rabbits. Approximately six months after the act became effective, a notation appeared in one of the farm journals to the effect that over $20,000 worth of scalps were submitted for collection of the $5 bounty for the first quarter of its operation, and this approximate amount was approved for payment.

The Pacific Rural Press for April 2, 1892, reported that even the sheepmen did not realize that there would be so many varmints sent in. As a result of nine months' operation, 20,299 scalps had been certified to by county clerks, representing $101,495.

In the Legislature of 1893 there was extensive argument directed to the repeal of this law, and in the Assembly recommendation was made for its reenactment but with the bounty cut from $5 to $2.50 to reduce the enormous expense, and with the provision that the scalps be destroyed in the presence of the board of supervisors of the county from which they were to be certified. This act did not pass so the 1891 law remained operative.

On June 17, 1893, after $187,000 had been paid out and with many claims pending, the State Board of Examiners (Governor, Secretary of State and Attorney General) refused to pay out any more money from the General Fund on the ground that the Legislature had not indicated any special fund from which the moneys were to be paid, and consequently had made no appropriation for the purpose; and that there was no requirement that the Board of Examiners had to audit the claims submitted.

The board insisted upon further instructions and orders from the Legislature, since its members had analyzed the measure as being one for the performance of services rather than one for an appropriation.

In May, 1894, one of the persons having a claim for coyote scalps apparently mustered sufficient courage to file suit in the nature of a mandamus action, demanding payment for $365 (73 scalps). By this time the accumulation due was $129,000 for all claims submitted to the State.

On January 24, 1895, Governor Budd exercised his authority in signing a repeal bill (Ch. 1, Stats. 1895) to take effect immediately. Because this measure was pending in the Legislature, a number of persons were flocking in with scalps, many of them promoters who had developed quite a trade in channeling scalps from Arizona, Nevada and other States into the California counties for payment. The Governor was credited with wishing to forestall the necessity for paying out hundreds of thousands of dollars for coyotes collected from all over the West.

An effort was then made to have a bill pass the Legislature which would appropriate $275,000 to pay just claims which had accrued prior to the passage of the repeal act.

Finally the 1901 Legislature enacted a measure (Ch. 214, Stats. 1901) authorizing the honoring of just claims by having the petitioners bring suit, within one year, in the superior court to establish their right. By this time a relatively few individuals had had the many claims assigned to them so that in all about 20 or 25 individuals represented the claimants. The Bank of D. O. Mills in Sacramento had approximately $50,000 in claims.

In December, 1902, the superior court in Sacramento entered judgments against the State aggregating $126,505 under this new law. A number of claims were rejected until further substantiating evidence was presented. Those moneys allowed by the several superior courts were in fact never paid until the State Supreme Court finally settled the matter in September, 1904, when they handed down a decision to compel the State to pay $287,615. Add this to the $187,485 paid before the Board of Examiners refused to pay and we have a total sum of over $475,000 for coyote scalps submitted between March, 1891, and June, 1893.

The Supreme Court, in the Ingram case in 1894, decided that the law was constitutional but that the fault lay in the provision that the Treasurer could not pay out State moneys unless an audit by the Board of Examiners was first had. It would appear that the experience that the State went through at that time was so unsatisfactory that attempts at any new bounty law on coyotes in California have never again prevailed.

Over and above the foregoing, there still remained bounty provisions for predators in the several counties varying for coyotes from $1 in Mono County to $20 in Sonoma County (1919). Our records show that in 1911 there were 27 California counties paying bounties on coyotes, 29 in 1919, 10 in 1931 and 7 in 1944.

Commenting on "the dangerous bounty system," Mr. Joseph Dixon in 1920, when a member of the Staff of the University of California, stated in Bulletin 320 (Calif. Agr. Exper. Sta., Pages 395-6): "The bounty system is, at best, well-nigh futile; this is well illustrated by the coyote act of our own state, * * * It is the opinion of those who have made a study of this question that the bounty system is not only vastly expensive and productive of endless fraud, but that in no known case has it given any general or permanent relief."

One expensive and fraudulent practice developed about 1920 in connection with bounty collections in North Dakota is reported by R. E. Bateman of Billings, Montana, and corroborated by Louis Knowles of Fair Oaks, California, both of whom investigated this case. It appears that an individual made coyote pup scalps from the ears of a large variety of ground squirrel. These were put in sacks and presented, in a bad state of preservation, for the payment of bounty. The fraudulent scalps were collected upon in such counties as Renville, Bottineau, Rollette, Towner, Cavalier, Ward, McHenry, Benson and Ramsey. They were in most instances presented to the county auditor in such a condition that he was willing to permit the man to make his claim without a count or examination of the ears. The claimant then offered to destroy the bag of scalps, which the county representative was very willing to permit. The rotting scalps were then carried into another county and a similar claim was made. In one season about $15,000 was reported to have been collected by one such perpetrator before the fraud was stopped.

The Biennial Report of the Michigan Department of Conservation for 1921-22 carries the following paragraph:

> The history of the Michigan bounty law on predacious things is dotted with the work of those who padded bounty orders, manufactured woodchuck scalps by sewing ears on pieces of pelts, collected bounty on house-cats claiming them to be "wildcats"; of substituting blackbird heads for baby crow heads; of claimants stealing from township clerks the once bountied and discarded scalps and heads; of others who purchased Wisconsin weasel, where no bounty is paid, and collected a bounty in Michigan on them, falsely swearing they had been captured in this State.

In spite of these and similar experiences in other States, Utah passed a revised bounty fund bill in 1925. This revised law required that the entire skin be presented to the State together with a sworn statement that the animal had been killed within the State not to exceed 60 days prior to the claim. The State took the skin and paid the claimant a bounty of $3 on bobcats, $6 on coyotes, $10 on bears, and $15 each on wolves and mountain lions.

The law did not contemplate the destruction of coyotes and other predators during the denning season or summer months; nor did it provide for payments on young, or immature, animals. During the life of the law predators were taken as indicated in Table 1. Payments made in 1923 and 1924 are also indicated.

Table 1. Predators and Bounties In Utah, 1923-1932

Year	*Number of Predators*	*Cost*
1923	4,799	$ 18,579.00
1924	7,308	28,294.00
1926*	1,374	7,693.00
1927	4,997	28,178.00
1928	4,997	29,276.00
1929-1930	17,366	96,422.00
1931-1932	14,917	81,559.00
	55,758	$290,001.00

*No bounties paid during 1925. Funds were used up to pay 1924 claims.

By 1932 funds had been periodically exhausted and overdrafts created, and after that year no further payments were made. It was generally felt that the bulk of predators paid for were from other States since they were claimed on mainly from counties bordering other States.

A new Utah bounty law was conceived and enacted in 1943 (H.B. No. 95) to become effective March 1, 1944. It provides for the payment of $15 on mountain lions, $15 on grey or black wolves, and $6 each on coyotes and bobcats. The law requires that hides be presented with at least three feet intact. The feet are cut off to mark the skin which is then returned to the trapper for him to salvage any fur value. Funds are obtained for payment of the bounties by levies of 25 and 10 mills, respectively on each dollar valuation of all sheep and turkeys in each county in the State. A State bounty fund is thereby created. Control areas, inspectors, and county boards to assist the State Board of Agriculture, are provided, but without administrative funds which were later supplied from other revenue sources. Affidavits are made by inspectors, county boards and county claimants for filing with the county clerk before bounty claims can be paid by the State Auditor. Records are required, violations described and penalties established by the act. In September, 1944, we began to make inquiries concerning progress under this law, and arrived at the following viewpoints, which may require revision later.

Bounty payments under this new act were to become effective March 1, 1944, although predators collected after September 1, 1943, were permitted presentation. It is reported that up to August 15, 1944, 11,607 predatory animals were taken under this law at a cost of $70,194. This sum clearly can not represent the actual total cost, since it does not include local and State administrative charges. Nor does it represent the final cost to the livestock and poultry industries which, in order to gain the services of the bounty hunters, appear to be virtually obliged in many instances to subsidize them further by salary payment, with or without accommodations. Also, there appears still to be in existence the additional millage tax on sheep (5 mills) and cattle (2 mills) under the older 1925 enactment (so-called Cooperative Law) used half for paid hunters and trappers and half to be paid out for bounty claims up to the amount available.

In Utah the sheep and wool producing industry bears the heaviest burden of taxation to raise the funds to pay bounties, yet 71 per cent of the predators taken for bounty claims were taken in those Utah counties which border other States, except for two counties bordering Wyoming and Colorado but not readily accessible from the Wyoming and Colorado sides. Thus, circumstances force one to conclude that there must again be a heavy traffic of predator skins from other States into Utah for the purpose of obtaining bounty payments. This would seem to be supported by figures on catches made in other years and by other than bounty hunters, which show that the interior counties containing Utah's important summer ranges are normally populated quite heavily with predatory animals, especially coyotes. As a result, many stockmen for whom protection was intended now are hiring their own hunters to supplement whatever help may be obtained from bounties.

This practice of hiring private hunters, giving them the fur and in addition permitting them to collect the bounty, is also practiced in other parts of Utah. Several such cases are cited below; they seem to show that the bounty system alone fails to accomplish its purpose of preventing livestock and poultry losses.

Moon Brothers together with J. T. Murdock and several other stockmen from near Hanna, Utah, engaged a hunter (Nelson, from Salmon River, Idaho) at the rate of $150 a month to trap their range in Duchesne County, Utah. According to a statement by Murdock, 100 coyotes were taken by Nelson during four months (November to February). Nelson should have received not less than $14 each for the furs from coyotes he trapped at the then current prime pelt prices, making $1,400. The $6 bounty returned $600 and the salary paid by stockmen another $600. This would make a total of $2,600 for the 100 coyotes. When the furs began to lose value in the spring this trapper would not remain, but returned to Idaho.

Pete Moynier and Henry Dussiere together with 15 other interested livestock growers of Carbon County, Utah, are paying Trapper R. L. Hoggatt of Price, Utah, $250 a month to trap coyotes, and he keeps the fur and bounty. These men have signed a two year contract with Hoggatt whereby they agree to pay him at the $250 rate and grant him the sole privilege of trapping on their range to the complete exclusion of other trappers.

The Keller Sheep Company of Tremonton, Utah, operates in the Upper Logan Canyon in the Franklin Basin area and pays Trapper Dick Anderson $100 a month plus an additional $5 bounty per coyote. Anderson keeps the fur and State bounty.

We understand also that the requirement that the entire skin with three feet attached be exhibited has been set aside, so now it is quite generally the practice to require presentation of only the scalp and three feet when claim is made.

Another undesirable condition is inferable from observation made on the Utah system. Few trappers, regardless of whether publicly or privately engaged, can be sure that their trapped animals and traps will not be stolen. The district agent of the U. S. Fish and Wildlife Service at Salt Lake City has the following record of losses of predators and equipment by his field men, showing increased losses (thefts) in 1944 over 1943:

Table 2. Report of Losses By Theft of Predators and Equipment In Utah

Fiscal year	Coyotes	Bobcats	Traps	Getter guns	Total
1944	108	3	140	4	255
1943	21	2	38	0	61
Difference	87	1	102	4	194

Such stolen predators, of course, increase the cost per predator to the Fish and Wildlife Service under the paid hunter-trapper plan and at the same time represent predators that might readily be bountied yet would have been taken in any case.

Another inequality seems to appear from an analysis of the areas of bounty payment revenue source as compared with areas from which bounties are claimed. The following table prepared from figures furnished through the Utah State Auditor's Office shows that the counties or stockmen do not always receive the direct benefit from their assessment and perhaps even little indirect benefit in some areas. The largest claims are not necessarily made from the counties paying the greatest millage tax, and some counties making large payments collect for very few predators, e.g., Emery County. Further, comparison with a map of Utah shows that the border counties turn in bounty claims on the greatest number of predators.

Table 3. Distribution By County of Partial Bounties and Taxes Paid, Utah, 1944

County	Bountied coyotes	Bountied bobcats	Bountied cougars	Bounties paid	Taxes paid
Beaver	262	16	2	$1,698.00	$6,129.47
Box Elder	1,703	137	--	11,040.00	9,539.50
Cache	73	12	--	510.00	------
Carbon	87	21	--	678.00	2,350.38
Daggett	63	4	--	402.00	1,091.52
Davis	132	4	--	816.00	495.50
Duchesne	365	62	10	2,712.00	4,554.63
Emery	52	10	--	372.00	4,223.52
Garfield	486	95	4	3,546.00	2,692.28
Grand	51	16	--	402.00	2,428.40
Iron	493	74	3	3,447.00	6,664.33
Jaub	644	74	5	4,383.00	4,160.58
Kane	369	129	--	2,988.00	1,474.86
Millard	1,256	80	1-Wolf	8,031.00	19,530.38
Morgan	67	6	--	438.00	854.25
Piute	62	51	1	693.00	751.20
Rich	226	17	--	1,458.00	2,589.25
Salt Lake	60	1	--	366.00	428.41
San Juan	290	78	--	2,208.00	5,332.95
Sanpete	230	34	--	1,614.00	4,622.72
Sevier	111	38	1	909.00	2,061.91
Summit	299	7	--	1,836.00	1,149.00
Tooele	595	67	--	3,972.00	15,510.64
Uintah	798	117	--	5,490.00	11,087.24
Utah	451	42	16	3,198.00	1,715.54
Wasach	245	11	--	1,536.00	349.15
Washington	437	262	1	4,209.00	960.90
Wayne	113	31	--	864.00	1,533.28
Weber	44	1	--	270.00	264.61

One rather untenable idea seems to prevail in Utah, namely, that the bounty plan can be worked alongside the paid hunter-trapper system, supported in most western states in cooperation with the U. S. Fish and Wildlife Service, and that such a dual set-up will be the ultimate panacea to bring about a complete predatory animal clean-up. The fact is that the first effect of this set-up is to work hardship on the public services in that their trained men leave them to take up the more profitable work of hunting for bounties and for the salaries offered by ranchers. The records show that out of 54 men claiming bounties in 22 of Utah's 29 counties, 26 were former government hunters. It seems probable that when the cream of the volume is taken off these men will seek to return to the greater security of government employment. In the meantime the painstaking campaign against those predators which are actually causing economic losses but which are not sufficiently concentrated to attract bounty hunters suffers.

Our own association with the predator problem leads us to conclude that a systematic paid hunter plan will bring more lasting results under normal conditions. Paid hunters can be trained in den hunting, in certain tedious and specialized trapping methods, and in the use of quite selective poisoning processes for areas of high predator population and of the recently developed cyanide injector apparatus. By "normal conditions" we are referring to times when ammunition, gasoline and tire shortages do not keep the commercial trappers and hunters out of the field. Some of these latter are engaged in wartime duties or employment and the absence of their splendid work has been reflected in some areas by an increase in predator numbers. The dyed-in-the-wool commercial fur trapper follows his vocation regardless of the bounty incentive.

In certain California areas where because of climatic conditions pelts of coyotes are of low fur value commercial trappers are not particularly active; the added incentive of fur value would comparably be lacking to bounty hunters. Even more important, bounty inducement alone would certainly not be sufficient to meet a public emergency like an outbreak of rabies such as periodically occurs among coyotes, nor would it lead hunters into areas of difficult terrain to ferret out predators in the interest of preventing losses to valuable game species, as must be done by those employed in predatory animal control work by our State Division of Fish and Game.

In recent conversation with Stanley E. Piper who formerly supervised the predator control work in the Western States for the U. S. Biological Survey (Fish and Wildlife Service) we learned that after Wyoming had paid out $499,800 in wolf bounties over a 25-year period (1895-1919) without solving the problem, five years of systematic paid hunter-trapper activities under cooperative auspices definitely cleaned out the wolf menace.

In support of our belief, we find the following comment of W. C. Henderson, Associate Chief, U. S. Biological Survey, on Page 338 of the Journal of Mammalogy for August, 1930 (Vol. 11, No. 3):

> Studies had previously been made of the effectiveness of the bounty system in those States where it had been used for the repression of predatory animals for many years. From its investigations of this subject the Biological Survey was of the opinion that predatory animal control by the bounty system was unsatisfactory and ineffective. Not only had the bounty system been the basis of much fraud, but it had generally failed to accomplish its purpose. Many

> States had spent enormous sums over long periods, and still the predatory animals were not noticeably reduced in numbers. Bounty hunters carried on their operations where the animals could be most easily obtained, regardless of whether serious damage was being occasioned to livestock. Even in regions where heavy losses were being sustained by the stockmen and the ranchmen, the bounty hunter as a rule took only those animals that were most easily caught, as it was not profitable for him to devote the time necessary to capture the most cunning and destructive of the predators. In any event he was loath to take more than the annual crop, as to do so would put an end to his business.

The preceding statement leads to a mention of the reputed practice of bounty hunters to build up a breeding area by releasing female pups during den hunting and by liberating trapped females. This insures adequate breeding stock, and increases the number of trap-wise females whose capture through trapping by other than a super-wizard is almost impossible. Suffice it as an example to quote from an article by Gordon Griswold, President of the Nevada Wool Growers Association, in the National Wool Grower for November, 1943 (Vol. 33, No. 11, Pages 17-18):

> Nevada has had a bounty system and wants no more of it. Many instances of hunters releasing female coyotes and other abuses could be cited. One was employed by a group of sheepmen and permitted to retain the fur. This man took a great many coyotes yet there was no apparent reduction in sheep losses. However, when he was later replaced, his successor took 27 pegleg coyotes in 60 days; of these, 23 were females. This indicates that the first hunter was releasing females to assure a sustained yield of coyotes.

Too frequently, also, those who are responsible for checking scalps or other body parts submitted by bounty claimants are not sufficiently familiar with predator characteristics to be absolutely certain that the part is from the proper animal or from an animal typical for the locality. An apparently minor fraud of this character can lead to a major problem if repeated and not forcefully stopped.

Current agitation for bounties in some sections is due to a number of causes. The one most frequently stated, but greatly overemphasized, is that lack of bounty cheats the farm lads and ranch hands out of a chance to pick up cash to buy traps and ammunition to maintain their inherent interest in predator control. The others are enumerated below:

1. Abnormal wartime factors, such as scarcity of trained hunters and shortages of ammunition, traps and transportation, have kept down the effectiveness of regular commercial hunters and trappers, thus leading to a possible build-up of predator population in some areas.

2. The greatly increased value of livestock, poultry and other farm crops destroyed or attacked by predators has made more striking the dollars and cents loss and has highlighted the need for greater control activity.

3. Some sportsmen favor bounties to help cover their outlay for dogs, ammunition, guns and transportation.

4. Some localities fail to supply funds for any other methods of aiding in predator suppression.

The above reasons have minority adherents who overlook the major problems, which are: Systematic prevention of economic losses; concentration of predators where game and wildlife conservation can be most helped; persistent follow-through on especially wary stock-killers; and the health emergency which arises when rabies occurs in wild species.

In summary it might be stated that, save for the instance of wildcats in Pennsylvania under a wisely administered bounty law with proper upward adjustment in rates commensurate with scarcity, no record appears to demonstrate any satisfactory control of aggressive predators, such as wolves and coyotes, by a bounty scheme. For a number of reasons bounty plans have proved undesirable, since:

1. They do not encourage concentration of effort against individual livestock and game killers.

2. They do not encourage work when and where most needed, e.g., in the difficult terrain of summer stock ranges, or to protect valuable game species.

3. They permit hunters to concentrate their efforts during the season when pelts are prime, and to leave predators unmolested at other seasons.

4. Their early apparent value in turning in large numbers of animals dwindles until those left for "seed" build up a population sufficiently large to make bounty hunting profitable again.

5. They lead to fraudulent practises such as:

(a) Making claims for predators taken outside the paying State or area.

(b) Releasing trapped females to maintain a breeding stock.

(c) Submitting counterfeit or substitute parts of animals not legally eligible for bounty collection.

6. They encourage theft of animals and equipment from cooperative and other law-abiding trappers.

7. They do not provide means of meeting emergencies, such as rabies outbreaks, or excessive livestock or game killings concentrated in isolated regions.

8. The tax imposed to cover bounty payments seems at times to be an extra burden on livestock owners, in that it returns so little in the way of predator control that they feel obliged to hire trappers at their own expense.

OCCURRENCE OF THE BRAMBLE SHARK *(ECHINORHINUS BRUCUS)* IN CALIFORNIA[1]

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and

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On the basis of a photograph of a 62-inch, 100-pound specimen caught off Santa Barbara, California, in July, 1939, it has been suspected by California ichthyologists that the very rare but wide-ranging bramble shark, *Echinorhinus brucus* (Bonnaterre), occurs along the California coast. Since the shark was not preserved and the head had obviously been mutilated by an injury that had healed, and since this species had never been reported from near California, the identification did not seem assured and the record has not been published. This strange shark was examined and photographed at the shark processing plant at Moss Landing, California, by a fish and game warden, Charles Holtzhauser, who gave the notes and picture to Robert D. Byers, then on the research staff of the Bureau of Marine Fisheries. The data were then referred to Dr. George S. Myers of Stanford University, who made the identification on the basis of the photograph.

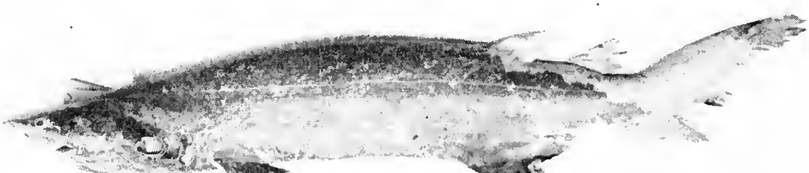

Fig. 16. Bramble shark six feet five inches long, caught off Los Angeles County in 1944; the first record for the eastern Pacific. Photograph taken by Donald H. Fry, Jr., from fresh specimen on day of capture.

The occurrence of the bramble shark in California is now definitely confirmed. On August 21, 1944, Capt. John DiMeglio of the boat "Arcturus" took a specimen more than six feet long near Point Vicente in Los Angeles County. It was caught in a gill-net that was set in 50 to 55 fathoms off Portuguese Bend (approximate position: Lat. 33° 43.0′ N., Long. 118° 22.5′ W.). Not recognizing the kind, Capt. DiMeglio pre-

[1] Contributions from the Scripps Institution of Oceanography New Series, No. 250. Submitted for publication, December, 1944.

sented the strange shark, eviscerated, to the California State Fisheries Laboratory. It has been donated to the United States National Museum, where it has been given catalogue number 130667. This is apparently the only specimen of the genus that is preserved in any North American museum.

So far as we can find, no record of this kind of shark from the eastern Pacific has been published. The only North American record appears to remain that of a seven-foot specimen which was washed ashore at Provincetown, Massachusetts, in December, 1878 (Goode and Bean, 1879, p. 31). The second and probably the only other report for the New World is that of an example about two and one-half meters (nearly ten feet) long from Mar del Plata, in the Province of Buenos Aires, Argentina (Berg, 1898, p. 10).

The bramble shark has been reported as somewhat common only on the Atlantic coast of Europe. It has also been recorded from the Mediterranean Sea and from West and South Africa, Australia, Tasmania, New Zealand and Japan (detailed references will be cited by Bigelow and Schroeder in their forthcoming treatise on the elasmobranch fishes of the western North Atlantic). It probably has a wide range in temperate and subtropical waters.

An Hawaiian specimen described by Pietschmann (1928, p. 297; 1930, pp. 3-4, Pl. 1 and Fig. 1) as *Echinorhinus cookei* seems to fall within the range of variation assigned to *E. brucus*. Pending a thorough comparative study of the genus, we regard this nominal species, and also *E. obesus* Smith from South Africa and *E. (Rubusqualus) mcCoyi* Whitley of Australia, as synonyms of *E. brucus*. Dr. Bigelow has compared the photographs of our specimen with sketches of a European specimen just made by Col. Tenison at the British Museum, and writes that this comparison confirms the view that there is no difference between the Pacific and Atlantic forms of *Echinorhinus*. We follow Garman (1913, p. 243) and more recent authors in adopting the name *E. brucus* (Bonnaterre, 1788) in preference to that of *E. spinosus* (Gmelin, 1789), on the basis of priority. We have, however, made no special study of the dates of publication in question. The synonymy of *E. brucus* will be treated in the monograph by Bigelow and Schroeder referred to above.

An outstanding character of this species of shark is the lack of an anal fin coupled with the small size of the two dorsal fins, of which the anterior one originates about opposite the insertion of the long-based pelvic. The peculiar teeth, similar in each jaw, have a very oblique main cusp and, at each side, a single subhorizontal secondary cusp (published descriptions and figures indicate that two or even three secondary cusps may be developed on one or both sides). The teeth number 12+13=25 in the upper jaw and 12+11=23 in the lower (left side counted first), and thus fall within the range of 22 to 26 in each jaw, as commonly accredited to the species. The skin is distinctively armed with isolated tubercular scales, each with a hard stellate base and a small spine at the summit (hence the common name "bramble shark"). The nostrils are divided by a sharply pointed flap from the front margin. There is a short fold around the corner of the mouth. Most of these specific characters are well shown in the two photographs of the California specimen (figures 16 and 17). After two months in cold storage this specimen was almost uniform dark brown, without clear indications of the dark spots reported in some descriptions.

Measurements follow of the California specimen, taken on the left side with the aid of special tuna-measuring calipers on the fresh specimen as soon as it had largely thawed out after having been hard-frozen for two months. The proportions are expressed as thousandths of the total length (196 centimeters). Greatest depth of body, about 141. Least depth of caudal peduncle, 62. Distance from tip of snout to first gill-slit, 192; to last gill-slit, 261; to insertion of pectoral fin, 260; to insertion of pelvic, 583; to origin of first dorsal fin, 590. Distance between origins of dorsal fins, 103. Interdorsal space, 39. Distance between bases of second dorsal and caudal fins, 37. Length of front

FIG. 17. Head of the California specimen of *Echinorhinus brucus*, showing structure of mouth, lips, teeth and nostrils, and the arrangement of the prickly scales. Photograph by Donald H. Fry, Jr.

margins of fins: first dorsal, 97; second dorsal, 88; upper caudal lobe, 218; lower caudal lobe, 117; pectoral, 115; pelvic, 89. Length of base of fins: first dorsal, 55; second dorsal, 51; pectoral, 72; pelvic, 104. Distance from origin of first dorsal fin to lateral line, 51. Height of first gill-slit, 44; of last gill-slit, 65. Length of snout: preocular, 81; preoral (from fold of lip), 72. Least distance between nostrils, 45. Width of left nostril, 15. Least interorbital width, 91. Length of orbit, 18. Suborbital width, 24. Width of mouth overall, 111. Length of mouth perpendicular to line joining ends of jaws, 41. Length of grooves at corner of mouth: upper, 16; lower, 19. Depth of snout above front of mouth, 51.

Although it was six feet, five inches long prior to preservation the male specimen at hand does not appear to have attained full maturity, for its claspers are very simple in structure, with merely a groove along one side, and are short, not reaching the posterior angle of the pelvic fin.

The taking of the bramble shark in California is a prompt confirmation of the opinion recently expressed in this journal by Barnhart and Hubbs (1944, p. 53) to the effect that many discoveries will follow upon a more thorough exploration of the fish fauna of the moderate depths along the coast of this State. Probably *Echinorhinus* will prove to be much less rare in California than the available data would seem to indicate.

Acknowledgements

For information and references dealing with the distribution of this shark we are particularly indebted to Henry B. Bigelow of the Museum of Comparative Zoology of Harvard University. Further advice has been received from Leonard P. Schultz of the United States Natural Museum and from three California ichthyologists, George S. Myers and Rolf L. Bolin of Stanford University and W. I. Follett of Oakland. Robert D. Byers, now of the Fish and Wildlife Service, has given data on the specimen that was caught off Santa Barbara. We also thank the Union Ice and Storage Company for the cold storage of the specimen. Donald H. Fry, Jr., of the California Division of Fish and Game, cooperated by taking the two photographs here reproduced.

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GAPEWORM IN CALIFORNIA QUAIL AND CHUKAR PARTRIDGE [1]

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Introduction

It is evident from our observations that gapeworm is a common parasite in some of our California game birds in captivity. Although there are no published reports of the occurrence of this parasite in either game birds or domestic poultry in California, we have observed it regularly in chukar partridge *(Alectoris graeca)* which we have autopsied at the Yountville Game Farm. We have not observed it in any birds from the Los Serranos Game Farm at Chino, nor are there any records of its occurrence there. We also have observed heavy infections in chukars at holding pens in Susanville during September, 1943, and again in quail *(Lophortyx californica)* at holding pens in Scotia in August, 1944. Gapeworms in domestic poultry and game birds in other parts of the world present a serious problem and mortality is high.

FIG. 18.

Drawing of male and female gapeworms. About 4 times natural size. (From Wehr, 1941).

These parasites have been reported from many species of birds. In the United States natural infections have been reported as occurring in ruffed grouse, bobwhite quail, and pheasant. Other investigators state that gapeworm infection apparently causes little or no distress to ruffed grouse and quail (eastern bobwhite) under natural conditions, but there are numerous reports of high mortality among pheasants, particularly from northwestern and eastern States. Although observation of the infections that occur in chukar and California quail leads us to the conclusion that mortality is high in infected birds of these species when in captivity, we have not observed these parasites in any of the wild birds examined.

Causative Agent

This disease is caused by a roundworm *(Syngamus trachea)* which lives in the windpipe of the bird. The worms are red from feeding on the blood of the bird. The female worms are from $\frac{1}{2}$ to 1 inch long, the males about $\frac{1}{5}$ of an inch. In the windpipe the males are permanently attached to the females, in copula (see Fig. 18). Nodules may occur on the

[1] Submitted for publication, December, 1944.

wall of the windpipe at the site of attachment of the worms. Ill effects are caused by loss of blood of the bird and blockage of the air passage.

Symptoms

The characteristic symptoms are usually readily observed in young birds which evidence gasping or coughing, hence the use of the common terms "gape" or "yap" disease. This usually develops within one or two weeks after infection. Quick jerks of the head and extension of the neck, indicating that the birds are not getting enough air, usually accompany this gasping. Prior to death the infected birds refuse food and water, become very weak and sluggish.

Adult chukars apparently do not show symptoms. Two adult birds maintained in the laboratory for a period of five months remained infected throughout this period. Older birds which overcome the effects of the infection but continue to harbor the worms serve as a constant source of spread.

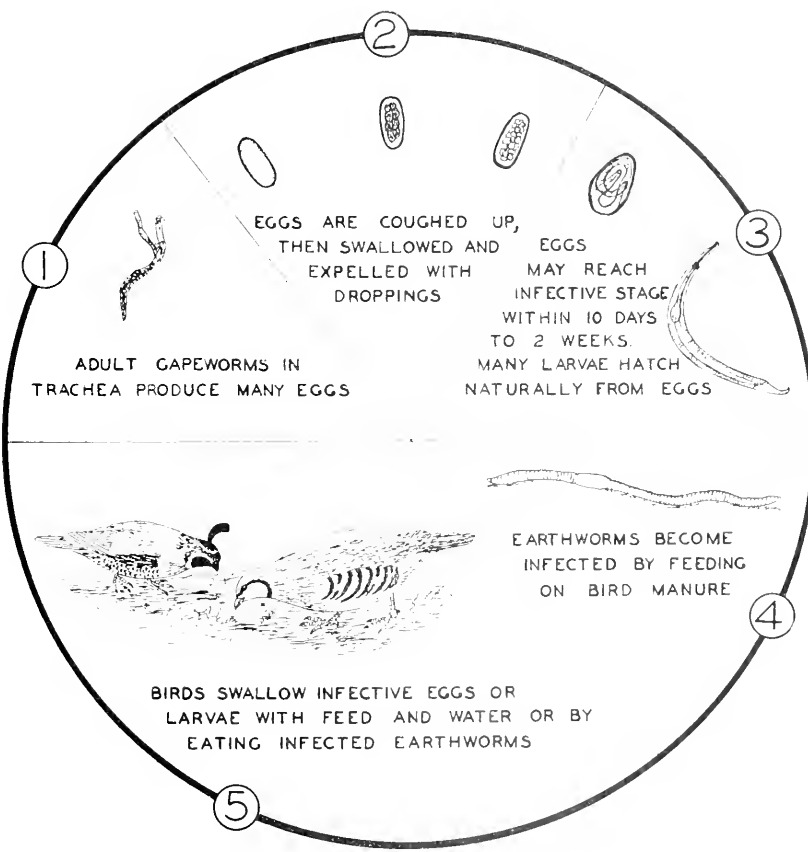

FIG. 19. Life history of gapeworm. (After Wehr, 1941).

Transmission

The adult gapeworms in the windpipe produce numerous eggs which are coughed up, then swallowed, and finally expelled with the bird's droppings. If these eggs are swallowed immediately by a susceptible bird, no infection occurs. The eggs must remain outside the body of the bird from 10 to 14 days before becoming infective. Some of the eggs may hatch and live as larvæ free in the soil. It has also been shown by other workers that the eggs or larvæ may be swallowed by earthworms. The birds become infected by eating the infective eggs or larvæ along with their food or water, or by eating the contaminated earthworms. This life cycle is pictured graphically in figure 19.

Prevention in Captive Birds

Sanitation is of chief importance in the prevention of this disease in game farm birds and in holding pens. Young birds should be kept separate from older birds and should not be placed on areas previously occupied by birds infected with gape disease. It is suggested that infected pens be allowed to remain dormant for at least two years. Droppings should be disposed of at least weekly and in such a manner that they will not be accessible to other birds. Holding pens should be placed, wherever possible, on sandy, well-drained soil.

Treatment

Gapeworm infections in wild birds would be extremely difficult to control and at present no technique is available for the control of such outbreaks should they occur. Since the release of infected birds not only would create the hazard of epidemic outbreaks in the existing population of wild game birds, but could also be spread to domestic fowl, it is imperative that the practice of releasing birds with gape disease be terminated.

Investigations conducted by the Bureau of Animal Industry, United States Department of Agriculture, have shown that birds can be effectively and efficiently treated with barium antimonyl tartrate. In a recent leaflet, Wehr (1941), has outlined this treatment as follows: "The infected birds are placed in a closed container or box (Fig. 20) and exposed to the powder for 15 to 20 minutes. The size of the dose is determined by the cubic capacity of the container. One ounce of barium antimonyl tartrate is sufficient for a box having a capacity of 8 cubic feet. The box should be deep enough to allow a space of at least 6 inches above the heads of the birds when standing erect. In the beginning, one-third of the total dose is blown into the box by means of a dust gun through an opening at the top. The box, if of a convenient size, is then tilted slowly from one side to the other several times. Tilting causes the birds to stir around in the box, thereby aiding in redispersing any powder that may have been settled on the feathers or the floor of the box, and forcing the birds to breathe more heavily and more frequently. This affords a better opportunity for the powder to reach the worms that may be located in the lower part of the windpipe. In the case of mature birds, when the treatment box is likely to be too heavy to tilt, a small electric fan may be placed on the floor of the box to keep the powder agitated. Five minutes after the introduction of the first one-third of the powder,

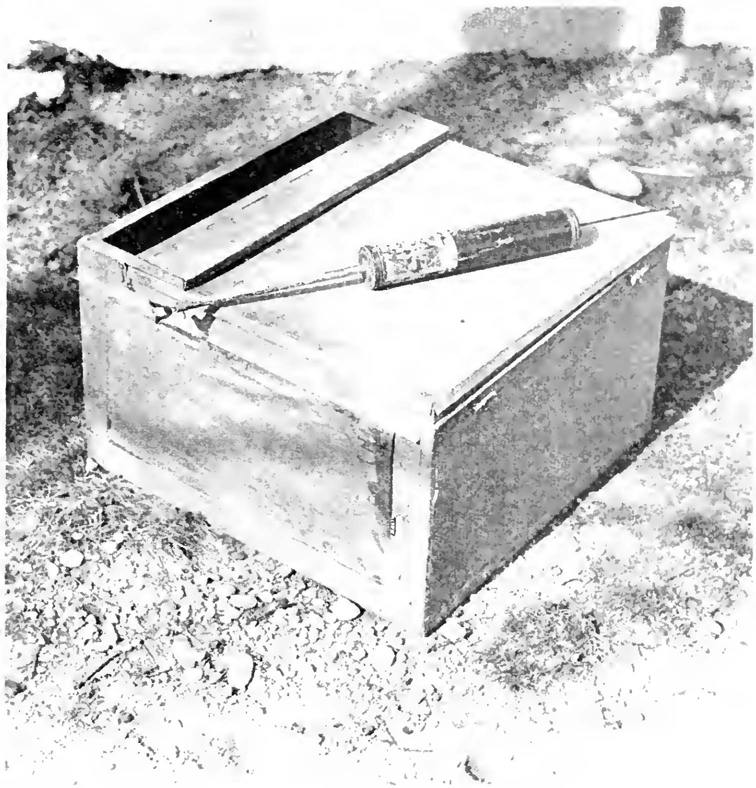

FIG. 20. Dust gun and box used for treating birds for gapeworm. (From Wehr, 1941)

the second one-third is introduced, and the tilting or the use of the fan is repeated. The remaining powder is introduced 10 to 15 minutes after the beginning of the treatment, and the box is again tilted or the fan used. The birds are released 5 to 10 minutes after the last of the powder has been blown into the box."

In a later paper, Wehr and Olivier (1943) reported on experimental treatment of young pheasants with this dust. Its efficiency approaches 100 per cent. They state that immediately following treatment, the eyes of a few of the birds appeared to be slightly irritated, probably as a result of some of the powdered drug being blown directly into the eyes. However, this condition did not persist and in a few hours the eyes of the affected birds became normal. Coughing, which had continued steadily from the seventh day after infection, ceased within a few hours after the birds were removed from the treatment box. There was only a slight interruption in feeding as a result of the treatment.

Wehr and Olivier also pointed out that because of the necessary confinement in the tight box for 16 to 20 minutes during treatment, the birds may become damp and overheated, and they recommend that following treatment the birds be placed in a warm, well-ventilated place until they become dry and cool.

Barium antimonyl tartrate can be obtained from several commercial concerns that specialize in poultry pharmaceuticals. It costs approximately $3 per pound so that the cost of the drug is slightly over one cent per bird for this treatment.

Literature Cited

Wehr, E. E.
1941. Controlling gapeworms in poultry. U. S. Dept. Agri. Leaflet No. 207, 6 pp.

Wehr, E. E. and L. Olivier
1943. The efficiency of barium antimonyl tartrate for the removal of gapeworms from pheasants. Proc. Helm. Soc. Wash., vol. 10, pp. 87-89.

EDITORIALS AND NOTES

FISHERIES AND THE CENTRAL VALLEY PROJECT

Of the many dams proposed for postwar construction in California, the series to be located on the Central Valley streams forms a system of far-reaching importance to our fish resources. Fortunately, consideration is being given to protection of the fisheries in the early stages of the planning. A board of consultants has been appointed by the U. S. Fish and Wildlife Service to give them special advice on the problem. The California State Division of Fish and Game is vitally interested, and the first article in this issue sets forth its recommendations.

Among the ideas put forward are several of a kind not heretofore found in reports of this nature. The most outstanding is the recommendation that, in the design of all dams and reservoirs, definite provision be made for specific storage capacity over and above the needs of power, irrigation, and other interests, to furnish water to be released in the streams below for the protection of fish life. In the case of dams like Bonneville on the Columbia River, where the full volume of the stream flows over the dam, this problem does not arise; but for many of the proposed California dams it is of paramount importance, in that they are designed to catch the runoff, store it, and in many cases divert it out of the natural channel. In the past, water has been stored for power, for irrigation, and for flood control; but no water has been stored for fish. California State law (Fish and Game Code, Sect. 525) provides that "The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam."

It is obvious that if a stream is inhabited by the full number of fish which its food production and other environmental conditions can support, the diversion from it of any appreciable quantity of water will make it impossible for that number of fish to continue to live there. Areas of the bottom which supported aquatic fish foods or served as spawning beds will become dry land; the velocity of the current will be reduced as the volume of flow decreases; and the temperatures will rise as the water becomes slower and shallower. It has been impossible in practice to demand fulfillment of the requirements of the law as worded, and the Fish and Game Commission, unable to stand firm on a legalized foundation, has had to fight for small releases of water to maintain at least some semblance of a fishery.

In practice, as water is diverted and the flow in a stream bed reaches low values, a critical point often occurs at which conditions are still suitable for fish but below which they become unsuitable. Inclusion in the design of dams and reservoirs of storage capacity specifically reserved for the purpose of supplying this minimum amount of water would be a long step forward in fish conservation.—*Brian Curtis, Editor,* California Fish and Game, *January, 1945.*

TWENTY-FIVE YEARS AGO IN "CALIFORNIA FISH AND GAME"

"The Mullet Fisheries of Salton Sea" by Will F. Thompson and Harold C. Bryant was one of the leading articles in CALIFORNIA FISH AND GAME twenty-five years ago. The mullet, *Mugil cephalus,* a form which can live in both salt and fresh water, occurs in the Colorado River, and it was presumably during the historic overflow of this river in 1905 and 1906 that it became established in the Salton Sea. In 1915 it was sufficiently abundant to support a small fishery, but received little market favor in spite of the fact that it has been looked upon as a great delicacy in Europe since Roman times. By 1918 Californians had apparently become more receptive, and 91,000 pounds were marketed. The principal figure in the fishery was a former New Englander, Captain Charles Davis, who, with eight trammel nets each 30 fathoms long, took 250 to 300 pounds daily, shipping to Los Angeles and San Francisco and receiving 15 cents a pound at the station. The fish were large, 2 to 2½ feet long.

Thompson and Bryant felt it very questionable whether this Salton Sea fishery could persist and indeed by 1921 these mullet had become so scare as to disappear from the commercial catch. However, an event unforeseeable by our authors, the great development of the Lower Colorado River, has brought in recent years a considerable inflow of waste irrigation water into the Sea, and the mullet has re-appeared in commercial numbers. In 1942 netting was permitted on an experimental basis, and in 1943 the fishery was re-established, with a July-December closed season, a 14-inch size limit, and with gear limited to the fixed gill net with five-inch minimum stretched mesh. In 1943 36,000 fish were reported taken weighing 187,000 pounds; and in 1944, 58,500 weighing 337,000 pounds. In 1944 the price ranged from 4 to 12 cents a pound to the fisherman. In 1945 to date the fishery has suffered from the use of Salton Sea as an aerial bombing range, and the resultant destruction of mullet.

Of long-range significance was the announcement in that issue of the bulletin of the agreement reached with the United States Forest Service whereby forest rangers would henceforth act as fish and game wardens, and our patrol force would reciprocate by acting as forest fire wardens. The two services have continued this cooperation in law enforcement ever since, to the benefit of both.

Of archaeological and sentimental, as well as piscatorial and economic interest is this sentence in an editorial discussion of the preceding season's herring catch: "None were salted or smoked, as the local demand for salted and smoked herring ended when the saloons closed on July 1st."
—*Brian Curtis, Editor,* CALIFORNIA FISH AND GAME, March, 1945.

REPORTS

FISH CASES

October, November, December, 1944

Offense	Number arrests	Fines imposed
Abalones: no license, undersize, bringing ashore mutilated	7	$320
Angling: no license, at night, failure to show fish on demand, snagging, illegally taken fish, fishing on fish ladder, fishing on spawning beds	27	560
Bass, striped: use more than one line, overlimit, undersize, at night, selling	34	1,067
Clams: undersize, no license	7	165
Commercial: illegal gill net, gill net closed district, net District 3 on Sunday, no license, using set lines District 13	27	1,305
Lobsters: undersize	4	300
Salmon: snag hooks, undersize, no license, untagged, shooting with rifle, at night	64	1,905
Spearing: closed area, on spawning beds, possess spear in fish ladder, gaff at dam, 300 ft. of stream	25	830
Sunfish: overlimit	1	25
Totals	196	$6,477

GAME CASES

October, November, December, 1944

Offense	Number arrests	Fines imposed
Deer: 2 deer in a 1 deer district, altering deer tags, take forked horn deer District 1¾, carry tags of another, closed district, failure to show deer on demand, fawn, doe, transfer tags to another, failure to tag, spotlighting, spike buck, failure to complete deer tags, refuge	98	$5,860
Deer meat: unstamped, closed season, illegal	9	315
Doves: overlimit, trapping, selling birds without a game breeder's license	31	1,250
Ducks: refuge, early and late shooting, overlimit, no license, shooting from power boat, closed season, unplugged gun	110	3,940
Failure to declare out-of-state game	3	125
Failure to make report of fur sales	1	10
Failure to show license on demand	1	10
Firearms: refuge	37	1,200
Hunting: no license, no deer tags, refuge, aiding and abetting juvenile in hunting without a license, purchase resident license while not a resident	25	415
Non-game birds	1	25
Pheasants: closed season, hen, no license, no tags, failure to tag	119	6,595
Pigeons: closed season	10	250
Pollution	2	250
Quail: closed season, overlimit, refuge	11	635
Seagulls	1	25
Shooting from vehicle, from public road, protected birds	9	135
Swans	6	240
Totals	474	$21,280

SEIZURES OF FISH AND GAME

October, November, December, 1944

Fish:	
Bass, black	2
Bass, striped, pounds	1,500
Clams	458
Lobsters	7
Lobster traps	45
Salmon	42
Salmon, king	25
Salmon, silver, pounds	45
Trout, rainbow	3
Trout, steelhead	1
Game:	
Deer	40
Deer meat, pounds	273
Doves	162
Ducks	668
Geese	51
Pheasants	12
Pheasants, cock	206
Pheasants, hen	47
Quail, valley	7
Rabbit, cottontail	1
Sagehens	2
Squirrel, gray	1
Swan	1
Woodducks	2

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(Continued from inside cover)

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